Source: SD1

Woolper Creek
Watershed Characterization Report

Prepared for: Sanitation District No. 1 of Northern Kentucky

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1. WATERSHED SUMMARY

Watershed characterization reports are being developed for sixteen watersheds located in Northern Kentucky that lie within the 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 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 33-square mile Woolper Creek watershed is located within Boone County in the North Study Basin. This creek originates near Hebron, west of the Cincinnati/Northern Kentucky International Airport and flows westward to the Ohio River (Figure 1). The dominant land cover is forest and roughly 28% of this watershed is developed.

The Kentucky Division of Water (KDOW) has designated Woolper 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 Double Lick Creek as an exceptional water and reference reach stream (401 KAR 10:030), and has also proposed this creek as a candidate for outstanding state resource water designation (401 KAR 10reg:030) in the drafted amendments to the Kentucky Administrative Regulations anticipated in February 2009.

Two segments of Woolper Creek and one segment of the Allen Fork tributary appear on the 303(d) list of impaired waterbodies (KDOW, 2008). The most recent aquatic habitat assessments generally indicate sites are not supporting of a diverse and productive ecosystem within this watershed, and most sites have poor biological conditions. A comparison of recent water quality data to applicable criteria revealed a single dissolved oxygen violation. Infrequent violations of dissolved oxygen, temperature and pH have been historically observed at the USGS continuous monitoring station between 2001 and 2005, but recent data from this location are still being reviewed and are not included in this assessment.

Potential pollutant sources in the watershed include sanitary sewer overflows (SSOs), KPDES permitted 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 sixteen different Northern Kentucky watersheds.

[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.

The WAT! calculated a fairly low fecal coliform loading potential for this watershed under year-round conditions and a slightly higher than average fecal coliform loading potential under base flow conditions. Overland runoff is predicted to be the dominant source under year-round conditions and septic systems are predicted to be the dominant source during base flow conditions.

The WAT! ranking is one of several factors that should be considered when prioritizing watersheds for improvement projects. Other factors include moderate-high public interest, one aquatic-dependent threatened and endangered species, and the designation of Double Lick Creek as an exceptional water and reference reach stream, and candidate for OSRW designation.

No additional water quality, biological or habitat sampling is recommended for this watershed, beyond that already planned. Next steps may include assessment of the impacts of bridge work on a planned sampling location. Additionally, coordination with KDOW might be also considered as they prepare for development of Total Maximum Daily Loads (TMDLs).

Figure 1. Woolper Creek Watershed

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2. WATERSHED FEATURES

Woolper Creek is located in Boone County in the North Study Basin, and drains a 33-square mile watershed. Woolper Creek originates in northeastern Boone County and flows westward for 13.9 miles to the Ohio River. Major tributaries include: Allen Fork, Double Lick Creek, Brandywine Creek and Ashbys Fork.

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 Woolper Creek.

2.1.1 Hydrology

An active USGS continuous monitoring station (03262001) is located on Woolper Creek along Woolper Road. The watershed area draining to the station is 24.2 square miles, approximately 73% of the Woolper Creek watershed. Daily discharge measurements are available at the station from December 2000 to the present[2]. The average flow at the station is 36 cfs (12/1/2000 - 9/30/2007), and 95% of flows are less than 154 cfs. Base flows at this location have been measured at less than 2 cfs, with flows increasing by up to three orders of magnitude during a storm event. The maximum flow recorded at the USGS station is 1,550 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 December 2000 and September 2007 there were 144 days with zero flow.

The 100-year floodplain extends up Woolper Creek for approximately 7.5 miles from the mouth, to approximately the Allen Fork confluence. The floodplain is widest downstream of the Ashbys Fork confluence. According to the Boone Comprehensive Plan, portions of the Woolper Creek watershed experience frequent flooding (BCPC, 2005). Furthermore, flooding in the Allen Fork watershed has been identified as a concern to the Darlington Farms Homeowners Association (Lighthiser et al., 2005).

2.1.2 Geology

The Woolper Creek watershed is located within the Outer Bluegrass Physiographic[3] Region, which is underlain primarily by Ordovician-age interbedded limestone and shale (Ray et. al., 1994). Although most of this watershed is underlain by bedrock with a moderate potential for karst development (Paylor and Currens, 2002), rocks in this region

[2] This analysis only uses approved data from USGS; at the time of the analysis data were approved through 9/30/2007.

[3] Physiographic regions are based on differences in geology, topography and hydrologic regime. The State of Kentucky is divided into five physiographic regions.

generally contain higher percentages of shale layers and do not develop extensive karst features (Ray et al., 1994)[4].

The mainstem of this creek cuts through the erodible shale found in the Kope formation. The rolling upland areas are underlain by the Grant Lake Limestone/Fairview and Bull Fork formations, which produce broad stream valleys. Groundwater yield varies depending on geological formation. Except near the headwaters, groundwater is generally unavailable on ridgetops. Wells in the valley bottoms can yield 100-500 gallons per day. This water is hard and may contain salt and hydrogen sulfide (Carey and Stickney, 2004).

The mouth of Woolper Creek was very likely glaciated 132,000 to 300,000 years ago. Conglomerate rock at the mouth of Woolper Creek is evidence of this and is an anomalous geological feature in the northern Kentucky region (Figure 2).

Figure 2. "Split Rock," a conglomerate rock from a glacial period over 130,000 years ago, near the mouth of Woolper Creek.

2.1.3 Topography

Higher elevations are generally found along a ridge on the eastern edge of the watershed. The highest point (922.1 feet) in the watershed is near North Bend Road and Petersburg Road. Other high areas include the northern-most and southern-most points in the watershed, the southeast corner of the watershed, and an interior hill near Idlewild Road. The lowest elevation in the watershed (453.6 feet at normal Ohio River pool) is located at the confluence of Woolper Creek with the Ohio River.

[4] 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.

2.1.4 Soils

The nature of soils and topography in a watershed plays an important role in both the amount of runoff generated and the amount of soil erosion that can occur. Most (85%) of the soils in the Woolper Creek watershed are classified as hydrologic soil group C (NRCS, 2006), meaning they have slow infiltration rates when thoroughly wetted. Another 11% of the soils are classified as hydrologic soil group D meaning water movement through the soil is restricted or very restricted. Soils in this group have a high runoff potential when thoroughly wet.

Nearly all of the soils in the watershed are ranked as either "highly erodible" (75%) or "fairly erodible" (23%), 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. Portions of this watershed are anticipated to undergo significant development in the future (Section 2.2.2).

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 3 (NCDC, 2008).

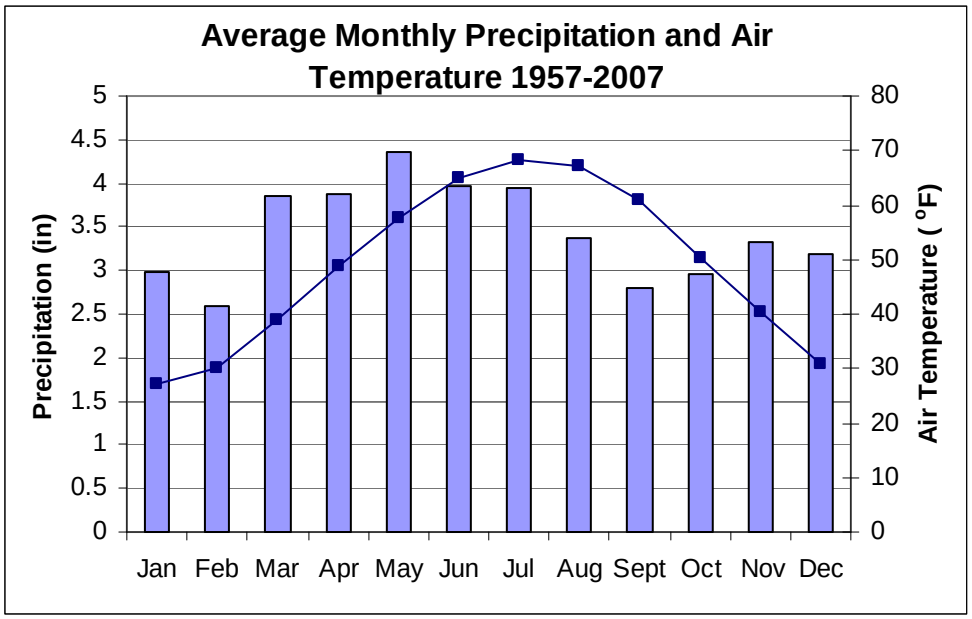

Figure 3. Average Monthly Precipitation and Air Temperature at the Cincinnati Northern Kentucky Airport (1957-2007)

2.1.6 Habitat

The Woolper Creek watershed lies within the Outer Bluegrass ecoregion[5], 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 1% 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 (Woods et al., 2002) and vegetation in pre-settlement times 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. In the eastern part of the watershed, Woolper Creek and Allen Fork (Figure 4) are impacted primarily by suburban development. Storm water runoff, channel erosion, eutrophication, high sediment loads, litter, riparian zone removal and channel straightening result in aquatic habitat simplification and reduce the creek's ability to support aquatic organisms. Other tributaries to Woolper Creek tend to be narrow and shallow, with some riparian vegetation (Figure 5).

