Source: SD1

Ohio River West Tributaries 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 Sanitation District No. 1's (SD1's) service area. The purpose of these 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, pollution 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.

This report characterizes the potential impacts on direct Ohio River tributaries that are located in the West Study Basin (Figure 1). Impacts on the Ohio River mainstem will be addressed through application of a detailed water quality model in future work. This report focuses only on a group of smaller tributaries that discharge directly to the Ohio River and not the Ohio River mainstem.

The Ohio River West watershed is entirely contained within Boone County and the land cover in this watershed is primarily forest and pasture/hay.

There are no active flow gages in this watershed, so it is not possible to characterize tributary flows. However, local topography is steep in places and runoff is expected to be rapid in these locations. Some very low, flat areas also exist near the Ohio River shoreline.

The Kentucky Division of Water (KDOW) has designated the Ohio River tributaries for warm water aquatic habitat, primary contact recreation, secondary contact recreation and domestic water supply, at applicable points of withdrawal. No waters within this watershed have been assessed as impaired (KDOW, 2008). Recent data reveal elevated levels of bacteria in Middle Creek, Lick Creek and Landing Creek and dissolved oxygen violations in Lick Creek.

Potential pollutant sources in this watershed include KPDES-permitted dischargers, septic systems and storm water runoff. The potential for these sources to generate fecal coliform bacteria loads has been assessed using a Watershed Assessment Tool (WAT!) [1]. The WAT! identifies potential sources within a watershed and estimates their possible impact. It also allows SD1 to compare and rank the sixteen different Northern Kentucky watersheds.

The WAT! calculated a very low fecal coliform loading potential under year-round conditions, and a high loading potential under base flow conditions. Overland storm water runoff is identified as the primary bacteria source under year-round conditions and septic systems are identified as the dominant source under base flow conditions.

[1] 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! ranking is one of several factors that should be considered when prioritizing watersheds for improvement projects. Other factors include moderate public interest due to past sampling and interest in developing additional parks and a greenway, the presence of one aquatic-dependent threatened and endangered species, the absence of any special designations, and the presence of public groundwater drinking water intakes.

Next steps for this watershed may include biological and habitat assessments to benchmark current conditions. Site visits and coordination with the health department would help to identify and upgrade failing septic systems. Finally, coordination with the permitting authority may be warranted as several permit violations were identified through a review of recent monitoring data.

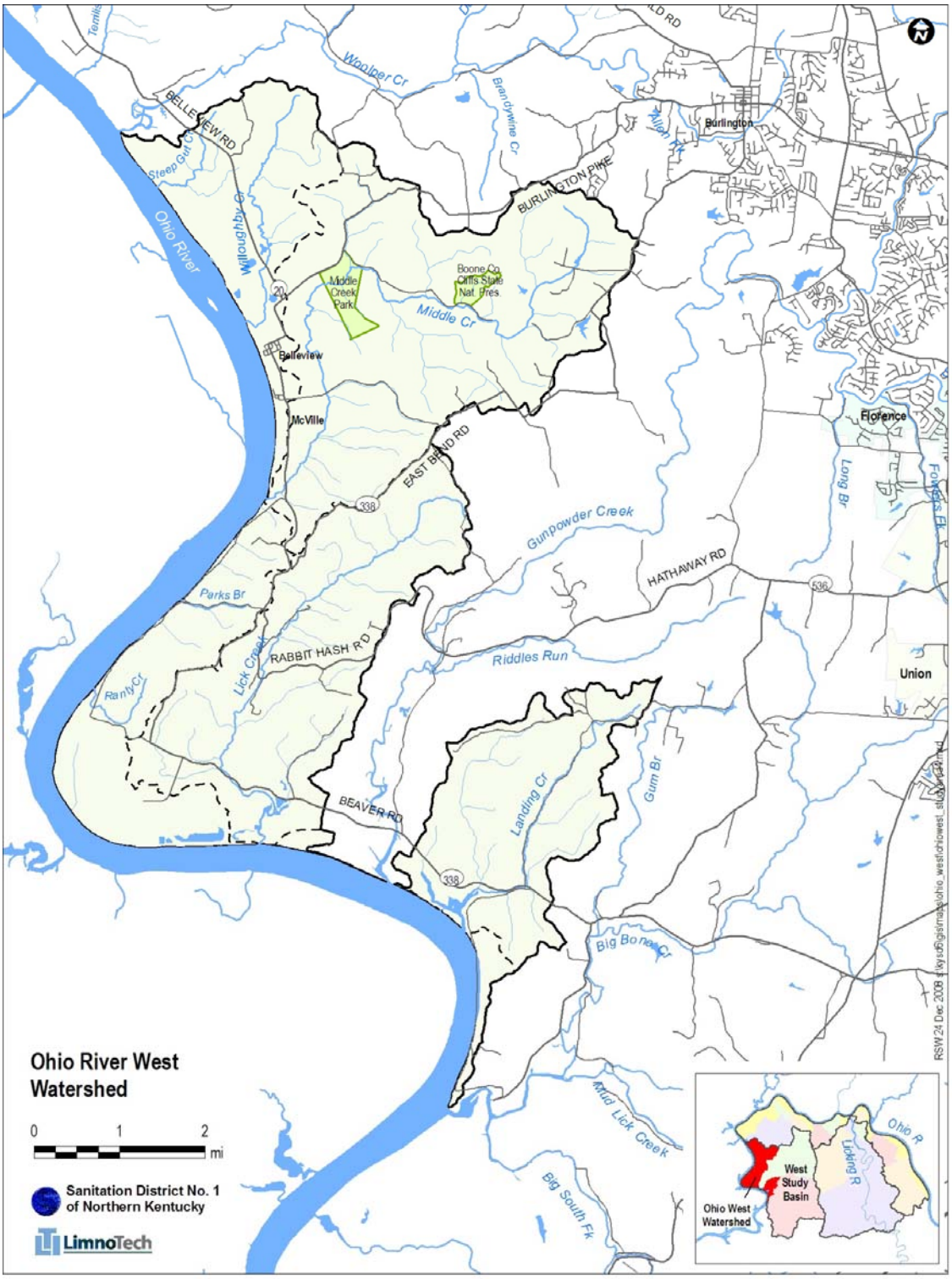

Figure 1. Ohio River West Watershed

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2. WATERSHED FEATURES

The Ohio River West tributaries are located within Boone County. This 33 mi^2 watershed includes Willoughby Creek, Middle Creek, Lick Creek and Landing Creek, as well as several small direct tributaries to the Ohio River between river mile (RM) 499.8 and RM 516.6 (Boone/Gallatin county line).

2.1 PHYSICAL AND NATURAL FEATURES

The following sections describe key features of the watershed and streams, including hydrology, geology, topography, soils, climate, and habitat. These features are important because they affect land uses, and shape the chemical, biological, and hydrologic characteristics of the Ohio River West tributaries.

2.1.1 Hydrology

The streams in this watershed are fairly small, with lengths of named streams ranging from 1.1 to 8.6 miles. There are no active USGS continuous monitoring stations on any of these streams.

