Final Total Maximum Daily Load for 11 Pathogen Impaired Stream Segments within the Lower Cumberland River Basin, USGS Hydrologic Unit 05130205

Caldwell, Crittenden, Livingston, and Lyon Counties, Kentucky

Eddy Creek, Caldwell County, KDOW

Submitted to:
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Kentucky UNBRIDLED SPIRIT

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November 2008

Kentucky Department for Environmental Protection
Division of Water

This report is approved for release

Sandra L. Gruzesky, P.E.
Director
Division of Water

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Date

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Total Maximum Daily Load (TMDL) Synopsis

State: Kentucky
Major River Basin: Lower Cumberland River
HUC8: 05130205
Counties: Caldwell, Crittenden, Livingston, and Lyon
Pollutant of Concern: Pathogens
Suspected Sources: Package plant or other permitted small flow discharges, animal feeding operations, agriculture, unknown.

Impaired Waterbodies for Pathogen TMDLs:

Waterbody Name	Impaired Segment (River Miles)	County	GNIS Number	Suspected Sources	Impaired Use
Claylick Creek into Cumberland River	1.9 to 4.8	Livingston	KY489591_01	Agriculture	Primary & Secondary Contact Recreation (nonsupport)
Eddy Creek into Cumberland River	8.4 to 10.5	Lyon	KY491550_01	Unknown	Primary Contact Recreation (nonsupport)
Eddy Creek into Cumberland River	13.0 to 15.7	Caldwell	KY491550_03	Package plant or other permitted small flow discharges	Primary Contact Recreation (nonsupport)
Dry Creek into Eddy Creek	0.0 to 3.6	Caldwell	KY491176_00	Animal Feeding Operations	Primary Contact Recreation (nonsupport)
Ferguson Creek into Cumberland River	0.0 to 1.2	Livingston	KY492034_01	Unknown	Primary Contact Recreation (nonsupport)
Hickory Creek into Cumberland River	0.0 to 3.9	Livingston	KY494122_00	Unknown	Primary Contact Recreation (nonsupport)
Livingston Creek into Cumberland River	4.6 to 7.0	Lyon/Caldwell	KY496913_01	Unknown	Primary Contact Recreation (nonsupport)
Richland Creek into Cumberland River	0.7 to 5.4	Livingston	KY501820_00	Unknown	Primary & Secondary Contact Recreation (nonsupport)
Sandy Creek into Cumberland River	0.0 to 2.3	Livingston	KY502979_00	Unknown	Primary Contact Recreation (nonsupport)
Skinframe Creek into Livingston Creek	0.0 to 4.8	Lyon	KY503607_00	Unknown	Primary Contact Recreation (nonsupport)
Sugar Creek into Cumberland River	2.2 to 6.9	Livingston	KY504655_01	Unknown	Primary Contact Recreation (nonsupport)

Total Maximum Daily Load (TMDL) Synopsis

Policy and Purpose to Water Quality:

Section 303(d) of the Federal Clean Water Act declares that "each State shall identify those waters within its boundaries for which effluent limitations… are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters…. Each State shall establish for the waters identified in this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies… for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety."

Kentucky Revised Statute (KRS) 224.70-100 states, "It is hereby declared to be the policy of this Commonwealth…. to provide a comprehensive program in the public interest for the prevention, abatement and control of pollution; to provide effective means for the execution and enforcement of such program; and to provide for cooperation with agencies of other states or of the federal government in carrying out these objectives…. the purposes of KRS Chapter 224: to safeguard from pollution the uncontaminated waters of the Commonwealth; to prevent the creation of any new pollution of the waters of the Commonwealth; and to abate any existing pollution."

Kentucky Water Quality Criteria (WQC) for Fecal Coliform:

Title 401 KAR 5:031 describe the standards used to "protect the surface waters of the Commonwealth, and thus protect water resources." Fecal coliform bacteria are pathogen indicator organisms. Fecal coliform data are used to indicate the degree of support for primary contact recreation (PCR) use. The stream is assessed as fully supporting the PCR use if the fecal coliform content does not exceed the criterion of 400 colonies per 100 ml in less than 20 percent of samples; it was assessed as partially supporting the PCR use if the criterion was not met in 25-33 percent of samples, and as not supporting the PCR use if the criterion was not met in greater than 33 percent of samples. Streams assessed as either nonsupport or partial support are considered impaired. Secondary contact recreation (SCR) was also assessed following the same method, using the criterion of 2000 colonies per 100 ml. Stream segments were sampled once per month during the primary contact recreation season of May 1 through October 31, 2000.

TMDL Endpoints (i.e., Water Quality Standard/ Fecal Coliform TMDL Target):

The TMDL Target is defined as the WQC minus the Margin of Safety (MOS). The MOS can be an implicit or explicit additional reduction applied to the Waste Load allocation (WLA), Load Allocation (LA) or to both types of sources that accounts for uncertainties in the data or TMDL calculations. The TMDL Target is thus 360 colonies per 100ml (400 col/100ml minus a 10% MOS).

Total Maximum Daily Load (TMDL) Synopsis

TMDL Equation and Definitions:

A TMDL calculation is performed as follows:

WLA + LA + MOS = TMDL

Where:
WLA = the Waste Load Allocation, including KPDES-permitted sources such as Sewage Treatment Plants (STPs; aka Wastewater Treatment Plants, WWTPs).
LA = the Load Allocation, including natural background and non-KPDES permitted sources.
MOS = the Margin of Safety, which can be an implicit or explicit additional reduction applied to the WLA, LA or both types of sources that accounts for uncertainties in the data or TMDL calculations. The MOS for these TMDLs was set at 10% to generate an explicit MOS.
TMDL = the maximum load the waterbody can naturally assimilate while still meeting the WQC of 400 colonies per 100 ml at a given flow, in units of colonies per day.

The TMDL calculation must take into account seasonality and other factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.

TMDL Calculations:

Due to the absence of stream gages or in-stream flow data in the Lower Cumberland Watershed, KDOW used the U.S. Geological Survey's (USGS's) Mean Annual Streamflow (MAF) values. The MAF values were calculated using a three-variable regression equation found in the USGS Water-Resources Investigations Report 02-4206 "Estimating Mean Annual Streamflow of Rural Streams in Kentucky" (http://ky.water.usgs.gov/pubs/wrir_2002_4206.pdf). The MAF values can be found on the Hydrology of Kentucky webpage (http://kygeonet.ky.gov/kyhydro/main.htm). Once obtained, major inputs (i.e. WWTP flow, which was set at the facility's design capacity) and withdrawals were integrated to generate a critical flow. The critical flow is then multiplied by the WQC minus the MOS (10%) times the appropriate conversion factors to obtain the TMDL target load.

The TMDL, allocations, and percent reductions for each impaired segment are provided below. Percent reductions are for informational purposes only and are discussed in Appendix A. In addition, pathogen-impaired segments addressed in this document could be converted to an *Escherichia coli* (*E. coli*) daily load by using the WQC for *E. coli* – these calculations are also provided and discussed in Appendix A.

Total Maximum Daily Load (TMDL) Synopsis

TMDLs and Allocations:

TMDL[1]	MOS [2]	WLA [3] Wastewater[4]		LA	Percent Reduction[5]
Claylick Creek into Cumberland River RM 1.9-4.8					
5.77×10^{11} col/day	5.77×10^{10} col/day	0.0 col/day		5.20×10^{11} col/day	89.09%
Eddy Creek into Cumberland River RM 8.4-10.5					
9.32×10^{11} col/day	9.32×10^{10} col/day	Princeton STP KY0028401	2.377×10^{10} col/day	8.15×10^{11} col/day	84.35%
		Fontaine Trailer Company KY0022225	1.174×10^{8} col/day		
		Total	2.389×10^{10} col/day		
Eddy Creek into Cumberland River RM 13.0-15.7					
3.48×10^{11} col/day	3.48×10^{10} col/day	Princeton STP KY0028401	2.377×10^{10} col/day	2.90×10^{11} col/day	52.63%
		Fontaine Trailer Company KY0022225	1.174×10^{8} col/day		
		Total	2.389×10^{10} col/day		
Dry Creek into Eddy Creek RM 0.0-3.6					
4.38×10^{11} col/day	4.38×10^{10} col/day	0.0 col/day		3.95×10^{11} col/day	77%
Ferguson Creek into Cumberland River RM 0.0-1.2					
7.63×10^{10} col/day	7.63×10^{9}col/day	0.0 col/day		6.87×10^{10} col/day	78.82%
Hickory Creek into Cumberland River RM 0.0-3.9					
1.08×10^{11} col/day	1.08×10^{10} col/day	0.0 col/day		9.69×10^{10} col/day	92.13%
Livingston Creek into Cumberland River RM 4.6-7.0					
1.37×10^{12} col/day	1.37×10^{11} col/day	0.0 col/day		1.23×10^{12} col/day	59.78%
Richland Creek into Cumberland River RM 0.7-5.4					
9.20×10^{10} col/day	9.20×10^{9} col/day	0.0 col/day		8.28×10^{10} col/day	91.63%
Sandy Creek into Cumberland River RM 0.0-2.3					
3.47×10^{11} col/day	3.47×10^{10} col/day	Salem STP KY0066541	2.43×10^{9} col/day	3.10×10^{11} col/day	96.60%
Skinframe Creek into Livingston Creek RM 0.0-4.8					
5.19×10^{11} col/day	5.19×10^{10} col/day	0.0 col/day		4.67×10^{11} col/day	71.65%

Total Maximum Daily Load (TMDL) Synopsis

TMDL[1]	MOS [2]	WLA [3] Wastewater[4]	LA	Percent Reduction[5]
Sugar Creek into Cumberland River RM 2.2-6.9				
1.29×10^{11} col/day	1.29×10^{10} col/day	0.0 col/day	1.16×10^{11} col/day	85%

Notes:

(1). TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. MAF is determined by the USGS. The TMDL is the sum of all components. Daily loads for *E. coli* are provided in Appendix A.

(2). MOS is explicitly set at 10% of the Water Quality Criterion

(3). Although Concentrated Animal Feeding Operations (CAFOs) receive allocations within the WLA, there are no permitted CAFOs present in the watersheds of concern. Any future CAFO cannot legally discharge to surface water, and therefore receives a WLA of zero. The only exception is holders of a CAFO Individual Permit who can discharge during a 24-hour, 25-year or greater storm event.

(4). Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Criterion in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value is based on design flow and acute permit limits and represents the maximum one-day load that can be discharged to the stream segment.

(5). Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml. Percent reductions are provided for informational purposes only – see Appendix A.

KPDES Wastewater Discharges to Surface Waters Addressed in these Pathogen TMDLs:

Facility Name	KPDES Permit No.	Design Flow (MGD)	Permit Limit (col/100mL)		WLA
			Monthly Avg.	Max Weekly Avg.	
Sandy Creek into Cumberland River RM 0.0-2.3					
Salem STP	KY0066541	0.16	200	400	2.43×10^{9} col/day
Eddy Creek into Cumberland River RM 8.4-10.5					
Princeton STP	KY0028401	1.57	200	400	2.38×10^{10} col/day
Fontaine Trailer Company	KY0022225	0.0075	200	400	1.17×10^{8} col/day
Eddy Creek into Cumberland River RM 13.0-15.7					
Princeton STP	KY0028401	1.57	200	400	2.38×10^{10} col/day
Fontaine Trailer Company	KY0022225	0.0075	200	400	1.17×10^{8} col/day

1.0 Introduction

Section 303(d) of the Clean Water Act requires states to identify waterbodies within their boundaries that have been assessed and are not currently meeting their designated uses (per 401 KAR 5:026 and 5:031). States must establish a priority ranking for such waters, taking into account its intended uses and the severity of the pollutant.

States are also required to develop Total Maximum Daily Loads (TMDLs) for the pollutants that cause each waterbody to fail to meet its designated uses. The TMDL process establishes the allowable amount (i.e. "load") of pollutant a waterbody can naturally assimilate while continuing to meet the water quality criteria (WQC) for each designated use. The pollutant load must be established at a level necessary to implement the applicable WQC with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. A TMDL can consequently provide an analytical foundation for identifying, planning, and implementing water quality-based controls to reduce pollution from both KPDES-permitted and non KPDES-permitted sources. The ultimate goal is the restoration and maintenance of water quality in the waterbody so that designated uses are met.

In 1998, Kentucky adopted the Watershed Management Framework (WMF) as a process for monitoring streams, assessing uses, developing TMDLs, and rehabilitating waters through local basin teams. The state's major watersheds were divided into five Basin Management Units (BMUs): BMU 1 (Kentucky River), BMU 2 (Salt and Licking River), BMU 3 (Tennessee-Mississippi-Cumberland Rivers, aka Four Rivers), BMU 4 (Green and Tradewater River) and BMU 5 (Big Sandy River, Little Sandy River and Tygarts Creek). Each BMU is intensively monitored once every five years by an interagency cooperative organized by the Kentucky Division of Water (KDOW). Waterbodies are identified as first priority for TMDL development if one or more designated uses are identified as nonsupport and second priority if the waterbody partially supports the designated use(s). The Lower Cumberland Basin was the focus of the 2000 monitoring season.

This TMDL report provides important pathogen allocations and reductions that could assist with developing detailed watershed plans to guide watershed restoration efforts. Watershed Plans for the pathogen impaired Lower Cumberland waterbodies should address both KPDES-permitted (point) and non KPDES-permitted (nonpoint) sources of pathogen loadings to the watersheds and should build on existing efforts as well as evaluate new approaches. Comprehensive Watershed Plans should consider both voluntary and regulatory approaches in order to meet water quality standards.

2.0 Problem Definition

The KDOW identified eleven waterbodies in the 2008 Integrated Report (KDOW 2008) from the Lower Cumberland River Basin as impaired (non-support) for primary contact recreation (PCR, i.e. swimming). All eleven waterbodies addressed in this TMDL are therefore first priority based upon their PCR impairment status (see Table 2.1). Data used to assess these waterbodies included fecal coliform data collected by Murray State University Center for Reservoir Research (Murray) (in cooperation with KDOW and as funded by a Section 319(h) Nonpoint Source

Implementation Grant) and the KDOW, as well as general watershed data (i.e. geology, land use, location of KPDES-permitted sources, etc.) analyzed in a geographic information systems (GIS) framework. Fecal coliform bacteria are used as an indicator of the presence of pathogen pollution. Suspected sources of impairment include KPDES-permitted sources (municipalities and facilities discharging above permit limits) and non-KPDES permitted sources (agriculture, illegal straight-pipe discharge, failing Onsite Wastewater Treatment Systems (OWTSs), rural runoff). The pathogen TMDL streams addressed in this TMDL document are listed in Table 2.1 and illustrated on Figure 2.1.

Table 2.1 Pathogen-impaired Waterbodies Addressed in this TMDL Document within the Lower Cumberland River Basin (USGS HUC 05130205)

Waterbody Name	Impaired Segment (River Miles)	County	GNIS Number	Suspected Sources	Impaired Use
Claylick Creek into Cumberland River	1.9 to 4.8	Livingston	KY489591_01	Agriculture	Primary & Secondary Contact Recreation (nonsupport)
Eddy Creek into Cumberland River	8.4 to 10.5	Lyon	KY491550_01	Unknown	Primary Contact Recreation (nonsupport)
Eddy Creek into Cumberland River	13.0 to 15.7	Caldwell	KY491550_03	Package plant or other permitted small flow discharges	Primary Contact Recreation (nonsupport)
Dry Creek into Eddy Creek	0.0 to 3.6	Caldwell	KY491176_00	Animal Feeding Operations	Primary Contact Recreation (nonsupport)
Ferguson Creek into Cumberland River	0.0 to 1.2	Livingston	KY492034_01	Unknown	Primary Contact Recreation (nonsupport)
Hickory Creek into Cumberland River	0.0 to 3.9	Livingston	KY494122_00	Unknown	Primary Contact Recreation (nonsupport)
Livingston Creek into Cumberland River	4.6 to 7.0	Lyon/Caldwell	KY496913_01	Unknown	Primary Contact Recreation (nonsupport)
Richland Creek into Cumberland River	0.7 to 5.4	Livingston	KY501820_00	Unknown	Primary & Secondary Contact Recreation (nonsupport)
Sandy Creek into Cumberland River	0.0 to 2.3	Livingston	KY502979_00	Unknown	Primary Contact Recreation (nonsupport)
Skinframe Creek into Livingston Creek	0.0 to 4.8	Lyon	KY503607_00	Unknown	Primary Contact Recreation (nonsupport)
Sugar Creek into Cumberland River	2.2 to 6.9	Livingston	KY504655_01	Unknown	Primary Contact Recreation (nonsupport)

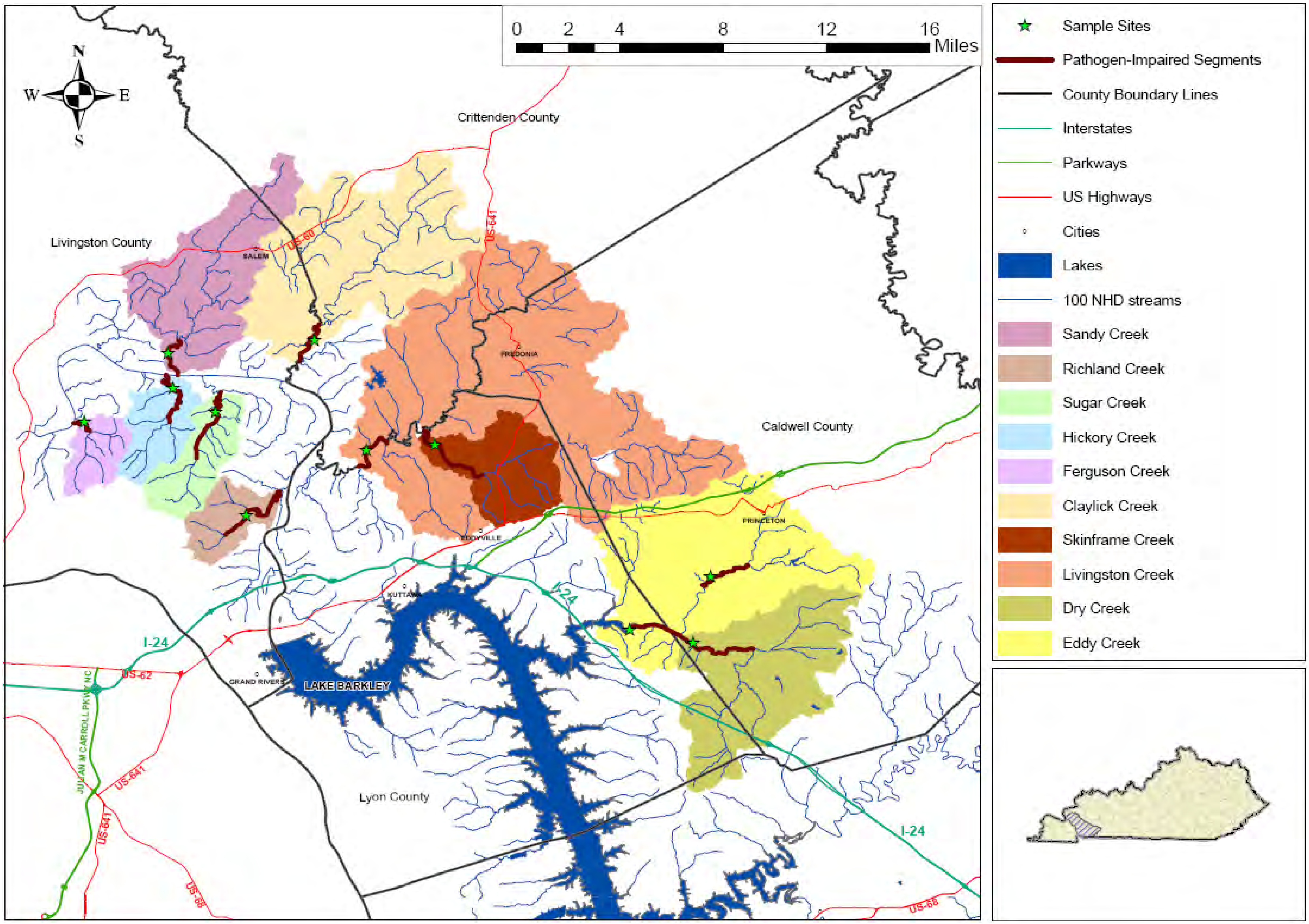

Figure 2.1 Location of Pathogen-impaired Streams within the Lower Cumberland River Basin (USGS HUC 05130205) Addressed in this TMDL Document

3.0 Physical Setting

The Lower Cumberland River Basin, United States Geological Survey (USGS) hydrologic unit code (HUC) #05130205 is located in western Kentucky including and just east of Lake Barkley. The area of interest is in the northern portion of the HUC (north of Trigg County) and encompasses parts of four counties: the eastern portion of Caldwell; southwest corner of Crittenden; southeast corner of Livingston; and the northern section of Lyon. The immediate watershed area (sum of the associated HUC 14 watershed area) of the eleven TMDL stream segments covers nearly 104 square miles of land – the comprehensive watershed area (total drainage to the pathogen-impaired stream segment) for all streams covers approximately 309 square miles. All streams drain to the Cumberland River (or Lake Barkley) with eventual discharge into the Ohio River near Smithland, Kentucky. The watersheds of concern lie in the Interior Plateau Level III ecoregion (Woods et al 2002). They also lie just west of the Dripping Springs Escarpment within the Mississippian Plateau (Pennyroyal) physiographic region. Four watersheds (Richland, Sugar, Hickory, and Ferguson) are bisected by the eastern border of the Mississippi Embayment physiographic region (McGrain 1983).

3.1 Geology

The eastern edge of the Lower Cumberland HUC generally follows the western edge of the Dripping Springs Escarpment – a sandstone-capped plateau of moderate relief. Formations in this vicinity were deposited around 320 million years ago during the Pennsylvanian age. There is also substantial karst geology in the area. In fact, much of the karst limestone bedrock (Ste. Genevieve and St. Louis) exposed at the surface and encountered just below is the same type of limestone that created Mammoth Cave, the world's largest known cave system and a UNESCO World Heritage Site. The limestone formations are of Mississippian age – deposited approximately 350 million years ago. Caves are more prevalent near the slope of the escarpment, such as Big Spring Cave in Princeton (the source of Eddy Creek). Most of the watersheds however lie in the valley bottoms and are characterized by typical "karst" topography - sinkhole plains, sinking streams, and springs (McGrain 1983; KGS 2002). A generalized block diagram of the karst limestone present in the area, drawn by James Currens of the Kentucky Geological Survey (KGS), is provided as Figure 3.1. A generalized geologic map overlain with mapped sinkholes, springs, and faults is included as Figure 3.2. Mississippian and Pennsylvanian age deposits are noted on Figure 3.2 as shades of green and blue.

Official watershed boundaries may not be accurate in well-developed karst regions. Although groundwater drainage generally follows topographic basin boundaries, this is not always true. Subsurface drainage transfer between surface watersheds in a karst region does occur, which increases or decreases the actual boundaries of an affected stream basin. The KDOW and the KGS maintain a Karst Atlas of groundwater tracing data and delineated basins (both as static PDF maps and ArcView shape files) that can be downloaded at http://kygeonet.ky.gov - this work is ongoing within the watersheds of concern and data is updated as information becomes available (Blair, KDOW Personal Communication 2008).

Recent continental deposits of alluvium are encountered in the vicinity of the basin's streams, Lake Barkley, and the Cumberland River. The four watersheds lying west of the Cumberland

River include unconsolidated sand, gravel, silt, and clay formations of Tertiary age, deposited 70 million years ago. The gravels encountered here are derived from the weathering of the adjacent limestone and chert formations (McGrain 1983; KGS 2002). Alluvium and Tertiary age deposits are noted on Figure 3.2 as shades of pink.

The Illinois-Kentucky fluorspar district encompasses the northern portion of the watersheds of concern (Caldwell, Crittenden, and Livingston Counties). The district is a network of closely spaced high-angle faults trending northeastward from the Mississippi Embayment creating conduits for mineral-rich fluids (KGS 2002).

The presence of faults in a watershed has the potential to influence groundwater/surface water flow - typically, surface water flow will parallel a fracture zone for a distance before sinking off a non-soluble bedrock into a soluble limestone bedrock, near a fault. In the same way, groundwater flow may parallel a fracture zone for a distance before emerging as a spring near the contact (fault) between the soluble limestone and non-soluble bedrock – for example, the flow route from Cook Spring to Muddy Fork near Hopkinsville is strongly influenced by the presence of a fault (Ray, KDOW Personal Communication 2007).

Karst topography can create geological hazards such as sudden surface collapse (due to sinkholes), flooding (if a karst pathway becomes clogged with debris or overloaded due to improper surface flow routing), and soil erosion. Karst topography also creates a concern for groundwater and surface water contamination. Areas underlain by karst hydrology can have rapid groundwater flow rates, with complex routes. Storm water and associated pollutants can quickly percolate through soils and sinkholes with little or no filtration or attenuation of the contaminants. Groundwater velocities within conduits are commonly measured in thousands of feet per day instead of the typical rate of inches or feet per year in non-karst systems – the maximum recorded conduit groundwater velocity in Kentucky exceeds 2600 feet per hour (Blair, KDOW Personal Communication 2008).