Figure 4. Allen Fork

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

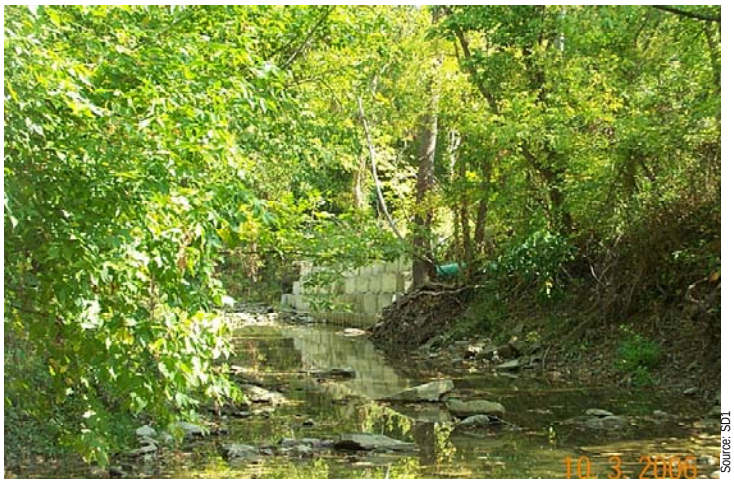

Figure 5. Ashby Fork at Intersection of Ashby Fork Road and Woolper Road

Closer to the mouth, shoreline vegetation has been removed, the channel has been straightened, and Woolper Creek has simplified aquatic habitats (Figure 6). A failed marina project near the mouth left a cut channel and large areas of bank unprotected from erosion (See Section 2.5 for more information).

Figure 6. Woolper Creek at RM 1.4 (left) and RM 0.6 (right)

The Split Rock Conservation Park is located near the mouth of Woolper Creek (Figure 1). This educational park promotes biodiversity, conservation practices, and restoration of native landscapes. Restored habitat areas include upland prairie (Figure 7, left photo), upland forest, wetted forest, wetland (Figure 7, right photo) and riparian habitats.

Figure 7. Natural Habitats Within Split Rock Conservation Park

Habitat assessments[6] were conducted at thirteen sites in the Woolper Creek watershed between 1999 and 2004 (Table 1). Aquatic habitat ratings within the watershed ranged from "not supporting" to "fully supporting" of aquatic habitats (Table 1).

[6] This assessment was conducted using EPA-established protocols. KDOW rated several components of physical habitat within the stream such as epifaunal substrate, embeddedness, sediment deposition, channel flow status, bank stability and riparian vegetation zone width, among others.

Table 1. Aquatic Habitat and Biological Sampling

Stream	River Mile	Monitoring							
		Habitat		Macroinvertebrates		Diatoms		Fish	
		Year	Ranking	Year(s)	Ranking	Year	Result	Year	Result
Allen Fork	4.5	2004	Not supporting	2004	Poor				
Allen Fork	0.2	2004	Supporting, but threatened	2004	Poor				
Ashbys Fork	1.9	2002	Fully supporting	2002	Excellent				
Double Lick Creek	0.1	2003	Partially supporting	2003	Fair	2003	Fair		
Unnamed tributary to Allen Fork at RM 2.1	0	2004	Partially supporting	2004	Poor				
Unnamed tributary to Allen Fork at RM 3.7	0	2004	Not supporting	2004	Poor				
Unnamed tributary to Allen Fork at RM 3.8	0	2004	Not supporting	2004	Poor	2004	Good		
Unnamed tributary to Woolper Ck at RM 13.0	0	2004	Not supporting	2004	Poor				
Unnamed tributary to Woolper Ck at RM 11.9	0	2004	Not supporting	2004	Poor	2004	Poor		
Unnamed tributary to Woolper Ck at RM 11.9	0.1	2004	Not supporting	2004	Poor				
Woolper Creek	3.9	1999	Supporting, but threatened					1999	Fair
Woolper Creek	11.9	2004	Not supporting	2004	Poor	2004	Poor		
Woolper Creek	13.6	2004	Not supporting	2004	Poor				
Woolper Creek	13.7					1999	Poor		

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 Woolper 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 8) using a variety of other datasets that represent current impervious conditions (roads, parking lots, buildings), open space lands (including parks), and surface waters.

Developed areas are sparse in the lower portion of the watershed, with development primarily occurring in the upper eastern portions of the watershed, near the towns of Burlington and Hebron.

Two major public parks, England-Idlewild Park and Boone Woods Park, and one private park, Split Rock Conservation Park (open to public by appointment only) are located in the watershed. In addition, the Boone County Fairgrounds hosts a variety of activities at their location near Burlington.

Forest is currently the dominant land cover in this watershed. 28% of the land is developed and 5% is covered with impervious surfaces.

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). Livestock were observed during a visit to the watershed and according to the Conservation District, horses are becoming a problem in the Hebron area, near the Woolper Creek headwaters (Campbell County Conservation District, 2007).

2.2.1.b Septic Systems

SD1 estimates that approximately 14% of all parcels in the Woolper Creek watershed are potentially serviced by septic systems. Properties potentially served by septic systems are found throughout the watershed.

Estimates of septic system failure rates are not available for Boone County; however anecdotal reports from Health Department inspectors suggest that 10% the septic systems may be operating improperly due to incorrect installation, lack of maintenance or age of the system (NKHD, 2008).

