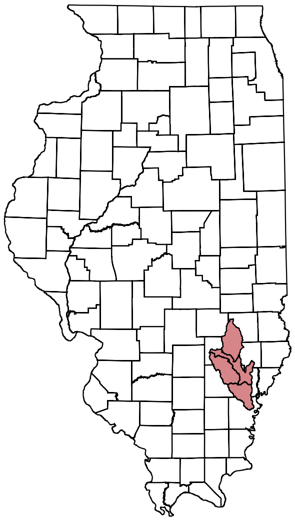
Illinois
Environmental
Protection Agency

Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

June 2008

IEPA/BOW/08-007

Little Wabash II Watershed TMDL Report



TMDL Development for the Little Wabash River II Watershed, Illinois

This file contains the following documents:

1) U.S. EPA Approval letter for Stage Three TMDL Report
2) Stage One Report: Watershed Characterization and Water Quality Analysis
3) Stage Two Report: Data Report
4) Stage Three Report: TMDL Development
5) IP Report

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

AUG 14 2008

REPLY TO THE ATTENTION OF:

WW-16J

Marcia Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

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BUREAU OF WATER
BUREAU CHIEF'S OFF

Dear Ms. Willhite:

The U. S. Environmental Protection Agency has reviewed the final Total Maximum Daily Loads from the Illinois Environmental Protection Agency for the Little Wabash River Watershed in Illinois. The TMDLs are for Fecal Coliform, Atrazine, Manganese, Ammonia, Chemical Biological Oxygen Demand, and Total Phosphorus, and address the recreational use and aquatic life impairments in this watershed.

Based on this review, EPA has determined that Illinois' TMDLs for Fecal Coliform, Atrazine, Manganese, Ammonia, Chemical Biological Oxygen Demand, and Total Phosphorus meet the requirements of Section 303(d) of the Clean Water Act and EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, EPA hereby approves fourteen TMDLs addressing fourteen impairments in the Little Wabash River Watershed in Illinois. The statutory and regulatory requirements, and EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Kevin Pierard, Chief of the Watersheds and Wetlands Branch, at 312-886-4448.

Sincerely yours,

Timothy C. Henry
Acting Director, Water Division

Enclosure
cc: Dean Studer, IEPA
Michael Eppley, IEPA

CDM

Illinois Environmental
Protection Agency

Little Wabash River Watershed TMDL
Stage One
Third Quarter Draft Report

June 2006

Draft Report

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Acronyms

°F	degrees Fahrenheit
BMP	best management practice
CWA	Clean Water Act
DMR	Discharge Monitoring Reports
DO	dissolved oxygen
ft	Foot or feet
GIS	geographic information system
HUC	Hydrologic Unit Code
IDA	Illinois Department of Agriculture
IDNR	Illinois Department of Natural Resources
IL-GAP	Illinois Gap Analysis Project
ILLCP	Illinois Interagency Landscape Classification Project
Illinois EPA	Illinois Environmental Protection Agency
INHS	Illinois Natural History Survey
IPCB	Illinois Pollution Control Board
LA	load allocation
LC	loading capacity
lb/d	pounds per day
mgd	Million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
MUID	Map Unit Identification
NA	Not applicable
NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
PCS	Permit Compliance System
SSURGO	Soil Survey Geographic Database
STATSGO	State Soil Geographic
STORET	Storage and Retrieval
STP	Sanitary Treatment Plant
TMDL	total maximum daily load

ug/L	Micrograms per liter
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	waste load allocation
WTP	Water Treatment Plant

Section 1

Goals and Objectives for Little Wabash River Watershed (0512011408, 0512011409, 0512011407, 0512011405)

1.1 Total Maximum Daily Load (TMDL) Overview

A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (Illinois EPA) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. Illinois EPA lists water bodies not meeting water quality standards every two years. This list is called the 303(d) list and water bodies on the list are then targeted for TMDL development.

In general, a TMDL is a quantitative assessment of water quality problems, contributing sources, and pollution reductions needed to attain water quality standards. The TMDL specifies the amount of pollution or other stressor that needs to be reduced to meet water quality standards, allocates pollution control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body.

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards provide the foundation for accomplishing two of the principal goals of the CWA. These goals are:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water

Water quality standards consist of three elements:

- The designated beneficial use or uses of a water body or segment of a water body
- The water quality criteria necessary to protect the use or uses of that particular water body
- An antidegradation policy

Examples of designated uses are recreation and protection of aquatic life. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement.

Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected.

1.2 TMDL Goals and Objectives for Little Wabash River Watershed

The Illinois EPA has a three-stage approach to TMDL development. The stages are:

- Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection
- Stage 2 – Data Collection (optional)
- Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

This report addresses Stage 1 TMDL development for the Little Wabash River watershed. Stage 2 and 3 will be conducted upon completion of Stage 1. Stage 2 is optional as data collection may not be necessary if additional data are not required to establish the TMDL.

Following this process, the TMDL goals and objectives for the Little Wabash River watershed will include developing TMDLs for all impaired water bodies within the watershed, describing all of the necessary elements of the TMDL, developing an implementation plan for each TMDL, and gaining public acceptance of the process. Following are the impaired water body segments in the Little Wabash River watershed for which a TMDL will be developed:

- Little Wabash River (C 09)
- Little Wabash River (C 22)
- Village Creek (CE 01)
- Clay City SCR (RCU)
- Little Wabash River (C 33)
- Johnson Creek (CCA-FF-A1)
- Pond Creek (CC-FF-D1)
- Fairfield Reservoir (RCZJ)
- Elm River (CD 01)
- Elm River (CD 04)
- Seminary Creek (CDG-FL-A1)
- Seminary Creek (CDG-FL-C6)
- Big Muddy River (CJ 06)
- Little Muddy River (CJA 02)
- Big Muddy Diversion Ditch (CJAE01)
- Newton Lake(RCR)

These impaired water body segments are shown on Figure 1-1. There are 16 impaired segments within the Little Wabash River watershed. Table 1-1 lists the water body segment, water body size, and potential causes of impairment for the water body.

Table 1-1 Impaired Water Bodies in Little Wabash River Watershed

Water Body Segment ID	Water Body Name	Size	Causes of Impairment with Numeric Water Quality Standards	Causes of Impairment with Assessment Guidelines
C 09	Little Wabash River	20.36 miles	Manganese, silver, pH, dissolved oxygen, atrazine, total fecal coliform	Sedimentation/siltation, total suspended solids (TSS), total phosphorus
C 22	Little Wabash River	21.4 miles	Total fecal coliform	
CE 01	Village Creek	12.3 miles	Manganese, dissolved oxygen	Sedimentation, habitat alterations (streams)
RCU	Clay City SCR	6 acres	Manganese	TSS, excess algal growth, total phosphorus
C 33	Little Wabash River	43.41 miles	Manganese, dissolved oxygen, atrazine	Sedimentation/siltation, TSS
CCA-FF-A1	Johnson Creek	1.87 miles	Dissolved oxygen	Habitat alterations (streams)
CC-FF-D1	Pond Creek	4.53 miles	Dissolved oxygen	Habitat alterations (streams)
RCZJ	Fairfield Reservoir	16 acres	Manganese	Excess algal growth
CD 01	Elm River	8.53 miles	Manganese, pH, dissolved oxygen, atrazine, total fecal coliform	Sedimentation/siltation, habitat alterations (streams), TSS
CD 04	Elm River	35.43 miles	Dissolved oxygen	Sedimentation/siltation, habitat alterations (streams)
CDG-FL-A1	Seminary Creek	1.47 miles	Dissolved oxygen	Total phosphorus
CDG-FL-C6	Seminary Creek	1.99 miles	Dissolved oxygen	Habitat alterations (streams), total phosphorus
CJ 06	Big Muddy Creek	36.62 miles	Manganese, dissolved oxygen	Sedimentation/siltation, habitat alterations (streams), TSS, total phosphorus
CJA 02	Little Muddy Creek	30.57 miles	Manganese, dissolved oxygen	Sedimentation/siltation, habitat alterations (streams)
CJAE01	Big Muddy Diversion Ditch	8.72 miles	Dissolved oxygen	Habitat alterations (streams)
RCR	Newton Lake	1,750 acres	Total phosphorus	TSS, excess algal growth, total phosphorus

Illinois EPA is currently only developing TMDLs for parameters that have numeric water quality standards, and therefore the remaining sections of this report will focus on the manganese, silver, pH, dissolved oxygen, atrazine, total fecal coliform, and total phosphorus (numeric standard) impairments in the Little Wabash River watershed. For potential causes that do not have numeric water quality standards as noted in Table 1-1, TMDLs will not be developed at this time. However, in the implementation plans completed during Stage 3 of the TMDL, many of these potential causes may be addressed by implementation of the pollutants with water quality standards.

The TMDL for the segments listed above will specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a water body can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality

These elements are combined into the following equation:

$$\mathbf{TMDL = LC = \Sigma WLA + \Sigma LA + MOS}$$

The TMDL developed must also take into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDL will be achieved will be described in the implementation plan. The implementation plan for the Little Wabash River watershed will describe how water quality standards will be attained. This implementation plan will include recommendations for implementing best management practices (BMPs), cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and timeframe for completion of implementation activities.

1.3 Report Overview

The remaining sections of this report contain:

- **Section 2 Little Wabash River Watershed Characteristics** provides a description of the watershed's location, topography, geology, land use, soils, population, and hydrology
- **Section 3 Public Participation and Involvement** discusses public participation activities that occurred throughout the TMDL development
- **Section 4 Little Wabash River Watershed Water Quality Standards** defines the water quality standards for the impaired water body

- **Section 5 Little Wabash River Watershed Characterization** presents the available water quality data needed to develop TMDLs, discusses the characteristics of the impaired reservoirs in the watershed, and also describes the point and non-point sources with potential to contribute to the watershed load.
- **Section 6 Approach to Developing TMDL and Identification of Data Needs** makes recommendations for the models and analysis that will be needed for TMDL development and also suggests segments for Stage 2 data collection.

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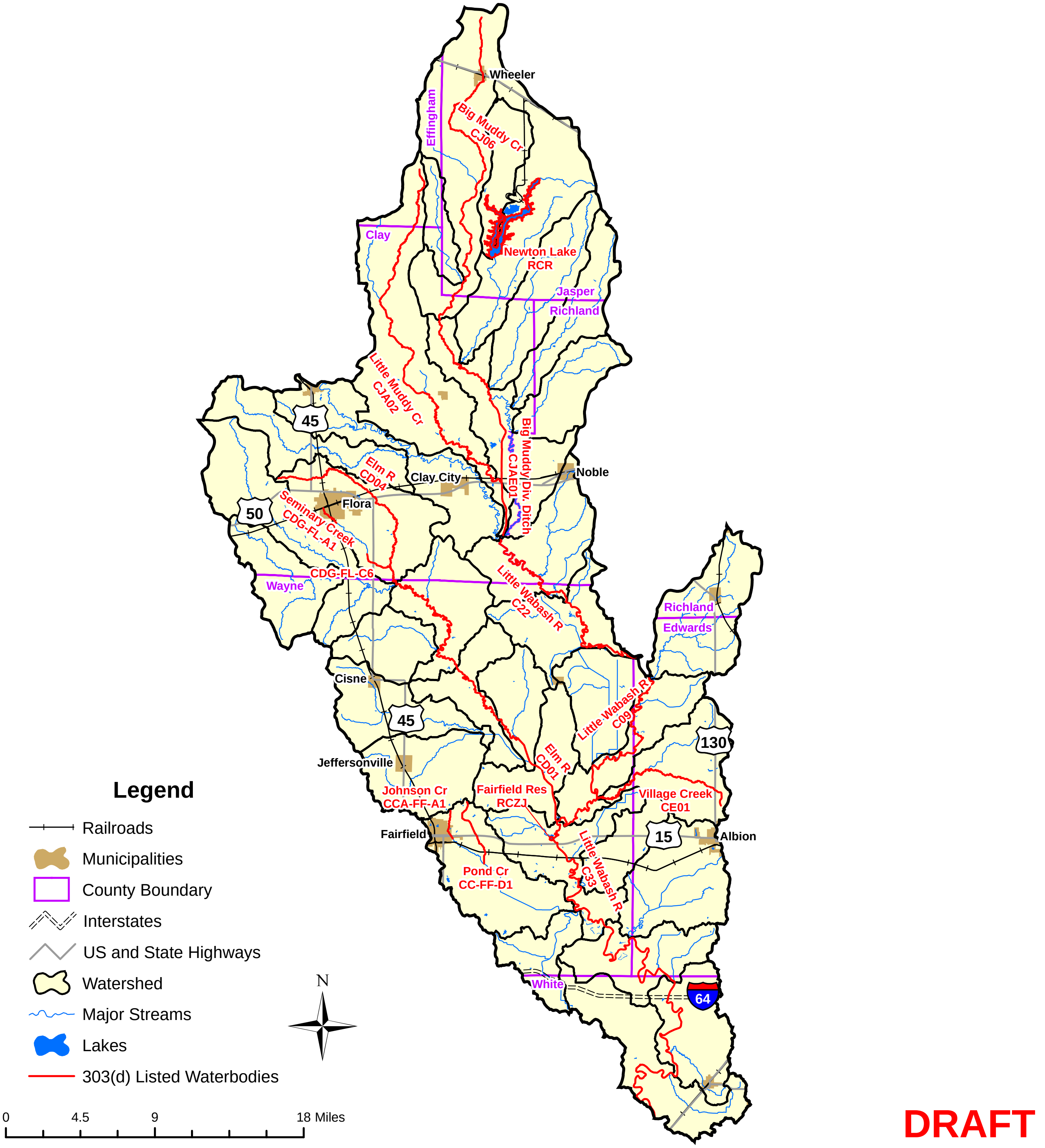

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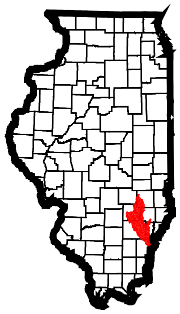

Figure 1-1
Little Wabsash River Watershed

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Section 2
Little Wabash River Watershed Description

2.1 Little Wabash River Watershed Location

The Little Wabash River watershed (Figure 1-1) is located in southern Illinois, flows in a southerly direction, and drains approximately 684,000 acres within the state of Illinois. The watershed covers land within Effingham, Jasper, Richland, Clay, Wayne, Edwards, and White Counties.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. National Elevation Dataset (NED) coverages containing 30-meter grid resolution elevation data are available from the USGS for each 1:24,000-topographic quadrangle in the United States. Elevation data for the Little Wabash River watershed were obtained by overlaying the NED grid onto the GIS-delineated watershed. Figure 2-1 shows the elevations found within the watershed.

Elevation in the Little Wabash River watershed ranges from 623 feet above sea level in the headwaters of Little Wabash River to 335 feet at its most downstream point in the southern end of the watershed. The absolute elevation change is 147 feet over the approximately 115-mile stream length of Little Wabash River, which yields a stream gradient of approximately 1.3 feet per mile.

2.3 Land Use

Land use data for the Little Wabash River watershed were extracted from the Illinois Gap Analysis Project (IL-GAP) Land Cover data layer. IL-GAP was started at the Illinois Natural History Survey (INHS) in 1996, and the land cover layer was the first component of the project. The IL-GAP Land Cover data layer is a product of the Illinois Interagency Landscape Classification Project (IILCP), an initiative to produce statewide land cover information on a recurring basis cooperatively managed by the United States Department of Agriculture National Agricultural Statistics Service (NASS), the Illinois Department of Agriculture (IDA), and the Illinois Department of Natural Resources (IDNR). The land cover data were generated using 30-meter grid resolution satellite imagery taken during 1999 and 2000. The IL-GAP Land Cover data layer contains 23 land cover categories, including detailed classification in the vegetated areas of Illinois. Appendix A contains a complete listing of land cover categories. (Source: IDNR, INHS, IDA, USDA NASS's 1:100,000 Scale Land Cover of Illinois 1999-2000, Raster Digital Data, Version 2.0, September 2003.)

The land use of the Little Wabash River watershed was determined by overlaying the IL-GAP Land Cover data layer onto the GIS-delineated watershed. Table 2-1 contains the land uses contributing to the Little Wabash River watershed, based on the IL-GAP land cover categories and also includes the area of each land cover category and percentage of the watershed area. Figure 2-2 illustrates the land uses of the watershed.

The land cover data reveal that approximately 552,323 acres, representing nearly 81 percent of the total watershed area, are devoted to agricultural activities. Corn and soybean farming account for nearly 29 percent and 35 percent of the watershed area, respectively; winter wheat and winter wheat/soybeans farming account for 7 percent and 9 percent, respectively; and rural grassland accounts for nearly 9 percent. Forested areas (including upland forests) cover about 13 percent of the watershed area. Other land cover categories represent less that 5 percent of the watershed area.

Table 2-1 Land Use in Little Wabash River Watershed

Land Cover Category	Area (Acres)	Percentage
Corn	196,477	28.7%
Soybeans	237,779	34.6%
Winter Wheat	2,890	0.4%
Other Small Grains & Hay	11,715	1.7%
Winter Wheat/Soybeans	44,239	6.5%
Other Agriculture	592	0.1%
Rural Grassland	58,632	8.6%
Upland	51,719	7.6%
Forested Areas	37,328	5.5%
High Density	1,486	0.2%
Low/Medium Density	4,514	0.7%
Urban Open Space	1,907	0.3%
Wetlands	29,447	4.3%
Surface Water	5,628	0.8%
Barren & Exposed Land	21	0.0%
Total	**684,374**	**100%**

1. Forested areas include partial canopy/savannah upland.
2. Wetlands include shallow marsh/wet meadow, deep marsh, seasonally/temporally flooded, floodplain forest, and shallow water.

2.4 Soils

Two types of soil data are available for use within the state of Illinois through the National Resource Conservation Service (NRCS). General soils data and map unit delineations for the entire state are provided as part of the State Soil Geographic (STATSGO) database. Soil maps for the database are produced by generalizing detailed soil survey data. The mapping scale for STATSGO is 1:250,000. More detailed soils data and spatial coverages are available through the Soil Survey Geographic (SSURGO) database for a limited number of counties. For SSURGO data, field mapping methods using national standards are used to construct the soil maps. Mapping scales generally range from 1:12,000 to 1:63,360 making SSURGO the most detailed level of NRCS soil mapping.

The Little Wabash River watershed falls within Effingham, Jasper, Richland, Clay, Wayne, Edwards, and White Counties. At this time, only STATGO data are available for these areas. Figure 2-3 displays the STATSGO soil map units in the Little Wabash River watershed. Attributes of the spatial coverage can be linked to the STATSGO database, which provides information on various chemical and physical soil characteristics for each map unit. Of particular interest for TMDL development are the hydrologic soil groups as well as the K-factor of the Universal Soil Loss Equation. The following sections describe and summarize the specified soil characteristics for the Little Wabash River watershed.

2.4.1 Little Wabash River Watershed Soil Characteristics

Table 2-2 contains the STATSGO Map Unit IDs (MUIDs) for the Little Wabash River watershed along with area, dominant hydrologic soil group, and K-factor range. Each of these characteristics is described in more detail in the following paragraphs. The predominant soil type in the watershed are soils categorized as a fine-grained and made up of silts and clays with a liquid limit of less than 50 percent that tend toward a lean clay to silt.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils are assigned to one of four groups. They are grouped according to their infiltration rates under saturated conditions during long duration storm events. Hydrologic soil groups B, C, and D are found within the Little Wabash River watershed with the majority of the watershed falling into category C. Category C soils are defined as "soils having a slow infiltration rate when thoroughly wet." C soils consist "chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture." These soils have a slow rate of water transmission (NRCS 2005).

A commonly used soil attribute is the K-factor. The K-factor:

> *Indicates the susceptibility of a soil to sheet and rill erosion by water.* (The K-factor) *is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the Little Wabash River watershed range from 0.1 to 0.43.

Table 2-2 Little Wabash River Watershed Soil Characteristics

STATSGO Map Unit ID	Acres	Percent of Watershed	Dominant Hydrologic Soil Group	K-factor Range
IL006	182860.51	26.7%	C/D	0.32-0.43
IL020	24976.77	3.7%	C	0.24-0.43
IL029	7043.87	1.0%	B/D	0.20-0.43
IL035	5239.70	0.8%	B/C	0.17-0.43
IL037	12322.88	1.8%	C	0.28-0.43
IL038	316659.30	46.3%	C	0.24-0.43
IL051	2233.92	0.3%	B	0.24-0.43
IL055	1943.55	0.3%	B	0.1-0.43
IL064	20606.57	3.0%	C	0.17-0.43
IL068	442.30	0.1%	C	0.28-0.43
IL069	109676.30	16.0%	C	0.2-0.43
TOTAL	**684005.67**	**100%**		

2.5 Population

Population data were retrieved from Census 2000 TIGER/Line Data from the U.S. Bureau of the Census. Geographic shape files of census blocks were downloaded for every county containing any portion of the watersheds. The block files were clipped to each watershed so that only block populations associated with the watershed would be counted. The census block demographic text file (PL94) containing population data were downloaded and linked to each watershed and summed. City populations were taken from the U.S. Bureau of the Census. For municipalities that are located across watershed borders, the population was estimated based on the percentage of area of municipality within the watershed boundary.

Approximately 33,000 people reside in the watershed. The municipalities in the Little Wabash River watershed are shown in Figure 1-1. The city of Flora is the largest population center in the watershed and contributes an estimated 5,000 people to total watershed population.

2.6 Climate and Streamflow

2.6.1 Climate

Southeastern Illinois has a temperate climate with hot summers and cold, snowy winters. Monthly precipitation and temperature data from the Flora 5 NW station (station id. 3109) in Clay County were extracted from the NCDC database for the years of 1901 through 2004. The data station in Flora, Illinois was chosen to be representative of meteorological conditions throughout the Little Wabash River watershed.

Table 2-3 contains the average monthly precipitation along with average high and low temperatures for the period of record. The average annual precipitation is approximately 41 inches.

Table 2-3 Average Monthly Climate Data in Flora, IL

Month	Total Precipitation (inches)	Maximum Temperature (degrees F)	Minimum Temperature (degrees F)
January	2.7	40	22
February	2.5	44	25
March	3.9	55	34
April	4.0	67	44
May	4.4	77	53
June	4.0	85	62
July	3.4	90	65
August	3.3	88	64
September	3.3	82	56
October	3.1	70	45
November	3.4	55	34
December	3.1	43	26
Total	**41.1**		

2.6.2 Streamflow

Analysis of the Little Wabash River watershed requires an understanding of flow throughout the drainage area. USGS gage 03379500 (Little Wabash River near Clay City, Illinois) is the only available data gage within the watershed with current data (Figure 2-4). The gage is located on segment C22 of the Little Wabash River. The station is approximately 4 miles downstream of the confluence with Little Muddy Creek.

Data were available for the gage from the USGS for the years 1915 through 2004. The average monthly flows recorded at the gage range from 213 cubic feet per second (cfs) in September to 1731 cfs in March with a mean annual monthly flow of 946 cfs (Figure 2-5).

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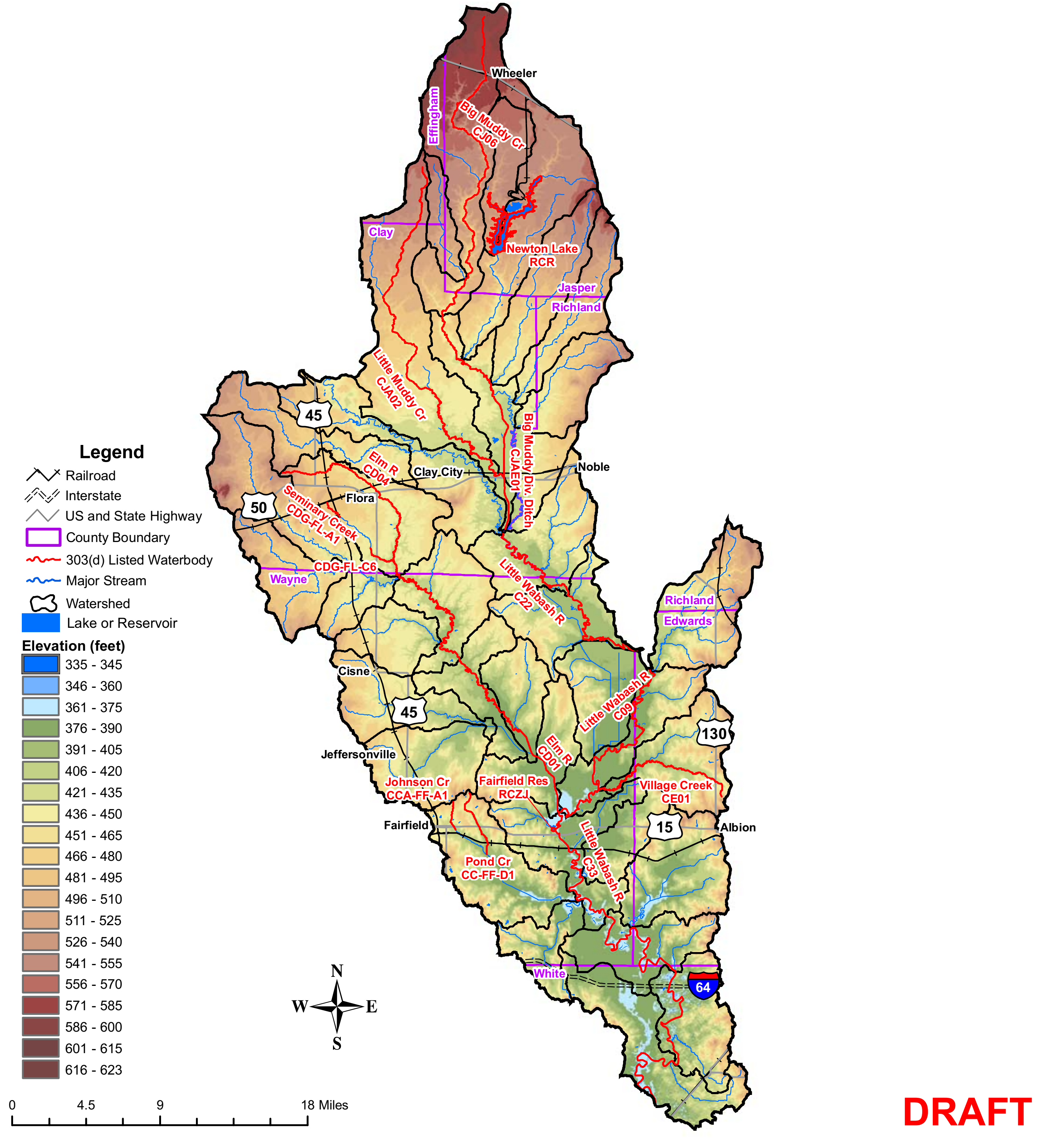

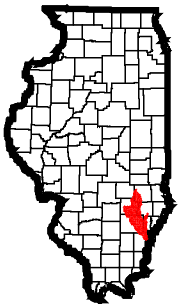

Figure 2-1
Little Wabsash River Watershed
Elevation

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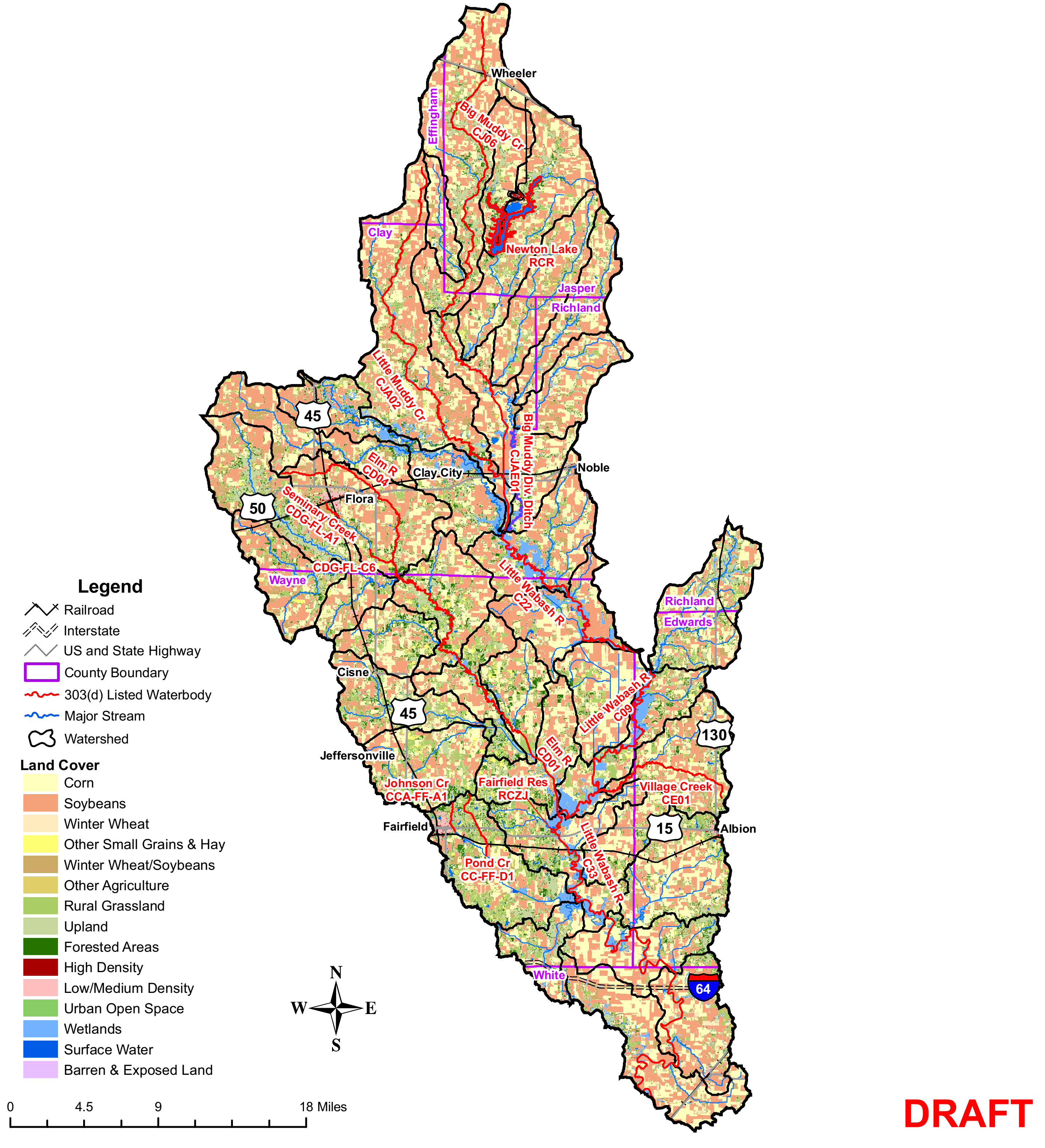

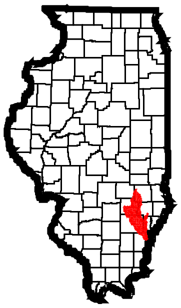

Figure 2-2
Little Wabsash River Watershed
Land Use

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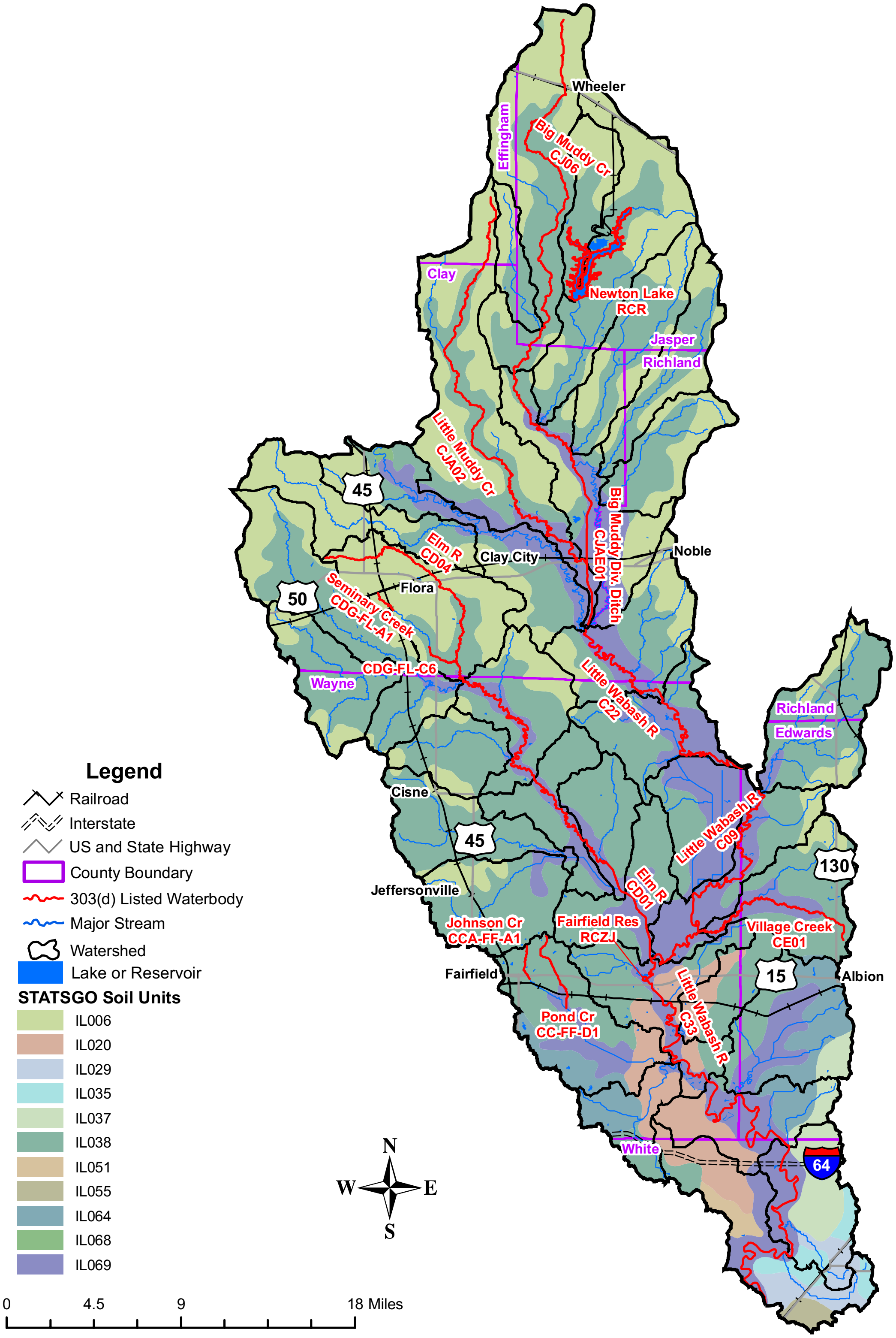

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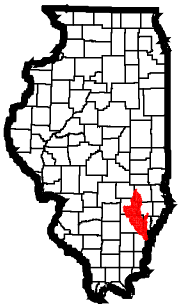

Figure 2-3
Little Wabsash River Watershed
Soils

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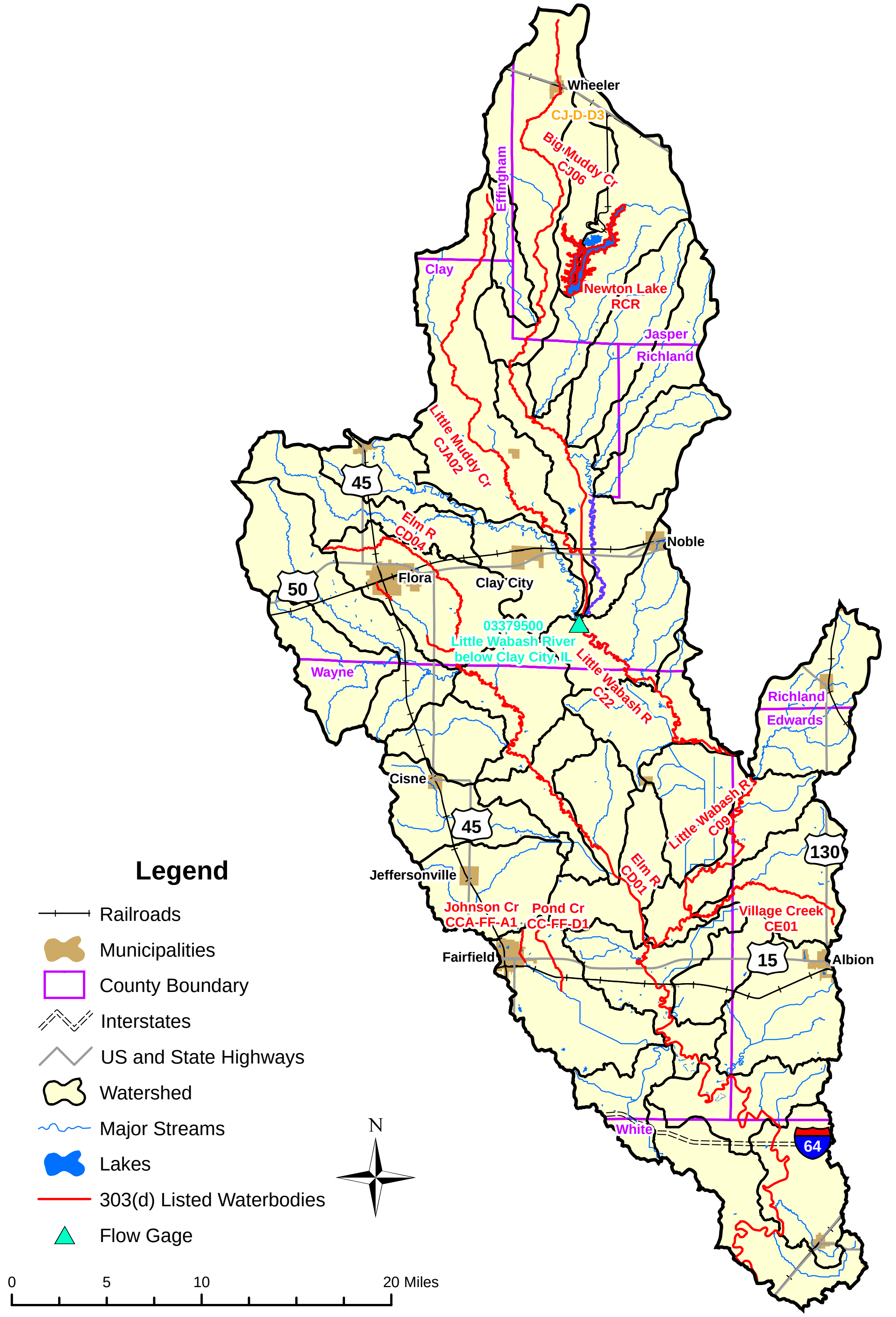

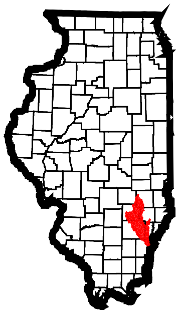

Figure 2-4: Flow Gages
Little Wabsash River Watershed

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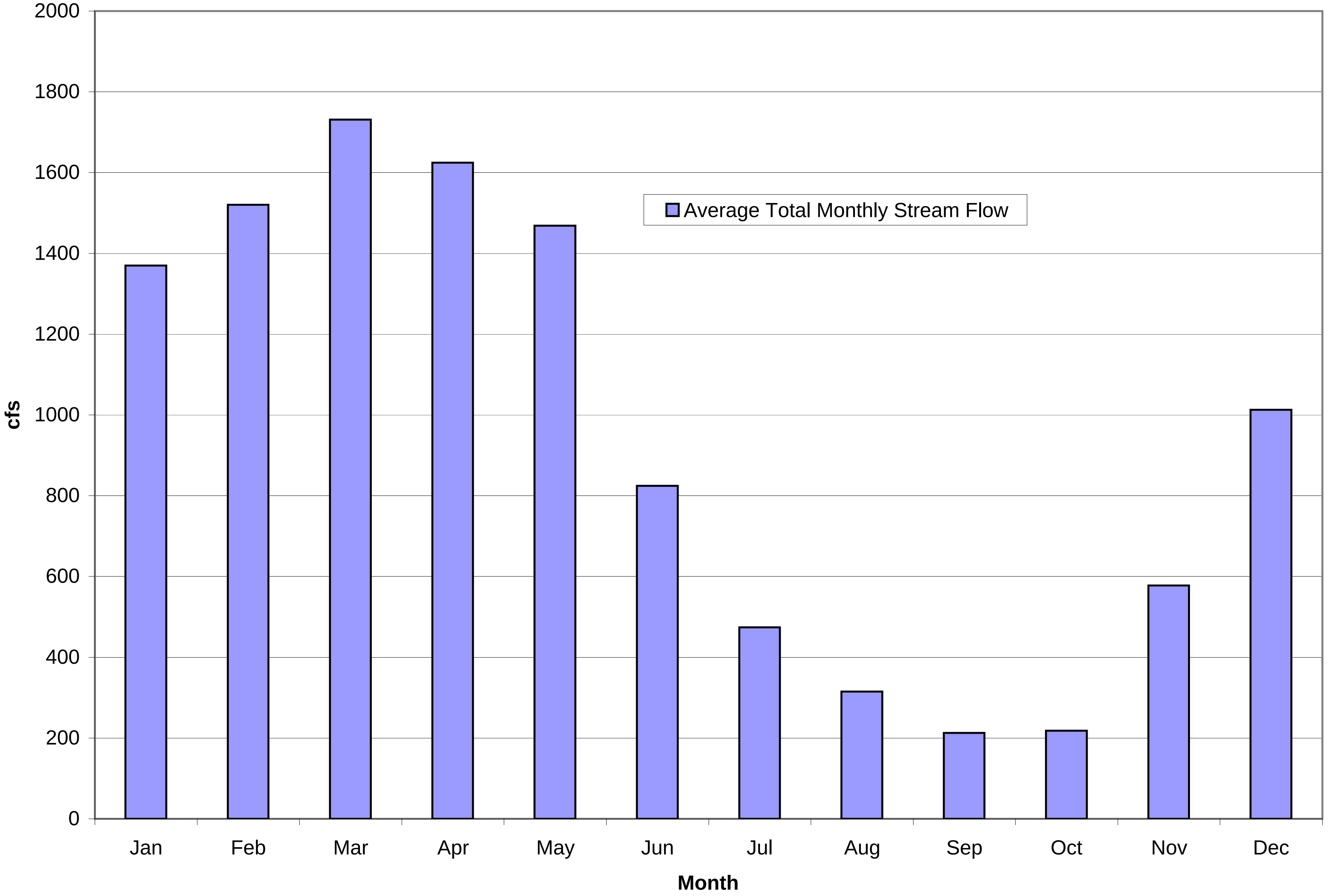

CDM

Figure 2-5:
Average Total Monthly Streamflow at
USGS gage 03379500
Little Wabash River below Clay City, IL

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Section 3
Public Participation and Involvement

3.1 Little Wabash River Watershed Public Participation and Involvement

Public knowledge, acceptance, and follow through are necessary to implement a plan to meet recommended TMDLs. It is important to involve the public as early in the process as possible to achieve maximum cooperation and counter concerns as to the purpose of the process and the regulatory authority to implement any recommendations.

Illinois EPA, along with CDM, will hold up to four public meetings within the watershed throughout the course of the TMDL development. This section will be updated once public meetings have occurred.

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Section 4
Little Wabash River Watershed Water Quality Standards

4.1 Illinois Water Quality Standards

Water quality standards are developed and enforced by the state to protect the "designated uses" of the state's waterways. In the state of Illinois, setting the water quality standards is the responsibility of the Illinois Pollution Control Board (IPCB). Illinois is required to update water quality standards every three years in accordance with the CWA. The standards requiring modifications are identified and prioritized by Illinois EPA, in conjunction with USEPA. New standards are then developed or revised during the three-year period.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois water quality standards are established in the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards.

4.2 Designated Uses

The waters of Illinois are classified by designated uses, which include: General Use, Public and Food Processing Water Supplies, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life Use (Illinois EPA 2005). The designated uses applicable to the Little Wabash River Watershed are the General Use and Public and Food Processing Water Supplies Use.

4.2.1 General Use

The General Use classification is defined by IPCB as standards that "will protect the state's water for aquatic life, wildlife, agricultural use, secondary contact use and most industrial uses and ensure the aesthetic quality of the state's aquatic environment." Primary contact uses are protected for all General Use waters whose physical configuration permits such use.

4.2.2 Public and Food Processing Water Supplies

The Public and Food Processing Water Supplies Use is defined by IPCB as standards that "are cumulative with the general use standards of Subpart B and must be met in all waters designated in Part 303 at any point at which water is withdrawn for treatment and distribution as a potable supply or for food processing."

4.3 Illinois Water Quality Standards

To make 303(d) listing determinations for aquatic life uses, Illinois EPA first collects biological data and if this data suggests that an impairment to aquatic life exists, then a comparison of available water quality data with water quality standards will then occur. For public and food processing water supply waters, Illinois EPA compares available data with water quality standards to make impairment determinations. Tables 4-1 and 4-2 present the water quality standards of the potential causes of impairment for both lakes and streams in the Little Wabash River Watershed. Only constituents with numeric water quality standards will have TMDLs developed at this time.

Table 4-1 Summary of Water Quality Standards for Potential Little Wabash River Watershed Lake Impairments

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies
Excess Algal Growth	NA	No numeric standard	No numeric standard
Manganese (total)	µg/L	1000	150
Total Phosphorus	mg/L	0.05$^{(1)}$	No numeric standard
Total Phosphorus - Statistical Guideline	NA	No numeric standard	No numeric standard
Total Suspended Solids	NA	No numeric standard	No numeric standard

µg/L = micrograms per liter mg/L = milligrams per liter NA = Not Applicable

(1) Standard applies in particular inland lakes and reservoirs (greater than 20 acres) and in any stream at the point where it enters any such lake or reservoir.

Table 4-2 Summary of Water Quality Standards for Potential Little Wabash River Watershed Stream Impairments

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies
Atrazine	mg/L	Acute standard$^{(1)}$ = 82 Chronic standard$^{(2)}$ = 9	No numeric standard
Habitat Alterations (Streams)	NA	No numeric standard	No numeric standard
Manganese (total)	µg/L	1000	150
Oxygen, Dissolved	mg/L	5.0 instantaneous minimum; 6.0 minimum during at least 16 hours of any 24 hour period	No numeric standard

Table 4-2 Summary of Water Quality Standards for Potential Little Wabash River Watershed Stream Impairments (continued)

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies
pH		6.5 minimum 9.0 maximum	No numeric standard
Sedimentation/ Siltation	NA	No numeric standard	No numeric standard
Silver (total)	µg/L	5	No numeric standard
Total Fecal Coliform	Count/ 100 mL	May through Oct – 200(3), 400(4) Nov though Apr – no numeric standard	2000(3)
Total Phosphorus - Statistical Guideline	mg/L	No numeric standard	No numeric standard
Total Suspended Solids	NA	No numeric standard	No numeric standard

µg/L = micrograms per liter mg/L = milligrams per liter NA = Not Applicable

(1) Not to be exceeded except as provided in 35 Ill. Adm. Code 302.208(d).

(2) Not to be exceeded by the average of at least three samples collected over peak atrazine application periods (Spring, Summer, and Fall).

(3) Geometric mean based on a minimum of 5 samples taken over not more than a 30 day period.

(4) Standard shall not be exceeded by more than 10% of the samples collected during any 30 day period.

4.4 Potential Pollutant Sources

In order to properly address the conditions within the Little Wabash River Watershed, potential pollution sources must be investigated for the pollutants where TMDLs will be developed. The following is a summary of the potential sources associated with the listed causes for the 303(d) listed segments in this watershed. They are summarized in Table 4-3.

Table 4-3 Summary of Potential Sources for Little Wabash River Watershed

Segment ID	Segment Name	Potential Causes	Potential Sources
C 09	Little Wabash River	Manganese, silver, pH, sedimentation/siltation, dissolved oxygen, total suspended solids, atrazine, total fecal coliform, total phosphorus	Agriculture, non-irrigated crop production, source unknown
C 22	Little Wabash River	Total fecal coliform	Source unknown
CE 01	Village Creek	Manganese, sedimentation/siltation, dissolved oxygen, habitat alterations (streams)	Agriculture, crop-related sources, non-irrigated crop production, resource extraction, petroleum activities, habitat modification (other than hydromodification), bank or shoreline modification/destabilization, source unknown
RCU	Clay City SCR	Manganese, total suspended solids, excess algal growth, total phosphorus	Agriculture, crop-related sources, non-irrigated crop production, source unknown
C 33	Little Wabash River	Manganese, sedimentation/siltation, dissolved oxygen, total suspended solids, atrazine	Agriculture, crop-related sources, off-farm animal holding/management area, source unknown
CCA-FF-A1	Johnson Creek	Dissolved oxygen, habitat alterations (streams)	Urban runoff/storm sewers, habitat modification (other than hydromodification), removal of riparian vegetation
CC-FF-D1	Pond Creek	Dissolved oxygen, habitat alterations (streams)	Hydromodification, channelization, habitat modification (other than hydromodification), removal of riparian vegetation
RCZJ	Fairfield Reservoir	Manganese, Excess Algal growth	Agriculture, Crop-related Sources, Nonirrigated Crop Production, Hydromodification, Flow Regulation/Modification, Unknown Sources
CD 01	Elm River	Manganese, pH, sedimentation/siltation, dissolved oxygen, habitat alterations (streams), total suspended solids, atrazine, total fecal coliform	Agriculture, crop-related sources, non-irrigated crop production, resources extraction, petroleum activities, hydromodification, channelization, source unknown
CD 04	Elm River	Sedimentation/siltation, dissolved oxygen, habitat alterations (streams)	Agriculture, crop-related sources, non-irrigated crop production, intensive animal feeding operations, habitat modification (other than hydromodification), bank or shoreline modification/destabilization
CDG-FL-A1	Seminary Creek	Dissolved oxygen, total phosphorus	Agriculture, crop-related sources, non-irrigated crop production, urban runoff/storm sewers
CDG-FL-C6	Seminary Creek	Dissolved oxygen, habitat alterations (streams), total phosphorus	Municipal point sources, agriculture, crop-related sources, non-irrigated crop production, urban runoff/storm sewers, habitat modification (other than hydromodification), bank or shoreline modification/destabilization

Table 4-3 Summary of Potential Sources for Little Wabash River Watershed (continued)

Segment ID	Segment Name	Potential Causes	Potential Sources
CJ 06	Big Muddy Creek	Manganese, sedimentation/siltation, dissolved oxygen, habitat alterations (streams), total suspended solid, total phosphorus	Agriculture, crop-related sources, non-irrigated crop production, intensive animal feeding operations, hydromodification, channelization, source unknown
CJA 02	Little Muddy Creek	Manganese, sedimentation/siltation, dissolved oxygen, habitat alterations (streams)	Agriculture, crop-related sources, non-irrigated crop production, intensive animal feeding operations, hydromodification, channelization, source unknown
CJAE01	Big Muddy Diversion Ditch	Dissolved oxygen, habitat alterations (streams)	Hydromodification, channelization, source unknown
RCR	Newton Lake	Total phosphorus, total suspended solids, excess algal growth, total phosphorus	Agriculture, crop-related sources, non-irrigated crop production, habitat modification (other than hydromodification), bank or shoreline modification/destabilization

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Section 5
Little Wabash River Watershed Characterization

Data were collected and reviewed from many sources in order to further characterize the Little Wabash River watershed. Data have been collected in regards to water quality, reservoirs, and both point and nonpoint sources. This information is presented and discussed in further detail in the remainder of this section.

5.1 Water Quality Data

There are 18 historic water quality stations within the Little Wabash River watershed that were used for this report. Figure 5-1 shows the water quality data stations within the watershed that contain data relevant to the impaired segments.

The impaired water body segments in the Little Wabash River watershed were presented in Section 1. Refer to Table 1-1 for impairment information specific to each segment. The following sections address both stream and lake impairments. Data are summarized by impairment and discussed in relation to the relevant Illinois numeric water quality standard. Data analysis is focused on all available data collected in the last ten years. The information presented in this section is a combination of USEPA Storage and Retrieval (STORET) database and Illinois EPA database data. STORET data are available for stations sampled prior to January 1, 1999 while Illinois EPA data (electronic and hard copy) are available for stations sampled after that date. The following sections will first discuss Little Wabash River watershed stream data followed by Little Wabash River watershed reservoir data.

5.1.1 Stream Water Quality Data

The Little Wabash River watershed has 13 impaired stream segments within its drainage area that are addressed in this report. All but two of the segments (Pond Creek segment CC-FF-D1 and Johnson Creek segment CCA-FF-A1) have been assessed based on monitoring data. Illinois EPA uses the terms “monitored” and “evaluated” for their assessment levels. These terms apply only to assessments of primary and secondary contact uses in lakes and to aquatic life use in lakes and streams. Illinois EPA considers monitored assessments to be more reliable than evaluated assessments. According to the State’s 303(d) List, monitored assessments are based on current site-specific monitoring data believed to accurately portray existing water quality conditions. Monitoring data can include biological, chemical, or physical data no more than five years old. Evaluated assessments are those for which the resource-quality determinations are based on data types other than those used for monitored assessments. Other information can include land-use information, location of known point and nonpoint potential sources, monitoring data generally more than five years old, volunteer data, or documented site-specific knowledge.

There are 14 active water quality monitoring stations on impaired segments within the watershed (see Figure 5-1). The data summarized in this section include water quality data for impaired constituents as well as parameters that could be useful in future modeling and analysis efforts. All historic data are available in Appendix B.

5.1.1.1 Dissolved Oxygen

The following segments are listed as impaired for dissolved oxygen (DO): C09 and C33 of the Little Wabash River; CE01 of Village Creek; CCA-FF-A1 of Johnson Creek; CC-FF-D1 of Pond Creek; CD01 and CD04 of Elm River; CDG-FL-A1 and CDG-FL-C6 of Seminary Creek; CJ06 of the Big Muddy Creek; CJA02 of Little Muddy Creek; and CJAE01 of the Big Muddy Diversion Ditch. Table 5-1 summarizes the available historic DO data for the impaired stream segments. The water quality standard for DO is a minimum concentration of 5.0 mg/L. The table shows the number of violations for each segment. Only one sample was available for Village Creek segment CE01, Big Muddy Diversion Ditch segment CJAE01, Johnson Creek segment CCA-FF-A1, Pond Creek segment CC-FF-D1, and Seminary Creek segments CDG-FL-A1 and CDG-FL-C6. The single samples collected on Village Creek and the Big Muddy Diversion Ditch do not violate the standard. The remaining segments each had at least one violation of the standard.

Table 5-1 Existing Dissolved Oxygen Data for Little Wabash River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (mg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
Little Wabash River Segment C09; Sample Location C09						
DO	5.0(1)	1999-2003; 43	7.3	11.4	3.2	7
Village Creek Segment CE01; Sample Locations CE02						
DO	5.0(1)	2002; 1	12.8	12.8	12.8	0
Little Wabash River Segment C33; Sample Location C33						
DO	5.0(1)	1999-2002; 5	5.5	9.6	2.1	3
Elm River Segment CD01; Sample Location CD01						
DO	5.0(1)	1990-2003; 123	7.1	14.5	1.1	32
Elm River Segment CD04; Sample Locations CD02 and CD08						
DO	5.0(1)	2003; 3	4.6	6.5	3.0	2
Johnson Creek Segment CCA-FF-A1; Sample Location A1						
DO	5.0(1)	1997; 1	4.2	4.2	4.2	1
Pond Creek Segment CC-FF-D1; Sample Location D1						
DO	5.0(1)	1997; 1	3.9	3.9	3.9	1
Seminary Creek Segment CDG-FL-A1; Sample Location A1						
DO	5.0(1)	1998; 1	4.5	4.5	4.5	1
Seminary Creek Segment CDG-FL-C6; Sample Location C6						
DO	5.0(1)	1998; 1	3.8	3.8	3.8	1
Big Muddy Creek Segment CJ06; Sample Location CJ06						
DO	5.0(1)	2002; 3	5.1	8.5	1.2	1
Little Muddy Creek Segment CJA02; Sample Location CJA02						
DO	5.0(1)	2000-2002; 4	4.6	6.5	2.6	3
Big Muddy Diversion Ditch Segment CJAE01; Sample Location CJAE01						
DO	5.0(1)	2000; 1	15.1	15.1	15.1	0

(1) Instantaneous Minimum

Figure 5-2 shows the DO concentrations over time on segment C09 of the Little Wabash River and segment CD01 of the Elm River. Table 5-2 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for DO. Where available, all nutrient, BOD, and total organic carbon data has been collected for possible use in future analysis.

Table 5-2 Data Availability for DO Data Needs Analysis and Future Modeling Efforts

Sample Location and Parameter	Period of Record	Number of Samples
Little Wabash River Segment C09; Sample Location C09		
Carbon, Total Organic (mg/L as C)	1999-2002	32
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1999-2002	32
Nitrogen, Ammonia, Total (mg/L as N)	1999-2002	32
Nitrogen, Kjeldahl, Total (mg/L as N)	1999-2002	21
Phosphorus, Dissolved (mg/L as P)	1999-2002	32
Phosphorus, Total (mg/L as P)	1999-2002	32
Little Wabash River Segment C33; Sample Location C33		
Carbon, Total Organic (mg/L)	1999-2002	4
Nitrogen, Ammonia (NH3), Total mg/L	1999-2002	4
Nitrogen, Kjeldahl, Total mg/L	1999	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1999-2002	4
Phosphorus as P, Dissolved mg/L	1999-2002	4
Phosphorus as P, Total mg/L	1999-2002	4
Phosphorus, Total, Bottom Deposit (mg/kg-P Dry Wgt)	2002	1
Elm River Segment CD01; Sample Location CD01		
Ammonia, Unionized (Calc Fr Temp-pH-NH4) (mg/L)	1990-1998	81
Ammonia, Unionized (mg/L as N)	1990-1998	81
Carbon, Total Organic (mg/L)	2001-2002	9
COD, .025N K2CR2O7 (mg/L)	1990-1993	34
Nitrite plus Nitrate, Total 1 Det. (mg/L as N)	1990-1998	81
Nitrogen, Ammonia (NH3), Total mg/L	1990-2002	112
Nitrogen, Kjeldahl, Total mg/L	1999-2002	21
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1999-2002	31
Phosphorus, Dissolved (mg/L as P)	1990-2002	112
Phosphorus, Total (mg/L as P)	1990-2002	112
Phosphorus, Total, Bottom Deposit (mg/kg-P Dry Wgt)	199-2002	2
Elm River Segment CD04; Sample Locations CD02 and CD08		
Carbon, Total Organic (mg/L)	2002	2
Nitrogen, Ammonia (NH3), Total mg/L	2002	2
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	2002	2
Phosphorus as P, Dissolved mg/L	2002	2
Phosphorus as P, Total mg/L	2002	2
Carbon, Total Organic (mg/L)	2002	2
Nitrogen, Ammonia (NH3), Total mg/L	2002	2
Johnson Creek Segment CCA-FF-A1; Sample Location A1		
Carbon, Total Organic (mg/L)	1997	1
Nitrogen, Ammonia (NH3), Total mg/L	1997	1
BOD Total (mg/L)	1997	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1997	1
Phosphorus as P, Total mg/L	1997	1
Pond Creek Segment CC-FF-D1; Sample Location D1		
Carbon, Total Organic (mg/L)	1997	1
Nitrogen, Ammonia (NH3), Total mg/L	1997	1
BOD Total (mg/L)	1997	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1997	1
Phosphorus as P, Total mg/L	1997	1

Table 5-2 Data Availability for DO Data Needs Analysis and Future Modeling Efforts (cont.)

Sample Location and Parameter	Period of Record	Number of Samples
Seminary Creek Segment CDG-FL-A1; Sample Location A1		
Carbon, Total Organic (mg/L)	1998	1
Nitrogen, Ammonia (NH3), Total mg/L	1998	1
BOD Total (mg/L)	1998	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1998	1
Phosphorus as P, Total mg/L	1998	1
Seminary Creek Segment CDG-FL-C6; Sample Location C6		
Carbon, Total Organic (mg/L)	1998	1
Nitrogen, Ammonia (NH3), Total mg/L	1998	1
BOD Total (mg/L)	1998	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1998	1
Phosphorus as P, Total mg/L	1998	1
Big Muddy Creek Segment CJ06; Sample Location CJ06		
Carbon, Total Organic (mg/L)	2002	2
Nitrogen, Ammonia (NH3), Total mg/L	2002	2
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	2002	2
Phosphorus as P, Dissolved mg/L	2002	2
Phosphorus as P, Total mg/L	2002	2
Little Muddy Creek Segment CJA02; Sample Location CJA02		
Carbon, Total Organic (mg/L)	2000-2002	3
Nitrogen, Ammonia (NH3), Total mg/L	2000-2002	3
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	2000-2002	3
Phosphorus as P, Dissolved mg/L	2000-2002	3
Phosphorus as P, Total mg/L	2000-2002	3
Big Muddy Diversion Ditch Segment CJAE01; Sample Location CJAE01		
Carbon, Total Organic (mg/L)	2000	1
Nitrogen, Ammonia (NH3), Total mg/L	2000	1
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	2000	1
Phosphorus as P, Dissolved mg/L	2000	1
Phosphorus as P, Total mg/L	2000	1

5.1.1.2 pH

Segment C09 of the Little Wabash River and segment CD01 of the Elm River are listed as impaired for pH. Table 5-3 summarizes the available historic pH data for the impaired stream segments (raw data contained in Appendix B). The table also shows the number of violations recorded on each segment. A sample was considered a violation if the value was not within the 6.5-9.0 pH range. Figure 5-3 shows the pH values recorded over time on both segments. The violating samples found on both segments were below 6.5 standard units.

Table 5-3 Existing pH Data for Little Wabash River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (su)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
Elm River Segment CD01; Sample Location						
pH	6.5-9.0	1990-2002; 112	7.2	8.2	6.1	6
Little Wabash River Segment C09; Sample Location						
pH	6.5-9.0	1999-2003; 43	7.0	7.8	6.1	2

5.1.1.3 Total Fecal Coliform

Segments C09 and C22 of Little Wabash River, and segment CD 01 of Elm River are listed as impaired for total fecal coliform. The general use water quality standard for total fecal coliform is:

- 200 cfu/100 mL geometric mean based on a minimum of five samples taken over not more than a 30 day period during the months of May through October
- 400 cfu/100 mL shall not be exceeded by more than 10 percent of the samples collected during any 30 day period during the months of May through October

There are no instances since 1990 where at least five samples have been collected during a 30 day period. The summary of data presented in Table 5-4 reflects single samples compared to the standards during the appropriate months. Figure 5-4 shows the total fecal coliform samples collected over time on each segment.