Karst pathways can serve as underground tributaries to surface water, and thus can serve as a transport pathway for fecal coliform to streams. The lack of sunlight, colder temperatures and moist environment of groundwater systems provide the means for pathogens to persist longer before reaching surface streams (Harter 2007). Improper waste management activities (i.e. dumping into sinkholes, poorly installed or failing OWTSs) or improper best management practices (i.e. lack of buffer strips around sinkholes in agricultural fields) can lead to direct contamination of water supplies. Karst also provides a challenge for nonpoint source pollution management as its pathways have long been regarded as "nature's sewer system" – sinkhole plains, sinking streams, and springs provide a direct connection between surface water and groundwater systems.

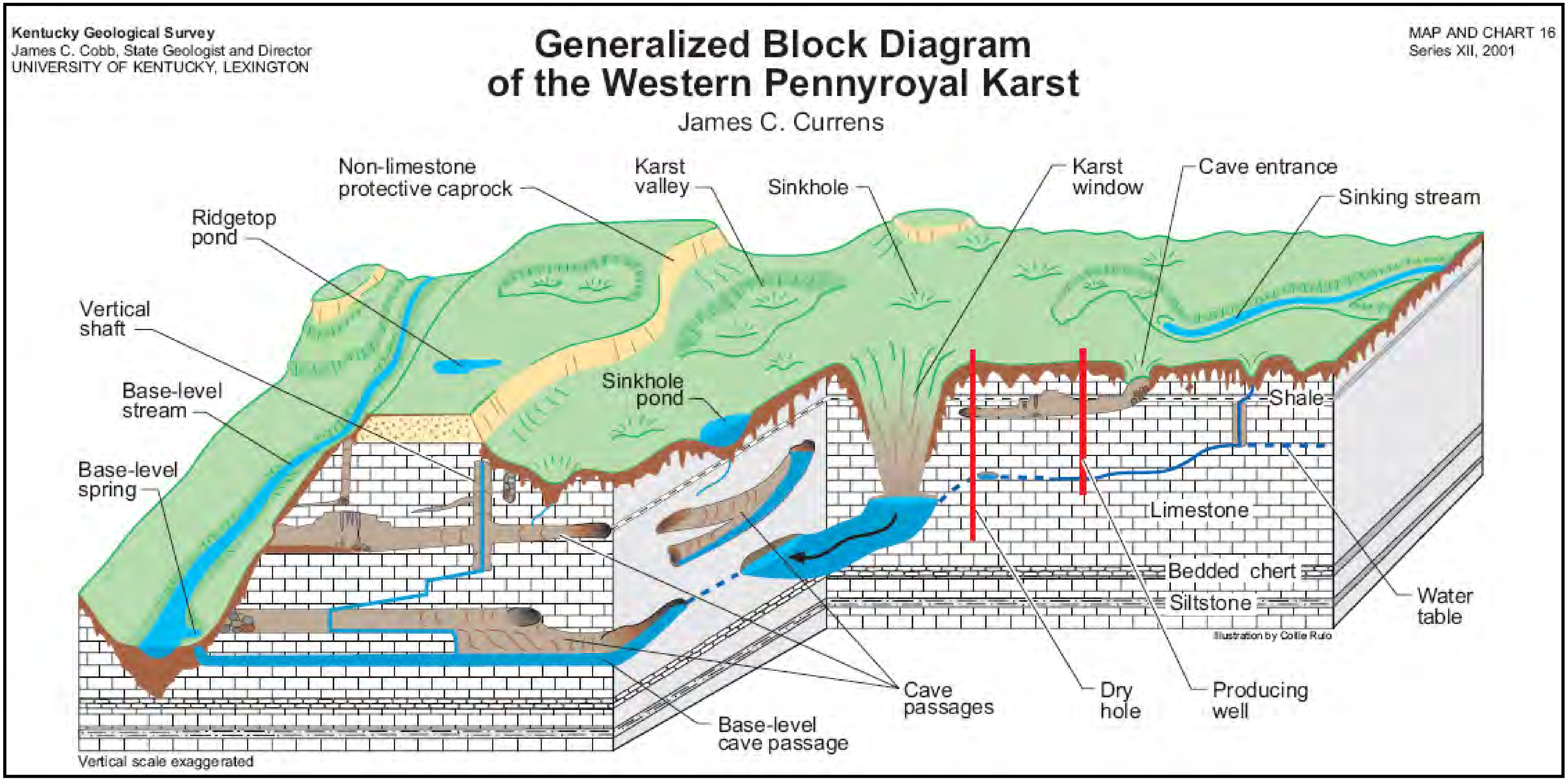

Figure 3.1 Generalized Block Diagram of the Karst Limestone Bedrock Encountered within the Lower Cumberland River Basin (USGS HUC 05130205) (Drawing Provided Courtesy of the Kentucky Geological Survey)

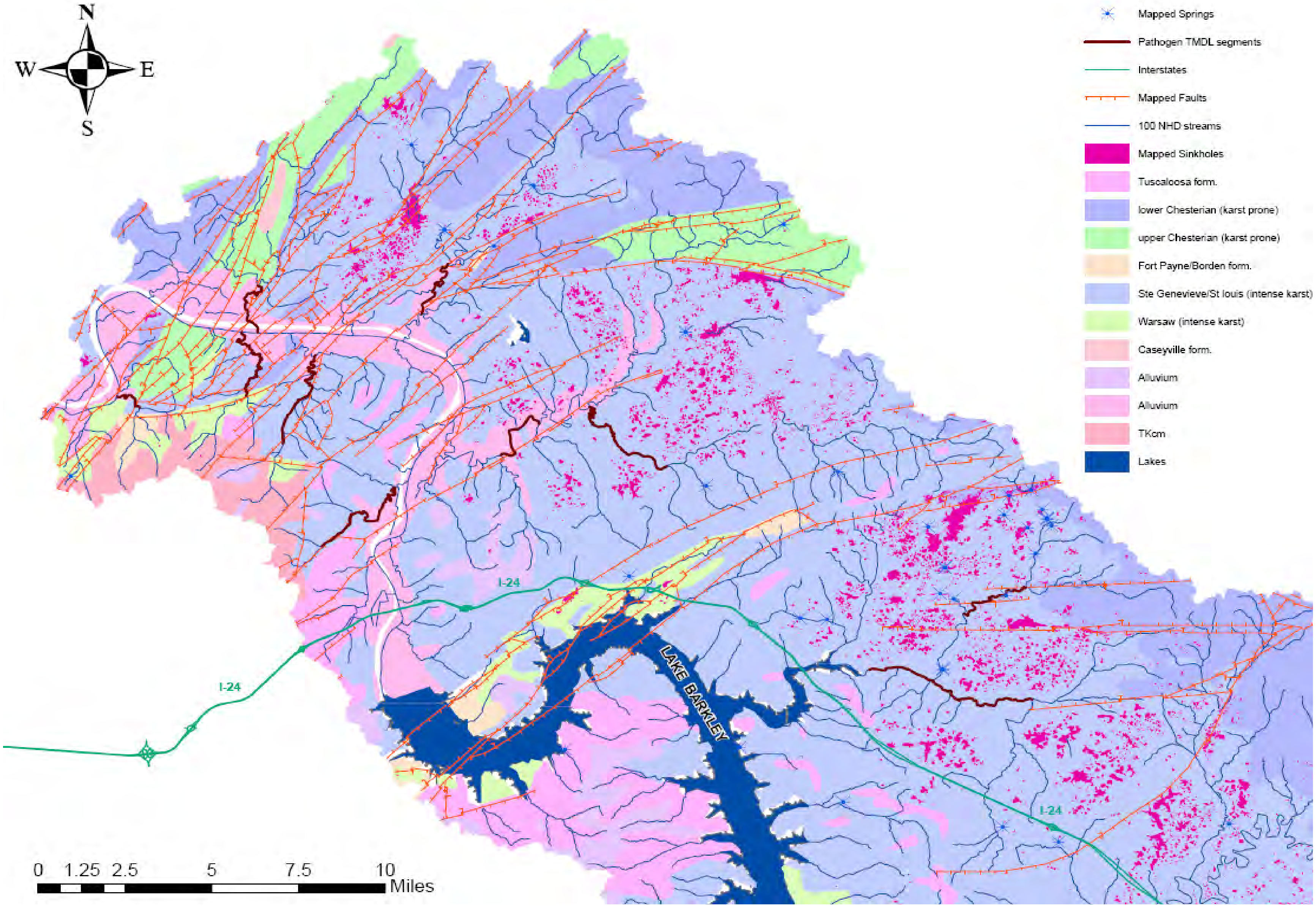

Figure 3.2 Generalized Geologic Map Demonstrating the Location of Faults and Abundance of Karst Media and Features in the Vicinity of Pathogen-impaired Waterbodies within the Lower Cumberland River Basin (USGS HUC 05130205)

3.2 Overall Land Use

Land use within the impaired watersheds is largely rural, including forest (53.1%) and agricultural (16.7% pasture and 20.1% row crops) land uses. Only 3.7% of the total land area is developed and includes several small cities (Princeton, Eddyville, Fredonia, and Salem). The 2001 National Land Cover Dataset (NLCD) overlain with the individual USGS HUC 14s within a GIS framework was used to determine land use areas in the watersheds. Table 3.1 summarizes the land use by percentage and square miles within each watershed's total drainage area. Figure 4 demonstrates the various land uses within the watersheds of concern. Individual land use maps of each watershed are included as Appendix A. Table 3.2 presents the approximate values for elevation, length, area and slope of the impaired streams. These values were obtained by comparing the National Hydrography Dataset (NHD; USGS 1999) stream mile-points with elevations from the Digital Elevation Model (DEM; USGS 2000) within a GIS framework.

As stated, agricultural land use within the watersheds of concern is primarily row crops. According to statistics obtained from the United States Department of Agriculture (USDA), dry hay is the principal row crop, followed by corn for grain and soybeans. Cattle and calves are the principal livestock commodity, followed by hogs and pigs.

Table 3.1 Summary of Land Use within the Watersheds of Concern (USGS HUC 05130205); Data Generated Using NLCD 2001 (USGS 2001)

Impaired Stream / Subwatershed Name/mi^2	Forest	Agricultural (total)	Pasture/Hay	Row Crops	Developed	Natural Grasslands	Wetlands	Barren Land
Claylick Creek	49.21%	43.34%	22.75%	20.58%	3.27%	2.49%	1.68%	0.01%
(square miles)	23.41	20.62	10.83	9.79	1.55	1.19	0.80	0.00
Eddy Creek*	29.83%	60.18%	20.40%	39.78%	7.81%	1.64%	0.49%	0.04%
(square miles)	22.56	45.51	15.43	30.08	5.91	1.24	0.37	0.03
Ferguson Creek	77.35%	9.9%	6.52%	3.37%	1.48%	6.59%	4.68%	0.0%
(square miles)	4.87	0.62	0.41	0.21	0.09	0.42	0.29	0.00
Hickory Creek	62.83%	24.22%	6.05%	18.17%	2.61%	4.83%	5.50%	0.0%
(square miles)	5.69	2.19	0.55	1.64	0.24	0.44	0.50	0.00
Livingston Creek**	32.83%	59.61%	29.62%	29.99%	5.04%	1.35%	1.08%	0.10%
(square miles)	37.03	67.24	33.41	33.83	5.68	1.52	1.22	0.11
Richland Creek	67.73%	22.73%	12.33%	10.41%	2.31%	2.82%	4.39%	0.01%
(square miles)	5.24	1.76	0.95	0.80	0.18	0.22	0.34	0.00
Sandy Creek	47.96%	43.36%	17.78%	25.58%	3.56%	1.56%	3.54%	0.03%
(square miles)	13.92	12.59	5.16	7.43	1.03	0.45	1.03	0.00
Sugar Creek	56.70%	30.56%	17.90%	12.65%	3.23%	3.61%	5.90%	0.0%
(square miles)	6.14	3.31	1.94	1.37	0.35	0.39	0.64	0.00

* Includes land use within the upper Eddy Creek and Dry Creek subwatershed drainage areas.
** Includes land use within the Skinframe Creek subwatershed drainage area.

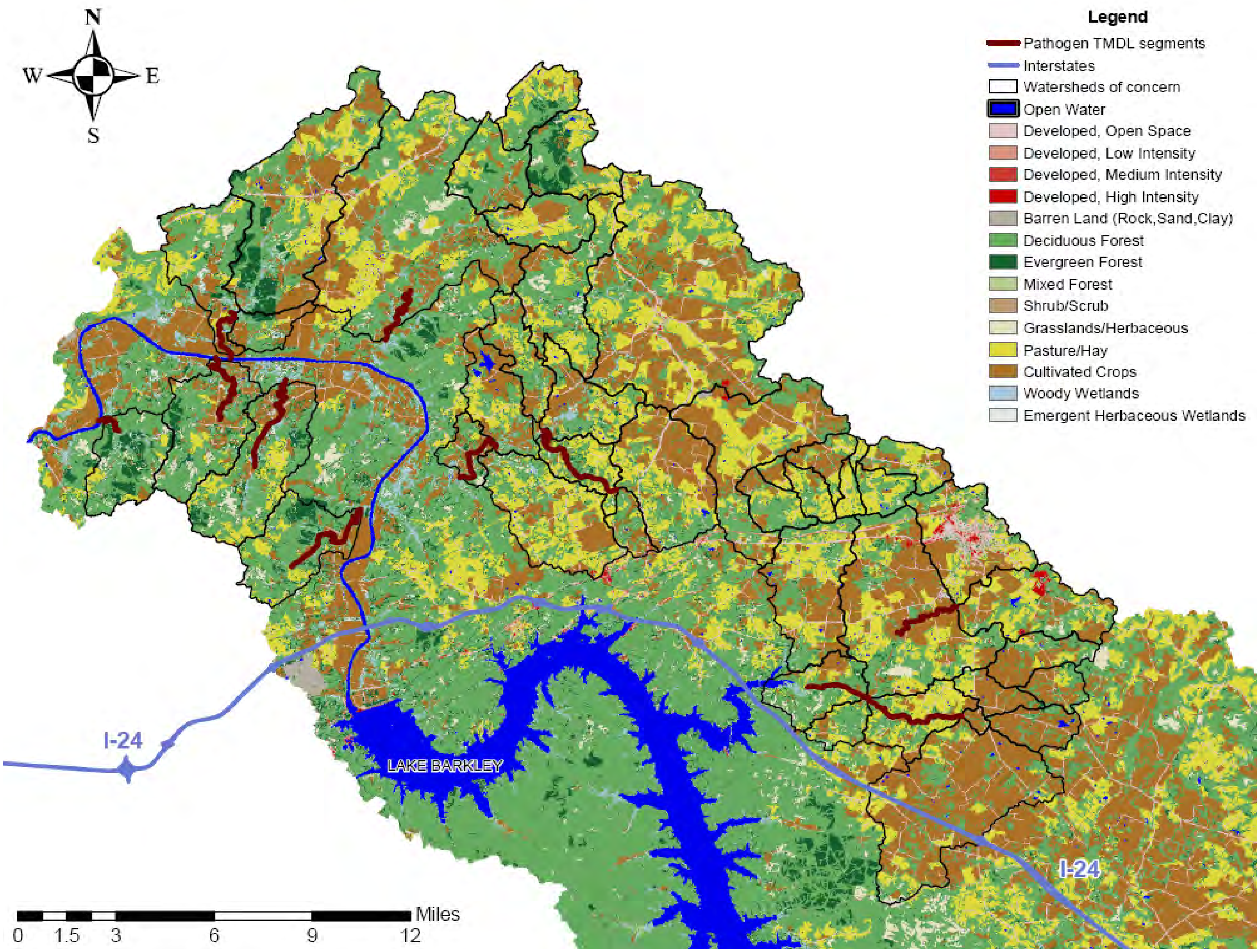

Figure 3.3 Land Use within the Lower Cumberland River Basin (USGS HUC 05130205) Watersheds of Concern

Table 3.2 Stream Configuration of the Pathogen-impaired Segments within the Lower Cumberland River Basin

Stream Name	Highest Elevation Point (ft msl) *	Lowest Elevation Point (ft msl) *	Length (mi) *	Slope (ft/mi) *	Drainage Area (mi^2)**
Claylick Creek	329	325	2.9	1.38	47.58
Eddy Creek (RM 8.4-10.5)	371	357	2.1	6.67	85.61
Eddy Creek (RM 13.0-15.7)	412	392	2.7	7.41	34.84
Dry Creek	418	371	3.6	13.1	34.04
Ferguson Creek	324	302	1.2	18.3	6.30
Hickory Creek	336	313	3.9	5.9	9.05
Livingston Creek	330	317	2.4	5.42	112.8
Richland Creek	348	320	4.7	5.96	7.73
Sandy Creek	320	319	2.3	0.43	29.03
Skinframe Creek	376	352	4.8	5.0	15.84
Sugar Creek	346	317	4.7	6.17	10.83

*Statistics are for the highest elevation point in the watershed to the downstream end of the pathogen-impaired segment; "ft msl" = feet above mean sea level (see Table 2.1).
**The Eddy Creek (RM 8.4 to 10.5) segment includes the drainage areas from the Eddy Creek (RM 13.0 to 15.7) segment as well as Dry Creek. The Livingston Creek segment includes the drainage area from Skinframe Creek.

4.0 Monitoring

The Kentucky Watershed Management Framework maintains two types of monitoring stations: ambient and rotating watershed stations. Ambient stations are fixed, permanent sample locations located in the downstream and mid-unit reaches of USGS 8-digit HUCs, upstream of major reservoirs and in the downstream reaches of major tributaries. The ambient stations of a watershed management unit are sampled monthly during the year the unit is in the monitoring phase of the watershed cycle. During the other four years of the watershed cycle, sampling frequency is reduced to bimonthly. Rotating watershed stations are selected for intensive (monthly) sampling for one year during the monitoring portion of the five (5) year watershed cycle. These are usually located at the downstream reaches of USGS 11-digit HUC watersheds, and many were coupled with biological sampling and USGS gaging stations. The KDOW follows water quality sample collection and preservation procedures found in its water quality monitoring Standard Operating Procedure manuals, available online (http://www.water.ky.gov/sw/swmonitor/sop/). The Lower Cumberland (Four Rivers) Basin was the focus of the 2000 monitoring season. One ambient monitoring station was located within the watersheds of concern on Livingston Creek at the KY-295 bridge (STORET Station ID CRW001); fecal coliform data collected from this site was used for TMDL development (see Section 8.3.5).

4.1 Nonpoint Source Monitoring

Section 319(h) of the Clean Water Act provides grant monies which support a wide variety of activities that work to reduce nonpoint source pollution to surface water. These activities include conducting assessments, providing technical assistance and education, monitoring, and developing and implementing TMDLs and watershed management plans. Organizations eligible for grant monies include local, State, or Federal government agencies, nonprofit organizations, and universities.

During the monitoring season, the Kentucky WMF intensively monitors the basin by an interagency cooperative organized by the KDOW. A Nonpoint Source Implementation Grant was awarded to Murray in cooperation with the KDOW Watershed Management Branch to expand upon fecal coliform assessments in the Four Rivers Basin. KDOW biologists worked with Murray to select monitoring stations. The eleven stream segments addressed in this TMDL were monitored once monthly for fecal coliform bacteria during the PCR season (May 1st through October 31st). Fecal coliform data collected by Murray and KDOW provided the basis for the impaired listings and subsequent TMDL development. Table 4.1 provides a listing of the sampling locations for each segment along with statistical analyses of the data. Figure 4.1 shows the impaired waterbodies with the location of Sewage Treatment Plant (STP) and Package Treatment Plant outfalls, sampling points where data were collected for the TMDL as well as the location of all relevant animal feeding operations (AFOs), concentrated animal feeding operations (CAFOs), and Kentucky No Discharge Operating Permit (KNDOP) facilities.

The river miles of five of the pathogen-impaired stream segments (Claylick, Ferguson, Hickory, Richland, and Sugar Creeks) have been changed since their original 2006 listing on the 303(d) list to better reflect the NHD which is based upon topographic maps. River mile segments listed in all tables of this report reflect these changes.

Table 4.1 Statistical Summary of Fecal Coliform Data Collected by Murray in the Lower Cumberland River Basin (USGS HUC 05130205) Watersheds of Concern

Station	Number of samples	% Exceeding Criteria (400 colonies/100ml)	Minimum (colonies/ 100mL)	Maximum (colonies/ 100mL)	Average (colonies/100mL)
Clay Lick Creek at Seven Branch (Seven Ridge) Road	6	66.67%	40	3600	1491.67
Eddy Creek (RM 8.4 to 10.5) at Eddy Creek Road bridge	6	50%	0	3350	975
Eddy Creek (RM 13.0 to 15.7) at KY-903 bridge	6	33.33%	40	900	365
Dry Creek at KY-903 bridge	6	33.3%	0	2600	561.67
Ferguson Creek at Scotts Chapel Road	6	66.67%	50	2200	813.33
Hickory Creek at Vaughn Road	6	66.67%	10	7600	1776.67
Livingston Creek at KY-295 bridge	12	41.67%	83	29,600	2850.0
Richland Creek at Tiline (Vanhooser) Road bridge	6	50%	0	6000	1623.5
Sandy Creek at Vicksburg (Head) Road	6	50%	30	19600	3643.33
Skinframe Creek at KY-1943 bridge	6	50%	90	1900	650

Station	Number of samples	% Exceeding Criteria (400 colonies/100ml)	Minimum (colonies/ 100mL)	Maximum (colonies/ 100mL)	Average (colonies/100mL)
Sugar Creek at US Highway 70	6	33.3%	10	3200	858.33

5.0 TMDL Target Identification

Title 401 KAR 5:031 describe the standards used to "protect the surface waters of the Commonwealth, and thus protect water resources." Fecal coliform bacteria are pathogen indicator organisms. Fecal coliform data are used to indicate the degree of support for PCR use. The stream is assessed as fully supporting the PCR use if the fecal coliform content does not exceed the criterion of 400 colonies per 100 ml in less than 20 percent of samples; it was assessed as partially supporting the PCR use if the criterion was not met in 25-33 percent of samples, and as nonsupport of the PCR use if the criterion was not met in greater than 33 percent of samples. Streams assessed as either nonsupport or partial support are considered impaired. Secondary contact recreation (SCR) was also assessed following the same method, using the criterion of 2000 colonies per 100 ml.

Escherichia coli (*E. coli*) can also be used as an indicator of pathogen organisms however Murray samples were analyzed for fecal coliform. The fecal coliform (and *E. coli*) criterion in 401 KAR 5:031 Section 7 (1)(a) specifically states that:

"[The] Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31. Fecal coliform criteria listed in subsection (2)(a) of this section shall apply during the remainder of the year.

There are insufficient fecal coliform data to calculate a 5-sample, 30-day geometric mean, so the latter criterion of 400 colonies per 100 ml was used as the WQC in order to calculate the associated pathogen TMDLs for the PCR designated use. Stream segments were sampled once per month during the 2000 PCR season.

The TMDL Target is defined as the WQC minus the Margin of Safety (MOS). The MOS can be an implicit or explicit additional reduction applied to the Waste Load Allocation (WLA), Load Allocation (LA) or to both types of sources that accounts for uncertainties in the data or TMDL calculations. For these TMDLs, a 10% explicit MOS (i.e., 10% of the WQC, but expressed as a daily load) was reserved to account for uncertainty. The TMDL Target is thus 360 col/100ml (400 col/100ml minus a 10% MOS).

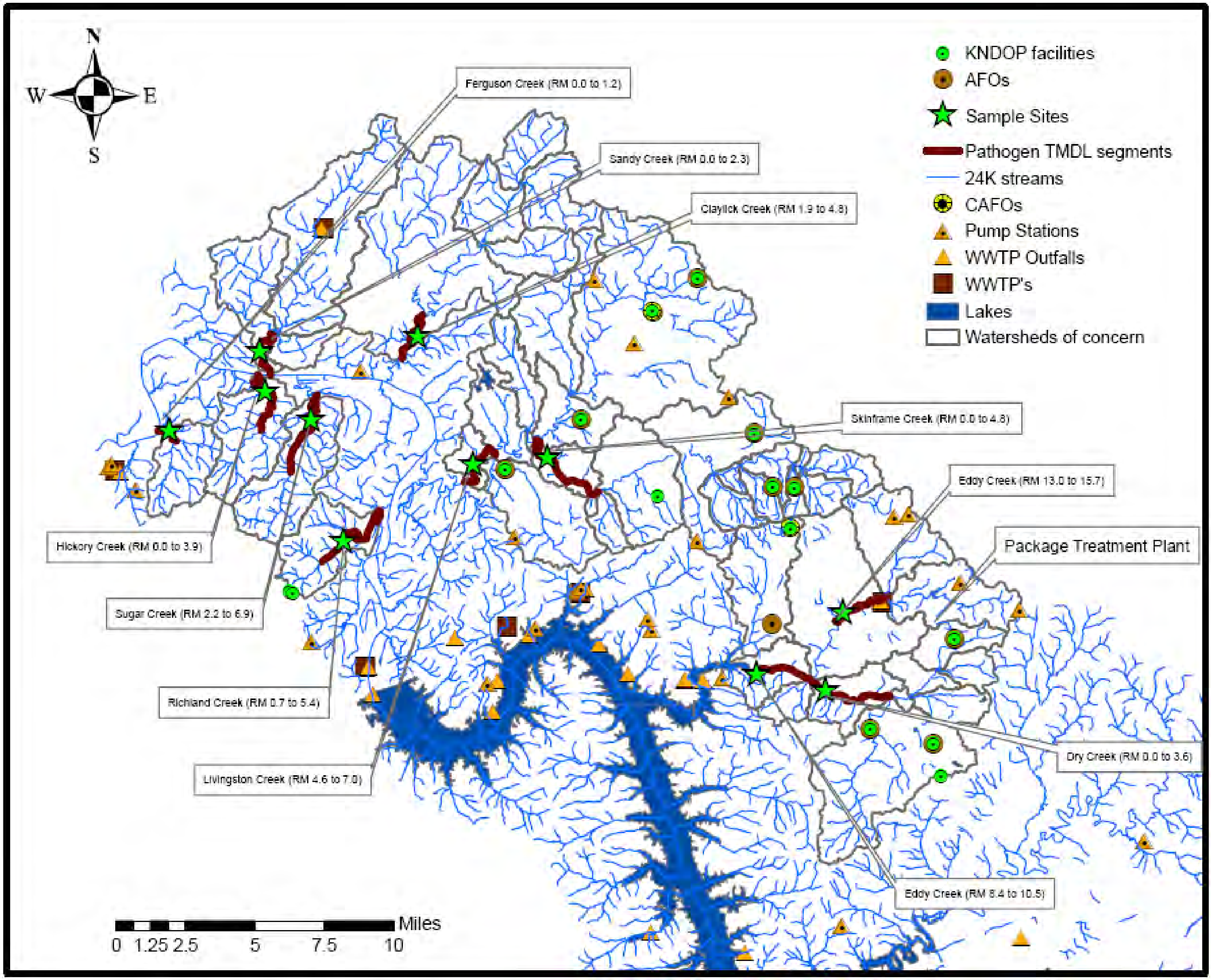

Figure 4.1 Location of Fecal Coliform Sample Sites and Pathogen-impaired Stream Segments within the Lower Cumberland River Basin Watersheds of Concern, Including KPDES-permitted Sources

6.0 Source Identification

For regulatory purposes, the sources of pathogens in a watershed can be placed into two broad categories: KPDES-permitted and non KPDES-permitted sources. A KPDES-permitted source requires a Kentucky Pollutant Discharge Elimination System (KPDES) discharge permit, Stormwater permit, or a Municipal Separate Storm Sewer System (MS4) permit from the KDOW. KPDES discharge permits include wastewater treatment facilities that discharge directly to a stream, facilities discharging stormwater, and some agricultural operations. The KPDES is not the only permitting program that may affect water quality or quantity within a watershed; other permitting examples include water withdrawal permits, permits to build structures within a floodplain, permits to construct an OWTS, and permits to land apply waste from sewage treatment plants. However, within the framework of the TMDL process a KPDES-permitted source is defined as one regulated under the KPDES program.