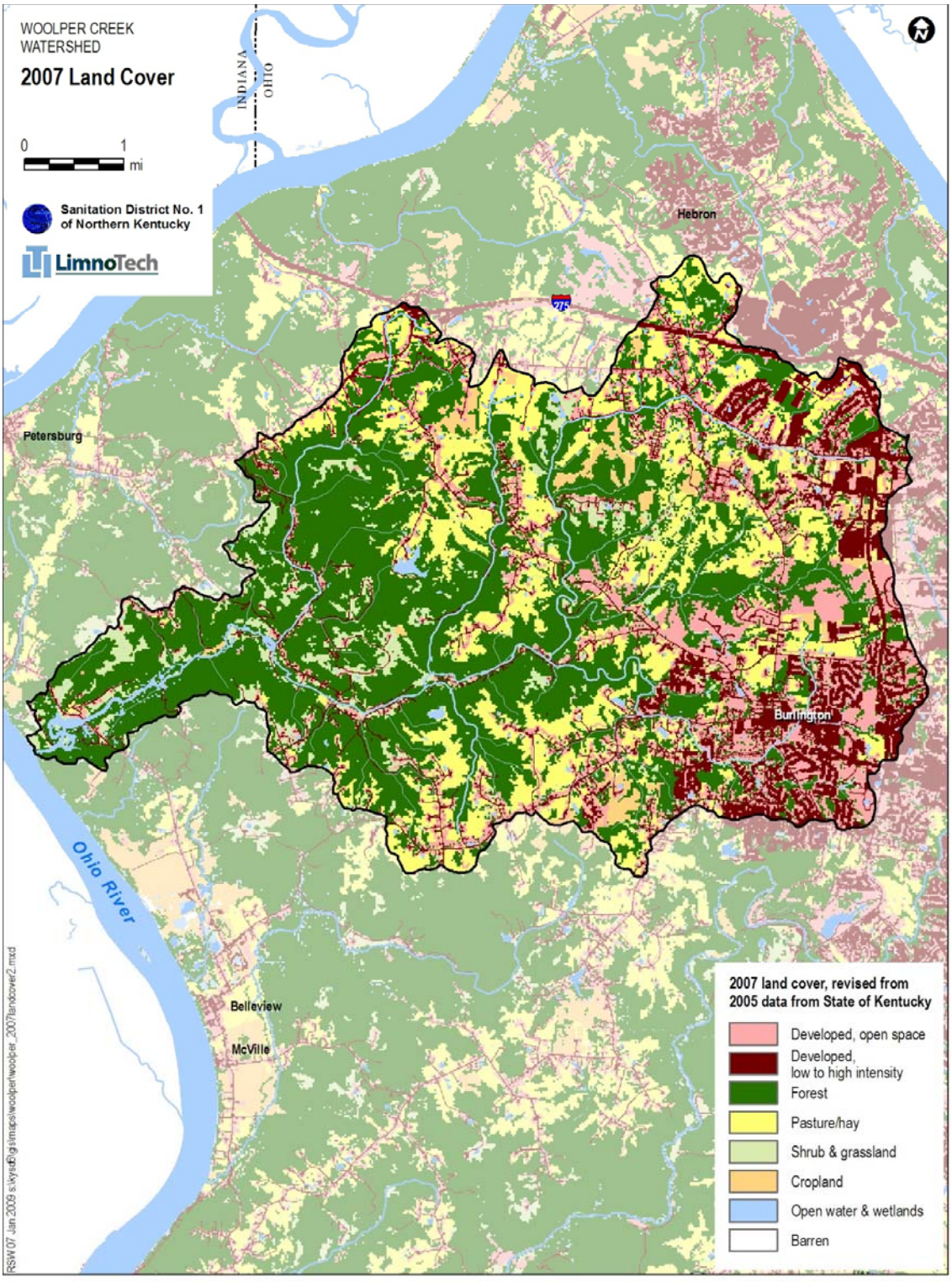

Figure 8. 2007 Land Cover

2.2.2 Future Conditions

The Allen Fork subwatershed and the headwaters of Woolper Creek, upstream of Allen Fork are predicted to become highly developed in the future. Figure 9 shows new development and construction near the headwaters of Woolper Creek. Some of the land located west of the airport's east-west runway is predicted to remain less developed or undeveloped, as the Cincinnati/Northern Kentucky Airport has worked with the Boone County Planning Commission to discourage residential development in some areas and has implemented a voluntary property acquisition program to reduce the impact of aircraft activity on residential areas.

One planned transportation project was identified in this watershed. This project will replace the bridge and approaches on Ashbys Fork Road over Ashbys Fork (Kentucky Transportation Cabinet, 2006).

Figure 9. New Development in the Woolper 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). Development is predicted to increase, with concurrent decreases in pasture/hay and forest (Figure 10). Developed lands are predicted to increase from 28% to 43% and impervious surfaces in the watershed are predicted to increase from 5% to 9%.

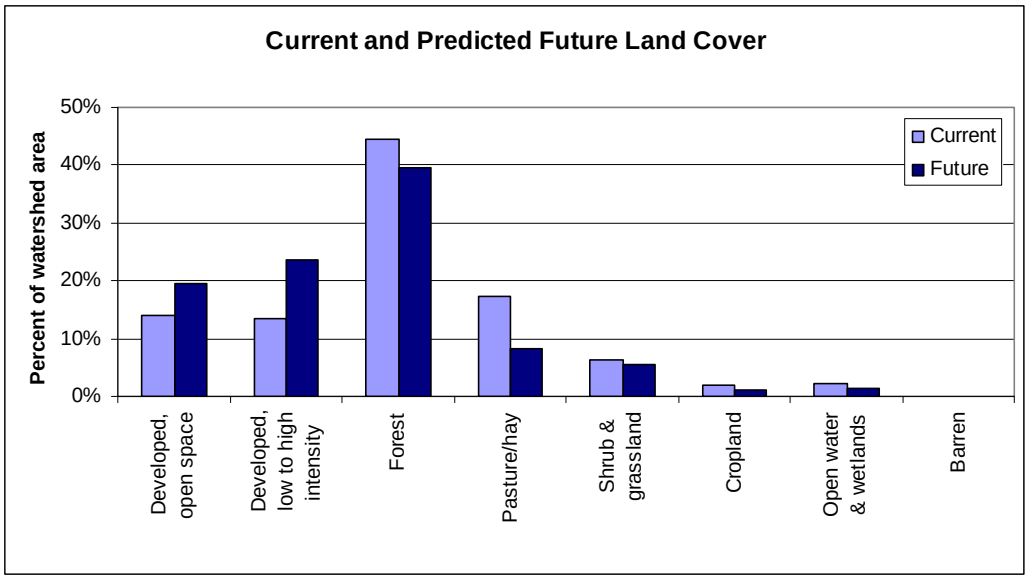

Figure 10. Current and Predicted Future Land Cover

2.3 INFRASTRUCTURE FEATURES

This section summarizes infrastructure features for the Woolper Creek watershed[7]. Approximately 38% of this watershed lies within SD1's separate sanitary sewer service area. The sanitary sewer infrastructure is located in the eastern portion of this watershed, and is comprised of approximately 74.9 miles of separate sewer lines.

Approximately 44% of this watershed lies within SD1's storm water service area. Within the service area, the storm waters system is comprised of approximately 175.9 miles of streams and channels and approximately 34.5 miles of pipes.

There is no combined sewer system area in this watershed.

The extent of the sanitary sewer and storm water service areas in this watershed is shown in Figure 11.

[7] 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.