Table 5-4 Total Fecal Coliform Data for Little Wabash River Watershed Impaired Stream Segment

Sample Location and Parameter	Period of Record and Number of Data Points	Geometric mean of all samples	Maximum	Minimum	Number of samples > 200 (1)	Number of samples > 400 (1)
Little Wabash River Segment C22; Sample Location C22						
Total Fecal Coliform (cfu/100 mL)	1990-2004; 101	241	29,000	10	52	35
Little Wabash River Segment C09; Sample Location C09						
Total Fecal Coliform (cfu/100 mL)	2004-2004; 12	142	10,000	8	2	2
Elm River Segment CD01; Sample Location CD01						
Total Fecal Coliform (cfu/100 mL)	1990-2004; 81	323	13,000	5	46	35

(1) Samples collected during the months of May through October

5.1.1.4. Manganese

The following segments are listed for impairments potentially caused by manganese: segments C09 and C33 of the Little Wabash River; CE01 or Village Creek; CD01 of Elm River; CJ06 of Big Muddy Creek; and CJA02 of Little Muddy Creek. The applicable water quality standard is a maximum total manganese concentration of 1,000 µg/L for general use and 150 µg/L for public water supply. Segments C09 and C33 are sources of public water and are subject to the more stringent standard. Table 5-5 summarizes the available historic manganese data since 1990 for the impaired stream segments. The table also shows the number of violations for each segment. Figure 5-5 plots the concentrations recorded on segments C09 and CD01 over time.

Table 5-5 Historic Manganese Data for Little Wabash River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (µg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
Little Wabash River Segment C09; Sampling Location C09						
Total Manganese	General Use: 1000	1999-2003; 43	391	950	70	0
	Public Water Supply: 150					39
Village Creek Segment CE01; Sampling Location CE02						
Total Manganese	General Use: 1000	2002; 1	2800	2800	2800	1
Little Wabash River Segment C33; Sampling Location C33						
Total Manganese	General Use: 1000	1999-2002; 5	586	1100	270	1
	Public Water Supply: 150					5
Elm River Segment CD01; Sampling Location CD01						
Total Manganese	General Use: 1000	1990-2002; 112	551	5600	15	13
Big Muddy Creek Segment CJ06; Sampling Location CJ06						
Total Manganese	General Use: 500	2002; 2	1770	3200	340	1
Little Muddy Creek Segment CJA02; Sampling Location CJA02						
Total Manganese	General Use: 1000	2000-2002; 4	1545	2400	180	3

5.1.1.5 Silver

Segment C09 of the Little Wabash River is listed as impaired for silver. The general use water quality standard for silver is a maximum total concentration of 5 µg/L. Table 5-6 contains a summary of the available total silver data collected on this segment. On February 19, 2002 a 15 µg/L total silver sample was collected. It is the only violation within the collected data set.

Table 5-6 Historic Silver Data for Little Wabash River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (µg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
Little Wabash River Segment C09; Sampling Location C09						
Total Silver	5	1999-2003; 43	3.3	15	3	1

5.1.1.6 Atrazine

Segments C09 and C33 of the Little Wabash River and segment CD01 of the Elm River are listed as impaired for atrazine. Table 5-7 summarizes available historic atrazine data on the segments. The water quality standard for atrazine states that the acute standard of 82 µg/L not be exceeded except as provided in 35 Ill. Adm. Code 302.208(d) and the chronic standard of 9 µg/L not be exceeded by the average of at least three samples collected over peak atrazine application periods (spring, summer, and fall). The chronic standard was violated once on segment C09 of the Little Wabash River and three times on segment CD01 of the Elm River. No water samples were available for segment C33 of the Little Wabash River. The values shown in the table for this segment reflect sediment data.

Table 5-7 Historic Atrazine Data for Little Wabash River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (µg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum
Little Wabash River Segment C09; Sampling Location C09					
Atrazine	chronic = 9	1999; 2	6.5	12	0.94
	Acute = 82				
Little Wabash River Segment C33; Sampling Location C33					
Atrazine (sediment)	NA	1999-2002; 2	50[(1), (2)]	50[(1), (2)]	50[(1), (2)]
	NA				
Elm River Segment CD01; Sampling Location CD01					
Atrazine	chronic = 9	1999-2002; 8	11.6	36	0.1
	Acute = 82				

(1) Samples were reported as less than the detection limit
(2) Sediment samples are in µg/kg.

5.1.2 Lake and Reservoir Water Quality Data

Fairfield Reservoir and Newton Lake are the impaired lakes within the watershed that are addressed in this report. The data summarized in this section include water quality data for the impaired constituents as well as parameters that could be useful in future modeling and analysis efforts. All historic data are available in Appendix B.

5.1.2.1 Fairfield Reservoir

There are three active stations in Fairfield Reservoir (see Figure 5-1). Fairfield Reservoir is listed as impaired for manganese. An inventory of all available manganese data are presented in Table 5-8.

Table 5-8 Fairfield Reservoir Data Inventory for Manganese

Fairfield Reservoir; Sample Locations RCZJ-1		
RCZJ-1	**Period of Record**	**Number of Samples**
Total Manganese	2000	5
Manganese in Bottom Deposits	2000	1

5.1.2.1.1 Manganese

The applicable water quality standard for manganese is 1,000 µg/L for general use and 150 µg/L for public water supplies. Table 5-9 shows all available manganese data for Fairfield Reservoir. Three out of five samples taken in 2000 violated the public water supply standard. The maximum total manganese concentration was 290 mg/L.

Table 5-9 Total Manganese Concentrations in Fairfield Reservoir

Fairfield Reservoir Site RCZJ-1			
Sample Date	**Sample Depth (ft)**	**Concentration (mg/L)**	**Violation**
5/10/2000	5	230	PWS
5/21/2000	6	140	None
7/12/2000	5	58	None
8/28/2000	4	290	PWS
10/19/2000	4	240	PWS

5.1.2.2 Newton Lake

There are three active stations on Newton Lake. The lake is listed for a total phosphorus impairment. An inventory of all available phosphorus data at all depths is presented in Table 5-10.

Table 5-10 Newton Lake Data Inventory for Impairments

Newton Lake Segment RCT; Sample Locations RCR-1, RCR-2, RCR-3		
RCR-1	**Period of Record**	**Number of Samples**
Total Phosphorus	1992-1998	30
Dissolved Phosphorus	1992-1998	29
Total Phosphorus in Bottom Deposits	1992-1995	3
RCR-2		
Total Phosphorus	1992-1998	16
Dissolved Phosphorus	1992-1998	16
RCR-3		
Total Phosphorus	1992-1998	16
Dissolved Phosphorus	1992-1998	16
Total Phosphorus in Bottom Deposits	1992-1995	3

Table 5-11 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for total phosphorus. DO and chlorophyll-a data has been collected where available.

Table 5-11 Newton Lake Data Availability for Data Needs Analysis and Future Modeling Efforts

Newton Lake Segment RCT; Sample Locations RCR-1, RCR-2, RCR-3		
RCR-1	**Period of Record**	**Number of Samples**
Chlorophyll-a Corrected	1992-1998	15
Chlorophyll-a Uncorrected	1992-1998	15
DO	1992-1998	310
RCR-2		
Chlorophyll-a Corrected	1992-1998	15
Chlorophyll-a Uncorrected	1992-1998	15
DO	1992-1998	150
RCR-3		
Chlorophyll-a Corrected	1992-1998	15
Chlorophyll-a Uncorrected	1992-1998	15
DO	1992-1998	152

5.1.2.2.1 Total Phosphorus

The water quality standard for total phosphorus is a maximum concentration of 0.05 mg/L. Compliance is assessed using samples collected at one-foot depth from the lake surface. The average total phosphorus concentrations at a one-foot depth for each year of available data at each monitoring site in Newton Lake are presented in Table 5-12.

Table 5-12 Average Total Phosphorus Concentrations (mg/L) in Newton Lake at one-foot depth

	RCR-1		**RCR-2**		**RCR-3**		**Lake Average**	
Year	**Data Count; Number of Violations**	**Average**	**Data Count; Number of Violations**	**Average**	**Data Count; Number of Violations**	**Average**	**Data Count; Number of Violations**	**Average**
1992	5;1	0.047	5;2	0.058	5;1	0.042	15;4	0.049
1995	5;3	0.058	6;6	0.078	6;3	0.086	17;12	0.074
1998	5;4	0.069	5;5	0.127	5;4	0.057	15;13	0.084

Figure 5-6 shows the average annual total phosphorus concentrations at each sampling location. Concentrations have increased each year with the exception of a slight decrease between 1995 and 1998 at site RCR-3.

5.2 Reservoir Characteristic

There are two impaired reservoirs in the Little Wabash River watershed. Reservoir information that can be used for future modeling efforts was collected from GIS analysis, the Illinois EPA, the U.S. Army Corp of Engineers, and USEPA water quality data. The following sections will discuss the available data for each reservoir.

5.2.1 Newton Lake

Newton Lake is located in Jasper County approximately eight miles southwest of the City of Newton. The lake has a surface area of 1,750 acres and a shoreline of 58 miles. Table 5-13 shows dam information for the lake while Table 5-14 contains depth information for each sampling location. The average maximum depth in Newton Lake is 38.2 feet.

Table 5-13 Newton Lake Dam Information (U.S. Army Corps of Engineers

Dam Length	1,700 feet
Dam Height	54 feet
Maximum Discharge	59,450 cfs
Maximum Storage	49,600 acre-feet
Normal Storage	28,500 acre-feet
Spillway Width	880 feet
Outlet Gate Type	S

Table 5-14 Average Depths (ft) for Newton Lake Segment RCR (Illinois EPA 2002 and USEPA 2002a)

Year	RCR-1	RCR-2	RCR-3
1992	37.1	17.7	19.1
1995	38.8	17.5	16.3
1998	38.7	17.2	18.1
Average	**38.2**	**17.5**	**17.8**

5.2.2 Fairfield Reservoir

Fairfield Reservoir is approximately 16 acres and is located on a tributary to the Little Wabash River in Wayne County east of the City of Fairfield. Table 5-15 shows dam information for the lake, while Table 5-16 contains depth information for the only sampling location on the lake. The average maximum water depth in 2000 was 9.0 feet.

Table 5-15 Fairfield Reservoir Dam Information (U.S. Army Corps of Engineers

Dam Length	1,160 feet
Dam Height	13 feet
Maximum Discharge	1,684 cfs
Maximum Storage	145 acre-feet
Normal Storage	37 acre-feet
Spillway Width	77 feet
Outlet Gate Type	U

Table 5-16 Average Depths (ft) for Fairfield Reservoir Segment RCZJ (Illinois EPA 2002 and USEPA 2002a)

Year	RCZJ-1
2000	9.0

5.3 Point Sources

Point sources for the Little Wabash River watershed have been separated into municipal/industrial sources and mining discharges. Available data have been summarized and are presented in the following sections.

5.3.1 Municipal and Industrial Point Sources

Permitted facilities must provide Discharge Monitoring Reports (DMRs) to Illinois EPA as part of their NPDES permit compliance. DMRs contain effluent discharge sampling results, which are then maintained in a database by the state. There are 17 point sources located within the Little Wabash River watershed. Figure 5-7 shows all permitted facilities that discharge directly to or upstream of the impaired segments addressed in this report. In order to assess point source contributions to the watershed, the data has been examined by receiving water and then by the downstream impaired segment that has the potential to receive the discharge. Receiving waters were determined through information contained in the USEPA Permit Compliance System (PCS) database. Maps were used to determine downstream impaired receiving water information when PCS data were not available. The impairments for each segment or downstream segment were considered when reviewing DMR data. Data has been summarized for any sampled parameter that is associated with a downstream impairment (i.e., all available nutrient and biological oxygen demand data were reviewed for segments that are impaired for dissolved oxygen [DO]). This will help in future model selection as well as source assessment and load allocation.

5.3.1.1 Little Wabash River Segments C 09 and C 22

There are six point sources with the potential to contribute discharges to Little Wabash River Segments C 09 and C 22. Segment C 09 is listed as impaired for manganese, silver, pH, DO, atrazine, and total fecal coliform. Segment C 22 is impaired for total fecal coliform. Table 5-17 contains a summary of available and pertinent DMR data for these point sources. Atrazine samples are not required by discharge permits; therefore, no atrazine data were available.

Table 5-17 Effluent Data from Point Sources Discharging To or Upstream of Little Wabash River Segments C 09 and C 22 (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Parkersburg STP 1999-2005 IL0071374	Unnamed tributary to Sugar Creek/Little Wabash River Segment C 09	Average Daily Flow	0.03 mgd	NA
		BOD, 5-Day	87.6 mg/L	
		CBOD, 5-Day	3.97 mg/L	5.19
		pH	7.60 su	

Table 5-17 Effluent Data from Point Sources Discharging To or Upstream of Little Wabash River Segments C 09 and C 22 (Illinois EPA 2005) (cont.)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Clay City WWTP 1992-2005 IL0020974	Unnamed ditch tributary to Little Wabash Creek/ Little Wabash River Segment C 22	Average Daily Flow	0.12 mgd	NA
		BOD, 5-Day	17.5 mg/L	
		CBOD, 5-Day	7.79 mg/L	4.11
		Total Fecal Coliform	223.6 mg/L	
		Oxygen, Dissolved	7.04 mg/L	
		pH	7.96 su	
Charleston STP 1989-2005 IL0021644	Cassell Creek/Little Wabash River Segment C 09	Average Daily Flow	3.3 mgd	NA
		BOD, 5-Day	79.7 mg/L	
		CBOD, 5-Day	18.6 mg/L	2.01
		Fecal Coliform	482 cfu	
		Nitrogen, Ammonia	0.434 mg/L	5.12
		Manganese	0.018 mg/L	
		pH	7.58 su	
Noble STP 1989-2005 IL0025500	Hog Run Creek/Little Wabash River Segment C 22	Average Daily Flow	0.1 mgd	NA
		BOD, 5-Day	35.0 mg/L	24.1
		CBOD, 5-Day	15.2 mg/L	15.1
		Fecal Coliform	261 cfu	
		Nitrogen, Ammonia	2.33 mg/L	
		pH	7.08 su	
Shell Pipeline-Clay City 2002-2003 IL0076074	NA/Little Wabash River Segment C 09	Average Daily Flow	0.105 mgd	NA
Mt. Erie WTP 1996-2005 ILG640143	Newton Branch/Little Wabash River Segment C 09	Average Daily Flow	0.0006 mgd	NA
		pH	8.14 su	

5.3.1.2 Little Wabash River Segment C 33, Johnson Creek Segment CCA-FF-A1, and Pond Creek Segment CC-FF-D1

There are three permitted facilities that discharge to or upstream of Johnson Creek, Pond Creek, and Little Wabash River segment C 33. Johnson and Pond Creek are listed as impaired for DO while segment C33 of the Little Wabash River is listed for manganese, DO, and atrazine impairments. Table 5-18 contains a summary of available DMR data for these point sources. No manganese or atrazine data were available.

Table 5-18 Effluent Data from Point Sources Discharging to or Upstream of Little Wabash River Segment C 33, Johnson Creek, and Pond Creek (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Fairfield STP 1989-2005 IL0020605	Johnson Creek/Johnson Creek Segment CCA-FF-A1 and Pond Creek Segment CC-FF-D1	Average Daily Flow	0.91 mgd	NA
		BOD, 5-Day	65.3 mg/L	61
		CBOD, 5-Day	1.97 mg/L	17.8
		Nitrogen, Ammonia	0.318 mg/L	2.45
Crossville STP 1999-2005 ILG580211	Elliott Creek/Little Wabash River Segment C 33	Average Daily Flow	0.25 mgd	NA
		BOD, 5-Day	138.3 mg/L	
		CBOD, 5-Day	13.4 mg/L	58.7
Fairfield WTP 1996-2005 ILG640137	NA/Little Wabash River Segment C 33	Average Daily Flow	0.044 mgd	NA

5.3.1.3 Elm River Segments CD 01 and CD 04 and Seminary Creek Segment CDG-FL-A1

There are five point sources with the potential to contribute discharge to Elm River segments CD 01 and CD 04 and Seminary Creek segment CDG-FL-A1 directly or through tributaries. Each of the segments is impaired for DO. In addition, segment CD 01 is also listed as impaired for manganese, pH, atrazine, and total fecal coliform. Table 5-19 contains a summary of available DMR data for these point sources. Atrazine data were not available.

Table 5-19 Effluent Data from Point Sources Discharging to Elm River Segments CD 01 and CD 04 and Seminary Creek Segment CDG-FL-A1 (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Flora STP 1989-2005 IL0020273	Seminary Creek/ Seminary Creek Segment CDG-FL-A1	Average Daily Flow	1.0 mgd	NA
		BOD, 5-Day	77.0 mg/L	417.9
		CBOD, 5-Day	19.0 mg/L	94.9
		Manganese	0.041	
		Nitrogen, Ammonia	0.603 mg/L	3.91
		pH	7.48 su	
Flora City of-Charlie Brown Pk 1999-2005 IL0047481	Unnamed tributary of Raccoon Creek/Elm River Segments CD 04	Average Daily Flow	0.003 mgd	NA
		BOD, 5-Day	41.6 mg/L	
		CBOD, 5-Day	0.812 mg/L	0.148
		Nitrogen, Ammonia	0.155 mg/L	0.0044
		pH	7.44 su	
Flora WTP 2000-2005 IL0074403	Unnamed tributary to Elm Creek/Elm River Segments CD 04	Average Daily Flow	0.027 mgd	NA
		pH	7.65 su	
Jeffersonville STP 1994-2005 ILG580076	Martin Creek/Elm River Segments CD 01	Average Daily Flow	0.032 mgd	NA
		BOD, 5-Day	244 mg/L	
		CBOD, 5-Day	22.3 mg/L	14.2
		pH	7.88 su	
Cisne STP 1999-2005 ILG580197	Deer Creek, Elm River, Little Wabash River/Elm River Segments CD 01	Average Daily Flow	0.08 mgd	NA
		BOD, 5-Day	136.5 mg/L	
		CBOD, 5-Day	11.8 mg/L	7.56
		pH	7.89 su	

5.3.1.4 Big Muddy Creek Segment CJ 06

There is only one point source with the potential to contribute discharge to Big Muddy Creek segment CJ 06. Segment CJ 06 is impaired for manganese and DO. Table 5-20 contains a summary of available DMR data for this point source. Manganese data were not available.

Table 5-20 Effluent Data from Point Sources Discharging Upstream of Big Muddy Creek Segment CJ 06 (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Dieterich STP 1992-2005 IL0044792	Tributary to Big Muddy Creek, Little Wabash River/Big Muddy Creek Segment CJ 06	Average Daily Flow	0.08 mgd	NA
		BOD, 5-Day	116.4 mg/L	—
		CBOD, 5-Day	20.6 mg/L	9.09
		Oxygen, Dissolved	16.7 mg/L	

5.3.1.5 Little Muddy Creek Segment CJA 02

There is one point source with the potential to contribute discharge to Little Muddy Creek segment CJA 02. Segment CJA 02 is impaired for manganese and DO. Table 5-21 contains a summary of available DMR data for this point source.

Table 5-21 Effluent Data from Point Sources Discharging Upstream of Little Muddy Creek Segment CJA 02 (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Greenville WTP 1994-2004 ILG640030	NA/Little Muddy Creek Segment CJA 02	Average Daily Flow	0.08 mgd	NA

5.3.1.6 Newton Lake Segment RCR

There is one point source that discharges to Newton Lake segment RCR. Segment RCR has a total phosphorus impairment. Table 5-22 contains a summary of available DMR data. Total phosphorus data were not available.

Table 5-22 Effluent Data from Point Sources Discharging To Newton Lake Segment RCR (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Ameren Energy-Newton 1989-2005 IL0049191	Newton Lake/Newton Lake Segment RCR	Average Daily Flow	415.7 mgd	NA

5.3.1.7 Other Impaired Segments

There are no permitted facilities that discharge to Village Creek segment CE 01, Fairfield Reservoir segment RCZJ, or Big Muddy Diversion Ditch CJA01.

5.3.2 Mining

There are no permitted mine sites or recently abandoned mines within the Little Wabash River watershed. If other mining data become available, it will be reviewed and appropriate information will be incorporated into Stage 3 of TMDL development.

5.4 Nonpoint Sources

There are many potential nonpoint sources of pollutant loading to the impaired segments in the Little Wabash River watershed. This section will discuss site-specific cropping practices, animal operations, and area septic systems. Data were collected through communication with local NRCS, Soil and Water Conservation District (SWCD), Public Health Department, and County Tax Department officials.

5.4.1 Crop Information

The majority of the land found within the Little Wabash River watershed is devoted to crops. Corn and soybean farming account for about 29 percent and 35 percent of the watershed respectively. Tillage practices can be categorized as conventional till, reduced till, mulch-till, and no-till. The percentage of each tillage practice for corn, soybeans, and small grains by county are generated by the Illinois Department of Agriculture from County Transect Surveys. The most recent survey was conducted in 2004. Data specific to the Little Wabash River watershed was not available; however, the Effingham, Jasper, Richland, Clay, Wayne, Edwards, and White County practices were available and are as shown.

Table 5-23 Tillage Practices in Effingham County

Tillage System	Corn	Soybean	Small Grain
Conventional	91%	63%	91%
Reduced - Till	2%	9%	0%
Mulch - Till	1%	3%	0%
No - Till	6%	25%	9%

Table 5-24 Tillage Practices in Jasper County

Tillage System	Corn	Soybean	Small Grain
Conventional	80%	21%	7%
Reduced - Till	5%	24%	34%
Mulch - Till	2%	7%	0%
No - Till	13%	48%	59%

Table 5-25 Tillage Practices in Richland County

Tillage System	Corn	Soybean	Small Grain
Conventional	61%	13%	87%
Reduced - Till	1%	2%	0%
Mulch - Till	11%	14%	3%
No - Till	27%	71%	10%

Table 5-26 Tillage Practices in Clay County

Tillage System	Corn	Soybean	Small Grain
Conventional	63%	26%	10%
Reduced - Till	1%	0%	10%
Mulch - Till	5%	9%	27%
No - Till	31%	64%	53%

Table 5-27 Tillage Practices in Wayne County

Tillage System	Corn	Soybean	Small Grain
Conventional	49%	18%	31%
Reduced - Till	17%	4%	46%
Mulch - Till	13%	16%	23%
No - Till	20%	62%	0%

Table 5-28 Tillage Practices in Edwards County

Tillage System	Corn	Soybean	Small Grain
Conventional	71%	31%	92%
Reduced - Till	0%	1%	0%
Mulch - Till	4%	19%	3%
No - Till	25%	50%	5%

Table 5-29 Tillage Practices in White County

Tillage System	Corn	Soybean	Small Grain
Conventional	37%	19%	0%
Reduced - Till	0%	2%	0%
Mulch - Till	2%	5%	0%
No - Till	61%	74%	100%

Estimates on tile drainage were provided by the County NRCS offices. Tile drainage in Clay County is not economically feasible because of tight clay subsoils. In the White County portion of the watershed, about one-quarter of the area has drainage tile installed. In addition to this drainage tile, about 2,000 acres of the White County portion of the watershed have been treated with terraces/tile. Jasper County has indicated that no tile drainage information is available. Tile drainage in the Richland County portion of the watershed is estimated to be 8,550 feet, including terraces and water and sediment control basins (WASCOBs). Approximately 20 to 25 percent of the Wayne County portion of the watershed is tiled, and approximately 35 to 40 percent of the Edwards portion of the watershed is tiled.

5.4.2 Animal Operations

Watershed specific animal numbers were not available for the Little Wabash River watershed. Data from the National Agricultural Statistics Service were reviewed and are presented below to show countywide livestock numbers. Data from Effingham, Jasper, Richland, Clay, Wayne, Edwards, and White Counties are presented in the following tables.

Table 5-30 Effingham County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	22,272	27,885	25%
Beef	5,480	4,723	-14%
Dairy	5,024	4,932	-2%
Hogs and Pigs	99,324	82,513	-17%
Poultry	701	608	-13%
Sheep and Lambs	921	918	0%
Horses and Ponies	NA	1,089	NA

Table 5-31 Jasper County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	12,813	10,332	-19%
Beef	3,018	3,004	0%
Dairy	1,980	1,130	-43%
Hogs and Pigs	108,660	88,901	-18%
Poultry	517	553	7%
Sheep and Lambs	424	263	-38%
Horses and Ponies	NA	448	NA

Table 5-32 Richland County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	6,947	4,278	-38%
Beef	2,703	NA	NA
Dairy	635	NA	NA
Hogs and Pigs	46,250	84,792	83%
Poultry	372	286	-23%
Sheep and Lambs	189	NA	NA
Horses and Ponies	NA	174	NA

Table 5-33 Clay County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	7,717	8,687	13%
Beef	3,516	NA	NA
Dairy	56	NA	NA
Hogs and Pigs	21,757	34,389	58%
Poultry	380	378	-1%
Sheep and Lambs	599	1,405	135%
Horses and Ponies	NA	562	NA

Table 5-34 Wayne County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	19,867	15,867	-20%
Beef	8,119	NA	NA
Dairy	602	NA	NA
Hogs and Pigs	59,253	59,970	1%
Poultry	441	479	9%
Sheep and Lambs	186	306	65%
Horses and Ponies	NA	858	NA

Table 5-35 Edwards County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	6,175	7,655	24%
Beef	2,632	3,496	33%
Dairy	NA	NA	NA
Hogs and Pigs	37,193	18,708	-50%
Poultry	79	137	73%
Sheep and Lambs	526	675	28%
Horses and Ponies	NA	196	NA

Table 5-36 White County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	6,625	6,447	-3%
Beef	3,498	2,990	-15%
Dairy	7	6	-14%
Hogs and Pigs	21,357	14,021	-34%
Poultry	622	384	-38%
Sheep and Lambs	72	NA	NA
Horses and Ponies	NA	457	NA

Illinois EPA provided a GIS shapefile illustrating the location of livestock facilities in the Little Wabash River basin. In 2000, Illinois EPA assessed the potential impact of each facility on water quality with regard to the size of the facility, the site condition and management, pollutant transport efficiency, and water resources vulnerability. This GIS data has been used as a reference since the surveys were conducted at the beginning of the decade. At the time of the survey, 57 facilities existed within the watershed. Of these facilities, nine were listed as feedlots and the rest were classified as animal management areas. There were also 11 dairies listed among the facilities.

Communications with local NRCS officials have also provided watershed-specific animal information. In the Clay County portion of the Little Wabash watershed, there are four impaired segments. The impaired segment of Big Muddy Creek has five hog operations of about 3,500 head each, two sheep operations of about 175 head each, and eight beef operations of about 350 head each in its subwatershed. The impaired segment of the Little Muddy Creek has one hog operation of about 1,500 swine in its subwatershed. The impaired segment of Seminary Creek has four beef operations of about 300 cattle each in its subwatershed. And finally, the impaired segment of the Elm River has two beef operations of 80 cattle each and one hog operation of 2,500 swine in its subwatershed.

The Jasper County NRCS indicated that within the Jasper County portion of the watershed, it is estimated that a total of 62 livestock operations exist. The majority of the livestock operations are beef, averaging between 50 and 150 head count, and swine, averaging between 300 and 700 head, with a few dairies, averaging between 50 and 150 head count. The White County portion of the watershed has approximately 15 cattle operations, all pasture (none confined), of approximately 200 cattle each. In the Richland County portion of the watershed, it is estimated that approximately six swine operations and seven cattle operations exist. Four swine operations have a head count greater than 100, two swine operations have a head count less than 100, and each of the cattle operations have a head count less than 30. In the portion of the watershed in Wayne County, it is estimated that the following livestock operations exist: 60 cattle operations with a total of 11,900 cows; 12 swine operations with a total of 12,000 hogs; 5 horse operations with a total of 600 horses; and 15 sheep/goat operations with a total of 1,500 sheep and goats. In the portion of the watershed in Edwards County, it is estimated that the following operations exist: 15 cattle operations with a total of 1,100 cows; 18 swine operations with a total of 10,000 hogs; five horse operations with a total of 120 horses; and 10 sheep/goat operations with a total of 500 sheep/goats.

5.4.3 Septic Systems

Many households in rural areas of Illinois that are not connected to municipal sewers make use of onsite sewage disposal systems, or septic systems. There are many types of septic systems, but the most common septic system is composed of a septic tank draining to a septic field, where nutrient removal occurs. However, the degree of nutrient removal is limited by soils and system upkeep and maintenance.

Table 5-37 Estimated Septic Systems within the Little Wabash River Watershed

County	Estimated No. of Septic Systems	Source of Septic Areas/ No. of Septic Systems
Effingham	negligible	
Clay	24	U.S. Census Bureau
Jasper	200	Health Department
Richland	560	Tax Assessor
Edwards	NA	
Wayne	2,638	Health Department
White	300	Health Department
Total	**3,722**	

Information on septic systems within the Little Wabash River watershed has been gathered from each of the counties that exist within the watershed boundaries. Generally, information on sewered and septic municipalities was obtained from the county health departments. However, in villages with populations less than 300, it was assumed that households are on septic systems (Illinois Department of Health) and U.S. Census Bureau data on number of households was used to estimate the number of septic systems. In some cases, county health departments were able to estimate the number of septic systems that exist. In counties where the health department was unable to provide estimates of the number of septic systems, the tax assessor was contacted to provide estimates of the number of existing residences located in areas known to be served by septic systems. Table 5-37 is a summary of the available septic system data in the Little Wabash River watershed.

Information on septic systems was obtained for five of the six major counties within the Little Wabash River watershed. There are approximately 3,700 septic systems in the watershed. It is estimated that all of the households within Jasper County, including the Village of Wheeler, are served by septic systems. In this county, where Newton Lake is located, 90 percent of the septic systems do not employ any form of secondary treatment. Generally, in this county, a septic tank discharges to a ditch, which drains to area waterbodies, including the Big Muddy River and Lake Newton.

5.5 Watershed Studies and Other Watershed Information

The extent of previous planning efforts within the Little Wabash watershed is not known. It is assumed that this information will become available through public meetings within the watershed community. In the event that other watershed-specific information becomes available, it will be reviewed and all applicable data will be incorporated during Stages 2 and 3 of TMDL development.

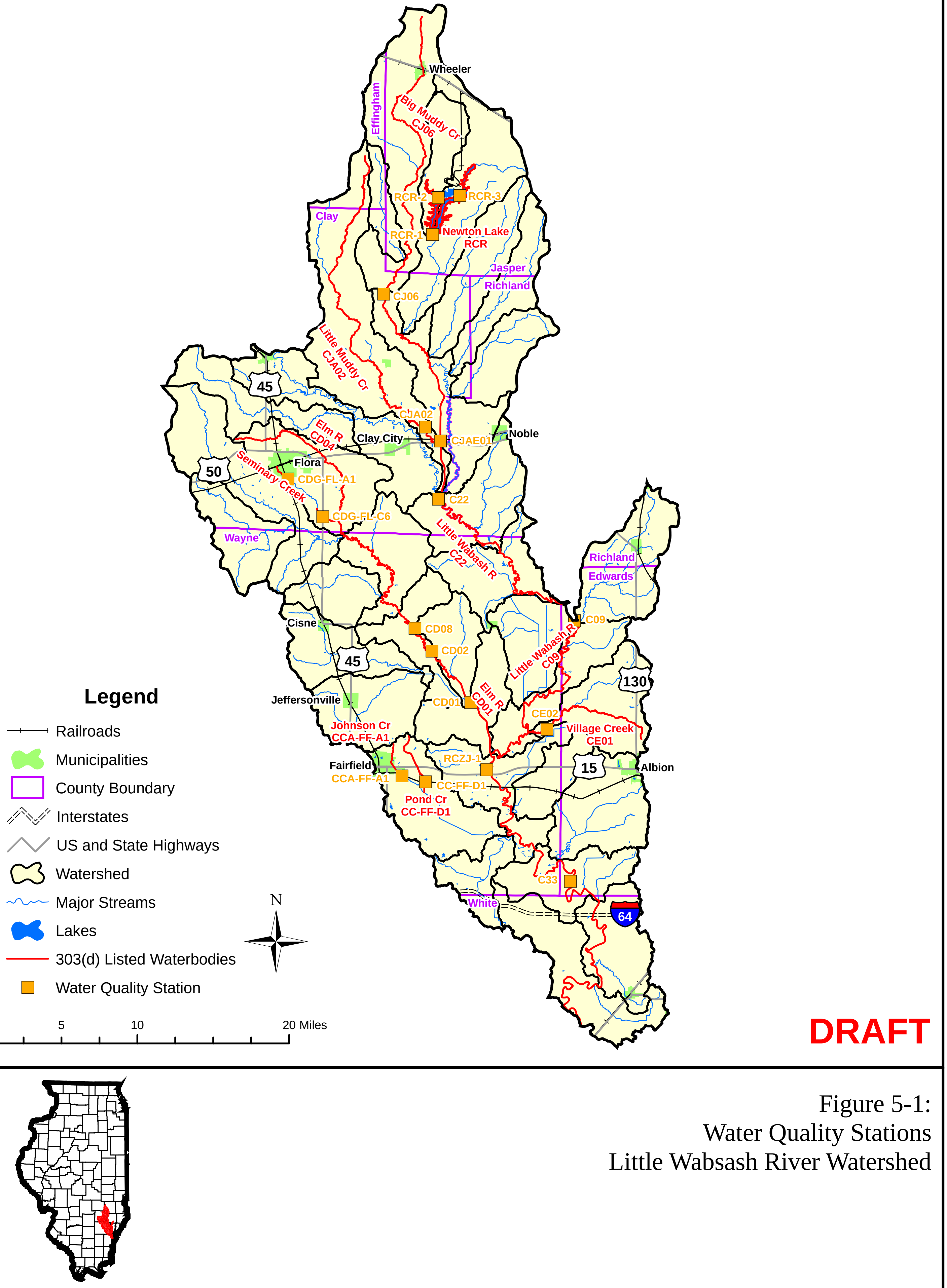

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Figure 5-1:
Water Quality Stations
Little Wabsash River Watershed

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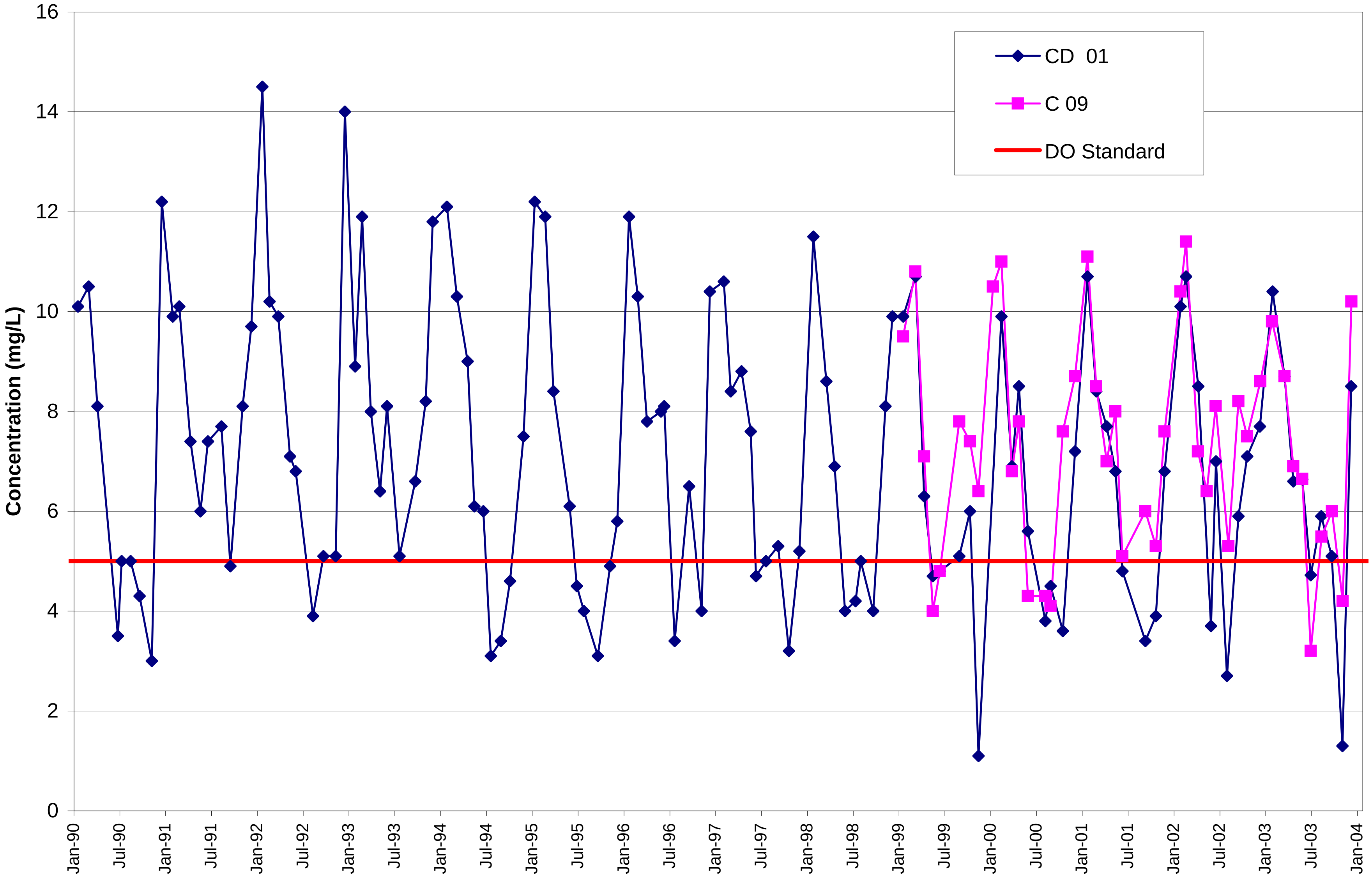

Figure 5-2:
DO Concentrations
Little Wabash River Segment C09 and
Elm River Segment CD01

CDM

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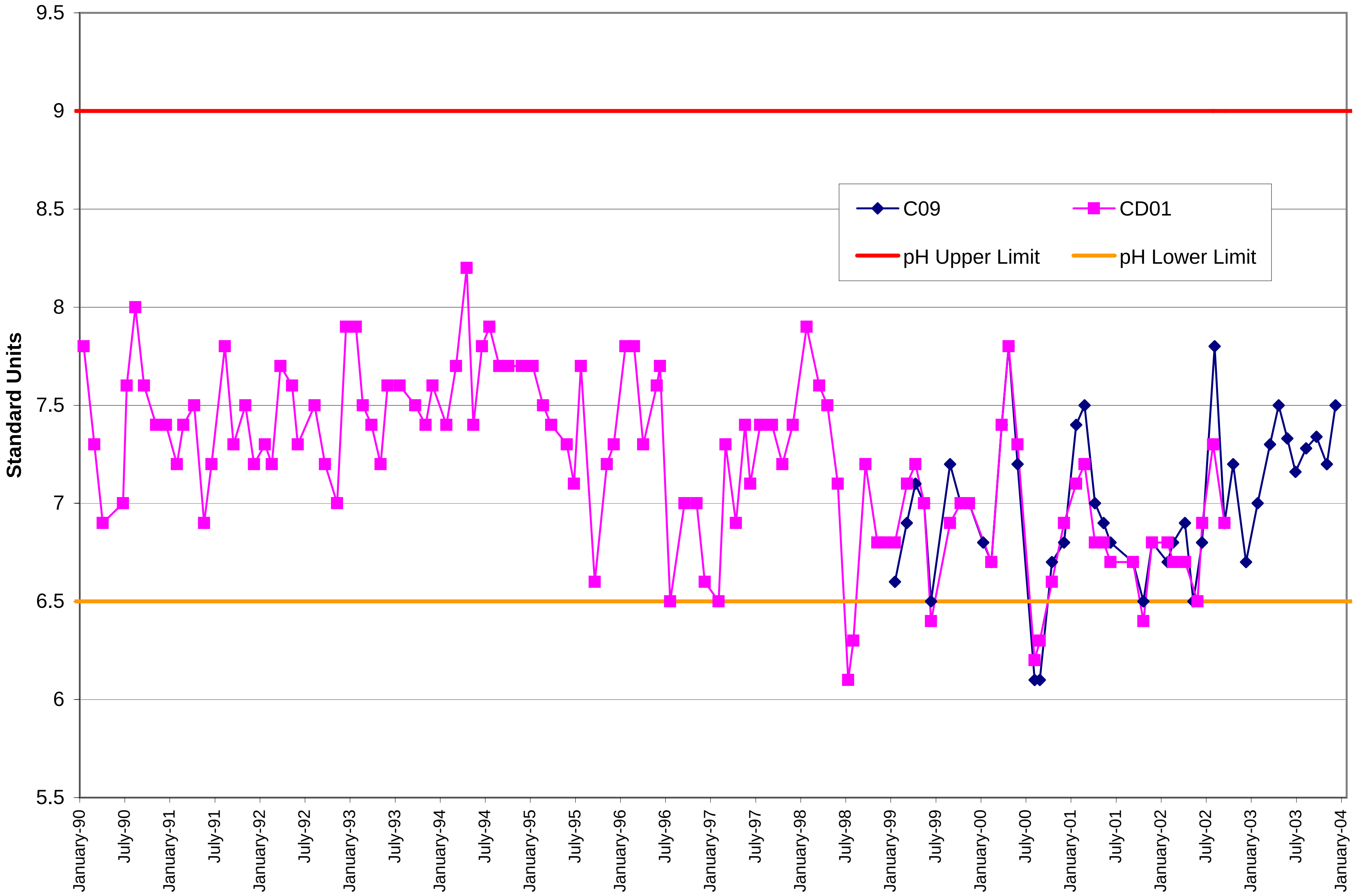

Figure 5-3:
pH Values
Little Wabash River Segment C09 and
Elm River Segment CD01

CDM

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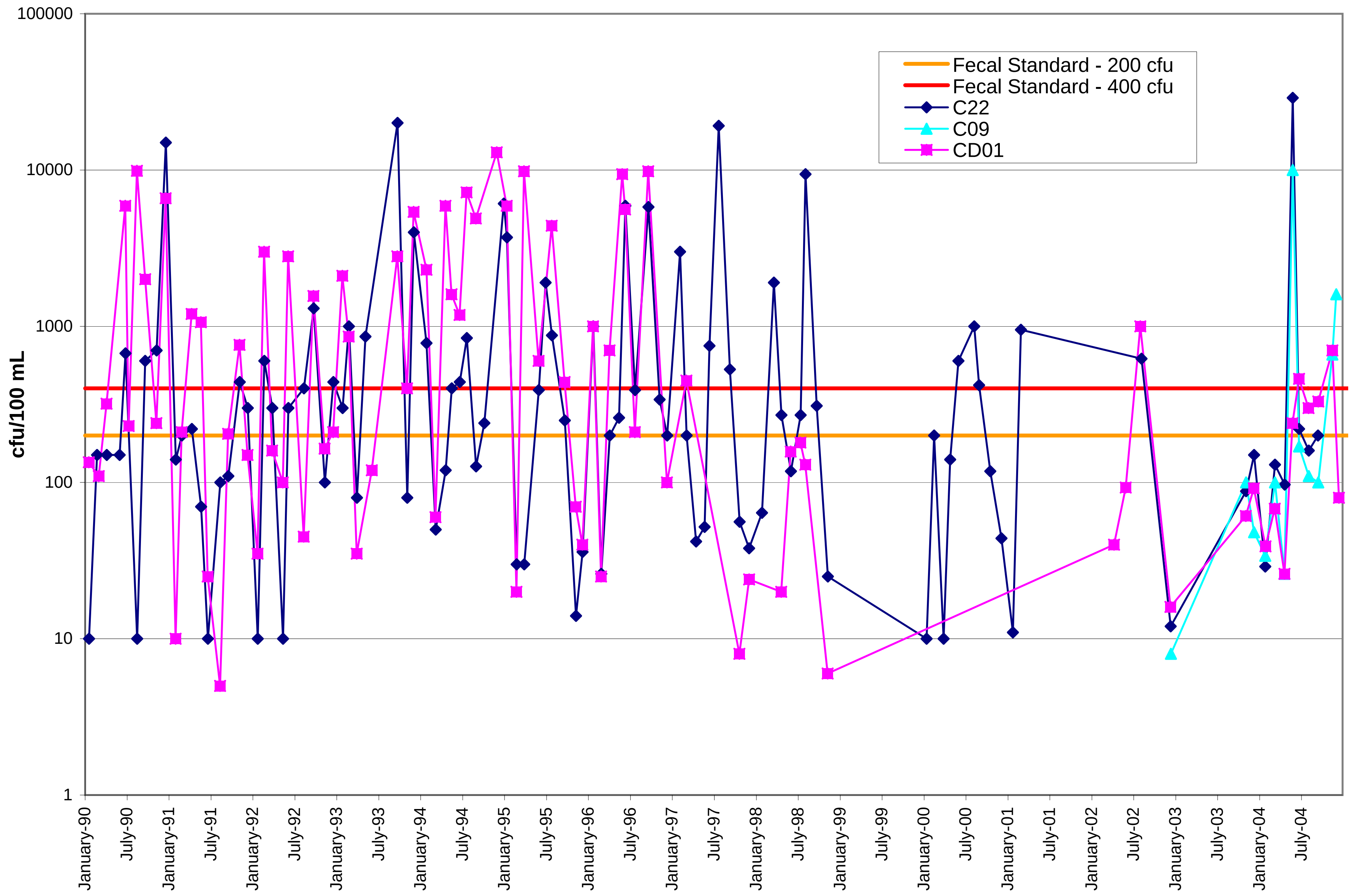

Figure 5-4:
Total Fecal Coliform
Little Wabash River C33, C09 and
Elm River CD01

CDM

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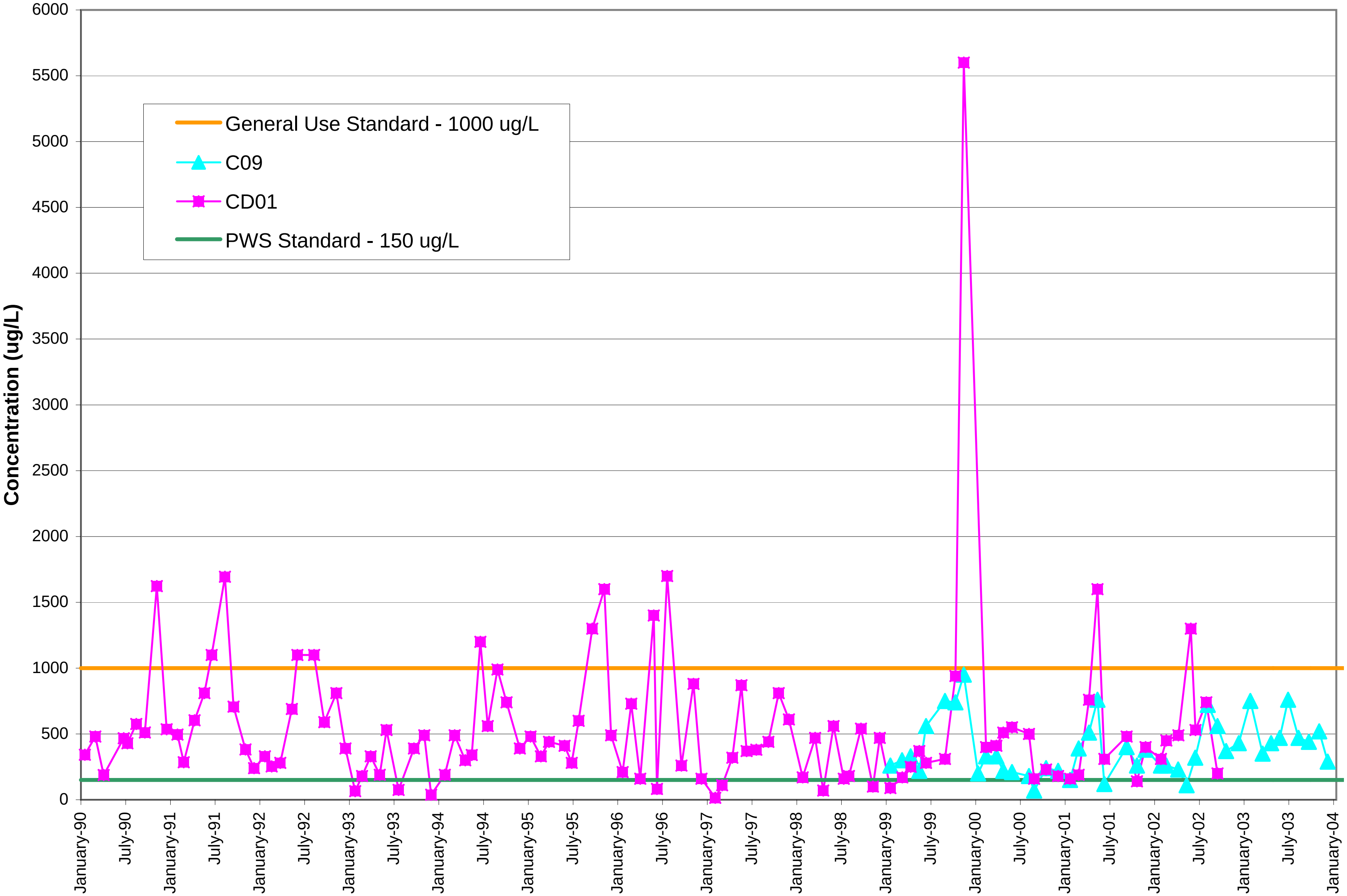

Figure 5-5:
Total Manganese Concentrations
Little Wabash Segment C09 and
Elm River Segment CD01

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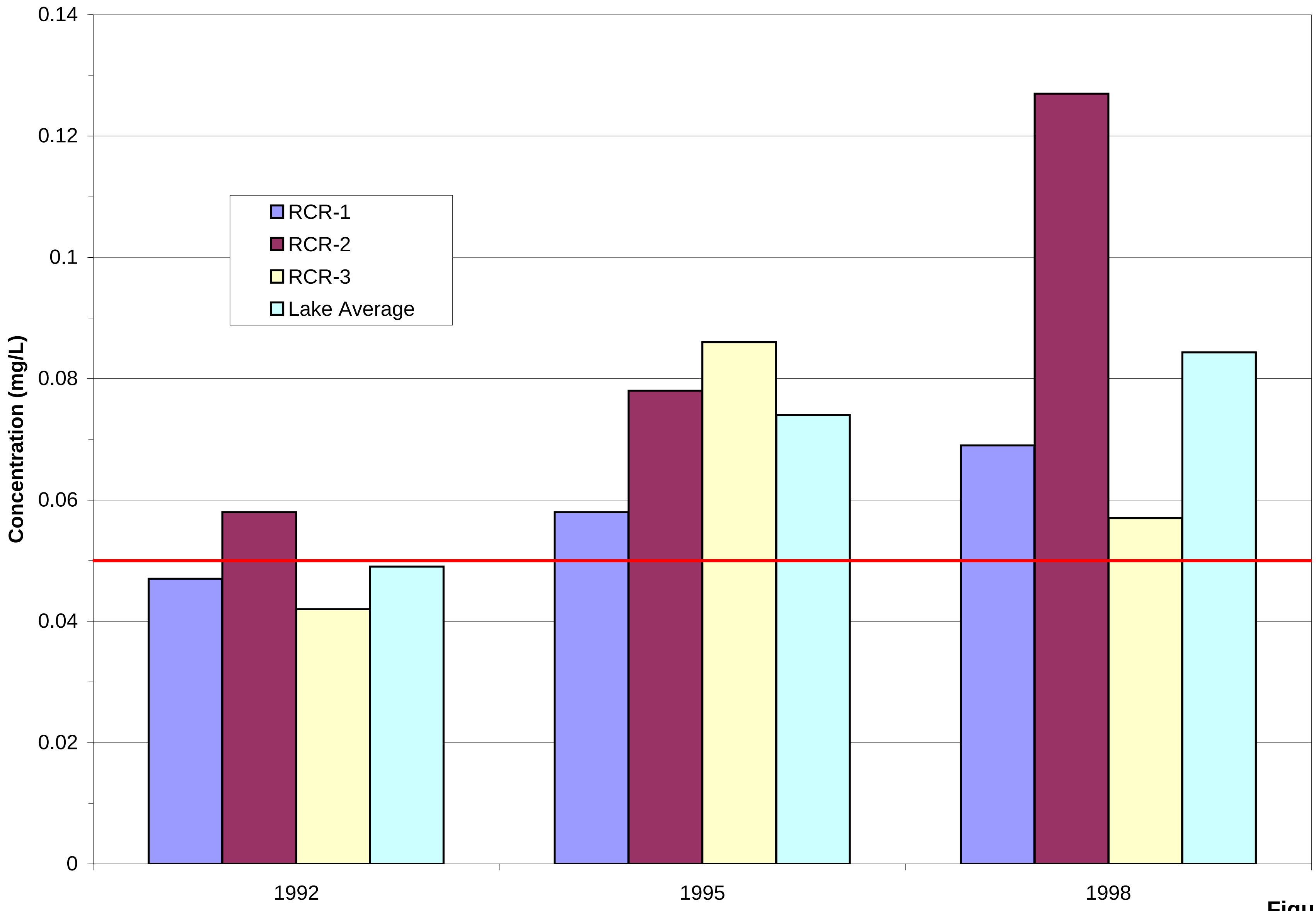

Figure 5-6:
Annual Average Total Phosphorus Concentrations
at One-Foot Depth
Newton Lake

CDM

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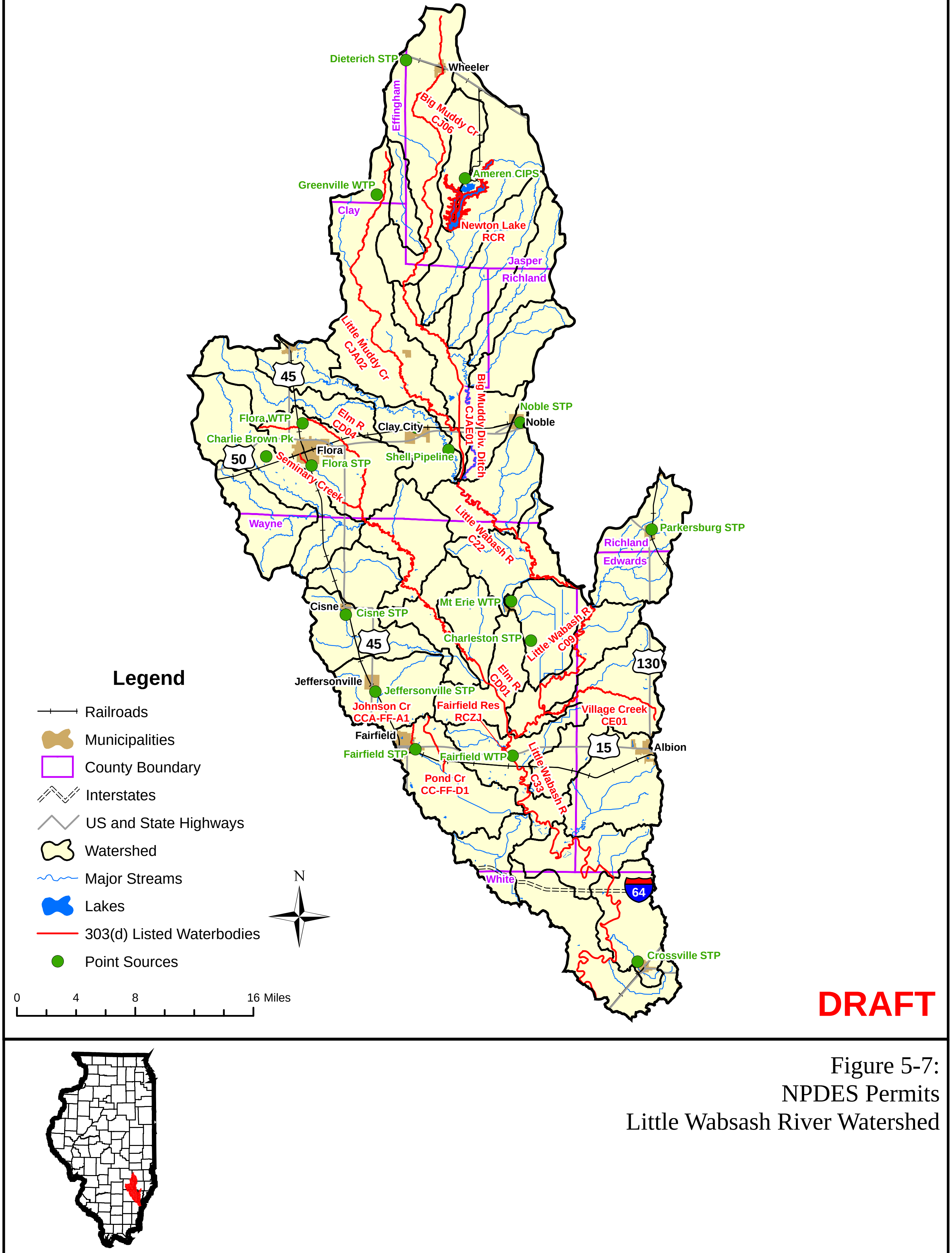

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Figure 5-7:
NPDES Permits
Little Wabsash River Watershed

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Section 6
Approach to Developing TMDL and Identification of Data Needs

Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing stream segments in the Little Wabash River watershed, manganese, pH, DO, total fecal coliform, silver, and atrazine are all of the parameters with numeric water quality standards. For the lakes in the Little Wabash River watershed, manganese and phosphorus are the only parameter with numeric water quality standards. Illinois EPA believes that addressing these impairments should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. Recommended technical approaches for developing TMDLs for streams and lakes are presented in this section. Additional data needs are also discussed.

6.1 Simple and Detailed Approaches for Developing TMDLs

The range of analyses used for developing TMDLs varies from simple to complex. Examples of a simple approach include mass-balance, load-duration, and simple watershed and receiving water models. Detailed approaches incorporate the use of complex watershed and receiving water models. Simple approaches typically require less data than detailed approaches and therefore these are the analyses recommended for the Little Wabash River watershed except for stream segments with major point sources whose NDPES permit may be affected by the TMDL's WLA. Establishing a link between pollutant loads and resulting water quality is one of the most important steps in developing a TMDL. As discussed above, this link can be established through a variety of techniques. The objective of the remainder of this section is to recommend approaches for establishing these links for the constituents of concern in the Little Wabash River watershed.

6.2 Approaches for Developing TMDLs for Stream Segments in Little Wabash River Watershed

The following segments in the Little Wabash River have a major facility discharging to or upstream of them: segments C09, C33 and C22 of the Little Wabash River; CCA-FF-A1 of Johnson Creek; CC-FF-D1 of Pond Creek; and both impaired segments of Seminary Creek. The remaining impaired stream segments do not have major point sources discharging to them. Approaches for developing TMDLs for areas with and without major point sources are described below.

6.2.1 Recommended Approach for DO TMDLs for Stream Segments without Major Point Sources

Segments CE01 of Village Creek, CD01 and CD04 of Elm River, CJ06 of Big Muddy Creek, CJA02 of Little Muddy Creek, and CJAE01 of the Big Muddy Diversion Ditch do not have major point sources discharging to them. Therefore, a simplified approach that involves simulating pollutant oxidation and stream reaeration only within a spreadsheet model is recommended for DO TMDL development. This model simulates steady-state stream DO as a function of carbonaceous and nitrogenous pollutant oxidation and atmospheric reaeration. The model allows for non-uniform stream hydraulics, hydrology, and pollutant loadings at any level of segmentation. It is also free of numerical dispersion as it relies on well-known analytical solutions rather than numerical approximations of the fundamental equations. The model assumes plug flow (no hydrodynamic dispersion), which is likely an acceptable assumption for most small to medium sized streams. The model also does not incorporate the impacts of stream plant life, which generally require site-specific data for meaningful parameterization. A watershed model will not be used for these segments. Using the spreadsheet model iteratively, the BOD loads estimated to cause the DO impairments and to maintain a DO of 5.0 mg/L will be calculated. These calculated loads will become the basis for recommending TMDL reductions if necessary.

Of the impaired segments mentioned above, only Elm River segment CD01 has adequate data to develop a TMDL. Data are limited to three or four samples on segment CD04 of the Elm River, CJ06 of Big Muddy Creek, and CJA02 of Little Muddy Creek. Only one sample exists for the impaired segments on Village Creek and the Big Muddy Diversion Ditch. Neither of those samples violated the standard. It is recommended that more data be collected to confirm impairment and to support the development of DO TMDLs for these segments.

6.2.2 Recommended Approach for DO TMDLs for Segments with Major Point Sources

The following segments in the Little Wabash River watershed potentially receive effluent from major dischargers in the basin: C09 and C33 of the Little Wabash River; CCA-FF-A1 of Johnson Creek; CC-FF-D1 of Pond Creek; and both impaired segments of Seminary Creek. For these segments a more complicated approach is recommended. This approach could incorporate the impacts of stream plant activity and possibly sediment oxygen demand (SOD). The approach would require a more sophisticated numerical model and an adequate level of measured data to aide in model parameterization.

The data for these segments does suggest impairment of the DO standard. However, data, especially spatial data, is limited, and therefore additional data collection is recommended for these segments. Specific data requirements include a synoptic (snapshot in time) water quality survey of this reach with careful attention to the location of the point source dischargers. This survey should include measurements of flow, hydraulics, DO, temperature, nutrients, and CBOD. The collected data will be used to support the model development and parameterization and will lend significant confidence to the TMDL conclusions.

This newly collected data could then be used to support the development and parameterization of a more sophisticated DO model for this stream, and therefore the use of the QUAL2E model (Brown and Barnwell 1985) could be utilized to accomplish the TMDL analysis for these impaired segments. QUAL2E is well-known and USEPA-supported. It simulates DO dynamics as a function of nitrogenous and carbonaceous oxygen demand, atmospheric reaeration, SOD, and phytoplankton photosynthesis and respiration. The model also simulates the fate and transport of nutrients and BOD and the presence and abundance of phytoplankton (as chlorophyll-a). Stream hydrodynamics and temperature are important controlling parameters in the model. The model is essentially only suited to steady-state simulations.

In addition to the QUAL2E model, a simple watershed model such as PLOAD, Unit Area Loads, or the Watershed Management Model is recommended to estimated BOD and nutrient loads from non-point sources in the watershed. This model will allow for allocation between point and nonpoint source loads and provide an understanding of percentage of loadings from point sources and nonpoint sources in the watershed.

6.2.3 Recommended Approach for pH TMDLs

Segments C09 of the Little Wabash River and CD01 of the Elm River are listed for pH impairments. Data from both segments have violated the standard although the number of violations on each segment is relatively low in relation to the total amount of available data. The source of the pH impairment is unknown since resource extraction is not present in this area of the watershed. For these TMDLs, a spreadsheet approach will be utilized, which takes into account natural conditions such as acid rain and soil buffering capacity.