Backwater effects from the Ohio River are expected near the mouth of some tributaries due to the construction of a series of dams on the Ohio River, which increased the Ohio River stage roughly 17 feet, submerging the mouths of many tributaries. The extent of the backwater effects on these tributaries is dependent upon elevation differences and on the Ohio River stage.

The100-year floodplains for Willoughby and Landing Creeks extend approximately one mile upstream of the mouth. The 100-year floodplains for Lick Creek and Middle Creek extend approximately three and five miles upstream of the mouth, respectively.

2.1.2 Geology

This watershed is located in the Outer Bluegrass Physiographic[2] Region, which is underlain primarily by Ordovician-age interbedded limestone and shale (Ray et. al., 1994). Although roughly one-third of this area 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)[3].

Lick, Landing and Middle Creeks traverse the erodible shale of the Kope Formation, with the rolling hills of the Grant Lake Limestone/Fairview formation found in the upland areas. Alluvium and glacial deposits are found near the Ohio River and consist of coarse sand and gravel beds. Groundwater yield in these areas may be high, and quality is good, but may have high iron content. Groundwater is generally much less available on hilltops and hillsides. Wells in the valley bottoms may yield 100-500 gallons per day; however, water is hard and may contain salt and hydrogen sulfide (Carey and Stickney, 2004).

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

[3] 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.

2.1.3 Topography

The land near the Ohio River is characterized by rolling hills with some steep slopes. Slopes near the shore of the Ohio River, especially on the inside edge of Ohio River bends, can be quite flat.

The highest elevation (910.8 feet) in this watershed is found on a hilltop in the Middle Creek watershed. Other high ground is located along East Bend Road and Burlington Pike, at the edge of the Middle Creek watershed. The lowest elevations in this watershed (453.6 feet at normal Ohio River pool) occur at the Ohio River shoreline.

2.1.4 Soils

The nature of soils and topography in a watershed play an important role in both the amount of runoff generated and the amount of soil erosion that can occur.

More than half (63%) of the soils in this watershed are classified as hydrologic soil group C (NRCS, 2006), meaning they have slow infiltration rates when thoroughly wetted.

Nearly all of the soils in this watershed are ranked as either "highly erodible" (55%) or "fairly erodible" (35%) 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. Future development is discussed in 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 2 (NCDC, 2008).

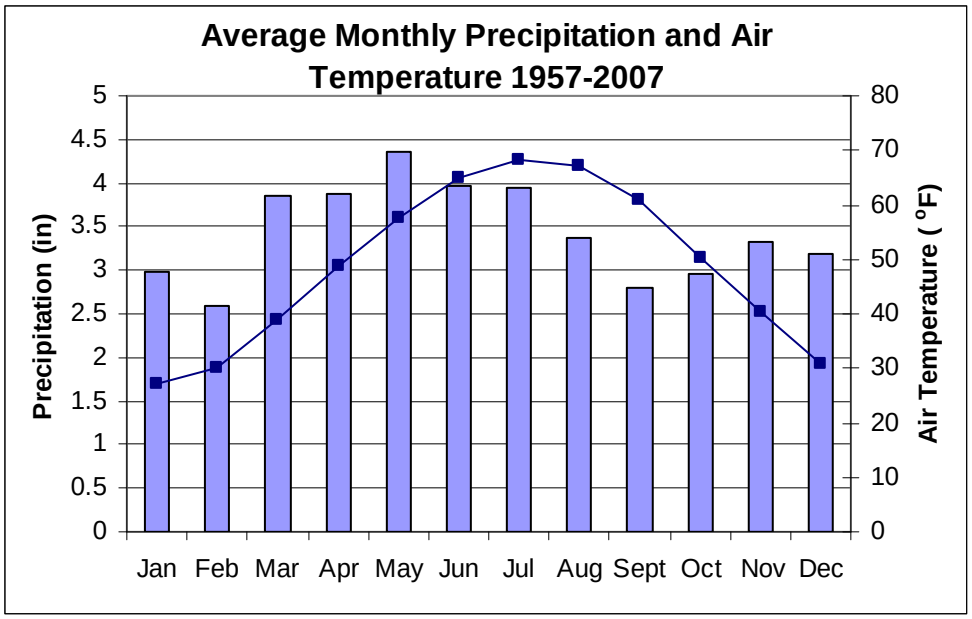

Figure 2. Average Monthly Precipitation and Air Temperature at the Cincinnati Northern Kentucky Airport (1957-2007)

2.1.6 Habitat

This watershed lies within the Outer Bluegrass ecoregion[4], 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 approximately 1% of the area in 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.

In 2007, erosion problems were evident in some of the streams (Figure 3). The turbid waters, bank erosion and reduced riparian areas shown in this figure are characteristics of several reaches of Middle Creek, although other portions of this creek appear to be in very good condition (Figure 4). According to the Conservation District, Lick Creek is in good condition and could be used as a reference stream (BCKCD, 2007).

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

Figure 3. Middle Creek near McVille

Figure 4. Middle Creek at Middle Creek Road (RM 5.5)

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).

The Kentucky State Nature Preserves Commission (KSNPC) monitors the occurrence of exemplary ecological communities, which are relatively undisturbed or have recovered sufficiently from previous disturbances and have the flora and fauna that is believed to represent the ecological communities that existed in Kentucky at the time of European colonization. KSNPC identified calcareous sub-xeric forest as being common in this watershed, and a rare example of an intact community of this type in Kentucky (KSNPC, 2007).

One habitat assessment[5] has been conducted (1999) at one site on Middle Creek. This site was rated as partially supporting of aquatic habitats (Table 1).

Table 1. Aquatic Habitat and Biological Sampling

Stream	River Mile	Habitat		Diatoms		Macroinvertebrates	
		Date	Ranking	Date	Ranking	Date	Ranking
Middle Creek	3.8	1999	Partially supporting			1999	Good
	5.7			2003	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 this 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 5) using a variety of other datasets that represent current impervious conditions (roads, parking lots, buildings), open space lands (including parks), and surface waters.

The dominant land cover in this watershed is forest, with lesser amounts of pasture/hay and cropland. Developed areas are infrequent (10%) and only 2% of the watershed is impervious. There are no incorporated communities in this watershed. Three large natural areas were identified in the Middle Creek watershed: the 230-acre Middle Creek Park, the Dinsmore Woods Nature Preserve, and Boone County Cliffs State Nature Preserve, which is owned by the Nature Conservancy. The Moonlight Hunt and Fish Club and Camargo Hunt Club are also located in the Middle Creek watershed. A portion of the 631-acre Adair Wildlife Management Area is located in the Landing Creek watershed.

2.2.1.a Animal operations

A tour of the watershed and a review of information obtained from the Conservation District (BCKCD, 2007) confirmed that beef cattle and horses are present in this watershed. There are no permitted concentrated animal feeding operations (CAFOs) or animal feeding operations (AFOs) in this watershed (Kentucky Geographic Network, 2008, 2008a).

2.2.1.b Septic Systems

SD1 estimates approximately 60% of all parcels in this watershed are potentially serviced by septic systems (Figure 11). Currently none of the parcels in this watershed are serviced by sanitary sewer.