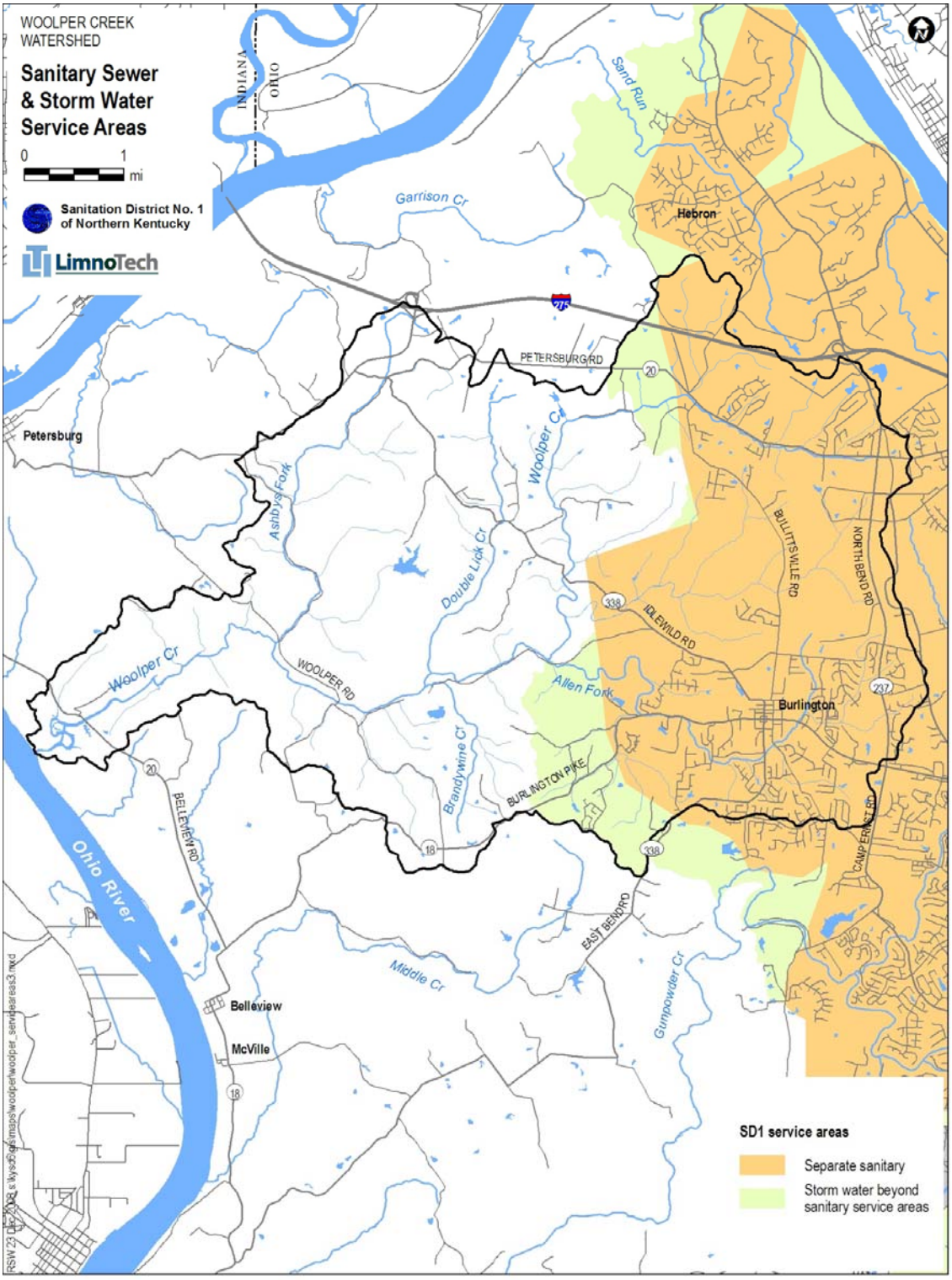

Figure 11. Sanitary Sewer and Storm Water Service Areas

2.3.1 Point Sources and Infrastructure

The occurrence of KPDES-permitted discharges, sewer overflows and storm water discharges is presented in this section.

2.3.1.a KPDES dischargers

There are eleven currently permitted, KPDES dischargers in the Woolper Creek watershed. All of these are sanitary wastewater discharges. Of these, one is an individual permit, while the remaining ten are general permits for residences.

Based on a review of recent effluent monitoring data (January 2007 to June 2008), it was observed that four of the permitted dischargers have violated permit limits for at least one of the following parameters: fecal coliform, total suspended solids, BOD_5, and total ammonia. KDOW requires effluent monitoring for the residential general permits (monitoring is required twice per year); however, data were not available for four 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.

Table 2. Permitted Dischargers

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Currently Permitted?[1]	Permit Violations
Ashbys Fork	KYG401071	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Ashbys Fork	KYG401543	Residence	0011	Minor	Sanitary wastewater Type B	Y	Fecal coliform, TSS
Double Lick Creek	KYG400073	Residence	0011	Minor	Sanitary wastewater Type B	Y	Fecal coliform, total ammonia
Double Lick Creek	KYG400322	Residence	0011	Minor	Sanitary wastewater Type B	Y	None
Double Lick Creek	KYG401889	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Allen Fork	KY0076546	Boone Co Animal Shelter	0012	Minor	Sanitary wastewater	N[2]	NA
Woolper Creek	KYG400219	Residence	0011	Minor	Sanitary wastewater Type B	Y	Fecal coliform
Woolper Creek	KYG400257	Residence	0011	Minor	Sanitary wastewater Type B	Y	BOD5, fecal coliform
Woolper Creek	KYG400072	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Woolper Creek	KY0050466	Ethans Glen Subd Sd #1	0011	Minor	Sanitary wastewater	Y	None
Woolper Creek	KYG400427	Residence	0011	Minor	Sanitary wastewater Type B	Y	None
Woolper Creek	KYG401656	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA

[1] Discharge is permitted as of June 2008

[2] Discharge permit inactive as of June 2008.

NA indicates monitoring data are not available

2.3.1.b Sewer overflows

There are no combined sewer overflows (CSOs) in this watershed.

There are six sanitary sewer overflows (SSOs) in Woolper Creek watershed (Table 3). Two of the SSOs are at pump stations. The Allen Fork pump station (2390PS1) has a known bypass and is included in the Pump Station Overflow Elimination Plan. The Bullitsville pump station (2370PS1) has had an overflow due to wet weather.

Table 3. Sanitary Sewer Overflow Points

Manhole ID	Direct Discharge to Waterbody	Typical Year Spill Frequency[a]	Typical Year Volume (MG)[a]
2390002	Allen Fork	0	0.00
2390006	Allen Fork	0	0.00
2390762	Allen Fork	3	0.06
2390008	Allen Fork	0	0.00
2370PS1 (Bullitsville pump station)	Tributary of Woolper Creek	0	0.00
2390PS1 (Allen Fork pump station)	Allen Fork	0	0.00

[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 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.

2.3.1.c Storm water discharges

Roughly the eastern third of the watershed is located within SD1's storm water service area. Storm water outfalls are located in the northern and southern portions of this area. In addition to storm water outfalls, there are also approximately eight suspected illicit activity points (SIAs) in the Woolper Creek watershed. 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. SIAs are located in the southeastern portion of the watershed in the Allen Fork watershed near Burlington.

Much of this watershed is located outside of SD1's storm water service area, so outfalls and illicit discharges may be located in these areas, but were not inventoried by SD1.

2.3.2 Recently Completed Infrastructure Projects

There are several recently completed infrastructure projects in the Woolper Creek watershed. These are:

- Strawberry Pump Station Elimination. The elimination of this station will help to attenuate the flow throughout the gravity portion, which will address surcharging in the system.
- SPCA Pump Station Elimination. The elimination of this station will also help to attenuate the flow throughout the gravity portion, which will address surcharging in the system.

- Allen Fork Pump Station Modifications and Improvements. This project increased the station's pumping capacity, thereby reducing upstream SSOs.
- Allen Fork Collection System (Phase I Improvements). This project provided wet weather capacity to eliminate sanitary sewer overflows in the collection system by upsizing existing sewers. This project also included the construction of the new Burlington Pump Station to intercept flows and provide additional dry and wet weather pumping. This project addressed two known SSOs and several suspected SSOs in the Burlington area.
- Main Street Sewer Assessment project. Completed in 2005, this project extended sewer lines, giving 17 properties the opportunity to connect to sewer service.
- Burlington Sewer Assessment Project. Completed in 2001, this project extended sewer lines, giving 137 properties the opportunity to connect to sewer service.
- Coral Sewer Assessment Project. Completed in 2005, this project extended sewer lines, giving 106 properties the opportunity to connect to sewer service.
- Hebron Sewer Assessment Project. Completed in 2005, this project extended sewer lines, giving 89 properties the opportunity to connect to sewer service.

2.3.3 Planned Infrastructure Improvement Projects

SD1 has one planned infrastructure improvement project in the Woolper Creek watershed.

- Allen Fork Collection System (Phase II Improvements). This project will build on the current Allen Fork Phase I improvements by identifying and constructing projects to remove infiltration and inflow, increase pumping capacity and store wet weather flows in new equalization basins upstream of the Allen Fork and Burlington Pump Stations. This project will work in concert with the Watershed Plans in the Consent Decree to abate three known SSOs and several suspected SSOs in the Allen Fork service area.

Project information is presented in Table 4.

Table 4. Planned Infrastructure Improvement Projects

Capital Improvement Project Title	Goal	Anticipated Start Date	Anticipated Completion Date	Project Total (Preliminary Estimate)
Allen Fork Collection System - Phase II Improvements	Abate SSOs	Part of Watershed Plans in Consent Decree		$34,444,000

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 (ONRW);

- 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 waterbodies in the Woolper Creek watershed have been designated as Outstanding National Resource Waters (401 KAR 10:030) and there are no National Marine Sanctuaries in the watershed (NOAA, 2008). Additionally, there are no known commercial shellfish beds within this watershed nor is shellfish harvest for consumption by private individuals known to occur. Therefore these three criteria were determined not to be relevant to the identification of sensitive waters in the Woolper Creek watershed. The remaining three criteria are discussed below.

2.4.1 Threatened & Endangered Species or Their Designated Critical Habitat

Threatened and endangered species and species of concern and their designated critical habitat within the Woolper Creek watershed were identified by contacting the Kentucky State Nature Preserves Commission (KSNPC). KSNPC identified four species in this watershed (KSNPC, 2007; Table 5), and one of these, running buffalo clover, is threatened (state) and endangered (federal). This plant has been recently (2004) observed in this watershed.