6.2.4 Recommended Approach for Fecal Coliform TMDLs

Segments C09 and C22 of the Little Wabash River, and segment CD 01 of Elm River are listed as impaired for total fecal coliform. The general use water quality standard for total fecal coliform is:

- 200 cfu/100 mL geometric mean based on a minimum of five samples taken over not more than a 30-day period during the months of May through October
- 400 cfu/100 mL shall not be exceeded by more than 10 percent of the samples collected during any 30-day period during the months of May through October

As discussed in Section 5.1.1.3, there have been no instances when five or more samples have been taken within a 30-day period. Although this is the case on each segment, it is believed that adequate data exist to support TMDL development.

The recommended approach for developing TMDLs for these segments would be to use the load-duration curve method. The load-duration methodology uses the cumulative frequency distribution of streamflow and pollutant concentration data to estimate the allowable loads for a waterbody.

6.2.5 Recommended Approach for Manganese and Silver TMDLs

Segments C09 and C33 of the Little Wabash River, CE01 of Village Creek, CD01 of Elm River, CJ06 of Big Muddy Creek, and CJA02 of Little Muddy Creek are impaired for manganese. A violating sample has been collected on each segment; however, data are extremely limited on CE01 of Village Creek, C33 of the Little Wabash River, CJ06 of Big Muddy Creek, and CJA02 of Little Muddy Creek. It is recommended that more data be collected on each of these segments. Segment C09 of the Little Wabash River is also listed as impaired for silver. Only one sample out of the available 43 was above the standard. It is recommended that data be collected on this segment to confirm the impairment. Once adequate data are available for each segment, an empirical loading and spreadsheet analysis will be utilized to calculate these TMDLs since no apparent sources of manganese or silver have been identified to date within the watershed.

6.2.6 Recommended Approach for Atrazine TMDLs

Segments C09 and C33 of the Little Wabash River and CD01 of the Elm River are listed as impaired for atrazine. Data does suggest that an impairment exists on C09 and CD01; however, data are limited. Only sediment samples were available on segment C33. It is recommended that more data be collected to confirm an impairment on C33 and to provide adequate data for TMDL development on all segments. If more data becomes available and impairment is confirmed, the recommended methodology for establishing TMDLs for these segment is the use of a load-duration curve method. The load-duration methodology uses the cumulative frequency distribution of streamflow and pollutant concentration data to estimate the allowable loads for a waterbody.

6.3 Approaches for Developing TMDLs for Lake Segments in the Little Wabash River Watershed

Recommended TMDL approaches for lakes within the Little Wabash River watershed will not be separated into those lakes with or without major point source discharges. It is assumed that for the lakes in the watershed, enough data exists to develop a simple model for use in TMDL development.

6.3.1 Recommended Approach for Total Phosphorus TMDLs

Newton Lake is impaired for phosphorus. The BATHTUB model is recommended for lake phosphorus assessments in this watershed. The BATHTUB model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and mean depth. (USEPA 1997). Oxygen conditions in the model are simulated as meta and hypolimnetic depletion rates, rather than explicit concentrations. Watershed loadings to the lakes will be based on empirical data or tributary data available in the lake watersheds.

6.3.2 Recommended Approach for Manganese TMDLs

Fairfield Reservoir is a source of public water. Therefore, the applicable water quality standard for manganese in the lake is 150 µg/L. For this TMDL, manganese will not be analyzed because it is assumed that development of a DO TMDL will control the manganese concentrations. The TMDL will first investigate dissolved oxygen levels throughout the water column. The lake is not impaired for DO, however DO compliance is assessed at one-foot depth from the surface. A preliminary review of DO concentrations at greater depths shows that DO levels in the summer have been recorded as low as 0.7 mg/L (sampled at 9 feet in June 2000). The manganese target will then be maintenance of higher hypolimnetic DO concentrations, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no DO in lake bottom waters. The cause of the lack of DO in lake bottom waters is unknown and it is recommended that a spreadsheet analysis be utilized to calculate this TMDL.

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CDM

Illinois Environmental Protection Agency

Stage 2 Data Report

March 2007

Final Report

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Contents

Section 1 Introduction

Section 2 Field Activities

Section 3 Quality Assurance Review

Section 4 Conclusions

Appendices (see attached CD)

Appendix A *Sampling Location Photographs*
Appendix B *Stream Flow Data*
Appendix C *Analytical Data*
Appendix D *Continuous Monitoring Data and Charts*
Appendix E *QAPP*

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Figures

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Tables

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Section 1

Introduction

The Illinois Environmental Protection Agency (Illinois EPA) has a three-stage approach to total maximum daily load (TMDL) development. The stages are:

Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection

Stage 2 – Data Collection (optional)

Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

This report addresses data collection associated with Stage 2 TMDL development for the following watersheds:

- Bay Creek
- Cahokia Creek/Holiday Shores Lake
- Cedar Creek/Cedar Lake
- Crab Orchard Creek/Crab Orchard Lake
- Crooked Creek
- Little Wabash River
- Mary's River/North Fork Cox Creek
- Sangamon River/Lake Decatur
- Shoal Creek
- South Fork Saline River/Lake of Egypt
- South Fork Sangamon River/Lake Taylorville

Sampling has been completed based on the recommendations presented in Section 6 of each watershed's Stage 1 TMDL report and the sampling plan described within the quality assurance project plan (QAPP). The Stage 2 data will supplement existing data collected and assessed as part of Stage 1 of TMDL development and will support the development of TMDLs under Stage 3 of the process. Where adequate supporting data exist, data collected during Stage 2 activities may also be used to support the delisting of certain parameters from the state 303(d) list.

The remaining sections of this report contain:

- **Section 2 Field Activities** includes information on sampling locations as well as field parameter, grab sample and continuous monitoring data
- **Section 3 Quality Assurance Review** discusses changes in the sampling plan from the original QAPP, data verification and validity, and conformance to the data quality objectives
- **Section 4 Conclusions** summarizes the Stage 2 work and makes recommendations for moving forward

Section 2
Field Activities

TMDL streams were sampled by CDM twice during the fall of 2006 to collect data needed to support water quality modeling and TMDL development. The first round of Stage 2 data collection took place between August 28 and September 29, 2006. The second round of Stage 2 data collection took place between October 16 and November 17, 2006. In addition, three segments within the Little Wabash River watershed were sampled by Illinois EPA between April and August of 2006. Over the course the sampling project, 32 streams (out of a possible 33) and one lake were sampled within the eleven Stage 2 watersheds. Table 2-1 contains data collection dates for each watershed.

Table 2-1: Stage 2 Data Collection Field Dates

Watershed	First Round Dates (2006)	Second Round Dates (2006)
Bay Creek	9/25-9/29	10/30-11/6
Cahokia Creek/Holiday Shores Lake	8/28-9/6	10/16-10/20
Cedar Lake	9/5-9/14	10/30-11/6
Crab Orchard Lake	9/5-9/14	10/30-11/6
Crooked Creek	9/5-9/14	10/16-10/20
South Fork Saline River/Lake of Egypt	9/25-9/29	10/30-11/6
Little Wabash River - CDM	9/5-9/14	10/30-11/16
Little Wabash River – Illinois EPA	4/18-8/8	
Mary's River	9/5-9/14	10/16-10/20
Sangamon River/Lake Decatur	8/28-9/6	10/30-11/3
Shoal	8/28-9/6	10/16-10/20
South Fork Sangamon River/Lake Taylorville	8/28-9/6	10/30-11/3

Sampling was conducted in accordance with the QAPP by CDM personnel at stream and lake locations with sufficient water and access. When time permitted, alternate locations were investigated if water and/or access were limited at original locations. Figures 2-1 through 2-11 show sampling locations used for Stage 2 data collection for each watershed. Refer to section 3.1 for further information related to sampling location changes from the original QAPP. Appendix A contains pictures of each sampling location. The sampling and analysis activities conducted at each sampling location included:

- In-stream field parameterization
- Grab samples for laboratory analysis
- Continuous monitoring
- Stream gaging

2.1 Instream field parameters

Water quality measurements for pH, temperature, dissolved oxygen (DO), conductivity, and turbidity were taken at each accessible sampling location where water was present using an In-Situ 9500 Profiler water quality meter. In-Situ 9500 Profilers were calibrated each morning of field activity. Water quality readings were taken at each accessible site with adequate water at the center of flow and values were recorded in field books. These values are presented in Table 2-2. Table 2-2 also contains sample location latitude and longitude as well as explanatory information as to why a limited number of sites were not sampled.

At each site with adequate and safely wadeable streamflow, flow measurements were recorded using a Marsh McBirney 2000 flow meter. Appendix B contains flow meter data and stream discharge analysis for these sites.

2.2 Grab Samples

Grab samples were collected based on the causes of impairment identified in the 303(d) list as well as data needed to support TMDL development under Stage 3. Samples collected on Owl Creek and South Fork Sangamon River were analyzed by Prairie Analytical Laboratories in Springfield, IL and all other samples collected by CDM were analyzed by ARDL, Inc in Mt. Vernon, IL. Samples were delivered in person to the laboratory or exchanged with laboratory personnel in the field. Select segments in the Little Wabash watershed (Elm River segment CD01, and Little Wabash River segments C09 and C33) were sampled by Illinois EPA and analyzed by the Illinois EPA Laboratory in Champaign, IL.

Table 2-3 contains data collected at each location associated with impairment status. Values shown in bold face with gray background violated the applicable water quality standard. All data analyzed by the laboratories are contained in Appendix C. This appendix includes the data shown in Table 2-3 as well as all other parameters that were sampled in order to support Stage 3 TMDL development. In addition, Appendix C shows data qualifiers as well as detection limits for all samples.

2.3 Continuous Monitoring

In-Situ 9500 Professional XP multi-parameter data-logging sondes were used for continuous data measurements on streams impaired by low DO and/or pH. The sondes were calibrated prior to deployment then deployed for at least 3 days at select locations with adequate water and access. DO, pH, conductivity and temperature data were recorded at 15 minute intervals during sonde deployment, after which the sonde was removed and data were downloaded to a laptop computer. The continuous data associated with impairment causes are presented in Appendix D. Because sondes were not field checked at the time of retrieval, there is a possibility that some experienced times of drying or build-up of sedimentation during deployment. A column was added to the data presented in Appendix D to estimate acceptable or “suspect” data. Data were deemed suspect when low conductivity or high temperature values indicate that the meter was likely out of the water or also at times when field log books indicated that the sonde had not yet been deployed or had been pulled from the stream. The data that were deemed acceptable were plotted on Figures D-1 through D-26. The charts are grouped by watershed and show data collected during the first and second round of sampling at each location.

Violations of the instantaneous DO standard (5.0 mg/L minimum) were not recorded during either monitoring period on the following segments that are currently listed for impairment caused by low DO:

- Cedar Creek AJF16 (Figure D-1)
- Big Muddy River N99 (Figure D-4)
- Shoal Creek OI05 (Figures D-22 and D-23)
- South Fork Saline River ATH08 (Figure D-24)

According to Table B-2 of the Illinois Integrated Water Quality Report (2006), the aquatic life use may also be impaired if DO concentrations are below 6.0 mg/L for more than 16 hours of any 24 hour period. Appendix D also contains this analysis for the segments that did not violate the instantaneous minimum standard. The number of values recorded below 6.0 mg/L during any 24 hour period were counted and if any count was above 64 (64 values equates to 16 hours worth of data), the stream was considered to be potentially impaired by low DO. The following segments did not experience a violation of either the 5.0 mg/L instantaneous standard or the 6.0 mg/L standard as described above:

- Cedar Creek AJF16 (Figure D-1)
- Shoal Creek OI05 (Figures D-22 and D-23)
- South Fork Saline River ATH08 (Figure D-24)

Violations of the pH standard (6.5 minimum, 9.0 maximum) were not recorded during either monitoring period on the following segments that are currently listed for impairment caused by pH:

- Crab Orchard Creek ND12 (Figure D-5)
- Briers Creek ATHS01 (Figure D-25)

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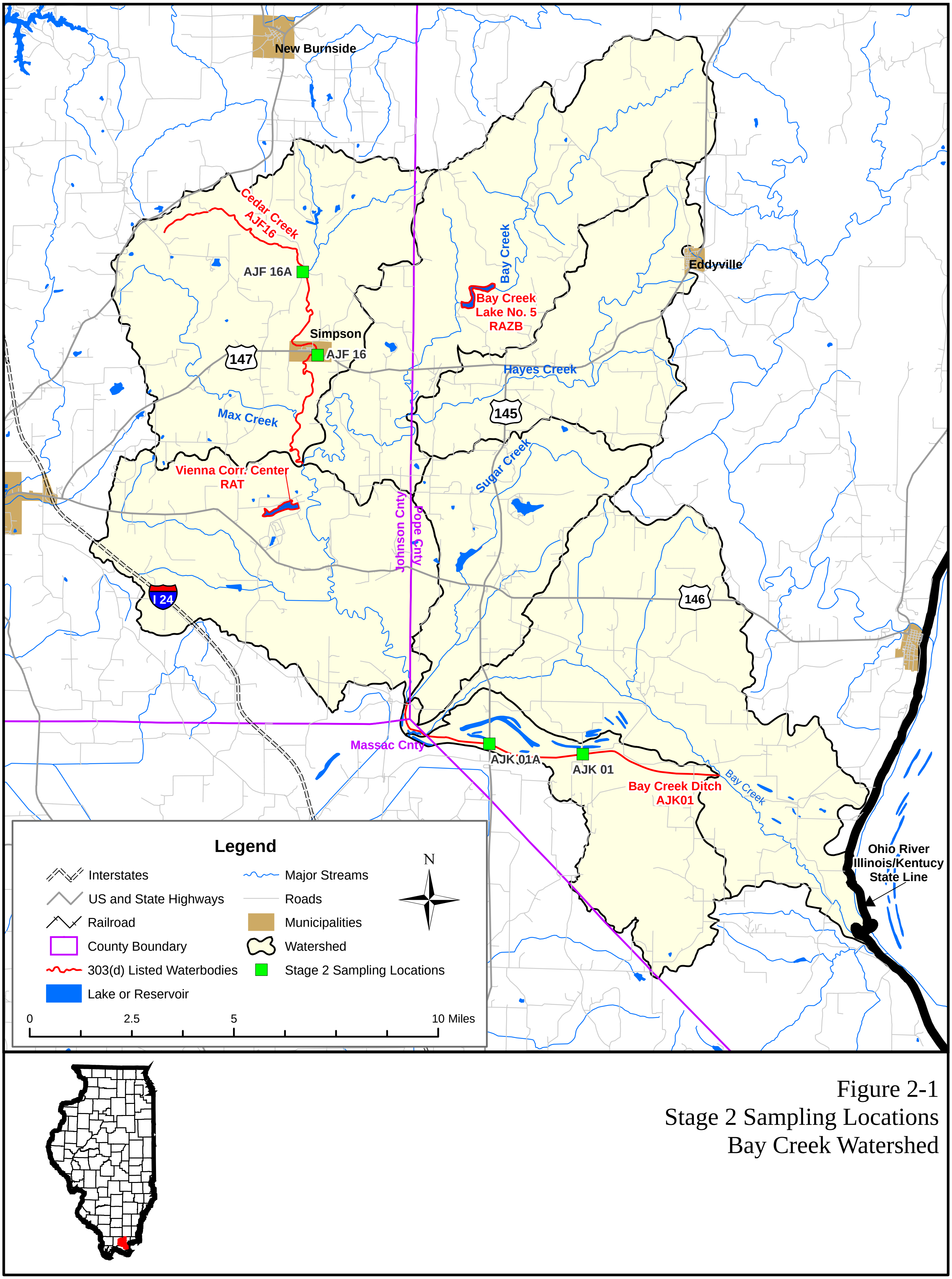

Figure 2-1
Stage 2 Sampling Locations
Bay Creek Watershed

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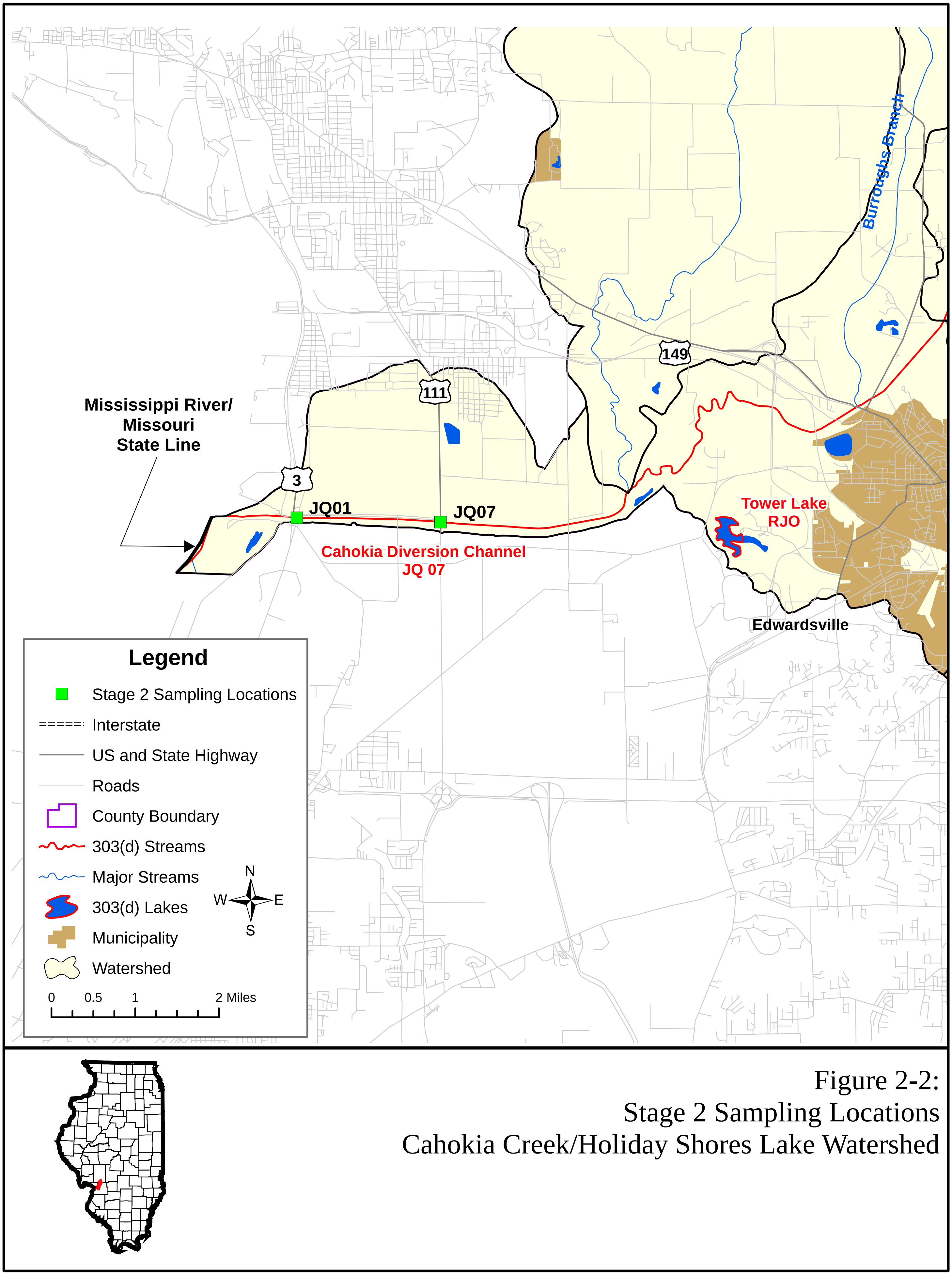

Figure 2-2:
Stage 2 Sampling Locations
Cahokia Creek/Holiday Shores Lake Watershed

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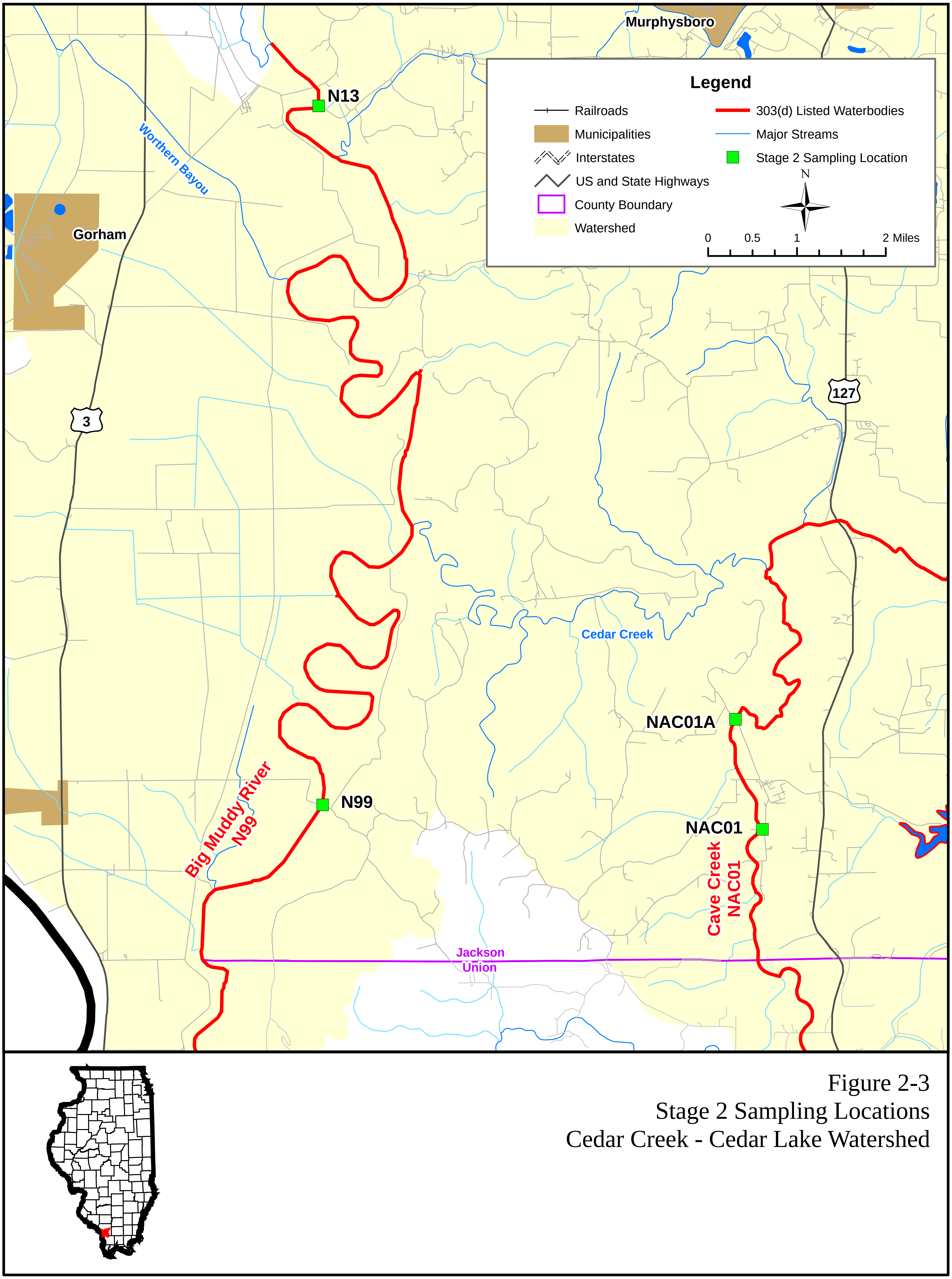

Figure 2-3
Stage 2 Sampling Locations
Cedar Creek - Cedar Lake Watershed

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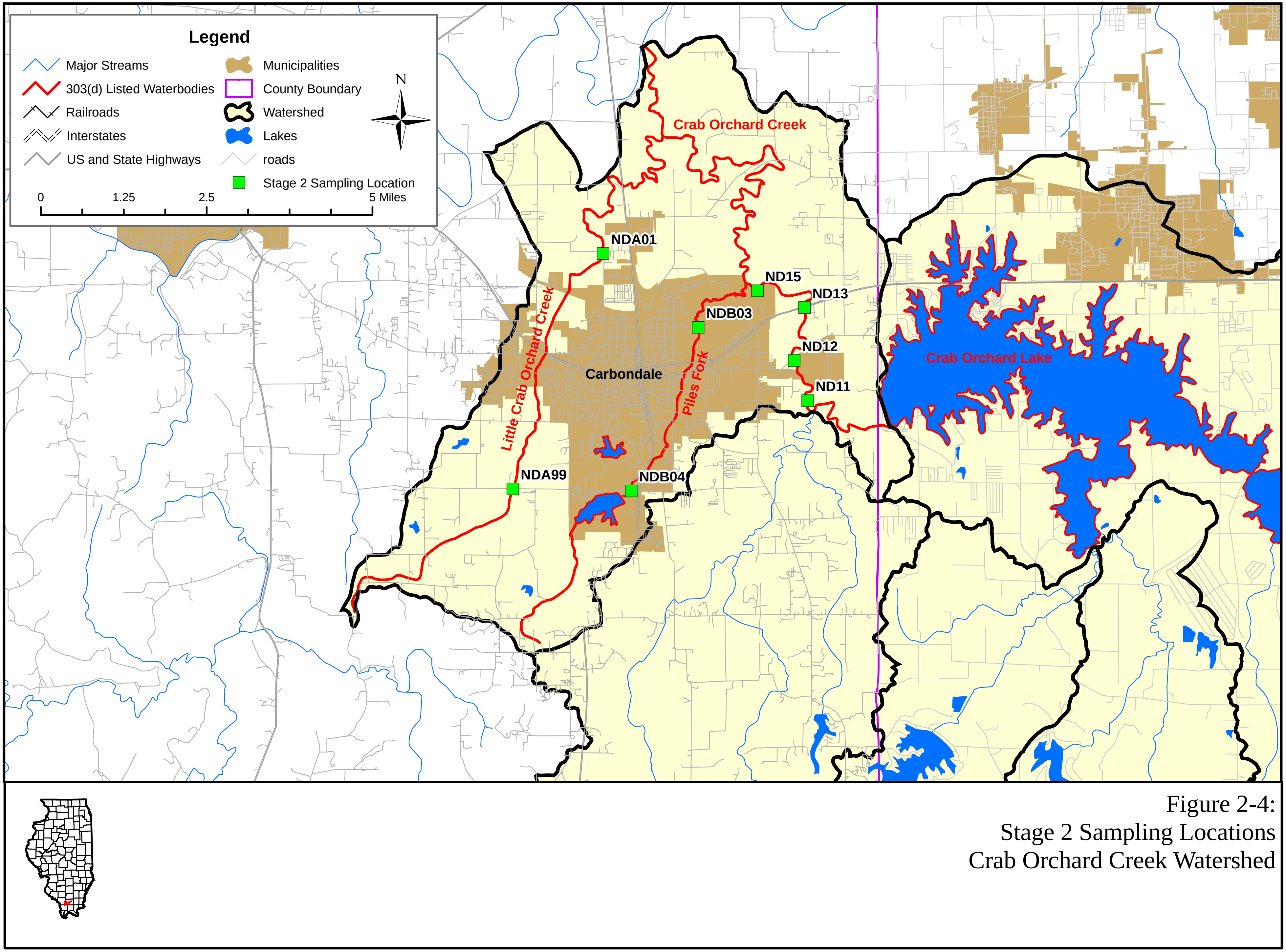

Figure 2-4:
Stage 2 Sampling Locations
Crab Orchard Creek Watershed

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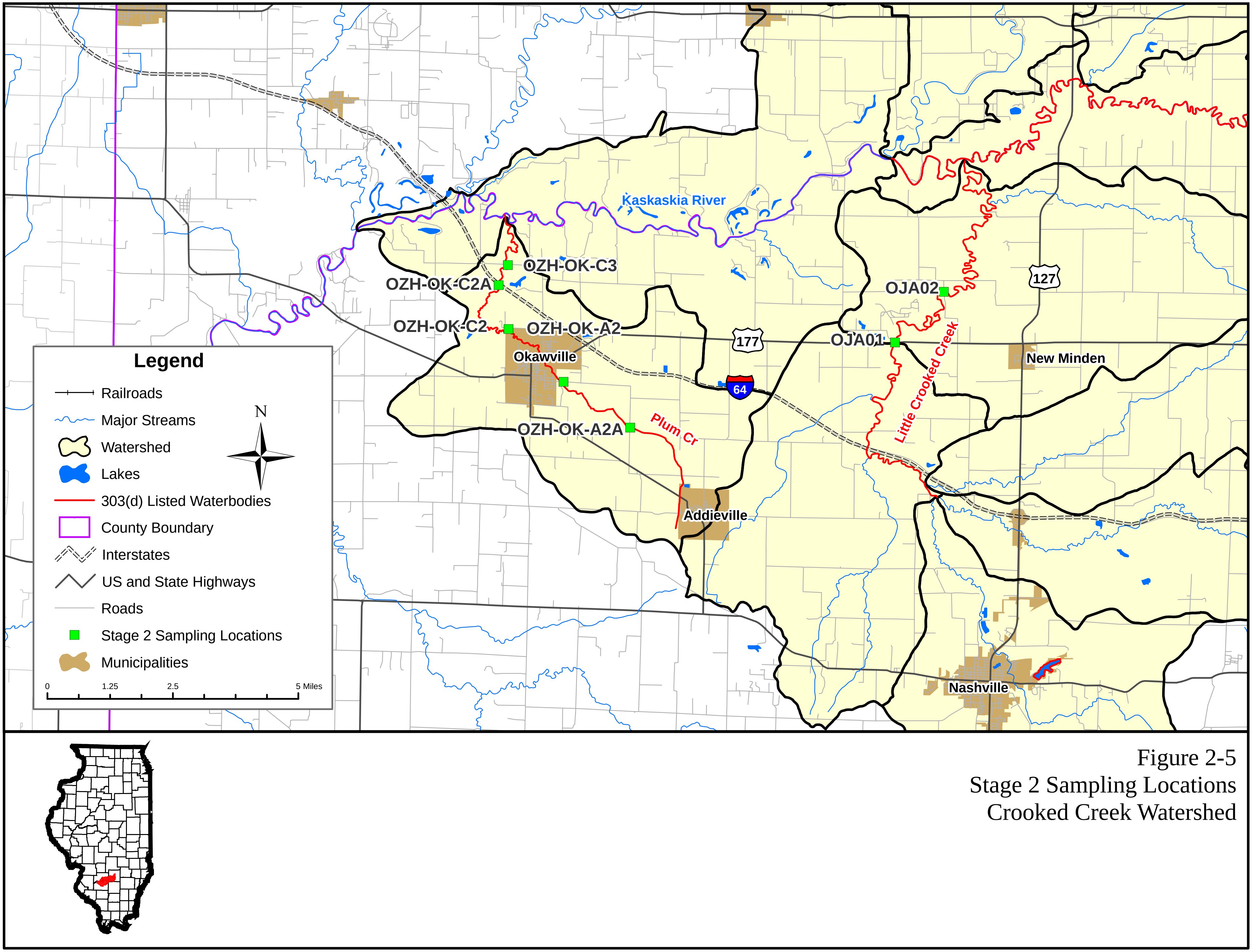

Figure 2-5
Stage 2 Sampling Locations
Crooked Creek Watershed

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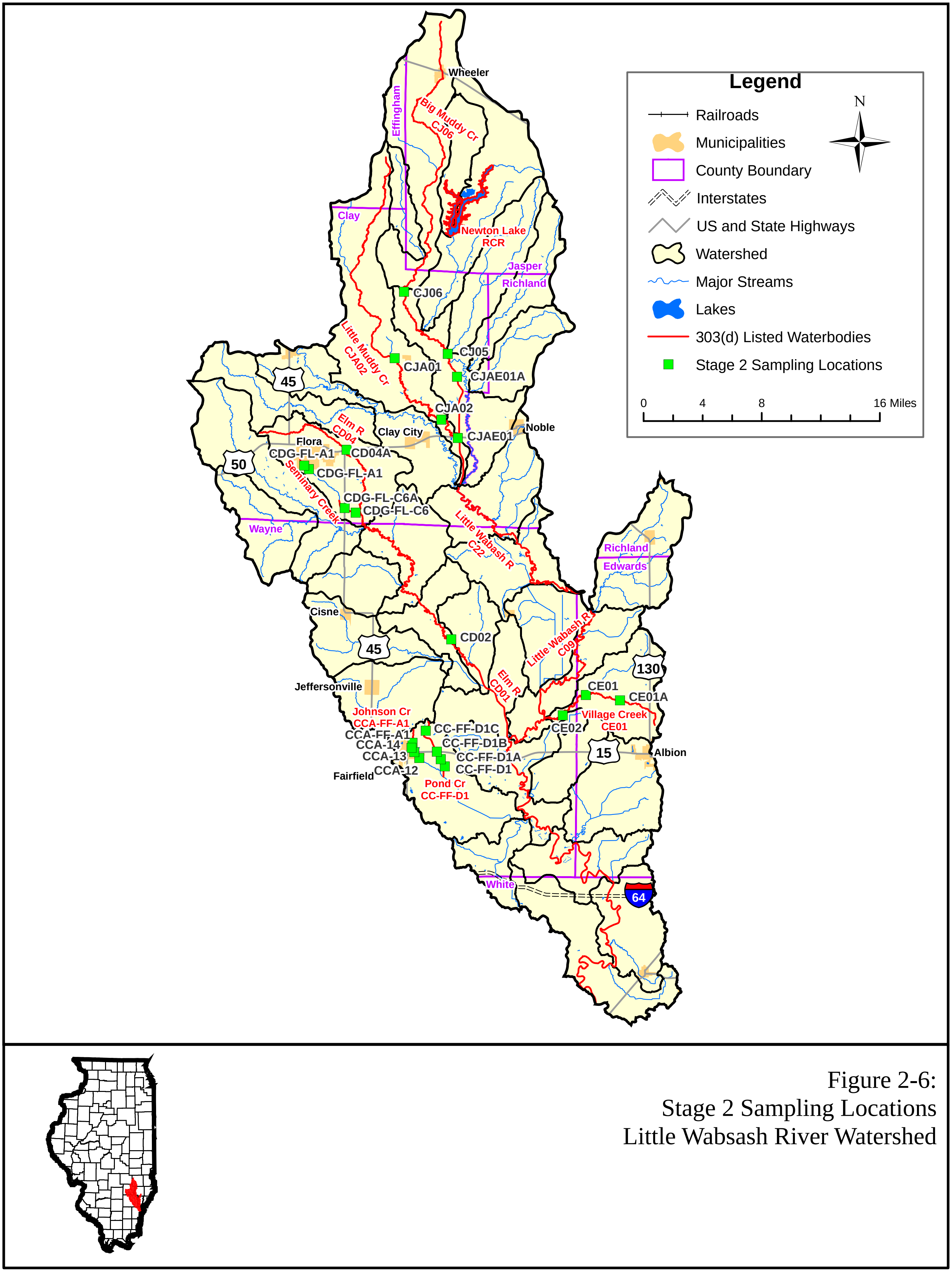

Figure 2-6:
Stage 2 Sampling Locations
Little Wabsash River Watershed

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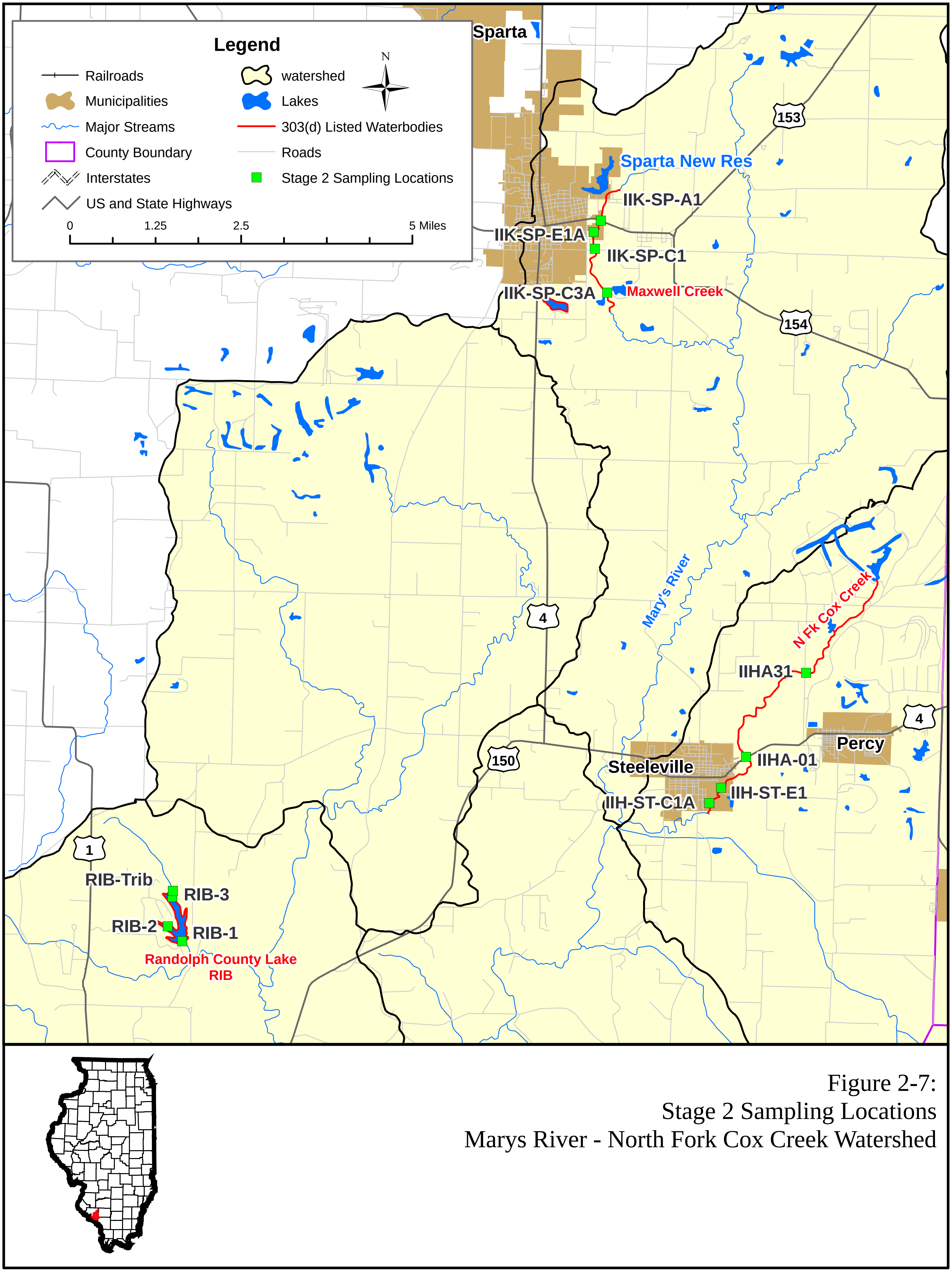

Figure 2-7:
Stage 2 Sampling Locations
Marys River - North Fork Cox Creek Watershed

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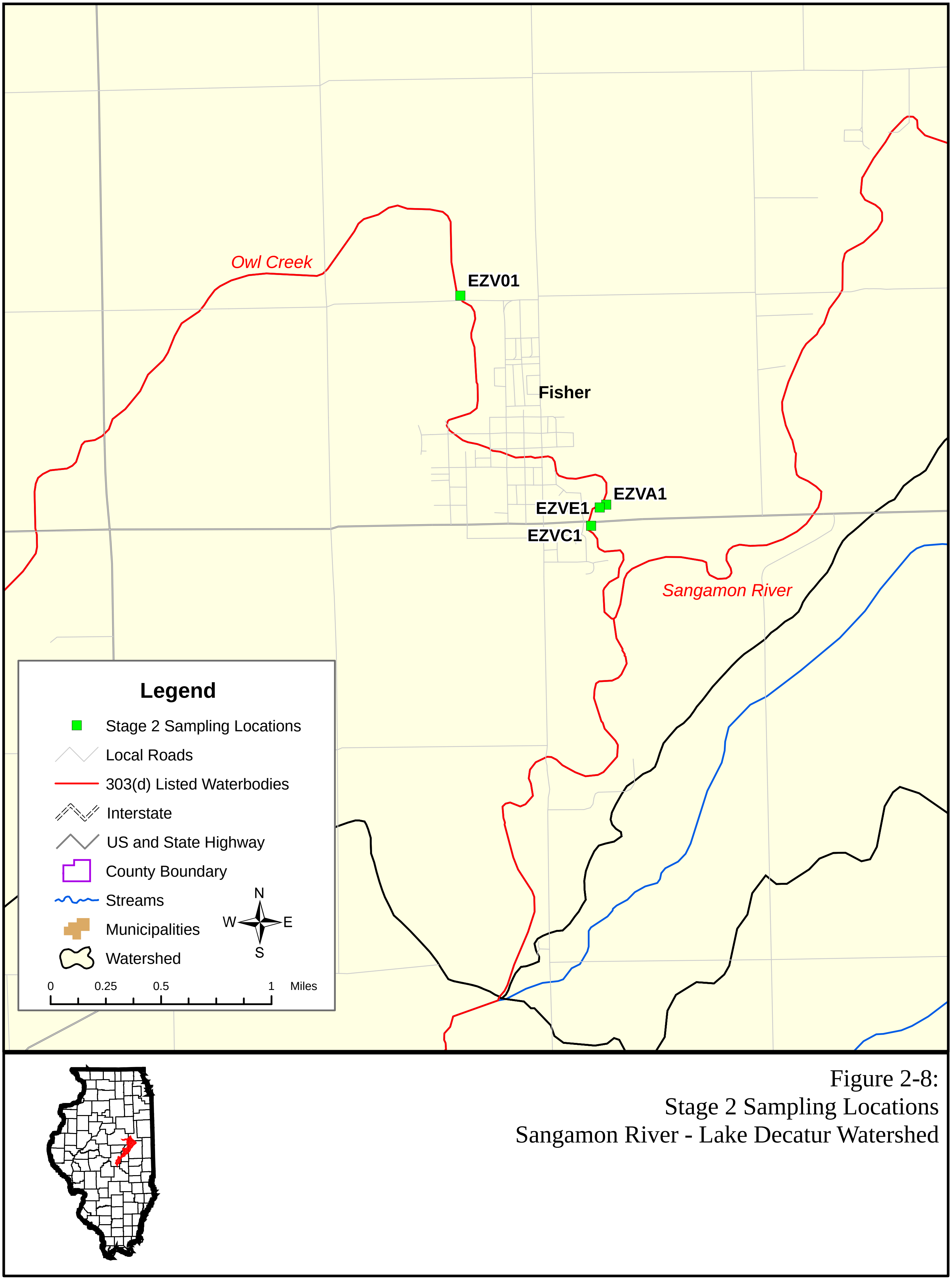

Figure 2-8:
Stage 2 Sampling Locations
Sangamon River - Lake Decatur Watershed

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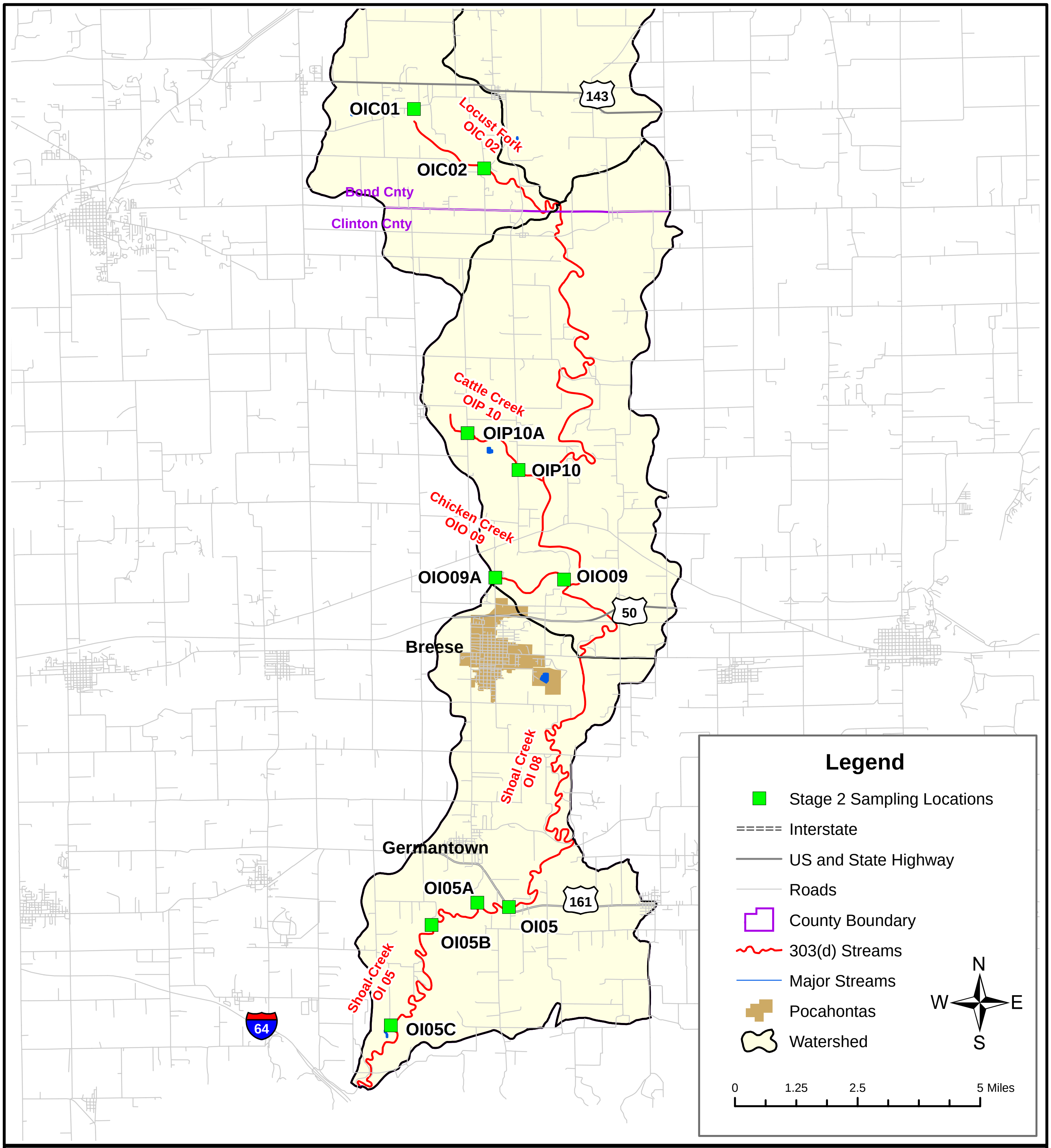

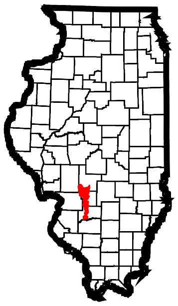

Figure 2-9:
Stage 2 Sampling Locations
Shoal Creek Watershed

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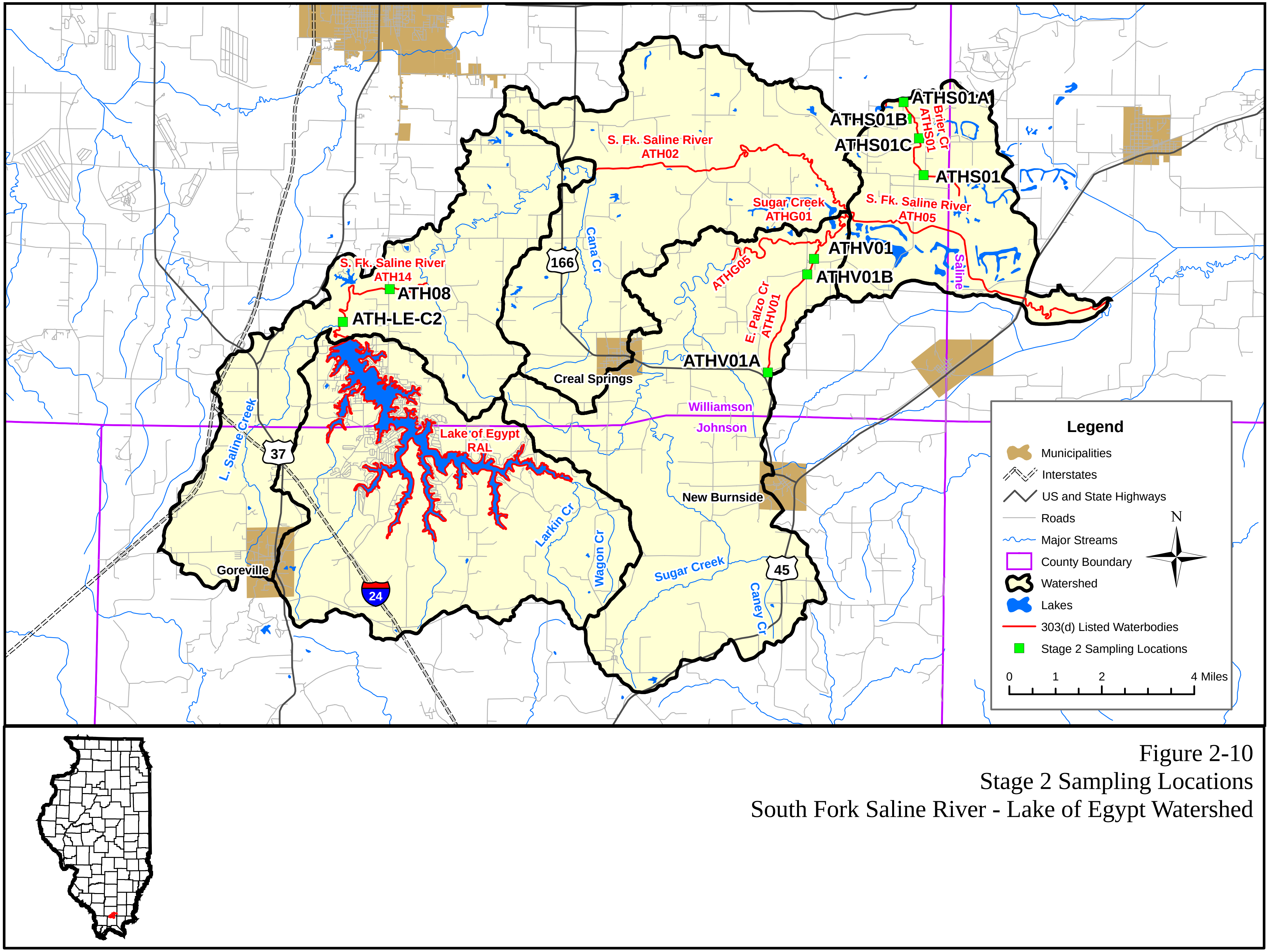

Figure 2-10
Stage 2 Sampling Locations
South Fork Saline River - Lake of Egypt Watershed

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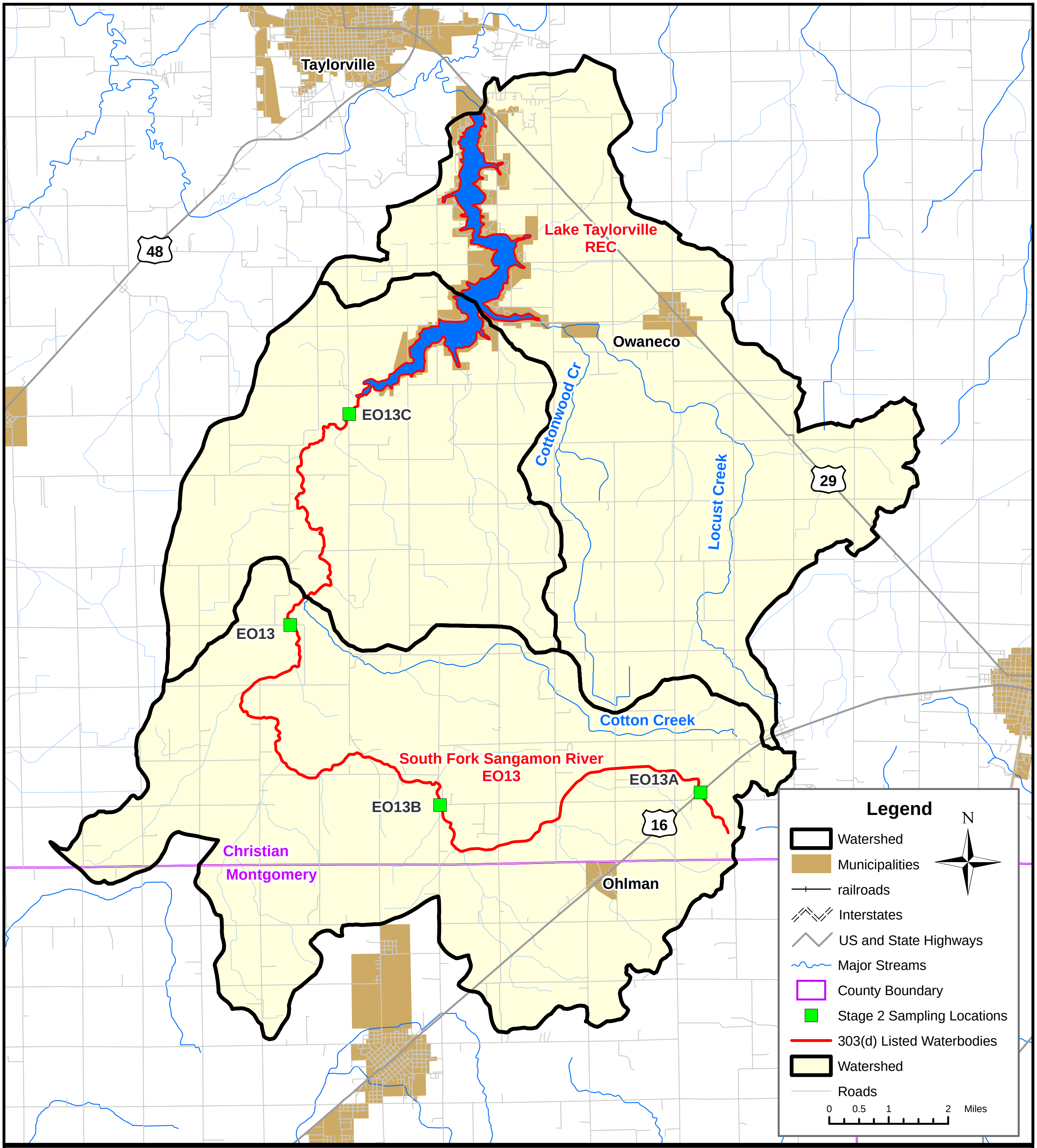

Figure 2-11:
Stage 2 Sampling Locations
South Fork Sangamon River - Lake Taylorville Watershed