A non KPDES-permitted source does not include surface or ground water dischargers regulated by the KPDES program but does include non-point sources of pollution. Non-point sources of pollution are caused by runoff from precipitation over and/or through the ground and are relative to land use.

6.1 KPDES-Permitted Sources

KPDES-permitted sources include all sources regulated by KPDES including point sources. KPDES defines a point source in 401 KAR 5:002 as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or concentrated animal feeding operation (CAFO), from which pollutants are or may be discharged. The term does not include agricultural and stormwater run-off or return flows from irrigated agriculture." KPDES is not the only permitting program for sources that may discharge to surface water within a watershed, as mentioned above. A Waste Load Allocation (WLA) is assigned to KPDES-permitted sources.

6.1.1 Wastewater Dischargers

Information obtained from the Water Resource Information System (WRIS, www.wris.ky.gov), KDOW Surface Water Permits Branch, and Water Infrastructure Branch was used to confirm information associated with wastewater dischargers in the watersheds of concern as well as acquire background information and any future planned expansions. In addition, in October 1999 and March 2000 the Pennyrile Area Development District (PEADD) wrote a "Summary of Water Systems" and "Summary of Wastewater Treatment Systems," respectively, as part of the "Strategic Water Resource Development Plan" (SWRDP) compiled and released by the Water Resource Development Commission of the Governor's Office. Information from these reports is for informative purposes only unless confirmed by one of the above mentioned KDOW Branches. Table 6.1 lists all of the KPDES Wastewater dischargers within the pathogen-impaired watersheds of concern. Discharge Monitoring Report (DMR) data is included in Appendix B.

The City of Fredonia Water and Sewer Department operates a sanitary sewer collection system and Regional Planning Area which serves all of the residences and businesses within its corporate limits (Bertelson, KDOW Personal Communication 2008). The city is under contract with the city of Eddyville for treatment services at their facility (Kentucky Infrastructure Authority 2000). Though the city of Fredonia transfers their wastewater to the city of Eddyville sewerage system for treatment, some of their collection system and two pump stations lie within the Livingston and Skinframe Creek watersheds. System and/or pump station malfunction as well as system overflow during periods of power outages or high precipitation are potential sources of pathogens within these watersheds. As of spring 2008, the system is not under a sewer sanction and KDOW is unaware of planned wastewater collection or treatment projects (Bertleson, KDOW Personal Communication 2008).

The Salem Municipal Water System operates a sanitary sewer collection and treatment system and Regional Planning Area which serves all of the residences and businesses within its corporate limits (Bertelson, KDOW Personal Communication 2008). The system was established in 1982 - ninety-five percent of its sewer lines are 20 years or older. The system relies on 8,823 linear feet of force main and 51,839 linear feet of gravity lines along with eight submersible pumps located at four different lift stations to collect the wastewater. As of November 2006, the system was servicing 351 residential and 56 commercial customers (Kentucky Infrastructure Authority 2008). The system operates one treatment facility (Salem STP) which discharges to Sandy Creek and has a design capacity of 0.16 million gallons per day (MGD). According to DMR data submitted by Salem to KDOW from 1999 to 2007, the facility has not exceeded their daily maximum or average monthly permit limits since 2002. Historical violations typically pertain to total suspended solids with only one exceedance for fecal coliform bacteria noted in March 1999. A Regional Facility Plan was received and approved by KDOW in July 2007 for replacement of the wastewater treatment plant (WWTP) sludge handling process and pump station upgrades. As of spring 2008, the system is not under a sewer sanction and KDOW is unaware of planned wastewater collection or treatment projects (Bertelson, KDOW Personal Communication 2008).

The City of Princeton Water and Wastewater Commission operates a sanitary sewer collection and treatment system and Regional Planning Area which serves all of the residences and businesses within its corporate limits (Bertelson, KDOW Personal Communication 2008). The system was established in 1997 though the collection lines were installed between 1984 and 2000. The system relies on 21,656 linear feet of force main and 279,371 linear feet of gravity lines along with twelve submersible pumps located at six different locations to collect the wastewater. As of November 2006, the system was servicing 2,393 residential, 448 commercial, and 5 industrial customers (Kentucky Infrastructure Authority 2008). The system operates one treatment facility (Princeton STP) which discharges to Eddy Creek and has a design capacity of 1.57 MGD. In 2000, the facility reported operating at approximately 70% of its design capacity. As of the latest permit issuance (August 2005), the facility reported producing up to 1,092 dry metric tons of sludge per year (USEPA 2008a). The sludge is hauled to Donaldson Farms for composting in Nebo, Kentucky which is outside of the watersheds of concern (Bickner, KDWM Personal Communication 2008). According to DMR data submitted by Princeton to KDOW from 1999 to 2007, the facility has not exceeded their daily maximum or average monthly permit limits since 2005. Historical exceedances typically pertain to total suspended solids and dissolved oxygen - no exceedances for pathogens were noted. Princeton has a project on the Clean Water State Revolving Fund Priority List and the WRIS for cleaning, televising, and inspection of their sewer system to develop a Sanitary Sewer Evaluation Study (SSES) for

Infiltration/Inflow removal. As of spring 2008, the system is not under a sewer sanction and KDOW is unaware of any other planned wastewater collection or treatment projects (Bertelson, KDOW Personal Communication 2008). Despite the lack of violations in their DMR reports, a Notice of Violation (NOV) was issued to the facility in December 2007 for sanitary sewer overflows into surface streams and sewage backup into residential homes (Schmidt, KDOW Personal Communication 2008). However, as mentioned above development of the SSES should help Princeton with their infiltration/inflow troubles.

Fontaine Trailer Company operates a small package treatment plant approximately 3.5 miles south of the city of Princeton. Fontaine specializes in the construction and sale of flatbed and horse trailers and has undergone management changes in the last decade. The onsite treatment system has a design capacity of 0.0075 MGD and discharges to an unnamed tributary of Goose Creek (which discharges to the Eddy Creek (RM 8.4 to 10.5) segment). In the past, the facility has discharged to an onsite sinkhole (which may discharge to Dry Creek or Eddy Creek, pending dye trace information). According to DMR data submitted by Fontaine to KDOW from 1999 to 2007, the facility had numerous exceedances in 2000 tapering off to one or two in subsequent years. Approximately seventy percent of the exceedances were related to fecal coliform bacteria. The facility also has failed to submit many of its DMRs in a timely manner.

As discussed in the *"Strategic Water Resource Development Plan"*, the counties associated with this report have a mostly "agricultural based economy with those areas outside of the incorporated areas of the county being very sparsely populated - extension of sewer lines may be financially unfeasible." Though the PEADD has identified several areas for future installation of KPDES-permitted residential treatment units to solve this problem (as well as non KPDES-permitted "cluster systems", larger OWTSs designed to serve two or more households) there are currently no such permits active in the watersheds of concern (USEPA 2008a).

Table 6.1 KPDES Wastewater Facilities Associated with the Development of the Lower Cumberland River Basin Pathogen TMDLs

Name	KPDES Permit No.	Design Flow (MGD)	Fecal Coliform Limits (colonies/100ml)	
			Daily Maximum	Monthly Average
Princeton STP	KY0028401	1.57	400	200
Salem STP	KY0066541	0.16	400	200
City of Fredonia	KYP000048	n/a	n/a	n/a
Eddyville STP*	KY0027979	0.75	400	200
Fontaine Trailer Company	KY0022225	0.0075	400	200

* Eddyville STP does not discharge to a pathogen-impaired stream and is not directly affected by this document however their sewerage system covers some areas of the watersheds of concern.

6.1.2 Municipal Separate Storm Sewer System Sources

In developed areas, polluted stormwater runoff is often diverted and concentrated into MS4s, where it ultimately discharges to surface waters with little or no treatment. MS4s are defined in 401 KAR 5:002, Section 1(184) as "a conveyance, or system of conveyances, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains: 1. owned or operated by a state, city, town, county, district, associated or other public body…having jurisdiction over disposal of…storm water…that discharges to waters of the Commonwealth; 2. designed or used for collecting or conveying storm water; 3. which is not a combined sewer; 4. which is not part of a publicly-owned treatment works (POTW)."

The USEPA established Phase I of the NPDES Stormwater Program in 1990 to address MS4 sources of contamination. Phase I MS4s were designated "medium" if they were located in an incorporated place or county with a population between 100,000 and 249,999 and "large" if the population was 250,000 or greater. Phase I was implemented in Kentucky in 1992 and included only two areas: Lexington-Fayette County and Louisville. Phase II of the Stormwater Program began regulating small MS4s if they met the automatic designation criteria, i.e. they were located within the boundaries of a Bureau of the Census-defined "urbanized area" based on the latest Census. Urbanized areas are defined as having a residential population of at least 50,000 and an overall population density of 1,000 people per square mile. The KPDES/NPDES permitting authority may also designate a small MS4 as "regulated" if its discharges have been determined to cause, or have the potential to cause an adverse effect on water quality or if the small MS4 is physically interconnected to another system in such a way that it allows for direct discharge into the second system. Phase II was implemented in Kentucky in 2003 and currently includes 210 targeted communities. There are currently no regulated MS4 communities within the pathogen-impaired watersheds.

6.1.3 Agricultural Permitted Sources

AFOs are defined by 401 KAR 5:002 as "a lot or facility, other than an aquatic animal production facility, where the following conditions are met:

1. Animals, other than aquatic animals, have been, are, or will be stabled or confined and fed or maintained for a total of forty-five (45) days or more in any twelve (12) month period; and
2. Crops, vegetation forage growth, or postharvest residues are not sustained in the normal growing season over any portion of the lot or facility.

AFOs that will or are anticipated to discharge to the waters of the Commonwealth are required to obtain a KPDES permit pursuant to 401 KAR 5:060, Section 10. "Discharge" means that *process wastewater* or water that comes into contact with the *production area* and discharges to the waters of the Commonwealth. *Process wastewater* means water directly or indirectly used in the operation of the AFO for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning, or flushing pens, barns, manure pits, or other AFO facilities; direct contact swimming, washing, or spray cooling of animals; or dust control. Process wastewater also includes any water which comes into contact with any raw materials, products, or byproducts including manure, litter, feed, milk, eggs, or bedding. If the animal feeding operation is managing the waste generated at the facility as a liquid, a construction permit must be obtained pursuant to 401 KAR 5:005.

There are currently ten AFOs within the watersheds of concern however none of them have permits to discharge to waters of the commonwealth (USEPA 2008a). AFOs that do not intentionally discharge and are not anticipated to discharge are discussed in Section 6.2.1.

Operations that are defined as a CAFO pursuant to 401 KAR 5:060, Section 10, are required to obtain a KPDES permit. In order to be categorized as a CAFO, an operation must first meet the definition of an AFO. There are then two additional requirements that define an operation as a CAFO if either is met: (1) there are more than 300 animal units confined and there is a discharge to the waters of the commonwealth, or (2) there are more than 1,000 animal units confined. A CAFO actually discharges or intends to discharge to waters of the Commonwealth. 40 CFR 122.23 (b) and 401 KAR 5:060 defines the number of animals that comprise a CAFO. KPDES has the authority to designate smaller facilities as CAFOs if environmental circumstances warrant the designation.

Once defined as a CAFO, the operation can be permitted under a KPDES General Permit or a KPDES Individual Permit, depending upon the nature of the operation. Conditions of both types of permits include no discharge to surface waters. However, holders of a KPDES Individual Permit may discharge to surface waters during a 25-year (24-hour) or greater storm event.

There are no KPDES-permitted CAFOs within the watersheds of concern (USEPA 2008a).

6.2 Non KPDES-Permitted Sources

Non KPDES-permitted sources include all sources not permitted by the KPDES permitting program, and are often referred to as nonpoint sources. According to 401 KAR 5:002 nonpoint means "any source of pollutants not defined as a point source, as used in this chapter." Nonpoint (non KPDES-permitted) sources of pollution are often associated with land use. While KPDES permits are not required for non KPDES-permitted sources, their loads to surface water are still regulated by laws such as the Kentucky Agricultural Water Quality Act (AWQA, KRS 224.71-100 through 224.71-145, i.e., implementation of individual agriculture water quality plans and corrective measures), the federal Clean Water Act (i.e., the TMDL process) and 401 KAR 5:037 (Groundwater Protection Plans (GPPs)), among others. A Load Allocation (LA) is assigned to non KPDES-permitted sources.

Unlike KPDES-permitted sources, non KPDES-permitted sources typically discharge pollutants to surface water in response to rain events (MS4s are a notable exception, as they are a KPDES-permitted source that discharges to surface water in response to rain events through a system of storm drains, curbs, gutters, etc.). Non KPDES-permitted sources for pathogens exist in the watershed, and fall into various categories including agriculture, properly functioning OWTSs, failing OWTSs, household pets and natural background, which in the case of pathogens in a rural watershed means wildlife. Straight-pipes are a type of illegal, non KPDES-permitted source that may exist in the watershed, but none are known to exist with certainty.

The "Strategic Water Resource Development Plan", mentioned in Section 6.1, identifies areas within the watersheds of concern with "problems in the area of sewer disposal." Most of these problems are associated with poor soils, a shallow soil profile, small lots, and impoverished areas (Kentucky Infrastructure Authority 2000). As mentioned in Section 3, the watersheds of concern are located in a karst region. The KGS has developed Generalized Geologic Maps for Land-Use Planning for every county of the State to inform individuals of the general geologic bedrock condition that can affect a site and its intended uses. For example, a vast extent of the watershed areas have limestone bedrock – according to the planning guidance, this type of rock carries severe limitations for septic tank disposal systems. A severe limitation is one that is "difficult to overcome and commonly is not feasible because of the expense involved." Figure 6.1 is a karst conceptual model included with Land-Use Planning maps and reprinted with permission from the KGS.

6.2.1 Kentucky No Discharge Operating Permits

As stated in 401 KAR 5:005, facilities with agricultural waste handling systems or that dispose of their effluent by spray irrigation but do not discharge to surface waters are required to obtain a KNDOP from the KDOW prior to construction and operation. These operations handle liquid waste in a storage component of the operation (e.g. lagoon, pit, or tank) and land apply the waste via spray irrigation or injection to cropped acreages. Land application of the waste that results in runoff to a stream is prohibited. Facilities that handle animal waste as a liquid are required to submit a Short Form B, construction plans, and a Comprehensive Nutrient Management Plan to the KDOW. Also included in KNDOP requirements are golf courses which land apply treated wastewater via spray irrigation, typically from a holding pond - some industrial operations also spray-irrigate. However neither of these operations are known to exist in the watersheds of concern.

AFOs that do not discharge or intend to discharge obtain KNDOP permits. Ten AFOs are present in the watersheds of concern, mostly within the Skinframe/Livingston Creek and Eddy/Dry Creek watersheds - there are six dairy and four swine operations. Locations of the ten AFOs are shown on Figure 5 and within Section 8 (KDOW 2006).

6.2.2 Agriculture

The Kentucky AWQA was passed by the 1994 General Assembly. The law focuses on the protection of surface water and groundwater resources from agricultural and silvicultural activities. The Act created the Kentucky Agriculture Water Quality Authority (KAWQA), a 15-member peer group made up of farmers and representatives from various agencies and organizations. The Act requires all farms greater than 10 acres in size to adhere to the Best Management Practices (BMPs) specified in the Kentucky Agriculture Water Quality Plan. Specific BMPs have been designated for all operations.

The USDA compiles agricultural statistics at the county level and reports results every five years in Agricultural Census reports. Select agricultural statistics reported in the last Census for the associated counties are shown in Table 6.2. According to USDA, results from the 2007 Agricultural Census will be released in early 2009.

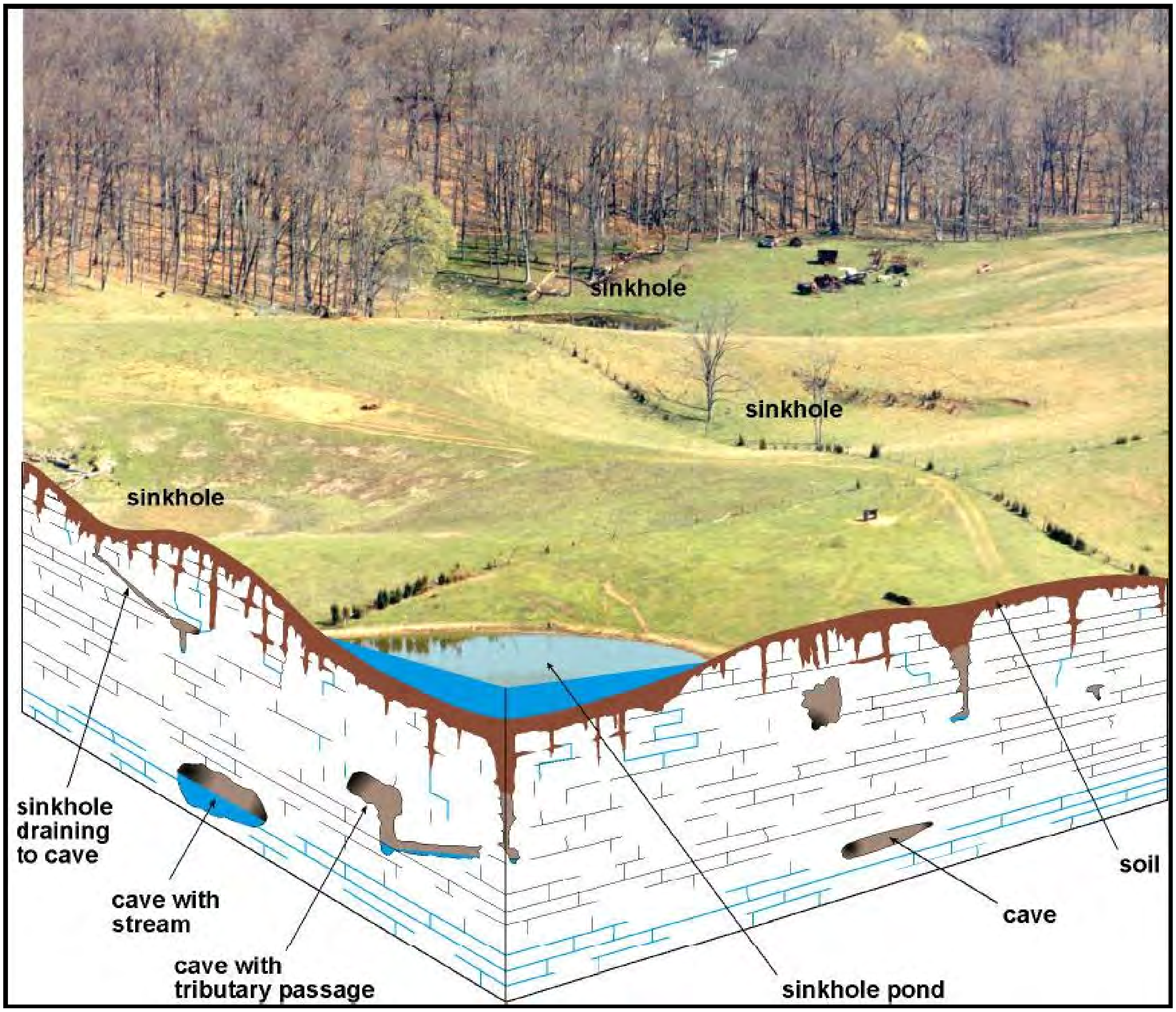

Figure 6.1 A Karst Conceptual Model of the Lower Cumberland Basin Watersheds of Concern Depicting the Correlations Between Surface and Ground Water, Land Use, and Karst Terrains (KGS 2005)

Table 6.2 USDA Agricultural Statistics for the Counties Associated with the Pathogen-impaired Watersheds (2002)

Statistic	County			
	Caldwell	Crittenden	Livingston	Lyon
Farms (number/acres)	673/ 147,207	698/ 156,656	518/ 145,822	304/ 56,411
Cattle and Calves Inventory (farms/ total number)	294/ 15,322	367/ 19,624	248/ 16,819	135/ 6,088
Beef Cows (farms/total number)	253/ 8,337	327/ 10,415	228/ 9,567	126/ 3,886
Milk Cows (farms/total number)	8/ 535	31/ 218	4/ 52	4/ 75
Hogs and Pigs (farms/ total number)	12/ 8,807	29/ 667	7/ 422	3/ (D)*
Layers 20 weeks old or older (farms/total number)	17/ 574	41/ 1,079	9/ 174	13/ 242
Broilers & other meat-type chickens sold (farm/total number)	-	9/ (D)*	6 / 2,076,005	-
Corn for grain (acres)	20,321	7,425	4,600	4,998

Statistic	County			
	Caldwell	Crittenden	Livingston	Lyon
Land in Orchards (acres)	(D)*	11	8	(D)*
Tobacco (acres)	546	2	(D)*	203
Wheat for grain (acres)	5,329	1,251	2,750	676
Soybeans for beans (acres)	24,765	9,545	16,001	5,765

* Withheld by USDA to avoid disclosing data for individual farms.

The Ohio State University Agricultural Extension Service released a guidance document for the management of livestock manure. The document contains manure characteristics, handling/storage and application procedures and also addresses some of the issues and considerations involved with manure management (James 2006). A similar (though as not detailed) document is available from the North Carolina State University College of Agriculture and Life Sciences (Shaffer 2005). These documents could be used to estimate pathogenic contributions from livestock if it could be determined how much manure actually made it to a stream since it is unrealistic that an animal would be directly contributing to a stream throughout the day. However if Standard Operating Procedures for wastewater collection systems and BMPs are utilized at AFOs and CAFOs, pathogenic contributions to surface waters from livestock should not cause a violation of the WQC. Numbers and types of animals (taken from the latest permit issuance) present at AFOs and CAFOs within the watersheds of concern are provided in Table 6.3.

In 2005, both Caldwell and Crittenden counties had a total of $20,000,000 – 34,999,999 in cash receipts from crops followed by Livingston County with $10,000,000 – 19,999,999 and Lyon county ($0 – 9,999,999). Crops may be a source of pathogens if manure is used as a fertilizer. However if BMPs are utilized (as discussed on the KAWQA webpage, http://www.conservation.ky.gov/programs/kawqa/)), pathogenic contributions to surface waters should not cause a violation of the WQC.

Table 6.3 Numbers and Types of Animals from KPDES-Permitted AFOs and CAFOs within the Watersheds of Concern

Stream Name	Number of animal units
Eddy/Dry Creeks (dairy)	276
Eddy/Dry Creeks (swine)	2,435
Livingston/Skinframe Creeks (dairy)	502
Livingston/Skinframe Creeks (swine)	19,033

6.2.3 Human Waste Contribution

Human waste disposal is of particular concern in rural areas. Areas not served by sewers either employ an OWTS or do not treat their sewage. OWTSs including septic tanks are commonly used in areas where providing a centralized sewage collection and treatment system is not cost effective or practical. When properly sited, designed, constructed, maintained, and operated, septic systems are an effective means of disposing and treating domestic waste. The effluent from a well-functioning OWTS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, they can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both groundwater and surface water.