Running buffalo clover is a small herbaceous plant (Figure 12) that inhabits streambanks and upland areas. Erosion is noted as the biggest threat to this plant (KSNPC, 2006). Other factors contributing to running buffalo clover population declines are loss of bison populations, increasing non-native plant populations and overall habitat loss (USFWS, 2003).

Figure 12. Running Buffalo Clover, *trifolium stoloniferum.*

The remaining three species in Table 5 are species of concern. Only one, the northern leopard frog, relies on aquatic habitats. It inhabits various habitats including slowly flowing areas in creeks and rivers, springs, the nearshore area of lakes, bogs, fens, herbaceous wetlands, riparian areas and grasslands (NatureServe, 2007). Threats to the northern leopard frog include habitat loss, commercial overexploitation and competition with introduced species (NatureServe, 2007). The northern leopard frog was last observed in this watershed in 1946.

The redback salamander (*Plethodon cinereus*) and barn owl (*Tyto alba*) are species of concern that are not dependent upon aquatic habitats (Nature Serve, 2007). The redback salamander is dependent upon woodland habitats (NatureServe 2007), while the barn owl inhabits meadows and grasslands.

Table 5. Endangered Species, Threatened Species and Species of Concern

Taxonomic Group	Common Name	Scientific Name	Status[a, c]	Last Observed	Habitat(s)	Identified Threats
Vascular Plants	Running Buffalo Clover	*Trifolium stoloniferum*	Federal - Endangered State - Threatened	2004	Riparian areas, upland areas[a]	Habitat loss, non-native species, bison decline [d]
Amphibians	Redback Salamander	*Plethodon cinereus*	State - Special Concern	1987	Woodlands[b]	Habitat loss/degradation
	Northern Leopard Frog	*Rana pipiens*	State - Special Concern	1946	Ponds, wetlands, grasslands	Habitat loss, non-native species, commercial overexploitation
Breeding Birds	Barn Owl	*Tyto alba*	State - Special Concern	1987	Open grasslands and fields	Habitat loss

[a] KSNPC, 2006

[b] Nature Serve, 2007

[c] KSNPC, 2007

[d] USFWS, 2003

2.4.2 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). However, 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.

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

2.4.3 Public Drinking Water Intakes or their Designated Protection Areas

There are no public drinking water intakes from surface waters or active public water supply wells in this watershed. The nearest public drinking water intake from surface waters is located on the Ohio River near Louisville, Kentucky.

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 the entire Woolper Creek watershed lies within SWAPP Zone 2, reflecting the fact that this watershed is more than 25 miles upstream of the nearest water intake.

Drinking water supply features are shown in Figure 13.

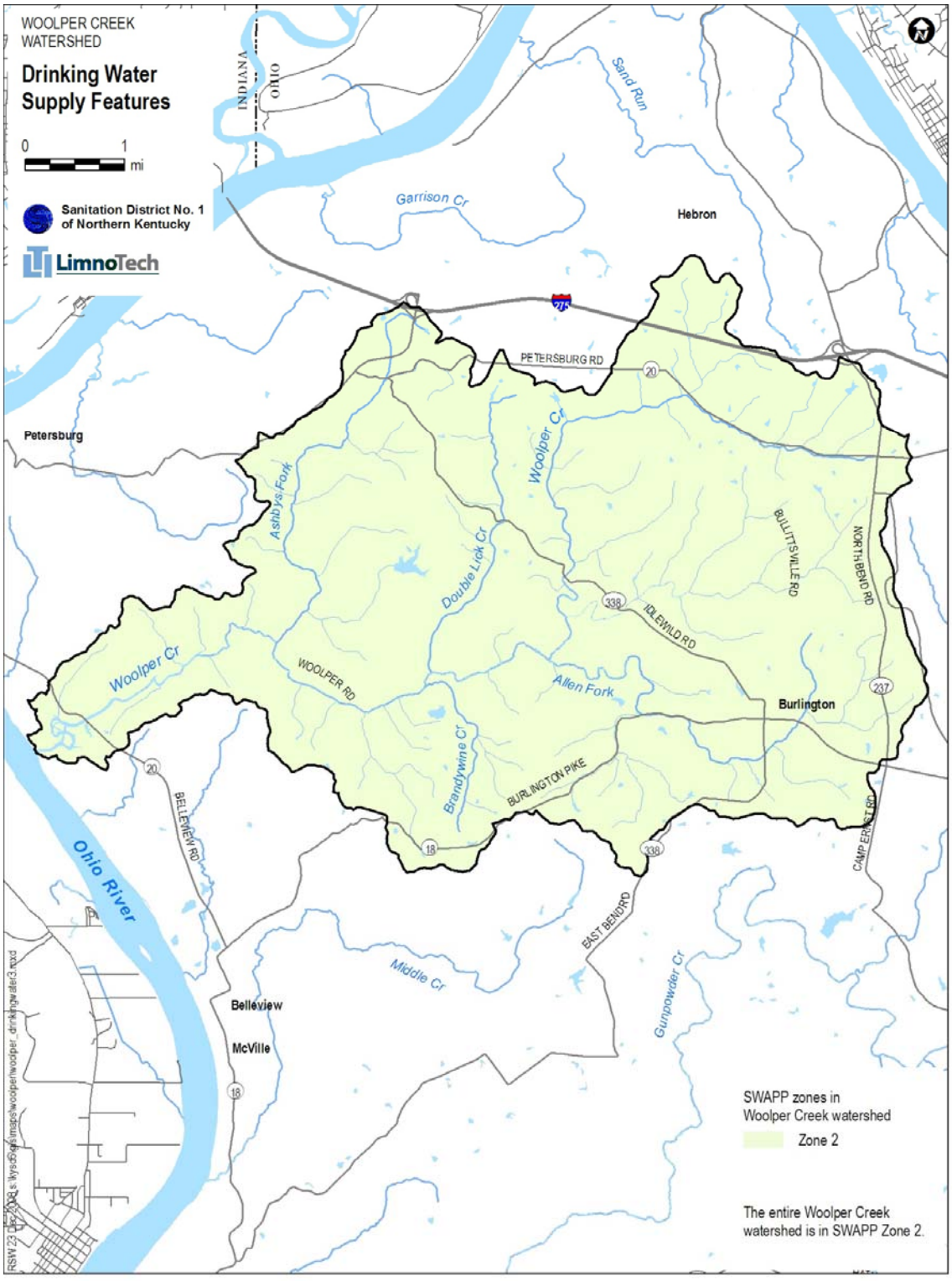

Figure 13. Drinking Water Supply Features

2.5 PUBLIC INTEREST/WATERSHED GROUP ACTIVITIES

Public interest in this watershed is rated moderate-high due to past sampling by many organizations (Section 4.2) and improvement projects, such as those described below.

Boone County Public Works Department, in partnership with SD1 sponsored the Allen Fork Headwater Feasibility Study to address flooding and sedimentation in Darlington Farms Lake, which is an impoundment on Allen Fork. This study was completed in 2005 and discussed the feasibility of various control options to improve the lake and reduce storm water runoff. This study identified the streams in Boone Woods Park as among the most impaired and a priority for stream restoration and riparian buffer enhancement and conservation. Boone County and the Northern Kentucky University Center for Applied Ecology (CAE) have developed a preliminary scope for stream and wetland restoration for portions of Allen Fork tributaries that traverse Boone Woods Park. Construction is planned to begin in Fall 2008, with project maintenance and monitoring continuing through 2013.

The CAE completed construction and habitat restoration activities in 2005 and 2006 at Burlington Elementary School in the Allen Fork subwatershed. This work involved wetlands creation for storm water treatment and habitat, channel stabilization of 700 feet of a tributary to Allen Fork, restoration of floodplain access and riparian forest restoration, among other things.

In summer 2008, the CAE plans to initiate construction work for stream, wetland and riparian buffer restoration near the mouth of Woolper Creek to repair damage done in 1991 during a marina construction project. The marina project cut a straight channel through a meander within the creek's natural path and dredged seven acres of ponds and wetland habitat (Figure 14). The marina was never completed due to environmental and financial concerns at the time and the dredge material was left close to the creek side, where it erodes during rain events. Funding for this project is through the Kentucky In-lieu fee Program. Project maintenance and monitoring will be conducted for five years following completion of construction.