[5] 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.

The Northern Kentucky Health Department does not currently have estimates for septic system failure rates in Boone County. Anecdotal reports from Health Department inspectors suggest that 10% of septic systems in Northern Kentucky may be operating improperly due to incorrect installation, lack of maintenance or age of system (NKHD, 2008).

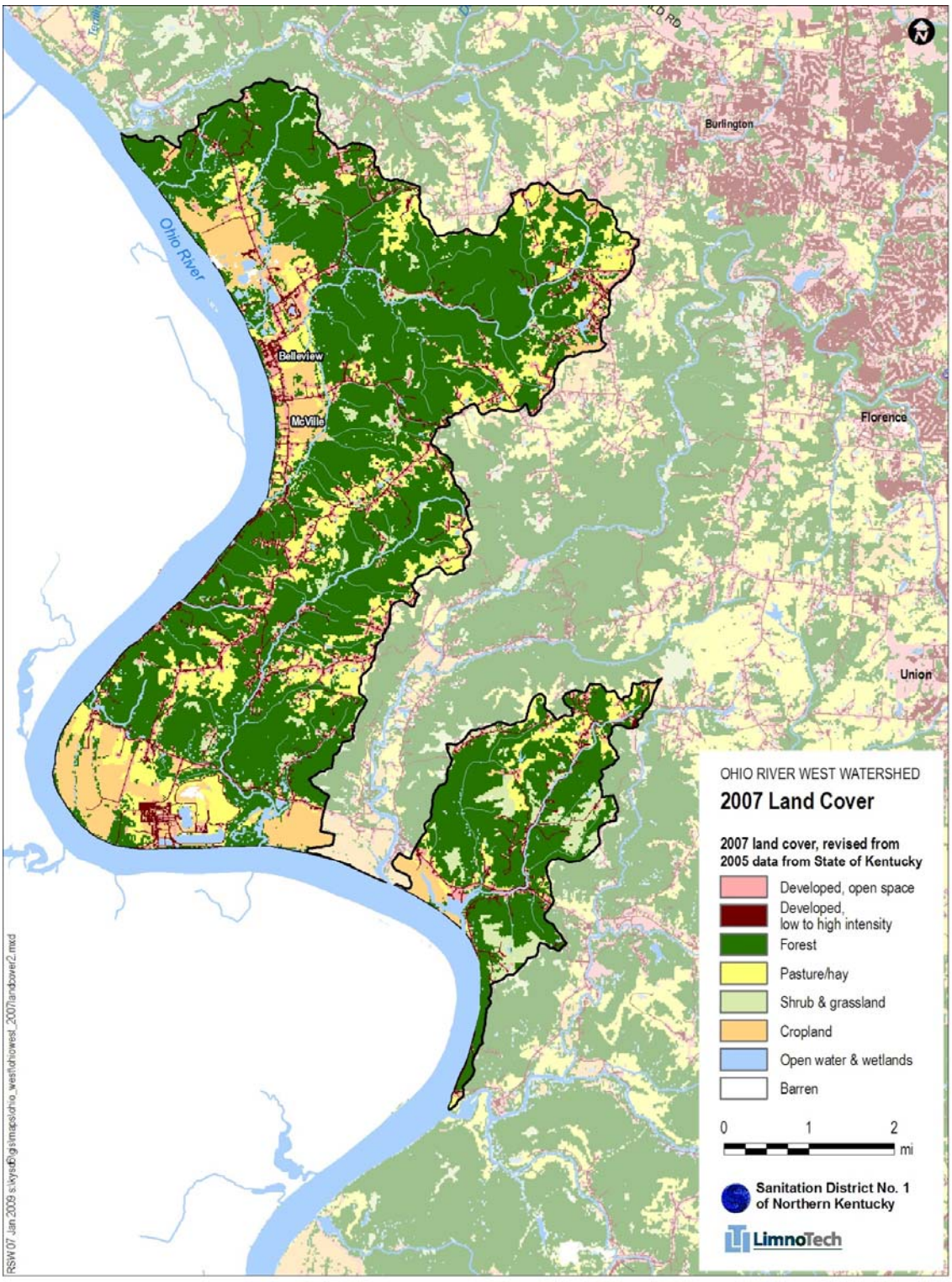

Figure 5. 2007 Land Cover

2.2.2 Future Conditions

The western areas of Boone County are anticipated to experience modest population growth in the form of non-subdivision single family residences and small, low density subdivisions (BCPC, 2005).

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 extend westward from Florence, following ridgelines and replacing lands that are currently pasture and forest. Some flat areas near the Ohio River may also be developed. In the future, forest is predicted to remain the dominant land cover followed by developed areas (19%), and the amount of impervious surfaces is predicted to increase from 2% to 4% (Figure 6).

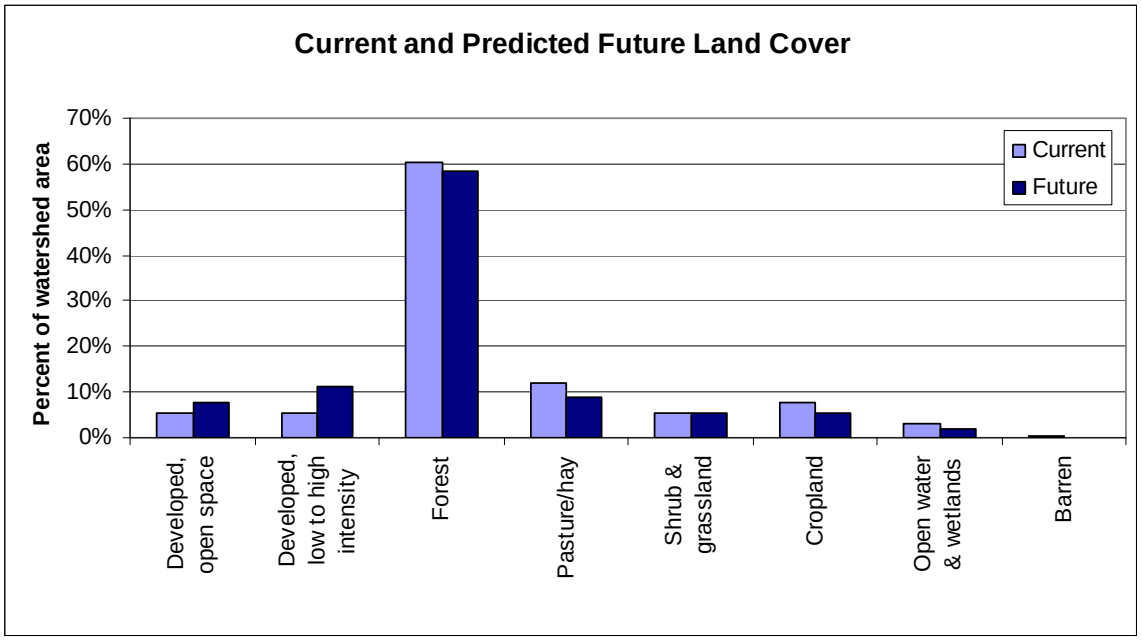

Figure 6. Current and Predicted Future Land Cover

2.3 INFRASTRUCTURE FEATURES

SD1's sanitary infrastructure and storm water service area do not extend into the Ohio River West watershed[6].