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Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. ^oC	Depth (ft)
Bay Creek	Cedar Creek	AJF16	37.4661	88.7508	9/25/2006	18:00	6.5	117.0	7.8	8.9	63.9	NA
	Cedar Creek	AJF16	37.4661	88.7508	11/3/2006	11:05	7.2	164.5	8.6	11.0	7.0	NA
	Cedar Creek	AJF16A	37.4954	88.7592	9/25/2006	18:15	6.6	81.0	15.6	9.4	64.0	NA
	Cedar Creek	AJF16A	37.4954	88.7592	11/2/2006	13:30	7.3	101.8	5.4	11.6	9.2	NA
	Bay Creek Ditch	AJK01	37.3245	88.6337	9/25/2006	15:58	6.3	74.0	17.2	5.6	66.6	NA
	Bay Creek Ditch	AJK01	37.3245	88.6337	10/31/2006	8:15	7.2	91.6	20.4	8.2	12.8	NA
	Bay Creek Ditch	AJK01A	37.3282	88.6747	9/25/2006	NOT SAMPLED *Site flooded over banks into surrounding fields with no access/alternate site not located*						NA
	Bay Creek Ditch	AJK01A	37.3282	88.6747	10/31/2006	8:45	7.1	91.1	44.5	6.1	13.2	NA
Cahokia Creek/Holiday Shores Lake	Cahokia Diversion Ditch	JQ01	38.8054	90.1023	8/31/2006	13:40	7.4	606.7	62.3	3.4	23.9	NA
	Cahokia Diversion Ditch	JQ01	38.8054	90.1023	10/17/2006	14:45	8.3	459.8	92.9	9.6	12.6	NA
	Cahokia Diversion Ditch	JQ07	38.8050	90.0673	8/31/2006	14:45	7.4	498.6	68.0	5.3	23.0	NA
	Cahokia Diversion Ditch	JQ07	38.8050	90.0673	10/17/2006	14:15	8.3	427.0	115.8	9.4	12.8	NA
Cedar Creek	Big Muddy River	N13	37.7392	89.4284	9/7/2006	11:15	7.6	646.1	45.5	8.1	29.9	NA
	Big Muddy River	N13	37.7392	89.4284	11/1/2006	10:45	7.1	319.1	258.5	8.2	11.2	NA
	Big Muddy River	N99	37.6252	89.4284	9/7/2006	12:15	7.7	749.5	40.2	10.1	23.6	NA
	Big Muddy River	N99	37.6252	89.4284	11/1/2006	9:45	7.4	333.4	188.4	7.8	11.5	NA
	Cave Creek	NAC01	37.6154	89.3395	9/11/2006	11:45	7.8	288.4	N/A	7.6	20.4	NA
	Cave Creek	NAC01	37.6154	89.3395	11/1/2006	11:45	7.8	213.2	24.0	10.6	9.8	NA
	Cave Creek	NAC01A	37.6380	89.5660	9/11/2006	11:15	7.5	330.3	N/A	4.9	20.5	NA
	Cave Creek	NAC01A	37.6380	89.5660	11/1/2006	12:15	7.7	227.7	20.6	10.1	10.2	NA
Crab Orchard Creek	Crab Orchard Creek	ND11	37.7198	89.1717	9/6/2006	12:15	7.3	385.9	N/A	5.2	20.1	NA
	Crab Orchard Creek	ND11	37.7198	89.1717	11/1/2006	14:00	7.7	229.6	26.7	10.1	11.7	NA
	Crab Orchard Creek	ND12	37.7286	89.1753	9/6/2006	13:15	7.3	502.7	N/A	6.4	24.2	NA
	Crab Orchard Creek	ND12	37.7286	89.1753	11/1/2006	15:00	7.7	233.4	52.2	10.4	11.7	NA
	Crab Orchard Creek	ND13	37.7402	89.1723	9/6/2006	15:00	7.4	494.1	N/A	6.0	22.2	NA
	Crab Orchard Creek	ND13	37.7402	89.1723	11/1/2006	15:45	7.3	234.7	19.0	11.1	11.8	NA
	Crab Orchard Creek	ND15	37.7440	89.1852	9/6/2006	16:30	7.0	470.0	N/A	6.8	22.4	NA
	Crab Orchard Creek	ND15	37.7440	89.1852	11/1/2006	NOT SAMPLED *Site located behind Walmart parking lot and not accessible due to large chain link fence/no available alternate sites*						NA
	Little Crab Orchard Creek	NDA01	37.7525	89.2276	9/6/2006	18:00	7.3	242.5	N/A	2.1	19.2	NA
	Little Crab Orchard Creek	NDA01	37.7525	89.2276	11/2/2006	8:30	7.0	225.5	30.4	8.2	6.3	NA
	Little Crab Orchard Creek	NDA99	37.7011	89.2531	9/9/2006	NOT SAMPLED *Site dry and road crossings in the vacinity of site were also dry*						NA
	Little Crab Orchard Creek	NDA99	37.7011	89.2531	11/2/2006	10:30	8.7	190.5	17.0	12.3	5.5	NA
	Piles Fork	NDB03	37.7361	89.2016	9/7/2006	10:00	7.3	404.0	7.4	1.6	18.5	NA
	Piles Fork	NDB03	37.7361	89.2016	11/2/2006	9:15	7.7	240.7	25.5	10.3	7.3	NA
	Piles Fork	NDB04	37.7004	89.2205	9/9/2006	7:40	7.7	753.7	7.8	3.6	17.6	NA
	Piles Fork	NDB04	37.7004	89.2205	11/2/2006	11:00	8.1	154.9	56.5	11.5	10.2	NA
Crooked Creek	Little Crooked Creek	OJA-01	38.4416	89.4170	9/7/2006	17:45	7.0	274.0	22.5	3.7	20.3	NA
	Little Crooked Creek	OJA-01	38.4416	89.4170	10/19/2006	14:05	7.5	335.4	84.1	4.7	12.0	NA
	Little Crooked Creek	OJA-02	38.4564	89.3992	9/8/2006	11:15	7.0	284.8	20.2	3.1	19.7	NA
	Little Crooked Creek	OJA-02	38.4564	89.3992	10/19/2006	14:35	7.3	332.5	48.1	3.8	12.4	NA
	Plum Creek	OZH-OK-A2	38.4290	89.5387	9/8/2006	14:00	7.9	663.3	10.4	6.8	23.9	NA
	Plum Creek	OZH-OK-A2	38.4290	89.5387	10/19/2006	10:50	7.6	390.6	51.8	5.3	11.2	NA
	Plum Creek	OZH-OK-A2A	38.4160	89.5140	9/8/2006	16:45	7.8	503.2	56.9	8.5	22.3	NA
	Plum Creek	OZH-OK-A2A	38.4160	89.5140	10/19/2006	11:20	7.8	341.6	74.7	9.0	9.8	NA
	Plum Creek	OZH-OK-C2	38.4441	89.5592	9/8/2006	12:45	7.3	367.1	11.2	1.1	18.8	NA
	Plum Creek	OZH-OK-C2	38.4441	89.5592	10/19/2006	10:15	7.4	361.7	66.4	2.5	12.0	NA
	Plum Creek	OZH-OK-C2A	38.4568	89.5630	9/8/2006	17:30	7.8	977.9	13.4	4.6	20.7	NA
	Plum Creek	OZH-OK-C2A	38.4568	89.5630	10/19/2006	13:40	7.7	433.1	48.8	3.2	11.5	NA
	Plum Creek	OZH-OK-C3	38.4626	89.5598	9/8/2006	15:00	7.7	983.2	38.5	4.1	21.2	NA
	Plum Creek	OZH-OK-C3	38.4626	89.5598	10/19/2006	9:35	7.5	384.1	556.5	5.2	11.7	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash	Little Wabash River	C09	38.4407	88.2581	1/25/2005	14:00	7.3	415	42	12.1	1.1	NA
	Little Wabash River	C09	38.4407	88.2581	3/17/2005	8:00	8.3	700	23	14.9	7	NA
	Little Wabash River	C09	38.4407	88.2581	4/19/2005	14:30	7.8	535	50	7.3	18.8	NA
	Little Wabash River	C09	38.4407	88.2581	5/9/2005	10:30	7.3	738	60	6.7	19.7	NA
	Little Wabash River	C09	38.4407	88.2581	6/23/2005	7:30	7.7	690	47	5.1	26	NA
	Little Wabash River	C09	38.4407	88.2581	8/23/2005	13:00	7.2	290	70	4.2	27.1	NA
	Little Wabash River	C09	38.4407	88.2581	9/27/2005	16:00	7.8	533	25	7.5	24.6	NA
	Little Wabash River	C09	38.4407	88.2581	10/27/2005	14:00	7.8	550	11	8.7	11.7	NA
	Little Wabash River	C09	38.4407	88.2581	12/6/2005	13:00	7.6	375	70	11.8	1.6	NA
	Little Wabash River	C09	38.4407	88.2581	2/1/2006	13:00	7.6	390	200	9.3	6.8	NA
	Little Wabash River	C09	38.4407	88.2581	3/15/2006	10:00	6.6	150	130	6.2	12.4	NA
	Little Wabash River	C09	38.4407	88.2581	4/18/2006	16:00	7.9	572	40	8.1	20.1	NA
	Little Wabash River	C09	38.4407	88.2581	4/26/2006	10:00	7.8	580	59	7.2	17.7	NA
	Little Wabash River	C09	38.4407	88.2581	5/1/2006	9:45	7.5	543	75	6.4	16.2	NA
	Little Wabash River	C09	38.4407	88.2581	5/10/2006	10:00	7.4	475		6.2	18.5	NA
	Little Wabash River	C09	38.4407	88.2581	5/17/2006	11:00	7.4	421	70	7.4	14.7	NA
	Little Wabash River	C09	38.4407	88.2581	5/24/2006	9:45	7.5	473		6.6	18.9	NA
	Little Wabash River	C09	38.4407	88.2581	5/31/2006	10:20	7.2	352		4	25.3	NA
	Little Wabash River	C09	38.4407	88.2581	6/7/2006	10:15	7.2	345		4.3	23.3	NA
	Little Wabash River	C09	38.4407	88.2581	6/15/2006	8:50	7.4	536	55	5.2	23.9	NA
	Little Wabash River	C09	38.4407	88.2581	6/22/2006	10:05	7.5	608	65	4.4	28.4	NA
	Little Wabash River	C09	38.4407	88.2581	6/27/2006	10:40	7.44	462	64	4.9	24.17	NA
	Little Wabash River	C09	38.4407	88.2581	7/5/2006	10:30	7.2	321		4.4	27.5	NA
	Little Wabash River	C09	38.4407	88.2581	7/12/2006	10:30	7.3	456		3.8	25.3	NA
	Little Wabash River	C09	38.4407	88.2581	7/20/2006	10:00	7.4	372		4.8	29.4	NA
	Little Wabash River	C09	38.4407	88.2581	7/27/2006	10:00	7.2	239		4.8	26.4	NA
	Little Wabash River	C09	38.4407	88.2581	8/1/2006	8:30	7.3	306	65	4.5	30.3	NA
	Little Wabash River	C09	38.4407	88.2581	8/8/2006	11:05	7.3	392	55	4.75	28.4	NA
	Little Wabash River	C33	38.2699	88.1377	4/18/2006	11:00	7.1	418	35	4.4	19.8	NA
	Little Wabash River	C33	38.2699	88.1377	4/26/2006	12:15	7.7	607	56	6	19	NA
	Little Wabash River	C33	38.2699	88.1377	5/1/2006	11:45	7.7	597	58	6.8	16.8	NA
	Little Wabash River	C33	38.2699	88.1377	5/10/2006	12:20	7.3	409		5.3	18.7	NA
	Little Wabash River	C33	38.2699	88.1377	5/17/2006	14:00	7.4	462	90	7.2	15.5	NA
	Little Wabash River	C33	38.2699	88.1377	5/24/2006	12:15	7.4	494		6.4	19.9	NA
	Little Wabash River	C33	38.2699	88.1377	5/31/2006	12:40	7.2	449		3.9	25.4	NA
	Little Wabash River	C33	38.2699	88.1377	6/7/2006	12:30	6.8	286		3	23.01	NA
	Little Wabash River	C33	38.2699	88.1377	6/15/2006	11:05	7.5	511	45	8.1	25.1	NA
	Little Wabash River	C33	38.2699	88.1377	6/22/2006	12:00	7.2	546	38	3	29.8	NA
	Little Wabash River	C33	38.2699	88.1377	6/27/2006	11:50	7.4	548	61	4.8	26.17	NA
	Little Wabash River	C33	38.2699	88.1377	7/5/2006	13:00	7.3	334		5.8	29	NA
	Little Wabash River	C33	38.2699	88.1377	7/12/2006	12:30	7.1	326		3.4	25.3	NA
	Little Wabash River	C33	38.2699	88.1377	7/20/2006	12:20	6.9	247		3.4	29.9	NA
	Little Wabash River	C33	38.2699	88.1377	7/27/2006	12:10	7.5	308		6.4	27.4	NA
	Little Wabash River	C33	38.2699	88.1377	8/1/2006	10:30	7.3	296	40	4.7	30.8	NA
	Little Wabash River	C33	38.2699	88.1377	8/8/2006	13:30	7.3	361	40	4.9	29.8	NA
	Johnson Creek	CCA12	38.3732	88.3449	9/9/2006	13:05	8.2	1402.0	13.4	14.2	28.4	NA
	Johnson Creek	CCA12	38.3732	88.3449	11/14/2006	9:45	7.5	651.4	645.5	7.7	7.0	NA
	Johnson Creek	CCA13	38.3789	88.3511	9/9/2006	14:30	8.6	1517.0	3.1	14.9	25.4	NA
	Johnson Creek	CCA13	38.3789	88.3511	11/14/2006	10:15	7.7	649.4	19.0	12.8	8.1	NA
	Johnson Creek	CCA14A	38.3830	88.3546	9/9/2006	15:25	7.6	836.0	3.6	5.7	21.6	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash (cont.)	Johnson Creek	CCA14A	38.3830	88.3546	11/14/2006	10:25	7.7	694.2	2.4	12.5	8.0	NA
	Johnson Creek	CCAFFA1A	38.3881	88.3535	9/10/2006	10:50	7.4	788.0	5.9	3.8	19.8	NA
	Johnson Creek	CCAFFA1A	38.3881	88.3535	11/14/2006	10:45	7.4	789.8	4.3	12.3	7.5	NA
	Pond Creek	CCFFD1	38.3648	88.3130	9/9/2006	10:30	7.7	576.0	8.6	7.1	19.5	NA
	Pond Creek	CCFFD1	38.3648	88.3130	10/31/2006	10:10	7.6	8719.7	29.2	8.2	3.8	NA
	Pond Creek	CCFFD1A	38.3720	88.3181	9/9/2006	NOT SAMPLED *Site Dry/no available alternate sites*						NA
	Pond Creek	CCFFD1A	38.3720	88.3181	11/9/2006	12:15	7.3	742.5	9.1	11.2	13.6	NA
	Pond Creek	CCFFD1B	38.3793	88.3230	9/9/2006	11:45	7.5	784.0	10.0	8.6	22.9	NA
	Pond Creek	CCFFD1B	38.3793	88.3230	11/9/2006	11:35	7.3	827.9	4.1	12.1	12.7	NA
	Pond Creek	CCFFD1C	38.3999	88.3370	9/10/2006	12:10	8.0	3941.0	17.8	11.9	19.3	NA
	Pond Creek	CCFFD1C	38.3999	88.3370	10/31/2006	11:20	8.8	1394.0		14.4	4.4	NA
	Elm River	CD01	38.5184	88.1320	1/26/2005	13:00	7.1	388	36	9.1	1.4	NA
	Elm River	CD01	38.5184	88.1320	3/15/2005	11:30	8.4	950	7.2	14.6	6.2	NA
	Elm River	CD01	38.5184	88.1320	4/20/2005	11:30	7.4	670	60	6.7	20.1	NA
	Elm River	CD01	38.5184	88.1320	5/5/2005	13:00	7.5	625	27	7.6	13.8	NA
	Elm River	CD01	38.5184	88.1320	6/23/2005	10:00	7.5	1050	22	5.2	24.7	NA
	Elm River	CD01	38.5184	88.1320	8/18/2005	11:00	7.6	730	34	3.6	24.6	NA
	Elm River	CD01	38.5184	88.1320	9/29/2005	11:30	7.6	700	17	3.6	18.5	NA
	Elm River	CD01	38.5184	88.1320	10/18/2005	11:30	7.5	680	8.2	5.9	15	NA
	Elm River	CD01	38.5184	88.1320	12/8/2005	10:30	7.4	321	65	9.6	0.3	NA
	Elm River	CD01	38.5184	88.1320	2/1/2006	15:00	7.5	430	80	9.1	7	NA
	Elm River	CD01	38.5184	88.1320	3/1/2006	13:30	7.4	840	42	10.2	9.1	NA
	Elm River	CD01	38.5184	88.1320	4/6/2006	11:00	7.3	440	90	8.6	13.5	NA
	Elm River	CD01	38.5184	88.1320	4/18/2006	14:30	7.3	670	40	5.6	20.9	NA
	Elm River	CD01	38.5184	88.1320	4/26/2006	11:15	7.5	860		6.2	15.9	NA
	Elm River	CD01	38.5184	88.1320	5/1/2006	11:00	7.4	958		5.9	15.2	NA
	Elm River	CD01	38.5184	88.1320	5/10/2006	11:10	7.2	489		5	18.2	NA
	Elm River	CD01	38.5184	88.1320	5/17/2006	9:30	7.1	484	35	7	13.8	NA
	Elm River	CD01	38.5184	88.1320	5/24/2006	11:20	7.2	594		5.7	18.5	NA
	Elm River	CD01	38.5184	88.1320	5/31/2006	11:30	7.2	605		3.8	25.7	NA
	Elm River	CD01	38.5184	88.1320	6/7/2006	11:25	7	346		4.5	23.4	NA
	Elm River	CD01	38.5184	88.1320	6/15/2006	9:50	7.1	622		4.6	22.5	NA
	Elm River	CD01	38.5184	88.1320	6/22/2006	11:15	7.1	443		4.6	27.9	NA
	Elm River	CD01	38.5184	88.1320	6/27/2006	9:15	6.77	229	91	5	21.95	NA
	Elm River	CD01	38.5184	88.1320	7/5/2006	11:50	7.2	588		3.6	26.6	NA
	Elm River	CD01	38.5184	88.1320	7/12/2006	11:30	7.2	569		4.2	23.9	NA
	Elm River	CD01	38.5184	88.1320	7/20/2006	11:15	7	285		2.8	28.2	NA
	Elm River	CD01	38.5184	88.1320	7/27/2006	11:05	7.1	346		3.5	25.8	NA
	Elm River	CD01	38.5184	88.1320	8/1/2006	9:20	7.3	382		4	27.8	NA
	Elm River	CD01	38.5184	88.1320	8/8/2006	12:20	7.1	425		4.1	26.3	NA
	Elm River	CD02	38.6751	88.4362	9/8/2006	17:45	7.5	344.0	15.9	8.1	23.2	NA
	Elm River	CD02	38.6751	88.4362	11/8/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	Elm River	CD02A	38.4894	88.3051	9/12/2006	12:51	7.2	404.0	15.7	3.8	22.0	NA
	Elm River	CD02A	38.4894	88.3051	11/8/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	Seminary Creek	CDFGLC6	38.6180	88.4384	9/8/2006	12:25	7.7	708.0	4.2	6.6	19.5	NA
	Seminary Creek	CDFGLC6	38.6180	88.4384	11/8/2006	17:00	7.5	527.6	17.5	10.5	12.4	NA
	Seminary Creek	CDFGLC6A	38.6135	88.4245	9/8/2006	11:10	7.7	720.0	201.2	7.0	20.1	NA
	Seminary Creek	CDFGLC6A	38.6135	88.4245	11/8/2006	16:45	7.3	561.7	15.1	12.0	13.5	NA
	Seminary Creek	CDGFLA1	38.6561	88.4832	9/8/2006	15:40	7.9	558.0	7.0	10.0	22.0	NA
	Seminary Creek	CDGFLA1	38.6561	88.4832	11/8/2006	14:45	7.3	385.0	12.5	14.3	12.7	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash (cont.)	Seminary Creek	CDGFLA1A	38.6595	88.4890	9/8/2006	13:45	7.4	362.0	22.7	2.6	19.0	NA
	Seminary Creek	CDGFLA1A	38.6595	88.4890	11/8/2006	15:50	7.2	429.8	16.8	15.1	12.7	NA
	Village Creek	CE01	38.4348	88.1369	9/6/2006	17:30	8.1	610.0	11.4	9.9	24.9	NA
	Village Creek	CE01	38.4348	88.1369	11/14/2006	8:45	7.5	697.9	8.0	10.6	6.8	NA
	Village Creek	CE01A	38.4294	88.0943	9/12/2006	17:05	7.2	327.0	145.2	5.8	22.6	NA
	Village Creek	CE01A	38.4294	88.0943	11/9/2006	13:45	7.2	607.2	8.7	11.2	14.2	NA
	Village Creek	CE02	38.4150	88.1659	9/6/2006	15:20	7.8	568.0	15.7	7.9	25.0	NA
	Village Creek	CE02	38.4150	88.1659	11/9/2006	12:55	7.5	587.4	14.1	10.7	13.1	NA
	Big Muddy Creek	CJ05	38.7693	88.3093	9/7/2006	16:45	8.2	63.1	11.4	10.5	23.6	NA
	Big Muddy Creek	CJ05	38.7693	88.3093	11/8/2006	11:30	7.4	457.0	32.5	12.4	8.3	NA
	Big Muddy Creek	CJ06	38.8298	88.3642	9/7/2006	18:10	7.5	588.0	34.6	4.9	21.8	NA
	Big Muddy Creek	CJ06	38.8298	88.3642	11/8/2006	11:00	7.3	455.1	15.8	11.6	10.6	NA
	Little Muddy Creek	CJA01	38.7647	88.3760	9/12/2006	10:20	7.0	321.0	9.5	3.4	20.9	NA
	Little Muddy Creek	CJA01	38.7647	88.3760	11/13/2006	12:00	7.0	267.9	113.2	10.1	7.4	NA
	Little Muddy Creek	CJA02	38.7047	88.3174	9/7/2006	14:20	6.8	554.0	45.9	2.8	20.4	NA
	Little Muddy Creek	CJA02	38.7047	88.3174	11/8/2006	12:30	7.0	497.0	35.8	9.3	10.4	NA
	Big Muddy Diversion Ditch	CJAE01	38.6865	88.2967	9/7/2006	12:10	7.1	1946.0	26.9	9.1	22.2	NA
	Big Muddy Diversion Ditch	CJAE01	38.6865	88.2967	11/8/2006	13:05	7.3	478.2	30.8	10.8	11.7	NA
	Big Muddy Diversion Ditch	CJAE01A	38.7467	88.2977	9/7/2006	15:45	8.1	908.0	6.5	10.3	24.3	NA
	Big Muddy Diversion Ditch	CJAE01A	38.7467	88.2977	11/13/2006	12:30	7.6	452.9	37.8	9.8	8.2	NA
Mary's River/North Fork Cox Creek	North Fork Cox Creek	IIHA01	38.0114	89.6460	9/9/2006	17:40	7.9	2073.0	N/A	10.0	22.0	NA
	North Fork Cox Creek	IIHA01	38.0114	89.6460	10/18/2006	14:25	8.3	2995.0	13.5	8.1	15.4	NA
	North Fork Cox Creek	IIHA31	38.0293	89.6303	9/9/2006	17:10	8.2	3491.0	N/A	9.6	23.9	NA
	North Fork Cox Creek	IIHA31	38.0293	89.6303	10/18/2006	14:45	8.4	3215.0	8.5	8.6	15.5	NA
	North Fork Cox Creek	IIHA-STC1	38.0015	89.6557	9/9/2006	16:15	7.8	3019.0	N/A	7.1	21.9	NA
	North Fork Cox Creek	IIHA-STC1	38.0015	89.6557	10/18/2006	14:00	8.1	1990.0	20.0	7.0	14.9	NA
	North Fork Cox Creek	IIHA-STE1	38.0048	89.6526	9/9/2006	15:45	7.8	3422.0	N/A	6.9	20.7	NA
	North Fork Cox Creek	IIHA-STE1	38.0048	89.6526	10/18/2006	13:40	8.0	2505.0	16.3	6.0	14.7	NA
	Maxwell Creek	IIKSPA1	38.1242	89.6870	9/7/2006	NOT SAMPLED *Site dry during both visits/available alternate locations also dry*						NA
	Maxwell Creek	IIKSPA1	38.1242	89.6870	10/17/2006							NA
	Maxwell Creek	IIKSPC1	38.1182	89.6885	9/7/2006	15:30	7.3	968.1	4.8	2.0	24.3	NA
	Maxwell Creek	IIKSPC1	38.1182	89.6885	10/17/2006	8:20	7.1	561.5	22.3	20.2	18.4	NA
	Maxwell Creek	IIKSPC3A	38.1090	89.6850	9/7/2006	15:00	7.5	997.0	4.4	2.6	21.6	NA
	Maxwell Creek	IIKSPC3A	38.1090	89.6850	10/17/2006	8:45	7.5	457.8	19.2	6.5	15.4	NA
	Maxwell Creek	IIKSPE1A	38.1218	89.6889	9/7/2006	NOT SAMPLED *Site dry during both visits/available alternate locations also dry*						NA
	Maxwell Creek	IIKSPE1A	38.1218	89.6889	10/17/2006							NA
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:00	9.1	279.7	N/A	13.9	25.6	1
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:02	9.1	279.5	N/A	13.9	24.9	2
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:04	9.1	279.2	N/A	13.8	24.7	3
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:06	9.1	278.8	N/A	13.9	24.6	4
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:08	9.0	279.3	N/A	13.2	24.4	5
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:10	9.0	279.7	N/A	12.6	24.3	6
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:12	8.9	280.4	N/A	11.8	24.2	7
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:14	8.2	286.0	N/A	6.2	23.9	8
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:16	7.8	287.4	N/A	4.4	23.7	9
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:18	7.6	288.9	N/A	2.5	23.5	10
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:20	7.3	290.3	N/A	0.3	23.1	11
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:22	7.3	296.0	N/A	0.1	22.7	12
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:24	7.1	317.6	N/A	0.0	21.2	13
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:26	7.1	332.7	N/A	0.0	18.5	14
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:28	7.1	330.3	N/A	0.0	17.1	15

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Mary's River/North Fork Cox Creek (cont.)	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:30	7.1	329.6	N/A	0.0	16.1	16
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:32	7.1	329.9	N/A	0.0	14.7	17
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:34	7.1	330.0	N/A	0.0	13.6	18
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:36	7.1	332.4	N/A	0.0	12.4	19
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:38	7.1	335.4	N/A	0.0	11.8	20
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:40	7.1	341.7	N/A	0.0	11.3	21
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:42	7.1	347.9	N/A	0.0	10.9	22
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:44	7.1	350.1	N/A	0.0	10.8	23
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:46	7.1	352.6	N/A	0.0	10.6	24
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:48	7.0	363.8	N/A	0.0	10.2	25
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	8.0	306.1	5.6	7.1	15.8	0
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	305.0	6.7	5.4	15.7	3.28
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	304.9	5.9	5.4	15.7	6.56
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	303.6	6.6	5.3	15.6	9.84
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.7	303.5	7.1	5.3	15.6	13.12
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.6	304.0	11.9	4.5	13.3	16.4
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.5	371.4	9.8	0.6	12.7	19.68
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.6	392.9	8.3	0.5	10.9	22.96
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.5	435.0	63.4	0.3	10.1	26.24
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:00	9.0	286.4	N/A	13.3	27.0	1
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:02	9.0	282.2	N/A	13.8	26.8	2
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:04	9.1	279.7	N/A	14.7	25.0	3
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:06	9.0	280.2	N/A	14.3	24.7	4
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:08	8.9	282.2	N/A	12.5	24.4	5
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:10	8.6	286.3	N/A	9.0	24.1	6
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:12	8.1	290.2	N/A	6.0	24.0	7
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:14	7.8	292.2	N/A	4.0	23.9	8
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:16	7.7	292.7	N/A	3.1	23.8	9
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	8.0	304.9	10.3	7.1	16.0	0
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.9	304.5	7.0	6.7	15.9	3.28
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.8	304.5	6.6	6.4	15.9	6.56
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.8	304.5	6.3	6.3	15.8	9.84
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:00	9.0	283.0	N/A	13.2	26.4	1
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:02	9.0	283.3	N/A	12.9	26.5	2
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:04	9.0	281.0	N/A	12.8	25.8	3
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:06	9.0	280.4	N/A	12.9	25.0	4
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:08	9.0	279.7	N/A	12.9	24.6	5
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:10	9.0	279.7	N/A	12.6	24.5	6
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	8.0	305.0	8.8	7.9	16.0	0
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	7.9	304.7	8.7	7.1	16.0	3.28
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	7.8	304.7	10.4	6.7	16.0	6.56
	Randolph County Lake Tributary	RIB-Trib	37.9813	89.7988	9/9/2006	13:20	9.0	284.0	N/A	12.9	28.4	NA
	Randolph County Lake Tributary	RIB-Trib	37.9813	89.7988	10/18/2006	11:45	8.1	341.7	46.3	8.3	16.2	NA
Sangamon River/Lake Decatur	Owl Creek	EZV01	40.3254	88.3531	8/30/2006	12:50	7.4	669.0	50.8	8.5	21.2	NA
	Owl Creek	EZV01	40.3254	88.3531	11/2/2006	9:25	8.2	856.7		12.2	5.1	NA
	Owl Creek	EZVA1	40.3115	88.3409	8/30/2006	11:05	7.7	606.9	52.3	6.5	19.0	NA
	Owl Creek	EZVA1	40.3115	88.3409	11/2/2006	10:33	8.2	856.3		11.8	4.7	NA
	Owl Creek	EZVC1	40.3101	88.3423	8/30/2006	10:25	7.3	1450.0	25.6	5.0	21.0	NA
	Owl Creek	EZVC1	40.3101	88.3423	11/2/2006	12:20	8.1	990.7		11.7	6.0	NA
	Owl Creek	EZVE1	40.3113	88.3415	8/30/2006	10:45	7.5	1497.0	20.3	11.1	21.5	NA
	Owl Creek	EZVE1	40.3113	88.3415	11/2/2006	12:59	8.3	859.8		12.5	6.1	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Shoal Creek	Shoal Creek	OI05	38.5361	89.5213	9/1/2006	12:35	7.5	563.4	38.7	9.1	22.9	NA
	Shoal Creek	OI05	38.5361	89.5213	10/17/2006	11:30	7.9	604.4	39.7	8.5	12.0	NA
	Shoal Creek	OI05A	38.5370	89.5330	9/1/2006	NOT SAMPLED *Site located at end of private road with chained fence/alternate location not located*						NA
	Shoal Creek	OI05A	38.5370	89.5330	10/17/2006							NA
	Shoal Creek	OI05B	38.5333	89.5496	9/1/2006	14:20	7.8	542.2	43.0	10.8	26.2	NA
	Shoal Creek	OI05B	38.5333	89.5496	10/17/2006	11:15	7.9	542.4	72.7	8.7	12.3	NA
	Shoal Creek	OI05C	38.5020	89.5661	9/1/2006	15:40	7.8	535.3	43.5	10.2	23.5	NA
	Shoal Creek	OI05C	38.5020	89.5661	10/16/2006	10:30	8.0	578.9	46.0	9.4	12.1	NA
	Locust Fork	OIC01	38.7715	89.5556	8/31/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	Locust Fork	OIC01	38.7715	89.5556	10/19/2006	12:20	7.8	401.1	24.3	3.8	10.0	NA
	Locust Fork	OIC02	38.7536	89.5288	8/31/2006	17:50	8.0	499.6	23.2	9.4	24.2	NA
	Locust Fork	OIC02	38.7536	89.5288	10/17/2006	13:00	7.7	422.2	26.9	5.2	14.2	NA
	Chicken Creek	OIO09	38.6407	89.5025	9/1/2006	NOT SAMPLED *Sites dry during both visits/sites located at only two road crossings on segment*						NA
	Chicken Creek	OIO09	38.6407	89.5025	10/17/2006							NA
	Chicken Creek	OIO09A	38.6373	89.5260	9/1/2006							NA
	Chicken Creek	OIO09A	38.6373	89.5260	10/17/2006							NA
	Cattle Creek	OIP10	38.6649	89.5170	8/31/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	Cattle Creek	OIP10	38.6649	89.5170	10/17/2006	12:05	7.9	928.0	105.6	2.0	14.2	NA
	Cattle Creek	OIP10A	38.6744	89.5359	8/31/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	Cattle Creek	OIP10A	38.6744	89.5359	10/17/2006							NA
South Fork Saline River/Lake of Egypt	South Fork Saline River	ATH08	37.6399	88.9281	9/26/2006	10:20	7.1	165.0	0.6	8.7	23.6	NA
	South Fork Saline River	ATH08	37.6399	88.9281	10/31/2006	11:15	6.6	213.1	10.0	8.8	19.0	NA
	South Fork Saline River	ATH14	NA	NA	9/26/2006	NOT SAMPLED *Sites located on private property and/or not accessible by roads* *No other road crossings available on segment*						NA
	South Fork Saline River	ATH14	NA	NA	10/31/2006							NA
	South Fork Saline River	ATHLEC1	NA	NA	9/26/2006							NA
	South Fork Saline River	ATHLEC1	NA	NA	10/31/2006							NA
	South Fork Saline River	ATHLEC2	37.6295	88.9465	9/26/2006	9:45	6.6	81.0	15.6	9.4	18.1	NA
	South Fork Saline River	ATHLEC2	37.6295	88.9465	10/31/2006	12:00	6.8	137.7	11.6	9.6	17.1	NA
	Briers Creek	ATHS01	37.6766	88.7178	9/11/2006	11:30	7.6	1997.0	2.0	9.1	21.3	NA
	Briers Creek	ATHS01	37.6766	88.7178	9/27/2006	9:00	7.3	1392.0	3.4	10.2	15.5	NA
	Briers Creek	ATHS01	37.6766	88.7178	10/30/2006	16:30	7.1	1281.0	19.6	9.4	13.7	NA
	Briers Creek	ATHS01	37.6766	88.7178	11/15/2006	10:25	7.0	700.1	185.3	4.6	9.4	NA
	Briers Creek	ATHS01A	37.6995	88.7257	9/11/2006	10:00	7.1	765.0	5.6	9.7	17.9	NA
	Briers Creek	ATHS01A	37.6995	88.7257	9/27/2006	11:30	7.5	817.0	1.9	9.7	17.0	NA
	Briers Creek	ATHS01A	37.6995	88.7257	11/2/2006	12:00	8.0	862.8	3.0	8.5	9.5	NA
	Briers Creek	ATHS01A	37.6995	88.7257	11/15/2006	11:10	6.8	226.1	36.3	5.4	10.2	NA
	Briers Creek	ATHS01B	37.6943	88.7245	9/11/2006	10:25	7.2	507.0	6.2	9.5	17.8	NA
	Briers Creek	ATHS01B	37.6943	88.7245	9/27/2006	10:35	6.7	500.0	0.5	9.7	17.3	NA
	Briers Creek	ATHS01B	37.6943	88.7245	11/2/2006	12:20	7.4	726.7	2.9	9.9	9.5	NA
	Briers Creek	ATHS01B	37.6943	89.7640	11/15/2006	11:30	6.8	198.9	69.1	4.0	10.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	9/11/2006	12:55	6.8	2071.0	21.5	6.3	19.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	9/27/2006	9:30	7.0	1571.0	2.2	9.8	15.1	NA
	Briers Creek	ATHS01C	37.6882	88.7195	10/31/2006	14:30	7.4	1296.0	4.5	9.4	12.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	11/15/2006	10:45	7.0	848.6	90.7	8.8	9.5	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	9/11/2006	10:40	6.9	375.0	16.4	6.7	22.7	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	9/27/2006	NOT SAMPLED *Site flooded over road with no safe access/no other road crossings on segment*						NA
	East Palzo Creek	ATHV01	37.6502	88.7608	10/31/2006	13:40	6.5	490.6	14.2	7.6	12.4	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	11/15/2006	10:00	6.3	554.5	200.0	5.1	9.4	NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	9/11/2006	8:25	7.2	1878.0	1.7	6.6	18.8	
	East Palzo Creek	ATHV01A	37.6143	88.7788	9/27/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	10/31/2006							NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	11/15/2006	9:05	6.8	158.9	81.9	9.0	9.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	9/11/2006	8:55	6.9	481.0	28.8	6.0	19.1	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	9/26/2006	12:30	6.2	405.0	4.6	10.9	17.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	10/31/2006	13:00	6.4	498.2	23.8	8.7	12.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	11/15/2006	9:35	6.1	435.0	243.8	5.6	9.4	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
South Fork Sangamon River/ Lake Taylorville	South Fork Sangamon River	EO13	39.4072	89.3164	8/30/2006	18:10	7.3	719.3	7.2	6.3	20.4	NA
	South Fork Sangamon River	EO13	39.4072	89.3164	11/2/2006	16:50	7.7	528.5		6.5	6.1	NA
	South Fork Sangamon River	EO13A	39.2700	89.1880	8/30/2006	19:55	7.3	754.7	7.6	9.7	21.6	NA
	South Fork Sangamon River	EO13A	39.2700	89.1880	11/2/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	South Fork Sangamon River	EO13B	39.3630	89.2700	8/30/2006	19:25	7.6	1112.0	60.1	8.3	21.6	NA
	South Fork Sangamon River	EO13B	39.3630	89.2700	11/2/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	South Fork Sangamon River	EO13C	39.4590	89.2970	8/30/2006	18:55	7.0	56.9	96.0	3.8	21.1	NA
	South Fork Sangamon River	EO13C	39.4590	89.2970	11/2/2006	16:25	8.2	954.1		5.8	6.4	NA

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH(1)	DO(1)	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc (6)	Dissolved Iron	Total Silver	Dissolved Copper (6)	TP	Atrazine (5)	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Bay Creek	Cedar Creek	AJF16	9/25/2006	18:00		8.9	0.25										
			11/3/2006	11:05		11.0	0.12										
		AJF16A	9/25/2006	18:15		9.4	0.23										
			11/2/2006	13:30		11.6	0.08										
	Bay Creek Ditch	AJK01	9/25/2006	15:58		5.6	0.16										
			10/31/2006	8:15		8.2	0.05										
		AJK01A	10/31/2006	8:45		6.1	0.06										
Cahokia Creek/Holiday Shores Lake	Cahokia Diversion Ditch	JQ07	10/4/2006	16:35		5.3								ND			
			10/17/2006	14:15		9.4								ND			
		JQ01	10/4/2006	16:20		**3.4**								ND			
			10/17/2006	14:45		9.6								ND			
Cedar Creek	Big Muddy River	N99	9/7/2006	12:15		10.1		186									
			11/1/2006	9:45		7.8		75									
		N13	9/7/2006	11:15		8.1		144									
			11/1/2006	10:45		8.2		68									
	Cave Creek	NAC01	9/11/2006	11:45		7.6											
			11/1/2006	11:45		10.6											
		NAC01A	9/11/2006	11:15		**4.9**											
			11/1/2006	12:15		10.1											
Crab Orchard Lake	Crab Orchard Creek	ND11	9/6/2006	12:15	7.3	5.2	1.00										
			11/1/2006	14:00	7.7	10.1	0.26										
		ND12	9/6/2006	13:15	7.3		0.17										
			11/1/2006	15:00	7.7		ND										
		ND13	9/6/2006	15:00		6.0											
			11/1/2006	15:45		11.1											
		ND15	9/6/2006	16:30		6.8											
	Little Crab Orchard Creek	NDA01	9/6/2006	18:00		**2.1**	**2.00**										
			11/2/2006	8:30		8.2	0.20										
		NDA99	11/2/2006	10:30		12.3	0.03										
	Piles Fork	NDB03	9/7/2006	10:00		**1.6**											
			11/2/2006	9:15		10.3											
		NDB04	9/9/2006	7:40		**3.6**											
			11/2/2006	11:00		11.5											
Crooked Creek	Plum Creek	OZH-OK-A2	9/8/2006	14:00		6.8	0.65										
			10/19/2006	10:50		5.3	0.33										
		OZH-OK-A2A	9/8/2006	16:25		8.5	0.20										
			10/19/2006	11:20		9.0	0.22										
		OZH-OK-C2	9/8/2006	12:45		**1.1**											
			10/19/2006	10:15		**2.5**											
		OZH-OK-C2A	9/8/2006	17:30		**4.6**											
			10/19/2006	13:40		**3.2**											
		OZH-OK-C3	9/9/2006	15:00		**4.1**	0.30										
			10/19/2006	9:35		5.2	0.77										
	Little Crooked Creek	OJA-01	9/7/2006	17:45		**3.7**	0.14										
			10/19/2006	14:05		**4.7**	0.17										
		OJA-02	9/8/2006	11:15		**3.1**	0.14										
			10/19/2006	14:35		**3.8**	0.17										

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH(1)	DO(1)	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc (6)	Dissolved Iron	Total Silver	Dissolved Copper (6)	TP	Atrazine (5)	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Village Creek	CE01	9/6/2006	17:30		9.9	0.17										
			11/14/2006	8:45		10.6	0.10										
		CE02	9/6/2006	15:20		7.9	0.80										
			11/9/2006	12:55		10.7	0.11										
		CE01A	9/12/2006	17:05		5.8	0.41										
			11/9/2006	13:45		11.2	0.08										
	Johnson Creek	CCAFFA1A	9/10/2006	10:50		**3.8**											
			11/14/2006	10:45		12.3											
		CCA12	9/9/2006	13:05		14.2											
			11/14/2006	9:45		7.7											
		CCA13	9/9/2006	14:30		14.9											
			11/14/2006	10:15		12.8											
		CCA14A	9/9/2006	15:25		5.7											
			11/14/2006	10:25		12.5											
	Pond Creek	CCFFD1	9/9/2006	10:30		7.1											
			10/31/2006	10:10		8.2											
		CCFFD1A	11/9/2006	12:15		11.2											
		CCFFD1B	9/9/2006	11:45		8.6											
			11/9/2006	11:35		12.1											
		CCFFD1C	9/10/2006	12:10		11.9											
			10/31/2006	11:20		14.4											
	Seminary Creek	CDGFLA1	9/8/2006	15:40		10.0											
			11/8/2006	14:45		14.3											
		CDGFLA1A	9/8/2006	13:45		**2.6**											
			11/8/2006	15:50		15.1											
		CDFGLC6	9/8/2006	12:25		6.6											
			11/8/2006	17:00		10.5											
		CDFGLC6A	9/8/2006	11:10		7.0											
			11/8/2006	16:45		12.0											
	Big Muddy Creek	CJ06	9/7/2006	18:10		**4.9**	0.54										
			11/8/2006	11:00		11.6	0.39										
		CJ05	9/7/2006	16:45		10.5	0.04										
			11/8/2006	11:30		12.4	0.07										
	Little Muddy Creek	CJA02	9/7/2006	4:20		**2.8**	**1.30**										
			11/8/2006	12:30		9.3	0.39										
		CJA01	9/12/2006	10:20		**3.4**	**1.30**										
			11/13/2006	12:00		10.1	0.17										
	Big Muddy Diversion Ditch	CJAE01	9/7/2006	12:10		9.1											
			11/8/2006	13:05		10.8											
		CJAE01A	9/7/2006	15:45		10.3											
			11/13/2006	12:30		9.8											

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH$^{(1)}$	DO$^{(1)}$	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc $^{(6)}$	Dissolved Iron	Total Silver	Dissolved Copper $^{(6)}$	TP	Atrazine $^{(5)}$	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Elm River	CD02A	9/12/2006	12:51		**3.8**											
		CD02	9/8/2006	17:45		8.1											
		CD01	4/18/2006	14:30												0.12	
			4/26/2006	11:15												0.16	
			5/1/2006	11:00												0.27	
			5/17/2006	9:30												**19.00**	
			5/24/2006	11:20												**15.00**	
			5/31/2006	11:30												8.30	
			6/7/2006	11:25												5.70	
			6/15/2006	9:50												2.80	
			6/22/2006	11:15												1.20	
			6/27/2006	9:15												4.20	
			7/5/2006	11:50												2.40	
			7/12/2006	11:30												0.92	
			7/20/2006	11:15												2.40	
			7/27/2006	11:05												2.60	
			8/1/2006	9:20												2.60	
			8/8/2006	12:20												1.60	
	Little Wabash River	C33 $^{(4)}$	4/18/2006	11:00												0.55	
			4/26/2006	12:15			**0.35**									1.10	
			5/1/2006	11:45			**0.50**									0.71	
			5/10/2006	12:20			**0.41**										
			5/17/2006	14:00												**19.00**	
			5/24/2006	12:15			**0.38**									8.10	
			5/31/2006	12:40			**0.37**									**13.00**	
			6/7/2006	12:30			**0.44**									6.30	
			6/15/2006	11:05												5.30	
			6/22/2006	12:00			**0.76**									2.60	
			6/27/2006	11:50												2.50	
			7/5/2006	13:00			**0.50**									1.70	
			7/12/2006	12:30			**0.54**									1.00	
			7/20/2006	12:20			**0.46**									2.30	
			7/27/2006	12:10												0.64	
			8/1/2006	10:30												0.66	
			8/8/2006	13:30												0.50	

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH$^{(1)}$	DO$^{(1)}$	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc $^{(6)}$	Dissolved Iron	Total Silver	Dissolved Copper $^{(6)}$	TP	Atrazine $^{(5)}$	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Little Wabash River	C09	3/17/2005	8:00		14.9											
			4/19/2005	14:30		7.3											
			5/9/2005	10:30		6.7											
			6/23/2005	7:30		5.1											
			8/23/2005	13:00		**4.2**											
			9/27/2005	16:00		7.5											
			10/27/2005	14:00		8.7											
			12/6/2005	13:00		11.8											
			2/1/2006	12:30		9.3											
			3/15/2006	10:00		6.2											
			4/18/2006	16:00												0.27	
			4/26/2006	10:00									ND			0.62	
			5/1/2006	9:45									ND			0.59	
			5/10/2006	10:00									ND				
			5/17/2006	11:00									ND			**20.00**	
			5/24/2006	9:45									ND			6.30	
			5/31/2006	10:20									ND			**24.00**	
			6/7/2006	10:15									ND			4.20	
			6/15/2006	8:50									ND			1.80	
			6/22/2006	10:05									ND			1.20	
			6/27/2006	10:40									ND			1.50	
			7/5/2006	10:30									ND			1.20	
			7/12/2006	10:30									ND			0.96	
			7/20/2006	10:00									ND			1.60	
			7/27/2006	10:00									ND			0.72	
			8/1/2006	8:30									ND			0.63	
			8/8/2006	11:05									ND			0.40	
			8/18/2006	16:00									ND				
Mary's River/North Fork Cox Creek	North Fork Cox Creek	IIHA31	9/9/2006	17:10				**1610**	**3110**								
			10/18/2006	14:45				**1830**	**2830**								
		IIHA01	9/9/2006	17:40				**1850**	**3090**								
			10/18/2006	14:25				**1630**	**2540**								
		IIHA-STE1	9/9/2006	15:40					**3090**								
			10/18/2006	13:40					**1340**								
		IIHA-STC1	9/9/2006	16:15					**2530**								
			10/18/2006	14:00					**1400**								
	Maxwell Creek	IIKSPC1	9/7/2006	15:30		**2.0**											
			10/17/2006	8:20		20.2											
		IIKSPC3A	9/7/2006	15:00		**2.6**											
			10/17/2006	8:45		6.5											
	Randolph County Lake	RIB-1$^{(3)}$	9/9/2006	12:00											0.04		
			10/18/2006	10:45											**0.130**		
		RIB-2 $^{(3)}$	9/9/2006	14:00											0.04		
			10/18/2006	12:05											**0.053**		
		RIB-3 $^{(3)}$	9/9/2006	13:00											0.04		
			10/18/2006	11:15											**0.100**		

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					$pH^{(1)}$	$DO^{(1)}$	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc $^{(6)}$	Dissolved Iron	Total Silver	Dissolved Copper $^{(6)}$	TP	Atrazine $^{(5)}$	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Sangamon River/ Lake Decatur	Owl Creek	EZV01	8/30/2006	12:50		8.5											
			11/2/2006	9:25		12.2											
		EZVA1	8/30/2006	11:05		6.5											
			11/2/2006	10:33		11.8											
		EZVE1	8/30/2006	10:45		11.1											
			11/2/2006	12:59		12.5											
		EZVC1	8/30/2006	10:25		**5.0**											
			11/2/2006	12:20		11.7											
Shoal Creek	Shoal Creek	OI05	9/1/2006	12:35		9.1											
			10/17/2006	11:30		8.5											
		OI05B	9/1/2006	14:20		10.8											
			10/17/2006	11:15		8.7											
		OI05C	9/1/2006	15:40		10.2											
			10/16/2006	10:30		9.4											
	Locust Fork	OIC01	10/19/2006	12:20		**3.8**	0.18										
		OIC02	8/31/2006	17:50		9.4	0.35										
			10/17/2006	13:00		5.2	0.08										
	Cattle Creek	OIP10	10/17/2006	12:05		**2.0**			928[2]					0.021			5.8
South Fork Saline River/ Lake of Egypt	Briers Creek	ATHS01	9/11/2006	11:30	7.6	9.1	0.65	**1250**	**1960**		0.020	0.310	ND				
			9/27/2006	9:00	7.3	10.2	**2.00**	**951**	**1490**		0.022	ND	ND				
			10//2006	11:30							ND	ND					
			10/30/2006	16:30			**1.50**	**656**	**1120**		0.035	ND	ND				
			11/15/2006	10:25			**1.40**	281	469		0.028	**1.10**	ND				
		ATHS01A	9/27/2006	11:30	7.5	9.7	0.10	294	678		ND	**1.10**	ND				
			10/4/2006	10:50							ND	ND					
			11/2/2006	12:00	8.0	8.5	0.11	219	597		0.012	ND	ND				
			11/15/2006	11:10	6.8	5.4	0.12	65	213		ND	**1.40**	ND				
		ATHS01B	9/13/2006	10:40			0.18	143	418			ND	ND				
			9/27/2006	10:35	6.7	9.7	0.17	196	414		ND	ND	ND				
			10/4/2006	11:05							0.013	ND					
			11/2/2006	12:20	7.4	9.9	0.22	373	608		0.018	ND	ND				
			11/15/2006	11:30	6.8	**4.0**						**2.10**					
		ATHS01C	9/11/2006	12:55			**8.70**	**1290**	**2150**			**5.00**	ND				
			9/27/2006	9:30	7.0	9.8	**4.10**	**1100**	**1660**		ND	0.78	ND				
			10/4/2006	11:20							ND	**2.20**					
			10/31/2006	14:30	7.4	9.4	**1.90**	**691**	**1190**		ND	0.17	ND				
			11/15/2006	10:45	7.0	8.8	0.93	338	667		ND	0.470	ND				

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH$^{(1)}$	DO$^{(1)}$	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc $^{(6)}$	Dissolved Iron	Total Silver	Dissolved Copper $^{(6)}$	TP	Atrazine $^{(5)}$	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
South Fork Saline River/ Lake of Egypt	East Palzo Creek	ATHV01A	9/11/2006	10:40	6.9	6.7	**1.40**		**1560**			ND					
			10/31/2006	13:40	6.5	7.6	**1.80**		375			0.160		ND			
			11/15/2006	10:00	**6.3**	5.1	0.09		211			**2.60**		ND			
		ATHV01	9/11/2006	10:40	6.9	6.7	0.38		262			ND					
			10/4/2006	12:30								0.13		ND			
			10/31/2006	13:40	6.5	7.6	**1.80**		375			0.16		ND			
			11/15/2006	10:00	**6.3**	5.1	**2.10**		324			0.340		ND			
		ATHV01B	9/11/2006	8:55	6.9	6.0	0.41		388			ND					
			9/26/2006	12:30	**6.2**	10.9	1.00		323			ND		ND			
			10/4/2006	11:50								ND		ND			
			10/31/2006	13:00	**6.4**	8.7	**1.60**		341			ND		ND			
			11/15/2006	9:35	**6.1**	5.6	**1.60**		225			0.100		ND			
	South Fork Saline River	ATHLEC2	9/26/2006	9:45		9.4											
			10/31/2006	12:00		9.6											
		ATH08	9/26/2006	10:20		8.7											
			10/31/2006	11:15		8.8											
South Fork Sangamon River/ Lake Taylorville	South Fork Sangamon River	EO13A	8/30/2006	19:55		9.7	0.61			0.05							
		EO13	8/30/2006	18:10		6.3	0.49			0.20							
			11/2/2006	16:50		6.5	0.33			0.08							
		EO13B	8/30/2006	19:25		8.3	**1.18**			0.20							
		EO13C	8/30/2006	18:55		**3.8**	**5.49**			0.27							
			11/2/2006	16:25		5.8	0.38			0.13							

Shaded cells indicate exceedances of the applicable water quality standard

1 pH and DO values in this table represent field parameters sampled using the In-Site 9500 Profiler. Continuous DO and pH data are available in Appendix D.

2 Value shown is for conductivity. TDS standard corresponds to 1667 uS/cm specific conductance

3 Values shown were collected at one-foot depth.

4 Segment C33 is a source of public water. Therefore the applicable manganese standard is 150 ug/L.

5 Chronic criteria for atrazine is 9 ug/L and a single exceedance of this value indicates a potential cause of impairment

6 Corresponding hardness values were used to calculate standards. Analytical data can be found in Appendix C.

Section 3
Quality Assurance Review

A review was conducted to assess the quality and usability of data generated from Stage 2 work activities and to review compliance with the original sampling plan and objectives developed for the QAPP. Field and laboratory methods were deemed in accordance with the QAPP. Minor deviations from the original plan occurred and all are discussed below.

3.1 Deviations from original Sampling Plan (QAPP)

The following issues and/or concerns developed during the sampling events:

- Sampling during the week of September 25th followed a heavy precipitation event which resulted in high stream flows and flooding at Bay Creek Ditch segment AJK01A and East Palzo Creek segment ATHV01.
- In-field filtering was not performed for dissolved phosphorus or dissolved metal samples. Illinois EPA requested additional information on this procedure. CDM along with ARDL, Inc drafted text for Illinois EPA to validate this sampling practice. Total versus dissolved samples are discussed further in section 3.2.2.
- All locations on Chicken Creek (OIO09) were dry during both sample periods; therefore no samples were collected for this segment.
- The following sites had no water during either sampling event: Maxwell Creek IIKSPA1 and IIKSPE1A, and Cattle Creek OIP10A. Alternate locations were not found.
- Access was not available to the following sites during either sampling event: Shoal Creek OIO5A, South Fork Saline River sites ATH14 and ATHLEC1. Alternate locations were not found.
- Site EZVA1 on Owl Creek was moved from the location proposed in the QAPP to the intersection of Owl Creek and County Road 3100 due to better stream flow.
- Only one round of sampling was conducted at the following sites due to access or water volume issues (refer to Table 2-2 for specific dates and issues): Locust Fork OIC01, Cattle Creek OIP10, Crab Orchard Creek ND15, Little Crab Orchard Creek NDA99, Pond Creek CCFFD1A, East Palzo Creek ATHV01 and ATHV01A, and Bay Creek Ditch AJK01A.
- Due to field crew error only one round of sampling was conducted at South Fork Sangamon River EO13A and EO13B and Elm River locations CD02 and CD02A.

3.2 Data Verification and Validation

A data quality review was performed on all laboratory data. The review consisted of an evaluation of laboratory QC and field QC samples. Laboratory QC included an evaluation of method blanks, matrix spikes, matrix spike duplicates, laboratory control samples and holding times. Field QC included an evaluation of field duplicates. No decontamination rinsate blanks were collected.

No laboratory violation resulted in the qualification of CDM collected data. While some matrix spikes had percent recoveries outside of the established limits, all other QC associated with the samples were acceptable. When a matrix spike was reported outside of the control limits, the laboratory control samples had percent recoveries within the established control limits, indicating a matrix effect on the sample analysis and no need to qualify the data. All samples were analyzed within the control limits.

An evaluation of the phosphorus data (total versus dissolved) was performed to determine the effects of filtering the samples immediately versus waiting up to 48 to 64 hours. All samples were received by the laboratories on ice and at 4^0C (+/-). A total of 161 samples have been analyzed for both total and dissolved phosphorus by method 365.2. Of the 161 samples, a total of 10 samples sets had a phosphorus concentration of greater than 1 mg/L (100 times higher than the reporting limit and considered significant when controlling based on RPDs). One of these samples had relative percent difference (RPD) between the total and dissolved fraction of the sample of greater than 100. Precision values of less that 25 % RPD are considered acceptable for sample results reported significantly above the reporting limit. Sample EO13C had total phosphorus measured at 2.09 mg/L and dissolved phosphorus measured at 0.52 mg/L. The TSS measured in this sample was 159 mg/L. The suspended solids contained in this sample may have absorbed the available phosphorus, but all other results in samples with phosphorus concentrations above 1mg/L show that this reaction is not taking place. Sampling or analytical variations may explain the elevated RPD between the sample and the duplicate. Total phosphorus and dissolved phosphorus results for samples with phosphorus concentrations above 1 mg/L are not significantly different.

Looking at all other results, there does not appear to be a correlation between the difference of total and dissolved phosphorus and the TSS concentration. Suspended solids absorbing dissolved phosphorus would be the likely mechanism for lowering the dissolved phosphorus concentrations. Based on the lack of this correlation, dissolved phosphorus concentration would not be significantly different if the samples were filtered immediately versus filtering at the laboratory 48-hours after collection.

Finally, field and laboratory quality control data were collected to assess bias associated between field and laboratory methods. Positive sample results and relative percent difference (RPD) are presented in Table 3-1.

3.3 Data Quality Objectives

The data generated during the Stage 2 investigation conformed to the data quality objectives established in the QAPP. A completeness criterion of 90% was established and easily achieved. No data have been qualified that were collected by CDM personnel and analyzed by ARDL, Inc or Prairie Analytical laboratories. Data qualifiers were applied to some of the data collected by Illinois EPA personnel. All qualifiers are included with the laboratory data contained in Appendix C.

Table 3-1: Duplicate Pair Sample Results

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
AJK01-DUP	Solids, total suspended	24.2	MG/L	9/25/2006	
AJK01	Solids, total suspended	25	MG/L	9/25/2006	3.252033
ATHS01A-DUP	Hardness (CA/MG)	435.1	MG CACO3/L	11/2/2006	
ATHS01A	Hardness (CA/MG)	445	MG CACO3/L	11/2/2006	2.249744
ATHS01A-DUP	Solids, total dissolved	604	MG/L	11/2/2006	
ATHS01A	Solids, total dissolved	597	MG/L	11/2/2006	-1.1657
ATHS01A-DUP	Chloride	5.13	MG/L	9/27/2006	
ATHS01A	Chloride	5.1	MG/L	9/27/2006	-0.64556
ATHS01A-DUP	Solids, total dissolved	675	MG/L	9/27/2006	
ATHS01A	Solids, total dissolved	678	MG/L	9/27/2006	0.443459
ATHS01A-DUP	Sulfate	290.63	MG/L	9/27/2006	
ATHS01A	Sulfate	294	MG/L	9/27/2006	1.154242
ATHS01C-DUP	Chloride	5.38	MG/L	9/11/2006	
ATHS01C	Chloride	5.4	MG/L	9/11/2006	0.388903
ATHS01C-DUP	Sulfate	1297.83	MG/L	9/11/2006	
ATHS01C	Sulfate	1290	MG/L	9/11/2006	-0.60514
ATHS01-FIELDDUP	Alkalinity	113	MG/L	10/30/2006	
ATHS01	Alkalinity	108	MG/L	10/30/2006	-4.52489
ATHS01-FIELDDUP	Chloride	4.9	MG/L	10/30/2006	
ATHS01	Chloride	4.9	MG/L	10/30/2006	0
ATHS01-FIELDDUP	Hardness (CA/MG)	673	MG CACO3/L	10/30/2006	
ATHS01	Hardness (CA/MG)	668	MG CACO3/L	10/30/2006	-0.74571
ATHS01-FIELDDUP	Iron	68200	MG/KG	10/30/2006	
ATHS01	Iron	93800	MG/KG	10/30/2006	31.60494
ATHS01-FIELDDUP	Manganese	1130	MG/KG	10/30/2006	
ATHS01	Manganese	1480	MG/KG	10/30/2006	26.81992
ATHS01-FIELDDUP	Manganese	1.5	MG/L	10/30/2006	
ATHS01	Manganese	1.5	MG/L	10/30/2006	0
ATHS01-FIELDDUP	Nitrate-Nitrite	0.06	MG/L	10/30/2006	
ATHS01	Nitrate-Nitrite	0.06	MG/L	10/30/2006	-11.9658
ATHS01-FIELDDUP	Phosphorus, diss	0.05	MG/L	10/30/2006	
ATHS01	Phosphorus, diss	0.05	MG/L	10/30/2006	8.163265
ATHS01-FIELDDUP	Phosphorus, total	0.04	MG/L	10/30/2006	
ATHS01	Phosphorus, total	0.03	MG/L	10/30/2006	-26.8657
ATHS01-FIELDDUP	Solids, total	69.7	%	10/30/2006	
ATHS01	Solids, total	74.5	%	10/30/2006	6.65742
ATHS01-FIELDDUP	Solids, total dissolved	1040	MG/L	10/30/2006	
ATHS01	Solids, total dissolved	1070	MG/L	10/30/2006	2.843602
ATHS01-FIELDDUP	Solids, total suspended	4.3	MG/L	10/30/2006	
ATHS01	Solids, total suspended	5.6	MG/L	10/30/2006	26.26263
ATHS01-FIELDDUP	Sulfate	662	MG/L	10/30/2006	
ATHS01	Sulfate	604	MG/L	10/30/2006	-9.16272
ATHS01-FIELDDUP	Zinc	106	MG/KG	10/30/2006	
ATHS01	Zinc	116	MG/KG	10/30/2006	9.009009
ATHS01-FIELDDUP	Zinc, diss	0.02	MG/L	10/30/2006	
ATHS01	Zinc, diss	0.03	MG/L	10/30/2006	8.333333
ATHS01-DUP	Alkalinity	60.9	MG/L	11/15/2006	
ATHS01	Alkalinity	56.8	MG/L	11/15/2006	-6.96686
ATHS01-DUP	Hardness (CA/MG)	340.14	MG CACO3/L	11/15/2006	
ATHS01	Hardness (CA/MG)	337	MG CACO3/L	11/15/2006	-0.92743
ATHS01-DUP	Solids, total dissolved	481	MG/L	11/15/2006	

Table 3-1: Duplicate Pair Sample Results (continued)

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
ATHS01	Solids, total suspended	151	MG/L	11/15/2006	-104.43
ATHS01-DUP	Hardness (CA/MG)	1035.17	MG CACO3/L	9/27/2006	
ATHS01	Hardness (CA/MG)	1030	MG CACO3/L	9/27/2006	-0.50069
ATHV01B-DUP	Alkalinity	15.3	MG/L	9/26/2006	
ATHV01B	Alkalinity	15.3	MG/L	9/26/2006	0
ATHV01B-DUP	Solids, total	72.5	%	9/26/2006	
ATHV01B	Solids, total	71.9	%	9/26/2006	-0.83102
CCFFD1-DUP	Chlorophyll	5.5	MG/CU.M.	9/9/2006	
CCFFD1	Chlorophyll	5	MG/CU.M.	9/9/2006	-9.52381
CE01A-DUP	Solids, total suspended	134	MG/L	9/12/2006	
CE01A	Solids, total suspended	137	MG/L	9/12/2006	2.214022
CJA02-DUP	Biological Oxygen Demand	4	MG/L	11/8/2006	
CJA02	Biological Oxygen Demand	3.7	MG/L	11/8/2006	-7.79221
EO13-DUP	Biological Oxygen Demand	6.3	MG/L	11/2/2006	
EO13	Biological Oxygen Demand	6.3	MG/L	11/2/2006	0
EO13-DUP	Solids, total suspended	8.4	MG/L	11/2/2006	
EO13	Solids, total suspended	7.6	MG/L	11/2/2006	-10
IIAA01-DUP	Chloride	21.71	MG/L	9/9/2006	
IIAA01	Chloride	21.7	MG/L	9/9/2006	-0.0258
IIAA01-DUP	Sulfate	1832.11	MG/L	9/9/2006	
IIAA01	Sulfate	1850	MG/L	9/9/2006	0.971725
IIHA01-DUP	Chloride	21.71	MG/L	9/9/2006	
IIHA01	Chloride	21.7	MG/L	9/9/2006	-0.0258
IIHA01-DUP	Sulfate	1832.11	MG/L	9/9/2006	
IIHA01	Sulfate	1850	MG/L	9/9/2006	0.971725
IIHA31-DUP	Hardness (CA/MG)	1290.87	MG CACO3/L	9/9/2006	
IIHA31	Hardness (CA/MG)	1300	MG CACO3/L	9/9/2006	0.704783
IIHA31-DUP	Hardness (CA/MG)	1306.27	MG CACO3/L	10/18/2006	
IIHA31	Hardness (CA/MG)	1280	MG CACO3/L	10/18/2006	-2.0315
IIHA31-DUP	Chloride	19.5	MG/L	10/18/2006	
IIHA31	Chloride	19.4	MG/L	10/18/2006	-0.51363
IIHA31-DUP	Solids, total dissolved	2850	MG/L	10/18/2006	
IIHA31	Solids, total dissolved	2830	MG/L	10/18/2006	-0.70423
IIHA31-DUP	Sulfate	1783.35	MG/L	10/18/2006	
IIHA31	Sulfate	1830	MG/L	10/18/2006	2.582091
IIHA-STE1-DUP	Solids, total dissolved	3100	MG/L	9/9/2006	
IIHA-STE1	Solids, total dissolved	3090	MG/L	9/9/2006	-0.3231
IIKSPC3A-DUP	Biological Oxygen Demand	11	MG/L	9/7/2006	
IIKSPC3A	Biological Oxygen Demand	11	MG/L	9/7/2006	0
JQ01-DUP	Chlorophyll	11.8	MG/CU.M.	8/31/2006	
JQ-01	Chlorophyll	13.2	MG/CU.M.	8/31/2006	11.2
JQ01-DUP	Hardness (CA/MG)	221.3	MG CACO3/L	8/31/2006	
JQ-01	Hardness (CA/MG)	221	MG CACO3/L	8/31/2006	-0.13565
ND11-DUP	Solids, total suspended	16.2	MG/L	11/1/2006	
ND11	Solids, total suspended	15	MG/L	11/1/2006	-7.69231
ND11-DUP	Alkalinity	90.2	MG/L	9/6/2006	
ND11	Alkalinity	90.2	MG/L	9/6/2006	0
NDA01-DUP	Solids, total suspended	18.2	MG/L	9/6/2006	
NDA01	Solids, total suspended	16.6	MG/L	9/6/2006	-9.1954
NDB04-DUP	Chlorophyll	26.9	MG/CU.M.	11/2/2006	
NDB04	Chlorophyll	25.7	MG/CU.M.	11/2/2006	-4.56274
OI05C-DUP	Biological Oxygen Demand	4.6	MG/L	9/1/2006	
OI05C	Biological Oxygen Demand	5.1	MG/L	9/1/2006	10.30928
OIC02-DUP	Solids, total suspended	14	MG/L	8/31/2006	
OIC02	Solids, total suspended	13.7	MG/L	8/31/2006	-2.16606
OIC02-DUP	Solids, total suspended	18.5	MG/L	10/17/2006	

Table 3-1: Duplicate Pair Sample Results (continued)

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
OIC02	Solids, total suspended	16.8	MG/L	10/17/2006	-9.63173
OIP10-DUP	Hardness (CA/MG)	278.52	MG CACO3/L	10/17/2006	
OIP10	Hardness (CA/MG)	286	MG CACO3/L	10/17/2006	2.650039
OZH-OK-A2A-DUP	Chlorophyll	155.4	MG/CU.M.	9/8/2006	
OZH-OK-A2A	Chlorophyll	126	MG/CU.M.	9/8/2006	-20.8955

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Section 4
Conclusions

Data collected during Stage 2 have been deemed adequate and usable for Stage 3 TMDL development (see discussion in Section 3). Table 4-1 contains information for each segment sampled during Stage 2 with regards to its impairment status. The table contains information on the number of historic samples available prior to Stage 2 data collection, the number of historic violations as well as the date of the last recorded violation. The intention of this table is to assist any future determination on the impairment status of the Stage 2 stream segments.