Source: Mark Jacobs, Boone County Conservation District & Split Rock Conservation Park

Figure 14. Woolper Creek Channel Cut for Marina Construction.

Finally, the Boone County Greenways Plan is under development but was not available at the time of this report. This plan may contain additional information on proposed greenways in this watershed.

3. WATERBODY USES

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

3.1 DESIGNATED USES

Woolper 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 uses 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.

Double Lick Creek (Figure 15) has been categorized as exceptional by the cabinet pursuant to 401 KAR 10:030 and is also a waterbody defined in the cabinet's reference reach network. Furthermore, this creek is identified as a candidate for outstanding state resource water designation (401 KAR 10reg:030) in the drafted amendments to the Kentucky Administrative Regulations anticipated in February 2009.

- **Exceptional waters** means a surface water categorized as exceptional by the cabinet pursuant to 401 KAR 10:030.
- **Outstanding state resource waters** means a surface water categorized by the cabinet as an outstanding national resource water pursuant to 401 KAR 10:031.

Figure 15. Double Lick Creek (RM 1.0)

3.2 CURRENT USES

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

- The most recent (2004) biological sampling reflects poor conditions at many locations in this watershed.
- The most recent (2004) aquatic habitat assessment revealed conditions that are not supporting at many locations. Two tributary locations were found to have slightly better habitat, ranking partially supporting and supporting, but threatened.
- There are currently no swimming advisories for Woolper Creek. However, KDOW and the Division of Public Health Protection and Safety in the Cabinet for Health and Family Services 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, 2007a).
- 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, 2007b).
- One fishing access site is located on Inglewood Park Lake, in the England-Idlewild Park (http://kygeonet.ky.gov/kdfwr/viewer.htm). An additional site is located at the Boone County Fairgrounds.
- Woolper Creek is identified by the Kentucky Department of Fish and Wildlife Resources as a smallmouth bass stream, based on fish populations (Ross, undated).
- There are no surface drinking water intakes in the watershed.
- There are no active public water supply groundwater wells in this watershed (KDOW, 2008b; 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

Two segments of Woolper Creek and a 2.6-mile segment on the Allen Fork tributary to Woolper Creek appear on Kentucky's 2008 303(d) list of impaired waters (Table 6; KDOW, 2008).

Table 6. 303(d)-listed Waterbodies

Waterbody Segment	Designated Uses (use support)	Pollutants	Suspected Sources
Woolper Creek RM 11.9 – 14.0	Primary Contact Recreation (Not Supporting) Warm Water Aquatic Habitat (Not Supporting)	Fecal coliform Total suspended solids Nutrient/eutrophication biological indicators Organic enrichment (sewage) biological indicators	Illegal dumps or other inappropriate waste disposal; Impacts from hydrostructure flow regulation/modification; Urban runoff/storm sewers
Woolper Creek RM 2.8 – 7.2	Primary Contact Recreation (Not Supporting)	Fecal coliform	Agriculture
Allen Fork RM 2.0 – 4.6	Warm Water Aquatic Habitat (Partially Supporting)	Sedimentation/siltation Nutrient/eutrophication biological indicators	Habitat modification other than hydromodification; Unspecified urban storm water

The data used to list Woolper Creek RM 11.9-14.0 for fecal coliform were collected prior to 2000 and could not be located (KDOW, 2007d, Morehead State University, 2007, KDOW, 2008b). The bacteria data used to initially list Woolper Creek RM 2.8 – 7.2 were also not available (KDOW, 2007d). As described in Sections 2.3.2 and 2.5, several improvement projects have been completed since the 303(d) listing.

KDOW has completed nutrient, organic enrichment and total suspended solids data collection during 2006, and may collect additional sediment data, if needed. Once data collection is complete, KDOW will develop the sediment TMDLs. The TMDLs for nutrients and organic enrichment will not be initiated until after nutrient criteria are promulgated by the state (KDOW, 2008).

4.2 MONITORING PROGRAMS

Water quality data have been collected in this watershed by KDOW, Northern Kentucky University (NKU), Licking River Watershed Watch (LRWW), 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. Available data exists for the main stem of Woolper Creek, three named tributaries (Allen Fork, Ashbys Fork and Double Lick Creek) and several unnamed tributaries.

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	Number of Samples[b]
NKU	2001	Fecal coliform, E. coli	Woolper Cr. RM 7.5	1 sample (8/25/2001)
NKU	2002	Atrazine	Woolper Cr. RM 7.5	1 sample (5/18/2002)
NKU	2003	Fecal coliform	Woolper Cr. RM 4.1, 7.5; Ashbys Fork RM 0.0	1 sample (7/10/2003)
NKU	2003	Estradiol (horomone), fecal coliform, alkalinity, chloride, hardness, conductivity, sulfate, TSS, temperature, nutrients	Woolper Cr. RM 4.1, 7.5; Ashbys Fork RM 0.0	1 sample (9/6/2003)
LRWW	2002	Fecal coliform	Woolper Cr. RM 7.5	1 sample (7/12/2002)
LRWW	2003	Fecal coliform	Woolper Cr. RM 4.1, 7.5; Ashbys Fork RM 0.0	1 sample (5/14/2003)
LRWW	2003	Fecal coliform	Woolper Cr. RM 9.6	1 sample (9/5/2003)
LRWW	2004	Fecal coliform, E. coli	Woolper Cr. RM 7.5; Allen Fork RM 2.1	3 samples (May, July, Sept) for Woolper Cr.; 1 sample (Sept) for Allen Fork
Conservation District	2004-2006[a]	Fecal coliform, E. coli, alkalinity, chloride, DO, pH, conductivity, temperature, sulfate, TSS, nutrients	Woolper Cr. RM 4.1, 9.6; Double Lick Cr. RM 1.9; Ashbys Fork RM 0.0	8 samples for Woolper Cr. RM 4.1 and Ashbys Fork RM 0.0; 7 samples for Woolper Cr. RM 9.6; 4 samples for Double Lick Cr. RM 1.9
SD1	2006	Fecal coliform, E. coli, DO, pH, conductivity, turbidity, temperature	Woolper Cr. RM 1.4, 5.0, 8.8; Allen Fork RM 0.1; Ashbys Fork RM 0.0	2 samples from baseline survey (10/3/2006 & 10/23/2006)
SD1	2007	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, turbidity, TSS, temperature, nutrients	Woolper Cr. RM 1.4, 5.0, 8.8; Allen Fork RM 0.1; Ashbys Fork RM 0.0	1 sample (8/14/2007)
SD1	2008[a]	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, turbidity, TSS, temperature, nutrients	Woolper Cr. RM 1.4, 5.0, 8.8; Allen Fork RM 0.1; Ashbys Fork RM 0.0	1 sample (8/27/2008)

Table 7. Summary of Water Quality Monitoring Data - Continued

Entity	Dates	Parameters Sampled	Sampling Locations	Number of Samples[b]
KDOW	1985	Fecal coliform, Fecal strep	Allen Fork RM 2.5	1 sample (3/5/1985)
KDOW	1999	DO, pH, conductivity, temperature	Woolper Cr. RM 3.9	1 sample (8/3/1999)
KDOW	2003	Conductivity, pH, temperature	Double Lick Cr. RM 0.1	1 sample (5/27/2003)
KDOW	2004	DO, pH, conductivity, temperature	Unnamed trib. to Allen Fork (ALF3.7-UNT0.0); Unnamed trib. to Woolper Cr. (WPC11.9-UNT0.1)	1 sample (Mar 2004)
KDOW	2004-2005	Alkalinity, CBOD, chloride, hardness, DO, pH, conductivity, sulfate, TOC, TSS, temperature, nutrients	Woolper Cr. RM 11.9, 13.6; Allen Fork RM 0.1, 4.5; 2 unnamed tribs. to Woolper Cr. (WPC13.0-UNT0.0; WPC11.9-UNT0.0) 2 unnamed tribs to Allen Fork (ALF3.8-UNT0.0; ALF2.1-UNT0.0)	1 sample per month (Mar 2004 to Feb 2005 - two samples in Aug, but no sample in Oct)
USGS	2000-present[a]	Gage height, discharge, precipitation, DO, DO % sat, DO equilibrium, pH, conductivity, turbidity, temperature	USGS Station No. 03262001; Woolper Cr. RM 5.0	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 in Woolper Creek during base flow conditions with at least one survey per year. The five sampling locations are on Woolper Creek at RM 1.4, 5.0, and 8.8, Allen Fork RM 0.1 and Ashbys Fork RM 0.0. Typical analyses will include bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters.