2.3.1 Point Sources and Infrastructure

There are no SD1 sanitary or storm water discharges in this watershed. Other KPDES-permitted dischargers are described below.

2.3.1.a KPDES dischargers

There are twenty-four KPDES-permitted dischargers in this watershed. All of these permits are for sanitary wastewater, and the majority (20) of these are covered under general permits for residences. One permitee also has permitted discharges of several process-related waste streams, as well as storm water.

Based on a review of recent effluent monitoring data (January 2007 to June 2008), it was observed that seven of the permitted dischargers in this watershed have violated permit limits for at least one of the following parameters: total suspended solids (TSS), total ammonia, 5-day biochemical oxygen demand (BOD_5), fecal coliform, and total chlorine. KDOW requires effluent monitoring for the residential general permits (monitoring is required twice per year); however, data were not available for ten 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%. Permitted dischargers are presented in Table 2 (KDOW, 2007).

2.3.1.b Sewer overflows

No sewer overflows were identified in this watershed.

2.3.1.c Storm water discharges

The entire Ohio River West watershed is located outside of SD1's storm water service area, so outfalls and other illicit discharges may be located in these areas, but were not inventoried by SD1. A storm water outfall covered by an individual KPDES permit is presented in Section 2.3.1.a.

[6] 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.

Table 2. Permitted Dischargers

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Permit Violations
Ohio River	KYG400397	Residence	0011	Minor	Sanitary wastewater Type B	NA
Ohio River	KYG400497	Residence	0011	Minor	Sanitary wastewater Type B	NA
Ohio River	KYG400581	Residence	0011	Minor	Sanitary wastewater Type B	NA
Ohio River	KYG400923	Residence	0011	Minor	Sanitary wastewater Type B	TSS
Ohio River	KYG401141	Residence	0011	Minor	Sanitary wastewater Type B	Total ammonia, TSS
Ohio River	KYG400083	Residence	0011	Minor	Sanitary wastewater Type B	NA
Ohio River	KYG400371	Residence	0011	Minor	Sanitary wastewater Type B	None
Ohio River	KYG400504	Residence	0011	Minor	Sanitary wastewater Type B	None
Ohio River	KYG400517	Residence	0011	Minor	Sanitary wastewater Type B	None
Ohio River	KYG401331	Residence	0011	Minor	Sanitary wastewater Type B	None
Ohio River	KYG401702	Residence	0011	Minor	Sanitary wastewater Type B	None
Ohio River	KYG401949	Residence	0011	Minor	Sanitary wastewater Type B	NA
Ohio River	KYG400527	Residence	0011	Minor	Sanitary wastewater Type B	Fecal coliform
Ohio River	KYG401237	Residence	0011	Minor	Sanitary wastewater Type B	Fecal coliform
Ohio River	KY0040444	Duke Energy Kentucky Inc	0011	Major	Ash pond	None
			0012	Major	Ash pond	None
			0031	Major	Close cooling water heat ex by	None
			0071	Major	Sanitary wastewater(internal)	None
			0081	Major	Metal cleaning waste(internal)	NA
			0101	Major	Cooling tower blowdown(internal)	None
			0102	Major	Cooling tower blowdown (internal)	NA
			0111	Major	Plant intake	None
			0112	Major	Plant intake	None
			0141	Major	Plant storm water runoff	None
Ohio River	KY0075639	River Ridge Park Inc	001G	Minor	Sanitary wastewater	BOD5, fecal coliform, total ammonia, TSS
Ohio River	KY0077917	Arlinghaus Properties	0012	Minor	Sanitary wastewater	Fecal coliform, total chlorine
Ohio River	KY0080691	Charles H Kelly Elem School	0012	Minor	Sanitary wastewater	None
Landing Creek	KYG400011	Residence	0011	Minor	Sanitary wastewater Type B	NA
Landing Creek	KYG400410	Residence	0011	Minor	Sanitary wastewater Type B	NA
Lick Creek	KYG400084	Residence	0011	Minor	Sanitary wastewater Type B	NA
Lick Creek	KYG401018	Residence	0011	Minor	Sanitary wastewater Type B	NA
Middle Creek	KYG400213	Residence	0011	Minor	Sanitary wastewater Type B	Fecal coliform
Middle Creek	KYG401739	Residence	0011	Minor	Sanitary wastewater Type B	NA

NA – Monitoring data were not available.

2.3.2 Recently Completed Infrastructure Projects

No recently completed infrastructure projects were identified.

2.3.3 Ongoing or Planned Infrastructure Improvement Projects

The SD1 has two projects that are ongoing or planned. These are:

- Western Regional Water Reclamation Facility (WRWRF). The new WRWRF will receive and treat redirected flow from the current Lakeview and Taylorsport Pump Station service areas, both of which currently have overflows within their respective watersheds. The treatment plant is being sized initially to treat 15 MGD dry weather flow and 30 MGD peak wet weather flow. Flows above this peak will be stored in the upstream conveyance tunnel. Future upgrades to the treatment plant will allow treatment capacity up to 45 MGD dry weather flow and 60 MGD peak wet weather flow.
- Western Regional Conveyance System. This project will convey flows from the current Lakeview and Taylorsport Pump Station service areas, to the new WRWRF. The diverted flow will be conveyed and stored within a new 8.5 feet diameter tunnel.

These two projects will convey and treat diverted flows from the current Lakeview and Taylorsport Pump Station service areas. This work will: (1) free up capacity at the Dry Creek Treatment Plant; (2) increase capacity in the current separate conveyance system; and (3) eliminate several pump stations currently in operation. While these projects will occur in the Ohio River West watershed, the reduction of SSOs is expected to be seen in the Banklick Creek, Gunpowder Creek, Dry Creek, Woolper Creek, Ohio River North and Elijahs Creek watersheds.

Project information is provided in Table 3.

Table 3. Planned Watershed Infrastructure Improvement Projects

Capital Improvement Project Title	Goal	Anticipated Start Date	Anticipated Completion Date	Project Total
Western Regional Conveyance System to WRWRF	Decrease existing SSOs and pump station overflows in other watersheds and increase available capacity at Dry Creek WWTP	2008	2013	$117,900,000
Western Regional Water Reclamation Facility	Decrease existing SSOs in other watersheds and increase available capacity at Dry Creek WWTP	2008	2013	$61,635,000

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 waters have been designated by the State of Kentucky as Outstanding National Resource Waters (401 KAR 10:030), and no National Marine Sanctuaries have been designated within the project study area (NOAA, 2008). 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 study area. The remaining three criteria are discussed below.

2.4.1 Threatened & Endangered Species or Their Designated Critical Habitat

Threatened and endangered species, species of concern and their designated critical habitat within this watershed were identified by contacting the Kentucky State Nature Preserves Commission (KSNPC). KSNPC identified four species in this watershed (Table 4, KSNPC, 2007), and only one of these, running buffalo clover, is threatened and endangered. Running buffalo clover is a small herbaceous plant (Figure 7) that inhabits streambanks and upland areas, and erosion is noted as the biggest threat (KSNPC, 2006). Other factors contributing to population declines are loss of bison populations, non-native plants, and overall habitat loss (USFWS, 2003).