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Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Bay Creek	Cedar Creek	AJF16	Dissolved Oxygen	1	1	2000	Continuous	0	Delist
			Manganese	1	0	-	4	0	Delist
	Bay Creek Ditch	AJK01	Dissolved Oxygen	3	3	1987	Continuous	Multiple	Impaired
			Manganese	3	3	1987	3	0	Delist
Cahokia Creek/ Holiday Shores Lake	Cahokia Diversion Ditch	JQ07	Dissolved Oxygen	147	130	2005	Continuous	Multiple	Impaired
			Copper	5	1	1998	4	0	Delist
Cedar Creek	Big Muddy River	N99	Dissolved Oxygen	3	1	2002	Continuous	*	Impaired
			Sulfates	3	0	-	4	0	Delist
	Cave Creek	NAC01	Dissolved Oxygen	2	1	1995	Continuous	1	Impaired
Crab Orchard Lake	Crab Orchard Creek	ND11	Dissolved Oxygen	2	1	2000	Continuous	Multiple	Impaired
			Manganese	2	2	2000	2	0	Delist
			pH	3	2	2004	Continuous	Multiple	Impaired
	Crab Orchard Creek	ND12	pH	3	1	2004	Continuous	0	Delist
			Manganese	2	1	2000	2	0	Delist
	Crab Orchard Creek	ND13	Dissolved Oxygen	4	4	2000	Continuous	Multiple	Impaired
	Little Crab Orchard Creek	NDA01	Dissolved Oxygen	2	1	1995	Continuous	Multiple	Impaired
			Manganese	2	1	1995	3	1	Impaired
	Piles Fork	NDB03	Dissolved Oxygen	2	1	1995	Continuous	Multiple	Impaired
Crooked Creek	Plum Creek	OZH-OK-A2	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek		Manganese	1	1	2002	4	0	Delist
	Plum Creek	OZH-OK-C2	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek	OZH-OK-C3	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek		Manganese	1	1	2002	2	0	Delist
	Little Crooked Creek	OJA-01	Dissolved Oxygen	5	4	2002	Continuous	Multiple	Impaired
			Manganese	5	2	2002	4	0	Delist

Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Little Wabash	Little Wabash River	C09	Dissolved Oxygen	43	7	2003	Continuous	Multiple	Impaired
			Silver	43	1	2002	18	0	Delist
			Atrazine	2	1	1991	16	2	Impaired
		C33	Dissolved Oxygen	5	3	2002	Continuous	Multiple	Impaired
			Manganese	5	5	2002	10	10	Impaired
			Atrazine	NA	NA	NA	16	2	Impaired
	Village Creek	CE01	Dissolved Oxygen	1	0	NA	Continuous	Multiple	Impaired
			Manganese	1	1	2002	6	0	Delist
	Johnson Creek	CCAFFA1	Dissolved Oxygen	1	1	1997	Continuous	Multiple	Impaired
	Pond Creek	CCFFD1	Dissolved Oxygen	1	1	1997	Continuous	Multiple	Impaired
	Elm River	CD01	Atrazine	8	3	2002	16	2	Impaired
		CD02	Dissolved Oxygen	3	2	2003	Continuous	Multiple	Impaired
	Seminary Creek	CDGFLA1	Dissolved Oxygen	1	1	1998	Continuous	Multiple	Impaired
	Seminary Creek	CDFGLC6	Dissolved Oxygen	1	1	1998	Continuous	Multiple	Impaired
	Big Muddy Creek	CJ06	Dissolved Oxygen	3	1	2002	Continuous	Multiple	Impaired
			Manganese	2	1	2002	6	0	Delist
	Little Muddy Creek	CJA02	Dissolved Oxygen	4	3	2002	Continuous	Multiple	Impaired
			Manganese	4	3	2002	4	2	Impaired
	Big Muddy Diversion Ditch	CJAE01	Dissolved Oxygen	1	0	2000	Continuous	Multiple	Impaired
Mary's River/ North Fork Cox Creek	North Fork Cox Creek	IIHA31	Sulfates	2	2	1995	4	4	Impaired
			TDS	2	2	1995	4	4	Impaired
	North Fork Cox Creek	IIHA-STC1	TDS	1	1	1995	4	2	Impaired
	Maxwell Creek	IIKSPC1A	Dissolved Oxygen	2	2	19999	Continuous	Multiple	Impaired
	Randolph County Lake	RIB	Total Phosphorus	11	3	1993	6	2	Impaired
Sangamon River/ Lake Decatur	Owl Creek	EZV	Dissolved Oxygen	3	1	1998	Continuous	Multiple	Impaired

Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Shoal Creek	Shoal Creek	OI05	Dissolved Oxygen	3	1	2002	Continuous	0	Delist
	Locust Fork	OIC01	Dissolved Oxygen	3	1	1991	Continuous	Multiple	Impaired
			Manganese	3	1	1991	2	0	Delist
	Chicken Creek	OIO09	Dissolved Oxygen	2	1	1991	0	0	No Water
	Cattle Creek	OIP10	Dissolved Oxygen	3	2	1991	Continuous	Multiple	Impaired
			Ammonia	3	1	1991	1	0	Delist
			TDS	3	1	1991	1	0	Delist
South Fork Saline River/ Lake of Egypt	Briers Creek	ATHS01	Zinc	2	2	1993	13	0	Delist
			Iron	3	3	1993	16	3	Impaired
			Manganese	3	3	1993	8	4	Impaired
			Silver	3	1	1993	12	0	Delist
			Sulfates	3	3	1993	16	6	Impaired
			TDS	2	1	1993	16	9	Impaired
			pH	3	3	1993	Continuous	0	Delist
			Dissolved Oxygen	2	1	1993	Continuous	1	Impaired
	East Palzo Creek	ATHV01	Copper	3	2	1993	5	0	Delist
			Iron	3	3	1993	7	1	Impaired
			Manganese	3	3	1993	7	3	Impaired
			TDS	0		-	7	1	Impaired
			pH	3	3	1993	Continuous	Multiple	Impaired
	South Fork Saline River	ATH14	Dissolved Oxygen	8	1	2000	Continuous	0	Delist
South Fork Sangamon/ Lake Taylorville	South Fork Sangamon River	EO13	Dissolved Oxygen	1	1	1989	Continuous	Multiple	Impaired
			Boron	1	1	1989	6	0	Delist
			Manganese	1	1	1989	6	2	Impaired

* Continuous data did not violate the 5.0 mg/L instantaneous DO standard, however, continuous data collected at site N13 experienced more than 16 hours below 6.0 mg/L in a 24 hour period

For Appendices, please contact Jennifer Clarke at the Illinois EPA for information.

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TMDL Development for the Little Wabash River Watershed, Illinois

FINAL REPORT

June 2, 2008

Submitted to:
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
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1.0 INTRODUCTION

A total maximum daily load (TMDL) is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. The overall goals and objectives in developing TMDLs for the listed waterbodies in the Little Wabash River watershed include:

- Assess the water quality of the impaired waterbodies and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine the maximum load the waterbodies can receive and fully support all of their designated uses.
- Use the best available science and available data to determine current loads of pollutants to the impaired waterbodies.
- If current loads exceed the maximum allowable load, determine the load reduction that is needed.
- Identify feasible and cost-effective actions that can be taken to reduce loads.
- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.
- Submit a final TMDL report to U.S. EPA for review and approval.

The Illinois Environmental Protection Agency (IEPA) has a three-stage approach to TMDL development. The stages are:

1) Stage 1 for the Little Wabash River watershed was completed by the consulting firm Camp Dresser & McKee (CDM) in January 2007 and involved characterization of the watershed, assessment of the available water quality data, identification of additional data needs for the development of credible TMDLs and recommendation of potential technical approaches for TMDL development (Appendix F).
2) Stage 2 was completed by CDM in March 2007 and involved the collection of additional chemical water quality and continuous dissolved oxygen data as well as channel morphology and discharge measurements at twenty-three monitoring locations (Appendix G**)**.
3) This report addresses Stage 3 of the project which involves modeling, TMDL development, and preparation of a project implementation plan.

Several segments have been de-listed since the Stage 1 report due to newer ambient data or Stage 2 Data. A summary of the de-listed segments is provided below and included in Table 1.

- Little Wabash River segment C-09 was originally listed as impaired for silver. However, additional data collected in 2006 indicated no exceedances of the silver water quality standard (Appendix G and Table 1) and this segment will be recommended for de-listing in the 2008 Integrated Report. No TMDL has therefore been developed.
- Village Creek was originally listed as impaired for manganese. However, additional data collected in 2006 indicated no exceedances of the manganese water quality standard (Appendix G

and Table 1) and this segment will be recommended for de-listing in the 2008 Integrated Report. No TMDL has therefore been developed.

- Big Muddy Creek was originally listed as impaired for manganese. However, additional data collected in 2006 indicated no exceedances of the manganese water quality standard and this segment will be recommended for de-listing in the 2008 Integrated Report. No TMDL has therefore been developed.

Table 1. De-listed Little Wabash Segments

Segment and Segment ID	**Parameter**	**Water Quality Standard**	**Original Listing Violation # exceed/#sample**	**Original Violation Value (µg/l)**	**2006 Stage 2 Data Count**	**Number of Violations**
Little Wabash River (C09)	Silver	5 µg/l	1 of 43 (2002)	15	18	0
Village Creek (CE01)	Manganese	1,000 µg/l	1 of 1 (2002)	2,800	6	0
Big Muddy Creek (CJ06)	Manganese	1,000 µg/l	1 of 2 (2002)	3,200	6	0

2.0 BACKGROUND

The entire Little Wabash River watershed has a drainage area of approximately 3170 square miles and spans two 8 digit hydrologic unit codes (05120114 and 05120115) as defined by USGS Geological Survey (USGS). The watershed is located in south-eastern Illinois flowing south to the Wabash River (Figure 1). The portion of the watershed addressed in this report has a drainage area of 1060 square miles and encompasses seven counties with Wayne County covering 32 percent of the watershed followed by Clay (27%), Jasper (12%), Edwards (11%), Richland (9%), and White (7%). Small portions of the watershed also lie in Effingham (2%) County. Approximately 33,000 people reside in the watershed. The city of Flora is the largest population center in the watershed and contributes an estimated 5,000 people to total watershed population.

The Little Wabash River originates in south-western Coles County and flows approximately 237 miles south and east to its confluence with the Wabash River near New Haven, a point approximately 13 miles upstream from the Ohio River. Major tributaries to the Little Wabash addressed in this report include Big Muddy Creek, Little Muddy Creek, Elm River, and Village Creek. Agriculture is the dominant land use in the watershed (Figure 2) and additional information on the characteristics of the watershed (e.g., soil types, topography, hydrology) can be found in Appendix F.

Table 3 identifies the Little Wabash River's impaired segments, including the causes of impairment addressed by TMDLs in this report. IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. IEPA believes that addressing the impairments with numeric water quality standards should lead to an overall improvement in water quality due to the interrelated nature of other listed pollutants. Pollutants can be interrelated because they originate from the same source or are transported together. For example, Newton Lake is listed for both phosphorus and total suspended solids, but IEPA only has numeric lake water quality standards for phosphorus. However, phosphorus binds to sediment and therefore some of the management measures taken to reduce phosphorus loads (e.g., buffer strips, reducing streambank erosion) should also target reductions in loads of suspended solids.

To illustrate the interrelated nature of pollutants, Table 2 summarizes information on the removal of other pollutants relative to TSS. For example, the data indicate that 5.65 pounds of phosphorus are removed for each 10 pounds of TSS. The data are based on information on nine Midwestern studies summarized in Winer, R., 2000, *National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition* (Center for Watershed Protection. Ellicott City, MD). Ratios of removal of other pollutants to TSS removal were calculated for each study, and then summarized as median values.

Table 2. Relative Pollutant Removal Efficiencies

Pollutant	Median removal relative to TSS
Total Suspended Solids	1.000
Total Nitrogen	0.456
Total Phosphorus	0.565
Biochemical Oxygen Demand	0.738
Fecal Coliform	0.778
Copper	0.833
Zinc	0.845

Table 3. 2006 303(d) List Information for the Little Wabash River Watershed. Bold font indicates cause will be addressed by a TMDL in this report.

Waterbody Name	Waterbody Segment	Segment Length (miles) and Lake Area (acres)	Cause of Impairment	Impaired Designated Use
Little Wabash River	C-09	21.83	**Atrazine**	Public Water Supplies
			Dissolved Oxygen	Aquatic Life
			Total Fecal Coliform	Primary Contact Recreation
			Manganese	Public Water Supplies
			pH	Aquatic Life
			Total Phosphorus	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Silver*	Aquatic Life
			Total Suspended Solids	Aquatic Life
Little Wabash River	C-22	21.4	**Total Fecal Coliform**	Primary Contact Recreation
Village Creek	CE-01	12.3	**Dissolved Oxygen**	Aquatic Life
			Manganese*	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Little Wabash River	C-33	43.41	**Atrazine**	Public Water Supplies
			Dissolved Oxygen	Aquatic Life
			Manganese	Public Water Supplies
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Johnson Creek	CCA-FF-A1	1.87	**Dissolved Oxygen**	Aquatic Life
Pond Creek	CC-FF-D1	4.53	**Dissolved Oxygen**	Aquatic Life
Fairfield Reservoir	RCZJ	16	**Manganese**	Public Water Supplies
			Impairment Unknown	Aesthetic Quality
Elm River	CD-01	8.53	**Atrazine**	Aquatic Life
			Dissolved Oxygen	Aquatic Life
			Total Fecal Coliform	Primary Contact Recreation
			Manganese	Aquatic Life
			pH	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Elm River	CD-04	35.43	**Dissolved Oxygen**	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Seminary Creek	CDG-FL-A1	1.47	**Dissolved Oxygen**	Aquatic Life
			Total Phosphorus	Aquatic Life
Seminary Creek	CDG-FL-C6	1.99	**Dissolved Oxygen**	Aquatic Life
			Total Phosphorus	Aquatic Life

Table 3 (continued). 2006 303(d) List Information for the Little Wabash River Watershed. Bold font indicates cause will be addressed by a TMDL in this report.

Waterbody Name	Waterbody Segment	Segment Length (miles) and Lake Area (acres)	Cause of Impairment	Impaired Designated Use
Big Muddy Creek	CJ-06	26.62	**Dissolved Oxygen**	Aquatic Life
			Manganese*	Aquatic Life
			Total Phosphorus	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Little Muddy Creek	CJA-02	30.57	**Manganese**	Aquatic Life
			Dissolved Oxygen	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Big Muddy Diversion Ditch	CJAE-01	8.72	**Dissolved Oxygen**	Aquatic Life
Newton Lake	RCR	1,750	**Total Phosphorus**	Aesthetic Quality
			Total Suspended Solids	Aesthetic Quality

*Recommended for de-listing (see Section 1).

Figure 1. Location of the Little Wabash Watershed

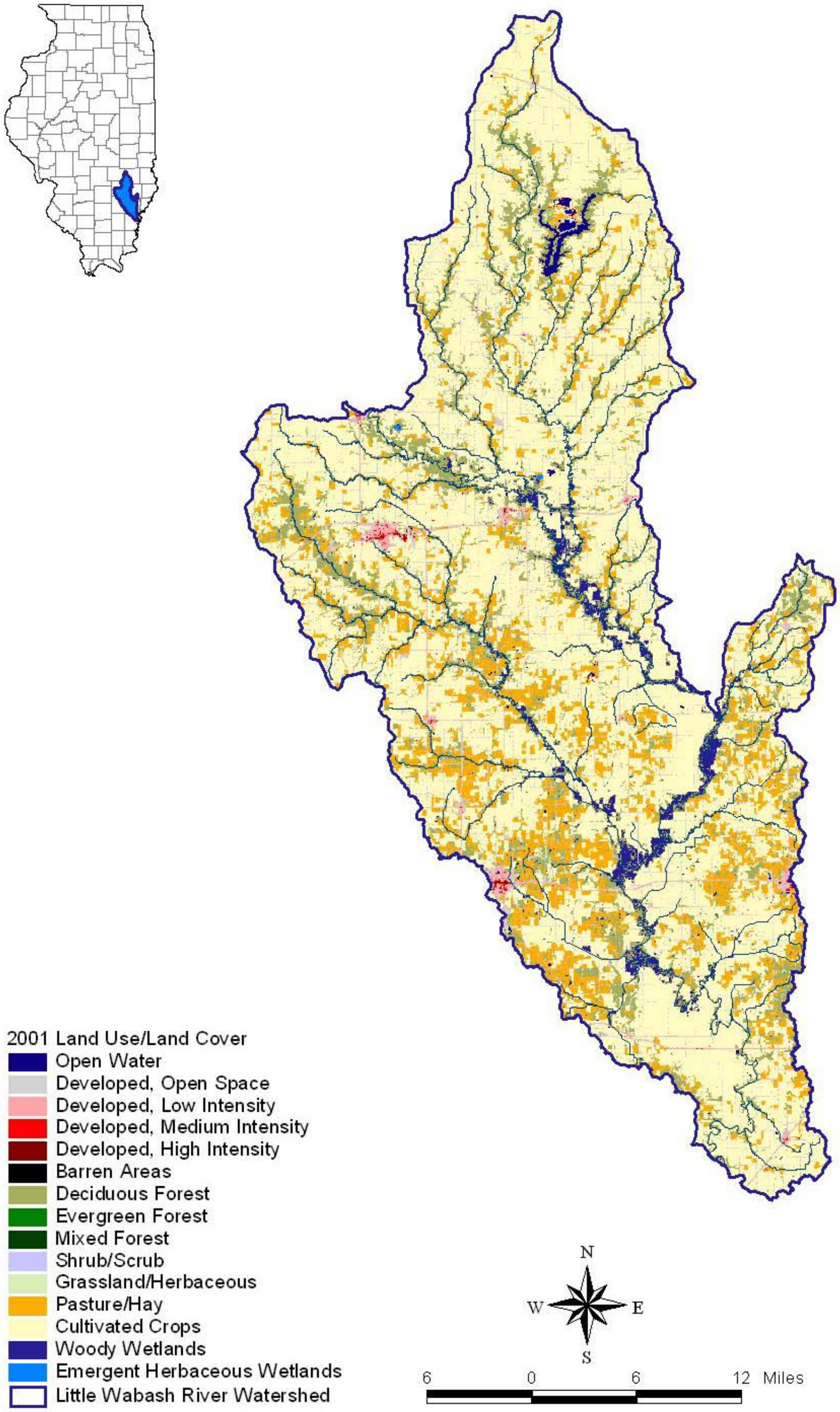

Figure 2. Land Use in the Little Wabash Watershed addressed in this report.

3.0 APPLICABLE WATER QUALITY STANDARDS

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive and still achieve water quality standards. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. A description of the water quality standards that apply to this TMDL is presented below and detailed comparisons of the available water quality data to the standards are provided in Appendix F and Appendix G.

3.1 Use Support Guidelines

IEPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB) to assess the designated use support for Illinois waterbodies. The following are the use support designations provided by the IPCB that apply to water bodies in the Little Wabash watershed:

General Use Standards - These standards protect for aquatic life, wildlife, agricultural, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

Public and food processing water supply standards – These standards are cumulative with the general use standards and apply to waters of the state at any point at which water is withdrawn for treatment and distribution as a potable supply to the public or for food processing.

Water quality standards used for TMDL development in the Little Wabash River watershed are listed below for lakes (Table 4) and streams (Table 5). The exact language of the standards is available from the Illinois Pollution Control Board, Title 35, Chapter I, Part 302 at the following Web site:

http://www.ipcb.state.il.us/documents/dsweb/Get/Document-33354/

Table 4. Summary of Water Quality Standards for the Little Wabash River Watershed Lake Impairments.

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies	Section for Regulatory Citation[b]
Manganese	µg/L	1,000	150	General use: 302.208 Public Water Supply: 302.304
Total Phosphorus	mg/L	0.05[a]	No numeric standard	302.205

[a] Standard only applies in lakes/reservoirs that are greater than 20 acres in surface area and in any stream at the point where it enters such a lake/reservoir.

[b] All IEPA water quality standards are published by the Illinois Pollution Control Board under Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board. Part 302. Water Quality Standards. Subpart A: General Water Quality Provisions.

Table 5. Summary of Water Quality Standards for the Little Wabash River Watershed Stream Impairments.

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies	Section for Regulatory Citation[f]
Atrazine	µg/L	Acute= 82[a]	3	302.601 to 302.669[g]
		Chronic= 9[b]		
Dissolved Oxygen	mg/L	5.0 instantaneous minimum	No numeric standard	302.206
		6.0 minimum during at least 16 hours of any 24 hour period		
Fecal coliform[c]	cfu/100 mL	400 in <10% of samples[d]	Geomean[d] <2,000	General use: 302.209 Public Water Supply: 302.306
		Geomean < 200[e]		
Manganese	µg/L	1,000	150	General use: 302.208 Public Water Supply: 302.304
pH	S.U.	> 6.5 and <9.0	No numeric standard	302.204

[a] Not to be exceeded except as provided in 35 Ill. Adm. Code 302.208(d)

[b] Not to be exceeded by the average of at least three samples collected over peak atrazine application periods (Spring, Summer, and Fall)

[c] Fecal coliform standards are for the recreation season only (May through October)

[d] Standard shall not be exceeded by more than 10% of the samples collected during a 30 day period

[e] Geometric mean based on minimum of 5 samples taken over not more than a 30 day period

[f] All IEPA water quality standards are published by the Illinois Pollution Control Board under Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board. Part 302. Water Quality Standards. Subpart A: General Water Quality Provisions.

[g] The atrazine criteria are a derived water quality standard. Additional information can be found in the *Illinois Integrated Water Quality Report and Section 303(d) List – 2006* (IEPA, 2006)

4.0 POLLUTANT SOURCES

The Little Wabash River II watershed contains waterbodies listed for impairments due to total phosphorus, dissolved oxygen, manganese, atrazine, and fecal coliform. Most of the impairments, with the exception of total phosphorus, exist throughout the watershed. Both point and nonpoint sources contribute to the impairments. This section describes each major source category as well as the impacts and contributions to pollutant loading in this watershed.

4.1 Point Source Dischargers

There are 17 facilities regulated by the National Pollutant Discharge Elimination System that are allowed to discharge industrial or municipal wastewater to waterbodies located in the Little Wabash River II watershed. Information on these dischargers is shown in Table 6. Blank cells in the table indicate that permit information was not available for that parameter.

Table 6. Wastewater Treatment Plants Discharging to Impaired Streams within the Little Wabash River II Watershed.

Facility Name	Permit Number	Receiving Stream	Design Average Flow (MGD)	Design Maximum Flow (MGD)	Daily Fecal Coliform Limit (count/100 mL)	Daily CBOD Limit (mg/L)	Daily Ammonia Limit (mg/L)
Ameren Cips - Newton	IL0049191	Newton Lake	415.7		No Fecal Discharge	30	
Charleston STP	IL0021644	Cassell Creek	3.3	6	400	20	3 (April-Oct) 3.4 (Nov-March)
Cisne STP	ILG580197	Deer Creek, Elm River, Little Wabash River	0.08	0.2	Year-round disinfection exemption		
Clay City WWTP	IL0020974	Unnamed ditch tributary to Little Wabash Creek	0.12	0.3	Year-round disinfection exemption		
Crossville STP	ILG580211	Elliott Creek	0.25	0.82	Year-round disinfection exemption		
Dieterich STP	IL0044792	Tributary to Big Muddy Creek, Little Wabash River	0.08	0.2	Year-round disinfection exemption	25 Monthly Average 40 Weekly Average	
Fairfield STP	IL0020605	Johnson Creek	0.91	2.2	Year-round disinfection exemption	20	3 (April-Oct) 8 (Nov-March)
Fairfield WTP	ILG640137	NA	0.124	0.248	No Fecal Discharge		
Flora City Of-Charlie Brown Pk	IL0047481	Unnamed tributary of Raccoon Creek	0.003	0.007	400	20	3 (April-Oct) 8 (Nov-March)
Flora STP	IL0020273	Seminary Creek	1	1.8	Year-round disinfection exemption	20	6.2 (April-Oct) 13.5 (Nov-March)

Table 10. (Cont.) Wastewater Treatment Plants Discharging to Impaired Streams within the Little Wabash River II Watershed.

Facility Name	Permit Number	Receiving Stream	Design Average Flow (MGD)	Design Maximum Flow (MGD)	Daily Fecal Coliform Limit (count/100 mL)	Daily CBOD Limit (mg/L)	Daily Ammonia Limit (mg/L)
Flora WTP	IL0074403	Unnamed tributary to Elm Creek	0.027		No Fecal Discharge		
Greenville WTP	IL0045764	Kingsbury Branch	0.66		Year-round disinfection exemption		
Jeffersonville STP	ILG580076	Martin Creek	0.032	0.08	Year-round disinfection exemption		
Mt. Erie WTP	ILG640143	Newton Branch	0.0006		No Fecal Discharge		
Noble STP	IL0025500	Hog Run Creek	0.1	0.25	Year-round disinfection exemption	25 Monthly Average 40 Weekly Average	
Parkersburg STP	IL0071374	Unnamed tributary to Sugar Creek	0.03	0.123	Year-round disinfection exemption		
Shell Pipeline – Clay City	IL0076074		Inactive	Inactive	Inactive	Inactive	Inactive

Notes: The Shell Pipeline-Clay City used to hold a permit (IL0076074) to discharge into an unnamed tributary to Salt Creek; however, this facility ceased operations in April 2007; N/A = Not Available

Though the Ameren Cips facility has a permitted discharge rate of 415.7 MGD, the main discharge is for condenser cooling water and is assumed to have a net zero effect on the lake volume and pollutant loads as water is withdrawn and then discharged back to the lake. The cumulative design flows of the other outfalls result in a total daily discharge of 9.311 MGD to Newton Lake. This value was used to estimate pollutant loading and daily flows from this facility.

4.1.1 Phosphorus

None of the point source dischargers in the watershed are required to monitor for total phosphorus so it is not possible to accurately estimate the existing load from point sources. Only one waterbody is currently listed for phosphorus and it is not likely that the sole point source in that watershed (Ameren Cips) is contributing a significant fraction of the total load. There are two sewage treatment plant outfalls at this facility with approximate average flows of 0.016 MGD. Assuming a total phosphorus concentration of 4 mg/L from the effluent based on literature values (Litke, 1999) yields an approximate daily load of 195 lb/yr.

4.1.2 Dissolved Oxygen

Impacts on dissolved oxygen concentrations resulting from point source dischargers may be due to nutrient induced eutrophication, oxidation of ammonia and other compounds, or degradation of biodegradable organic material. Based on the findings of the QUAL2K TMDL modeling, reducing or even eliminating loads from point source dischargers will not result in impaired segments meeting the dissolved oxygen targets.

4.1.3 Fecal Coliform

Sewage from treatment plants treating domestic and/or municipal waste contains fecal coliform bacteria, which is indigenous to sanitary sewage. In Illinois, a number of these treatment plants have applied for and received disinfection exemptions, which allow a facility to discharge wastewater without disinfection. All of these treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. Facilities with year-round disinfection exemptions may be required to provide the Agency with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions. Sewage treatment plants are likely the only point source inputs of fecal coliform in the Little Wabash River II watershed. Each of the plants in the watershed operates under a disinfection exemption for primary effluent. Disinfection of excessive flows, however, is required. Though the permits do not require that facilities monitor fecal coliform in the primary effluent, concentrations that occur from excessive flows through the combined sewer overflow (CSO) must be monitored. The EPA Water Discharge Permits Query (PCS) contains little data for these facilities concerning the fecal coliform concentrations measured during CSOs.

4.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are not typically a significant source of pollutant loading if they are operating as designed. However, if the failure rates of systems in this watershed are high, then the loading from this source may be significant. At this time, no database of onsite wastewater treatment systems is available for the Little Wabash River II watershed, so it is difficult to estimate levels of performance.

Pollutant loading rates from properly functioning onsite wastewater systems are typically insignificant. However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems, loading rates to receiving waterbodies may be relatively high. It is suggested that each system in the watershed be inspected to accurately quantify the loading from this source. Systems older than 20 years and those located close to the lakes or streams should be prioritized for inspection.

4.2.1 Phosphorus

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Phosphorus is removed from the wastewater by adsorption to soil particles. Plant uptake by vegetation growing over the drainfield is assumed negligible since all of the phosphorus is removed in the soil treatment zone. Failing systems that either short circuit the soil adsorption field or cause effluent to pool at the ground surface are assumed to retain phosphorus through plant uptake only (average annual uptake rate of 0.2 g/capita/day). Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank effluent directly to a waterbody or other transport line (such as an agricultural tile drain) do not allow for soil zone treatment or plant uptake.

4.2.2 Dissolved Oxygen

Septic systems contribute nutrient loads to the environment that may result in eutrophication of streams and lakes. The systems also discharge substances that consume oxygen during decomposition, referred to as biochemical oxygen demand or BOD. Once these substances reach the streams and lakes in the watershed, their decay will consume oxygen and decrease concentrations.

4.2.3 Fecal Coliform

Even properly functioning onsite wastewater systems contribute fecal coliform loading to the surrounding environment. Typically, by the time effluent reaches the groundwater zone, concentrations have been reduced by 99.99 percent by natural processes (Siegrist et al., 2000). However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems such as tile drains, loading rates to receiving waterbodies may be relatively high. In order to accurately quantify the loading in the Little Wabash River II watershed, an inspection of each system would be needed. Systems older than 20 years and those located close to waterbodies should be inspected first.

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Fecal coliform concentrations are typically reduced by 99.99 percent (Siegrist et al., 2000). Failing systems that short circuit the soil adsorption field, result in ponding on the ground surface, or backup into homes will have concentrations typical of raw (untreated) sewage. Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank directly to a waterbody or other transport line (such as an agricultural tile drain) will also have concentrations similar to raw sewage.

4.3 Crop Production

The majority of land in the Little Wabash River II watershed (72 percent) is used for production of corn, soybeans, wheat, and other small grains. Due to application of commercial fertilizer, manure, and pesticides, as well as increased rates of erosion, pollutant loads from croplands are relatively high compared to other land uses. This section of the report describes the mechanisms of pollutant loading from farmland for each of the TMDL pollutants causing impairments in the watershed.

4.3.1 Phosphorus

Agriculture is a primary land use throughout the Little Wabash River II watershed. Phosphorus impairments, however, are only present in Newton Lake in Jasper County. In this watershed, approximately 17,650 acres of land are used to grow corn, soybeans, wheat, and other grains. Based on data presented by Gentry et al. (2007), phosphorus loading rates from tiled agricultural fields in east-central Illinois range from 0.5 to 1.5 lb/ac/yr. Based on this data, the phosphorus loads to Newton Lake from crop production areas may range from 8,825 to 26,475 lb/yr assuming that all of the fields are artificially drained. If a significant amount of the farmland is not artificially drained, these values may underestimate the loading from this source.

4.3.2 Dissolved Oxygen

Crop production activities likely have indirect impacts on dissolved oxygen concentrations. Issues related to eutrophication will be mitigated by controlling phosphorus loads. Runoff concentrations and sediment-bound levels of biodegradable organic material should be negligible. This excludes fields that spread manure for fertilizer, but these loads are discussed in Section 4.4.

4.3.3 Manganese

Impairments due to manganese occur throughout the Little Wabash River II watershed. Manganese is found naturally in the environment in groundwater and soils. Because crop production tends to increase rates of erosion, the sediment bound manganese loads tend to increase from this land use. In addition, much of the land farmed in this watershed is classified as highly erodible.

Typical concentrations of manganese in Southern Illinois range from 4 to 200 milligrams of manganese per kilogram of soil (mg/kg) with an average value of 23 mg/kg (Ebelhar, 2007). Based on data presented by Czapar et al. (2006), conventional chisel plow crop production activities in Midwestern states result in sediment loads of 7.5 tons/ac/yr. Approximately 895,350 acres of land are used for crop production in the Little Wabash River II watershed. Assuming a manganese concentration of 23 mg/kg percent yields an estimated loading rate from this source of 154.4 tons/yr.

4.3.4 Atrazine

Atrazine is a commonly used herbicide for controlling broadleaf and grassy weeds. Impairments due to atrazine are distributed throughout the Little Wabash River II watershed and the sole source is crop production. Because many herbicides are available for use, it is not possible to quantify the load to waterbodies in the watershed without site specific application data.

4.4 Animal Operations

Pollutant loading from animal operations can be a problem in both confined and pasture-based systems. Though the exact location of animal operations in the watershed is not known, countywide statistics indicate that a large number of livestock, swine, and poultry may exist

Agricultural animal operations are a potentially large source of pollutant loading if adequate best management practices (BMPs) are not in place to protect surface waters. Livestock operations either consist of confined or pasture-based systems. If a confined operation has greater than 1,000 animal units or is determined to threaten water quality, the operation requires a federal Concentrated Animal Feeding Operation (CAFO) permit. CAFOs are required to develop a nutrient management plan (NMP) as part of the CAFO permitting process (USEPA, 2003) which consists of manure management and disposal strategies that minimize the release of excess nutrients into surface and ground water. The CAFO NMPs are based on NRCS standards and technical expertise.

4.4.1 Phosphorus

Because the only phosphorus impairment in the watershed is for Newton Lake, phosphorus loads from animal operations will only be presented for the Newton Lake watershed. The Stage 1 report for the Little Wabash River II watershed summarized the 2002 Census of Agriculture data for Jasper County. These data were area weighted to estimate the number of animals in the Newton Lake watershed (Table 7). The phosphorus load from these animals might be significant and is discussed in more detail in the Implementation Plan.

Table 7. Estimated Number of Livestock and Poultry in the Newton Lake Watershed.

Animal	Number of Head
Poultry	48
Beef cattle	260
Dairy cattle	98
Other cattle: heifers, bulls, calves, etc.	536
Hogs and pigs	7,692
Sheep and lambs	23
Horses and ponies	39

4.4.2 Dissolved Oxygen

Dissolved oxygen impairments due to animal operations may result from degradation of organic material in the streams and lakes or eutrophication due to excessive nutrients which leads to eventual algal decay as well as nighttime respiration. Animals with access to streambanks will also exacerbate dissolved oxygen problems by increasing bank erosion and decreasing canopy cover. This impact is difficult to quantify, but can be controlled by animal management BMPs as discussed in the Implementation Plan.

4.4.3 Fecal Coliform

Fecal coliform impairments occur throughout the Little Wabash River II watershed; each county in the watershed contains animal operations that likely contribute to this load. The county statistics presented in the Stage 1 report are listed below for cattle, poultry, swine, and sheep in the watershed (Table 8).

Table 8. Estimated Number of Livestock and Poultry in the Little Wabash River II Watershed.

Animal	Number of Head
Poultry	829
Beef cattle	3,246
Dairy cattle	507
Other cattle: heifers, bulls, calves, etc.	20,835
Hogs and pigs	109,903
Sheep and lambs	1,461
Horses and ponies	1,127

4.5 Streambank and Lake Shore Erosion

Excessive erosion of streambanks and lake shores quickly degrades water quality and habitat. Both phosphorus and manganese contribute to the overall composition of sediment and once this sediment reaches a waterbody, these elements may be released through biological and chemical transformations. Release of phosphorus may increase rates of algal and plant growth (eutrophication), which leads to issues with dissolved oxygen concentrations, water treatability, and aesthetics. Manganese also effects water treatment operations and is detrimental to aquatic life at high concentrations.

In addition to the release of phosphorus and manganese, erosion will also reduce the stability of streambanks by undercutting the roots of established vegetation and altering the channel geometry. Loss of vegetative canopy and widening of a stream channel will allow more sunlight to reach the water column which may 1) increase rates of eutrophication, 2) increase water temperatures, and 3) decrease the amount of dissolved oxygen the water can hold.

The Illinois Department of Natural Resources (IDNR) has begun an inventory of streams in the State for inclusion in the Illinois Stream Information System (ISIS). So far, all reaches in the state draining at least 10 square miles are included in the database. IDNR (2004) assisted the Upper Little Wabash River Ecosystem Partnership (ULWREP) in identify reaches within the partnership that are considered channelized. A map of these reaches is shown in the report from IDNR to ULWREP attached in the Implementation Plan.

4.6 Internal Loading from Lake Bottom Sediments

Two lakes in the Little Wabash River II watershed are listed for pollutants that may be released from bottom sediments in anoxic lakes. Newton Lake in Jasper County is listed for phosphorus, and Fairfield Reservoir in Wayne County is listed for manganese.

Both manganese and phosphorus may be released internally from lake sediments when oxygen concentrations near the bottom of the lake reach low levels. Low dissolved oxygen in lakes may be caused by degradation of organic material or respiration of algae in the absence of sunlight. Conditions for low dissolved oxygen are more severe during the summer months when the water temperatures are higher and the water is able to contain less oxygen.

4.6.1 Phosphorus

Phosphorus concentrations in Newton Lake range from 0.029 mg/L to 0.317 mg/L at one foot depth. Estimating the fraction of phosphorus in the water column that originates from re-suspended sediment stores is difficult with the current data. Given that this lake has a relatively long residence time (based on the BATHTUB modeling), an average depth of 16 ft, and dissolved oxygen measurements observed near zero, it is likely that bottom sediments release phosphorus into the water column. More intensive water quality studies of the lake and its tributaries will be required to estimate the significance of this load but BMPs that reduce phosphorus and BOD_5 loads in the watershed will also mitigate the dissolved oxygen conditions that stimulate release from bottom sediments.

4.6.2 Manganese

Fairfield Reservoir is designated a water supply reservoir. Manganese concentrations in the lake range from 58 to 290 µg/L. There does not appear to be a significant correlation of manganese with depth, though lower concentrations tend to occur near the lake bottom. Fairfield Reservoir has a low residence time, an average depth of approximately 2.3 ft, and few dissolved oxygen measurements near zero. These factors, along with the manganese data which indicate lower concentrations near the lake bottom, suggest it is not likely that the bottom sediments are releasing significant amounts of manganese. Collection of additional manganese data in the lake and its tributaries will allow for a quantitative estimate from this source. If internal loading is deemed a significant source, then inlake management measures may be necessary.

4.7 Historic and Active Oil Mining Operations

The ULWREP (2007) discusses the impacts of historic and active oil mining operations on soil and water quality. Byproducts from the operation include a brine solution that is usually stored in a lagoon, discharged to a surface water, or land applied. The salt content reduces vegetative growth and therefore increased rates of erosion are prevalent at these sites. In addition, the brine solution contains high concentrations of manganese which may eventually reach surface waterbodies.

4.8 Domestic Pets and Wildlife Populations

Domestic pets such as cats and dogs and wildlife animals such as deer, geese, ducks, etc., can be significant sources of loading in watersheds that have high densities of urban populations or rural communities with relatively undisturbed land use patterns. In the Little Wabash River II watershed, where the majority of land is used for agricultural production, these sources are likely not significant relative to the loading from animal operations, exempt point source dischargers, and failing onsite wastewater systems.

5.0 TECHNICAL ANALYSIS

This section of the report describes the technical approaches that were used to calculate TMDLs within the Little Wabash River watershed. Load duration curves were used to estimate the current and allowable loads of atrazine, fecal coliform, and manganese loads for impaired streams in the Little Wabash watershed; the QUAL2K model was used to assess instream dissolved oxygen concentrations; and the BATHTUB model was used to assess lake water quality. Table 9 presents the listed water bodies and the corresponding modeling approach used to address each TMDL.

Table 9. 303(d) List Information and Modeling Approaches for the Little Wabash Watershed

Waterbody Name	Segment	Cause of Impairment	Modeling Approach
Little Wabash River	C-09	Atrazine	Load Duration Curve
		Dissolved Oxygen	QUAL2K
		Total Fecal Coliform	Load Duration Curve
		Manganese	Load Duration Curve
Little Wabash River	C-22	Total Fecal Coliform	Load Duration Curve
Village Creek	CE-01	Dissolved Oxygen	QUAL2K
Little Wabash River	C-33	Atrazine	Load Duration Curve
		Dissolved Oxygen	QUAL2K
		Manganese	Load Duration Curve
Johnson Creek	CCA-FF-A1	Dissolved Oxygen	QUAL2K
Pond Creek	CC-FF-D1	Dissolved Oxygen	QUAL2K
Fairfield Reservoir	RCJZ	Manganese	BATHTUB
Elm River	CD-01	Atrazine	Load Duration Curve
		Dissolved Oxygen	QUAL2K
		Fecal Coliform	Load Duration Curve
		Manganese	Load Duration Curve
Elm River	CD-04	Dissolved Oxygen	QUAL2K
Seminary Creek	CDG-FL-A1	Dissolved Oxygen	QUAL2K
Seminary Creek	CDG-FL-C6	Dissolved Oxygen	QUAL2K
Big Muddy Creek	CJ-06	Dissolved Oxygen	QUAL2K
Little Muddy Creek	CJA-02	Dissolved Oxygen	QUAL2K
		Manganese	Load Duration Curve
Big Muddy Diversion Ditch	CJAE-01	Dissolved Oxygen	QUAL2K
Newton Lake	RCR	Phosphorus	BATHTUB

5.1 Load Duration Curves

Load reductions for atrazine, fecal coliform, and manganese were determined through the use of load duration curves. The load duration curve demonstrates the allowable loadings of a pollutant at different flow regimes expected to occur in the impaired segment and still maintain the water quality standard. The following steps are taken:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points.

2. The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the water quality standard and by a conversion factor. The resulting points are graphed. Conversion factors are used to convert the concentration units of the target (e.g., mg/L) to loading units (e.g., kg/day) with the following factors used for this TMDL:
    - Flow (cfs) × TMDL Concentration Target (mg/L) × Conversion Factor (2.45) = Load (kg/day)
    - Flow (cfs) × TMDL Concentration Target (μg/L) × Conversion Factor (0.00245) = Load (kg/day)
    - Flow (cfs) × TMDL Concentration Target (MPN/100 mL) × Conversion Factor (24.5)= Load (million/day)

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected and a conversion factor. Then, the individual loads are plotted on the TMDL graph.

4. Points plotting above the curve represent deviations from the water quality standard and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards.

Atrazine, fecal coliform, and total manganese loadings were calculated for Little Wabash River segment C 09 and Elm River Segment CD 01. Atrazine and manganese loadings were calculated for the Little Wabash River Segment C33. Fecal coliform loadings were calculated for the Little Wabash River segment C22. The locations of these segments, along with the monitoring stations used for the load duration curves, are shown in Figure 3.

The stream flows used within a load duration curve may be grouped into various hydrologic conditions to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five “hydrologic conditions” (USEPA, 2007):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 10 summarizes the relationship between the five hydrologic conditions and potentially contributing source areas.

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and EPA’s implementing regulations. Because the approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

Table 10. Relationship Between Load Duration Curve Zones and Contributing Sources.

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			
Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)					

5.1.1 Stream Flow Estimates

Daily stream flows are needed to apply the load duration curve. There is one USGS gage with continuous flow data in the Little Wabash watershed (Figure 3). USGS gage 03379500 is located on the Little Wabash River segment C 22 at the same location as monitoring location C 22 (Figure 3).

Stream flows for the monitoring stations were extrapolated from the USGS station 03379500, using a multiplier based upon a comparison of the two drainage areas. For example, the drainage area to the water quality monitoring station C 09 is 1372 square miles and the drainage area of flow gage 03379500 is 1131 square miles. The drainage area ratio therefore equals 1.21 and the daily flows at the flow gage were multiplied by 1.21 to estimate the daily flows at station C 09. For sampling station C 22, daily stream flows from USGS station 03379500 were directly applied since the gage is co-located with the water quality sampling station. The drainage area for stations C 33, CD01, and CJA 02 are 1924 square miles, 251 square miles, and 66 square miles respectively. The drainage area ratios therefore equal 1.70, 0.22, and 0.06 for stations C 33, CD01, and CJA 02 respectively.

A further modification to the flow estimates was made to ensure that they accounted for the design flows of any upstream point sources (because the TMDL WLAs are based on design flows). In cases where the minimum estimated flows were less than the cumulative design flows from the point sources, the design flows were added to the flow record.

Figure 3. USGS, Load Duration Sampling Sites, and NPDES facilities in the Little Wabash River Watershed

5.2 QUAL2K Model

The QUAL2K water quality model was selected to assess the dissolved oxygen impairments in the Little Wabash River watershed. QUAL2K is supported by U.S. EPA and has been used extensively for TMDL development and point source permitting issues across the country, especially for issues related to dissolved oxygen concentrations. QUAL2K has also been used previously by Illinois EPA for TMDL development. QUAL2K is well accepted within the scientific community because of its proven ability to simulate the processes important to dissolved oxygen conditions within streams. The QUAL2K model is suitable for simulating the hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth, and dissolved oxygen dynamics.

Ten QUAL2K models were set up for each of the following impaired streams to address low dissolved oxygen conditions:

- Little Wabash River (Segment C 09)
- Little Wabash River (Segment C 33)
- Johnson Creek
- Pond Creek
- Elm River
- Seminary Creek
- Village Creek
- Big Muddy Creek
- Little Muddy Creek
- Big Muddy Diversion Ditch

Illinois' water quality standard requires a minimum dissolved oxygen concentration of 5 mg/L at all times and a 6.0 minimum during at least 16 hours of any 24 hour period. Once the model was setup and calibrated for each stream, a series of scenarios were run to evaluate the most likely cause of the observed low dissolved oxygen. The calibration goals for the QUAL2K modeling were to best match the observed water quality data using model parameters that are within the accepted range of values. Flow and dissolved oxygen were the primary focus of the calibration, but good simulations of other parameters were needed to obtain a good fit to the dissolved oxygen data. The reaction rates for nutrients and related eutrophication processes were selected within the range of the literature values (Brown and Barnwell, 1986).

These results are summarized in Section 7.0 and a detailed discussion of the QUAL2K model is included in Appendix D.

5.3 BATHTUB Model

The USACE BATHTUB model was selected for modeling water quality in Newton Lake and Fairfield Reservoir. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network, which accounts for pollutant transport and sedimentation. In addition, the BATHTUB model incorporates internal phosphorus loadings into its calculations. Eutrophication-related water quality conditions (e.g., phosphorus, nitrogen, chlorophyll *a*, and transparency) are predicted using empirical relationships previously developed and tested for reservoir applications (Walker, 1987). Manganese can also be simulated as a conservative substance. BATHTUB was determined to be appropriate because it addresses the primary parameters of concern (phosphorus and manganese) and has been used previously for reservoir TMDLs in Illinois and elsewhere. A detailed discussion for each of the individual BATHTUB models is included in Appendix E.

Typically, watershed loads are input to the BATHTUB model and used to simulate average in-lake pollutant concentrations. However, for Fairfield Reservoir and Newton Lake, watershed and tributary data are not available to estimate loads to the lake. A “reverse” BATHTUB model was therefore developed where average inlake concentrations were used to estimate the load required given annual flow volume and lake bathymetry data. No adjustment of the calibration factors were needed with this simulation because the loads were set by year to match average observed concentrations (i.e., calibration factors were left to the BATHTUB default settings). It is recognized that this approach is based upon an assumption that Newton Lake and Fairfield Reservoir behave similarly to the empirical models upon which the BATHTUB model is based. This is believed to be a valid assumption given that the characteristics of these two waterbodies are typical of constructed reservoirs, the primary focus of the BATHTUB database (Walker, 1987).

Lake bathymetry data were available from the Stage 1 report and are summarized in Table 11. Maps of the IEPA monitoring stations for each lake are shown in Figure 4 and Figure 5.

Table 11. Bathymetry Data for the Little Wabash River Watershed Lakes.

Lake	Parameter	Value
Fairfield Reservoir	Normal Pool Volume (ac-ft)	37
	Normal Pool Surface Area (ac)	16
	Maximum Depth (ft)	11
	Mean Depth (ft)	2.3
Newton Lake	Normal Pool Volume (ac-ft)	28,500
	Normal Pool Surface Area (ac)	1,750
	Maximum Depth (ft)	41
	Mean Depth (ft)	16.3

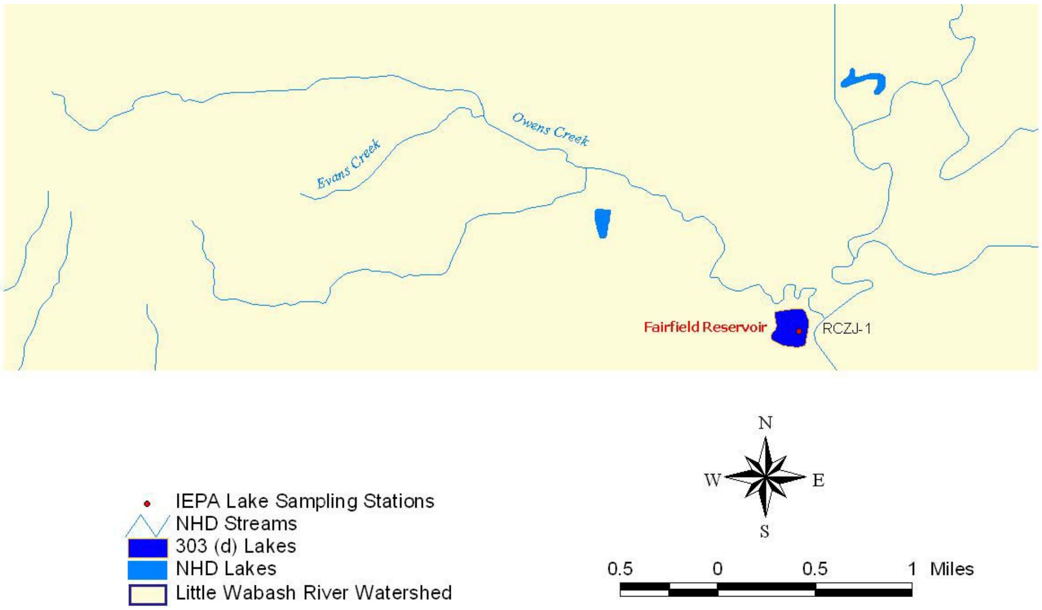

Figure 4. Fairfield Reservoir Lake Monitoring Stations

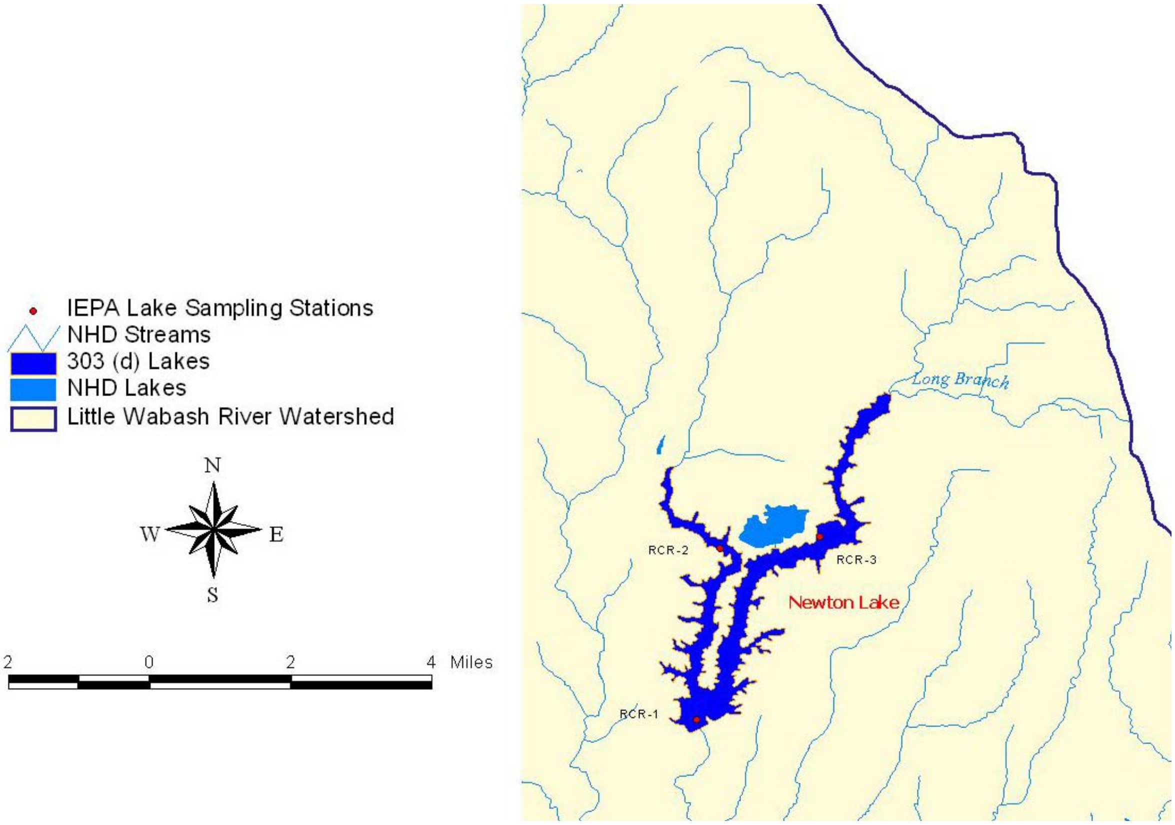

Figure 5. Newton Lake Monitoring Stations

BATHTUB was set up to simulate phosphorus response in Newton Lake for the years 1992, 1995, and 1998 and manganese response in Fairfield Reservoir in 2000 to correspond with the available water quality data. Watershed loads and total flow volumes to these lakes are summarized by year in Table 12. Stream flows are displayed in million gallons (MG) per year.

Table 12. Annual Watershed Flows and Loads to the Little Wabash River Watershed Lakes.

Lake	Year	Volume of Inflow	Manganese Load (kg/yr)	Total Phosphorus Load (kg/yr)
Fairfield Reservoir	2000	2,109 million gallons/year	1,660 kg/yr 3,660 lb/yr	Not Modeled
Newton Lake	1992	8,764 million gallons/year	Not Modeled	5,550 kg/yr 12,236 lb/yr
	1995	12,236 million gallons/year	Not Modeled	15,670 kg/yr 34,546 lb/yr
	1998	16,525 million gallons/year	Not Modeled	24,470 kg/yr 53,947 lb/yr

6.0 TMDLS DEVELOPED WITHIN THE LITTLE WABASH RIVER WATERSHED

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (including natural background levels). In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

A summary of the TMDL allocations for the Little Wabash River watershed is presented in this section of the report, organized according to pollutants and modeling analysis.

6.1 Loading Capacity for Streams in the Little Wabash River Watershed

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. U.S. EPA regulations define loading capacity as the greatest amount of a pollutant that a waterbody can receive without violating water quality standards. The loading capacity is often referred to as the “allowable” load. The following sections provide the TMDL results for the Little Wabash River, Elm River, and Little Muddy Creek, which were based on application of the load duration method. Appendix A presents the details of the load duration analysis.

6.1.1 Loading Capacity of Little Wabash River Stream Segment C 09

Existing and allowable loads were calculated for the Little Wabash River at station C 09 located upstream of the Sugar Creek confluence. This location drains 1372 square miles and land use/land cover is primarily agricultural (72%). A total of 18 atrazine samples, 36 fecal coliform samples, and 43 manganese samples were available for the load duration analysis (Appendix A).

The Little Wabash River at station C 09 is designated as a public water supply and IEPA therefore had to determine whether the TMDL should be based on either the aquatic life atrazine criterion (9 µg/L) or the public water supply (3 µg/L) criterion. The TMDL was based on the aquatic life criterion because there are insufficient data to make a direct comparison to the public water supply criterion. It is important to note that although the TMDL is based on meeting the 9 µg/L aquatic life criterion, the 3.0 µg/L public water supply criterion still applies and is expected to be met.

Both the geometric mean (200 cfu/100 mL) and the not-to-exceed (400 cfu/100 mL) components of Illinois’s fecal coliform water quality standard were evaluated as part of this study. The results of the load duration analysis based on the not-to-exceed 400 cfu/100 mL standard are presented in Appendix A for information purposes. The TMDL is based on meeting the geometric mean component of the standard because it is more restrictive and ensures both standards will be met. The Illinois fecal coliform standard is designated for the months of May to October and so only fecal coliform data (and estimated flows) collected during these months were used for the analysis.

Table 13 presents the TMDL summary for this assessment location. The current observed loads for each flow regime are based on the highest observed flow in each regime. Results of the load duration analysis indicate that significant load reductions of atrazine are needed for mid-range to high flow conditions, significant reductions of manganese are needed for all flow conditions, and significant fecal coliform reductions are needed in moist to high flow conditions.

Potential sources of fecal coliform in this segment include livestock, private sewage systems, and discharges from the following permitted National Pollutant Discharge Elimination System (NPDES) facilities:

- Charleston STP (permit number IL0021644)
- Clay City WWTP (permit number IL0020974)
- Dieterich STP (permit number IL0044792)
- Noble STP (permit number IL0025500)
- Parkersburg STP (permit number IL0071374)

Loads from these permittees are further discussed in Section 6.1.6. Wildlife, including waterfowl and terrestrial animals, might also be significant sources of fecal coliform.

Private surface sewage systems are common in the area and if not treated properly can release untreated sewage to local waterways. It has been estimated that statewide between 20 and 60 percent of surface discharging systems are failing or have failed (IEPA, 2004) suggesting that such systems may be a significant source of pollutants). Livestock and animal feeding operations are also potential contributors of fecal coliform to Segment C 09.

The high manganese levels are primarily attributed to natural background conditions. Many of the soils in Little Wabash contain naturally-occurring manganese concentrations or accumulations and most soils in the watershed are acidic (pH of 6.6). Low pH accelerates the manganese movement into solution and its transportation through baseflow and or/runoff. Release of manganese from river bottom sediments is also a potential source of manganese. Increased erosion from crop production areas and streambank erosion may also be causing elevated manganese levels in the watershed. Additionally, a historic source of manganese in the watershed might have been oil operations in the Little Wabash River watershed. In the past, the process of extracting the oil included pumping out brine water, which is typically high in manganese, and dumping it on the surface or storing it in lagoons that drained to surface waters.

Therefore, the observed manganese levels are likely due to a combination of the natural geochemical environment and historic oil operation practices. This issue will be further explored during the development of the implementation plan. None of the permitted point sources located along stream segment C 09 are required to monitor or control for manganese as none of them would be expected to discharge high concentrations of this parameter.

The primary source of atrazine within the watershed is believed to be runoff from agricultural activities. Similar to manganese, none of the permitted point sources located along stream segment C 09 are required to monitor or control for atrazine as none of them would be expected to discharge significant concentrations of this parameter.

Table 13. Atrazine, Fecal Coliform, and Manganese TMDL Summary for Stream Segment C 09

Station C 09 TMDL		**High Flows (6016.91 cfs)**	**Moist Conditions (1151.22 cfs)**	**Mid-Range Flows (174.69 cfs)**	**Dry Conditions (31.54 cfs)**	**Low Flows (8.25 cfs)**
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Atrazine (kg/day)	Current Load	176.65	56.33	10.26	0.34	No Data
	Current Concentration (µg/L)	12.0	20.0	24.0	4.4	No Data
	TMDL= LA+WLA+MOS	132.49	25.35	3.85	0.69	0.18
	LA	119.24	22.81	3.46	0.63	0.16
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	13.25	2.53	0.38	0.07	0.02
	TMDL Reduction (%)	**33%**	**60%**	**66%**	**0%**	No Data
	TMDL Concentration (µg/L)	9	9	9	9	9
Fecal Coliform (Million/ day)	Current Load	130,071,504	473,273,464	384,052	87,962	23,775
	Current Concentration (cfu/100 mL)	884	16813	90	114	118
	TMDL= LA+WLA+MOS	31,071,818	8,456,375	698,276	152,176	72,045
	LA	30,396,448	8,404,341	646,242	124,694	44,563
	WLA: Charleston STP Outfall Pipe 001	45,425	45,425	45,425	24,984	24,984
	WLA: Charleston STP Outfall Pipe A01	618,233	n/a	n/a	n/a	n/a
	WLA: Clay City WWTP Outfall Pipe 001	2,271	2,271	2,271	908	908
	WLA: Clay City WWTP Outfall Pipe 002	5,103	0	0	0	0
	WLA: Dieterich STP	1,514	1,514	1,514	606	606
	WLA: Noble STP	1,893	1,893	1,893	757	757
	WLA: Parkersburg STP	931	931	931	227	227
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS	Implicit	Implicit	Implicit	Implicit	Implicit
	TMDL Reduction (%)	**76%**	**98%**	**0%**	**0%**	**0%**
	TMDL Concentration (cfu/100 mL)	200	200	200	200	200
Manganese (kg/day)	Current Load	8243.7	2370.2	287.4	147.2	21.1
	Current Concentration (mg/L)	560.3	842.0	672.9	1908.7	1046.0
	TMDL= LA+WLA+MOS	2223.7	306.7	83.3	9.3	4.0
	LA	2001.3	276.1	74.9	8.4	3.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	222.4	30.7	8.3	0.9	0.4
	TMDL Reduction (%)	**76%**	**88%**	**74%**	**94%**	**83%**
	TMDL Concentration (mg/L)	150	150	150	150	150

Notes: n/a = Not Applicable because there are no NPDES permittees discharging to this segment. An entry of “n/a” for the WLA counts as zero in the calculation of the TMDL.

6.1.2 Loading Capacity of Stream Segment C 22

Existing and allowable loads of fecal coliform were calculated for the Little Wabash River at station C 22 located between the confluence of the Little Wabash River and Big Muddy Creek and the confluence of the Little Wabash River and Fox River. This location drains 1131 square miles and land use/land cover is primarily agricultural (71%). A total of 114 fecal coliform samples were available for the load duration analysis (Appendix A).

Table 14 presents the TMDL summary for this assessment location. Results of the load duration analysis indicate that fecal coliform observations exceed the loading limit during all but the low flow condition.

There were numerous observed fecal coliform loadings that exceeded the standard during all but low flow conditions. Potential sources of fecal coliform include livestock, animal feeding operations, private surface sewage disposal systems, and the three NPDES permitted dischargers that are allowed to discharge fecal coliform to the Little Wabash River or its tributaries:

- Clay City WWTP (permit number IL0020974)
- Dieterich STP (permit number IL0044792)
- Noble STP (permit number IL0025500)

Loads from these permittees are further discussed in Section 6.1.6. Wildlife, including waterfowl and terrestrial animals, might also be significant sources of fecal coliform.

Table 14. Fecal Coliform TMDL Summary for Stream Segment C 22

Station C 22 TMDL		High Flows (3800.46 cfs)	Moist Conditions (347.96 cfs)	Mid-Range Flows (52.46 cfs)	Dry Conditions (21.46 cfs)	Low Flows (7.21 cfs)
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	1,859,622,719	1,128,443,282	1,053,977	3,187,206	17,386
	Current Concentration (cfu/100 mL)	20,012	132,633	822	6,074	99
	TMDL= LA+WLA+MOS	18,596,227	1,702,623	256,699	105,013	35,283
	LA	18,585,446	1,696,945	251,021	102,742	33,012
	WLA: Clay City WWTP Outfall Pipe 001	2,271	2,271	2,271	908	908
	WLA: Clay City WWTP Outfall Pipe 002	5,103	0	0	0	0
	WLA: Dieterich STP	1,514	1,514	1,514	606	606
	WLA: Noble STP	1,893	1,893	1,893	757	757
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS	Implicit	Implicit	Implicit	Implicit	Implicit
	TMDL Reduction (%)	**99%**	**>99%**	**76%**	**97%**	**0%**
	TMDL Concentration (cfu/100 mL)	200	200	200	200	200

Notes: n/a = Not Applicable because there are no NPDES permittees discharging to this segment. An entry of "n/a" for the WLA counts as zero in the calculation of the TMDL.

6.1.3 Loading Capacity of Stream Segment C 33

Existing and allowable loads were calculated for the Little Wabash River at station C 33 located between the confluence of the Little Wabash River and Elm River and the confluence of the Little Wabash River and Skillet Fork. This location drains 1924 square miles and land use/land cover is primarily agricultural (73%). A total of 16 atrazine samples and 15 manganese samples were available for the load duration analysis (Appendix A).

Table 15 presents the TMDL summary for this assessment location. The current observed loads for each flow regime are based on the highest observed flow in each regime. Results of the load duration analysis indicate that significant load reductions of both atrazine and manganese are needed for all flow conditions that had corresponding water quality data.

The observed manganese levels are likely due to a combination of the natural geochemical environment and historic oil operation practices. Increased erosion from crop production areas and streambank erosion may also be causing elevated manganese levels in the watershed. The primary source of atrazine within the watershed is believed to be runoff from agricultural activities. None of the permitted point sources located along stream segment C 33 are required to monitor or control for manganese or atrazine as none of them would be expected to discharge significant concentrations of these parameters.

Table 15. Atrazine and Manganese TMDL Summary for Stream Segment C 33

Station C 33 TMDL		High Flows (9689.75 cfs)	Moist Conditions (1614.39 cfs)	Mid-Range Flows (244.97 cfs)	Dry Conditions (44.23 cfs)	Low Flows (11.57 cfs)
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Atrazine (kg/day)	Current Load	No Data	75.04	7.79	1.39	No Data
	Current Concentration (µg/L)	No Data	19.0	13.0	12.9	No Data
	TMDL= LA+WLA+MOS	213.36	35.55	5.39	0.97	0.25
	LA	192.02	31.99	4.85	0.88	0.23
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	21.34	3.55	0.54	0.10	0.03
	TMDL Reduction (%)	No Data	**57%**	**38%**	**37%**	No Data
	TMDL Concentration (µg/L)	9	9	9	9	9
Manganese (kg/day)	Current Load	No Data	771	405	166	No Data
	Current Concentration (mg/L)	No Data	195.3	676.1	1534.9	No Data
	TMDL= LA+WLA+MOS	3,556	413	90	16	5
	LA	3,200	372	81	14	5
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	356	41	9	2	1
	TMDL Reduction (%)	No Data	**52%**	**80%**	**92%**	No Data
	TMDL Concentration (mg/L)	150	150	150	150	150

Notes: n/a = Not Applicable because there are no NPDES permittees discharging to this segment. An entry of “n/a” for the WLA counts as zero in the calculation of the TMDL.