SD1 is planning to collect wet weather data at the same five locations in 2009. Attempts will be made to collect data during three discrete storm events of varying characteristics (total rainfall, maximum intensity). Samples will be analyzed for bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters. Within each event, samples will be collected near hour 0, 2, 4, 6, 12, 24, 36 and 48 hours of the start of the storm, though these intervals are dependent on the storm characteristics and may be changed if necessary.

Biological monitoring is planned for Woolper Creek in 2009 at the baseline locations and on Double Lick Creek, a current reference station. This will include a habitat survey along with fish and macroinvertebrates population assessments.

Additionally, surveys to assess the degree of stream hydromodification are currently underway.

The USGS will continue to operate the stage gage, and measure flow and water quality (physical parameters) at RM 5.0 (station 03262001). This station is operated and funded via a cooperative agreement between USGS and SD1.

4.3 WATER QUALITY DATA ANALYSIS

Historical water quality data (1992-2005) have been analyzed to identify past water quality problems in this watershed. Historical exceedances of bacteria, dissolved oxygen, pH and temperature criteria were identified. Temperature violations were only observed at the USGS continuous monitoring 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 on instream water quality. This analysis revealed that dissolved oxygen violations have occurred. The recent data analysis does not include the most recent data from the Conservation District or the continuous USGS measurements. These data are still 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.

A summary of historical water quality data are presented in Tables 8, 9 and 10 for those parameters that exceed their applicable criteria. In addition to the violations identified through analysis of the discrete measurements, limited violations of the dissolved oxygen, pH and temperature criteria have also been historically observed at the continuous USGS continuous monitoring station (Woolper Creek RM 5.0).

Measurements for parameters or locations not shown met water quality criteria.

Table 8. Historical Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform bacteria		*E. coli* bacteria	
		# samples	% of samples in exceeding criteria[a]	# samples	% of samples in exceeding criteria[a]
Woolper Creek	4.1	8	63%	4	25%
Woolper Creek	7.5	8	88%	3	100%
Woolper Creek	9.6	5	40%	3	66%
Ashbys Fork	0.0	8	50%	4	100%
Double Lick Creek	1.9	2	50%	2	50%
Allen Fork	2.1	1	0%	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.

Table 9. Historical Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation[a]
Woolper Creek	4.1	4	25%
Unnamed tributary entering Woolper Creek at RM 11.9	0.0	12	8%

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

Dissolved oxygen measurements less than 4 mg/l were observed at the USGS station in Water Years 2002, 2004 and 2005. All violations occurred between June and September (CEG, 2007).

Table 10. Historical pH Violations

Stream	River Mile	Parameters violating criteria	
		pH	
		# measurements	% of measurements in violation[a]
Woolper Creek	13.6	12	8%
Allen Fork	0.1	12	8%
Unnamed tributary entering Allen Fork at RM 2.1	0.0	11	9%

[a] The pH criteria are between 6.0 and 9.0 su. The violations noted above exceeded 9 su.

Infrequent pH and temperature violations have also been observed at the USGS station. These all occurred in WY 2002 and WY 2005 (CEG, 2007).

4.3.1 Recent Data

Recent water quality data were available for analysis from Woolper Creek, Allen Fork and Ashbys Fork. A summary of recent water quality violations is presented in Table 11, for the single parameter that violated applicable criteria. Measurements for parameters and locations not shown met water quality criteria. Only one sample from Ashbys Fork violated the dissolved oxygen criterion. Recent data collected at the USGS station are still being reviewed and will be included in the next update of this report.

Recent bacteria data collected from three locations in Woolper Creek (RM 1.4, 5.0, and 8.8), one in Allen Fork (RM 0.1), and one in Ashbys Fork (RM 0.0) revealed that all samples were less than the fecal coliform and *E. coli* criteria under base flow conditions.

Table 11. Recent Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation[a]
Ashbys Fork	0.0	3	33%

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

4.3.1.a Dissolved oxygen

Recent dissolved oxygen measurements have been recorded at five locations throughout the watershed. Of these, only one exceeded the DO criteria of 4 mg/l (Ashbys Fork had a measurement of 3.4 mg/l DO on August 2007).

4.4 BIOLOGICAL CONDITIONS

Macroinvertebrate communities are susceptible to water quality and habitat degradation, and data from these communities are used as a tool to detect changes in habitat and water quality and assessing stream health (KDOW 2008c). KDOW sampled macroinvertebrates at twelve sites within the Woolper Creek watershed between 2002 and 2004. The MBI[8] scores ranged from poor to excellent (Table 1).

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, 2008c). Diatoms were measured at five sites within the Woolper Creek watershed in 1999, 2003 and 2004 (Table 1). Scores ranged from poor to good, based on diatom measurements (Table 1).

In 1999, KDOW collected fish from one site on Woolper Creek (RM 3.9). The KIBI score[9] calculated for this site indicated "fair" conditions. Historically, Woolper Creek has had a good fishery, boasting crappie, bass and catfish (Kentucky Post, 2006); however, this is not reflected in the one-time fish sampling event within the watershed.

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 and 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.

[8] The macroinvertebrate data collected by KDOW were used to calculate the Kentucky 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.

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

For the period 2000 to 2005, Woolper Creek (RM 5.0) had an average P/R ratio that ranks median among the eight monitored sites, suggesting that stream metabolism at this site, is dominated by organic consumption processes, similar to the other monitored sites. Further, fluctuations in average annual metabolism measures for the Woolper Creek site appear to vary the least when compared to those observed at other monitoring sites for the 2000-2005 period. Continued evaluation of stream metabolism at the Woolper Creek station 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.

5. SOURCE ANALYSIS

This section summarizes potential pollutant sources in the Woolper Creek watershed in order 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 were identified within the Woolper Creek watershed, based on the watershed characterization information discussed previously. The only recent observed violation, dissolved oxygen, was observed during base flow conditions; however all potential sources currently identified are summarized in Table 12, and their locations are shown in Figure 16. There are no CSOs in this watershed.

Table 12. Summary of Potential Sources

	Woolper Creek Headwaters to Allen Fork (RM 7.6)	Allen Fork	Ashbys Fork	Woolper Creek Allen Fork (RM 7.6) to mouth
Recent observed impairments =>	303(d)[b]: bacteria, total suspended solids, nutrients, organic enrichment	303(d): sedimentation, nutrients[c]	Dissolved oxygen	303(d): bacteria[d,e]
SSO[a]	0	4		
SSO-pump station	1	1		
Septic systems	Many	Many	Many	Many
KPDES– sanitary outfalls[f]	3		2	6
Storm water runoff	Urban	Urban	Rural	Rural
Stream bank erosion		Observed	Observed	Observed
Watershed improvements		Planned Allen Fork Collection system (Phase 2) project to abate 3 known SSOs and several suspected SSOs. 2 CAE improvement projects[g] to reduce and treat storm water		CAE project[g] near mouth to conduct stream, wetland and riparian buffer restoration.

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

[b] Illegal dumps or other inappropriate waste disposal, impacts from hydrostructure flow regulation/modification, and urban runoff/storm sewers are identified as potential sources contributing to the impairment of the primary contact recreation and warm water aquatic habitat uses (KDOW, 2008).

[c] Habitat modification other than hydromodification and unspecified urban storm water are identified as potential sources contributing to the impairment of the warm water aquatic habitat use (KDOW, 2008).

[d] Agriculture is identified as a potential source contributing to the impairment of the primary contact recreation use (KDOW, 2008).

[e] DO, pH and temperature violations have historically been observed at the USGS station at RM 5.0, but recent data have not been reviewed.

[f] Excludes permitted CSOs.