The urban areas surrounding the cities in the Lower Cumberland (i.e. Salem, Eddyville, Princeton, and Fredonia) have sewerage systems, whereas outlying rural areas in the watershed have OWTSs or may not treat their sewage. The USDA Natural Resources Conservation Service (NRCS) publishes county soil surveys and rates the performance of septic tank absorption fields, defined as the area in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Soil ratings are based on soil properties, site features, and the observed performance of the soils - permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of septic tank effluents. Soils in the study area include the Crider, Loring, Memphis, Nicholson, and Zanesville series. USDA rates these soil series as somewhat to very limited for installation of septic tank absorption fields due to slope and severely eroded soils (i.e. shallow soil profiles; USDA 1980,1981). Based on the soil ratings and prevailing karst formations it is likely many of the septic systems in the watersheds of concern are not functioning properly. Failing OWTSs are probable sources of pathogens.

A type of non KPDES-permitted source that may exist in the Lower Cumberland watersheds is straight-pipes, which are discrete conveyances that discharge sewage, gray water (i.e., water from household sinks, laundry, etc.) and stormwater to the surface waters of the Commonwealth without treatment. Although straight-pipes meet the definition of a point source as defined in 401 KAR 5:002, EPA considers them to be part of the LA as they are a non KPDES-permitted source.

In order to gain a rough estimate of the number of OWTSs present in the watersheds, statistics from the 2000 US Census were analyzed. The watershed area not on sewer service was determined by subtracting the corporate boundary areas from the total watershed area (within a GIS framework). Census data on the number of households within the county were then used to estimate the average number of households operating OWTSs (or having no treatment of sewage) in each watershed (Tables 6.4a and 6.4b). Watershed level numbers for those traversing multiple Counties were determined by subtracting the watershed area (mi^2) from each County area (mi^2) (within a GIS framework) and aggregating the totals (Table 6.4b).

Table 6.4a County Statistics from the 2000 US Census Bureau Demographic Profile

County/ City	Population	Persons per square mile	Occupied households	Average in household
Caldwell County	13,060	38		2.36
Crittenden County	9,384	26		2.42
Livingston County	9,804	31		2.42
Lyon County	8,080	37		2.26
Trigg County	12,597	28		2.39
Princeton, KY	6,536		2,810	2.24
Salem, KY	769		322	2.14
Fredonia, KY	420		206	2.37

Table 6.4b Watershed Averages Derived from Census 2000 Statistics

Watershed/ Stream Name	Watershed Area (not on sewer; mi^2)	Average population in watershed (not on sewer)	Corporate area (mi^2)	Average # of households operating OWTSs or not treating sewage
Claylick Creek	47.24	997 (955+42)	0.34	**412**
Eddy/Dry Creeks	77.80	2,927 (2316+575+36)	7.81	**1,250 (981+254+15)**
Ferguson Creek	6.30	195 (6.3*31)		**81**
Hickory Creek	9.05	281 (9.05*31)		**117**
Livingston/Skinframe Creeks	101.19	3,799 (1683+832+1284)	1.92	**1,625 (713+344+568)**
Richland Creek	7.73	240 (7.73*31)		**100**
Sandy Creek	28.56	870 (80+790)	0.47	**360**
Sugar Creek	10.83	336 (10.83*31)		**140**
Watershed Name (those divided by Counties)	**Counties in Watershed**	**Watershed area (mi^2) within County**	**Watershed area (mi^2) within County minus corporate area**	
Claylick Creek	Crittenden	36.75		
	Livingston	10.83	10.49	
Eddy/Dry Creeks	Caldwell	68.76	60.95	
	Lyon	15.54		
	Trigg	1.3		
Livingston/ Skinframe Creeks	Caldwell	44.90	44.28	
	Crittenden	31.99		
	Lyon	35.97	34.72	
Sandy Creek	Crittenden	3.07		
	Livingston	25.96	25.49	

6.2.4 Household Pets

Although household pets undoubtedly exist in the watersheds of concern, their contribution to the LA is deemed to be minimal compared to other sources in the rural portions of the watershed. Pet waste may, however, be a larger contributor to pathogen runoff within the corporate limits of a city as urban areas tend to have a higher density of households and less permeable surfaces than rural areas.

According to the American Veterinary Medical Association, there are 0.58 dogs per household nationally. Using statistics from Table 6.4b, estimates of dog populations within each watershed were calculated (Table 6.5).

Table 6.5 Estimated Dog Populations within the Watersheds of Concern and Associated Corporate Areas

Stream/City Name	Average # of households (rural areas)	Average # of households (within corporate area)	Dog population
Claylick Creek	412		238.96
Eddy/Dry Creeks	1,250		725
Ferguson Creek	81		46.98
Hickory Creek	117		67.86
Livingston/Skinframe Creeks	1,625		942.5
Richland Creek	100		58
Sandy Creek	360		208.8
Sugar Creek	140		81.2
Princeton, KY		2,810	1629.8
Salem, KY		322	186.76
Fredonia, KY		206	119.48

6.2.5 Wildlife

Wildlife undoubtedly contributes to pathogen loading especially considering the higher percentage of forested land in most of the watersheds. The Kentucky Department of Fish and Wildlife Resources estimate deer densities per square mile for all counties of Kentucky (Yancy, Personal Communication, 2008). There are approximately 24 deer per square mile in Caldwell County (6,833 total), 53 in Crittenden (12,907 total), 30 in Livingston (6,440 total), 12 in Lyon County (1,289 total), and 14 in Trigg County (3,258 total).

Estimates of deer populations are shown for each watershed in Table 6.6. Corporate areas were subtracted from the total watershed area on the assumption that deer remain constant throughout the year and are present (and evenly distributed) on all land classified as agricultural, forested, grasslands, and wetlands. Estimates of numbers of other types of wildlife are not available for Kentucky.

As stated above, although wildlife contributes pathogens to surface water, such contributions represent natural background conditions and receive no reductions within a TMDL. Wildlife such as opossums, raccoons, rats, and birds that reside within the corporate boundaries may be a larger contributor to pathogen runoff as urban areas tend to have less permeable surfaces.

Table 6.6 Estimated Deer Populations within the Watersheds of Concern

Stream/City Name	Watershed Area (excluding corporate areas; mi^2)	Estimated Deer Population in Watershed
Claylick Creek	47.24	2,273 (1948+325)
Eddy/Dry Creeks	77.80	1,855 (1650+187+18)
Ferguson Creek	6.30	189
Hickory Creek	9.05	272
Livingston/Skinframe Creeks	101.19	3,206 (1078+1696+432)
Richland Creek	7.73	232
Sandy Creek	28.56	942 (163+779)
Sugar Creek	10.83	325

6.3 Illegal Sources.

Both KPDES-permitted and non KPDES-permitted sources can discharge pathogens to surface water illegally - this includes sources which are illegal simply by their existence, such as straight-pipes, as well as legal sources that are operating illegally (e.g., outside of regulations, permit limits or conditions, etc., such as a WWTP bypass). Such sources receive no allocation of any kind in the TMDL process (see Section 7.0 for TMDL allocations).

In addition to straight-pipes, another illegal source related to human waste disposal is failing OWTSs, which receive an allocation of zero. Sanitary Sewer Overflows (SSOs) are discharges without a permit and are also illegal sources which receive no allocation.

Another potential illegal source is livestock on farms which have no BMPs (as required under the AWQA) as well as farms where BMPs are present but are insufficient or failing in a manner that causes or contributes to surface water impairment. Also included are KNDOPs, AFOs and CAFOs not in compliance with the appropriate regulations that cause or contribute to a surface water impairment.

KDOW expects implementation of these TMDLs to begin with the elimination of illegal sources. This is intended to prevent legally operating sources from having to effect reductions in order to accommodate the pollutant loading of illegal sources.

Note this Section of the TMDL is not intended to summarize the universe of potential illegal sources that may discharge pollutants into surface waters, nor does it attempt to summarize the universe of legal sources that may be operating illegally. Instead, it gives examples of illegal sources known to be present or that could be present in the watersheds (e.g., straight-pipes) and sets the allocation for these (and other potential illegal sources) at zero.

7.0 Total Maximum Daily Load

The USEPA defines a TMDL as "a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs (USEPA 2008b)."

7.1 TMDL Equation and Definitions

A TMDL calculation is performed through a variety of methods but uses the following equation.

WLA + LA + MOS = TMDL

Where:
WLA = the Waste Load Allocation, including point sources and other KPDES-permitted sources such as WWTPs.
LA = the Load Allocation, including natural background and non KPDES-permitted sources.
MOS = the Margin of Safety, which can be an implicit or explicit additional reduction applied to the WLA, LA or both types of sources that accounts for uncertainties in the data or TMDL calculations. The MOS for these TMDLs was explicitly set at 10%.
TMDL = the maximum load the waterbody can naturally assimilate while still meeting the WQC of 400 colonies per 100 ml at a given flow, in units of colonies per day.

The TMDL calculation must take into account seasonality and other factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses. The TMDL Target is defined as the WQC minus the MOS (or 90% of the TMDL) which is then divided among the WLA and LA. The TMDL Target concentration is then the WQC (400 col/100ml) minus a 10% MOS or 360 colonies per 100ml.

However, regardless of the procedure used to calculate the TMDL, reductions from existing conditions ultimately must be effected within the watershed only until all stream segments meet the PCR use, or until all sources (except wildlife) are discharging in compliance with the WQC. Once the WQC is met, all sources (apart from wildlife) must continue to discharge at a load that meets the WQC.

A 'percent reduction' was calculated for informational purposes only to illustrate the difference between existing conditions and the TMDL Target at the time the streams were sampled (i.e. the 2000 PCR season). The percent reduction for each impaired segment is provided and discussed in Appendix A.

7.2 Critical Condition

In order to better understand the relationship between pollutant inputs and the ability of a stream to meet its designated uses, a critical condition is analyzed. The critical condition is established by evaluating the impact of temporal variations on source behavior and stream loading. The critical condition for nonpoint source pathogen loading typically occurs after a runoff event, preceded by an extended dry period - pathogens accumulate on the land surface (during the dry period) and are subsequently washed off by the rainfall. The critical condition for point source loading typically occurs during periods of low streamflow when dilution (of effluent) is minimized. Because the Lower Cumberland includes both types of sources, and the PCR use applies only during the recreational season, the critical period was defined as May 1st through October 31st.

7.3 WLA and LA

The WLA and LA represent the final pollutant loading allocations that are allowed in the watershed per the WQC and after application of the MOS.

7.3.1 Waste Load Allocation

The WLA is the portion of the TMDL allocated to KPDES-permitted sources within the watersheds of concern. For these watersheds, wastewater treatment facilities and package treatment plants were the KPDES-permitted sources whose individual WLAs were calculated using the permitted fecal coliform concentration limits (i.e. the WQC of 400 col/100 ml) and facility design flow by means of the following equation:

WLA = Flow * WQC * Conversion factor

Where:
Flow = the maximum design flow of the facility in units of million gallons per day (MGD)
Concentration = the actual permit limit in units of colonies per 100ml
Conversion factor = the conversion applied to achieve units of colonies per day

The sum of the individual WLAs will be used to express the WLA if multiple facilities are present in the watershed (such as Eddy Creek). If KPDES-permitted CAFOs or regulated MS4 areas were present in the watersheds, their individual allocated WLAs would be included in the aggregate WLA. WLAs for each watershed of concern were calculated and are presented and discussed in Section 8.

As discussed in Section 6.3, KDOW expects implementation of these pathogen TMDLs to begin with the elimination of illegal sources (i.e. WWTP bypasses and SSOs).

7.3.2 Load Allocation

The LA is the portion of the TMDL where non KPDES-permitted (e.g., nonpoint) sources, or those not permitted by KPDES receive their allocation within the TMDL. Nonpoint sources of pollution are often relative to land use. Within the watersheds of concern, these sources can include agriculture, possible illegal straight-pipes, natural background (i.e. wildlife), failing OWTSs and household pets. The individual LAs were calculated by means of the following equation:

LA = TMDL – MOS (explicitly set at 10%) – WLA (i.e. KPDES-permitted sources)

LAs for each watershed of concern were calculated and are presented and discussed in Section 8. As discussed in Section 6.3, implementation of these pathogen TMDLs is expected to begin with the elimination of illegal sources such as failing OWTSs and straight-pipes if present in the watershed. In addition, facilities not in compliance with KNDOP regulations or BMP requirements under the AWQA are also illegal and are expected to come into compliance.

7.4 Margin of Safety

The MOS can be an implicit (using conservative assumptions) or explicit (a reserved portion) additional reduction applied to the WLA, LA or to both types of sources that accounts for uncertainties in the data or TMDL calculations. All TMDLs in this document utilize an explicit margin of safety -- only 90% of the WQC was incorporated into the TMDLs (leaving a 10% MOS for uncertainties in calculations).

8.0 Data Analysis

Pathogen TMDLs have been developed using a range of techniques from sophisticated watershed-based computer modeling to qualitative assumptions and a simple mass balance. An approach focusing on the WQC and Mean Annual Streamflow (MAF) was utilized for development of these Lower Cumberland pathogen TMDLs. Title 401 KAR 5:031 describe the standards in place to "protect the surface waters of the Commonwealth" and thus provide a WQC (or limit) that a surface water can receive while continuing to support its designated use(s).

The best available data from various sources was analyzed and spatial analysis was performed within a GIS framework to obtain MAF values, assess KPDES-permitted and non KPDES-permitted sources, and appropriately assign TMDL loads.

8.1 TMDLs Calculated as a Daily Load

Federal guidelines of the Clean Water Act require a TMDL to be expressed in terms of a daily load. Due to the limited amount of data available, particularly the absence of stream gages or in-stream flow data, a method was developed utilizing the WQC and MAF. The USGS has generated a MAF value for streams across Kentucky. The MAF values were calculated using the equation found in the USGS Water-Resources Investigations Report 02-4206 "Estimating Mean Annual Streamflow of Rural Streams in Kentucky" (http://ky.water.usgs.gov/pubs/wrir_2002_4206.pdf). The MAF values can be found on the Hydrology of Kentucky webpage (http://kygeonet.ky.gov/kyhydro/main.htm). Once obtained, major inputs (i.e. WWTP design capacity) were added to the MAF to generate a critical flow. There are no known surface water withdrawals within the watersheds of concern, if there had been their flow rate would have been subtracted from the MAF to generate the critical flow. The critical flow is then multiplied by the WQC minus the MOS (10%) times the appropriate conversion factors to obtain the TMDL Target (i.e., the allowable daily load).

8.2 Percent Reduction

As discussed in Section 7, a 'percent reduction' was calculated for informational purposes only to illustrate the difference between existing conditions and the TMDL Target at the time the streams were sampled (i.e. the 2000 PCR season). The percent reduction for each impaired segment is provided and discussed in Appendix A.

A TMDL provides a foundation for identifying, planning, and implementing water quality-based controls to reduce both point and nonpoint source pollution. Though the data used to calculate the percent reductions may be considered "historical", it provides a representation of the streams after rainfall events – the most important time to capture data associated with nonpoint sources. Therefore, the percent reduction should not be viewed as the TMDL but rather a goal to work towards in the implementation phase of the TMDL process with the ultimate goal being the restoration and maintenance of in-stream water quality so that designated uses are met.

8.3 Individual Stream Segment Analysis

Data collection and analysis from various sources (including Federal, State and local government and public entities) was carried out for each individually listed stream segment and its associated drainage area (i.e. USGS HUC 14 subwatersheds). Spatial analysis was also performed within a GIS framework. Most of the data collected for the development of this report can be accessed and downloaded from the KYGEONET or the Kentucky Watershed Modeling Information Portal (KWMIP) homepage (http://kwmip2.ky.gov/Portal).

8.3.1 Claylick Creek of the Cumberland River

Claylick Creek of the Cumberland River is a fourth order stream that also partially serves as the boundary between Livingston and Crittenden counties, near the impaired segment. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 1.9 to 4.8, approximately four miles south of Salem (Figure 7). The listing was a result of fecal coliform monitoring data collected at a site near Seven Ridge Road by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 66.7% of the samples collected – the 90th percentile concentration of all samples was 3300 colonies per 100 ml (Table 8.1). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be caused by non KPDES-permitted (nonpoint) sources in the watershed.

Table 8.1 Fecal Coliform Data Collected by Murray in the Claylick Creek Watershed (USGS HUC 05130205-260) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	3,600
06/19/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	3,000
07/25/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	1,350
08/22/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	60
09/26/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	900
10/24/00	Clay Lick Creek at Seven Branch (Seven Ridge) Road	40
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

The headwaters of the Claylick Creek watershed originate approximately eight miles northeast of the city of Salem and flow southwest toward the Cumberland River. The stream and watershed are characteristic of karst terrain with numerous sinkholes and sinking streams. The total drainage area of the watershed consists of five USGS HUC 14 subwatersheds (including Preacher and Clement Creeks) and 47.58 square miles (30,449.59 acres).

The USGS DEM indicates that the watershed drops about 300 feet in elevation from the headwaters to the downstream end of the impaired segment. There are no KPDES-permitted (point) sources in the watershed. As of the last Census (2000), there were between 967 and1483 households in the Livingston County portion of the watershed (the exact value was not reported, only a category) and between 0 and 966 on the Crittenden side. Sewer service is provided to residents within the corporate boundary of Salem (41% of their system lies in this watershed) and those along US Highway 60 – rural areas rely on OWTSs or do not treat their sewage. The predominant land use in the watershed is forested (49.2%) followed by pasture (22.8%) and row crops (20.6%). Only 3.3% of the watershed is developed land (Table 8.2).

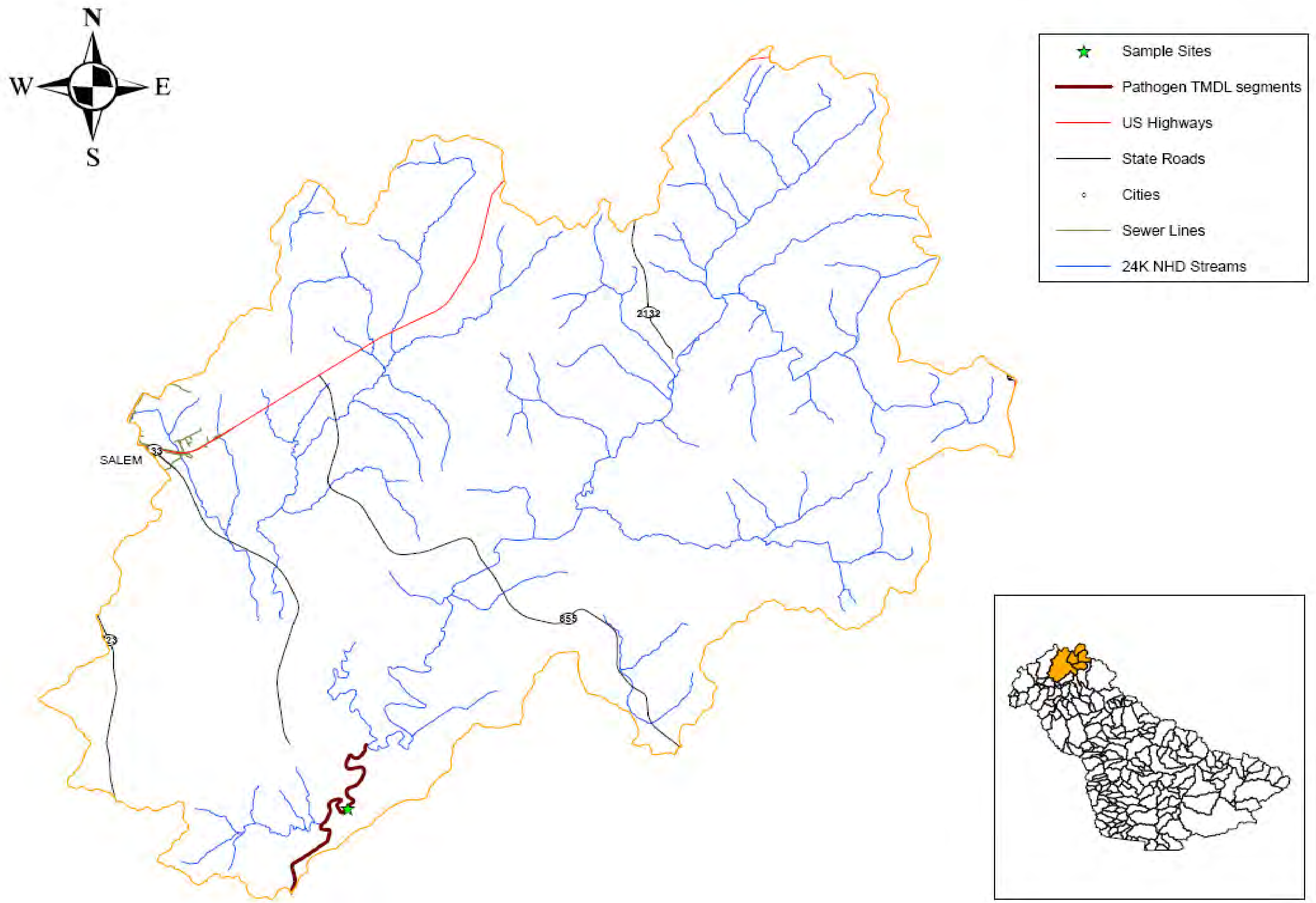

Figure 8.1 Location of the Claylick Creek Watershed within the Lower Cumberland River Basin (USGS HUC 05130205-260), Including the Impaired Segment

Table 8.2 Land Use in the Claylick Creek Watershed, Data Generated Using NLCD 2001 (USGS 2001)

Land Use	Percent of Total Area	Square Miles
Forest	49.21	23.41
Agriculture (total)	43.34	20.62
Pasture	22.75	10.83
Row Crop	20.58	9.79
Developed	3.27	1.55
Natural Grassland	2.49	1.19
Wetland	1.68	0.80
Barren	0.01	0.00

Based on the WQC and the MAF, the pathogen TMDL for the 2.9 mile impaired segment of Claylick Creek is 5.20×10^{11} colonies per day. According to the data presented, the watershed would have required an 89.09% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.3). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

Table 8.3 Summary of TMDL Components for Claylick Creek

WLA[(1)]	LA	MOS[(2)]	TMDL[(3)]	Mean Annual Flow (cfs) [(4)]	Percent Reduction[(5)]
0.0 col/day	5.20×10^{11} col/day	5.77×10^{10} col/day	5.77×10^{11} col/day	59	89.09%

Notes:
(1) Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment.
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.2 Dry Creek of Eddy Creek; Eddy Creek of the Cumberland River

The Eddy Creek (RM 8.4 to 10.5) impaired segment is a receiving stream for the entire Eddy Creek watershed (including the RM 13.0 to 15.7 impaired segment) as well as the Dry Creek impaired segment and watershed (Figure 8.2). For this reason, coupled with incomplete groundwater basin assessments, the watersheds of these impaired segments were analyzed and are presented together.

Dry Creek of Eddy Creek is a fifth order stream that lies within the southwestern corner of Caldwell County – the confluence with Eddy Creek is approximately ¼ mile east of the Lyon

County border. The stream was placed on the 2008 303(d) List (KDOW 2008) for nonsupport of the PCR designated use from river mile 0.0 to 3.6, approximately six miles south/southwest of Princeton. The listing was a result of fecal coliform monitoring data collected at a site near the KY-903 bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 33.33% of the samples collected by Murray – the 90th percentile concentration of all samples was 1,565 colonies per 100 ml (Table 8.4). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

Table 8.4 Fecal Coliform Data Collected by Murray in the Dry Creek Watershed (USGS HUC 05130205-230) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/25/00	Dry Creek at KY-903 Bridge	2,600
06/19/00	Dry Creek at KY-903 Bridge	530
07/25/00	Dry Creek at KY-903 Bridge	80
08/22/00	Dry Creek at KY-903 Bridge	30
09/26/00	Dry Creek at KY-903 Bridge	130
10/24/00	Dry Creek at KY-903 Bridge	0
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189-5,640
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain   Spotty Rain   Rain in 48hrs   No Rain   Exceedance of WQC

Eddy Creek of the Cumberland River is a fourth order stream that lies within the southwestern corner of Caldwell County – the stream's headwaters are located within the city of Princeton, just south of the Western Kentucky Parkway and approximately eleven miles east of Lake Barkley.

The Eddy Creek (RM 13.0 to 15.7) segment was placed on the 2008 303(d) List (KDOW 2008) for nonsupport of the PCR designated use, just south of the Princeton corporate limit, below their WWTP. The listing was a result of fecal coliform monitoring data collected at a site near the KY-903 bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 33.33% of the samples collected by Murray – the 90th percentile concentration of all samples was 760 colonies per 100 ml (Table 8.5). Fecal coliform concentrations appear to only exceed the standard during periods of heavy rainfall which suggests the loading may be influenced by SSOs/bypasses or non KPDES-permitted (nonpoint) sources in the watershed.

The Eddy Creek (RM 8.4 to 10.5) segment was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use, approximately six miles southwest of Princeton, just below the confluence with Dry Creek and above the backwaters of Lake Barkley. The listing was a result of fecal coliform monitoring data collected at a site near the Eddy Creek Road bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 50% of the samples collected – the 90th percentile concentration of all samples was 2,300 colonies per 100 ml (Table 8.5). Fecal coliform concentrations appear to dramatically increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

The headwaters of Eddy Creek originate within Princeton, while Dry Creek commences about four miles south of Princeton; both are approximately 8-9 miles east/southeast of Interstate 24 (which parallels Lake Barkley). The creeks flow west and northwest, respectively toward the Cumberland River. All streams and watersheds are characteristic of karst terrain with numerous sinkholes, springs, caves, and sinking streams. The city of Princeton was settled on Big Spring and is underlain with a network of cave systems – historical infrastructure is still present in the caves. The total drainage area of the watersheds, which drain into the Eddy Creek (RM 8.4 to 10.5) segment, is 85.61 square miles (54,791.29 acres) and includes thirteen USGS HUC 14 subwatersheds. The drainage area for the Eddy Creek (RM 13.0 to 15.7) segment is 34.84 square miles (22,295.97 acres) comprising three USGS HUC 14s (including Goose Creek). The Dry Creek drainage area is 34.04 square miles (21,787.75 acres) consisting of six USGS HUC 14s (including Wede Branch, Cantrell, and Dry Fork Creeks; Figure 8). The USGS DEM indicates that the Eddy Creek watershed drops nearly 200 feet in elevation from the headwaters to the first Eddy Creek (RM 13.0 to 15.7) impaired segment – the stream descends another fifty feet to the downstream end of the last Eddy Creek (RM 8.4 to 10.5) impaired segment. The Dry Creek watershed declines about 300 feet in elevation from the headwaters to the confluence with Eddy Creek.