6.1.4 Loading Capacity of Stream Segment CD 01

Existing and allowable loads were calculated for the Elm River at station CD 01 located between the confluence of Elm River and Emmons Creek and the mouth of Elm River. This location drains 251 square miles and land use/land cover is primarily agricultural (76%). A total of 19 atrazine samples, 113 fecal coliform samples, and 123 manganese samples were available for the load duration analysis (Appendix A).

Table 16 presents the TMDL summary for Stream Segment CD01. The current observed loads for each flow regime are based on the highest observed flow in each regime. Results of the load duration analysis indicate that significant load reductions of atrazine, fecal coliform, and manganese are needed for most flow conditions.

There were 28 observed fecal coliform samples that exceeded the standard during all flow conditions. Potential sources of fecal coliform include livestock, animal feeding operations, private surface sewage disposal systems, and the four NPDES permitted dischargers that are allowed to discharge fecal coliform to Elm River or its tributaries:

- Cisne STP (NPDES permit number ILG580197)

- Flora City of-Charlie Brown Pk (NPDES permit number IL0047481)
- Flora STP (NPDES permit number IL0020273)
- Jeffersonville STP (NPDES permit number ILG580076)

Loads from these permittees are further discussed in Section 6.1.6. Wildlife, including waterfowl and terrestrial animals, might also be significant sources of fecal coliform.
The observed manganese levels are likely due to a combination of the natural geochemical environment and historic oil operation practices. Increased erosion from crop production areas and streambank erosion may also be causing elevated manganese levels in the watershed. The primary source of atrazine within the watershed is believed to be runoff from agricultural activities. None of the permitted point sources located along stream segment CD 01 are required to monitor or control for manganese or atrazine as none of them would be expected to discharge significant concentrations of these parameters.

Table 16. Atrazine, Fecal Coliform, and Manganese TMDL Summary for Stream Segment CD 01

Station CD 01 TMDL		High Flows (1264.10 cfs)	Moist Conditions (158.23 cfs)	Mid-Range Flows (33.51 cfs)	Dry Conditions (5.55 cfs)	Low Flows (1.51 cfs)
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Atrazine (kg/day)	Current Load	No Data	9.790	1.230	0.130	No Data
	Current Concentration (µg/L)	No Data	25.3	15.0	9.6	No Data
	TMDL= LA+WLA+MOS	27.834	3.484	0.738	0.122	0.033
	LA	25.051	3.136	0.664	0.110	0.030
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	2.783	0.348	0.074	0.012	0.003
	TMDL Reduction (%)	No Data	**68%**	**46%**	**15%**	No Data
	TMDL Concentration (µg/L)	**9**	**9**	**9**	**9**	**9**
Fecal Coliform (Million/day)	Current Load	266,818,841	23,371,759	2,543,433	553,353	14,356
	Current Concentration (cfu/100 mL)	8,632	6,041	3,104	4,078	389
	TMDL= LA+WLA+MOS	5,839,887	304,931	62,764	28,560	14,006
	LA	5,824,034	289,078	46,911	20,096	5,542
	WLA: Cisne STP	1,514	1,514	1,514	606	606
	WLA: Flora City of-Charlie Brown Pk	106	106	106	45	45
	WLA: Flora STP	13,627	13,627	13,627	7,571	7,571
	WLA: Jeffersonville STP	606	606	606	242	242
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS	Implicit	Implicit	Implicit	Implicit	Implicit
	TMDL Reduction (%)	**98%**	**99%**	**98%**	**95%**	**2%**
	TMDL Concentration (cfu/100 mL)	200	200	200	200	200
Manganese (kg/day)	Current Load	3968.0	627.8	138.6	62.5	7.1
	Current Concentration (mg/L)	1283.8	1622.7	1691.6	4605.6	1923.0
	TMDL= LA+WLA+MOS	411.7	43.2	15.1	2.9	0.7
	LA	370.5	38.8	13.6	2.6	0.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	41.2	4.3	1.5	0.3	0.1
	TMDL Reduction (%)	**91%**	**94%**	**90%**	**96%**	**91%**
	TMDL Concentration (mg/L)	150	150	150	150	150

Notes: n/a = Not Applicable because there are no NPDES permittees discharging to this segment. An entry of “n/a” for the WLA counts as zero in the calculation of the TMDL.

6.1.5 Loading Capacity of Stream Segment CJA 02

Existing and allowable loads were calculated for Little Muddy Creek at station CJA 02. This location drains 66 square miles and land use/land cover is primarily agricultural (78%). A total of 6 manganese samples were available for the load duration analysis (Appendix A).

Table 17 presents the TMDL summary for this assessment location. The current observed loads for each flow regime are based on the highest observed flow in each regime. Results of the load duration analysis indicate that significant load reductions of manganese are needed for most flow conditions.

The observed manganese levels are likely due to a combination of the natural geochemical environment and historic oil operation practices. Increased erosion from crop production areas and streambank erosion may also be causing elevated manganese levels in the watershed. None of the permitted point sources located along stream segment CJA 02 are required to monitor or control for manganese as none of them would be expected to discharge significant concentrations of this parameter.

Table 17. Manganese TMDL Summary for Stream Segment CJA 02

Station CJA 02 TMDL		**High Flows (332.39 cfs)**	**Moist Conditions (38.57 cfs)**	**Mid-Range Flows (6.42 cfs)**	**Dry Conditions (1.11 cfs)**	**Low Flows (0.51 cfs)**
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Manganese (kg/day)	Current Load	No Data	16.99	6.12	6.51	2.61
	Current Concentration (mg/L)	No Data	180.2	389.9	2398.6	2093.0
	TMDL= LA+WLA+MOS	121.98	14.16	2.36	0.41	0.19
	LA	109.79	12.74	2.12	0.37	0.17
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	12.20	1.42	0.24	0.04	0.02
	TMDL Reduction (%)	No Data	**25%**	**65%**	**94%**	**94%**
	TMDL Concentration (mg/L)	150	150	150	150	150

Notes: n/a = Not Applicable because there are no NPDES permittees discharging to this segment. An entry of “n/a” for the WLA counts as zero in the calculation of the TMDL.

6.1.6 Waste Load Allocations

There are twelve facilities regulated by the National Pollutant Discharge Elimination System (NPDES) that are allowed to discharge fecal coliform in the Little Wabash River. Information on these and other dischargers in the watershed are shown in Table 18; the WLAs for fecal coliform are shown in Table 19.

Table 18. Wastewater treatment plants discharging to impaired streams within the Little Wabash River watershed.

Facility Name	Permit Number	Receiving Stream	Design Average Flow (MGD)	Design Maximum Flow (MGD)	Daily Fecal Coliform Limit (cfu/100 mL)	CBOD Limit (mg/L)	Daily Ammonia Limit (mg/L)
Ameren Cips - Newton	IL0049191	Newton Lake	415.7		No Fecal Discharge	30	
Charleston STP	IL0021644	Cassell Creek	3.3	6	400	20	3 (April-Oct) 3.4 (Nov-March)
Cisne STP	ILG580197	Deer Creek, Elm River, Little Wabash River	0.08	0.2	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Clay City WWTP	IL0020974	Unnamed ditch tributary to Little Wabash Creek	0.12	0.3	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Crossville STP	ILG580211	Elliott Creek	0.25	0.82	Disinfection Exemption		
Dieterich STP	IL0044792	Tributary to Big Muddy Creek	0.08	0.2	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Fairfield STP	IL0020605	Johnson Creek	0.91	2.2	Disinfection Exemption	20	3 (April-Oct) 8 (Nov-March)
Fairfield WTP	ILG640137	NA	0.124	0.248	No Fecal Discharge		
Flora City Of-Charlie Brown Pk	IL0047481	Unnamed tributary of Raccoon Creek	0.003	0.007	400	20	3 (April-Oct) 8 (Nov-March)
Flora STP	IL0020273	Seminary Creek	1	1.8	Disinfection Exemption	20	6.2 (April-Oct) 13.5 (Nov-March)
Flora WTP	IL0074403	Unnamed tributary to Elm Creek	0.027		No Fecal Discharge		
Greenville WTP	IL0045764	Kingsbury Branch	0.66		Disinfection Exemption		
Jeffersonville STP	ILG580076	Martin Creek	0.032	0.08	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Mt. Erie WTP	ILG640143	Newton Branch	0.0006		No Fecal Discharge		
Noble STP	IL0025500	Hog Run Creek	0.1	0.25	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Parkersburg STP	IL0071374	Unnamed tributary to Sugar Creek	0.03	0.123	Disinfection Exemption	25 M. Avg 40 W. Avg.	
Shell Pipeline – Clay City	IL0076074		Inactive	Inactive	Inactive	Inactive	Inactive

Notes: The Shell Pipeline-Clay City used to hold a permit (IL0076074) to discharge into an unnamed tributary to Salt Creek; however, this facility ceased operations in April 2007; N/A = Not Available; M. Avg = Monthly Average; W. Avg = Weekly Average

Sewage from treatment plants treating domestic and/or municipal waste contain fecal coliform–it is indigenous to sanitary sewage. In Illinois, a number of these treatment plants, including those identified in Table 18, have applied for and received disinfection exemptions which allow a facility to discharge wastewater without disinfection. All of these treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. WLAs for facilities with disinfection exemptions were therefore based on the design flows for each facility multiplied by 200 cfu/100 mL. The resulting WLAs apply at the end of their respective disinfection exemptions. Facilities with year-round disinfection exemptions may be required to provide IEPA with updated information to demonstrate compliance with these requirements and facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions.

The WLAs for IL0047481 outfall 001 were determined by multiplying the facilities maximum design flows by their permit limit (400 cfu/100 mL) during high to mid range flows and by multiplying the average design flows by the permit limit during low flows and moist conditions. The WLAs for Outfall 001 of each of the remaining facilities (those with disinfection exemptions) were determined by multiplying the average design flows by the geometric mean water quality permit limit (200 cfu/100 mL) during all flow ranges. The facilities with disinfection exemptions are required to meet the geometric mean standard at the nearest point downstream where recreational use occurs in the receiving water (not at the pipe outfall).

WLAs for Clay City Outfall 002 and Charleston STP Outfall A01 were set based on average reported flow information and the permit limit of 400 cfu/100 mL. The WLAs for these outfalls only apply to the high flow conditions as discharges from these stormwater-related outfalls should be limited to these high flow periods. Recent monitoring data for these outfalls are documented in Appendix C and indicate that the permit limit of 400 cfu/100 mL is usually met for each facility. There were two exceedances of the 400 cfu/100 mL standard from the Charleston STP Outfall Pipe A01 in 2000.

No manganese or atrazine WLAs were developed as none of the NPDES facilities are considered significant sources of either of these pollutants.

There are no municipal separate storm sewer system (MS4) communities regulated by NPDES in the Little Wabash Watershed and therefore no MS4 WLAs were assigned. Although the township of Flora is listed as an MS4 community, the township is mostly rural and requested that IEPA remove them from the list of MS4 communities requiring an NPDES permit. The request was granted by IEPA on January 24, 2005, stating that "…Flora Township would not need separate coverage under the Phase II MS4 Storm Water Permit."

Table 19. Fecal Coliform Limits and WLA for NPDES Facilities in the Little Wabash watershed.

WLA Summary		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
NPDES Permit	**Parameter**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Charleston STP Outfall Pipe 001	Flow (MGD)	6.00	6.00	6.00	3.30	3.30
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	90,850	90,850	90,850	49,967	49,967
Charleston STP Outfall Pipe A01	Flow (MGD)	39.05	0.00	0.00	0.00	0.00
	Value used to calculate WLA	400	N/A	N/A	N/A	N/A
	Fecal Coliform WLA (Million/day)	591,281	0	0	0	0
Cisne STP	Flow (MGD)	0.20	0.20	0.20	0.08	0.08
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	1,514	1,514	1,514	606	606
Clay City WWTP Outfall Pipe 001	Flow (MGD)	0.30	0.30	0.30	0.12	0.12
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	2,271	2,271	2,271	908	908
Clay City WWTP Outfall Pipe 002	Flow (MGD)	0.337	0	0	0	0
	Value used to calculate WLA	400	N/A	N/A	N/A	N/A
	Fecal Coliform WLA (Million/day)	5,103	0	0	0	0
Dieterich STP	Flow (MGD)	0.20	0.20	0.20	0.08	0.08
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	1,514	1,514	1,514	606	606
Flora City of-Charlie Brown Pk	Flow (MGD)	0.01	0.01	0.01	0.00	0.00
	Value used to calculate WLA	400				
	Fecal Coliform WLA (Million/day)	106	106	106	45	45

Table 19 (continued). Fecal Coliform Limits and WLA for NPDES Facilities in the Little Wabash watershed.

WLA Summary		**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
NPDES Permit	**Parameter**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Flora STP	Flow (MGD)	1.80	1.80	1.80	1.00	1.00
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	13,627	13,627	13,627	7,571	7,571
Jeffersonville STP	Flow (MGD)	0.08	0.08	0.08	0.03	0.03
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	606	606	606	242	242
Noble STP	Flow (MGD)	0.25	0.25	0.25	0.10	0.10
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	1,893	1,893	1,893	757	757
Parkersburg STP	Flow (MGD)	0.12	0.12	0.12	0.03	0.03
	Value used to calculate WLA	200				
	Fecal Coliform WLA (Million/day)	931	931	931	227	227

*Flows for CSO and stormwater outfalls were based on the average of reported flows during the recreational season where available and on the average flows when recreational season flows were not available.
Notes: MGD = million gallons per day; N/A = Not Applicable

6.1.7 Load Allocation

Load Allocations (LAs) are specified for nonpoint sources and natural background sources. The load allocations for the TMDLs presented in Section 6.1 are based on subtracting the allocations for WLAs and the MOS from the allowable loads. They are presented in Table 13, Table 14, Table 15, Table 16, and Table 17. The control of fecal coliform, atrazine, and manganese loadings from nonpoint sources such as wildlife and agriculture is addressed in the Little Wabash River project implementation plan.

6.1.8 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for uncertainties in the relationship between pollutants loads and receiving water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). A 10 percent explicit MOS has been applied as part of this TMDL for manganese and atrazine. The use of the load duration curve approach minimizes a great deal of uncertainty associated with the development of TMDLs because the calculation of the loading capacity is simply a function of flow multiplied by the target value. Most of the uncertainty is therefore associated with the estimated flows in each assessed segment which were based on extrapolating flows from the downstream USGS gage. The USGS gage used for the TMDLs (gage 03379500) is located on the Little Wabash River segment C 22 at the same location as monitoring location C 22 and is believed to be representative of the flows estimated for the other monitoring stations.

An implicit MOS is also associated with the fact that the estimated level of load reductions that are necessary are based on the maximum observed loads for each flow condition. The MOS for fecal coliform is an implicit one because the load duration analysis does not address die-off of pathogens and because the TMDL is based on meeting the geometric mean component of the standard rather than the not-to-exceed portion of the standard.

6.1.9 Critical Conditions and Seasonality

TMDLs should also take into account critical conditions and seasonal variations. Critical conditions refer to the periods when greatest reductions of pollutants are needed. The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. From the load duration approach it has been determined that critical conditions for fecal coliform and manganese occur during high flows (load reduction percentages are highest during these periods) and a separate loading capacity has been specified for these periods. Critical conditions for atrazine are associated with moist flow conditions that tend to occur during and after periods when atrazine is typically applied and a separate loading capacity for moist conditions is specified for atrazine.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. The load duration approach automatically accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow. Seasonal variations for fecal coliform TMDL are also addressed by only assessing conditions during the season when the water quality standard applies (May through October).

6.2 Loading Capacity for Lakes in the Little Wabash River Watershed

As described in Section 5.3, the BATHTUB model was used to simulate total phosphorus and manganese concentrations in the impaired lakes in the Little Wabash River watershed. After the models were calibrated, the loading capacity for Newton Lake was calculated by multiplying the needed load reduction by the average existing load the years in which data were available. This was considered appropriate because data were available for 1992 (a dry year), 1995 (an average year), and 1998 (a wet year). The loading capacity thus represents the typical load of pollutants that will result in meeting water quality standards. The Fairfield Reservoir loading capacity was based on the only year for which data are available (2000).

The following sections summarize the resulting TMDLs for Fairfield Reservoir and Newton Lake.

6.2.1 Fairfield Reservoir Loading Capacity

For Fairfield Reservoir, a manganese reduction of 28 percent is recommended to achieve the water quality standard as a long-term average over the entire simulated period. Table 20 shows the resulting average concentration if this reduction is implemented. Table 21 presents the existing load, loading capacity, margin of safety and load allocation for Fairfield Reservoir. Existing loads were estimated by using a reverse BATHTUB model where the user inputs loads to match observed concentrations (Appendix E).

Table 20. Average Total Manganese Concentration in Fairfield Reservoir with 28 Percent Reduction in Loading

Year	Fairfield Reservoir Manganese (µg/L)
2000	149.7

Table 21. TMDL Summary for Fairfield Reservoir.

Lake	Category	Manganese (kg/yr)	Manganese (kg/day)
Fairfield Reservoir	Existing Load	1,660	4.5
	Loading Capacity	1,195	3.3
	Wasteload Allocation	0	0.0
	Margin of Safety (5%)	60	0.2
	Load Allocation	1,135	3.1
	Reduction	28%	28%

6.2.2 Newton Lake Loading Capacity

For Newton Lake, a phosphorus reduction of 61 percent is recommended to achieve the water quality standard as a long-term average over the entire simulation period. Table 22 shows the average total phosphorus concentrations if a 61 percent reduction is implemented. Table 23 shows the existing load, loading capacity, wasteload allocation, margin of safety and load allocation for Newton Lake. The existing loads are the average annual loads to the lake from 1992 to 1998 (in years where observed data were available) determined using the “reverse” BATHTUB model, which is explained in Appendix E.

Table 22. Average Total Phosphorus Concentration in Newton Lake with 61 Percent Reduction in Loading

Year	Newton Lake TP (mg/L)
1992	0.0291
1995	0.0441
1998	0.0497

Table 23. TMDL Summary for Newton Lake.

Lake	Category	Phosphorus (kg/yr)	Phosphorus (kg/day)
Newton Lake	Existing Load	15,232	41.73
	Loading Capacity	5,942	16.33
	Wasteload Allocation	88	0.25
	Margin of Safety (5%)	299	0.91
	Load Allocation	5,554	15.17
	Reduction	61%	61%

6.2.3 Waste Load Allocations

There are no permitted dischargers of manganese to Fairfield Reservoir so wasteload allocations for manganese are zero. The Ameren facility has two sewage treatment plant (STP) outfalls which discharge total phosphorus to Newton Lake. The facility is not required to monitor for total phosphorus in its effluent so actual loads are unknown. Loads of total phosphorus from the STP outfalls were estimated by multiplying their average reported effluent flows by estimates of their total phosphorus concentrations. A literature value of 4 mg/L (Litke, 1999) was used to estimate the STP loads and the results are shown in Table 24; the resulting wasteload allocations are included in Table 23.

Table 24. WLA Summary for Ameren Cips (Permit IL0049191).

Outfall	Design Average Flow (million gallons per day)	TP Concentration (mg/L)[1]	TP Load (Kg/day)	TP Load (Kg/year)
001A	0.001	4 mg/L	0.02	5.53
003	0.015	4 mg/L	0.23	82.89

[1] Literature value from Litke, 1999.

6.2.4 Load Allocation

The allocations of loads for the Little Wabash River Watershed Lake TMDLs are summarized in Tables 17 and 19. The existing loads were determined using a reverse BATHTUB simulation in which loads were back calculated for each year based on observed inlake water quality concentrations. For Newton Lake, the allocations are based on an existing total phosphorus load calculated from the average of the loads from the three simulation years. For Fairfield Reservoir, the existing manganese load is equivalent to the year 2000 load because that was the only year for which inlake water quality data were available. The loading capacity was calculated based on the percent reduction of existing loads required to simulate concentrations at or below the water quality standard for each parameter. Five percent of the loading capacity is reserved for a margin of safety as required by the Clean Water Act (see Section 6.2.5 for more information on the margin of safety).

6.2.5 Margin of Safety

Section 303(d) of the Clean Water Act and U.S. EPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (U.S. EPA, 1991). A five percent explicit margin of safety has been incorporated into the Newton Lake and Fairfield Reservoir TMDLs by reserving a portion of the loading capacity. A relatively low margin of safety was applied because existing loads were calculated by using a reverse BATHTUB model where incoming loads were set to match observed concentrations assuming model default parameters for settling, re-suspension, etc. No calibration of the model was therefore required as the predicted lake concentrations matched the observed concentrations.

In addition, the manganese modeling also incorporates an internal margin of safety by assuming the manganese sedimentation rate is zero. In reality, some of the manganese entering the lake is likely being deposited on the bottom of the lake and thus not affecting water quality. The assumption that this is not occurring results in a more conservative (lower) estimate of the allowable load.

6.2.6 Critical Conditions and Seasonality

Section 303(d)(1)(C) of the Clean Water Act and U.S. EPA's regulations at 40 CFR 130.7(c)(1) require that a TMDL be established that addresses seasonal variations normally found in natural systems. Lake nutrients are typically highest during the summer and the BATHTUB User's manual suggests modeling summer months from May through September. However, for Newton Lake, the annual simulation was chosen because 1) the summer period simulation did not meet the nutrient turnover criteria for phosphorus, and 2) the annual model was more conservative in terms of required reductions. For Fairfield Reservoir, only six manganese measurements were collected, all in the year 2000. No apparent trend with season was observed and the lowest measurement was taken in July. To utilize all available data for this lake, an annual simulation was chosen. For both of these lakes, it is expected that the reductions required for the annual simulations will protect water quality during all seasons.

6.3 Reasonable Assurance, Monitoring, and Implementation

A detailed Implementation Plan has been developed to outline steps that can be taken to implement the TMDLs described in this report. The Implementation Plan identifies the most likely sources of each pollutant, describes controls that can be used to reduce loadings, provides information on available funding resources, and presents follow-up monitoring recommendations. The Key Findings of the Implementation Plan were as follows:

> *"The results of the TMDL study for the Little Wabash River II indicate that significant reductions of fecal coliform, atrazine, and manganese are needed to attain water quality standards throughout the drainage area. In addition, reductions of phosphorus loads to Newton Lake are required to bring this waterbody into compliance.*
>
> *The largest potential sources of pollutant loading in the watershed are agricultural practices. Manure from animal operations can contribute nutrients, pathogens, and biodegradable organic material. In addition, animals with access to stream channels can deposit fecal material directly into or near the stream and erode the banks as they climb in and out. This erosion leads to increased loads of sediment and manganese, a metal common in soils. The BMPs most likely to control loading from animal operations are 1)*

proper handling, storage, and final disposal practices for manure, 2) vegetative controls such as grassed waterways, filter strips, and constructed wetlands, 3) manure composting, and 4) restoration of riparian buffers.

Crop production in the watershed results in loadings of nutrients, sediment, manganese, and pesticides to the watershed. Application of fertilizers and pesticides contributes phosphorus and atrazine to the waterbodies when rain events wash pollutants into nearby streams or through underlying tile drain systems. Increased rates of erosion result in excessive sediment and manganese loads. The most cost-effective management strategy that addresses all pollutants of concern is conservation tillage. Other effective practices include grass waterways, filter strips, fertilizer and pesticide management, and restoration of riparian buffers.

Pollutant loads from point sources in the watershed may be significant, but the actual loads are difficult to estimate because several of the facilities are not required to monitor for the TMDL pollutants. Given that most of these facilities provide at least a secondary level of wastewater treatment, it is not likely that IEPA will require them to upgrade their plants to reduce nutrient or organic loading. However, the State may request that facilities submit fecal coliform data to verify that water quality standards are being met at the point the effluent meets a non-exempt reach.

The number of onsite wastewater treatment systems in the watershed is relatively sparse and loading from this source is likely not significant relative to the other sources. However, failing onsite systems may cause localized water quality impacts as well as risks to human health. Identifying these systems through a routine inspection program and encouraging proper maintenance and upkeep will minimize these impacts."

7.0 ASSESSMENT OF DISSOLVED OXYGEN ISSUES IN THE LITTLE WABASH RIVER WATERSHED

Nine streams in the Little Wabash River watershed are listed as impaired due to low dissolved oxygen concentrations:

- Little Wabash River (C 09 and C 33)
- Johnson Creek (CCA FF A1)
- Pond Creek (CC FF D1)
- Elm River (CD 01 and CD 04)
- Seminary Creek (CDG FL A1 and CDG FL C6)
- Village Creek (CE 01)
- Big Muddy Creek (CJ 06)
- Little Muddy Creek (CJA 02)
- Big Muddy Diversion Ditch (CJAE 01).

No TMDLs are being developed for these streams at this time due to the considerations described below.

7.1 Dissolved Oxygen Analysis for Little Wabash River (C 09)

Little Wabash River segment C 09 is listed as impaired due to low dissolved oxygen. The original listing was made based on 7 of 43 (16%) dissolved oxygen measurements being below the aquatic life water quality criterion of 5 mg/L. The impairment was confirmed based on the Stage 2 sampling which resulted in additional observations below 5 mg/L from continuous monitoring of dissolved oxygen (refer to Stage 1 and Stage 2 reports for details). The QUAL2K model was setup and calibrated to the August 2006 sampling data to further investigate the dissolved oxygen issues as explained in Section 5.2. Details of the QUAL2K modeling are provided in Appendix D.

To further investigate the cause of the low dissolved oxygen in the Little Wabash River, three separate analyses were conducted:

- Point and nonpoint source loads were reduced until both components of the dissolved oxygen water were met.
- The average dissolved oxygen re-aeration coefficient derived from the QUAL2K calibration was increased until both components of the dissolved oxygen water quality standard were met.
- The sediment oxygen demand derived from the QUAL2K calibration was decreased (while maintaining existing point and nonpoint source loads) until both components of the dissolved oxygen water quality standard were met.

The results of this analysis indicate that even complete removal of carbonaceous biochemical oxygen demand (CBOD) and total ammonia loads from both nonpoint and point sources are not enough to achieve the 5 mg/L or the 6 mg/L component of the standard. CBOD measures the rate of oxygen uptake by micro-organisms in a sample of water and is an indication of the amount of biodegradable carbon in organic matter. Total ammonia is the sum of ammonia (NH_3) and ammonium (NH_4+) and is significant because the conversion of ammonium to nitrate by bacteria consumes dissolved oxygen. It is infeasible to completely remove loads of CBOD and ammonium from a natural stream system, given that at least a portion of this load is associated with natural background sources. For example, leaf fall from vegetation near the water's edge, aquatic plants, and drainage from organically rich areas like swamps and bogs are all natural sources of material that consume oxygen.

The modeling analysis also suggests that the 6 mg/L water quality standard cannot be met even with the complete elimination of sediment oxygen demand (some of which is also expected to be natural). Although the water quality standards could be met if the average re-aeration rate is increased from 0.27 per day to 1.95 per day, increasing aeration in the stream would be technically difficult and is not a parameter for which a TMDL can be developed. Based on these considerations no TMDL will be developed at this time and instead methods to reduce pollutant loadings and increase in-stream re-aeration will be outlined in the Implementation Plan.

7.2 Dissolved Oxygen Analysis for Other Streams in the Little Wabash River Watershed

Similar analyses were conducted for the other streams in the Little Wabash River that are impaired due to low dissolved oxygen:

- Little Wabash River (C 33)
- Johnson Creek (CCA FF A1)
- Pond Creek (CC FF D1)
- Elm River (CD 01 and CD 04)
- Seminary Creek (CDG FL A1 and CDG FL C6)
- Village Creek (CE 01)
- Big Muddy Creek (CJ 06)
- Little Muddy Creek (CJA 02)
- Big Muddy Diversion Ditch (CJAE 01).

The results are summarized in Table 25 and indicate that meeting the dissolved oxygen water quality standards in most segments would require very large (potentially infeasible) reductions from point and nonpoint sources or sediment oxygen demand. Although the water quality standards could be met with increased re-aeration rates, increasing aeration in the streams would be technically difficult and is not a parameter for which a TMDL can be developed. Based on these considerations a TMDL has only been developed for Elm River (CD 01) (see Table 26). For all other segments no TMDLs were developed and instead methods to reduce pollutant loadings and increase in-stream re-aeration will be outlined in the Implementation Plan.

Table 25. Summary of dissolved oxygen QUAL2K analysis for streams in the Little Wabash River watershed impaired due to low dissolved oxygen.

Segment	Listing Confirmation	Load Reduction Results	SOD Reduction Results	Re-aeration Increase Results
Little Wabash River (C 33)	Original listing made based on 3 of 5 (60%) measurements below 5 mg/L; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of point and nonpoint source CBOD and total ammonia loads does not achieve WQS	Complete removal of SOD does not achieve WQS	Average re-aeration rate would need to be increased from 0.4 per day to 1.25 per day to achieve WQS
Johnson Creek (CCA FF A1)	Original listing made based on one dissolved oxygen measurement that was below 5 mg/L in 1997; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	87 percent point and nonpoint source CBOD and 85 percent ammonia load reductions needed to achieve WQS	Complete removal of SOD does not achieve WQS	Average re-aeration rate would need to be increased from 0.23 per day to 5 per day to achieve WQS
Pond Creek (CC FF D1)	Original listing made based on one dissolved oxygen measurement that was below 5 mg/L in 1997; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of nonpoint CBOD and total ammonia would not achieve WQS; no point sources discharging to this stream segment	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 0.2 per day to 5 per day to achieve WQS
Elm River (CD 01)	Original listing made based on 2 of 3 (67%) measurements below 5 mg/L; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Both water quality standards would be met with a 20 percent reduction of CBOD and total ammonia loads from point sources, a 36 percent reduction of CBOD loads from nonpoint sources, and a 40 percent reduction of ammonia loads from nonpoint sources.	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 1.15 per day to 1.7 per day
Elm River (CD 04)	No sampling performed at station CD 04 on Elm River. Impairment based on sampling at other locations on Elm River	WQS would be met with an 80 percent reduction of CBOD and total ammonia loads from point sources and a 79 percent reduction of CBOD and total ammonia loads from nonpoint sources.	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 0.43 per day to 1.5 per day to achieve WQS
Seminary Creek (CDG FL A1)	Original listing made based on one dissolved oxygen measurement that was below 5 mg/L in 1998; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of CBOD and total ammonia loads from nonpoint sources would achieve the 5 mg/L criterion but not the 6 mg/L criterion	Complete removal of SOD does not achieve WQS	Average re-aeration rate would need to be increased from 0.13 per day to 1.8 per day to achieve WQS

Segment	**Listing Confirmation**	**Load Reduction Results**	**SOD Reduction Results**	**Re-aeration Increase Results**
Seminary Creek (CDG FL C6)	Original listing made based on one dissolved oxygen measurement that was below 5 mg/L in 1998; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of CBOD and total ammonia loads from nonpoint sources would achieve the 5 mg/L criterion but not the 6 mg/L criterion	Complete removal of SOD does not achieve WQS	Average re-aeration rate would need to be increased from 0.13 per day to 4 per day to achieve WQS
Village Creek (CE 01)	Listing made based on continuous Stage 2 sampling (see Appendix G)	Complete removal of CBOD and total ammonia loads from nonpoint sources would achieve WQS. No point sources discharge to this segment	Complete removal of SOD does not achieve WQS	Average re-aeration rate would need to be increased from 0.45 per day to 1.75 per day to achieve WQS
Big Muddy Creek (CJ 06)	Original listing made based on 1 of 3 (33%) samples below 5 mg/L in 2002; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of CBOD and total ammonia loads from nonpoint sources would achieve the 5 mg/L criterion but not the 6 mg/L criterion	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 35 per day to 40 per day to achieve WQS
Little Muddy Creek (CJA 02)	Original listing made based on 3 of 4 (75%) samples below 5 mg/L in 2002; impairment confirmed based on continuous Stage 2 sampling (see Appendix G)	Complete removal of CBOD and total ammonia loads from nonpoint sources would not achieve WQS. No point sources discharge to this segment	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 5 per day to 15 per day to achieve WQS
Big Muddy Diversion Ditch (CJAE 01)	Listing made based on continuous Stage 2 sampling (see Appendix G)	Complete removal of point and nonpoint source CBOD and total ammonia loads does not achieve WQS	Complete removal of SOD achieves WQS	Average re-aeration rate would need to be increased from 5 per day to 10 per day to achieve WQS

Table 26. TMDL Summary for Elm River segment CD 01.

Category	**CBOD (kg/day)**	**CBOD (lb/day)**	**Total Ammonia (kg/day)**	**Total Ammonia (lb/day)**
Existing Load	659	1453	42	93
Loading Capacity	443.00	976.00	30.00	67.00
WLA: Cisne STP	10.00	22.00	1.00	2.00
WLA: Flora City Of-Charlie Brown Pk	0.36	0.80	0.03	0.06
WLA: Jeffersonville STP	4.00	9.00	0.45	1.00
WLA: Flora STP	61.00	134.00	19.00	42.00
Margin of Safety (5%)	A 10 percent MOS was explicitly incorporated into the TMDLs by identifying load reductions that will achieve minimum dissolved oxygen concentration of 5.5 mg/L and 6.6 mg/L instead of 5.0 mg/L and 6.0 mg/L (see water quality standards in Section 3.0)			
Load Allocation	367.64	810.20	9.52	21.94

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Appendix A : Load Duration Analysis

Appendix B : Atrazine, Fecal Coliform, and Manganese Data for Load Duration Analysis

Table B-1. Available Atrazine Data for Segment C 09

Date	Total Atrazine (µg/L)
6/14/1999	12
7/27/1999	0.94
4/18/2006	0.27
4/26/2006	0.62
5/1/2006	0.59
5/17/2006	20.00
5/24/2006	6.30
5/31/2006	24.00
6/7/2006	4.20
6/15/2006	1.80
6/22/2006	1.20
6/27/2006	1.50
7/5/2006	1.20
7/12/2006	0.96
7/20/2006	1.60
7/27/2006	0.72
8/1/2006	0.63
8/8/2006	0.40

Table B-2. Available Atrazine Data for Segment C 33

Date	Total Atrazine (μg/L)
4/18/2006	0.55
4/26/2006	1.1
5/1/2006	0.71
5/17/2006	19
5/24/2006	8.1
5/31/2006	13
6/7/2006	6.3
6/15/2006	5.3
6/22/2006	2.6
6/27/2006	2.5
7/5/2006	1.7
7/12/2006	1
7/20/2006	2.3
7/27/2006	0.64
8/1/2006	0.66
8/8/2006	0.5

Table B-3. Available Atrazine data for Segment CD 01

Date	Total Atrazine (µg/L)
4/9/2002	0.1
6/18/2002	26
8/1/2002	0.54
4/18/2006	0.12
4/26/2006	0.16
5/1/2006	0.27
5/17/2006	19.00
5/24/2006	15.00
5/31/2006	8.30
6/7/2006	5.70
6/15/2006	2.80
6/22/2006	1.20
6/27/2006	4.20
7/5/2006	2.40
7/12/2006	0.92
7/20/2006	2.40
7/27/2006	2.60
8/1/2006	2.60
8/8/2006	1.60

Table B-4. Available Fecal Coliform Data for Segment C 09

Date	Fecal Coliform (#/100mL)
01/12/00	80
02/14/00	165
03/27/00	280
04/24/00	120
05/30/00	700
08/07/00	960
08/28/00	820
10/16/00	96
12/04/00	46
01/22/01	29
02/26/01	800
04/09/01	33
05/14/01	26
06/11/01	110
08/06/01	104
09/10/01	80
10/22/01	240
11/26/01	580
01/28/02	42
02/19/02	9
04/08/02	30
05/13/02	100
09/16/02	16
10/21/02	66
12/12/02	8
11/05/03	100
12/10/03	48
01/27/04	34
03/10/04	100
04/20/04	26
05/26/04	10000
06/23/04	170
08/04/04	110
09/14/04	100
11/15/04	660
12/02/04	1600

Table B-5. Available Fecal Coliform Data for Segment C 22

Date	Fecal Coliform (#/100mL)
1/18/1990	10
2/22/1990	150
4/5/1990	150
5/31/1990	150
6/26/1990	670
8/16/1990	10
9/20/1990	600
11/8/1990	700
12/18/1990	15000
1/31/1991	140
2/26/1991	200
4/11/1991	220
5/21/1991	70
6/20/1991	10
8/13/1991	100
9/17/1991	110
11/5/1991	440
12/10/1991	300
1/23/1992	10
2/20/1992	600
3/26/1992	300
5/12/1992	10
6/4/1992	300
8/11/1992	400
9/22/1992	1300
11/10/1992	100
12/17/1992	440
1/26/1993	300
2/23/1993	1000
3/30/1993	80
5/6/1993	860
9/23/1993	20000
11/4/1993	80
12/2/1993	4000
1/27/1994	780
3/8/1994	50
4/20/1994	120

Date	Fecal Coliform (#/100mL)
5/17/1994	400
6/21/1994	440
7/21/1994	840
8/30/1994	127
10/6/1994	240
12/29/1994	6100
1/12/1995	3700
2/23/1995	30
3/28/1995	30
5/31/1995	390
6/29/1995	1900
7/27/1995	875
9/21/1995	250
11/9/1995	14
12/7/1995	36
1/23/1996	1000
2/27/1996	26
4/4/1996	200
5/14/1996	260
6/11/1996	5900
7/23/1996	390
9/19/1996	5800
11/7/1996	340
12/10/1996	200
2/4/1997	3000
3/4/1997	200
4/15/1997	42
5/22/1997	52
6/12/1997	750
7/22/1997	19200
9/9/1997	530
10/21/1997	56
12/2/1997	38
1/27/1998	64
3/19/1998	1900
4/21/1998	270
6/2/1998	118

Date	Fecal Coliform (#/100mL)
7/14/1998	270
8/4/1998	9400
9/22/1998	310
11/10/1998	25
1/13/2000	10
2/15/2000	200
3/28/2000	10
4/25/2000	140
5/31/2000	600
8/8/2000	1000
8/29/2000	420
10/17/2000	118
12/5/2000	44
1/23/2001	11
2/27/2001	950
4/9/2001	32
5/14/2001	980
6/11/2001	115
8/6/2001	70
9/10/2001	72
10/22/2001	300
11/26/2001	290
1/28/2002	16
2/19/2002	28
4/8/2002	300
5/13/2002	450
8/6/2002	620
9/16/2002	40
10/21/2002	38
12/11/2002	12
11/5/2003	88
12/10/2003	150
1/27/2004	29
3/10/2004	130
4/21/2004	97
5/26/2004	29000
6/23/2004	220

Date	Fecal Coliform (#/100mL)
8/4/2004	160
9/13/2004	200
11/30/2004	3100

Table B-6. Available Fecal Coliform Data for Segment CD 01

Date	Fecal Coliform (#/100mL)
1/17/1990	135
3/1/1990	110
4/4/1990	320
6/25/1990	5900
7/10/1990	230
8/15/1990	9900
9/19/1990	2000
11/7/1990	240
12/17/1990	6600
1/30/1991	10
2/25/1991	210
4/10/1991	1200
5/20/1991	1060
6/19/1991	25
8/12/1991	5
9/16/1991	205
11/4/1991	760
12/9/1991	150
1/22/1992	35
2/19/1992	3000
3/25/1992	160
5/11/1992	100
6/3/1992	2800
8/10/1992	45
9/21/1992	1560
11/9/1992	165
12/16/1992	210
1/25/1993	2100
2/22/1993	860
3/29/1993	35
6/2/1993	120
9/22/1993	2800

Date	Fecal Coliform (#/100mL)
11/3/1993	400
12/1/1993	5400
1/26/1994	2300
3/7/1994	60
4/19/1994	5900
5/16/1994	1600
6/20/1994	1180
7/20/1994	7200
8/29/1994	4900
11/28/1994	13000
1/11/1995	5900
2/22/1995	20
3/27/1995	9800
5/30/1995	600
7/26/1995	4400
9/20/1995	440
11/8/1995	70
12/6/1995	40
1/22/1996	1000
2/26/1996	25
4/3/1996	700
5/28/1996	9400
6/10/1996	5600
7/22/1996	210
9/18/1996	9800
11/6/1996	96
12/9/1996	100
2/3/1997	0
3/3/1997	450
4/14/1997	350
5/21/1997	44
6/11/1997	200
7/21/1997	370
9/8/1997	72
10/20/1997	8
12/1/1997	24
1/26/1998	96

Date	Fecal Coliform (#/100mL)
3/18/1998	2000
4/20/1998	20
6/1/1998	158
7/13/1998	180
8/3/1998	130
9/21/1998	92
11/9/1998	6
1/12/2000	88
2/14/2000	3000
3/27/2000	130
4/24/2000	220
5/30/2000	180
8/7/2000	900
8/28/2000	2160
10/16/2000	42
12/4/2000	26
1/22/2001	9
2/26/2001	500
4/9/2001	102
5/14/2001	100
6/11/2001	48
8/6/2001	82
9/10/2001	44
10/22/2001	76
11/26/2001	870
1/28/2002	38
2/19/2002	40
4/9/2002	40
5/30/2002	93
8/1/2002	1000
9/16/2002	150
10/21/2002	62
12/10/2002	16
11/4/2003	61
12/9/2003	92
1/28/2004	39
3/9/2004	68

Date	Fecal Coliform (#/100mL)
4/20/2004	26
5/25/2004	240
6/22/2004	460
8/3/2004	300
9/14/2004	330
11/15/2004	700
12/13/2004	80

Table B-7. Available Manganese Data for Segment C 09

Date	Total Manganese (µg/L)
1/19/1999	260
3/8/1999	300
4/12/1999	330
5/17/1999	220
6/14/1999	560
8/30/1999	750
10/12/1999	740
11/15/1999	950
1/12/2000	200
2/14/2000	330
3/27/2000	330
4/24/2000	220
5/30/2000	210
8/7/2000	180
8/28/2000	70
10/16/2000	240
12/4/2000	220
1/22/2001	150
2/26/2001	390
4/9/2001	510
5/14/2001	760
6/11/2001	120
9/10/2001	400
10/22/2001	260
11/26/2001	380
1/28/2002	260
2/19/2002	260
4/8/2002	230

Date	Total Manganese (µg/L)
5/13/2002	110
6/17/2002	320
8/7/2002	720
9/16/2002	560
10/21/2002	370
12/12/2002	430
1/28/2003	750
3/19/2003	350
4/23/2003	430
5/28/2003	470
7/1/2003	760
8/13/2003	470
9/24/2003	440
11/5/2003	520
12/10/2003	290

Table B-8. Available Manganese Data for Segment C 33

Date	Total Manganese (µg/L)
8/18/1999	1100
1/12/2000	230
6/27/2002	280
8/12/2002	1000
12/12/2002	280
4/26/2006	350
5/1/2006	500
5/10/2006	410
5/24/2006	380
5/31/2006	370
6/7/2006	440
6/22/2006	760
7/5/2006	500
7/12/2006	540
7/20/2006	460

Table B-9. Available Manganese Data for Segment CD 01

Date	Total Manganese (µg/L)
1/17/1990	342
3/1/1990	480
4/4/1990	188
6/25/1990	467
7/10/1990	429
8/15/1990	576
9/19/1990	511
11/7/1990	1623
12/17/1990	535
1/30/1991	495
2/25/1991	285
4/10/1991	604
5/20/1991	810
6/19/1991	1100
8/12/1991	1694
9/16/1991	707
11/4/1991	382
12/9/1991	240
1/22/1992	330
2/19/1992	253
3/25/1992	280
5/11/1992	690
6/3/1992	1100
8/10/1992	1100
9/21/1992	590
11/9/1992	810
12/16/1992	390
1/25/1993	65
2/22/1993	180
3/29/1993	330
5/5/1993	190
6/2/1993	530
7/21/1993	75
9/22/1993	390
11/3/1993	490
12/1/1993	38
1/26/1994	190
3/7/1994	490

Date	Total Manganese (µg/L)
4/19/1994	300
5/16/1994	340
6/20/1994	1200
7/20/1994	560
8/29/1994	990
10/5/1994	740
11/28/1994	390
1/11/1995	480
2/22/1995	330
3/27/1995	440
5/30/1995	410
6/28/1995	280
7/26/1995	600
9/20/1995	1300
11/8/1995	1600
12/6/1995	490
1/22/1996	210
2/26/1996	730
4/3/1996	160
5/28/1996	1400
6/10/1996	82
7/22/1996	1700
9/18/1996	260
11/6/1996	880
12/9/1996	160
2/3/1997	15
3/3/1997	110
4/14/1997	320
5/21/1997	870
6/11/1997	370
7/21/1997	380
9/8/1997	440
10/20/1997	810
12/1/1997	610
1/26/1998	170
3/18/1998	470
4/20/1998	70
6/1/1998	560
7/13/1998	160

Date	Total Manganese (µg/L)
8/3/1998	180
9/21/1998	540
11/9/1998	100
12/7/1998	470
1/19/1999	89
3/9/1999	170
4/12/1999	250
5/17/1999	370
6/14/1999	280
8/30/1999	310
10/12/1999	940
11/15/1999	5600
2/14/2000	400
3/27/2000	410
4/24/2000	510
5/30/2000	550
8/7/2000	500
8/28/2000	160
10/16/2000	230
12/4/2000	180
1/22/2001	160
2/26/2001	190
4/9/2001	760
5/14/2001	1600
6/11/2001	310
9/10/2001	480
10/22/2001	140
11/26/2001	400
1/28/2002	310
2/19/2002	450
4/9/2002	490
5/30/2002	1300
6/18/2002	530
8/1/2002	740
9/16/2002	200
10/21/2002	150
12/10/2002	610
1/30/2003	910
3/19/2003	360

Date	Total Manganese (µg/L)
4/23/2003	420
5/28/2003	380
7/1/2003	510
8/12/2003	190
9/23/2003	120
11/4/2003	1100
12/9/2003	210

Table B-10. Available Manganese Data for Segment CJA 02

Date	Total Manganese (µg/L)
1/12/2000	2400
6/26/2002	180
8/5/2002	1500
12/11/2002	2100
9/7/2006	1300
11/8/2006	390

Appendix C : Fecal Coliform Data for NPDES Facilities

Table C-1. Fecal Coliform Counts from Fairfield STP

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0020605	002	5/31/2002	385	10	Yes
IL0020605	002	2/28/2003	280	0.248	No
IL0020605	002	1/31/2005	8900	11.83	No

Table C-2. Fecal Coliform Counts from Clay City WWTP

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0020974	002	5/31/1998	180	294	Yes
IL0020974	002	6/30/1998	220	0.454	Yes
IL0020974	002	7/31/1998	300	0.35	Yes
IL0020974	002	10/31/1998	200	0.329	Yes
IL0020974	002	1/31/1999	180	0.633	No
IL0020974	002	2/28/1999	200	0.591	No
IL0020974	002	3/31/1999	300	0.44	No
IL0020974	002	4/30/1999	80	0.44	No
IL0020974	002	6/30/1999	180	0.432	Yes
IL0020974	002	3/31/2000	220	0.328	No
IL0020974	002	4/30/2000	280	0.348	No
IL0020974	002	6/30/2000	360	0.333	Yes
IL0020974	002	7/31/2000	200	0.653	Yes
IL0020974	002	10/31/2000	220	0.22	Yes
IL0020974	002	11/30/2000	180	0.222	No
IL0020974	002	12/31/2000	120	0.17	No
IL0020974	002	1/31/2001	260	0.247	No
IL0020974	002	2/28/2001	280	0.24	No
IL0020974	002	3/31/2001	220	0.226	No
IL0020974	002	12/31/2001	120	0.286	No
IL0020974	002	2/28/2002	240	0.319	No
IL0020974	002	3/31/2002	220	0.357	No
IL0020974	002	4/30/2002	180	0.323	No
IL0020974	002	5/31/2002	240	0.417	Yes
IL0020974	002	1/31/2003	180	0.142	No
IL0020974	002	2/28/2003	240	0.205	No
IL0020974	002	3/31/2003	200	0.259	No
IL0020974	002	4/30/2003	140	0.211	No

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0020974	002	5/31/2003	180	0.337	Yes
IL0020974	002	11/30/2003	240	0.489	No
IL0020974	002	1/31/2004	200	0.528	No
IL0020974	002	6/30/2004	260	0.245	Yes
IL0020974	002	11/30/2004	360		No
IL0020974	002	12/31/2004	340		No
IL0020974	002	1/31/2005	400		No
IL0020974	002	2/28/2005	320		No
IL0020974	002	3/31/2006	400	120	No
IL0020974	002	1/31/2007	180	0.343	No
IL0020974	002	3/31/2007	200	120	No

Table C-3. Fecal Coliform Counts from Charleston STP

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0021644	A01	6/30/2000	620	40.2	Yes
IL0021644	A01	7/31/2000	20	30.3	Yes
IL0021644	A01	8/31/2000	100	16.9	Yes
IL0021644	A01	9/30/2000	1160	12.6	Yes
IL0021644	A01	10/31/2000	220	37.1	Yes
IL0021644	A01	2/28/2001	0	9.04	No
IL0021644	A01	3/31/2001	10	5.3	No
IL0021644	A01	10/31/2001	40	7.36	Yes
IL0021644	A01	12/31/2001	370	34.26	No
IL0021644	A01	2/28/2002	50	9.48	No
IL0021644	A01	3/31/2002	20	50.99	No
IL0021644	A01	4/30/2002	550	77.19	No
IL0021644	A01	5/31/2002	60	138.3	Yes
IL0021644	A01	5/31/2003	0	29.67	Yes
IL0021644	A01	11/30/2003	360	20.8	No
IL0021644	A01	12/31/2003	300	10.2	No
IL0021644	A01	1/31/2004	240	31.57	No
IL0021644	A01	3/31/2004	1750	52.4	No
IL0021644	A01	4/30/2004	1600	5.34	No
IL0021644	A01	11/30/2004	560	2.5	No
IL0021644	A01	12/31/2004	1060	20.93	No
IL0021644	A01	1/31/2005	140	128.5	No

IL0021644	A01	2/28/2005	40	35	No
IL0021644	A01	3/31/2006	150	13	No
IL0021644	A01	4/30/2006	110	13.04	No
IL0021644	A01	1/31/2007	100	27.5	No

Table C-4. Fecal Coliform Counts from Noble STP

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0025500	002	10/31/1998	200	2.2	Yes
IL0025500	002	11/30/1998	150	0.108	No
IL0025500	002	12/31/1998	200	0.108	No
IL0025500	002	1/31/1999	150	0.073	No
IL0025500	002	2/28/1999	200	0.078	No
IL0025500	002	3/31/1999	200	0.022	No
IL0025500	002	4/30/1999	200	0.032	No
IL0025500	002	5/31/1999	200	0.023	Yes
IL0025500	002	6/30/1999	200	0.012	Yes
IL0025500	002	7/31/1999	200	0.01	Yes
IL0025500	002	8/31/1999	150	0.009	Yes
IL0025500	002	9/30/1999	170	0.001	Yes
IL0025500	001	5/31/1998	200	0.12	Yes
IL0025500	001	6/30/1998	0	2.5	Yes
IL0025500	001	7/31/1998	0	1.9	Yes
IL0025500	001	8/31/1998	0	2.3	Yes
IL0025500	001	9/30/1998	200	1.7	Yes

Table C-5. Fecal Coliform Counts from Flora City Of-Charlie Brown Pk

Permit	Pipe	Date	Fecal Count (cfu/100 mL)	Flows (MGD)	Recreation Season
IL0047481	001	6/30/1999	0	0.0119	Yes
IL0047481	001	7/31/1999	0	0.0134	Yes
IL0047481	001	8/31/1999	0	0.0023	Yes
IL0047481	001	6/30/2000	0	0.006	Yes
IL0047481	001	7/31/2000	0	0.005	Yes
IL0047481	001	6/30/2001	0	0.005	Yes
IL0047481	001	7/31/2001	0	0.006	Yes
IL0047481	001	8/31/2001	0	0.019	Yes
IL0047481	001	6/30/2002	0	0.08	Yes
IL0047481	001	7/31/2002	0	0.007	Yes
IL0047481	001	8/31/2002	0	0.004	Yes
IL0047481	001	6/30/2003	0	0.017	Yes
IL0047481	001	7/31/2003	0	0.017	Yes
IL0047481	001	8/31/2003	0	0.014	Yes
IL0047481	001	6/30/2004	0	0.004	Yes
IL0047481	001	7/31/2004	0	0.006	Yes
IL0047481	001	8/31/2004	0	0.002	Yes
IL0047481	001	6/30/2005	0	0.015	Yes
IL0047481	001	7/31/2005	0	0.004	Yes
IL0047481	001	6/30/2006	0	0.007	Yes
IL0047481	001	7/31/2006	0	0.004	Yes
IL0047481	001	8/31/2006	0	0.003	Yes
IL0047481	001	6/30/2007	0	0.004	Yes
IL0047481	001	7/31/2007	0	0.003	Yes

Appendix D : QUAL2K Modeling

D.0 Dissolved Oxygen Model (QUAL2K)

The QUAL2K water quality model was selected to assess water quality conditions for the dissolved oxygen impaired streams in the Little Wabash River watershed. QUAL2K is supported by U.S. EPA and has been used extensively for TMDL development and point source permitting issues across the country, especially for issues related to dissolved oxygen concentrations. The QUAL2K model is suitable for simulating hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth, and dissolved oxygen dynamics. Ten QUAL2K models were set up for each impaired stream to address the low dissolved oxygen conditions. The impaired streams were Little Wabash River (two segments), Johnson Creek, Pond Creek, Elm River, Seminary Creek, Village Creek, Big Muddy Creek, Little Muddy Creek, and Big Muddy Diversion Ditch.

The impaired streams were segmented into a series of stream reaches in the QUAL2K model and the stream reaches were further divided into cells (or “elements”). Flow and mass balance calculations are performed within each cell for each time step that the user specifies. The specifications of reach and element lengths for each QUAL2K model were determined based on the hydrogeometry of the streams, tributary locations, point and nonpoint source locations, and the flow and water quality sampling points.

QUAL2K models require hourly weather data to simulate temperature and other biochemical reactions. The hourly weather data for air temperature, dew point temperature, wind speed, and cloud cover were retrieved from the National Climatic Data Center (NCDC) web site and the available weather data for the Effingham County Memorial Airport was selected for all of the QUAL2K models.

Each model required two different sets of calibrations: (1) flow and (2) water quality. To be conservative, the date of the calibration was set to match the date of the lowest observed dissolved oxygen data (and where sufficient data were available for calibration). If observed flow data from the impaired segments were available, they were used during the calibration. When the observed flow data were not available, USGS data from gage 03379500 were used to estimate flow rates at each calibration location. The estimated flows were derived using the area weighted estimation method.

Flows from NPDES facilities were incorporated using monthly averaged reported flow data during the flow calibration period. After the calibrations were completed, the baseline conditions for flows from NPDES facilities were set using each facility’s design averaged flow. After inputting flows for headwaters, tributaries, and point sources, flow was calibrated by either subtracting or adding nonpoint source flows. Table D-1 shows the flows used to set up the baseline conditions for the models.

Table D-1. Baseline conditions for NPDES flow discharges

Facility Name	Permit Number	Receiving Stream	Discharge point(km)*	Flow (m^3/s)
Charleston STP	IL0021644	Little Wabash R(C-33)	72.5	0.144
Cisne STP	ILG580197	Elm R(CD-01)	6	0.0035
Clay City WWTP	IL0020974	Little Wabash R(C-09)	135	0.005
Crossville STP	ILG580211	Little Wabash R(C-33)	48.1	0.0109
Dieterich STP	IL0044792	Big Muddy Creek(CJ-06)	55	0.0011
Fairfield STP	IL0020605	Johnson Creek(CCA-FF-A1)	4.52	0.0398
Fairfield WTP	ILG640137	Little Wabash R(C-33)	66	0.0012
Flora City Of-Charlie Brown Pk	IL0047481	Elm R(CD-04)	26	0.0001
Flora STP	IL0020273	Seminary Creek(CDG-FL-A1)	64.5	0.0438
Flora WTP	IL0074403	Elm R(CD-04)	26	0.0012
Jeffersonville STP	ILG580076	Elm R(CD-01)	6	0.0014
Mt. Erie WTP	ILG640143	Little Wabash R(C-33)	72.5	0.0002
Noble STP	IL0025500	Little Wabash R(C-09)	126.2	0.00438
Parkersburg STP	IL0071374	Little Wabash R(C-33)	97.5	0.0013

* The stream starting point is 0 km.

Each QUAL2K model was calibrated to the following observed parameters (pending availability of the observed data):

- temperature
- dissolved oxygen (daily average and diel)
- carbonaceous biochemical oxygen demand
- nitrate
- total ammonia
- inorganic phosphorus
- phytoplankton
- total phosphorus
- total Kjeldahl nitrogen

When available, the observed water quality boundary concentrations were used to input as inflow loadings to the impaired segments. Sensitivity analyses were then conducted to determine the input loadings of the parameters from nonpoint sources by adjusting the loads during the calibration period. The reaction rates for nutrients and related eutrophication process were selected within the range of the literature values (Brown and Barnwell, 1986). In addition to nutrients and floating algae, sediment oxygen demand (SOD) was also incorporated in the models. Also, when the observed continuous DO data showed severe DO deficient and strong diel DO pattern with relatively low observed nutrients and chlorophyll a data, the existence of stream bottom plants/algae were considered in the model.

After the water quality calibrations were completed, the baseline for parameters concentrations from NPDES facilities were selected from either daily averaged or monthly averaged concentrations, depending on the permit. Table D-2 shows the baseline concentrations for NPDES facilities included in the models.

Table D-2. Base line conditions for NPDES water quality concentrations

Facility Name	Permit Number	Receiving Stream	Discharging point(km)*	CBOD5 (mg/L)	Total Ammonia (µg/L)
Charleston STP	IL0021644	Little Wabash R(C-33)	72.5	20	3000
Cisne STP	ILG580197	Elm R(CD-01)	6	25	-
Clay City WWTP	IL0020974	Little Wabash R(C-09)	135	25	-
Crossville STP	ILG580211	Little Wabash R(C-33)	48.1	52	-
Dieterich STP	IL0044792	Big Muddy Creek(CJ-06)	55	25	-
Fairfield STP	IL0020605	Johnson Creek(CCA-FF-A1)	4.52	20	3000
Fairfield WTP	ILG640137	Little Wabash R(C-33)	66	-	-
Flora City Of-Charlie Brown Pk	IL0047481	Elm R(CD-04)	26	20	3000
Flora STP	IL0020273	Seminary Creek(CDG-FL-A1)	64.5	20	6200
Flora WTP	IL0074403	Elm R(CD-04)	26	-	-
Jeffersonville STP	ILG580076	Elm R(CD-01)	6	25	-
Mt. Erie WTP	ILG640143	Little Wabash R(C-33)	72.5	-	-
Noble STP	IL0025500	Little Wabash R(C-09)	126.2	25	-
Parkersburg STP	IL0071374	Little Wabash R(C-33)	97.5	25	-

* The stream starting point is 0 km.

The following figures show the model calibration results. The X-axis in these figures represents the river mile location and the Y-axis represents the concentration of the water quality parameter being simulated. Units are typically mg/L. The figures illustrate the ability of the model to simulate historically observed water quality data within each stream. Simulated concentrations that are nearer to observed concentrations indicate better performance of the model; simulated concentrations that are farther away from observed concentrations indicate poorer performance of the model.

References

Brown and Barnwell. 1987. The Enhanced Stream Water Quality Models QUAL2E and Qual2E-UNCAS: Documentation and user manual, Linfield C. Brown and Thomas O. Barnwell, Jr. Department of Civil Engineering Tufts University, MA, 1987

Appendix E : BATHTUB Model

E.0 Estimating Existing Loads and Flows to the Little Wabash River Watershed Lakes

The ACOE BATHTUB model (Walker, 1987) was set up to simulate nutrient concentrations in Newton Lake using the second order nutrient response model. In a separate application, the model was altered to simulate manganese concentrations in Fairfield Reservoir using the fixed sedimentation option.

E.1 Fairfield Reservoir Watershed Loading

Annual flow rates to the Fairfield Reservoir were estimated by area weighting flows observed at USGS gage 03379500 on the Little Wabash River below Clay City, Il. The Fairfield Reservoir drainage area is approximately 7.5 square miles and the drainage area to the Little Wabash River gage is 1,131 square miles. Daily average flow rates at the gage were scaled down by 7.5/1,131 to estimate daily flows to the lake.

E.1.1 Fairfield Reservoir Sedimentation and Internal Loading

The USACOE BATHTUB model (Walker, 1987) was altered to simulate manganese concentrations in Fairfield Reservoir using the fixed sedimentation option. For a conservative estimate, and because concentrations near the lake bottom were actually less than those near the surface, the sedimentation rate was set to zero. The model was then used to back calculate the loads required to simulate the observed concentrations. The resulting load is equivalent to the external watershed load plus the net load resulting from sedimentation and release from bottom sediments. Sufficient data to estimate the internal load separately are not currently available.

E.1.2 Summary of Fairfield Reservoir Inlake Water Quality Data

Typically, watershed loads are input to the model and average inlake concentration is output. For Fairfield Reservoir, watershed and tributary data are not available to estimate loads to the lake, but a limited number of inlake observations of total manganese concentration have been collected across four months in 2000 at one sampling location (RCZJ-1). Tetra Tech developed a “reverse” BATHTUB model where average inlake concentrations were used to estimate the load required given annual flow volume and lake bathymetry data. No adjustment of the calibration factor was needed with this simulation because the loads were set by year to match average observed concentrations. Table E-1 summarizes the total manganese data by year.

Table E-1. Total Manganese Observations in Fairfield Reservoir (µg/L)

Year	Minimum	Average	Maximum
2000	58	208	290

The total manganese loads required to simulate the observed concentrations with the BATHTUB model are listed in Table E-2.

Table E-2. Annual Flows and Estimated Total Manganese Loads to Fairfield Reservoir

Year	Flow (MG)	Manganese Load (lb)
2000	2,109	3,660

E.1.3 Fairfield Reservoir BATHTUB Modeling Results

Once the existing manganese loads were determined for Fairfield Reservoir, an iterative process was used to determine the load reductions required to meet the water quality standard for this lake. Reducing loads by 28 percent will likely meet the water quality target.

E.2 Newton Lake Watershed Loading

Annual flow rates to Newton Lake were estimated by area weighting flows observed at USGS gage 03379500 on the Little Wabash River below Clay City, Il. The Newton Lake drainage area is approximately 43 square miles and the drainage area to the Little Wabash River gage is 1,131 square miles. Daily average flow rates at the gage were scaled down by 43/1,131 to estimate daily flows to the lake.