[g] CAE projects are described in Section 2.5.

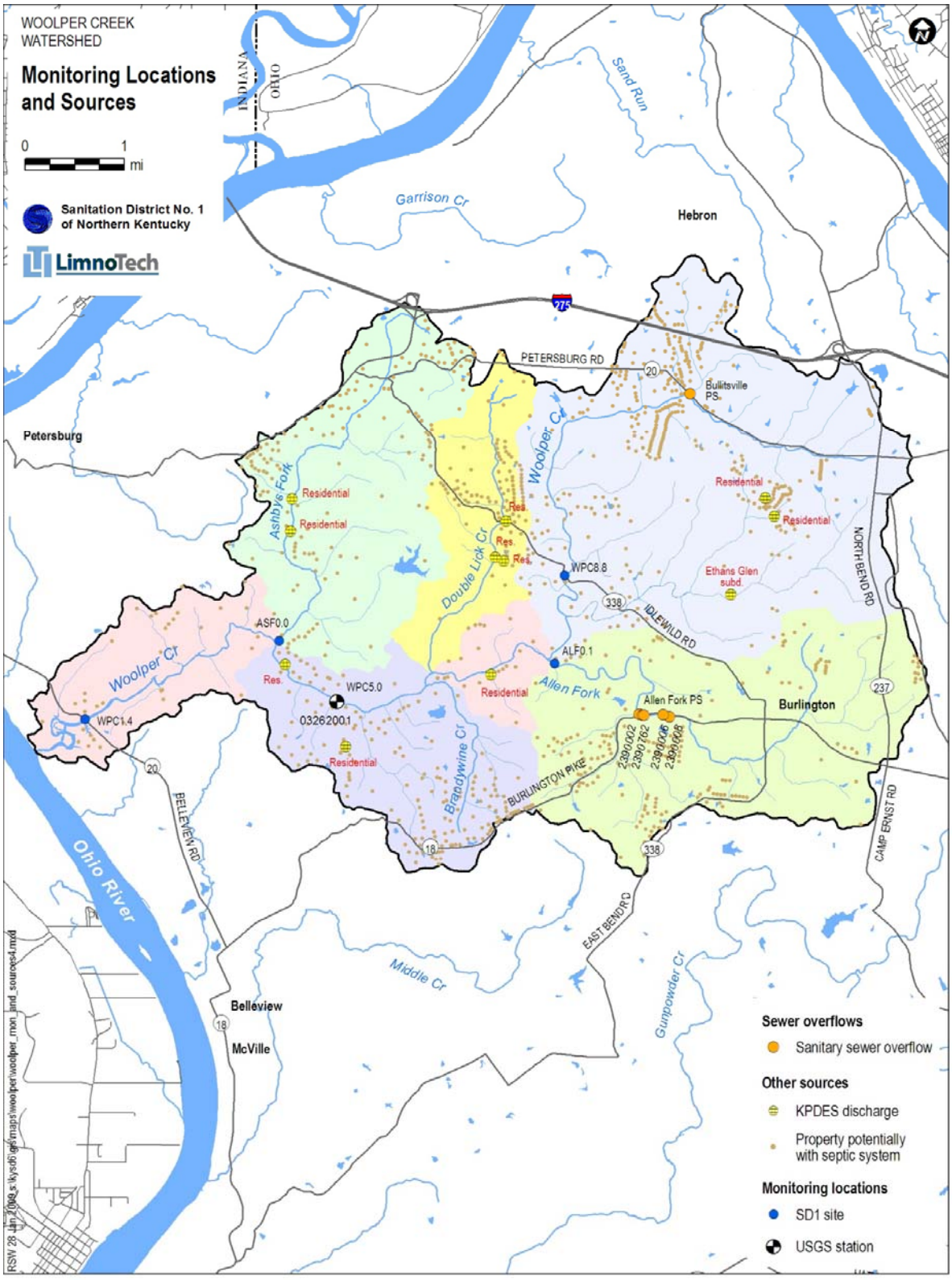

Figure 16. Monitoring Locations and Sources

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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[10] indicate that under year-round conditions, the Woolper 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 13.

Table 13. Watershed Ranking Considerations

CSO (#)	SSO (#)	SWAPP Zone	Aquatic-dependent T&E Species[a] (#)	Special Designations	Public interest	WAT! rank, year-round conditions[b]
						Bacteria
0	6	Zone 2 (due to Louisville intake)	1	Double Lick Creek – Exceptional water and reference reach designation	Moderate-High	13 of 16

[a]In addition to the one aquatic-dependent threatened and endangered (T&E) species, there is also 1 aquatic-dependent amphibian that is a State species of special concern. There are also two terrestrial species in this watershed, which are State species of special concern.

[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.

[10] 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

Woolper Creek has been sampled since 1985, and the USGS continuous monitoring station on Woolper Creek provides a good record of flow, DO, temperature and pH beginning in 2000. Recent storm flow data are not available and fish sampling has only been conducted at one location in this watershed.

SD1 has plans for wet weather event-based sampling in 2009 - 2010. This monitoring will better characterize the contribution of wet weather sources and overall stream health. Habitat and biological (fish and macroinvertebrates) assessments will also be conducted.

6.2.1 Data Gap Analysis

No additional water quality, biological or habitat sampling is recommended for this watershed, beyond that already planned. However, as described below, field investigation and data analysis are recommended, and coordination with KDOW should be considered.

The Ashbys Fork (RM 0.1) sampling site is located downstream of a bridge replacement project (Section 2.2.2). Therefore it is possible that this site may be impacted by the bridge work. A site visit in advance of the sampling should be considered.

It is recommended that the wet weather data be reviewed and analyzed, once sampling is completed, to better understand wet weather source contributions.

Two segments of Woolper Creek are identified as impaired due to bacteria (Section 4.1). There are no recent bacteria data for either of the two listed segments, and as indicated in Sections 2.3.2 and 2.5, many improvements have occurred in this watershed. SD1 sampling locations at RM 8.8 and RM 1.4 are downstream of the impaired segments and showed no base flow bacteria exceedances during 2006 and 2007. SD1 may consider coordinating with KDOW for the planned sampling to see if KDOW would consider using SD1 data to better characterize current conditions in Woolper Creek.

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 17. These WAT! results incorporate predicted sewer overflow volumes from infrastructure model simulations for 1992-1996 climatological conditions[11]. CSOs were not a factor in the WAT! results, as none occur in the watershed; however, flow estimates are available for two of the SSOs.

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.

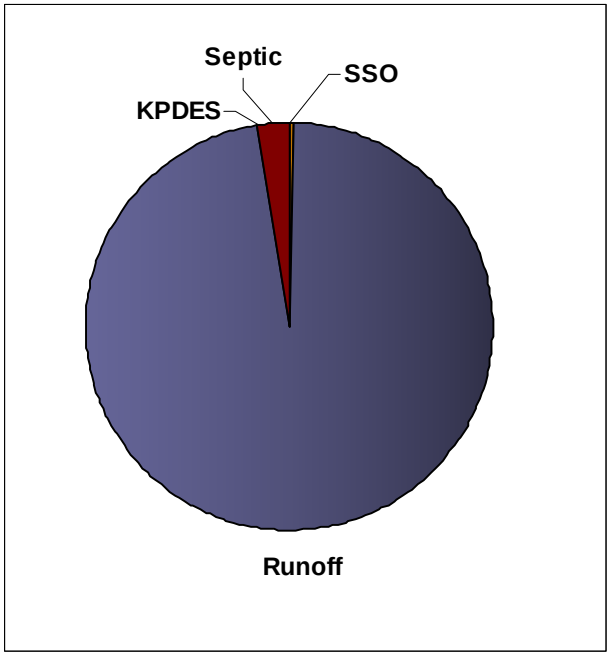

Figure 17. Initial Year-Round WAT! Results for Fecal Coliform

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.

[11] 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.

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 Woolper Creek watershed during year-round and base flow conditions is provided in Table 14.

Table 14. WAT! Watershed Rankings

	Rank for Year-Round Conditions[a,b]	Rank for Base flow Conditions[a,b]
Fecal coliform	13	5

[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 further populate and refine WAT! results and rankings, aiding in characterization of potential sources.

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