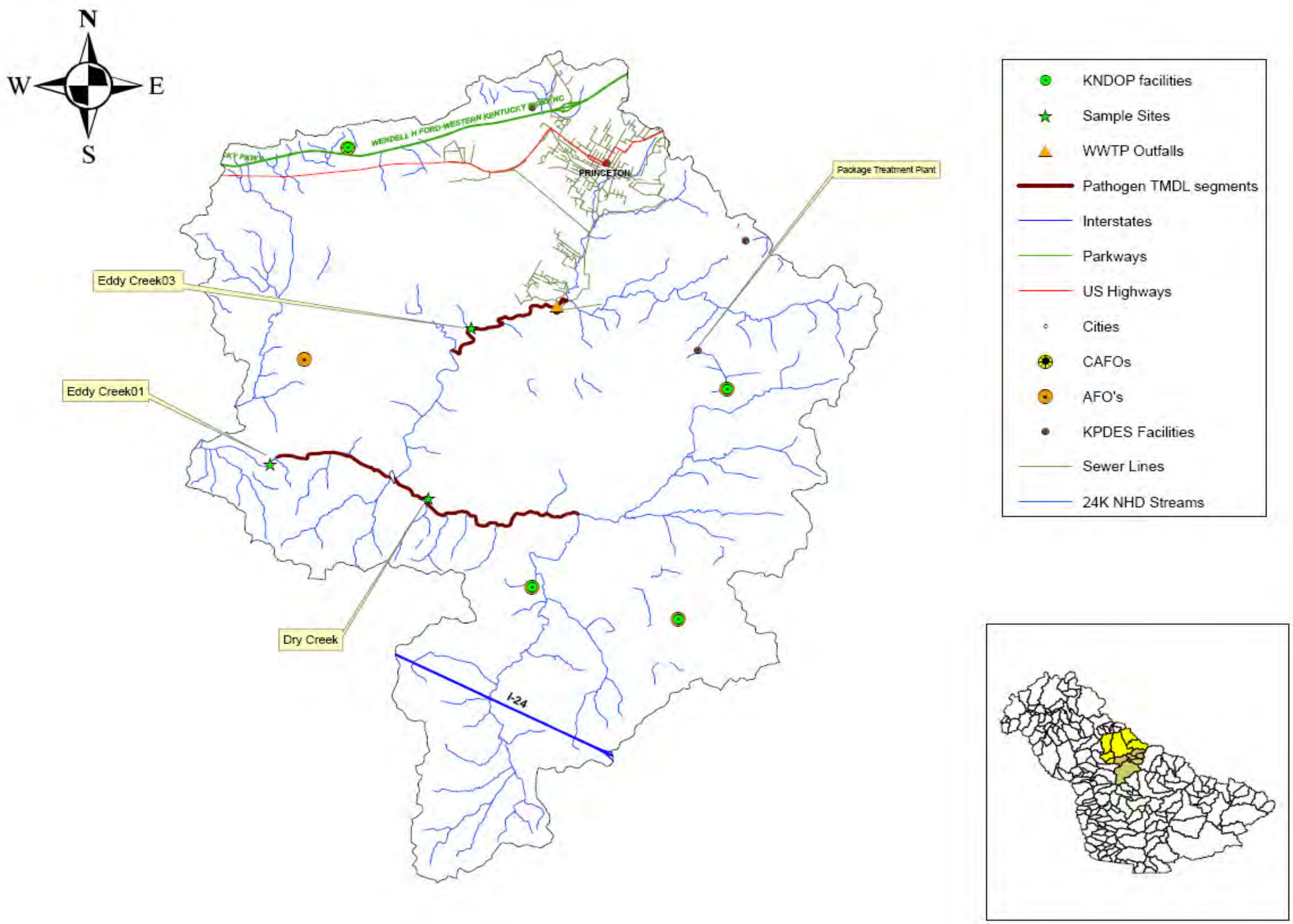

Figure 8.2 Location of the Eddy and Dry Creek Watersheds within the Lower Cumberland River Basin (USGS HUC 05130205-230), Including the Impaired Segments and KPDES-permitted Sources

Table 8.5 Fecal Coliform Data Collected by Murray in the Eddy Creek Watershed (USGS HUC 05130205-230) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/25/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	3,350
06/19/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	1,150
07/25/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	90
08/22/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	0
09/26/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	1,250
10/24/00	Eddy Creek (RM8.4 to 10.5) at Eddy Creek Road bridge	10
05/25/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	900
06/19/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	340
07/25/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	140
08/22/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	150
09/26/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	620
10/24/00	Eddy Creek (RM13.0 to 15.7) at KY-903 bridge	40
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

There are two KPDES-permitted facilities within the Eddy and Dry Creek watersheds. There are also five KNDOP-permitted AFOs, three in the Dry Creek watershed and two in Eddy Creek (Figure 8).

The Princeton sewage treatment plant (KY0028401) is located at the upstream end of the Eddy Creek (RM 13.0 to 15.7) impaired segment (approximately 2 miles southwest of Princeton) – 87% of its associated sewer collection system lies within the watershed boundaries comprising 22.43% (or 5000 acres) of this segment's total drainage area. The treatment plant has a design capacity of 1.57 MGD. The waste load allocation for the treatment plant is 1.38×10^{10} colonies per day.

Fontaine Trailer Company operates a small package treatment plant at their facility on KY-128, 3.5 miles south of Princeton. The package plant has a design capacity of 0.0075 MGD. The waste load allocation for the treatment plant is 6.61×10^{7} colonies per day. The facility has a history of exceeding their fecal coliform limits (four times in 2000, once in 2001, twice in 2002, and once in 2004) but has been in compliance for the last three years. The facility also has a history of late submittal of their discharge monitoring reports to KDOW and was overdue from September 2007 through the end of the year.

As of the last Census (2000), there were between 2059 and 2776 households in the Caldwell County portion of the watersheds and between 0 and 966 on the Lyon County side. The city of Princeton had a population of 6,536 and 2,810 occupied households within its corporate boundary. Sewer service is provided only to residents within the corporate boundary of Princeton and those along US Highway 62 – rural areas rely on OWTSs or do not treat their sewage. The predominant land use in the watersheds is agriculture (60.18%) particularly row crops (39.78%) followed by forested (29.83%) and developed land (7.81%; Table 8.6).

Table 8.6 Land Use in the Eddy and Dry Creek watersheds, Data generated using NLCD 2001 (USGS 2001)

Land Use	Percent of Total Area	Square Miles
Forest	29.83	22.56
Agriculture (total)	60.18	45.51
Pasture	20.40	15.43
Row Crop	39.78	30.08
Developed	7.81	5.91
Natural Grassland	1.64	1.24
Wetland	0.49	0.37
Barren	0.04	0.03

Based on the WQC and MAF, the pathogen TMDL for the 2.1 mile impaired segment of Eddy Creek (RM 8.4 to 10.5) is 9.32×10^{11} colonies per day. According to the data presented, the watershed would have required an 84.35% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC. The pathogen TMDL for the 2.7 mile impaired segment of Eddy Creek (RM 13.0 to 15.7) is 3.48×10^{11} colonies per day. According to the data presented, the watershed would have required a 52.63% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC. The pathogen TMDL for the 3.6 mile impaired segment of Dry Creek is 4.38×10^{11} colonies per day. According to the data presented, the watershed would have required a 77% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.7). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031, and must not cause or contribute to an existing impairment.

Table 8.7 Summary of TMDL Components for Eddy and Dry Creeks

WLA(1)		LA	MOS(2)	TMDL(3)	Mean Annual Flow (cfs)(4)	Percent Reduction(5)
Eddy Creek into Cumberland River RM 8.4-10.5						
Princeton STP KY0028401	2.38×10^{10} col/day					
Fontaine Trailer Company KY0022225	1.17×10^{8} col/day					
TOTAL	2.39×10^{10} col/day	8.15×10^{11} col/day	9.32×10^{10} col/day	9.32×10^{11} col/day	95.2	84.35%
Eddy Creek into Cumberland River RM 13.0-15.7						
Princeton STP KY0028401	2.38×10^{10} col/day					
Fontaine Trailer Company KY0022225	1.17×10^{8} col/day					
TOTAL	2.39×10^{10} col/day	2.90×10^{11} col/day	3.48×10^{10} col/day	3.48×10^{11} col/day	35.6	52.63%
Dry Creek into Eddy Creek RM 0.0-3.6						
0.0 col/day		3.95×10^{11} col/day	4.38×10^{10} col/day	4.38×10^{11} col/day	44.8	77%

Notes:
(1) WLA value represents the maximum one-day load that can be discharged to the stream segment based on design flow and acute permit limits. Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF values were taken at the downstream end of the impaired segment and adjusted as necessary to obtain the critical flow (i.e. WWTP design capacity inputs were added to the MAF).
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.3 Ferguson Creek of the Cumberland River

Ferguson Creek of the Cumberland River is a fourth order stream located approximately ten miles southwest of Salem in Livingston County (Figure 8.3). The creek empties into the Cumberland River roughly three miles upstream of the Ohio River and twenty-six miles downstream of the dam at Lake Barkley. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 0.0 to 1.2. The listing was a result of fecal coliform monitoring data collected at a site near Scotts Chapel Road by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 66.7% of the samples collected – the 90th percentile concentration of all samples was 1,700 colonies per 100 ml (Table 8.8). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

Table 8.8 Fecal Coliform Data Collected by Murray in the Ferguson Creek Watershed (USGS HUC 05130205-290-040) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Ferguson Creek at Scotts Chapel Road	580
06/19/00	Ferguson Creek at Scotts Chapel Road	1,200
07/25/00	Ferguson Creek at Scotts Chapel Road	380
08/22/00	Ferguson Creek at Scotts Chapel Road	470
09/26/00	Ferguson Creek at Scotts Chapel Road	2,200
10/24/00	Ferguson Creek at Scotts Chapel Road	50
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

The headwaters of the Ferguson Creek watershed originate approximately thirteen miles southwest of the city of Salem and flow northwest toward the Cumberland River. The vicinity surrounding the impaired segment (northern portion of the watershed) is characteristic of karst terrain with several sinkholes and sinking streams identified in the landscape. The total drainage area of the watershed is 6.30 square miles (4034.35 acres).

The USGS DEM indicates that the watershed drops around 200 feet in elevation from the headwaters to the downstream end of the impaired segment. There are no KPDES-permitted (point) sources in the watershed. As of the last Census (2000), there were between 2059 and 2776 households in the watershed. No sewer service is provided to residents – the rural area relies on OWTSs or does not treat their sewage. The predominant land use in the watershed is forested (77.35%) followed by natural grassland (6.59%) and pasture (6.52%). Only 1.48% of the watershed is developed land (Table 8.9).

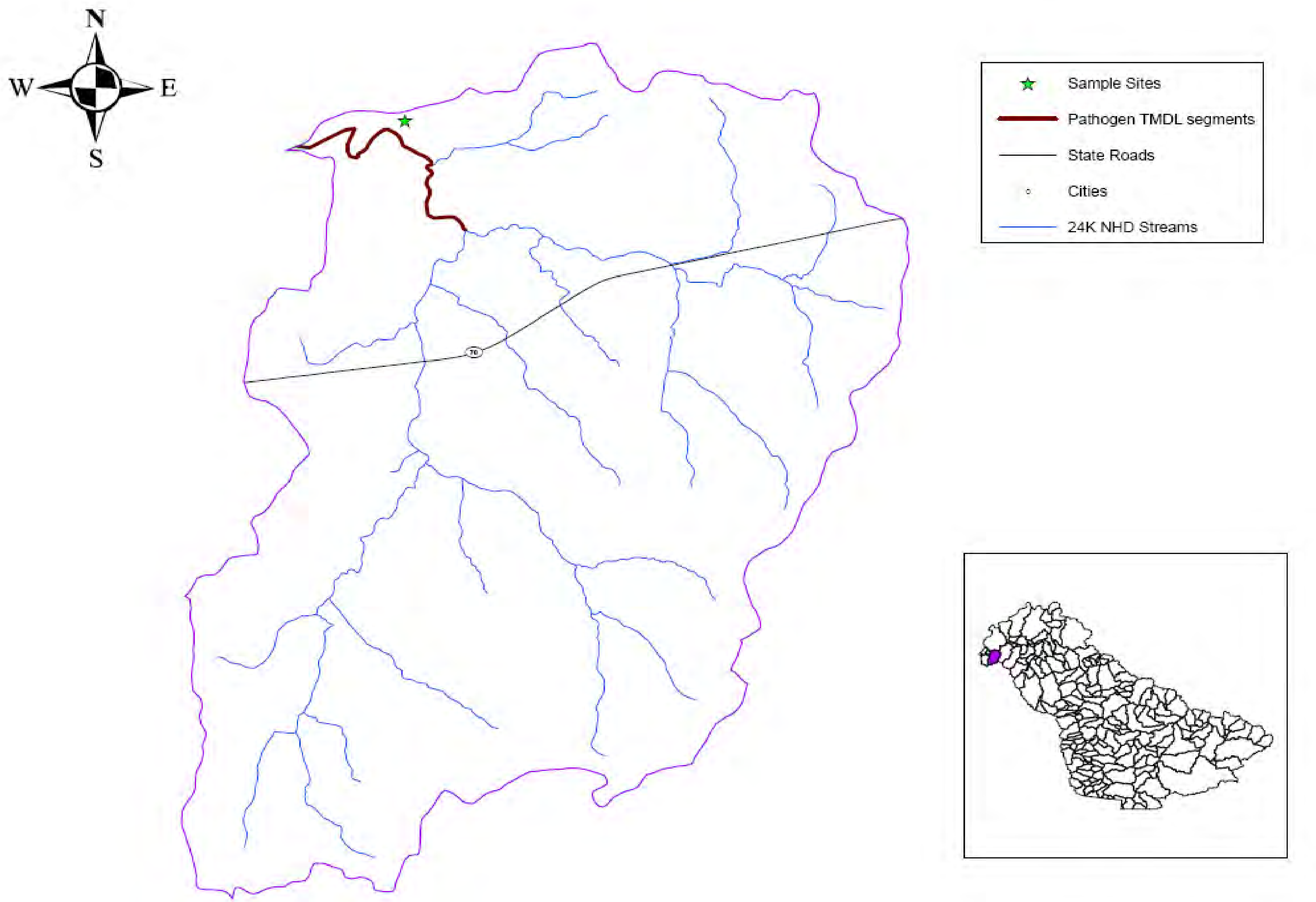

Figure 8.3 Location of the Ferguson Creek Watershed within the Lower Cumberland River Basin (USGS HUC 05130205-290-040), Including the Impaired Segment

Table 8.9 Land Use in the Ferguson Creek Watershed; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	77.35	4.87
Agriculture (total)	9.90	0.62
Pasture	6.52	0.41
Row Crop	3.37	0.21
Developed	1.48	0.09
Natural Grassland	6.59	0.42
Wetland	4.68	0.29
Barren	0.00	0.00

Based on the WQC and MAF, the pathogen TMDL for the 1.2 mile impaired segment of Ferguson Creek is 7.63×10^{10} colonies per day. According to the data presented, the watershed would have required a 78.82% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.10). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

Table 8.10 Summary of TMDL Components for Ferguson Creek

WLA[(1)]	LA	MOS[(2)]	TMDL[(3)]	Mean Annual Flow (cfs) [(4)]	Percent Reduction[(5)]
0.0 col/day	6.87×10^{10} col/day	7.63×10^{9} col/day	7.63×10^{10} col/day	7.8	78.82%

Notes:
(1) Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment.
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.4 Hickory Creek of the Cumberland River

Hickory Creek of the Cumberland River is a fourth order stream located approximately ten miles southwest of Salem in Livingston County (Figure 10). The creek empties into the Cumberland River roughly ten miles upstream of the Ohio River and nineteen miles downstream of the dam at Lake Barkley. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 0.0 to 3.9. The listing was a result of fecal coliform monitoring data collected at a site near Vaughn Road by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 66.7% of the samples collected – the

90th percentile concentration of all samples was 4,575 colonies per 100 ml (Table 8.11). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

Table 8.11 Fecal Coliform Data Collected by Murray in the Hickory Creek Watershed (USGS HUC 05130205-290-020) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Hickory Creek at Vaughn Road	7,600
06/19/00	Hickory Creek at Vaughn Road	1,550
07/25/00	Hickory Creek at Vaughn Road	490
08/22/00	Hickory Creek at Vaughn Road	60
09/26/00	Hickory Creek at Vaughn Road	950
10/24/00	Hickory Creek at Vaughn Road	10
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain   Spotty Rain   Rain in 48hrs   No Rain   Exceedance of WQC

The headwaters of the Hickory Creek watershed originate approximately nine miles north of the city of Grand Rivers and flow north toward the Cumberland River. The vicinity surrounding the impaired segment (northern two-thirds of the watershed) is characteristic of karst terrain with sinkholes and sinking streams. The total drainage area of the watershed is 9.05 square miles (5,790.28 acres).

The USGS DEM indicates that the watershed drops nearly 200 feet in elevation from the headwaters to the downstream end of the impaired segment. There are no KPDES-permitted (point) sources in the watershed. As of the last Census (2000), there were between 2059 and 2776 households in the watershed. No sewer service is provided to residents – the rural area relies on OWTSs or does not treat their sewage. The predominant land use in the watershed is forested (62.83%) followed by row crops (18.17%), pasture (6.05%) and wetlands (5.50%). Only 2.61% of the watershed is developed land (Table 8.12).

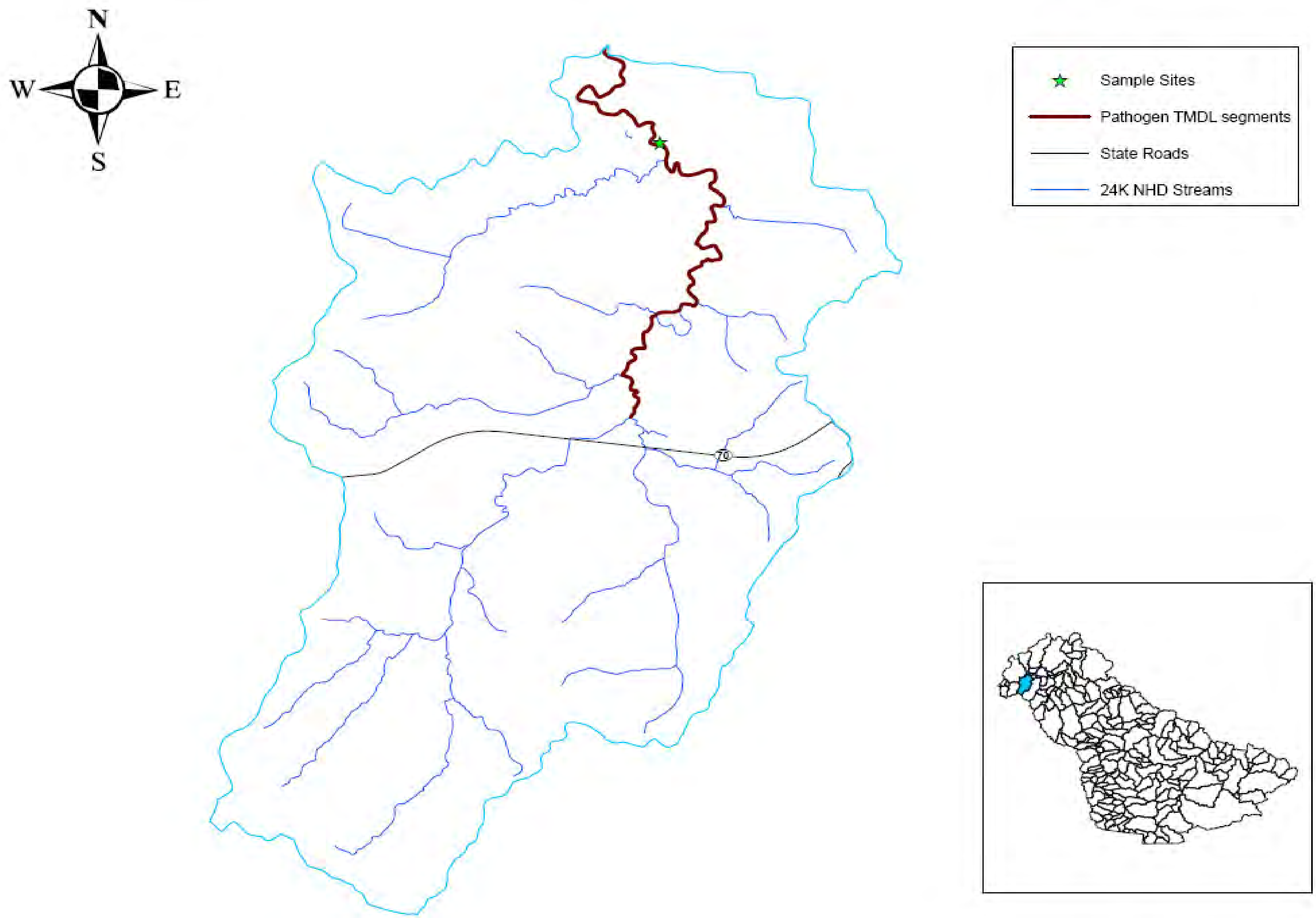

Figure 8.4 Location of the Hickory Creek Watershed within the Lower Cumberland River Basin (USGS HUC 05130205-290-020), Including the Impaired Segment

Table 8.12 Land Use in the Hickory Creek Watershed; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	62.83	5.69
Agriculture (total)	24.22	2.19
Pasture	6.05	0.55
Row Crop	18.17	1.64
Developed	2.61	0.24
Natural Grassland	4.83	0.44
Wetland	5.50	0.50
Barren	0.00	0.00

Based on the WQC and MAF, the pathogen TMDL for the 3.9 mile impaired segment of Hickory Creek is 1.08×10^{11} colonies per day. According to the data presented, the watershed would have required a 92.13% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.13). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

Table 8.13 Summary of TMDL Components for Hickory Creek

WLA(1)	LA	MOS(2)	TMDL(3)	Mean Annual Flow (cfs) (4)	Percent Reduction(5)
0.0 col/day	9.69×10^{10} col/day	1.08×10^{10} col/day	1.08×10^{11} col/day	11	92.13%

Notes:
(1) Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment.
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.5 Skinframe Creek of Livingston Creek and Livingston Creek of the Cumberland River

Livingston Creek is the receiving stream for the waters of Skinframe Creek. For this reason, coupled with incomplete groundwater basin assessments, the subwatersheds of the impaired segments were analyzed and are presented together. The comprehensive watershed lies within three counties: Livingston Creek serves as the southern boundary of Crittenden County to the north; Caldwell (to the east) and Lyon Counties divide the southern portion of the watershed nearly in half. The city of Fredonia is located in the northern area approximately five miles south of the northern watershed boundary and seven miles north of the Western Kentucky Parkway (Figure 8.5).