Figure 7. Running Buffalo Clover, Trifolium stoloniferum

Table 4 also lists the northern leopard frog on the state list of species of special concern that relies upon aquatic habitats, inhabiting slowly flowing areas in creeks and rivers, springs, the nearshore area of lakes, bogs, fens, herbaceous wetlands, riparian areas and grasslands. Threats to the northern leopard frog include habitat loss, commercial overexploitation, and competition with introduced species (NatureServe, 2007).

The redback salamander and the bank swallow are also identified as state species of special concern. These two species depend on upland habitats such as woodlands, grasslands and bluffs (KSNPC, 2007).

Table 4. Endangered Species, Threatened Species and Species of Concern

Taxonomic Group	Common name	Scientific name	Status[a]	Last Observed	Habitat(s)	Identified Threats
Amphibians						
	Northern Leopard Frog	*Rana pipiens*	State - Special Concern	1998	Ponds, wetlands, grasslands	Habitat loss, non-native species, commercial overexploitation[b]
	Redback Salamander	*Plethodon cinereus*	State - Special Concern	1992	Woodlands[a,b]	Habitat loss/degradation
Vascular Plants						
	Running Buffalo Clover	*Trifolium stoloniferum*	Federal - Endangered State - Threatened	2006	Riparian areas, upland areas[c]	Habitat loss, non-native species, bison decline [f]
Breeding Birds						
	Bank Swallow	*Riparia riparia*	State - Special Concern	1985	Steep riverbanks[d]	Rip-rapping of natural streams; human disturbance and channelization and stream bank modifications for flood control and bank stabilization[e]

[a] Source: KSNPC, 2007.

[b] Source: NatureServe, 2007.

[c] Source: KSNPC, 2006.

[d] Source: Robbins et al., 1983.

[e] NatureServe, 2008.

[f] 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.

The tributaries to the Ohio River in this watershed are designated for PCR. Although swimming is known to occur in the Ohio River, it is not clear whether or not swimming activity occurs in the tributaries, as public surveys on swimming in the area are unavailable. No public swimming beaches were identified in the watershed. Additional data will be gathered about uses of the creeks in this watershed.

2.4.3 Public Drinking Water Intakes or their Designated Protection Areas

There are no public drinking water intakes from surface waters 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 Ohio River West watershed lies within SWAPP Zone 2, reflecting the fact that this watershed is more than 25 miles upstream of the Louisville intake.

There are seven active public water supply wells in this watershed. Kentucky's Wellhead Protection Plan program requires public water suppliers that rely on ground water to develop a wellhead protection plan (WHPP) for their source water. The recharge area (wellhead protection area) of these wells is delineated as part of the WHPP using geologic and hydrologic data (http://www.water.ky.gov/gw/gwprotection/wellhead/). The wellhead protection areas are shown in Figure 8, along with other drinking water supply features. Several of the groundwater wells are located very close together and appear on this map as a single location.

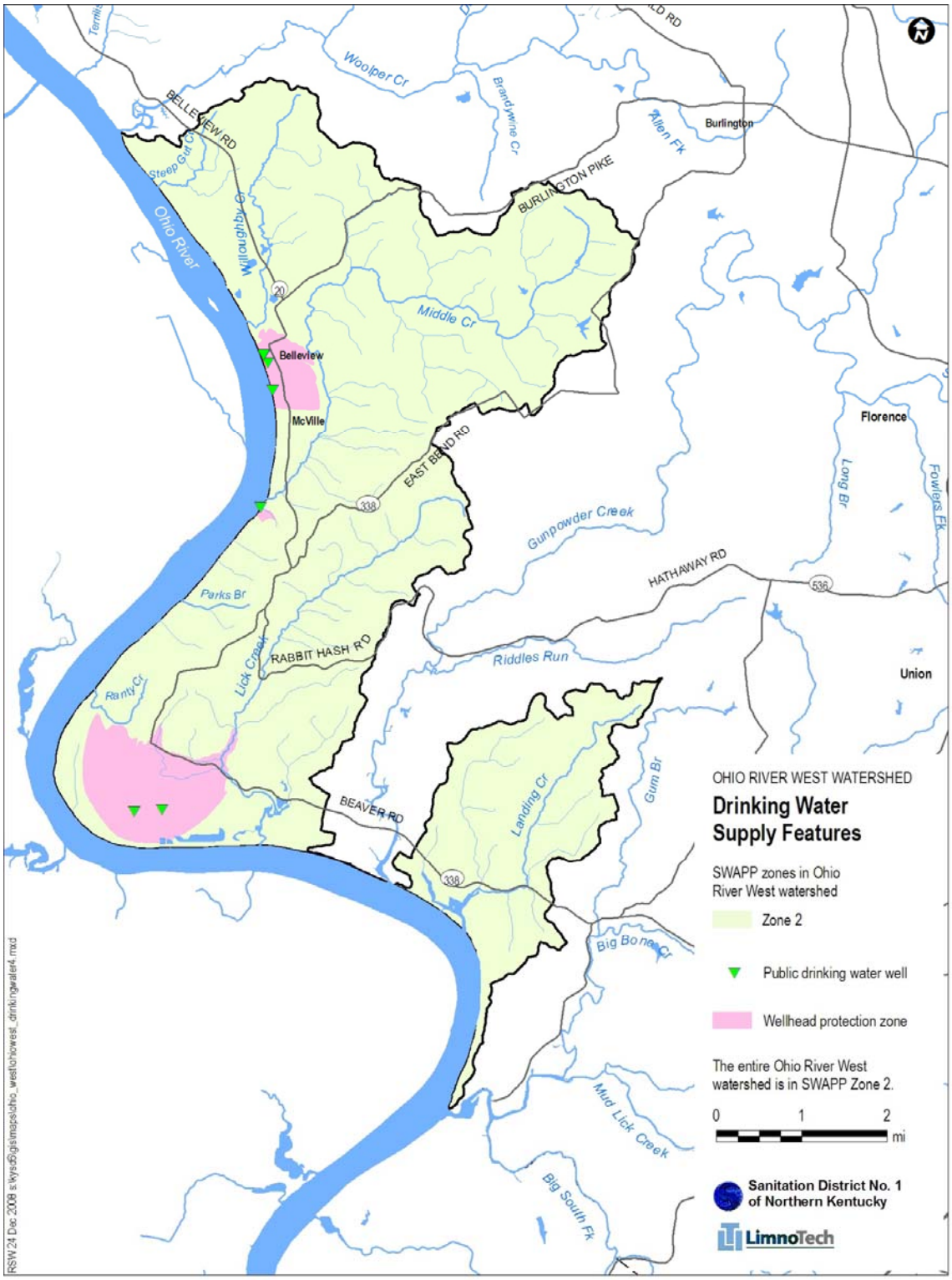

Figure 8. Drinking Water Supply Features

2.5 PUBLIC INTEREST/WATERSHED GROUP ACTIVITIES

Public interest in this watershed is rated moderate. Indicators of public interest in this watershed include past sampling and interest in protecting natural areas. Sampling has been conducted by several organizations (Section 4.2).