A major NPDES permitted facility, the Ameren Energy Generating Company, discharges directly to Newton Lake. Flows from this facility were also included in the estimates of daily flow to the lake. The main discharge is for condenser cooling water and is assumed to have a net zero effect on the lake volume as water is withdrawn and then discharged back to the lake. The cumulative design flows of the other outfalls result in a total daily discharge of 9.311 MGD to Newton Lake. This value was added to the estimated daily flows to the lake to account for the additional discharges.

E.2.1 Newton Lake Internal Loading

The ACOE BATHTUB model (Walker, 1987) was set up to simulate nutrient concentrations in Newton Lake using the second order nutrient response model. Internal phosphorus loading is accounted for in BATHTUB by application of a net phosphorus sedimentation rate (settling minus resuspension). For lakes with both tributary and inlake monitoring data, the Nürnberg method (1984) is often used to approximate the internal load based on mean depth, flushing rate, average inflow, and average outflow concentrations. For Newton Lake, no tributary measurements are available for computation of the internal load.

E.2.2 Summary of Newton Lake Inlake Water Quality Data

Typically, watershed loads are input to the model and average inlake concentration is output. For Newton Lake, watershed and tributary data are not available to estimate loads to the lake, but a limited number of inlake observations of total phosphorus concentration have been collected since 1992 at three stations. Tetra Tech developed a “reverse” BATHTUB model where average inlake concentrations were used to estimate the load required given annual flow volume and lake bathymetry data. The second order response model (default) was used to simulate phosphorus sedimentation and resuspension. No adjustment of the phosphorus calibration factor was needed with this simulation because the loads were set by year to match average observed concentrations. Table E-3 summarizes the total phosphorus data by year.

Table E-3. Total Annual Phosphorus Observations in Newton Lake (mg/L)

Year	Minimum	Average	Maximum
1992	0.029	0.049	0.095
1995	0.042	0.075	0.238
1998	0.040	0.085	0.317

The total phosphorus loads required to simulate the observed concentrations with the BATHTUB model are listed in Table E-2. An annual simulation was required for this lake to meet the turnover ratio criteria for the model.

Table E-4. Annual Flows and Estimated Total Phosphorus Loads to Newton Lake

Year	Flow (MG)	Phosphorus Load (lb)
1992	8,764	12,236
1995	12,236	34,546
1998	16,525	53,947

E.2.3 Newton Lake BATHTUB Modeling Results

Once the loads were determined for each modeling year, the BATHTUB model was used to determine the reduction in loading required to meet the phosphorus water quality standard. A reduction of 61 percent results in simulated concentrations below the target in each modeling year.

Appendix F : Stage 1 Report

Appendix G : Stage 2 Report

Appendix H : Responsiveness Summary

Little Wabash River II Watershed TMDL Implementation Plan

FINAL REPORT

November 12, 2007

Submitted to:
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
Springfield, IL 62702

Submitted by:
Tetra Tech, Inc.
Water Resources TMDL Center

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KEY FINDINGS

The results of the TMDL study for the Little Wabash River II indicate that significant reductions of fecal coliform, atrazine, and manganese are needed to attain water quality standards throughout the drainage area. In addition, reductions of phosphorus loads to Newton Lake are required to bring this waterbody into compliance.

The largest potential sources of pollutant loading in the watershed are agricultural practices. Manure from animal operations can contribute nutrients, pathogens, and biodegradable organic material. In addition, animals with access to stream channels can deposit fecal material directly into or near the stream and erode the banks as they climb in and out. This erosion leads to increased loads of sediment and manganese, a metal common in soils. The BMPs most likely to control loading from animal operations are 1) proper handling, storage, and final disposal practices for manure, 2) vegetative controls such as grassed waterways, filter strips, and constructed wetlands, 3) manure composting, and 4) restoration of riparian buffers.

Crop production in the watershed results in loadings of nutrients, sediment, manganese, and pesticides to the watershed. Application of fertilizers and pesticides contributes phosphorus and atrazine to the waterbodies when rain events wash pollutants into nearby streams or through underlying tile drain systems. Increased rates of erosion result in excessive sediment and manganese loads. The most cost-effective management strategy that addresses all pollutants of concern is conservation tillage. Other effective practices include grass waterways, filter strips, fertilizer and pesticide management, and restoration of riparian buffers.

Pollutant loads from point sources in the watershed may be significant, but the actual loads are difficult to estimate because several of the facilities are not required to monitor for the TMDL pollutants. Given that most of these facilities provide at least a secondary level of wastewater treatment, it is not likely that IEPA will require them to upgrade their plants to reduce nutrient or organic loading. However, the State may request that facilities submit fecal coliform data to verify that water quality standards are being met at the point the effluent meets a non-exempt reach. .

The number of onsite wastewater treatment systems in the watershed is relatively sparse and loading from this source is likely not significant relative to the other sources. However, failing onsite systems may cause localized water quality impacts as well as risks to human health. Identifying these systems through a routine inspection program and encouraging proper maintenance and upkeep will minimize these impacts.

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1.0 INTRODUCTION

The Clean Water Act and USEPA regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters identified as impaired on the Section 303(d) lists. Several waterbodies in the Little Wabash River II watershed are listed on Illinois' 2006 303(d) list as described in Table 1-1 and shown in Figure 1-1.

Table 1-1. 2006 303(d) List Information for the Little Wabash River II Watershed.

Waterbody Name	Waterbody Segment	Segment or Lake Size	Cause of Impairment	Impaired Designated Use
Little Wabash River	C 09	21.83 mi	Atrazine	Public Water Supplies
			Dissolved Oxygen	Aquatic Life
			Total Fecal Coliform	Primary Contact Recreation
			Manganese	Public Water Supplies
			pH	Aquatic Life
			Total Phosphorus	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Silver	Aquatic Life
			Total Suspended Solids	Aquatic Life
Little Wabash River	C 22	21.4 mi	Total Fecal Coliform	Primary Contact Recreation
Village Creek	CE-01	12.3 mi	Dissolved Oxygen	Aquatic Life
			Manganese	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Little Wabash River	C 33	43.41 mi	Atrazine	Public Water Supplies
			Dissolved Oxygen	Aquatic Life
			Manganese	Public Water Supplies
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Johnson Creek	CCA-FF-A1	1.87 mi	Dissolved Oxygen	Aquatic Life
Pond Creek	CC-FF-D1	4.53 mi	Dissolved Oxygen	Aquatic Life
Fairfield Reservoir	RCZJ	16 ac	Manganese	Public Water Supplies
			Impairment Unknown	Aesthetic Quality

Table 1-1. (Continued) 2006 303(d) List Information for Little Wabash River II Watershed.

Waterbody Name	Waterbody Segment	Segment or Lake Size	Cause of Impairment	Impaired Designated Use
Elm River	CD 01	8.53 mi	Atrazine	Aquatic Life
			Dissolved Oxygen	Aquatic Life
			Total Fecal Coliform	Primary Contact Recreation
			Manganese	Aquatic Life
			pH	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Elm River	CD 04	35.43 mi	Dissolved Oxygen	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Seminary Creek	CDG-FL-A1	1.47 mi	Dissolved Oxygen	Aquatic Life
			Total Phosphorus	Aquatic Life
Seminary Creek	CDG-FL-C6	1.99 mi	Dissolved Oxygen	Aquatic Life
			Total Phosphorus	Aquatic Life
Big Muddy Creek	CJ-06	26.62 mi	Dissolved Oxygen	Aquatic Life
			Manganese	Aquatic Life
			Total Phosphorus	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Total Suspended Solids	Aquatic Life
Little Muddy Creek	CJA 02	30.57 mi	Manganese	Aquatic Life
			Dissolved Oxygen	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
Big Muddy Diversion Ditch	CJAE-01	8.72 mi	Dissolved Oxygen	Aquatic Life
Newton Lake	RCR	1,750 ac	Total Phosphorus	Aesthetic Quality
			Total Suspended Solids	Aesthetic Quality

Figure 1-1. 303(d) Listed Reaches in the Little Wabash River II Watershed.

IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing waterbodies in the Little Wabash River II watershed, total phosphorus, dissolved oxygen, manganese, atrazine, and fecal coliform have numeric water quality standards. IEPA believes that addressing these impairments should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth and some of the management measures taken to reduce phosphorus loads (e.g., reducing agricultural erosion) should also reduce loads of suspended solids.

This project is being initiated in three stages. Stage One was completed in June 2006 and involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches. Stage Two involved additional data collection and was completed in March 2007. Stage Three involves modeling and TMDL analyses and the preparation of this implementation plan outlining how the TMDL reductions will be achieved.

The TMDLs for the waterbodies in the Little Wabash River II watershed were developed using load duration equations and the QUAL2K and BATHTUB models. Due to the number of listed segments in the watershed, this report does not summarize the results of the TMDL process. Readers interested in the details of each TMDL may refer to the corresponding Stage Three report.

2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

The purpose of this section of the report is to provide a brief background of the Little Wabash River II watershed. More detailed information on the soils, topography, land use/land cover, climate, and population are available in the Stage One Watershed Characterization Report.

Soils in the watershed are primarily IL038 (Bluford-Ava-Hickory), IL006 (Cisne-Hoyleton-Darmstadt), and IL069 (Bonnie-Belknap-Piopolis) (Figure 2-1). Soil erodibility factors reported for these soils in the STATSGO database range from 0.26 to 0.42, indicating moderate soil erodibility. Soils identified by STATSGO as highly erodible generally have slopes greater than 5 percent and represent only 9 percent of the total watershed area (Figure 2-2). Most of the highly erodible soils are currently on lands used for crop production or pasture.

The depths to the water table reported in the STATSGO database for soils in the Little Wabash River II watershed range from 0.3 feet to 5.9 feet. Tile drainage systems are usually placed 3 to 4 feet below the soil surface to lower the depth. The use of tile drains may be common in the watershed.

Land use/land cover in the watershed is largely crop production (61 percent) based on satellite imagery collected around 2001 (INHS, 2003) (Figure 2-3). Additional land use/land cover includes pasture/hay (11.5 percent), forest (16.6 percent), urban areas (8 percent), and wetlands (1.3 percent).

The northern half of the watershed discussed in this implementation plan is part of the Upper Little Wabash River Ecosystem Partnership (Figure 2-4). This partnership includes headwaters of the Little Wabash River as well as the Skillet Fork and Fox River watersheds. In 2007, the partnership developed a strategic watershed plan with the following goals: improve stream quality; improve water quality; increase the area of wetlands, forest, high quality pasture, and grasslands; protect groundwater; improve livestock operations; address point sources; and increase species richness (ULWREP, 2007). For the watershed addressed in this plan, most of the area that is contained in the partnership has been prioritized for addressing all of these goals comprehensively. A copy of the plan is included in Appendix A and the link to the partnership website is listed below.

http://www.littlewabash.com/index.htm

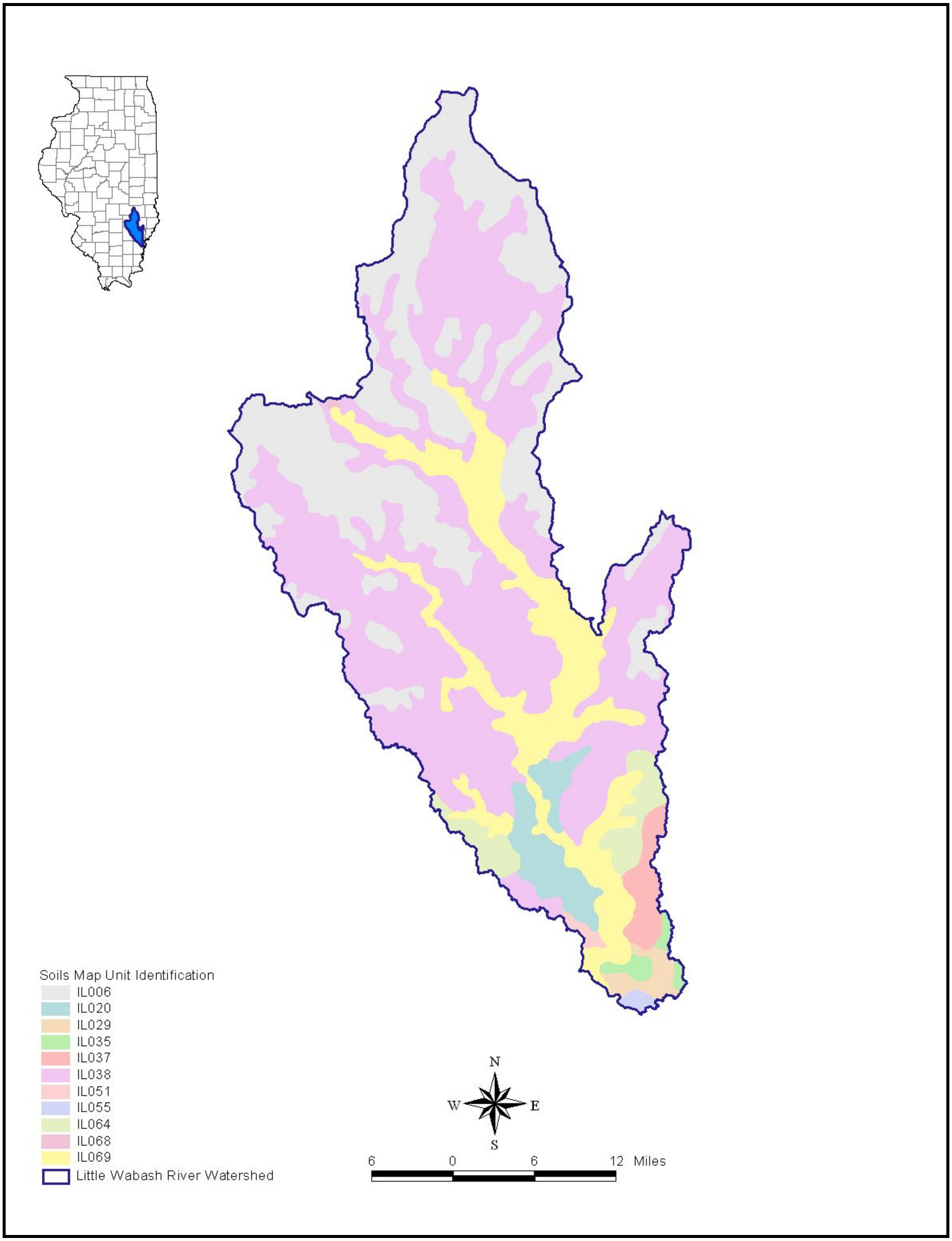

Figure 2-1. Soil Types in the Little Wabash River II Watershed.

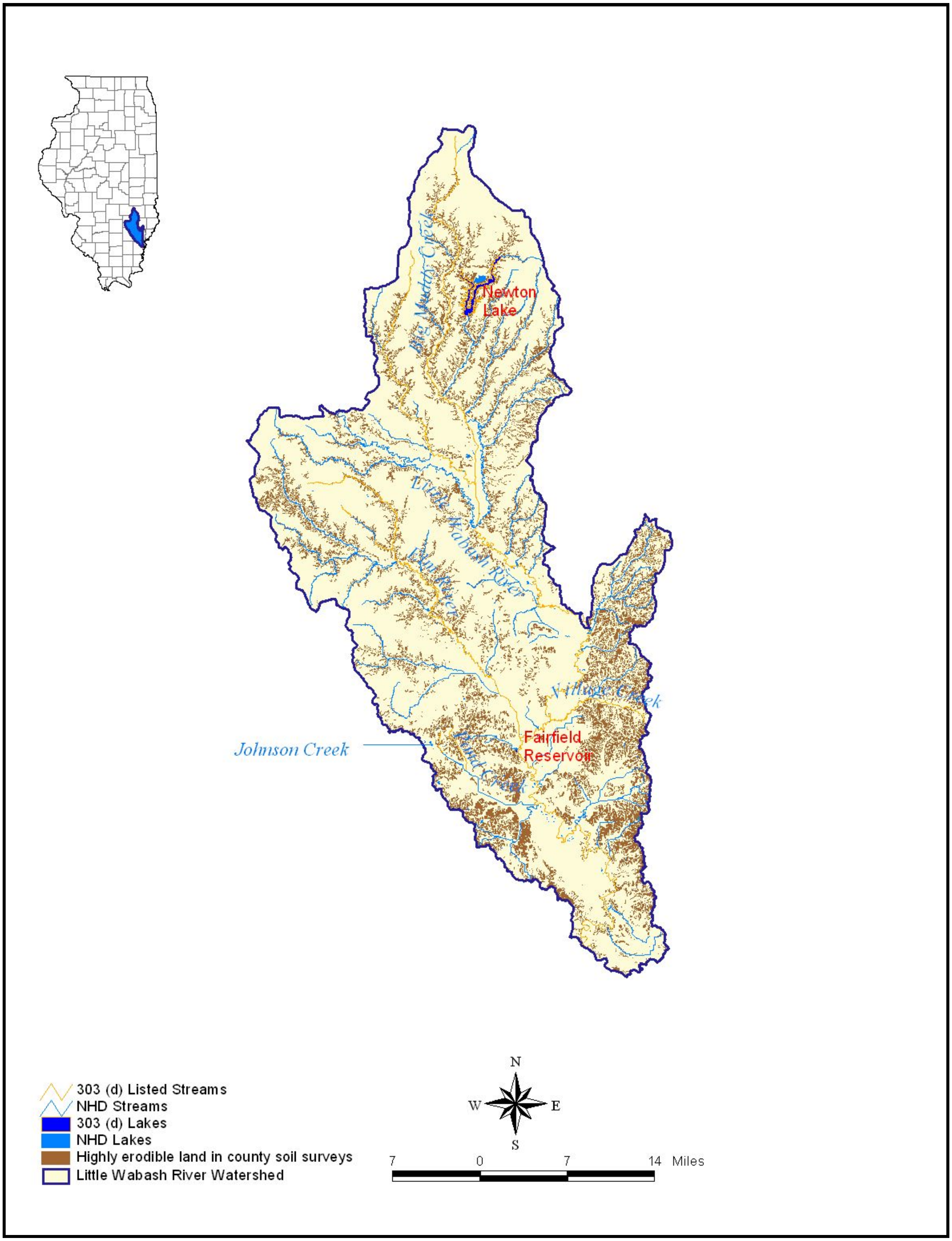

Figure 2-2. Highly Erodible Soils in the Little Wabash River II Watershed.

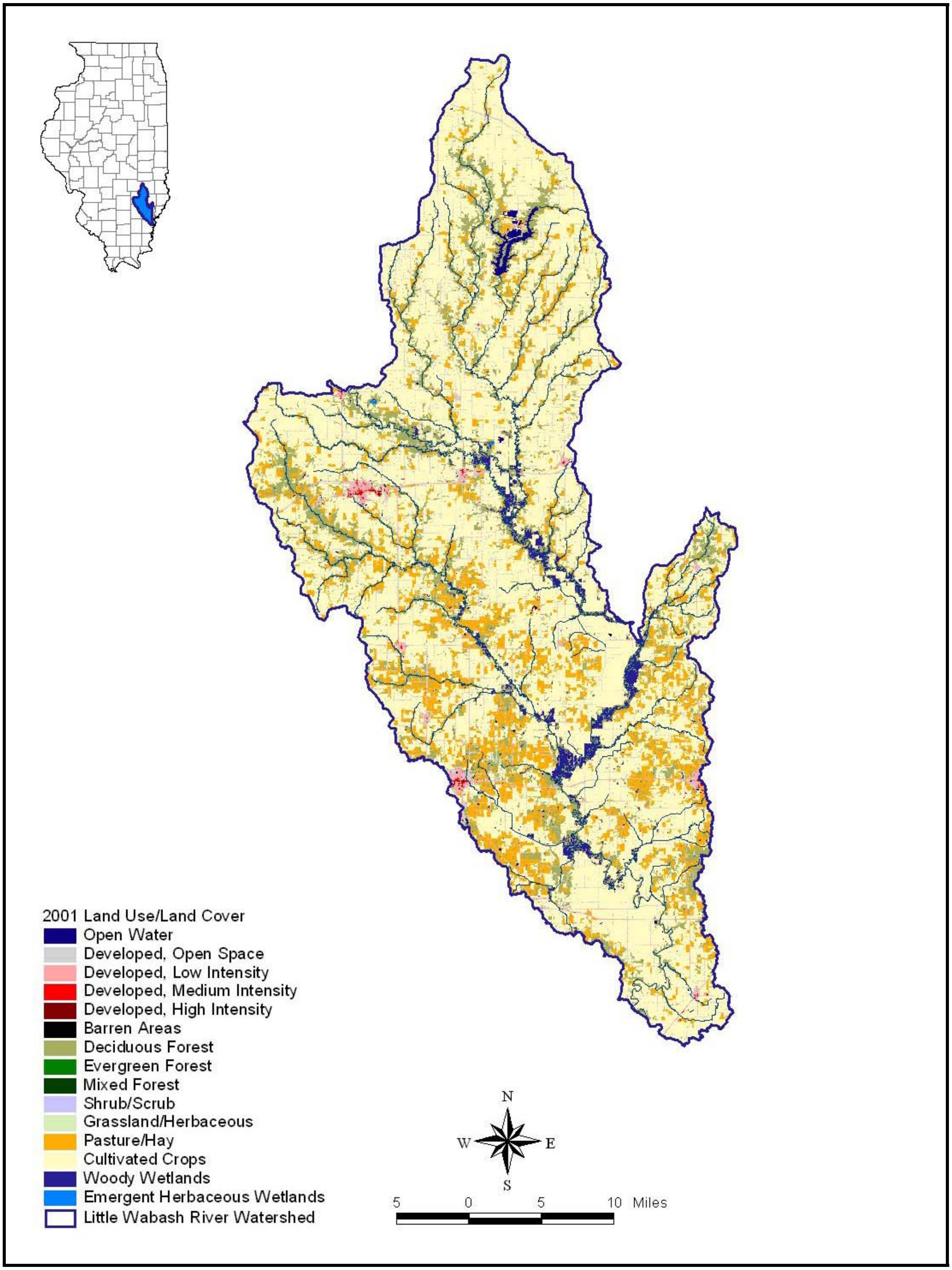

Figure 2-3. Land Use/Land Cover in the Little Wabash River II Watershed (Year 2001 NLCD Data).

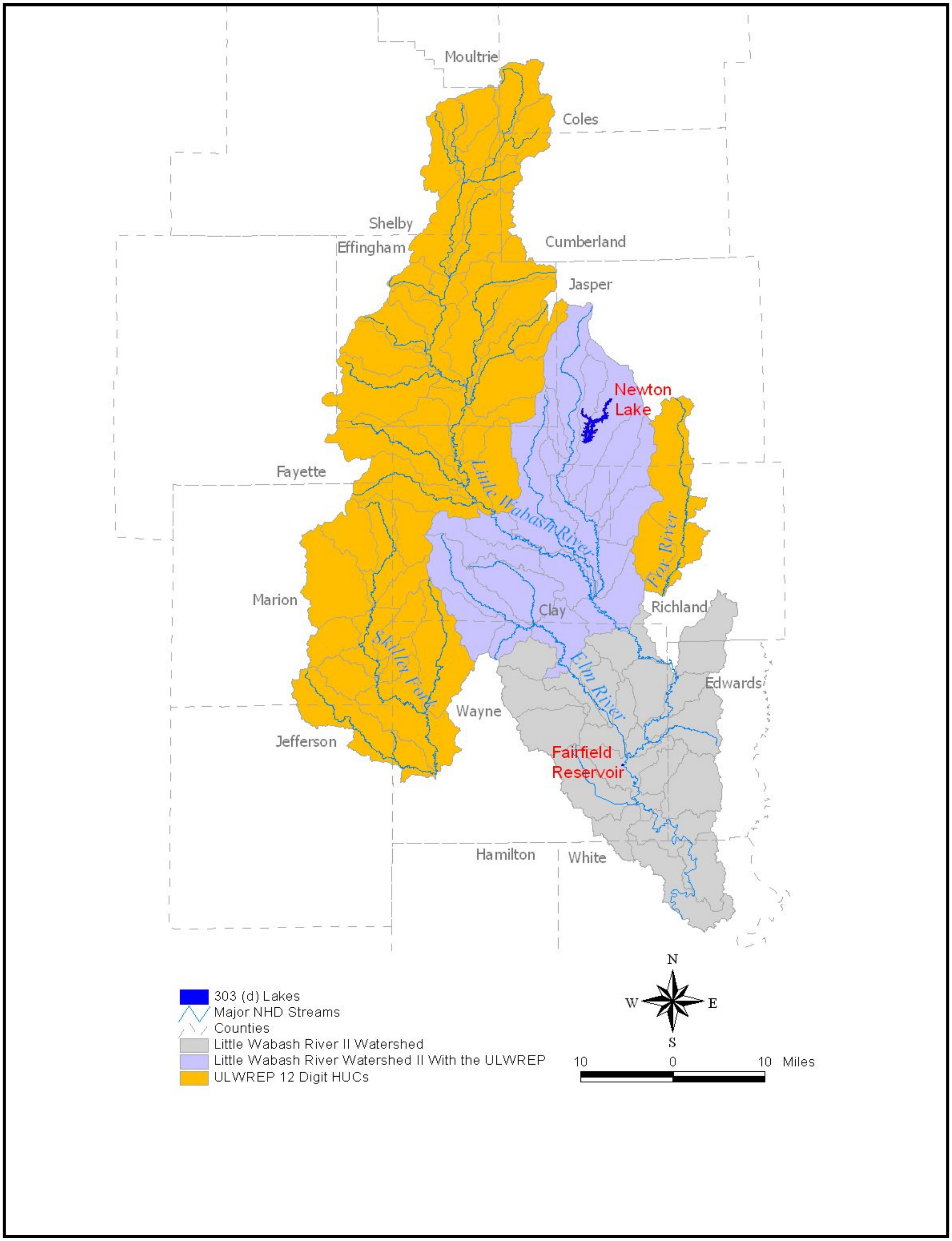

Figure 2-4. Portion of the Little Wabash River II Watershed Contained in the ULWREP.

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3.0 WATER QUALITY DATA, IMPAIRMENTS, AND TMDL ALLOCATIONS

Waters in the Little Wabash River II watershed are currently listed for several impairments. Those that carry numeric water quality standards (total phosphorus, dissolved oxygen, manganese, atrazine, and fecal coliform) are addressed in this implementation plan. This section presents the applicable water quality standards for each parameter and a summary of the listed reaches and TMDL allocations in the watershed. More detailed discussions of the available water quality data and TMDL development are presented in the Stage One Watershed Characterization Report and Stage Three TMDL Development Report, respectively. For the purposes of this report, which is targeted for stakeholders in the watershed, loads for mass-based pollutants are expressed in pounds per day or pounds per year. The TMDL report expressed loads in kilograms because the simulation models run and generate output in metric units.

To assess the designated use support for Illinois waterbodies, the IEPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB). The following are the use support designations applicable in the Little Wabash River II watershed:

General Use Standards - These standards protect for aquatic life, wildlife, agricultural use, primary contact recreation (where physical configuration of the waterbody permits it), secondary contact recreation, and most industrial uses. Primary contact recreation includes any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing. Secondary contact recreation includes any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

Public and Food Processing Water Supply Standards – These standards are cumulative with the general use standards and apply to waters of the state at any point at which water is withdrawn for treatment and distribution as a potable supply to the public or for food processing.

3.1 Total Phosphorus

3.1.1 Water Quality Standards

The numeric water quality standard for total phosphorus requires that concentrations at one foot from the water surface remain at or below 0.05 mg/L in lakes with a surface area of at least 20 ac. The standard also applies to streams at the point that they enter a lake or reservoir.

3.1.2 Impairments in the Little Wabash River II Watershed

Newton Lake is currently the only waterbody in the Little Wabash River II watershed in violation of the numeric phosphorus standard. Table 3-1 summarizes the total phosphorus data collected in Newton Lake; Figure 3-1 shows the location of Newton Lake in the watershed.

Table 3-1. Summary of Total Phosphorus Data Collected in Newton Lake.

Waterbody Name (Segment ID)	Number of Samples	Average TP (mg/L)	Exceedance (percent)
Newton Lake (RCR)	47	0.070	62

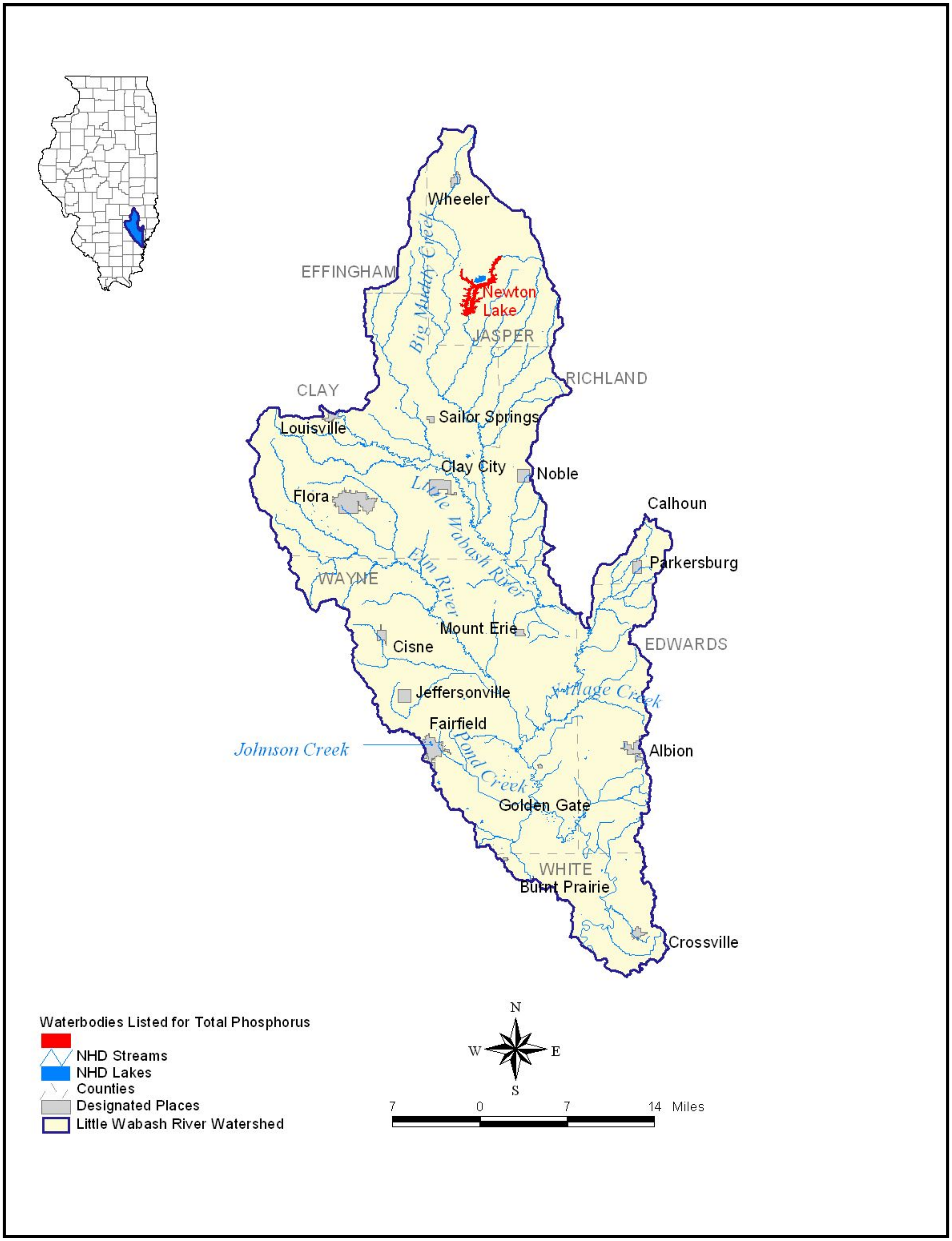


Figure 3-1. Waterbodies Listed for Phosphorus Impairment in the Little Wabash River II Watershed.

3.1.3 TMDL Allocations

The phosphorus TMDL for Newton Lake requires reductions in phosphorus loading of 61 percent. The allocations are summarized in Table 3-2.

Table 3-2. Phosphorus TMDL Allocations for Newton Lake

Lake	Category	Phosphorus (lb/yr)	Phosphorus (lb/d)
Newton Lake	Existing Load	33,580	92.0
	Loading Capacity	13,096	35.9
	Wasteload Allocation	195	0.5
	Margin of Safety	655	1.8
	Load Allocation	12,246	33.6

3.2 Dissolved Oxygen

3.2.1 Water Quality Standards

The numeric water quality standard for dissolved oxygen requires that concentrations in streams remain above 5 mg/L at all times and above 6 mg/L for at least 16 hours per day.

3.2.2 Impairments in the Little Wabash River II Watershed

Nine waterbodies in the Little Wabash River II watershed are listed for dissolved oxygen. Table 3-3 summarizes the dissolved oxygen data collected in these impaired reaches. Though the single samples collected on Village Creek and the Big Muddy Diversion Ditch do not violate the standard, these samples do indicate oversaturated conditions due to algal photosynthesis. It is likely that during the early morning hours when algae respire and consume oxygen, dissolved oxygen concentrations drop below the water quality standard. As shown in Figure 3-2, the impaired segments are located throughout the watershed.

Table 3-3. Summary of Dissolved Oxygen Data Collected in the Listed Reaches of the Little Wabash River II Watershed.

Waterbody Name (Segment ID)	Number of Samples	Minimum DO (mg/L)	Average DO (mg/L)	Maximum DO (mg/L)	Exceedance (percent)
Little Wabash River (C 09)	43	3.2	7.3	11.4	16
Little Wabash River (C 33)	5	2.1	5.5	9.6	60
Village Creek (CE 01)	1	12.8	12.8	12.8	0
Johnson Creek (CCA FF A1)	1	4.2	4.2	4.2	100
Pond Creek (CC FF D1)	1	3.9	3.9	3.9	100
Elm River (CD 01)	123	1.1	7.1	14.5	26
Elm River (CD 04)	3	3	4.6	6.5	67
Seminary Creek (CDG FL A1)	1	4.5	4.5	4.5	100
Seminary Creek (CDG FL C6)	1	3.8	3.8	3.8	100
Big Muddy Creek (CJ 06)	3	1.2	5.1	8.5	33
Little Muddy Creek (CJA 02)	4	2.6	4.6	6.5	75
Big Muddy Diversion Ditch (CJAE 01)	1	15.1	15.1	15.1	0

Figure 3-2. Waterbodies Listed for Dissolved Oxygen Impairment in the Little Wabash River II Watershed.

3.2.3 TMDL Allocations

No loading allocations were defined for the dissolved oxygen impairments in the Little Wabash River II watershed. QUAL2K modeling of each impaired reach determined that load reductions of degradable material from point and nonpoint sources would not achieve the water quality targets. The strategy for improving dissolved oxygen conditions in these waterbodies will combine pollutant load reduction, stream protection measures, and increased canopy cover. In some cases, stream restoration to improve reaeration may be needed.

3.3 Manganese

3.3.1 Water Quality Standards

The general use water quality standard for manganese is 1,000 µg/L, and the public and food processing water supply standard is 150 µg/L.

3.3.2 Impairments in the Little Wabash River II Watershed

Two waterbodies designated general use and three designated for public water supply are impaired for manganese. Table 3-4 summarizes the manganese data collected in the impaired segments. Figure 3-3 shows the location of the lake and streams in the watershed listed for manganese.

Table 3-4. Summary of Manganese (Mn) Data Collected in the Listed Reaches of the Little Wabash River II Watershed.

Waterbody Name (Segment ID)	Number of Samples	Minimum Mn (µg/L)	Average Mn (µg/L)	Maximum Mn (µg/L)	Exceedance (percent)
Data for Waterbodies Designated Public and Food Processing Supply Use					
Little Wabash River (C 09)	43	70	391	950	91
Little Wabash River (C 33)	15	230	507	1,100	100
Fairfield Reservoir (RCZJ)	6	58	208	290	67
Data for Waterbodies Designated General Use					
Elm River (CD 01)	123	15	542	5,600	11
Little Muddy Creek (CJA 02)	6	180	1,312	2,400	67

Figure 3-3. Waterbodies Listed for Manganese Impairment in the Little Wabash River II Watershed.

3.3.3 TMDL Allocations

TMDLs were developed differently for the flowing reaches in the watershed and the lake. For the streams and rivers, the load duration approach was used, and allocations for manganese were calculated for five flow regimes. The allocations for each reach and flow percentile are summarized in Table 3-5. For Fairfield Reservoir, allocations are based on an annual BATHTUB simulation and are not broken out by flow regime (Table 3-6). Values presented in the tables are given in pounds per day (lb/d) with the exception of the TMDL reductions which are given as percentages.

Table 3-5. Manganese TMDL Allocations for Waterbodies in the Little Wabash River II Watershed.

Manganese TMDLs (lb/d)		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Segment	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Little Wabash River (C 09)	Current Load	18,174.1	5,225.3	633.6	324.5	46.5
	TMDL= LA+WLA+MOS	4,902.4	676.2	183.6	20.5	8.8
	LA	4,412.1	608.7	165.1	18.5	7.9
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	490.3	67.7	18.3	2.0	0.9
	TMDL Reduction	76%	88%	74%	94%	83%
Little Wabash River (C 33)	Current Load	No Data	1,699.7	892.9	366.0	22.0
	TMDL= LA+WLA+MOS	7,839.6	910.5	198.4	35.3	11.0
	LA	7,054.7	820.1	178.6	30.9	11.0
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	784.8	90.4	19.8	4.4	2.2
	TMDL Reduction	No Data	52%	80%	92%	52%
Elm River (CD 01)	Current Load	8,747.9	1,384.0	305.6	137.8	15.7
	TMDL= LA+WLA+MOS	907.6	95.2	33.3	6.4	1.5
	LA	816.8	85.5	30.0	5.7	1.3
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	90.8	9.5	3.3	0.7	0.2
	TMDL Reduction	91%	94%	90%	96%	91%
Little Muddy Creek (CJA 02)	Current Load	No Data	37.5	13.5	14.4	5.8
	TMDL= LA+WLA+MOS	268.9	31.2	5.2	0.9	0.4
	LA	242.0	28.1	4.7	0.8	0.4
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	26.9	3.1	0.5	0.1	0.0
	TMDL Reduction	No Data	25%	65%	94%	94%

For the lake, a reverse BATHTUB model was used to estimate the required reductions based on samples of manganese collected in the water column. A reduction in loading of 28 percent is required to maintain the water quality standard.

Table 3-6. Manganese TMDL Allocations for Fairfield Reservoir.

Lake	Category	Manganese (lb/yr)	Manganese (lb/d)
Fairfield Reservoir	Existing Load	3,660	10.0
	Loading Capacity	2,635	7.2
	Wasteload Allocation	0	0.0
	Margin of Safety	132	0.4
	Load Allocation	2,503	6.9

3.4 Atrazine

3.4.1 Water Quality Standards

The acute water quality standard for atrazine in waters designated general use is 82 µg/L. The chronic standard in waters designated general use is 9 µg/L (evaluated as the average of at least three samples collected in the spring, summer, and fall). However, IEPA is currently requiring TMDLs be developed for all general use waters with any individual measurements greater than 9 µg/L as a proactive measure. For waters designated as public water supply, the running annual average must not exceed 3 µg/L and the instantaneous concentrations should not exceed 9 µg/L.

3.4.2 Impairments in the Little Wabash River II Watershed

Three segments in the watershed are listed for violation of the atrazine standards. Table 3-7 summarizes the atrazine data collected in the impaired waterbodies. Each segment has individual measurements that exceed 9 µg/L, and the public water supply segments of the Little Wabash River II exceeded the running average criteria of 3 µg/L in all sample years. Figure 3-4 shows the location of the segments listed for atrazine in the watershed.

Table 3-7. Summary of Atrazine Data Collected in the Listed Reaches of the Little Wabash River II Watershed.

Waterbody Name (Segment ID)	Number of Samples	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	Exceedance (percent)
Data for Waterbodies Designated Public and Food Processing Supply Use					
Little Wabash River (C 09)	18	0.27	4.39	24	17
Little Wabash River (C 33)	16	0.5	4.12	19	12
Data for Waterbodies Designated General Use					
Elm River (CD 01)	19	0.1	5.05	26	16

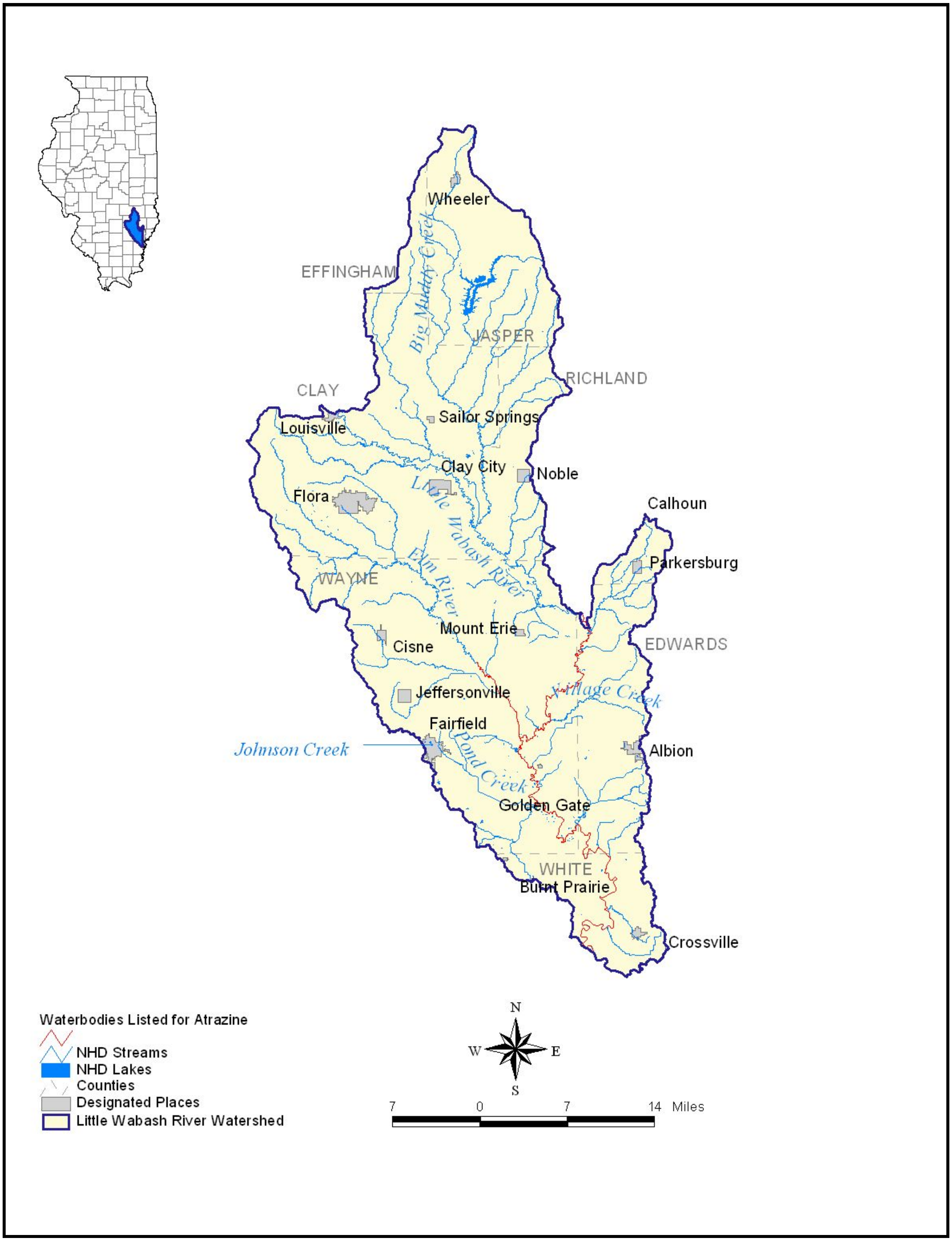


Figure 3-4. Waterbodies Listed for Atrazine Impairment in the Little Wabash River II Watershed.

3.4.3 TMDL Allocations

The atrazine TMDLs for waterbodies in the Little Wabash River II watershed were developed using a load duration approach which calculates a reduction for each hydrologic flow regime. The reductions required for each listed segment and flow regime are summarized in Table 3-8.

Table 3-8. Atrazine Reductions By Flow Regime for Waterbodies in the Little Wabash River II Watershed.

Atrazine TMDLs (lb/d)		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Segment	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Little Wabash River (C 09)	Current Load	389.4	124.2	22.6	0.8	No Data
	TMDL= LA+WLA+MOS	292.1	55.9	8.5	1.5	0.4
	LA	262.9	50.3	7.6	1.4	0.4
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	29.2	5.6	0.8	0.2	0.04
	TMDL Reduction	33%	60%	66%	0%	No Data
Little Wabash River (C 33)	Current Load	No Data	165.4	17.2	3.1	No Data
	TMDL= LA+WLA+MOS	470.4	78.4	11.9	2.1	0.6
	LA	423.3	70.5	10.7	1.9	0.5
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	47.0	7.8	1.2	0.2	0.1
	TMDL Reduction	No Data	57%	38%	37%	No Data
Elm River (CD 01)	Current Load	No Data	21.6	2.7	0.3	No Data
	TMDL= LA+WLA+MOS	61.4	7.7	1.6	0.3	0.1
	LA	55.2	6.9	1.5	0.2	0.1
	WLA	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	6.1	0.8	0.2	0.0	0.0
	TMDL Reduction	No Data	68%	46%	15%	No Data

3.5 Fecal Coliform

Fecal coliform is a commonly used indicator to test for the presence of fecal matter and pathogenic organisms. Because so many disease-causing organisms exist in the environment, it is less expensive to test for an indicator organism, such as fecal coliform bacteria, than it is to test for each individual pathogen. For this reason, most water quality regulations and water quality standards are written in terms of fecal coliform counts.

Unlike other water quality parameters which report concentration as mass per volume (e.g., mg/L or ppm), fecal coliform is usually reported as the number of bacterial colonies, or colony forming units, observed in 100 milliliters of sample. The abbreviated units for this measurement are cfu/100 mL; in some cases the cfu is omitted.

In general, total maximum daily loads (TMDLs) are reported as a load per day of pollutant (e.g., lb/d), rather than as a concentration (e.g., mg/L). This allows for comparison of the contribution from each source, which depends not only on the pollutant concentration, but also on the volume of water. TMDLs for fecal coliform must also be reported as a daily load (or in this case a count), rather than concentration. The daily loads are often on the order of billions and trillions of counts per day, and require the use of scientific notation for reporting.

Scientific notation was developed to write very small and very large numbers. This report deals with very large numbers, so the scientific format can be thought of as the number of zeros that must be added to a number (called the coefficient) for it to be displayed in normal format. The “E” in the scientific notation stands for exponent, and the two digit number that follows is the number of zeros to be added. For example, the number “1,000” can also be written as 1E03 because you add three zeros after the number one to get 1,000. The use of decimal places on the coefficient allows for reporting additional significant figures: 4.567E06 = 4,567,000. For this report, only two decimal places will be used, so that the previous example, rounded up, would be shown as 4.57E06.

3.5.1 Water Quality Standards

The fecal coliform water quality standards vary by season and designated use. For general use waterbodies during the months May through October, no more than 10 percent of samples collected within a 30-day period should exceed 400 cfu/100 mL, and the geometric mean of at least five samples collected within a 30-day period should not exceed 200 cfu/100 mL. From November through April, no numeric standard applies for general use waters. Public food and water processing supplies have a year round standard that the geometric mean of at least five samples collected within a 30-day period should not exceed 2,000 cfu/100 mL.

3.5.2 Impairments in the Little Wabash River II Watershed

Three segments in the Little Wabash River II watershed are listed for fecal coliform. During the summer months, all are regulated by the general use standards. During the winter months, segments designated as public water supply must also meet those year round standards (Little Wabash River C 09). Table 3-9 summarizes the fecal coliform data collected in the impaired waterbodies. Figure 3-5 shows the location of the segments in the watershed listed for fecal coliform.

Table 3-9. Summary of Fecal Coliform Data Collected in the Listed Reaches of the Little Wabash River II Watershed.

Waterbody Name (Segment ID)	Number of Samples	Minimum (cfu/100mL)	Geometric Mean (cfu/100mL)	Maximum (cfu/100mL)	Exceedance[1] (percent)
Data for Waterbodies Designated Public and Food Processing Supply Use					
Little Wabash River (C 09)	12	8	142	10,000	2
Data for Waterbodies Designated General Use					
Little Wabash River (C 22)	101	10	241	29,000	35
Elm River (CD 01)	81	5	323	13,000	35

[1] Percent of samples collected from May through October exceeding the 400 cfu/100 mL instantaneous standard.

Figure 3-5. Waterbodies Listed for Fecal Coliform Impairment in the Little Wabash River II Watershed.

3.5.3 TMDL Allocations

The fecal coliform TMDLs for impairments in the Little Wabash River II watershed are based on a load duration approach which outputs separate reductions for five flow regimes. The reductions for the three listed segments are summarized in **Error! Reference source not found.**.

Table 3-10. Fecal Coliform Reductions by Flow Regime for Waterbodies in the Little Wabash River II Watershed.

Fecal Coliform TMDLs (cfu/d)		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Segment	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Little Wabash River (C 09)	Current Load	1.30E+14	4.73E+14	3.84E+11	8.80E+10	2.38E+10
	TMDL= LA+WLA+MOS	3.11E+13	8.46E+12	6.98E+11	1.52E+11	7.20E+10
	LA	3.04E+13	8.40E+12	6.46E+11	1.25E+11	4.46E+10
	WLA: Charleston STP Outfall Pipe 001	4.54E+10	4.54E+10	4.54E+10	2.50E+10	2.50E+10
	WLA: Charleston STP Outfall Pipe A01	6.18E+11	n/a	n/a	n/a	n/a
	WLA: Clay City WWTP Outfall Pipe 001	2.27E+09	2.27E+09	2.27E+09	9.08E+08	9.08E+08
	WLA: Clay City WWTP Outfall Pipe 002	5.10E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	WLA: Dieterich STP	1.51E+09	1.51E+09	1.51E+09	6.06E+08	6.06E+08
	WLA: Noble STP	1.89E+09	1.89E+09	1.89E+09	7.57E+08	7.57E+08
	WLA: Parkersburg STP	9.31E+08	9.31E+08	9.31E+08	2.27E+08	2.27E+08
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (Implicit)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TMDL Reduction	76%	98%	0%	0%	0%
Little Wabash River (C 22)	Current Load	1.86E+15	1.13E+15	1.05E+12	3.19E+12	1.74E+10
	TMDL= LA+WLA+MOS	1.86E+13	1.70E+12	2.57E+11	1.05E+11	3.53E+10
	LA	1.86E+13	1.70E+12	2.51E+11	1.03E+11	3.30E+10
	WLA: Clay City WWTP Outfall Pipe 001	2.27E+09	2.27E+09	2.27E+09	9.08E+08	9.08E+08
	WLA: Clay City WWTP Outfall Pipe 002	5.10E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Fecal Coliform TMDLs (cfu/d)		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Segment	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
	WLA: Dieterich STP	1.51E+09	1.51E+09	1.51E+09	6.06E+08	6.06E+08
	WLA: Noble STP	1.89E+09	1.89E+09	1.89E+09	7.57E+08	7.57E+08
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (Implicit)	0	0	0	0	0
	TMDL Reduction	99%	>99%	76%	97%	0%
Elm River (CD 01)	Current Load	2.67E+14	2.34E+13	2.54E+12	5.53E+11	1.44E+10
	TMDL= LA+WLA+MOS	5.84E+12	3.05E+11	6.28E+10	2.86E+10	1.40E+10
	LA	5.82E+12	2.89E+11	4.69E+10	2.01E+10	5.54E+09
	WLA: Cisne STP	1.51E+09	1.51E+09	1.51E+09	6.06E+08	6.06E+08
	WLA: Flora City of-Charlie Brown Pk	1.06E+08	1.06E+08	1.06E+08	4.50E+07	4.50E+07
	WLA: Flora STP	1.36E+10	1.36E+10	1.36E+10	7.57E+09	7.57E+09
	WLA: Jeffersonville STP	6.06E+08	6.06E+08	6.06E+08	2.42E+08	2.42E+08
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (Implicit)	0	0	0	0	0
	TMDL Reduction	98%	99%	98%	95%	2%

4.0 POLLUTANT SOURCES IN THE LITTLE WABASH RIVER II WATERSHED

The Little Wabash River II watershed contains waterbodies listed for impairments due to total phosphorus, dissolved oxygen, manganese, atrazine, and fecal coliform. Most of the impairments, with the exception of total phosphorus, exist throughout the watershed. Both point and nonpoint sources contribute to the impairments. This section describes each major source category as well as the impacts and contributions to pollutant loading in this watershed.

4.1 Point Source Dischargers

There are 17 facilities regulated by the National Pollutant Discharge Elimination System that are allowed to discharge industrial or municipal wastewater to waterbodies located in the Little Wabash River II watershed. Information on these dischargers is shown in Table 4-1. Blank cells in the table indicate that permit information was not available for that parameter.

Table 4-1. Wastewater Treatment Plants Discharging to Impaired Streams within the Little Wabash River II Watershed.

Facility Name	Permit Number	Receiving Stream	Design Average Flow (MGD)	Design Maximum Flow (MGD)	Daily Fecal Coliform Limit (count/100 mL)	Daily CBOD Limit (mg/L)	Daily Ammonia Limit (mg/L)
Ameren Cips - Newton	IL0049191	Newton Lake	415.7		No Fecal Discharge	30	
Charleston STP	IL0021644	Cassell Creek	3.3	6	400	20	3 (April-Oct) 3.4 (Nov-March)
Cisne STP	ILG580197	Deer Creek, Elm River, Little Wabash River	0.08	0.2	Year-round disinfection exemption		
Clay City WWTP	IL0020974	Unnamed ditch tributary to Little Wabash Creek	0.12	0.3	Year-round disinfection exemption		
Crossville STP	ILG580211	Elliott Creek	0.25	0.82	Year-round disinfection exemption		
Dieterich STP	IL0044792	Tributary to Big Muddy Creek, Little Wabash River	0.08	0.2	Year-round disinfection exemption	25 Monthly Average 40 Weekly Average	
Fairfield STP	IL0020605	Johnson Creek	0.91	2.2	Year-round disinfection exemption	20	3 (April-Oct) 8 (Nov-March)
Fairfield WTP	ILG640137	NA	0.124	0.248	No Fecal Discharge		
Flora City Of-Charlie Brown Pk	IL0047481	Unnamed tributary of Raccoon Creek	0.003	0.007	400	20	3 (April-Oct) 8 (Nov-March)
Flora STP	IL0020273	Seminary Creek	1	1.8	Year-round disinfection exemption	20	6.2 (April-Oct) 13.5 (Nov-March)

Table 4-1. (Cont.) Wastewater Treatment Plants Discharging to Impaired Streams within the Little Wabash River II Watershed.

Facility Name	Permit Number	Receiving Stream	Design Average Flow (MGD)	Design Maximum Flow (MGD)	Daily Fecal Coliform Limit (count/100 mL)	Daily CBOD Limit (mg/L)	Daily Ammonia Limit (mg/L)
Flora WTP	IL0074403	Unnamed tributary to Elm Creek	0.027		No Fecal Discharge		
Greenville WTP	IL0045764	Kingsbury Branch	0.66		Year-round disinfection exemption		
Jeffersonville STP	ILG580076	Martin Creek	0.032	0.08	Year-round disinfection exemption		
Mt. Erie WTP	ILG640143	Newton Branch	0.0006		No Fecal Discharge		
Noble STP	IL0025500	Hog Run Creek	0.1	0.25	Year-round disinfection exemption	25 Monthly Average 40 Weekly Average	
Parkersburg STP	IL0071374	Unnamed tributary to Sugar Creek	0.03	0.123	Year-round disinfection exemption		
Shell Pipeline – Clay City	IL0076074		Inactive	Inactive	Inactive	Inactive	Inactive

Notes: The Shell Pipeline-Clay City used to hold a permit (IL0076074) to discharge into an unnamed tributary to Salt Creek; however, this facility ceased operations in April 2007; N/A = Not Available

Though the Ameren Cips facility has a permitted discharge rate of 415.7 MGD, the main discharge is for condenser cooling water and is assumed to have a net zero effect on the lake volume and pollutant loads as water is withdrawn and then discharged back to the lake. The cumulative design flows of the other outfalls result in a total daily discharge of 9.311 MGD to Newton Lake. This value was used to estimate pollutant loading and daily flows from this facility.

4.1.1 Phosphorus

None of the point source dischargers in the watershed are required to monitor for total phosphorus so it is not possible to accurately estimate the existing load from point sources. Only one waterbody is currently listed for phosphorus and it is not likely that the sole point source in that watershed (Ameren Cips) is contributing a significant fraction of the total load. There are two sewage treatment plant outfalls at this facility with approximate average flows of 0.016 MGD. Assuming a total phosphorus concentration of 4 mg/L from the effluent based on literature values (Litke, 1999) yields an approximate daily load of 195 lb/yr.

4.1.2 Dissolved Oxygen

Impacts on dissolved oxygen concentrations resulting from point source dischargers may be due to nutrient induced eutrophication, oxidation of ammonia and other compounds, or degradation of biodegradable organic material. Based on the findings of the QUAL2K TMDL modeling, reducing or even eliminating loads from point source dischargers will not result in impaired segments meeting the dissolved oxygen targets.

Less than half of the NPDES permitted dischargers in the watershed are required to monitor the amount of biodegradable organic material in their effluent. Loads from the facilities that do carry permit limits and are required to monitor their effluent are presented in Table 4-2 as average daily permitted loads. The permit limits for these facilities are reflective of secondary treatment levels and are not likely to be altered.

Table 4-2. Average Daily BOD_5 Loads from Facilities Carrying Permit Limitations.

Facility Name	Permit Number	Receiving Stream	BOD_5 (lb/d)
Ameren Cips - Newton	IL0049191	Newton Lake	2,331
Charleston STP	IL0021644	Cassell Creek	551
Flora STP	IL0020273	Seminary Creek	167
Fairfield STP	IL0020605	Johnson Creek	152
Clay City WWTP	IL0020974	Unnamed ditch tributary to Little Wabash Creek	25.0
Noble STP	IL0025500	Hog Run Creek	20.9
Cisne STP	ILG580197	Deer Creek, Elm River, Little Wabash River	16.7
Dieterich STP	IL0044792	Tributary to Big Muddy Creek, Little Wabash River	16.7
Jeffersonville STP	ILG580076	Martin Creek	6.68
Parkersburg STP	IL0071374	Unnamed tributary to Sugar Creek	6.26
Flora, City of - Charlie Brown Pk	IL0047481	Unnamed tributary of Raccoon Creek	0.50

4.1.3 Fecal Coliform

Sewage from treatment plants treating domestic and/or municipal waste contains fecal coliform bacteria, which is indigenous to sanitary sewage. In Illinois, a number of these treatment plants have applied for and received disinfection exemptions, which allow a facility to discharge wastewater without disinfection. All of these treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. Facilities with year-round disinfection exemptions may be required to provide the Agency with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions.

Sewage treatment plants are likely the only point source inputs of fecal coliform in the Little Wabash River II watershed. Each of the plants in the watershed operates under a disinfection exemption for primary effluent. Disinfection of excessive flows, however, is required. Though the permits do not require that facilities monitor fecal coliform in the primary effluent, concentrations that occur from excessive flows through the combined sewer overflow (CSO) must be monitored. The EPA Water Discharge Permits Query (PCS) contains little data for these facilities concerning the fecal coliform concentrations measured during CSOs (with the exception of IL0020605 which has three measurements listed).

Loads from the primary and excessive flow discharge pipes are difficult to quantify given the lack of monitoring data. Meeting fecal coliform water quality standards may require that these facilities disinfect and monitor the primary effluent. This implementation plan does address plant upgrades to include a disinfection process step in Section 5.1. In addition, controlling combined sewer overflows is addressed in Section 5.2.

4.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are not typically a significant source of pollutant loading if they are operating as designed. However, if the failure rates of systems in this watershed are high, then the loading from this source may be significant. At this time, no database of onsite wastewater treatment systems is available for the Little Wabash River II watershed, so it is difficult to estimate levels of performance.

Pollutant loading rates from properly functioning onsite wastewater systems are typically insignificant. However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems, loading rates to receiving waterbodies may be relatively high. It is suggested that each system in the watershed be inspected to accurately quantify the loading from this source. Systems older than 20 years and those located close to the lakes or streams should be prioritized for inspection.

4.2.1 Phosphorus

The only waterbody currently impaired due to total phosphorus is Newton Lake. To approximate the phosphorus loading rate from onsite wastewater systems in this drainage area, a rough calculation based on the population density of Jasper County, the area of the watershed, and net loading rates reported in the Generalized Watershed Loading Function (GWLF) User's manual were assumed.

Though a watershed model was not developed for the Newton Lake watershed, the GWLF user's manual (Haith et al., 1992) reports septic tank effluent loading rates and subsequent removal rates based on the use of phosphate detergents. Though phosphates have been banned from laundry detergents, dish detergents often contain between 4 and 8 percent phosphate by weight. The GWLF model assumes a septic tank effluent phosphorus loading rate for households using phosphate detergent of 2.5 g/capita/day. The model assumes a plant uptake rate of 0.4 g/capita/day of phosphorus during the growing season and 0.0 g/capita/day during the dormant season. Assuming a 6-month growing season (May through October), the average annual plant uptake rate is 0.2 g/capita/day.

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Phosphorus is removed from the wastewater by adsorption to soil particles. Plant uptake by vegetation growing over the drainfield is assumed negligible since all of the phosphorus is removed in the soil treatment zone. Failing systems that either short circuit the soil adsorption field or cause effluent to pool at the ground surface are assumed to retain phosphorus through plant uptake only (average annual uptake rate of 0.2 g/capita/day). Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank effluent directly to a waterbody or other transport line (such as an agricultural tile drain) do not allow for soil zone treatment or plant uptake.

The Stage 1 report for this watershed indicates that 200 onsite wastewater treatment systems are present in the Newton Lake watershed. According to the Census 2000 data, the average household size in Jasper County is 2.55 people per household. Assuming one onsite system per household, gives an estimated 510 people in the watershed served by onsite wastewater treatment systems.

The USEPA Onsite Wastewater Treatment Systems Manual (2002b) estimates that septic systems fail (do not perform as designed) at an average rate of 7 percent across the nation. The failure rate in the Little Wabash River II watershed is not known. Phosphorus loading rates under four scenarios were therefore calculated to show the range of loading from this source. System failures were distributed evenly over the three failure types: short circuiting, ponding, and directly discharging. Table 4-3 shows the phosphorus load if 0, 7, 15, 30, and 60 percent of systems in the watershed are failing.

Table 4-3. Failure Rate Scenarios and Resulting Phosphorus Loads to Newton Lake.