Skinframe Creek of Livingston Creek is a fifth order stream that lies within the northeastern corner of Lyon County – the confluence with Livingston Creek is also the Crittenden County border; Caldwell County is just over four miles to the east of the impaired segment. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 0.0 to 4.8. The listing was a result of fecal coliform monitoring data collected at a site near the KY-1943 bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 50% of the samples collected by Murray – the 90th percentile concentration of all samples was 1,270 colonies per 100 ml (Table 8.14). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

Table 8.14 Fecal Coliform Data Collected by Murray in the Skinframe Creek Watershed (USGS HUC 05130205-250) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Skinframe Creek at the KY-1943 bridge	1,900
06/19/00	Skinframe Creek at the KY-1943 bridge	610
07/25/00	Skinframe Creek at the KY-1943 bridge	640
08/22/00	Skinframe Creek at the KY-1943 bridge	270
09/26/00	Skinframe Creek at the KY-1943 bridge	390
10/24/00	Skinframe Creek at the KY-1943 bridge	90

Sample Date	Observed Weather	Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

Livingston Creek of the Cumberland River is a fourth order stream that serves as the southern border of Crittenden County – the headwaters of the stream includes the northwest corner of Caldwell County and the city of Fredonia. The downstream end of the impaired segment is roughly two miles (4.6 river miles) upstream of the confluence with the Cumberland River. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 4.6 to 7.0. The listing was a result of fecal coliform monitoring data collected at a site near the KY-295 bridge by Murray and KDOW during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 41.67% of the samples collected – the 90th percentile concentration of all samples was 895 colonies per 100 ml (Table 8.15). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

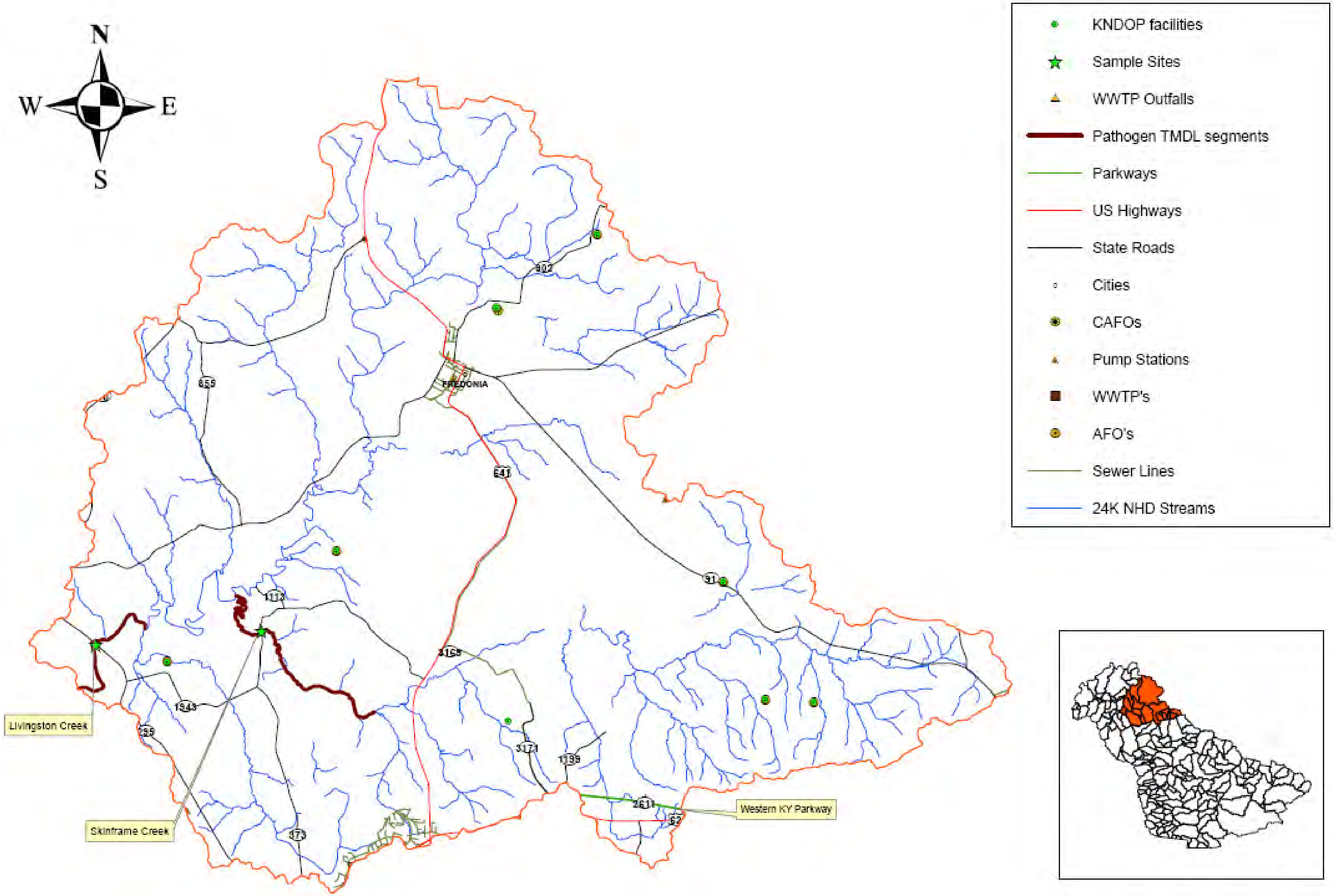

Figure 8.5 Location of the Livingston and Skinframe Creek Watersheds within the Lower Cumberland River Basin (USGS HUC 05130205-250), Including the Impaired Segments and KPDES-permitted Sources

Table 8.15 Fecal Coliform Data Collected by Murray and KDOW in the Livingston Creek Watershed (USGS HUC 05130205-260) Coupled with Murray Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Livingston Creek at the KY-295 bridge	29,600
06/19/00	Livingston Creek at the KY-295 bridge	800
07/25/00	Livingston Creek at the KY-295 bridge	850
08/22/00	Livingston Creek at the KY-295 bridge	320
09/26/00	Livingston Creek at the KY-295 bridge	900
10/24/00	Livingston Creek at the KY-295 bridge	250
05/09/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	173
06/19/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	733
07/18/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	83
08/22/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	123
09/19/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	145
10/17/00	KDOW STORET Station ID CRW001 (KY-295 bridge)	223

Sample Date	Observed Weather (by Murray)	Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

The headwaters of Livingston Creek originate 3.5-4.5 miles east of the city of Fredonia while Skinframe Creek commences about 8-10 miles south/southeast of Fredonia, parallel to the Western Kentucky Parkway. Skinframe Creek flows north while Livingston Creek flows west toward the Cumberland River. All streams and watersheds are highly characteristic of karst terrain with abundant sinkholes, springs, and sinking streams. Interim groundwater basin assessment data indicate the potential for the headwaters of Skinframe Creek (a sinking stream) to enter the subsurface and reappear as springs on Livingston Creek (near Fredonia), not lower Skinframe Creek (Ray, KDOW Personal Communication 2007). The total drainage area of the watersheds, which is received by the Livingston Creek segment is 112.79 square miles (72,190.19 acres) and comprises eighteen USGS HUC 14 subwatersheds (including Caldwell Spring, Crab, Tinsley, Hewlett, White Sulphur, McElroy, and Horseapple Creeks). The USGS DEM indicates that the comprehensive watershed drops nearly 400 feet in elevation from the headwaters to the downstream end of the Livingston Creek impaired segment – the stream descends another mere ten feet to the confluence with the Cumberland River.

There are no KPDES-permitted facilities in either watershed however there are eight KNDOP-permitted AFOs, four in each watershed (Figure 8.5). The Fredonia Water District (KY000048) holds a Kentucky Intermunicipal Operating Permit (KIMOP) for their sewer collection system which discharges to the Eddyville sewer collection system near the southern boundary of the watershed. The city of Fredonia is contracted with Eddyville STP (KY0027979) for treatment of their sanitary wastewater.

As of the last Census (2000), there were between 0 and 966 households in the greater part of the Livingston Creek watershed and between 2059 and 2776 households in the majority of the Skinframe Creek watershed. The city of Fredonia had a population of 420 with 206 occupied households within its corporate boundaries. Sewer service is provided to residents within the corporate boundaries of Fredonia (in the north) and Eddyville (in the southwest) and those along Highways 641 and 3171 – rural areas rely on OWTSs or do not treat their sewage. The predominant land use in the watersheds is agriculture (59.5%) followed by forested (32.92%) and developed land (5.07%; Table 8.16).

Table 8.16 Land Use in the Skinframe and Livingston Creek Watersheds; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	32.83	37.09
Agriculture (total)	59.61	67.24
Pasture	29.62	33.41
Row Crop	29.99	33.83
Developed	5.04	5.68
Natural Grassland	1.35	1.52
Wetland	1.08	1.22
Barren	0.10	0.11

Based on the WQC and MAF, the pathogen TMDL for the 4.8 mile impaired segment of Skinframe Creek is 5.19×10^{11} colonies per day. According to the data presented, the watershed would have required a 71.65% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC. The pathogen TMDL for the 2.4 mile impaired segment of Livingston Creek is 1.37×10^{12} colonies per day. According to the data presented, the watershed would have required a 59.78% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.17). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031, and must not cause or contribute to an existing impairment.

Table 8.17 Summary of TMDL Components for Livingston and Skinframe Creeks

WLA(1)	LA	MOS(2)	TMDL(3)	Mean Annual Flow (cfs) (4)	Percent Reduction(5)
Skinframe Creek into Livingston Creek RM 0.0-4.8					
0.0 col/day	4.67×10^{11} col/day	5.19×10^{10} col/day	5.19×10^{11} col/day	53	71.65%
Livingston Creek into Cumberland River RM 4.6-7.0					
0.0 col/day	1.23×10^{12} col/day	1.37×10^{11} col/day	1.37×10^{12} col/day	139.8	92.13%

Notes:
(1) Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment.
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.6 Richland Creek of the Cumberland River

Richland Creek of the Cumberland River is a fourth order stream located approximately five miles north of Grand Rivers in Livingston County (Figure 12). The creek empties into the Cumberland River roughly 7.5 miles downstream of the dam at Lake Barkley. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 0.7 to 5.4. The listing was a result of fecal coliform monitoring data collected at a site near the Tiline (Vanhooser) Road bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 50% of the samples collected – the 90th percentile concentration of all samples was 4,300 colonies per 100 ml (Table 8.18). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

The headwaters of the Richland Creek watershed originate approximately five miles north of the city of Grand Rivers and flow northeast toward the Cumberland River. The majority of the watershed (north of and including the upstream half of the impaired segment) is characteristic of karst terrain with sinkhole plains. The total drainage area of the watershed is 7.73 square miles (4948.15 acres).

Table 8.18 Fecal Coliform Data Collected by Murray in the Richland Creek Watershed (USGS HUC 05130205-240-030) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/25/00	Richland Creek at the Tiline (Vanhooser) Road bridge	6,000
06/19/00	Richland Creek at the Tiline (Vanhooser) Road bridge	2,600
07/25/00	Richland Creek at the Tiline (Vanhooser) Road bridge	300
08/22/00	Richland Creek at the Tiline (Vanhooser) Road bridge	0
09/26/00	Richland Creek at the Tiline (Vanhooser) Road bridge	850
10/24/00	Richland Creek at the Tiline (Vanhooser) Road bridge	0
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

The USGS DEM indicates that the watershed drops nearly 150 feet in elevation from the headwaters to the downstream end of the impaired segment – the stream barely descends another foot before entering the Cumberland River in less than one half mile. There are no KPDES-permitted (point) sources in the watershed. As of the last Census (2000), there were between 2059 and 2776 households in the watershed. No sewer service is provided to residents – the rural area relies on OWTSs or does not treat their sewage. The predominant land use in the watershed is forested (67.73%) followed by pasture (12.33%), row crops (10.41%) and wetlands (4.39%). Only 2.31% of the watershed is developed land (Table 8.19).

Table 8.19 Land Use in the Richland Creek Watershed; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	67.73	5.24
Agriculture (total)	22.73	1.76
Pasture	12.33	0.95
Row Crop	10.41	0.80
Developed	2.31	0.18
Natural Grassland	2.82	0.22
Wetland	4.39	0.34
Barren	0.01	0.00

Based on the WQC and MAF, the pathogen TMDL for the 4.7 mile impaired segment of Richland Creek is 9.20×10^{10} colonies per day. According to the data presented, the watershed would have required a 91.63% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.20). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

Table 8.20 Summary of TMDL Components for Richland Creek

WLA[1]	LA	MOS[2]	TMDL[3]	Mean Annual Flow (cfs) [4]	Percent Reduction[5]
0.0 col/day	8.28×10^{10} col/day	9.20×10^{9} col/day	9.20×10^{10} col/day	9.4	92.13%

Notes:
[1] Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
[2] MOS is explicit.
[3] TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
[4] The MAF value was taken at the downstream end of the impaired segment.
[5] Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

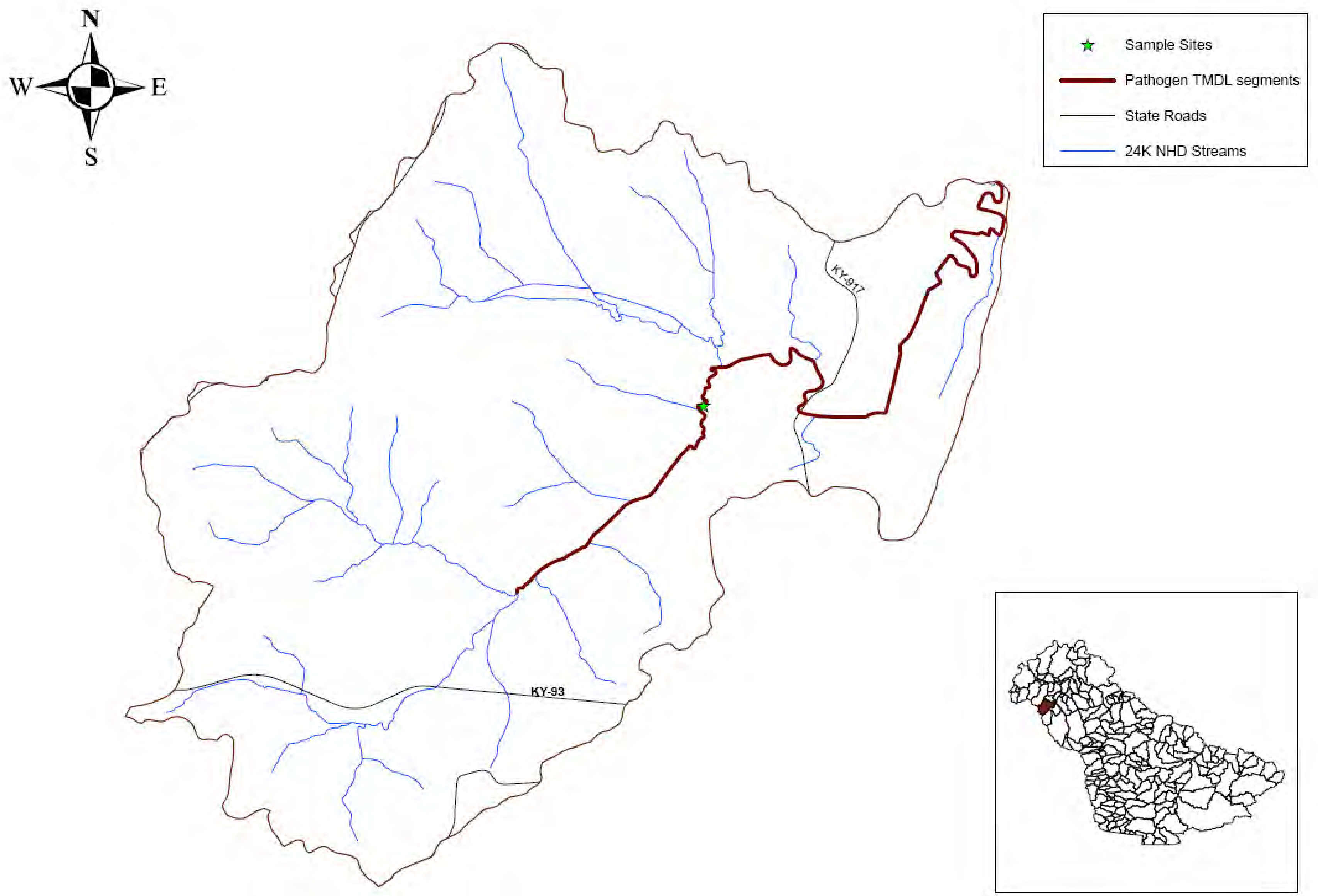

Figure 8.6 Location of the Richland Creek Watershed Within the Lower Cumberland Basin (USGS HUC 05130205-240-030), Including the Impaired Segment

8.3.7 Sandy Creek of the Cumberland River

Sandy Creek of the Cumberland River is a fourth order stream that lay almost completely within the southeast corner of Livingston County – the northeastern boundary of the watershed is located approximately two miles east of the Crittenden County border. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 0.0 to 2.3. The listing was a result of fecal coliform monitoring data collected at a site near Vicksburg (Head) Road by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 50% of the samples collected – the 90th percentile concentration of all samples was 10,575 colonies per 100 ml (Table 8.21). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

The headwaters of the Sandy Creek watershed originate approximately four miles northeast of the city of Salem and flow southwest toward the Cumberland River (Figure 8.7). The sinking stream and its watershed are characteristic of karst terrain with springs and sinkhole plains. Most of the watershed is underlain by Mississippian age limestone bedrock however the impaired segment is situated in more recent alluvial sediments. The total drainage area of the watershed consists of three USGS HUC 14 subwatersheds (including Cook Spring Branch) and 7.93 square miles (5074.05 acres). The USGS DEM indicates that the watershed drops more than 450 feet in elevation from the headwaters to the confluence with the Cumberland River - the 2.3 mile stretch of the impaired segment drops less than ten feet in elevation.

Table 8.21 Fecal Coliform Data Collected by Murray in the Sandy Creek Watershed (USGS HUC 05130205-280) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Sandy Creek at Vicksburg (Head) Road	19,600
06/19/00	Sandy Creek at Vicksburg (Head) Road	1,550
07/25/00	Sandy Creek at Vicksburg (Head) Road	430
08/22/00	Sandy Creek at Vicksburg (Head) Road	60
09/26/00	Sandy Creek at Vicksburg (Head) Road	190
10/24/00	Sandy Creek at Vicksburg (Head) Road	30

Sample Date	Observed Weather	Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain | Spotty Rain | Rain in 48hrs | No Rain | Exceedance of WQC

There are no KNDOP-permitted facilities but there is one KPDES-permitted facility within the Sandy Creek watershed (Figure 8.7).

The Salem sewage treatment plant (KY0066541) is located just over one mile west of the city of Salem at the edge of their western corporate boundary. The facility discharges to Sandy Creek approximately four miles upstream of the impaired segment – fifty-eight percent of their sewer collection system lay within the watershed boundaries. The treatment plant has a design capacity of 0.16 MGD. There has been only one exceedance of the maximum weekly average reported since the year 1999, occurring in March 1999. The waste load allocation for the treatment plant is 2.43×10^{9} colonies per day.

As of the last Census (2000), there were between 967 and 1483 households in the Livingston County portion of the watershed and between 0 and 966 on the Crittenden County side. The city of Salem had a population of 769 with 322 occupied households. Sewer service is provided to residents within the corporate boundary of Salem and those along US Highway 60 – rural areas rely on OWTSs or do not treat their sewage. The predominant land use in the watershed is forested (47.96%) followed by row crops (25.58%) and pasture (17.78%). Only 3.56% of the watershed is developed land (Table 8.22).

Table 8.22 Land Use in the Sandy Creek Watershed; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	47.96	13.92
Agriculture (total)	43.36	12.59
Pasture	17.78	5.16
Row Crop	25.58	7.43
Developed	3.56	1.03
Natural Grassland	1.56	0.45
Wetland	3.54	1.03
Barren	0.03	0.01

Based on the WQC and MAF, the pathogen TMDL for the 2.3 mile impaired segment of Sandy Creek is 3.13×10^{11} colonies per day. According to the data presented, the watershed would have required a 96.6% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.23). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

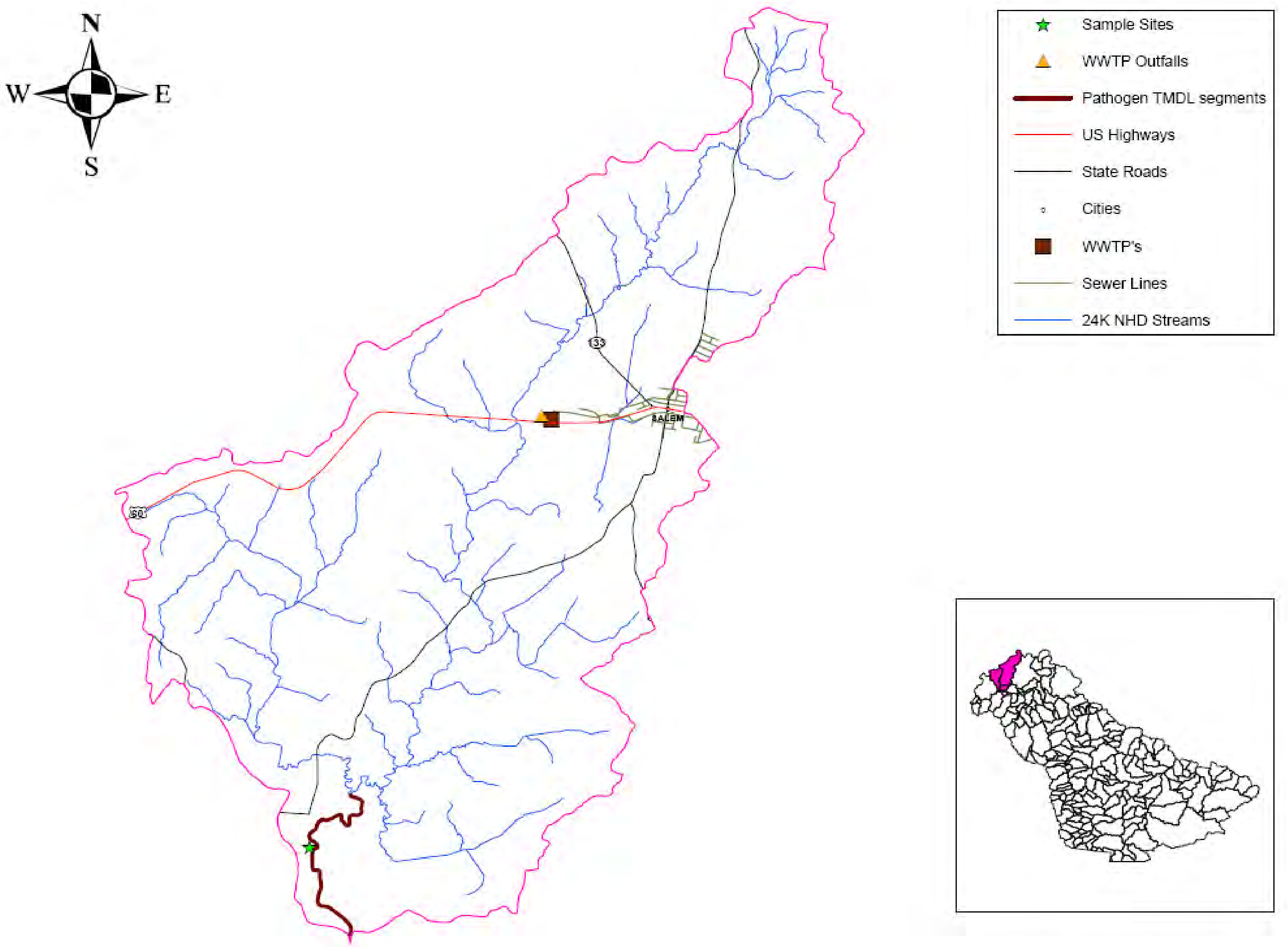

Figure 8.7 Location of the Sandy Creek Watershed within the Lower Cumberland River Basin (USGS HUC 05130205-280), Including the Impaired Segment and KPDES-permitted Sources

Table 8.23 Summary of TMDL Components for Sandy Creek

WLA[(1)]		LA	MOS[(2)]	TMDL[(3)]	Mean Annual Flow (cfs)[(4)]	Percent Reduction[(5)]
Salem STP KY0066541	2.43×10^{9} col/day	3.10×10^{11} col/day	3.47×10^{10} col/day	3.47×10^{11} col/day	35.5	96.6%
TOTAL	2.43×10^{9} col/day					

Notes:
(1) WLA value represents the maximum one-day load that can be discharged to the stream segment based on design flow and acute permit limits. Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment and adjusted as necessary to obtain the critical flow (i.e. WWTP design capacity input was added to the MAF).
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

8.3.8 Sugar Creek of the Cumberland River

Sugar Creek of the Cumberland River is a fourth order stream located approximately ten miles southwest of Salem in Livingston County. The creek empties into the Cumberland River roughly eleven miles upstream of the Ohio River and seventeen miles downstream of the dam at Lake Barkley. The stream was placed on the 2002 303(d) List (KDOW 2002) for nonsupport of the PCR designated use from river mile 2.2 to 6.9. The listing was a result of fecal coliform monitoring data collected at a site near the Highway 70 bridge by Murray during the 2000 PCR season. Exceedance of the WQC (400 col/100ml) was observed in 33.33% of the samples collected – the 90th percentile concentration of all samples was 2,400 colonies per 100 ml (Table 8.24). Fecal coliform concentrations appear to increase with increased amounts of precipitation which suggests the loading may be influenced by non KPDES-permitted (nonpoint) sources in the watershed.

The headwaters of the Sugar Creek watershed originate approximately seven miles north/northwest of the city of Grand Rivers and flow northeast toward the Cumberland River. The impaired segment is approximately seven miles south/southwest of Salem. The vicinity surrounding the impaired segment (northern half of the watershed) is characteristic of karst terrain with sinkhole plains and sinking streams. The total drainage area of the watershed is 10.83 square miles (6930.30 acres).

Table 8.24 Fecal Coliform Data Collected by Murray in the Sugar Creek Watershed (USGS HUC 05130205-270) Coupled with Observed Weather and Nearby Gage Data

Sample Date	Sample Location	Colonies/100mL
05/23/00	Sugar Creek at Highway 70	1,600
06/19/00	Sugar Creek at Highway 70	290
07/25/00	Sugar Creek at Highway 70	20
08/22/00	Sugar Creek at Highway 70	30
09/26/00	Sugar Creek at Highway 70	3,200
10/24/00	Sugar Creek at Highway 70	10
Sample Date	**Observed Weather**	**Little River Gage, daily mean ft^3/sec (Cadiz, KY ~30 miles south)**
5/23/2000	Very rainy	189
6/19/2000	Spotty rain	237
7/25/2000	Several days after light rainfall	61
8/22/2000	Several days after light rainfall	27
9/26/2000	Heavy rain early day of sampling	97
10/24/2000	Long period of no rain	23

Heavy Rain Spotty Rain Rain in 48hrs No Rain Exceedance of WQC

The USGS DEM indicates that the watershed drops more than 150 feet in elevation from the headwaters to the downstream end of the impaired segment – the stream barely descends another eight feet before emptying into the Cumberland River two miles downstream. There are no KPDES-permitted (point) sources in the watershed. As of the last Census (2000), there were between 2059 and 2776 households in the watershed. No sewer service is provided to residents – the rural area relies on OWTSs or does not treat their sewage. The predominant land use in the watershed is forested (56.70%) followed by pasture (17.90%), row crops (12.65%) and wetlands (5.90%). Only 3.23% of the watershed is developed land (Table 8.25).