The Boone County Comprehensive Plan (BCPC, 2005) recommends that lands adjacent to Boone Cliffs Nature Preserve be considered for preservation. The Boone Conservancy may pursue lands in these areas (BCPC, 2005) and Northern Kentucky University is working to get a greenway in this watershed that would include Boone Cliffs State Nature Preserve (BCKCD, 2007). In March, 2008, the Boone Conservancy and the Boone County Conservation District led an effort to plant over 3,000 trees at the Boone Conservancy Mine Reclamation Project Site (KY 18 & 20 in Belleview, KY), as part of a larger effort to conserve the quality of the Middle Creek watershed (BCKCD, 2008).

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.

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3. WATERBODY USES

This section describes designated and current uses for the streams in this watershed.

3.1 DESIGNATED USES

The tributaries in the Ohio River West watershed 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

An assessment of available information found the following information on uses:

- Habitat in Middle Creek was found to be partially supporting.
- Biological assessments for Middle Creek indicate variable conditions.
- 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 no swimming advisories for creeks in this watershed. 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).
- One Ohio River boating access site is located in this watershed (http://kygeonet.ky.gov/kdfwr/viewer.htm), at the Petersburg Boat Ramp.
- There are no surface drinking water intakes in this watershed.
- There are seven active public water supply groundwater wells in this watershed (KDOW, 2008a; KDOW, 2007c)

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4. WATERBODY CONDITIONS

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

4.1 303(d) STATUS AND POLLUTANTS OF CONCERN

None of the waterbodies in this watershed are listed on Kentucky's 2008 303(d) list of impaired waters (KDOW, 2008).

4.2 MONITORING PROGRAMS

Water quality data have been collected in this watershed by Licking River Watershed Watch (LRWW), Northern Kentucky University (NKU), the Conservation District and SD1. Data currently compiled by SD1 from known monitoring programs are presented in Table 5; however, only data which have been fully analyzed are discussed in Section 4.3 Water Quality Data Analysis. Available data exists for Middle Creek, Lick Creek and Landing Creek.

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

Table 5. Summary of Water Quality Monitoring Data

Entity	Dates	Parameters Sampled	Sampling Locations[b]	Number of Samples
NKU	2003	Fecal coliform, alkalinity, chloride, hardness, conductivity, sulfate, TSS, temperature, nutrients	Middle Cr. RM 0.5	1 sample (9/6/2003)
NKU	2001, 2003	Fecal coliform, E. coli, dissolved oxygen (DO), pH	Middle Cr. RM 0.5	2 samples (8/25/2001 & 7/10/2003)
NKU	2002	Atrazine, DO, pH, temperature	Middle Cr. RM 0.5	1 sample (5/18/2002)
LRWW	2003	Fecal coliform	Middle Cr. RM 0.5	2 samples (7/12/2002 & 5/14/2003)
LRWW	2004	Fecal coliform, E. coli	Middle Cr. RM 0.5	3 samples (5/22/2004, 7/1/2004 & 9/13/2004)
Conservation District	2005-2006	Fecal coliform, E. coli, alkalinity, chloride, DO, pH, conductivity, sulfate, temperature, nutrients	Middle Cr. RM 1.8, 7.3	5 samples (May, July, & Sept of 2005; May & July of 2006)
SD1	2006	Fecal coliform, E. coli, DO, pH, conductivity, turbidity, temperature	Landing Cr. RM 1.4; Lick Cr. RM 1.6; Middle Cr. RM 1.8, 5.5	2 samples from baseline survey (9/27/2006 & 10/16/2006)
SD1	2007	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, turbidity, TSS, temperature, turbidity, nutrients	Landing Cr. RM 1.4; Lick Cr. RM 1.6; Middle Cr. RM 1.8, 5.5	1 Sample (7/31/2007)
SD1	2008[a]	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, turbidity, TSS, temperature, turbidity, nutrients	Landing Cr. RM 1.4; Lick Cr. RM 1.6; Middle Cr. RM 1.8, 5.5	1 Sample (10/21/2008)

[a] Data not analyzed in Section 4.3

[b] RM = River mile

4.2.1 Future Sampling

SD1 plans to continue monitoring this watershed during base flow conditions with at least one survey per year. The four sampling locations are: Middle Creek at RM 1.8 and RM 5.5, Landing Creek RM 1.4 and Lick Creek RM 1.6. Typical analyses will include bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters.

Additionally, because of its potential to provide insight into least impacted conditions, one site on Middle Creek (MDC5.5) will be sampled for habitat and biology.

Surveys to assess the degree of stream hydromodification are also planned by SD1 in this watershed.

4.3 WATER QUALITY DATA ANALYSIS

Historical water quality data (2001-2005) have been analyzed to identify past water quality problems in this watershed. 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. The recent data analysis does not include the data collected by the Conservation District or the 2008 SD1 data. These data are still being reviewed and will be included in the next update of this report.

4.3.1 Historical Data

Historical data reveal past bacteria exceedances and dissolved oxygen violations in this watershed. Locations where historical water quality issues have been observed are presented in Tables 6 and 7. Measurements for parameters or locations not shown met water quality criteria.

Table 6. 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]
Middle Creek	0.5	8	50%	3	100%
Middle Creek	1.8	3	67%	3	67%
Middle Creek	7.3	3	100%	3	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, however, 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 7. Historical Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation[a]
Middle Creek	1.8	3	33%

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

4.3.2 Recent Data

Recent water quality data were available for Middle Creek (RM 1.8 and 5.5), Lick Creek (RM 1.6) and Landing Creek (RM 1.4). These four locations were sampled for fecal coliform (11 samples total) and *E. coli* (11 samples total). Two of the locations met the applicable fecal coliform criteria and one location met the applicable *E. coli* criteria. Eleven dissolved oxygen measurements were also recorded. Dissolved oxygen violations were only observed at one of the four locations.

A summary of recent water quality findings are presented in Tables 8 and 9. Measurements for locations and parameters not shown met applicable water quality criteria.

Table 8. 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]
Middle Creek	1.8	3	33%	3	33%
Lick Creek	1.6	3	67%	3	67%
Landing Creek	1.4	3	0%	3	33%

[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. Recent Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation[a]
Lick Creek	1.6	3	33%

[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

SD1 conducted bacteria sampling in this watershed during three surveys in 2006-2007. All bacteria samples were collected during base flow conditions. As shown in Figure 9, elevated base flow levels of fecal coliform were observed in Middle Creek and Lick Creek. The maximum base flow fecal coliform concentration of 4,800 cfu/100 ml was recorded in Middle Creek at RM 1.8. As shown in Figure 10, a similar pattern was observed for *E. coli*, with four elevated base flow samples. The maximum *E. coli* concentration, 3,700 cfu/100 ml, was recorded in Middle Creek at RM 1.8. Measurements at other locations met the water quality criteria for bacteria.