Table 8.25 Land Use in the Sugar Creek Watershed; Data Generated Using NLCD 2001 (USGS 2001)

Land Use	% of Total Area	Square Miles
Forest	56.70	6.14
Agriculture (total)	30.56	3.31
Pasture	17.90	1.94
Row Crop	12.65	1.37
Developed	3.23	0.35
Natural Grassland	3.61	0.39
Wetland	5.90	0.64
Barren	0.00	0.00

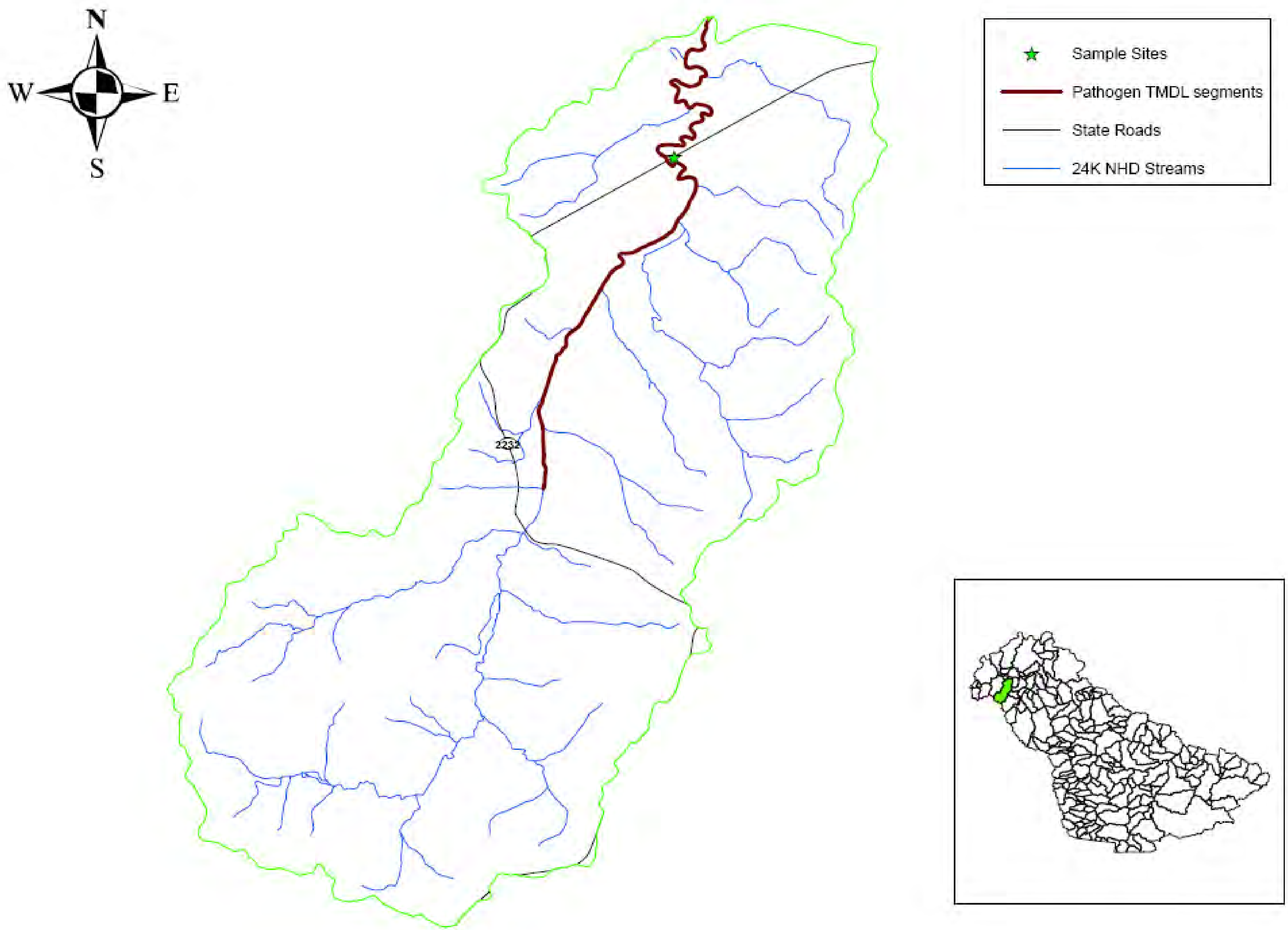

Figure 8.8 Location of the Sugar Creek Watershed within the Lower Cumberland River Basin (USGS HUC 05130205-270), Including the Impaired Segment

Based on the WQC and MAF, the pathogen TMDL for the 4.7 mile impaired segment of Sugar Creek is 1.29×10^{11} colonies per day. According to the data presented, the watershed would have required an 85% reduction in pathogen loading during the 2000 PCR season in order to meet the WQC (Table 8.26). In addition, any future KPDES wastewater permitted sources must meet permit limits based on the WQC in 401 KAR 5:031 and must not cause or contribute to an existing impairment.

Table 8.26 Summary of TMDL Components for Sugar Creek

WLA(1)	LA	MOS(2)	TMDL(3)	Mean Annual Flow (cfs) (4)	Percent Reduction(5)
0.0 col/day	1.16×10^{11} col/day	1.29×10^{10} col/day	1.29×10^{11} col/day	13.2	85%

Notes:
(1) Any future KPDES wastewater permitted sources must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment. WLA value based on design flow and acute permit limits and represents the maximum one-day load the facility can discharge.
(2) MOS is explicit.
(3) TMDLs are expressed as daily loads of fecal colonies by multiplying the WQC by the mean annual streamflow (MAF) and the appropriate conversion factor. Daily loads for *E. coli* are provided in Appendix A.
(4) The MAF value was taken at the downstream end of the impaired segment.
(5) Overall reduction needed during the 2000 PCR season to achieve the TMDL target of 360 colonies per 100ml.

9.0 Implementation

Section 303(e) of the Clean Water Act and 40 CFR Part 130, Section 130.5, require States to have a continuing planning process (CPP) composed of several parts specified in the Act and the regulation. The CPP provides an outline of agency programs and the available authority to address water issues. Under the CPP umbrella, the Watershed Management Branch of KDOW will provide technical support and leadership with developing and implementing watershed plans to address water quality and quantity problems and threats. Developing watershed plans enables more effective targeting of limited restoration funds and resources, thus improving environmental benefit, protection and recovery.

Watershed plans provide an integrative approach for identifying and describing how, when, who and what actions should be taken in order to meet water quality standards. At this time, comprehensive watershed restoration plans for the pathogen impaired watersheds in the Lower Cumberland River Basin have not been developed. Pollutant trading may be a viable management strategy to consider for meeting the TMDL load reduction goals.

The TMDL waterbodies in the Lower Cumberland River Basin are located in karst terrain. Groundwater basins in this western portion of the Mississippian Plateau physiographic region are largely unmapped. Subsurface streams draining these basins discharge to surface waters at discrete springs and spring runs (KDOW 2006). In order to assess the nonpoint source impacts to groundwater and to integrate ground- and surface water quality information, combined with biological data to better define the nexus between surface and subsurface flow systems, the Kentucky Division of Water requested and received §319(h) Nonpoint Source Implementation Grant funding. The Division's Groundwater Branch received $92,400 in federal §319(h) financial support as part of the FFY2007 grant to conduct this important groundwater assessment work in Livingston, Crittenden, Lyon, Caldwell and Trigg counties (KDOW, 2006). The project is scheduled to be completed in three years (December, 2010). It is vital that watershed restoration plans incorporate this valuable groundwater information into any restoration action strategy.

Watershed Plans should incorporate watershed restoration and protection mechanisms available under the Kentucky Agriculture Water Quality Act. The Kentucky Agriculture Water Quality Act (KRS 224.71-100 through 224.71-140) was passed by the 1994 General Assembly. The law focuses on the protection of surface water and groundwater resources from agricultural and silvicultural activities. The Act created the Kentucky Agriculture Water Quality Authority, a 15-member peer group made up of producers and representatives from various agencies and organizations. The Act requires all farms greater than 10 acres in size to adhere to the Best Management Practices (BMPs) specified in the Kentucky Agriculture Water Quality Plan. Specific BMPs have been designated for all operations. All producers in the Lower Cumberland pathogen impaired watersheds should have developed and implemented their individual Agriculture Water Quality Plans. State and federal financial support have been provided to assist producers with implementing the BMPs specified in their Agriculture Water Quality Plans.

The Kentucky Soil Erosion and Water Quality Cost Share Program have provided significant cost-share assistance to landowners for agricultural BMP installation in Lyon, Livingston and Caldwell Counties. The cost-share Program began in 1995 and is administered through the Kentucky Division of Conservation. Local oversight is provided by county Conservation Districts, with technical assistance provided by the United States Department of Agriculture-Natural Resources and Conservation Service. Since 1995, the Kentucky Division of Conservation has approved 128 applications from producers in Lyon, Livingston and Caldwell Counties (KDOC, 2008). These approved applications exceed $736,000 in State cost-share assistance for BMP implementation (KDOC, 2008). Specifically, 44 applications were approved for Lyon County totaling $197,307, seventeen applications were approved for Livingston County totaling $117,487, and 67 applications were approved for Caldwell County totaling $421,886 (KDOC, 2008).

In addition to agricultural sources, human contributions of pathogens in the watersheds must be addressed as well. All KPDES-permitted wastewater facilities must meet permit limits based on the WQC in 401 KAR 5:031, and must not cause or contribute to an existing impairment. Non KPDES-permitted wastewater is another likely source of pathogens in these impaired watersheds. The populations in many of these watersheds is low, as a result, a good deal of these watersheds are not sewered, so non-existent and failing OWTSs are likely sources of pathogens. Watershed plans should include an inventory of septic systems in the watershed, their installation dates and note whether they are likely to be performing adequately, or failing. The plans should further evaluate alternative (non-septic) onsite wastewater treatment systems including decentralized wastewater treatment options to remediate areas with failing systems. The Plan should also incorporate the requirements of Groundwater Protection Plans for management, operation and maintenance of OWTSs. All straight-pipe discharges of wastewater are illegal and must be eliminated in order to reduce pathogen loading in the watershed.

In 2002, the Four Rivers Basin Team identified the Cumberland River below Vicksburg and Claylick Creek as Basin Team Priorities for restoration action - Livingston Creek was added in 2005. Watershed Plan developers are encouraged to coordinate with the Four Rivers Basin Team in order to collaborate resources and streamline activities. To learn more about Basin Teams and watershed management in Kentucky, visit the Watersheds web pages at: http://www.watersheds.ky.gov/.

10.0 Public Participation

This TMDL document was published for an extended 30-day public comment beginning September 9th, 2008 and ending October 17th, 2008. A public notice was sent to all newspapers in the Commonwealth of Kentucky and advertisements were purchased in the newspapers of highest circulation published in Caldwell, Crittenden, Livingston, and Lyon Counties (the Herald-Ledger in Eddyville, KY and the Princeton Times in Princeton, KY). Additionally, the public notice was distributed electronically through the 'Nonpoint Source Pollution Control' mailing list (http://www.water.ky.gov/sw/nps/Mailing+List.htm) of persons interested in water quality issues as well as the 'Press Release' mailing list maintained by the Governor's Office of media outlets across the Commonwealth.

All comments received during the public notice period have been incorporated into the administrative record for this TMDL. After consideration of each comment received, revisions were made to the final TMDL report and responses were prepared and mailed to each individual/ agency participating in the public notice process.

11.0 References

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Appendix A

- Percent Reduction Calculations -

For informational purposes only, a "percent reduction" was calculated for all pathogen-impaired waterbodies addressed in this TMDL to illustrate the percent reduction that would have been required during the 2000 PCR season to meet the TMDL target (see Section 5 and Equation 1). The existing load was calculated as the 90th percentile of the fecal coliform results collected at each sample site (during the 2000 PCR season) multiplied by the MAF and converted to a load.

((Existing load – TMDL target)/ Existing Load) * 100 = % reduction required **(Equation 1)**

While providing additional information, the percent reduction calculation is not equivalent to the TMDL; the TMDL is the load that the waterbody can naturally assimilate while continuing to meet its designated uses (i.e. PCR and SCR). The TMDL is equal to the critical flow rate (MAF) multiplied by the WQC of 400 colonies/ 100 ml (minus a MOS), which is then multiplied by a conversion factor that allows the load to be expressed in colonies per day.

Therefore, the percent reduction is a determination of how much the measured concentrations exceeded the WQC at the time the samples were taken (i.e. the 2000 PCR season). It does not determine the percent reduction needed at any other time as in-stream concentrations are likely to be different. Unlike the calculated percent reductions, the TMDL is a constant based upon the WQC and critical flow, whereas the percent reduction changes based upon in-stream fecal coliform concentrations.

The percent reduction for each waterbody is presented in Table A1 and shown within its respective watershed on Figure A1.

- *E. coli* Equivalent TMDL Calculations –

The KDOW has started using *E. coli* as the preferred pathogen indicator organism for assessment, monitoring, and permitting purposes. Because the streams addressed in this document were monitored and assessed using fecal coliform indicator organisms, the TMDLs were calculated using the WQC for fecal coliform. However the stream segments could be converted to an *E. coli* daily load by using the WQC for *E. coli* (240 colonies/ 100 ml) in the TMDL calculations (MAF x WQC x conversion factors) or by multiplying the fecal coliform TMDL by the *E. coli* WQC and dividing by the WQC for fecal coliform (400 colonies/100 ml; Table A1). It should be noted that percent reductions could not be converted for *E. coli* since samples were analyzed for fecal coliform.

Table A1 Percent Reduction and *E. coli* Equivalent for Pathogen TMDL Waterbodies within the Lower Cumberland River Basin (USGS HUC 05100205)

Waterbody Name	Impaired Segment (River Miles)	County	GNIS Number	Suspected Sources	*E. coli* TMDL	Percent Reduction
Claylick Creek into Cumberland River	1.9 to 4.8	Livingston	KY489591_01	Agriculture	3.46×10^{11} col/day	89.09%
Eddy Creek into Cumberland River	8.4 to 10.5	Lyon	KY491550_01	Unknown	5.59×10^{11} col/day	84.35%
Eddy Creek into Cumberland River	13.0 to 15.7	Caldwell	KY491550_03	Package plant or other permitted small flow discharges	2.09×10^{11} col/day	52.63%
Dry Creek into Eddy Creek	0.0 to 3.6	Caldwell	KY491176_00	Animal Feeding Operations	2.63×10^{11} col/day	77%
Ferguson Creek into Cumberland River	0.0 to 1.2	Livingston	KY492034_01	Unknown	4.58×10^{10} col/day	78.82%
Hickory Creek into Cumberland River	0.0 to 3.9	Livingston	KY494122_00	Unknown	6.46×10^{10} col/day	92.13%
Livingston Creek into Cumberland River	4.6 to 7.0	Lyon/Caldwell	KY496913_01	Unknown	8.21×10^{11} col/day	59.78%
Richland Creek into Cumberland River	0.7 to 5.4	Livingston	KY501820_00	Unknown	5.52×10^{10} col/day	91.63%
Sandy Creek into Cumberland River	0.0 to 2.3	Livingston	KY502979_00	Unknown	2.08×10^{11} col/day	96.6%
Skinframe Creek into Livingston Creek	0.0 to 4.8	Lyon	KY503607_00	Unknown	3.11×10^{11} col/day	71.65%
Sugar Creek into Cumberland River	2.2 to 6.9	Livingston	KY504655_01	Unknown	7.75×10^{10} col/day	85%

- Land Use Analysis -

The land uses generated by the 2001 NLCD were consolidated for presentation purposes within the report. All forested land (deciduous, evergreen and mixed) and shrubbery was aggregated and reported as one category. Further, all residential land use area was aggregated and reported as one category; developed land. The NLCD returned small but positive values for three types of residential land uses—Developed Open Space, Low-Intensity Residential, and High-Intensity Residential. Developed Open Space is a term applied to differing types of land use, within urban areas it is the designation given to parkland and other green areas. However, in rural watersheds such as many of those found in the Lower Cumberland, it denotes residential areas with insufficient density to be classified as Low-Intensity Residential but is mainly composed of single family residences on large lots (James Seay, 2006, Personal Communication). Further descriptions of the NLCD classifications are provided below. Individual NLCD images of the watersheds of concern, including the impaired segment and any KPDES-permitted sources proceed.

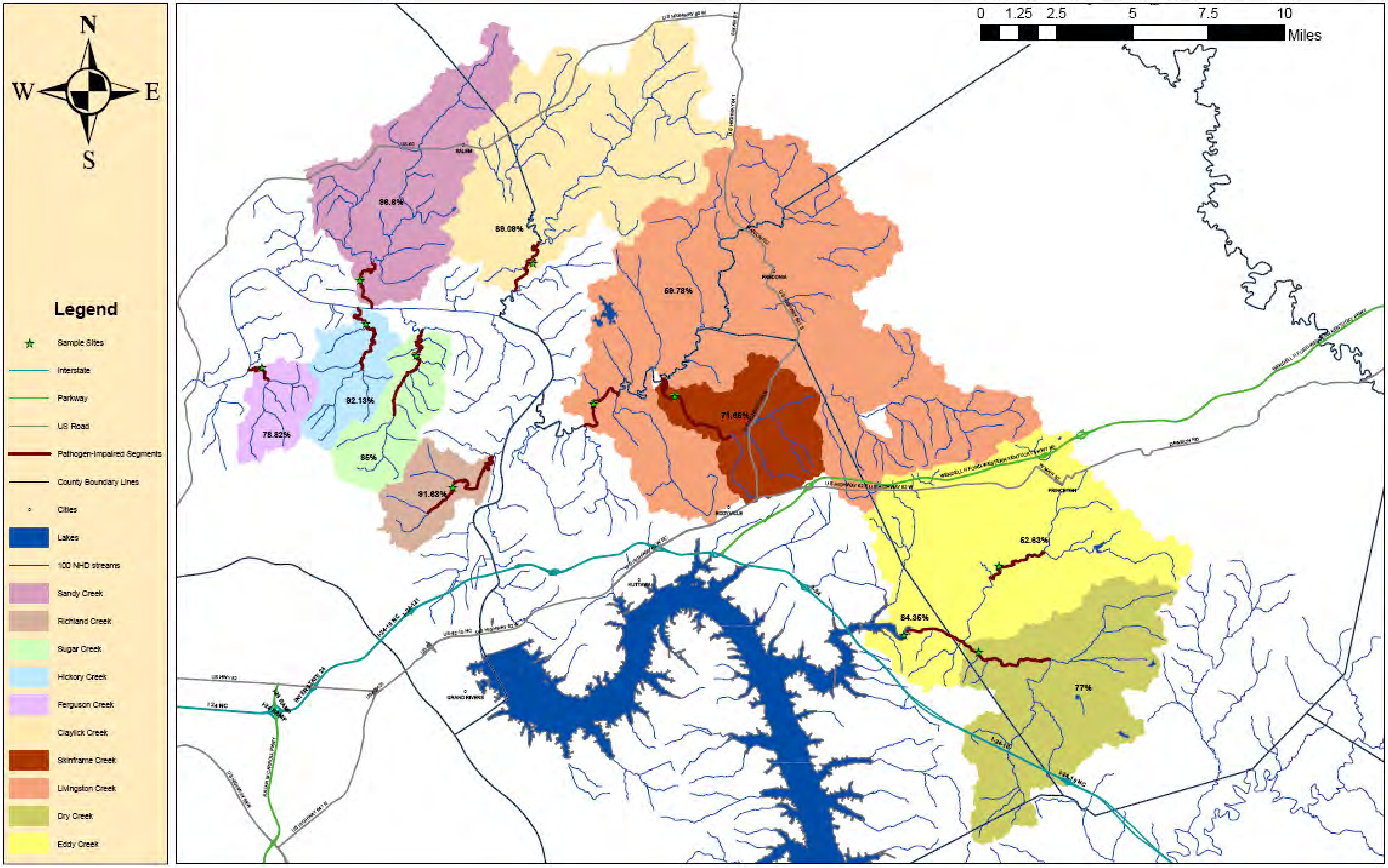


Figure A.1 Percent Reduction for Pathogen TMDL Waterbodies Addressed in this Document within the Lower Cumberland River Basin (USGS HUC 05100205)

National Land Cover Database Class Descriptions

(Homer et al, 2004)

(11) Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.

(21) Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

(22) Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

(23) Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

(24) Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

(31) Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

(41) Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

(42) Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

(43) Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

(52) Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

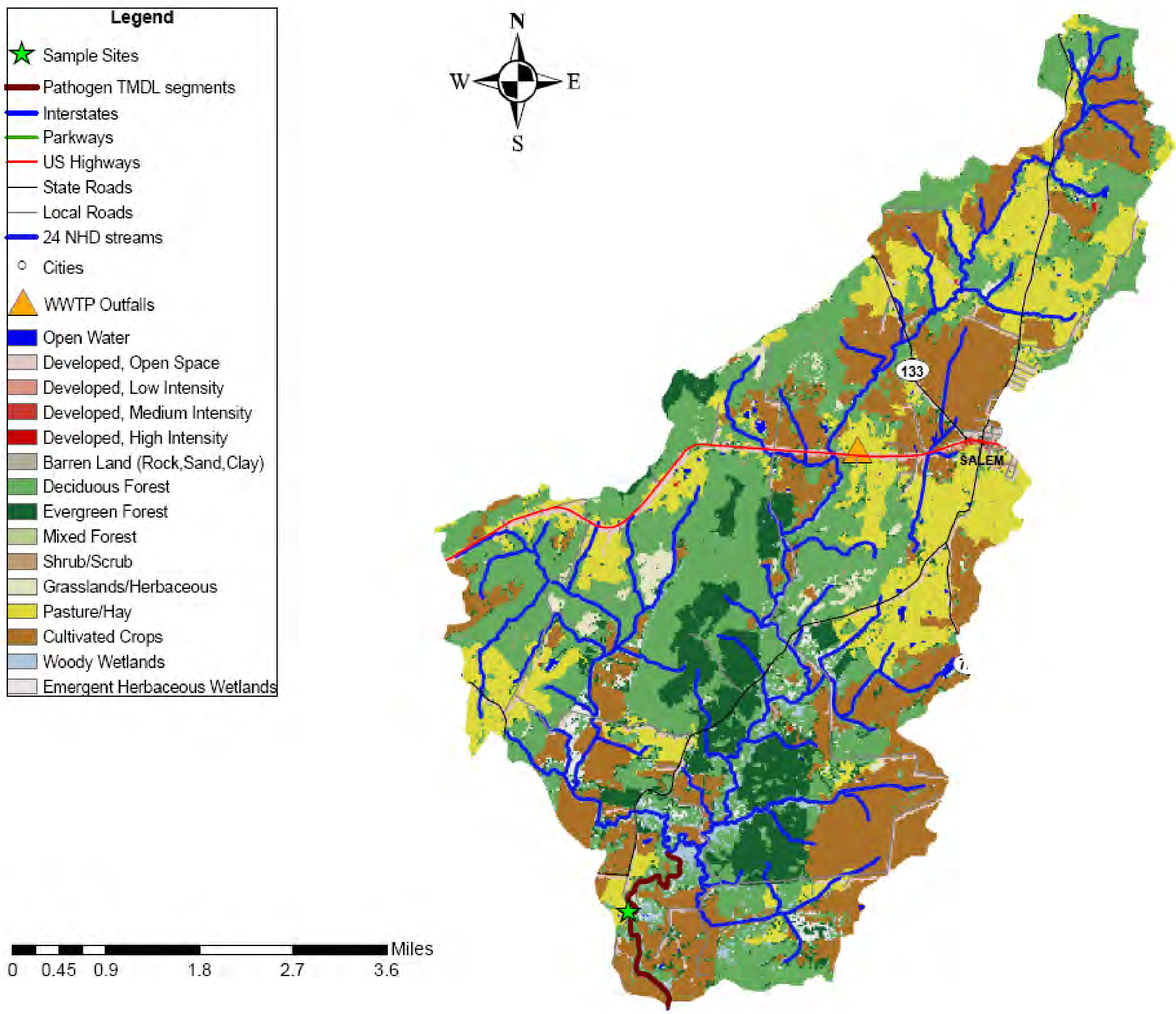
(71) Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

(81) Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

(82) Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

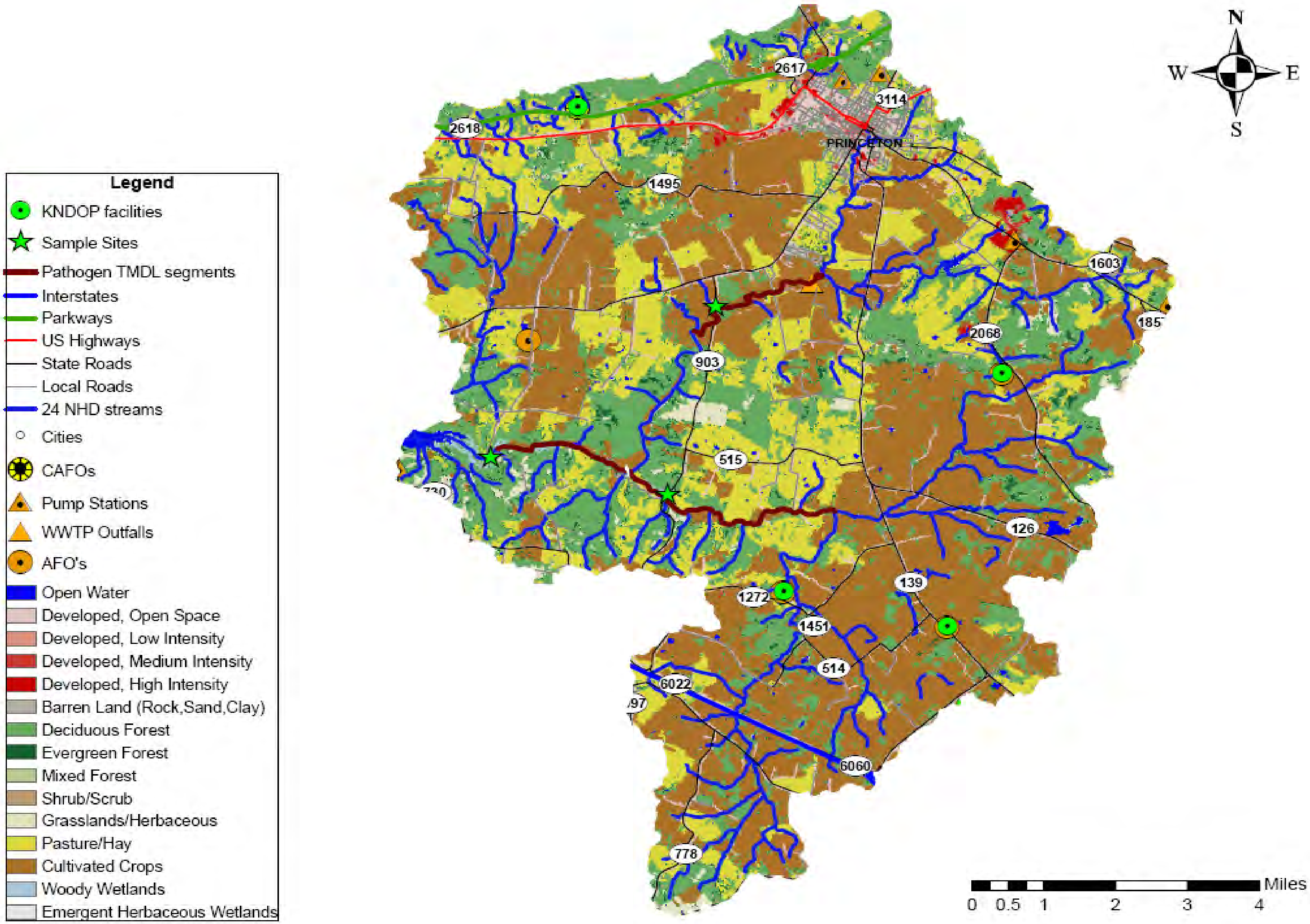
(90) Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

(95) Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

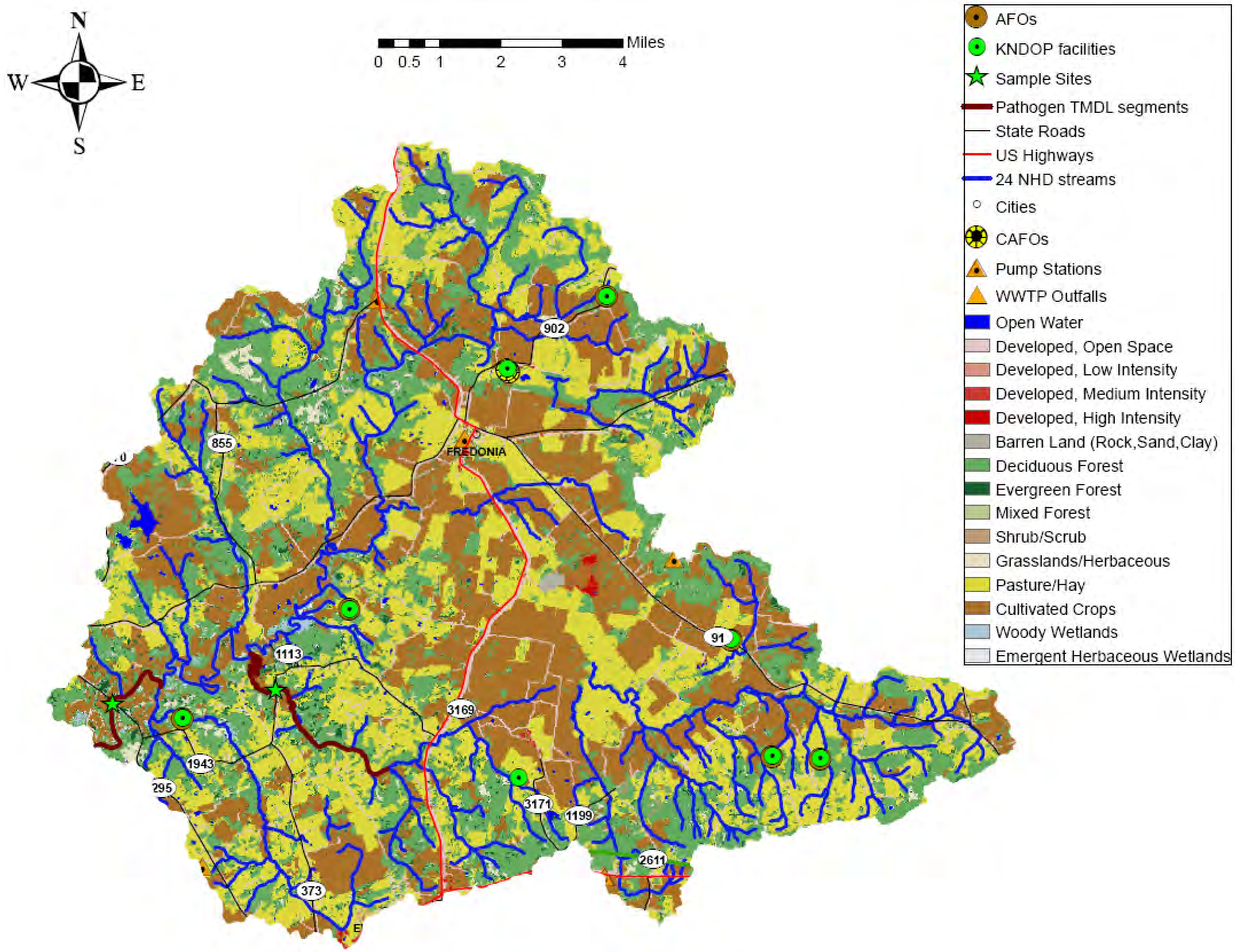


B.1 NLCD image of the Sandy Creek watershed

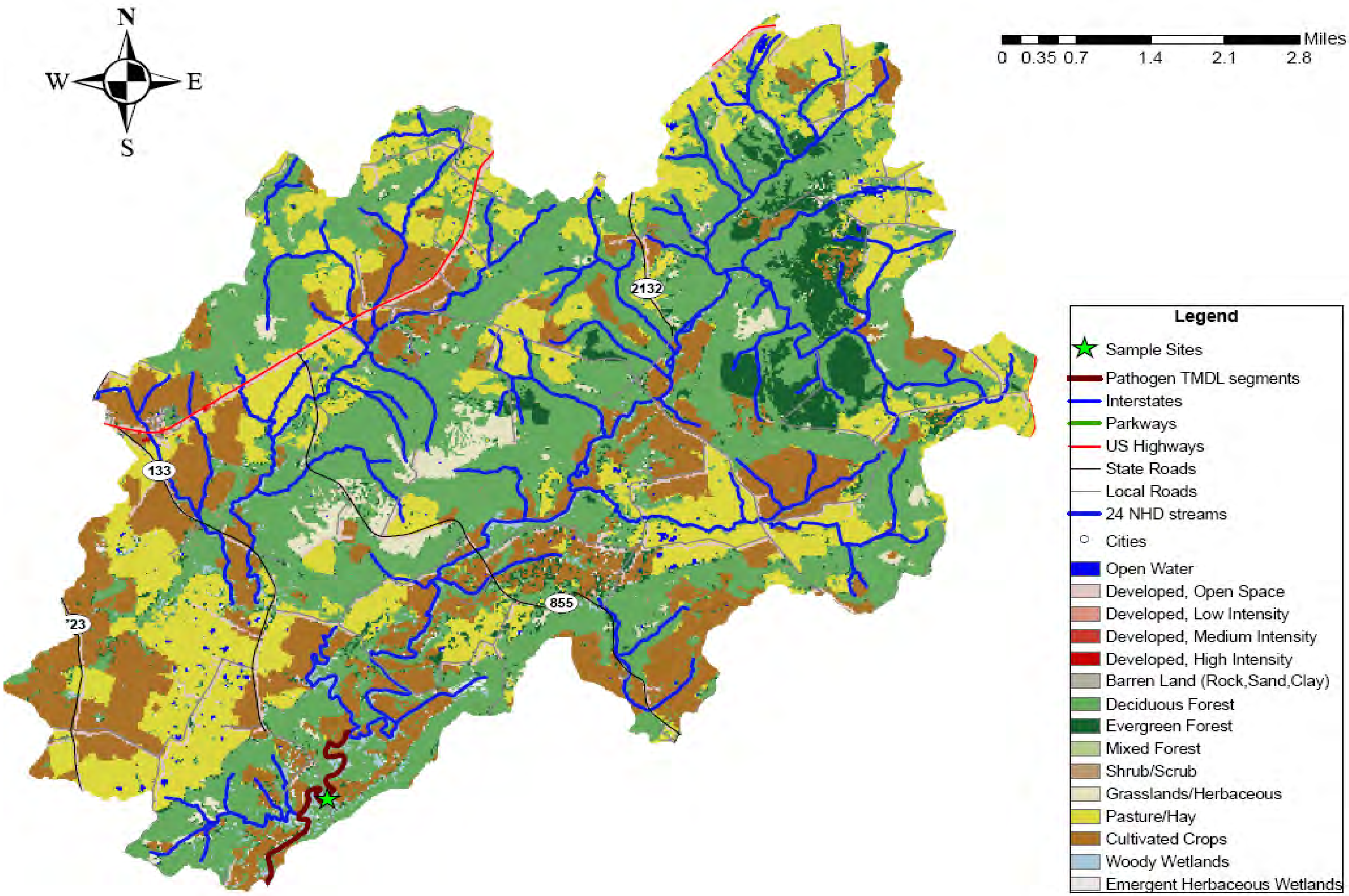
B2. NLCD image of the Eddy and Dry Creek watersheds.



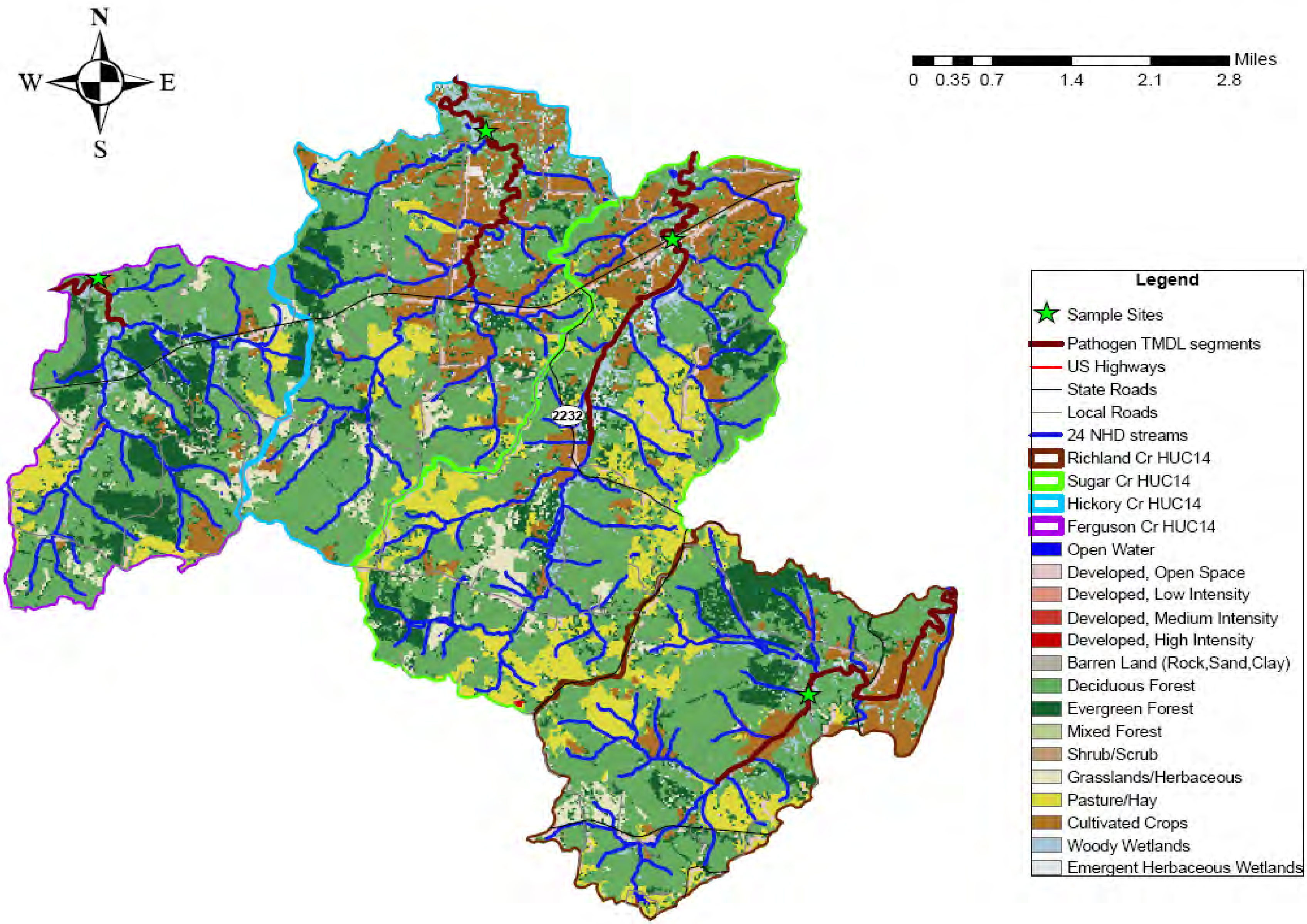
B3. NLCD image of the Livingston and Skinframe Creek watersheds.



B4. NLCD image of the Claylick Creek watershed.



B5. NLCD image of the Richland, Sugar, Hickory, and Ferguson Creek watersheds.



Appendix B

- Data -

Below are data that did not appear in the text of the report but were used to assess KPDES-permitted sources. Data flagged with a greater than symbol (">") represents the lowest dilution analyzed of a sample - these data were assessed as listed, although the actual concentration is likely higher.

Table A1. Individual Results of Quarterly Discharge Monitoring Reports for Princeton STP (KY0028401) in the Eddy Creek Watershed.

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
1/31/1999	5	11
2/28/1999	2	5
3/31/1999	11	22
4/30/1999	8	18
5/31/1999	5	5
6/30/1999	13	20
7/31/1999	18	43
8/31/1999	19	37
9/30/1999	21	28
10/31/1999	14	34
11/30/1999	24	31
12/31/1999	13	30
1/31/2000	13	31
2/29/2000	15	31
3/31/2000	4	7
4/30/2000	15	26
5/31/2000	30	58
6/30/2000	45	97
7/31/2000	36	103
8/31/2000	3	4
9/30/2000	8	16
10/31/2000	1	3
11/30/2000	1	2

Fecal Coliform (colonies/100mL)		
Reporting Date	**Monthly Average (limit:200)**	**Max Weekly Average (limit:400)**
12/31/2000	1	3
1/31/2001	3	6
2/28/2001	16	43
3/31/2001	8	39
4/30/2001	1	2
5/31/2001	6	8
6/30/2001	6	22
7/31/2001	2	6
8/31/2001	8	28
9/30/2001	6	15
10/31/2001	5	10
11/30/2001	17	37
12/31/2001	11	37
1/31/2002	8	14
2/28/2002	5	13
3/31/2002	4	5
4/30/2002	3	> 37
5/31/2002	28	40
6/30/2002	20	42
7/31/2002	44	100
8/31/2002	45	129
9/30/2002	32	56
10/31/2002	33	87
11/30/2002	12	20
12/31/2002	22	27
1/31/2003	42	115
2/28/2003	2	4
3/31/2003	6	18
4/30/2003	14	19
5/31/2003	23	59
6/30/2003	72	179
7/31/2003	31	37
8/31/2003	42	78
9/30/2003	28	54

Fecal Coliform (colonies/100mL)		
Reporting Date	**Monthly Average (limit:200)**	**Max Weekly Average (limit:400)**
10/31/2003	15	31
11/30/2003	16	21
12/31/2003	9	15
1/31/2004	4	7
2/29/2004	8	25
3/31/2004	6	7
4/30/2004	34	35
5/31/2004	10	12
6/30/2004	8	12
7/31/2004	10	16
8/31/2004	11	14
9/30/2004	30	72
10/31/2004	10	23
11/30/2004	23	26
12/31/2004	29	51
1/31/2005	9	23
2/28/2005	23	35
3/31/2005	27	66
4/30/2005	10	22
5/31/2005	33	114
6/30/2005	18	42
7/31/2005	14	18
8/31/2005	40	106
9/30/2005	21	43
10/31/2005	18	28
11/30/2005	31	61
12/31/2005	6	10
1/31/2006	86	197
2/28/2006	33	48
3/31/2006	9	20
4/30/2006	21	35
5/31/2006	35	40
6/30/2006	25	34
7/31/2006	21	30
8/31/2006	16	42

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
9/30/2006	12	83
10/31/2006	11	14
11/30/2006	15	0
12/31/2006	6	37
1/31/2007	21	27
2/28/2007	31	57
3/31/2007	7	16
4/30/2007	7	12
5/31/2007	6	7
6/30/2007	11	18
7/31/2007	22	25
8/31/2007	25	46
9/30/2007	22	45
10/31/2007	20	31
11/30/2007	21	35
12/31/2007	18	45
Percent Exceedances		
	0.0%	0.0%

Exceedance of Limit

Table A2. Individual Results of Quarterly Discharge Monitoring Reports for Fontaine Trailer Company (KY0022225) in the Eddy/Dry Creek Watershed.

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
1/31/1999	< 5.0	< 5.0
2/28/1999	< 5.0	< 5.0
3/31/1999	10	10
4/30/1999	5.1	5.1
5/31/1999	23	23
6/30/1999	120	120
7/31/1999		

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
8/31/1999		
9/30/1999		
10/31/1999		
11/30/1999		
12/31/1999		
1/31/2000	< 2.0	< 2.0
2/29/2000	< 2.0	< 2.0
3/31/2000	360	360
4/30/2000	260	260
5/31/2000	30	30
6/30/2000	< 5	< 5
7/31/2000	< 5.0	< 5.0
8/31/2000	< 5.0	< 5.0
9/30/2000	265	265
10/31/2000	< 5	< 5
11/30/2000	315	315
12/31/2000	< 5	< 5
1/31/2001	< 5	< 5
2/28/2001	< 5	< 5
3/31/2001	< 5	< 5
4/30/2001	< 5.0	< 5.0
5/31/2001	125	125
6/30/2001	10	10
7/31/2001	400	400
8/31/2001	25	25
9/30/2001	110	110
10/31/2001	145	145
11/30/2001	120	120
12/31/2001	< 5.0	< 5.0
1/31/2002	10.0	10.0
2/28/2002	20.0	20.0
3/31/2002	545	545
4/30/2002	10	10
5/31/2002	125	125

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
6/30/2002	260	260
7/31/2002	15	15
8/31/2002	< 5.0	< 5.0
9/30/2002	40	40
10/31/2002	5	5
11/30/2002	< 5.0	< 5.0
12/31/2002	< 5	< 5
1/31/2003		
2/28/2003	< 5.0	< 5.0
3/31/2003	< 5.0	< 5.0
4/30/2003	25	25
5/31/2003	20	20
6/30/2003	200	200
7/31/2003	85	85
8/31/2003	15	15
9/30/2003	< 5	< 5
10/31/2003	10	10
11/30/2003	20	20
12/31/2003	< 5	< 5
1/31/2004	< 5	< 5
2/29/2004	< 5.0	< 5.0
3/31/2004	< 5	< 5
4/30/2004	< 5	< 5
5/31/2004	< 5	< 5
6/30/2004	10	10
7/31/2004	300	300
8/31/2004	< 5	< 5
9/30/2004	10	10
10/31/2004	< 5	< 5
11/30/2004	5	5
12/31/2004	< 5	< 5
1/31/2005	< 5	< 5
2/28/2005		
3/31/2005	< 5	< 5
4/30/2005	60	60

Fecal Coliform (colonies/100mL)		
Reporting Date	**Monthly Average (limit:200)**	**Max Weekly Average (limit:400)**
5/31/2005	< 5	< 5
6/30/2005	< 5	< 5
7/31/2005	115	115
8/31/2005	< 5	< 5
9/30/2005	< 5	< 5
10/31/2005	< 5.0	< 5.0
11/30/2005	< 5.0	< 5.0
12/31/2005	< 5	< 5
1/31/2006	< 5	< 5
2/28/2006	< 5.0	< 5.0
3/31/2006	< 5	< 5
4/30/2006	< 5	< 5
5/31/2006	< 3	< 3
6/30/2006		
7/31/2006	< 3	< 3
8/31/2006	< 4	< 4
9/30/2006	< 5	< 5
10/31/2006	< 5	< 5
11/30/2006	< 5	< 5
12/31/2006	< 5	< 5
1/31/2007	< 5	< 5
2/28/2007	< 5	< 5
3/31/2007	< 5	< 5
4/30/2007	< 5	< 5
5/31/2007	< 5	< 5
6/30/2007	< 5	< 5
7/31/2007	30	30
8/31/2007		
9/30/2007		
Percent Exceedances		
	(8) 7.6%	(1) 0.01%

Exceedance of Limit

Table A3. Individual Results of Quarterly Discharge Monitoring Reports for Salem STP (KY0066541) in the Sandy Creek Watershed.

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
1/31/1999	0.0	0.0
2/28/1999	0.0	0.0
3/31/1999	360	360
4/30/1999	73.0	73.0
5/31/1999	73.0	73.0
6/30/1999	1	1
7/31/1999	3	3
8/31/1999	2	2
9/30/1999	0.0	0.0
10/31/1999	0.0	0.0
11/30/1999	127	127
12/31/1999	0	0
1/31/2000	3	3
2/29/2000	9	9
3/31/2000	6	6
4/30/2000	3	3
5/31/2000	1	1
6/30/2000	4	4
7/31/2000	43	43
8/31/2000	23	23
9/30/2000	7	7
10/31/2000	1	1
11/30/2000	0	0
12/31/2000	0	0
1/31/2001	0	0
2/28/2001	100	100
3/31/2001	0	0
4/30/2001	0	0
5/31/2001	0.0	0.0
6/30/2001	7	7
7/31/2001	80	80

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
8/31/2001	80	80
9/30/2001	38	38
10/31/2001	0	0
11/30/2001	0	0
12/31/2001	0.0	0.0
1/31/2002	128	128
2/28/2002	0.0	0.0
3/31/2002	0.0	0.0
4/30/2002	0	0
5/31/2002	125	125
6/30/2002	0	0
7/31/2002	78	78
8/31/2002	3	3
9/30/2002	0	0
10/31/2002	4	4
11/30/2002	2	2
12/31/2002	130	130
1/31/2003	42	42
2/28/2003	0.0	0.0
3/31/2003	1	1
4/30/2003	18	18
5/31/2003	35	35
6/30/2003	50	50
7/31/2003	35	35
8/31/2003	70	100
9/30/2003	33	100
10/31/2003	22	100
11/30/2003	14	25
12/31/2003	24	100
1/31/2004	16	30
2/29/2004	51	180
3/31/2004	3	15
4/30/2004	3	5
5/31/2004	9	37
6/30/2004	4	18

Fecal Coliform (colonies/100mL)		
Reporting Date	Monthly Average (limit:200)	Max Weekly Average (limit:400)
7/31/2004	3.46	17
8/31/2004	36	208
9/30/2004	35	160
10/31/2004	8.3	27.9
11/30/2004	4	18
12/31/2004	11	126
1/31/2005	15	79
2/28/2005	10	63
3/31/2005	7	78
4/30/2005	5.3	10
5/31/2005	7	29
6/30/2005	3.3	12.8
7/31/2005	4.4	53
8/31/2005	8	17
9/30/2005	< 7	< 28
10/31/2005	< 2	< 2
11/30/2005	< 2	< 2
12/31/2005	< 3	< 3
1/31/2006	2.3	3.9
2/28/2006	9	23
3/31/2006	5.62	126
4/30/2006	5	93
5/31/2006	< 6	< 40
6/30/2006	7	10
7/31/2006	23	100
8/31/2006	< 8	44
9/30/2006	25	100
10/31/2006	10	177
11/30/2006	5	45
12/31/2006	< 2	< 2
1/31/2007	< 4	< 17
2/28/2007	56	199
3/31/2007	13	125
4/30/2007	15	125
5/31/2007	12	125

Fecal Coliform (colonies/100mL)		
Reporting Date	**Monthly Average (limit:200)**	**Max Weekly Average (limit:400)**
6/30/2007	17	78
7/31/2007	15	72
8/31/2007	10	18
9/30/2007	< 2	< 2
10/31/2007	5	125
11/30/2007	8	29
12/31/2007	10	39
Percent Exceedances		
	(1) 0.01%	0.0%

Exceedance of Limit