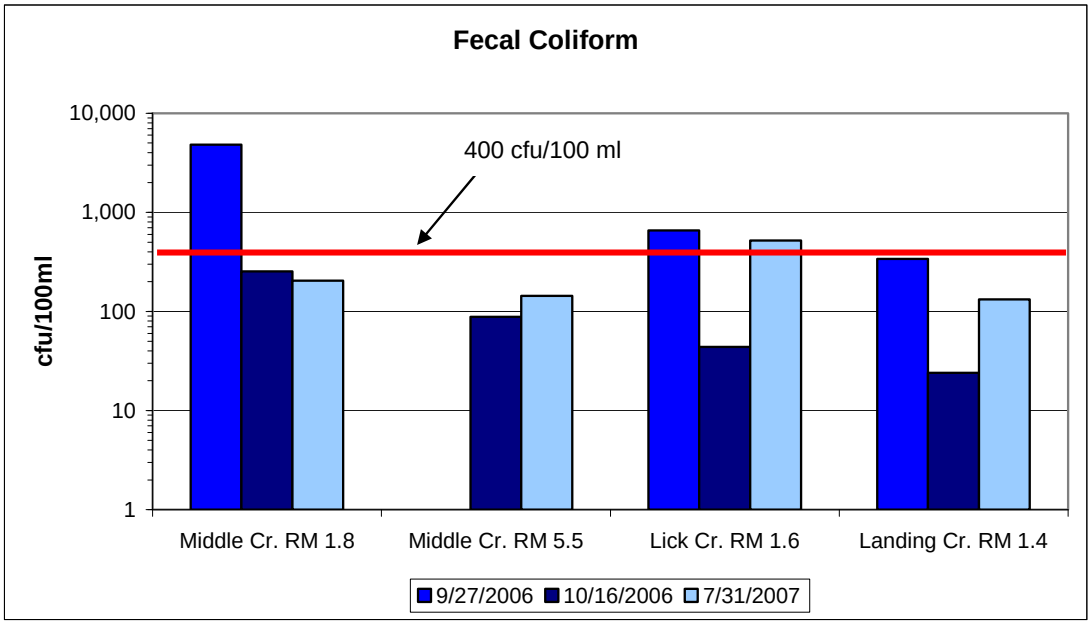

Figure 9. 2006-2007 Base Flow Fecal Coliform Results Compared to 400 cfu per 100 ml Criterion

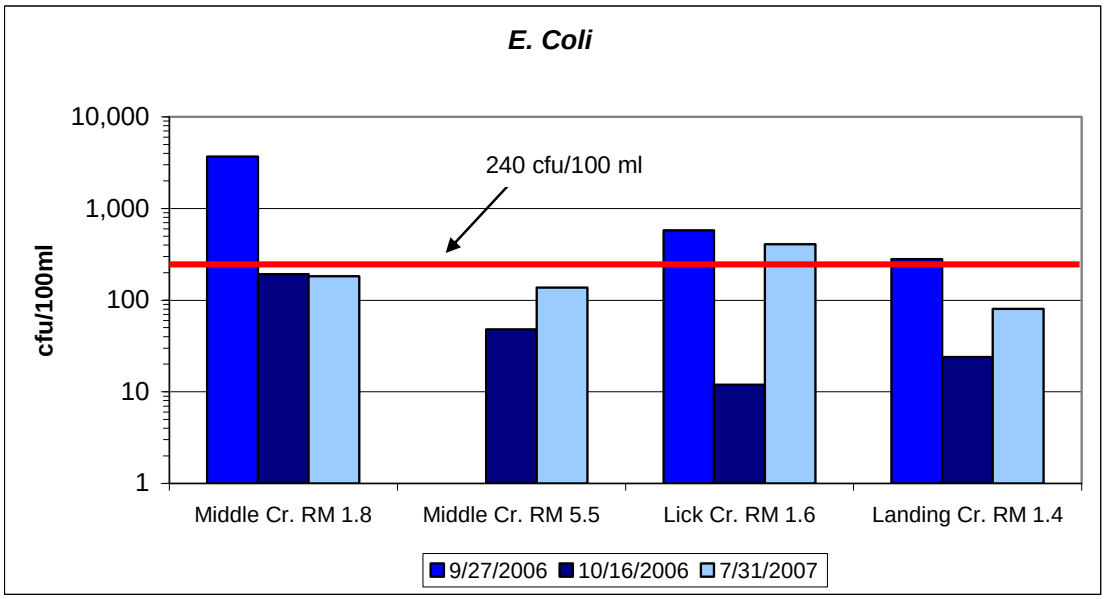

Figure 10. 2006-2007 Base Flow *E. Coli* Results Compared to 240 cfu per 100 ml Criterion

4.3.2.b Dissolved oxygen

One of three recent dissolved oxygen measurements collected at Lick Creek RM 1.6 violated the dissolved oxygen criterion. A concentration of 2.8 mg/l was recorded on July 31, 2007. Measurements at other locations met the water quality criterion of 4 mg/l.

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 2008b). KDOW sampled macroinvertebrates at one site on Middle Creek in 1999. The MBI[7] score calculated for Middle Creek produced a ranking of "good" (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, 2008b). Based on diatom communities sampled in 2003, Middle Creek received a ranking of "poor" (Table 1).

[7] 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.

5. SOURCE ANALYSIS

This section summarizes potential pollutant sources in the Ohio River West watershed based on the watershed characterization and recent water quality data.

5.1 WATERSHED SOURCE ANALYSIS

Sources within the Ohio River West watershed are summarized in Table 10 and shown in Figure 11. Sources within the Middle Creek, Lick Creek and Landing Creek subwatersheds are presented separately because these creeks were identified as having recent water quality concerns. Although all of the recent exceedances were observed during base flow conditions, all potential sources are included in this summary.

Table 10. Summary of Potential Sources

	Direct drainage	Middle Creek	Lick Creek	Landing Creek
Recent observed impairment =>		Bacteria, Erosion (observed)	Bacteria, dissolved oxygen	Bacteria
Septic	Many	Many	Many	Many
# KPDES permitted sanitary outfalls[a]	18	2	2	2
# KPDES storm water/other outfalls[b]	4			
Storm water runoff	Rural	Rural	Rural	Rural
Watershed improvements		*Recent tree planting at mine reclamation site.* *Interest in developing a greenway that would include Boone Cliffs State Nature Preserve.*		

[a] Excluding permitted CSOs (there are no CSOs present in this watershed).

[b] Plant intakes and internal outfalls are excluded. Additionally, one ash pond outfall includes sanitary discharge from an internal outfall, and is therefore counted twice in this table.

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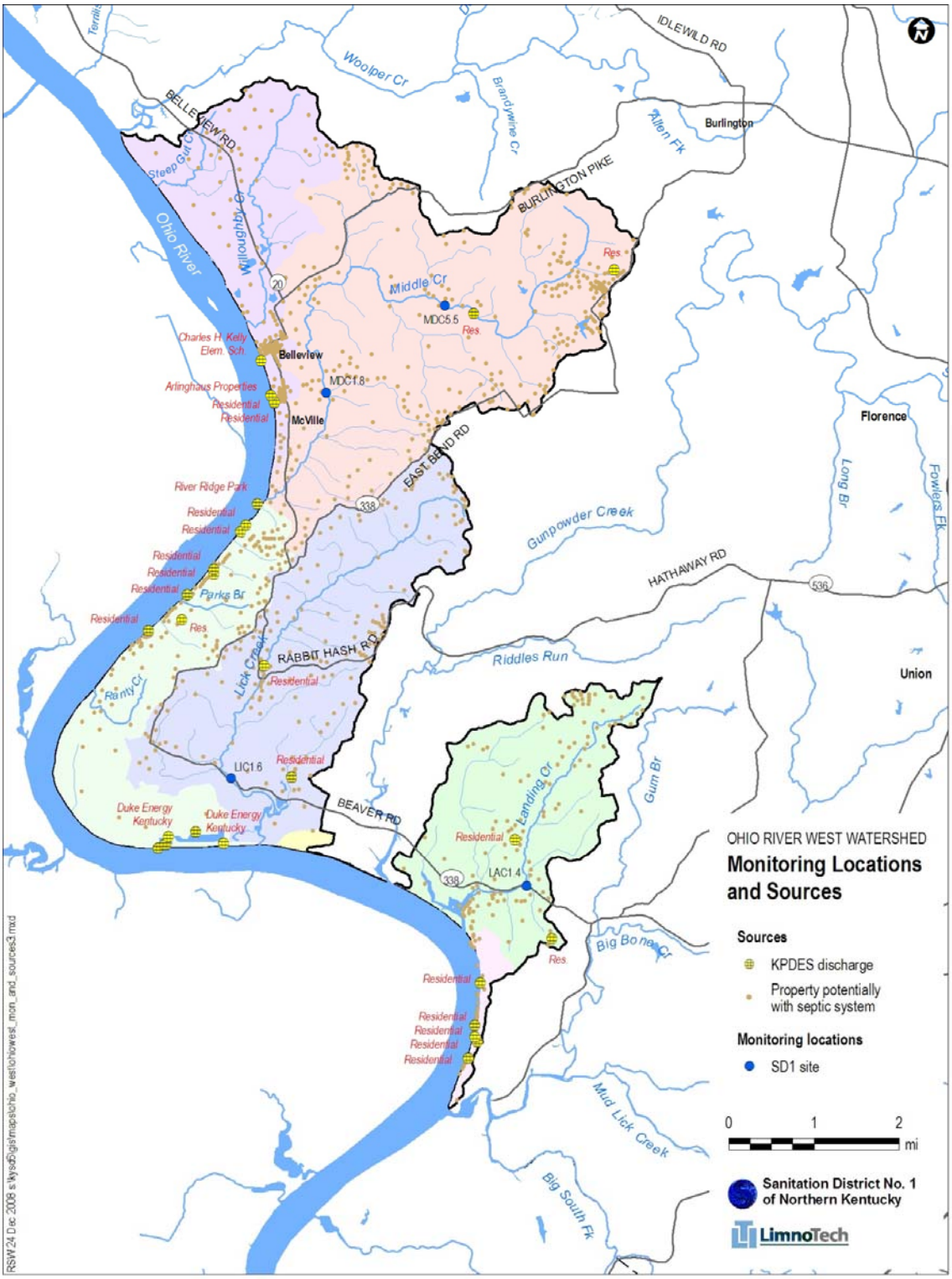

Figure 11. Monitoring Locations and Sources

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[8] indicate that under year-round conditions, the Ohio River West watershed has the lowest rank (analogous to load) for fecal coliform, relative to the other sixteen identified watersheds in SD1's jurisdictional area.

In addition to WAT! results, other factors such as the 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 11.

Table 11. Watershed Ranking Considerations

CSOs[a] (#)	SSOs[a] (#)	Public Drinking Water	Aquatic-dependent T&E Species (#)[b]	Special Designation	Public interest	WAT! Rank, year-round conditions[c]
						Bacteria
0	0	SWAPP Zone 2 (due to Louisville intake) 7 groundwater wells	1	None	Moderate	16 of 16

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

[b] There is one additional aquatic-dependent species and two terrestrial species that are State species of special concern.

[c] 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.

[8] 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

Water quality monitoring has been completed for three streams. Additionally, Middle Creek has also been assessed for habitat and biology. Flows have not been measured in any streams in this watershed.

6.2.1 Data Gap Analysis

SD1 plans to conduct additional baseline water quality sampling in this watershed (Section 4.2.1), along with biological and habitat assessments at one site in Middle Creek.

Lick Creek and possibly Landing Creek should be considered for future habitat and biological monitoring, to benchmark current conditions. As stated previously, Lick Creek was identified by the Conservation District as being relatively unimpacted.

Coordination with the local health department is also recommended to identify and upgrade failing septic systems, as is an investigation of dry weather bacteria sources in the Middle Creek, Lick Creek and Landing Creek watersheds, due to base flow bacteria levels. Base flow bacteria monitoring upstream and downstream of areas with higher septic or livestock densities would be useful for quantifying the impact of these sources.

Finally, coordination with the permitting authority should be considered as several permit violations were identified through a review of recent monitoring data.

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 12. These WAT! results incorporate predicted sewer overflow volumes from infrastructure model simulations for 1992-1996 climatological conditions[9]. Neither CSOs nor SSOs were a factor in the WAT! results, as none occur in the watershed.

Under year-round conditions, the largest source of fecal coliform is storm water runoff (Figure 12). 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.

[9] 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.

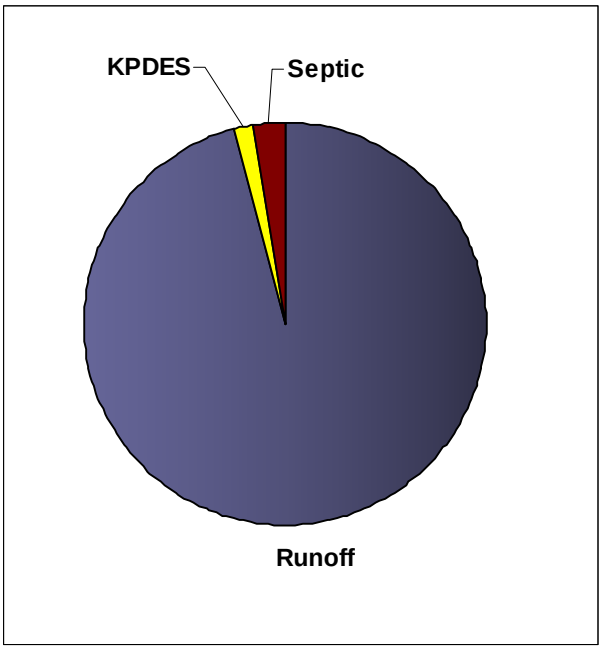

Figure 12. Initial Year-Round WAT! Results for Fecal Coliform

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 RANK

The WAT! produced a ranking, for the 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 watershed 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 Ohio River West watershed during year-round and base flow conditions is provided in Table 12.

Table 12. WAT! Watershed Rankings

	Rank for Year-Round Conditions[a,b]	Rank for Base flow Conditions[a,b]
Fecal coliform	16	2

[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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