Failure Rate[1] (%)	Average Annual Phosphorus Load (lb/yr)
0	0
7[2]	39
15	84
30	168
60	336

[1] Failures are assumed distributed evenly over short-circuiting, ponded, and directly discharging systems.
[2] This is the average annual failure rate across the nation.

4.2.2 Dissolved Oxygen

Septic systems contribute nutrient loads to the environment that may result in eutrophication of streams and lakes. The systems also discharge substances that consume oxygen during decomposition, referred to as biochemical oxygen demand or BOD. Once these substances reach the streams and lakes in the watershed, their decay will consume oxygen and decrease concentrations.

Quantifying the impacts of septic systems on oxygen concentrations is difficult because so many factors influence oxygen concentrations: decay rates of BOD, algal growth and respiration rates, reaeration rates, and so on. Since the algae and plant life in this watershed are likely limited by phosphorus for their growth, and phosphorus loading was discussed in the previous section, this section will discuss the BOD loading rates for normal and failing onsite systems. Because oxygen impairments exist in segments throughout the entire Little Wabash River II watershed, the total number of people served by onsite wastewater treatment systems will be used to approximate loading (not just the people in the Newton Lake watershed). According to the Stage 1 report and an assumed household size of 2.5 people per household; 9,300 people are served by onsite wastewater treatment systems. To approximate the BOD loading rate from onsite wastewater systems, a rough calculation based on the population served by onsite systems and typical loading rates reported in the literature was assumed.

Measurements of biological oxygen demand are typically reported as a five-day biological oxygen demand or BOD_5. This value represents the amount of oxygen consumed over a five day period. Typical BOD_5 concentrations from septic tank effluent range from 140 to 200 mg/L. Reductions of approximately 90 percent occur in the drainfield of a properly functioning system (Siegrist et al., 2000). A malfunctioning system, however, does not provide adequate soil-zone treatment, and concentrations similar to tank effluent are typical. Translating these concentrations to daily loads from the population served is achieved by assuming a wastewater generation rate. Rates reported in the literature are typically 120 gpd (gallons per person per day). In addition, assumptions regarding the rate of failure are needed. Unfortunately, estimates of failure are difficult to ascertain unless a formal inspection program exists, and few communities have such programs in place. In tile-drained agricultural watersheds such as this one, loading rates are often high due to direct connection of septic tank effluent to the tile drain lines (Bird, 2006).

As with total phosphorus, BOD_5 loading rates under five scenarios were calculated to show the range of loading from this source. Table 4-4 shows the range of BOD_5 load if 0, 7, 15, 30, and 60 percent of systems in the watershed are failing.

Table 4-4. Failure Rate Scenarios and Resulting BOD_5 Loads in the Little Wabash River II Watershed.

Failure Rate (%)	Load From Normal Systems (lb/d)	Load From Failing Systems (lb/d)	Total Load (lb/d)
0	98 to 140	0	98 to 140
7[1]	91 to 130	68 to 98	159 to 228
15	83 to 119	147 to 210	230 to 328
30	68 to 98	294 to 419	362 to 517
60	39 to 56	587 to 838	626 to 894

[1] This is the average annual failure rate across the nation.

4.2.3 Fecal Coliform

Even properly functioning onsite wastewater systems contribute fecal coliform loading to the surrounding environment. Typically, by the time effluent reaches the groundwater zone, concentrations have been reduced by 99.99 percent by natural processes (Siegrist et al., 2000). However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems such as tile drains, loading rates to receiving waterbodies may be relatively high. In order to accurately quantify the loading in the Little Wabash River II watershed, an inspection of each system would be needed. Systems older than 20 years and those located close to waterbodies should be inspected first.

Fecal coliform impairments occur throughout the Little Wabash River II Watershed. Approximately 9,300 people are served by onsite wastewater treatment systems according to the Stage 1 report. To approximate the fecal coliform loading rate from onsite wastewater systems, a rough calculation based on the population served by onsite systems and typical loading rates reported in the literature was assumed.

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Fecal coliform concentrations are typically reduced by 99.99 percent (Siegrist et al., 2000). Failing systems that short circuit the soil adsorption field, result in ponding on the ground surface, or backup into homes will have concentrations typical of raw (untreated) sewage. Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank directly to a waterbody or other transport line (such as an agricultural tile drain) will also have concentrations similar to raw sewage.

A properly functioning onsite wastewater treatment system typically achieves fecal coliform concentrations of 100 to 10,000 cfu/100 mL (Siegrist et al., 2000), or an average reduction in loading of 99.99 percent. A malfunctioning system, however, does not provide adequate soil-zone treatment, and concentrations of 1E06 to 1E08 cfu/100 mL are typical (Siegrist et al., 2000). Translating these concentrations to daily loads from the population served is achieved by assuming a wastewater generation rate. Rates reported in the literature are typically 120 gpd (gallons per person per day). In addition, assumptions regarding the rate of failure are needed. As discussed above, estimating failure rates in this watershed is difficult because a formal inspection program does not exist.

Fecal coliform loading rates under five scenarios were calculated to show the range of loading from this source. Table 4-5 shows the range of fecal coliform load if 0, 7, 15, 30, and 60 percent of systems in the watershed are failing. Note that when a failure rate other than 0 is assumed, the total load is displayed equivalent to the load from failing systems because only two decimal places are shown in the number format (e.g., 3,000,000,000 plus 2,260,000,000,000 equals 2,263,000,000,000 which displays as 2.26E12).

Table 4-5. Failure Rate Scenarios and Resulting Fecal Coliform Loads in the Little Wabash River II Watershed.

Failure Rate (%)	Load From Normal Systems (cfu/d)	Load From Failing Systems (cfu/d)	Total Load (cfu/d)
0	3.17E+09 to 3.17E+11	0	3.17E+09 to 3.17E+11
7[1]	2.95E+09 to 2.95E+11	2.96E+12 to 2.96E+14	2.96E+12 to 2.96E+14
15	2.69E+09 to 2.69E+11	6.34E+12 to 6.34E+14	6.34E+12 to 6.34E+14
30	2.22E+09 to 2.22E+11	1.27E+13 to 1.27E+15	1.27E+13 to 1.27E+15
60	1.27E+09 to 1.27E+11	2.54E+13 to 2.54E+15	2.54E+13 to 2.54E+15

[1] This is the average annual failure rate across the nation.

4.3 Crop Production

The majority of land in the Little Wabash River II watershed (72 percent) is used for production of corn, soybeans, wheat, and other small grains. Due to application of commercial fertilizer, manure, and pesticides, as well as increased rates of erosion, pollutant loads from croplands are relatively high compared to other land uses. This section of the implementation plan describes the mechanisms of pollutant loading from farmland for each of the TMDL pollutants causing impairments in the watershed.

4.3.1 Phosphorus

Agriculture is a primary land use throughout the Little Wabash River II watershed. Phosphorus impairments, however, are only present in Newton Lake in Jasper County. In this watershed, approximately 17,650 acres of land are used to grow corn, soybeans, wheat, and other grains. Based on data presented by Gentry et al. (2007), phosphorus loading rates from tiled agricultural fields in east-central Illinois range from 0.5 to 1.5 lb/ac/yr. Based on this data, the phosphorus loads to Newton Lake from crop production areas may range from 8,825 to 26,475 lb/yr assuming that all of the fields are artificially drained. If a significant amount of the farmland is not artificially drained, these values may underestimate the loading from this source.

4.3.2 Dissolved Oxygen

Crop production activities likely have indirect impacts on dissolved oxygen concentrations. Issues related to eutrophication will be mitigated by controlling phosphorus loads. Runoff concentrations and sediment-bound levels of biodegradable organic material should be negligible. This excludes fields that spread manure for fertilizer, but these loads are discussed in Section 4.4.2.

4.3.3 Manganese

Impairments due to manganese occur throughout the Little Wabash River II watershed, and crop production is likely the most significant contributor. Manganese is found naturally in the environment in groundwater and soils. Because crop production tends to increase rates of erosion, the sediment bound manganese loads tend to increase from this land use. In addition, much of the land farmed in this watershed is classified as highly erodible (Figure 2-2).

Typical concentrations of manganese in Southern Illinois range from 4 to 200 milligrams of manganese per kilogram of soil (mg/kg) with an average value of 23 mg/kg (Ebelhar, 2007). Based on data presented by Czapar et al. (2006), conventional chisel plow crop production activities in Midwestern states result in sediment loads of 7.5 tons/ac/yr. Approximately 895,350 acres of land are used for crop production in the Little Wabash River II watershed. Assuming a manganese concentration of 23 mg/kg percent yields an estimated loading rate from this source of 154.4 tons/yr.

4.3.4 Atrazine

Atrazine is a commonly used herbicide for controlling broadleaf and grassy weeds. Impairments due to atrazine are distributed throughout the Little Wabash River II watershed and the sole source is crop production. Because many herbicides are available for use, it is not possible to quantify the load to waterbodies in the watershed without site specific application data.

4.4 Animal Operations

Pollutant loading from animal operations can be a problem in both confined and pasture-based systems. Though the exact location of animal operations in the watershed is not known, countywide statistics indicate that a large number of livestock, swine, and poultry may exist. Figure 4-1 shows an example of poorly managed animal wastes that may contaminate nearby surface waters.

(Photo courtesy of USDA NRCS.)

Figure 4-1. Example of Poorly Managed Animal Waste.

Agricultural animal operations are a potentially large source of pollutant loading if adequate best management practices (BMPs) are not in place to protect surface waters. Livestock operations either consist of confined or pasture-based systems. If a confined operation has greater than 1,000 animal units or is determined to threaten water quality, the operation requires a federal Concentrated Animal Feeding Operation (CAFO) permit. CAFOs are required to develop a nutrient management plan (NMP) as part of the CAFO permitting process (USEPA, 2003) which consists of manure management and disposal strategies that minimize the release of excess nutrients into surface and ground water. The CAFO NMPs are based on NRCS standards and technical expertise.

4.4.1 Phosphorus

Because the only phosphorus impairment in the watershed is for Newton Lake, phosphorus loads from animal operations will only be presented for the Newton Lake watershed. The Stage 1 report for the Little Wabash River II watershed summarized the 2002 Census of Agriculture data for Jasper County. These data were area weighted to estimate the number of animals in the Newton Lake watershed (Table 4-6).

Table 4-6. Estimated Number of Livestock and Poultry in the Newton Lake Watershed.

Animal	Number of Head
Poultry	48
Beef cattle	260
Dairy cattle	98
Other cattle: heifers, bulls, calves, etc.	536
Hogs and pigs	7,692
Sheep and lambs	23
Horses and ponies	39

Large animals produce more fecal matter per animal compared to smaller animals, so the concept of animal unit is used to normalize loading from various operations. Total phosphorus loading rates are usually given as pounds per animal unit per day. Table 4-7 lists the number of animals equivalent to one animal unit (IDA, 2001) for each of the livestock and poultry classes likely present in the watershed, as well as the total phosphorus loading rate (USEPA, 2002a) from one animal unit. In addition, the table lists the total number of animal units in the watershed and resulting total phosphorus load. Figure 4-2 shows the relative contribution from each category to the potential load.

Table 4-7. Animal Unit Data and Total Phosphorus Loading Rates for the Newton Lake Watershed.

Animal	Number of Animals in One Animal Unit	Number of Animal Units in Watershed	Total Phosphorus Load (lb/au/d)	Total Phosphorus Load (lb/yr)
Poultry	50	1	0.32	112
Beef cattle	1	260	0.16	15,180
Dairy cattle	0.71	138	0.14	7,037
Other cattle: heifers, bulls, calves, etc.	1	536	0.16	31,319
Hogs and pigs	2.5	3,077	0.13	145,999
Sheep and lambs	10	2	0.05	41
Horses and ponies	0.5	78	0.16	4,528
Total Phosphorus Load from Agricultural Animals in the Newton Lake Watershed				**204,215**

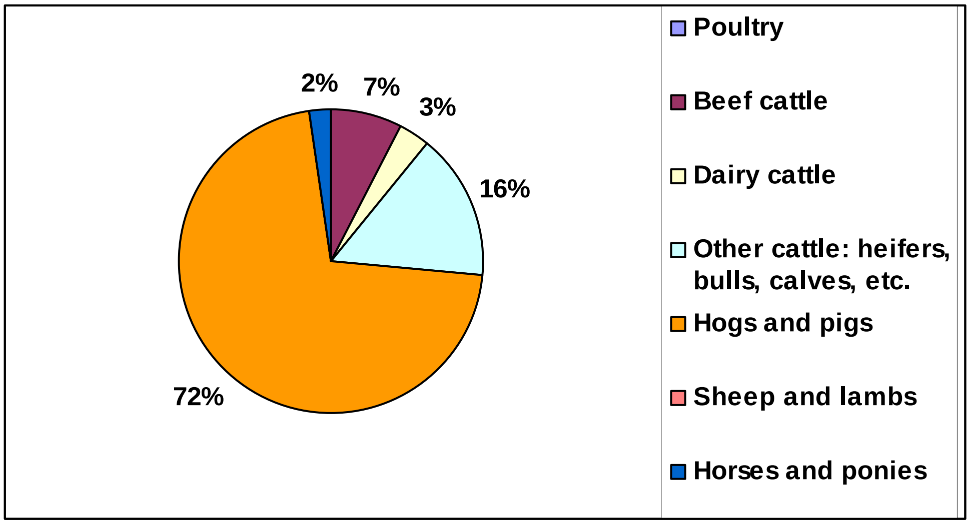


Figure 4-2. Percent Contribution to the Potential Phosphorus Load from Agricultural Animals.

4.4.2 Dissolved Oxygen

Dissolved oxygen impairments due to animal operations may result from degradation of organic material in the streams and lakes or eutrophication due to excessive nutrients which leads to eventual algal decay as well as nighttime respiration. As total phosphorus is discussed separately in this report, the dissolved oxygen impairments caused by animal operations will be discussed relative to the loading of organic material. It should be noted that animals with access to streambanks will exacerbate dissolved oxygen problems by increasing bank erosion and decreasing canopy cover. This impact is difficult to quantify, but can be controlled by animal management BMPs as discussed in Section 5.0.

Dissolved oxygen impairments occur throughout the Little Wabash River II watershed, and each county in the watershed contains animal operations that likely contribute to this impairment. The county statistics presented in the Stage 1 report are listed below for cattle, poultry, swine, and sheep in the watershed (Table 4-8).

Table 4-8. Estimated Number of Livestock and Poultry in the Little Wabash River II Watershed.

Animal	Number of Head
Poultry	829
Beef cattle	3,246
Dairy cattle	507
Other cattle: heifers, bulls, calves, etc.	20,835
Hogs and pigs	109,903
Sheep and lambs	1,461
Horses and ponies	1,127

Loading rates of organic material are often expressed as the biological oxygen demand over a five day period (BOD_5). USEPA (1999a) has summarized the BOD_5 loading rates from various animal species as pounds per day per animal unit. This data along with the number of animal units in the watershed and the resulting BOD_5 load is summarized in Table 4-9. Figure 4-3 shows the relative contribution from each category to the potential load.

Table 4-9. Animal Unit Data and BOD_5 Loading Rates for the Little Wabash River II Watershed.

Animal	Number of Animals in One Animal Unit	Number of Animal Units in Watershed	BOD_5 Load (lb/au/d)	BOD_5 Load (lb/d)
Poultry	50	17	3.3	55
Beef cattle	1	3,246	1.6	5,193
Dairy cattle	0.71	715	1.6	1,143
Other cattle: heifers, bulls, calves, etc.	1	20,835	1.6	33,336
Hogs and pigs	2.5	43,961	3.1	136,279
Sheep and lambs	10	146	1.7	248
Horses and ponies	0.5	2,254	1.7	3,832
BOD_5 Load from Agricultural Animals in the Little Wabash River Watershed				**176,255**

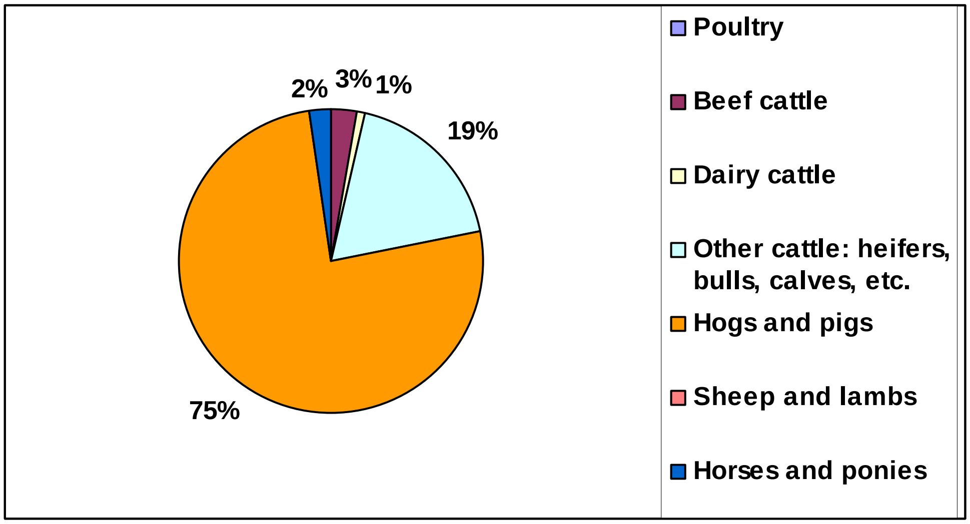


Figure 4-3. Percent Contribution to the BOD_5 Load from Agricultural Animals.

4.4.3 Fecal Coliform

Fecal coliform impairments occur throughout the Little Wabash River II watershed; each county in the watershed contains animal operations that likely contribute to this load. The county statistics presented in the Stage 1 report are listed below for cattle, poultry, swine, and sheep in the watershed (Table 4-10).

Table 4-10. Estimated Number of Livestock and Poultry in the Little Wabash River II Watershed.

Animal	Number of Head
Poultry	829
Beef cattle	3,246
Dairy cattle	507
Other cattle: heifers, bulls, calves, etc.	20,835
Hogs and pigs	109,903
Sheep and lambs	1,461
Horses and ponies	1,127

Fecal coliform loading rates are usually given as the bacterial count per animal unit per day. Table 4-11 lists the number of animals equivalent to one animal unit (IDA, 2001) for each of the livestock and poultry classes likely present in the watershed, as well as the fecal coliform loading rate (USEPA, 2002a; ASAE, 1998; USEPA, 1999) from one animal unit. In addition, the table lists the total number of animal units in the watershed and resulting fecal coliform load. Figure 4-4 shows the relative contribution from each category to the potential load.

Table 4-11. Animal Unit Data and Fecal Coliform Loading Rates for the Little Wabash River II Watershed.

Animal	Number of Animals in One Animal Unit	Number of Animal Units in Watershed	Fecal Coliform Load (cfu/au/d)	Total Fecal Coliform Load (cfu/d)
Poultry	50	17	9.74E+14	1.61E+16
Beef cattle	1	3,246	3.71E+13	1.20E+17
Dairy cattle	0.71	715	2.87E+13	2.05E+16
Other cattle: heifers, bulls, calves, etc.	1	20,835	3.71E+13	7.73E+17
Hogs and pigs	2.5	43,961	8.90E+10	3.91E+15
Sheep and lambs	10	146	2.00E+11	2.92E+13
Horses and ponies	0.5	2,254	4.20E+08	9.47E+11
Total Fecal Coliform Load from Agricultural Animals in the Little Wabash River II Watershed				**9.34E+17**

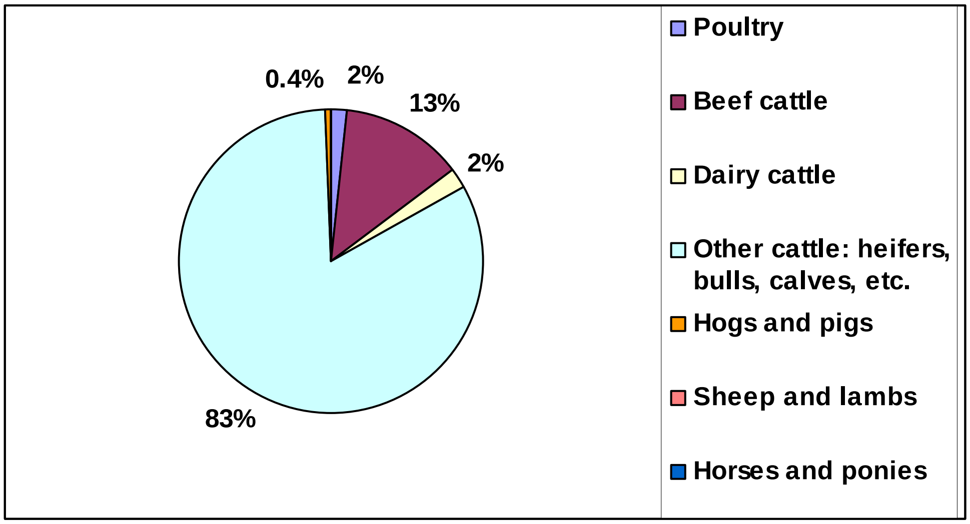


Figure 4-4. Percent Contribution to the Potential Fecal Coliform Load from Agricultural Animals.

4.5 Streambank and Lake Shore Erosion

Excessive erosion of streambanks and lake shores quickly degrades water quality and habitat. Both phosphorus and manganese contribute to the overall composition of sediment and once this sediment reaches a waterbody, these elements may be released through biological and chemical transformations. Release of phosphorus may increase rates of algal and plant growth (eutrophication), which leads to issues with dissolved oxygen concentrations, water treatability, and aesthetics. Manganese also effects water treatment operations and is detrimental to aquatic life at high concentrations.

In addition to the release of phosphorus and manganese, erosion will also reduce the stability of streambanks by undercutting the roots of established vegetation and altering the channel geometry. Loss of vegetative canopy and widening of a stream channel will allow more sunlight to reach the water column which may 1) increase rates of eutrophication, 2) increase water temperatures, and 3) decrease the amount of dissolved oxygen the water can hold.

The Illinois Department of Natural Resources (IDNR) has begun an inventory of streams in the State for inclusion in the Illinois Stream Information System (ISIS). So far, all reaches in the state draining at least 10 square miles are included in the database. IDNR (2004) assisted the ULWREP in identify reaches within the partnership that are considered channelized. A map of these reaches is shown in the report from IDNR to ULWREP attached in Appendix B.

For those stream channels and lake shores that have not yet been inventoried by IDNR, the most cost-effective way to assess erosion is to visually inspect representative reaches of each channel or lake and rank the channel stability using a bank erosion index. Banks or shorelines ranked moderately to severely eroding could be targeted for stabilization efforts. A more time and resource intensive method is to determine the rate of erosion by inserting bank pins and measuring the rate of recession. Once soil loss estimates are obtained, reaches can be prioritized for restoration and protection.

Without quantitative estimates of streambank and shoreline erosion, it is not possible to estimate the phosphorus or manganese loading from this source or the impacts on dissolved oxygen. Fortunately several of the BMPs described in Section 5.0 that control pollutant loads and runoff volumes will also help control streambank and lakeshore erosion.

4.6 Internal Loading from Lake Bottom Sediments

Two lakes in the Little Wabash River II watershed are listed for pollutants that may be released from bottom sediments in anoxic lakes. Newton Lake in Jasper County is listed for phosphorus, and Fairfield Reservoir in Wayne County is listed for manganese.

Both manganese and phosphorus may be released internally from lake sediments when oxygen concentrations near the bottom of the lake reach low levels. Low dissolved oxygen in lakes may be caused by degradation of organic material or respiration of algae in the absence of sunlight. Conditions for low dissolved oxygen are more severe during the summer months when the water temperatures are higher and the water is able to contain less oxygen.

Three stations in Newton Lake are monitored for dissolved oxygen. Figure 4-5 shows all of the measurements collected in the lake and indicates that anoxic conditions likely occur in the lower depths. Data in Fairfield Reservoir (Figure 4-6) were collected at one station (near the dam), and do not indicate severe anoxia at the lake bottom (only one measurement less than 2 mg/L was observed).

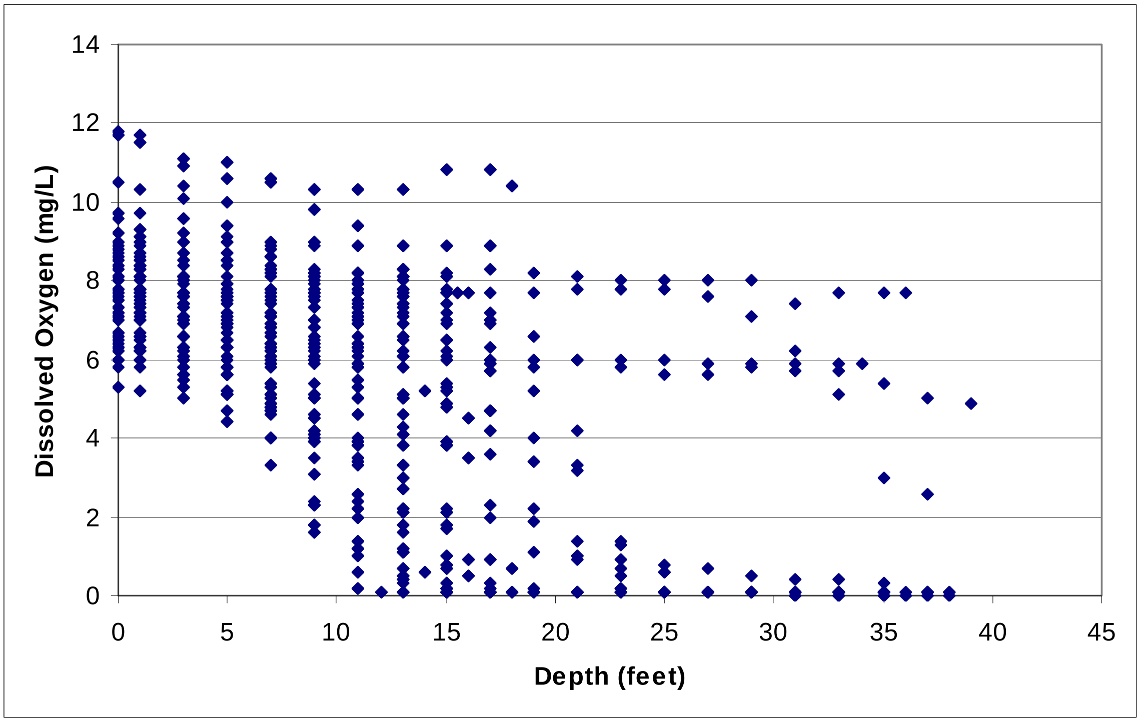


Figure 4-5. Dissolved Oxygen Profile for Newton Lake.

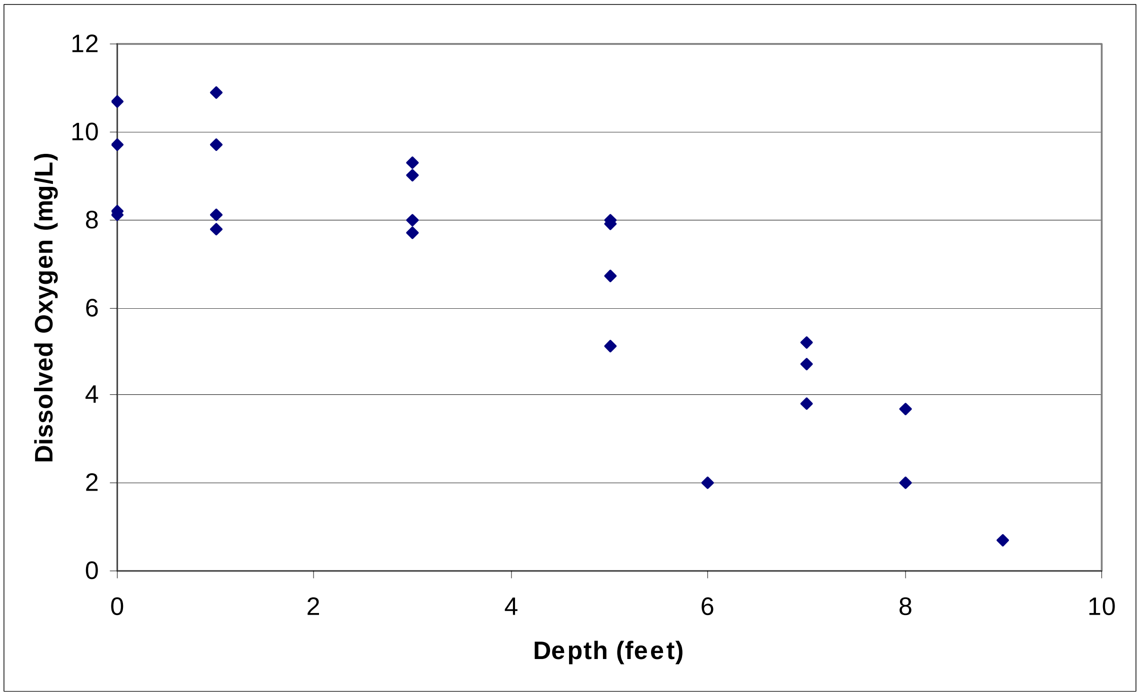


Figure 4-6. Dissolved Oxygen Profile for Fairfield Reservoir.

4.6.1 Phosphorus

Phosphorus concentrations in Newton Lake range from 0.029 mg/L to 0.317 mg/L at one foot depth. Estimating the fraction of phosphorus in the water column that originates from re-suspended sediment stores is difficult with the current data. Given that this lake has a relatively long residence time (based on TMDL lake modeling), an average depth of 16 ft, and dissolved oxygen measurements observed near zero, it is likely that bottom sediments release phosphorus into the water column. More intensive water quality studies of the lake and its tributaries will be required to estimate the significance of this load but inlake management strategies are discussed in Section 5.0 since it may be significant. In addition, BMPs that reduce phosphorus and BOD_5 loads in the watershed will also mitigate the dissolved oxygen conditions that stimulate release from bottom sediments.

4.6.2 Manganese

Fairfield Reservoir is designated a water supply reservoir. Manganese concentrations in the lake range from 58 to 290 µg/L. There does not appear to be a significant correlation of manganese with depth, though lower concentrations tend to occur near the lake bottom. Fairfield Reservoir has a low residence time, an average depth of approximately 2.3 ft, and few dissolved oxygen measurements near zero. These factors, along with the manganese data which indicate lower concentrations near the lake bottom, suggest it is not likely that the bottom sediments are releasing significant amounts of manganese. Collection of additional manganese data in the lake and its tributaries will allow for a quantitative estimate from this source. If internal loading is deemed a significant source, then the inlake management measures may be necessary.

4.7 Historic and Active Oil Mining Operations

The ULWREP (2007) discusses the impacts of historic and active oil mining operations on soil and water quality. Byproducts from the operation include a brine solution that is usually stored in a lagoon, discharged to a surface water, or land applied. The salt content reduces vegetative growth and therefore increased rates of erosion are prevalent at these sites. In addition, the brine solution contains high concentrations of manganese which may eventually reach surface waterbodies. Appendix A contains the ULWREP report and shows a map of the oil operations in that section of the watershed. This implementation plan will not focus on BMPs to address current oil operations as many of the operations are no longer active.

4.8 Domestic Pets and Wildlife Populations

Domestic pets such as cats and dogs and wildlife animals such as deer, geese, ducks, etc., can be significant sources of loading in watersheds that have high densities of urban populations or rural communities with relatively undisturbed land use patterns. In the Little Wabash River II watershed, where the majority of land is used for agricultural production, these sources are likely not significant relative to the loading from animal operations, exempt point source dischargers, and failing onsite wastewater systems.

5.0 BEST MANAGEMENT PRACTICES

Controlling pollutant loading to the impaired reaches of the Little Wabash River II watershed will require implementation of various BMPs depending on the pollutant(s) of concern and major sources of loading. This section describes BMPs that may be used to reduce loading from point source dischargers, onsite wastewater treatment systems, agricultural operations, inlake resuspension, and streambank erosion. At this time, BMPs to address historic mining operations are not included in the implementation plan.

The net costs associated with the BMPs described in this plan depend on the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc.). In addition, some practices require that land be taken out of farm production and converted to treatment areas, which results in a loss of income from the cash crop. On the other hand, taking land out of production does save money on future seed, fertilizer, labor, etc., and this must be accounted for as well. This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life. Incentive plans, carbon trading, and cost share programs are discussed separately in Section 8.0.

The costs presented in this section are discussed in year 2004 dollars because this is the latest year for which gross income estimates for corn and soybean production are available. Market prices can fluctuate significantly from year to year based on supply and demand factors, so applying straight rates of inflation to convert crop incomes from one year to the next is not appropriate. The cost to construct, maintain, and operate the BMPs is assumed to follow a yearly inflation rate of 3 percent since these components are not as dependent on such factors as weather and consumer demand. Therefore, all prices for BMP costs have been converted to year 2004 dollars to develop a net cost for each BMP. Inflated prices are rounded to the nearest quarter of a dollar since most of the costs were reported in whole dollars per acre, not dollars and cents.

Gross 2004 income estimates for corn and soybean in Illinois are $510/ac and $473/ac, respectively (IASS, 2004). Accounting for operating and ownership costs results in net incomes from corn and soybean farms of $140/ac and $217/ac (USDA-ERS, 2005). The average net annual income of $178/ac was therefore used to estimate the annual loss from BMPs that take a portion of land out of farm production. The average value is considered appropriate since most farms operate on a 2-year crop rotation.

5.1 Disinfection of Primary Effluent from Sewage Treatment Plants

The majority of the sewage treatment plants in the Little Wabash River II watershed operate under a disinfection exemption. Reducing the fecal coliform concentrations from a primary outfall of an exempt facility to 200 cfu/100 mL will require a permit change and disinfection of the effluent prior to discharge. Common disinfection techniques include chlorination, ozonation, and ultraviolet (UV) disinfection. In most cases, chlorination is the most cost-effective alternative, although residuals and oxidized compounds are toxic to aquatic life; subsequent dechlorination may be necessary prior to discharge which will increase costs similar to the other two options (USEPA, 1999b). The options most frequently employed are discussed below.

Chlorination

Chlorine compounds used for disinfection are usually either chlorine gas or hypochlorite solutions though other liquid and solid forms are available. Oxidation of cellular material destroys pathogenic organisms. The remaining chlorine residuals provide additional disinfection, but may also react with organic material to form harmful byproducts. To reduce the impacts on aquatic life from chlorine residuals and byproducts, a dechlorination step is often included in the treatment process (USEPA, 1999b).

The advantages of chlorine disinfection are

- Generally more cost-effective relative to UV disinfection or ozonation if dechlorination is not required
- Residuals continue to provide disinfection after discharge
- Effective against a wide array of pathogens
- Capable of oxidizing some organic and inorganic compounds
- Provides some odor control
- Allows for flexible dosing

There are several disadvantages as well:

- Chlorine residuals are toxic to aquatic life and may require dechlorination, which may increase costs by 30 to 50 percent
- Highly corrosive and toxic with expensive shipping and handling costs
- Meeting Uniform Fire Code requirements can increase costs by 25 percent
- Oxidation of some organic compounds can produce toxic byproducts
- Effluent has increased concentrations of dissolved solids and chloride

More information about disinfection with chlorine is available online at
http://www.consolidatedtreatment.com/manuals/Fact_sheet_chlorine_disinfection.pdf

Ozonation

Ozone is generated onsite by passing a high voltage current through air or pure oxygen (USEPA, 1999c). The resulting gas (O_3) provides disinfection by destroying the cell wall, damaging DNA, and breaking carbon bonds. The advantages of ozonation include

- Ozone is more effective than chlorine and has no harmful residuals
- Ozone is generated onsite so there are no hazardous transport issues
- Short contact time of 10 to 30 minutes
- Elevates the DO of the effluent

Disadvantages are

- More complex technology than UV light or chlorine disinfection
- Highly reactive and corrosive
- Not economical for wastewater with high concentrations of BOD, TSS, COD, or TOC
- Initial capital, maintenance, and operating costs are typically higher than for UV light or chlorine disinfection

More information about ozonation is available online at
http://www.epa.gov/owmitnet/mtb/ozon.pdf

Ultraviolet Disinfection

UV radiation is generated by passing an electrical current through a lamp containing mercury vapor. The radiation attacks the genetic material of the organisms, destroying reproductive capabilities (NSFC, 1998).

The advantages of UV disinfection are

- Highly effective
- Destruction of pathogens occurs by physical process, so no chemicals must be transported or stored
- No harmful residuals
- Easy to operate
- Short contact time (20 to 30 min)
- Requires less space than chlorination or ozonation

Disadvantages of UV disinfection are

- Organisms can sometimes regenerate
- Turbidity and TSS can interfere with disinfection at high concentrations
- Not as cost effective compared to chlorination alone, but when fire code regulations and dechlorination are considered, costs are comparable.

More information about disinfection with UV radiation is available online at http://www.nsfc.wvu.edu/nsfc/pdf/eti/UV_Dis_tech.pdf

5.1.1 Effectiveness

Because the sewage treatment plants that operate under a disinfection exemption are not required to monitor fecal coliform concentrations in the primary effluent, it is difficult to estimate the existing load from this source. The use of disinfection techniques to reduce fecal coliform concentrations to 200 cfu/100 mL should result in a substantial reduction in loading from this source.

5.1.2 Costs

Upgrading the existing sewage treatment plants to include disinfection prior to discharge can be achieved with either chlorination, ozonation, or UV radiation processes. The costs associated with these three techniques include upfront capital costs to construct additional process units, operating and maintenance costs for chemicals, electricity, labor, etc., as well as chemical storage and fire code requirements associated with the chlorination option. The USEPA compares costs of chlorination, ozonation, and UV disinfection in a series of fact sheets available online. This information is summarized below as well as in Table 5-1. Prices in the fact sheets were listed in either 1995 or 1998 dollars and have not been updated more recently. Prices have been converted to year 2004 dollars, assuming a 3 percent per year inflation rate, for comparison with the other BMPs discussed in this plan that must be described in year 2004 dollars.

Chlorine dosage usually ranges from 5 mg/L to 20 mg/L depending on the wastewater characteristics and desired level of disinfection. The cost of adding a chlorination/dechlorination system meeting fire code requirements and treating 1 MGD of wastewater with a chlorine dosage of 10 mg/L cost approximately $1,260,000 in 1995 with annual operation and maintenance costs of $59,200 (USEPA, 1999b). If a

3 percent per year inflation rate is assumed, these costs in 2004 dollars are $1,640,000 and $77,200, respectively.

Costs for ozonation were given by USEPA (1999c) in 1998 dollars. The capital cost in 1998 for treating 1 MGD of secondary wastewater with BOD and TSS concentrations each less than 30 mg/L was $300,000. The operating and maintenance costs were listed at $18,500 plus the cost of electricity. In 2004 dollars, these costs are $358,200 and $22,000, respectively.

Ultraviolet radiation costs were listed in 1995 dollars by USEPA (1995) relative to the cost per bulb. Based on vendor information available online, approximately 40 bulbs would be required to treat 1 MGD of secondary wastewater. Based on the information presented, the capital cost in 2004 for a 1 MGD facility would be approximately $750,000 and the annual operating and maintenance costs would range from $4,500 to $5,100.

Table 5-1 compares the costs for these three disinfection technologies. Annualized costs are calculated assuming a 20-year system life for each technology before major repairs or replacement would be required.

Table 5-1. Comparison of Disinfection Costs (2004) per 1 MGD of Sewage Treatment Plant Effluent.

Technology	Capital Costs	Annual Operating and Maintenance Costs	Annualized Costs
Chlorination (10 mg/L dosage), dechlorination, fire code regulations	$1,640,000	$77,200	$159,200
Ozonation	$358,200	$22,000	$39,900, plus cost of electricity
UV Disinfection	$750,000	$4,500 to $5,100	$42,000 to $42,600

5.2 Control of Combined Sewer Overflows (CSOs)

Combined sewer systems transport both wastewater and stormwater/snowmelt to the treatment plant. During extremely wet weather, if the capacity of the system is exceeded, the plants are designed to overflow to surface waterbodies such as streams or lakes. In 1994, EPA issued a list of nine minimum control measures that will reduce the frequency and volume of overflows without requiring significant engineering or construction to implement. The nine controls are listed below (USEPA, 1994):

- Proper operating and maintenance procedures should be followed for the sewer system, treatment plant, and CSO outfalls. Periodic inspections are necessary to identify problem areas.
- Maximize use of the collection system for storage:
    - Remove obstructions and repair valves and flow devices
    - Adjust storage levels in the sewer system
    - Restrict the rate of stormwater flows:
        - Disconnect impervious surfaces
        - Use localized detention
    - Upgrade or adjust the rate of lift stations

  - Remove obstructions in the conveyance system
- Review and modification of pretreatment requirements to ensure that CSO impacts are minimized:
  - Minimize impacts of discharges from industrial and commercial facilities
  - May need to require more onsite storage of process wastewater or stormwater runoff
- Maximize flow to the POTW for treatment:
  - Assess the capacity of the pumping stations, major interceptors, and individual process units
  - Identify locations of additional available capacity
  - Identify unused units or storage facilities onsite that may be used to store excess flows
- Elimination of CSOs during dry weather:
  - Initiate an inspection program to identify dry weather overflows
  - Adjust or repair flow regulators
  - Fix gates stuck in the open position
  - Remove blockages that prevent the wastewater from entering the interceptor
  - Cleanout interceptors
  - Repair sewer lines that are infiltrated by groundwater
- Control of solid and floatable materials in CSOs:
  - Use of baffles, screens, and racks to reduce solids
  - Street sweeping
- Pollution prevention programs to reduce contaminants in CSOs:
  - Education, street sweeping, solid waste and recycling collection programs
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts:
  - Notifying the public of the locations, health concerns, impacts on the environment
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls:
  - Record the flow and duration of each CSO event as well as the total daily rainfall
  - Quality monitoring for permit requirements or modeling exercises

The USEPA Guidance for Nine Minimum Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0030.pdf

The Water Environment Research Foundation suggests a decentralized approach to minimizing the frequency and volumes of CSO events (WERF, 2005). This approach utilizes individual site BMPs that encourage evapotranspiration and infiltration to reduce the volume of runoff, rather than storing large volumes of stormwater from larger land areas in the conventional, centralized controls. Practices that reduce CSOs include

- routing gutter downspouts to pervious surfaces

- collecting rainwater in barrels and cisterns
- using vegetative controls such as vegetated roofs, filter strips, grass swales, pocket wetlands, or rain gardens
- porous pavement
- infiltration ditches
- soil amendments that improve vegetative growth and/or increase water retention
- tree box filters.

Excessive stormwater volumes contributing to CSOs typically occur in urban areas with large amounts of impervious surface, overly compacted soil, and little pervious or open space. Because decentralized controls treat a smaller volume of stormwater runoff, they require a smaller footprint and are easier to incorporate into a pre-existing landscape compared to the larger, more conventional practices such as stormwater detention ponds. However, retrofitting a previously developed area with BMPs does present challenges which must be considered during design: potential damage to roadway and building foundations, issues with standing water and mosquito breeding, and perceptions of private property owners. All of these may be overcome with proper planning and education.

If the nine minimum controls, including decentralized BMPs, do not reduce the frequency and impacts of CSOs from the two sewage treatment plants (STPs), then long-term measures may be required. These are listed below and described in more detail in the Combined Sewer Overflows Guidance for Long-term Control Plan (USEPA, 1995):

- Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls
- A public participation process that actively involves the affected public in the decision making to select long-term CSO controls
- Consideration of sensitive areas as the highest priority for controlling overflows
- Evaluation of alternatives that will enable the permittee, in consultation with the NPDES permitting authority, water quality standards (WQS) authority, and the public, to select CSO controls that will meet Clean Water Act (CWA) requirements
- Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives
- Operational plan revisions to include agreed-upon long-term CSO controls
- Maximization of treatment at the existing publicly owned treatment works (POTW) treatment plant for wet weather flows
- An implementation schedule for CSO controls
- A post-construction compliance monitoring program adequate to verify compliance with water quality-based CWA requirements and ascertain the effectiveness of CSO controls

The USEPA Guidance for Long-term Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0272.pdf

5.2.1 Effectiveness

The effectiveness of CSO controls on reducing the fecal coliform load depends on the existing flows and frequencies of CSOs and the fecal coliform concentrations present in the releases. Most sewage treatment plants in Illinois, even those that discharge primary effluent under a disinfection exemption, are required to disinfect releases that occur as a result of CSOs. It may be possible with the controls described in this section to reduce fecal coliform loading from this source substantially.

5.2.2 Costs

Relative to the cost of upgrading the sewage treatment plants to include a disinfection process, instituting the nine minimum controls for CSOs should be a minimal cost to each facility. Plant operators and inspection personnel are likely already on hand to perform most of these functions if they aren't already. If the nine minimum controls are not effective in reducing the fecal coliform loading from the CSOs, the more costly long-term measures may be needed. These may include additional monitoring, modeling, and plant upgrades to provide adequate storage during wet weather events.

5.3 Proper Maintenance of Onsite Systems

The most effective BMP for managing loads from septic systems is regular maintenance. Unfortunately, most people do not think about their wastewater systems until a major malfunction occurs (e.g., sewage backs up into the house or onto the lawn). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Good housekeeping measures relating to septic systems are listed below (Goo, 2004; CWP, 2004):

- Inspect system annually and pump system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).
- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

Education is a crucial component of reducing pollution from septic systems. Many owners are not familiar with USEPA recommendations concerning maintenance schedules. Education can occur through public meetings, mass mailings, and radio and television advertisements.

The USEPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would help identify those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally regulate septic systems by creating a database of all the systems in the area. This database usually contains information on the size, age, and type of system. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. These databases allow the communities to detect problem areas and ensure proper maintenance.

At this time, there is not a formal inspection and maintenance program in the watershed. The County Health Departments do issue permits for new onsite systems and major repairs and investigate complaints as they arise.

5.3.1 Effectiveness

The reductions in pollutant loading resulting from improved operation and maintenance of all systems in the watershed depends on the wastewater characteristics and the level of failure present in the watershed. Reducing the level of failure to 0 percent may result in the following load reductions:

- Phosphorus loads to Newton Lake may be reduced by 39 to 336 lb/d.
- BOD_5 loads in the Little Wabash River II watershed may be reduced by 530 to 750 lb/d.
- Fecal coliform loads in the watershed may be reduced by 99.99 percent.

5.3.2 Costs

Septic tanks are designed to accumulate sludge in the bottom portion of the tank while allowing water to pass into the drain field. If the tank is not pumped out regularly, the sludge can accumulate and eventually become deep enough to enter the drain field. Pumping the tank every three to five years prolongs the life of the system by protecting the drain field from solid material that may cause clogs and system backups.

The cost to pump a septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year. Septic tanks that are not maintained will likely require replacement which may cost between $2,000 and $10,000.

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 3,720 households in the watershed. After the initial inspection of each system and creation of the database, only systems with no subsequent maintenance records would need to be inspected. A recent inspection program in South Carolina found that inspections cost approximately $160 per system (Hajjar, 2000).

Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings, mass mailings, and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems (Table 5-2).

The costs associated with education and inspection programs will vary depending on the level of effort required to communicate the importance of proper maintenance and the number of systems in the area.

Table 5-2. Costs Associated with Maintaining and Replacing an Onsite Wastewater Treatment System.

Action	Cost per System	Frequency	Annual Cost per System
Pumping	$250 to $350	Once every 3 to 5 years	$70 to $85
Inspection	$160	Initially all systems should be inspected, followed by 5 year inspections for systems not on record as being maintained	Up to $32, assuming all systems have to be inspected once every five years, which is not likely
Replacement	$2,000 to $10,000	With proper maintenance, system life should be 30 years	$67 to $333
Education	$1	Public reminders should occur once per year	$1

5.4 Nutrient Management Plans

The majority of nutrient loading from farmland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). In heavily fertilized areas, soil phosphorus content has increased significantly over natural levels. Parties responsible for reducing loads due to excessive fertilization include farmers and local agricultural service agencies that provide fertilization guidelines.

The primary BMP for reducing phosphorus loading from excessive fertilization is the development of a nutrient management plan. The plan should address fertilizer application rates, methods, and timing. Initial soil phosphorus concentrations are determined by onsite soil testing, which is available from local vendors. Losses through plant uptake are subtracted, and gains from organic sources such as manure application or industrial/municipal wastewater are added. The resulting phosphorus content is then compared to local guidelines to determine if fertilizer should be added to support crop growth and maintain current phosphorus levels. In some cases, the soil phosphorus content is too high, and no fertilizer should be added until stores are reduced by crop uptake to target levels.

Soil phosphorus tests are used to measure the phosphorus available for crop growth. Test results reported in parts per million (ppm) can be converted to lb/ac by multiplying by 2 (USDA, 2003). Based on a survey of state soil testing laboratories in 1997, 64 percent of soils in Illinois had high soil phosphorus test concentrations (> 50 ppm). By 2000, the percentage of soils testing high decreased to 58 percent (USDA, 2003). Guidelines in the Illinois Agronomy Handbook (IAH) recommend maintaining soil test phosphorus content in southeastern Illinois at 25 ppm (50 lb/ac). Soils that test at or above 35 ppm (70 lb/ac) should not be fertilized until subsequent crop uptake decreases the test to 25 ppm (50 lb/ac) (IAH, 2002). Soil phosphorus tests should be conducted once every three or four years to monitor accumulation or depletion of phosphorus (USDA, 2003).

Table 5-3 and Table 5-4 show buildup, maintenance, and total application rates for various starting soil test concentrations for sample corn and soybean yields, respectively. For a complete listing of buildup and maintenance rates for the three inherent availability zones and varying yields of corn, soybeans, oats, wheat, and grasses, see Chapter 11 of the IAH.

Starting Soil Test Phosphorus	***Fertilization Guidelines***
Less than 25 ppm:	*Buildup plus maintenance*
Between 25 and 35 ppm:	*Maintenance only*
Greater than 35 ppm:	*None*

Table 5-3. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Corn Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	71	139
15 (30)	45	71	116
20 (40)	22	71	93
25 (50)	0	71	71
30 (60)	0	71	71
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).

[2] Maintenance rates assume a corn yield of 165 bushels per acre. The IAH lists maintenance rates discretely for yields of 90 to 200 bushels per acre.

Table 5-4. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Soybean Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	51	119
15 (30)	45	51	96
20 (40)	22	51	73
25 (50)	0	51	51
30 (60)	0	51	51
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).
[2] Maintenance rates assume a soybean yield of 60 bushels per acre. The IAH lists maintenance rates discretely for yields of 30 to 100 bushels per acre.

Nutrient management plans also address methods of application. Fertilizer may be applied directly to the surface, placed in bands below and to the side of seeds, or incorporated in the top several inches of the soil profile through injection or tillage. Surface applications that are not followed by incorporation may result in accumulation of phosphorus at the soil surface and increased dissolved phosphorus concentrations in surface runoff (Mallarino, 2004).

Methods of phosphorus application have shown no impact on crop yield (Mallarino, 2004). The Champaign County Soil and Water Conservation District (CCSWCD) reports that deep placement of phosphorus in bands next to the seed zone requires only one-third to one-half the amount of phosphorus fertilizer to achieve the same yields and that on average, fertilizer application rates were decreased by 13 lb/ac (Stikkers, 2007). Thus, deep placement will not only reduce the amount of phosphorus available for transport, but will also result in lower fertilizer costs. Figure 5-1 shows the deep placement attachment used by the CCSWCD.

The NRCS provides additional information on nutrient management planning at:
http://efotg.nrcs.usda.gov/references/public/IL/590.pdf

The Illinois Agronomy Handbook may be found online at:
http://iah.aces.uiuc.edu/

(Photo Courtesy of CCSWCD)

Figure 5-1. Deep Placement Phosphorus Attachment Unit for Strip-till Toolbar.

For corn-soybean rotations, it is recommended that phosphorus fertilizer be applied once every two years, following harvest of the corn crop if application consists of broadcast followed by incorporation (UME, 1996). Band placement should occur prior to or during corn planting, depending on the type of field equipment available. Fertilizer should be applied when the chance of a large precipitation event is low. Application to frozen ground or snow cover should be strongly discouraged. Researchers studying loads from agricultural fields in east-central Illinois found that fertilizer application to frozen ground or snow followed by a rain event could transport 40 percent of the total annual phosphorus load (Gentry et al., 2007).

Recent technological developments in field equipment allow for fertilizer to be applied at varying rates across a field. Crop yield and net profits are optimized with this variable rate technology (IAH, 2002). Precision farming typically divides fields into 1- to 3-acre plots that are specifically managed for seed, chemical, and water requirements. Operating costs are reduced and crop yields typically increase, though upfront equipment costs may be high.

5.4.1 Effectiveness

The effectiveness of nutrient management plans (application rates, methods, and timing) in reducing phosphorus loading from agricultural land will be site specific. The following reductions are reported in the literature:

- 35 percent average reduction of total phosphorus load reported in Pennsylvania (USEPA, 2003).
- 20 to 50 percent total phosphorus load reductions with subsurface application at agronomic rates (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 percent reduction in total phosphorus concentrations when fertilizer is incorporated to a minimum depth of two inches prior to planting (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 to 50 percent reduction in total phosphorus with subsurface application, such as deep placement (HWRCI, 2005).
- 60 percent reduction in runoff concentrations of phosphorus when the following precipitation event occurred 10 days after fertilizer application, as opposed to 24 hours after application (HWRCI, 2005).
- Nutrient management plans will also reduce the dissolved oxygen impairments in the watershed by reducing the nutrients available to stimulate eutrophication.

5.4.2 Costs

A good nutrient management plan should address the rates, methods, and timing of fertilizer application. To determine the appropriate fertilizer rates, consultants in Illinois typically charge $6 to $18 per acre, which includes soil testing, manure analysis, scaled maps, and site specific recommendations for fertilizer management (USEPA, 2003). The Champaign County Soil and Water Conservation District (CCSWCD, 2003) estimates savings of approximately $10/ac during each plan cycle (4 years) by applying fertilizer at recommended rates. Actual savings (or costs) depend on the reduction (or increase) in fertilizer application rates required by the nutrient management plan as well as other farm management recommendations.

Placing the fertilizer below and to the side of the seed bed (referred to as banding) reduces the required application by one third to one half to achieve the same crop yields. In Champaign County, phosphorus application rates were reduced by approximately 13 lb/ac with this method. The equipment needed for deep placement costs up to $113,000 (Stikkers, 2007). Alternatively the equipment can be rented or the entire process hired out. The Heartland Regional Water Coordination Initiative lists the cost for deep placement of phosphorus fertilizer at $3.50/ac per application (HRWCI, 2005).

Table 5-5 summarizes the assumptions used to develop the annualized cost for this BMP.

Table 5-5. Costs Calculations for Nutrient Management Plans.

Item	Costs and Frequency	Annualized Costs (Savings)
Soil Testing and Determination of Rates	Costs $6/ac to $18/ac Every four years	$1.50/ac/yr to $4.50/ac/yr
Savings on Fertilizer	Saves $10/ac Every four years	($2.50/ac/yr)
Deep Placement of Phosphorus	Costs $3.50/ac Every two years	$1.75/ac/yr
Average Annual Costs		**$0.75/ac/yr to $3.75/ac/yr**

5.5 Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residuals not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al., 2004).

Several practices are commonly used to maintain the suggested 30 percent cover:

- No-till systems disturb only a small row of soil during planting, and typically use a drill or knife to plant seeds below the soil surface.
- Strip till operations leave the areas between rows undisturbed, but remove residual cover above the seed to allow for proper moisture and temperature conditions for seed germination.
- Ridge till systems leave the soil undisturbed between harvest and planting: cultivation during the growing season is used to form ridges around growing plants. During or prior to the next planting, the top half to two inches of soil, residuals, and weed seeds are removed, leaving a relatively moist seed bed.
- Mulch till systems are any practice that results in at least 30 percent residual surface cover, excluding no-till and ridge till systems.

The NRCS provides additional information on these conservation tillage practices:
no-till and strip till: http://efotg.nrcs.usda.gov/references/public/IL/329a.pdf
ridge till: http://efotg.nrcs.usda.gov/references/public/IL/329b.pdf
mulch till: http://efotg.nrcs.usda.gov/references/public/IL/329c.pdf

Tillage system practices are not available specifically for the Little Wabash River II watershed; however, countywide tillage system surveys are performed by the Illinois Department of Agriculture every two years. It is assumed that the general tillage practice trends measured in the counties is applicable to the watershed and the results of the 2006 surveys are presented in Table 5-6. Mulch till and no-till are considered conservation tillage practices: reduced till practices do not maintain 30 percent ground cover.

In 2006, the use of conservation tillage practices on corn fields typically occurred on less than 50 percent of the fields surveyed. The exception is White County, where 68 percent of corn fields employ conservation tillage practices. It is more common for soybean fields to use conservation practices. At least 72 percent of soybean fields in each county use some form of conservation tillage, with the exception of Effingham County, which only has 49 percent of soybean fields using conservation practices. Practices on small grain fields vary widely from county to county with 100 percent of fields in White County using conservation tillage practices but less than 20 percent of fields employing these practices in Richland and Effingham counties.

Table 5-6. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in 2006.

Crop Field Type	Tillage Practice				Conservation Tillage
	Conventional Till	Reduced-till	Mulch Till	No Till	
Clay County					
Corn	54	7	8	31	**39**
Soybean	15	5	6	75	**81**
Small Grain	9	1	18	71	**89**
Edwards County					
Corn	53	0	13	34	**47**
Soybean	9	0	23	67	**90**
Small Grain	36	0	5	60	**65**
Effingham County					
Corn	77	10	4	10	**14**
Soybean	33	18	12	37	**49**
Small Grain	82	0	2	16	**18**
Jasper County					
Corn	76	3	2	19	**21**
Soybean	24	4	4	68	**72**
Small Grain	0	10	3	86	**89**
Richland County					
Corn	63	0	7	30	**37**
Soybean	9	1	12	78	**90**
Small Grain	81	0	7	12	**19**
Wayne County					
Corn	20	30	15	35	**50**
Soybean	10	6	18	66	**84**
Small Grain	11	46	37	6	**43**
White County					
Corn	32	0	1	67	**68**
Soybean	15	2	7	77	**84**
Small Grain	0	0	0	100	**100**

Source: IDA, 2006.

Corn residues are more durable and capable of sustaining the required 30 percent cover required for conservation tillage. Soybeans generate less residue, the residue degrades more quickly, and supplemental measures or special care may be necessary to meet the 30 percent cover requirement (UME, 1996). Figure 5-2 shows a comparison of ground cover under conventional and conservation tillage practices.

Figure 5-2. Comparison of Conventional (left) and Conservation (right) Tillage Practices.

Though no-till systems are more effective in reducing sediment loading from crop fields, they tend to concentrate phosphorus in the upper two inches of the soil profile due to surface application of fertilizer and decomposition of plant material (IAH, 2002; UME, 1996). This pool of phosphorus readily mixes with precipitation and can lead to increased concentrations of dissolved phosphorus in surface runoff. Chisel plowing may be required once every several years to reduce stratification of phosphorus in the soil profile.

5.5.1 Effectiveness

Czapar et al. (2006) summarize past and present tillage practices and their impacts on erosion control and nutrient delivery. Historically, the mold board plow was used to prepare the field for planting. This practice disturbed 100 percent of the soil surface and resulted in basically no residual material. Today, conventional tillage typically employs the chisel plow, which is not as disruptive to the soil surface and tends to leave a small amount of residue on the field (0 to 15 percent). Mulch till systems were classified as leaving 30 percent residue; percent cover was not quantified for the no-till systems in this study. The researchers used WEPP modeling to simulate changes in sediment and nutrient loading for these tillage practices. Relative to mold board plowing, chisel plowing reduced phosphorus loads leaving the field by 38 percent, strip tilling reduced loads by 80 percent, and no-till reduced loads by 85 percent. If chisel plowing is now considered conventional, then the strip till and no-till practices are capable of reducing phosphorus loads by 68 percent and 76 percent, respectively (Czapar et al., 2006).

The IAH (2002) defines conservation tillage as any tillage practice that results in at least 30 percent coverage of the soil surface by crop residuals after planting. Tillage practices leaving 20 to 30 percent residual cover after planting reduce erosion by approximately 50 percent compared to bare soil. Practices that result in 70 percent residual cover reduce erosion by approximately 90 percent (IAH, 2002). Manganese reductions will be similar since this pollutant is primarily sediment bound.

USEPA (2003) reports the findings of several studies regarding the impacts of tillage practices on pesticide loading. Ridge till practices reduced pesticide loads by 90 percent and no-till reduced loads by an average of 67 percent. In addition, no-till reduced runoff losses by 69 percent, which will protect streambanks from erosion and loss of canopy cover (USEPA, 2003).

The reductions achieved by conservation tillage reported in these studies are summarized below:

- 68 to 76 percent reduction in total phosphorus.
- 50 percent reduction in sediment, and likely manganese, for practices leaving 20 to 30 percent residual cover.
- 90 percent reduction in sediment, and likely manganese, for practices leaving 70 percent residual cover.
- 90 percent reduction in pesticide loading for ridge till practices.
- 67 percent reduction in pesticide loading for no-till practices.
- 69 percent reduction in runoff losses for no-till practices.

5.5.2 Costs

Conservation tillage practices generally require fewer trips to the field, saving on labor, fuel, and equipment repair costs, though increased weed production may result in higher pesticide costs relative to conventional till (USDA, 1999). In general, conservation tillage results in increased profits relative to conventional tillage (Olson and Senjem, 2002; Buman et al., 2004; Czapar, 2006). The HRWCI (2005) lists no additional costs for conservation tillage.

Hydrologic inputs are often the limiting factor for crop yields and farm profits. Conservation practices reduce evaporative losses by covering the soil surface. USDA (1999) reports a 30 percent reduction in evaporative losses when 30 percent ground cover is maintained. Harman et al. (2003) and the Southwest Farm Press (2001) report substantial yield increases during dry years on farms managed with conservation or no-till systems compared to conventional till systems.

Depending on the type of equipment currently used, replacing conventional till equipment with no-till equipment can either result in a net savings or slight cost to the producer. Al-Kaisi et al. (2000) estimate that converting conventional equipment to no-till equipment costs approximately $1.25 to $2.25/ac/yr, but that for new equipment, purchasing no-till equipment is less expensive than conventional equipment. Other researchers report a net gain when conventional equipment is sold to purchase no-till equipment (Harman et al., 2003).

Table 5-7 summarizes the available information for determining average annual cost for this BMP.

Table 5-7. Costs Calculations for Conservation Tillage

Item	Costs and Frequency	Annualized Costs (Savings)
Conversion of Conventional Equipment to Conservation Equipment	Costs presented in literature were already averaged out to yearly per acre costs: $1.25/ac/yr to $2.25/ac/yr	$1.25/ac/yr to $2.25/ac/yr
Operating Costs of Conservation Tillage Relative to Conventional Costs	$0/ac/yr	$0/ac/yr
Average Annual Costs		**$1.25/ac/yr to $2.25/ac/yr**

5.6 Cover Crops

Grasses and legumes may be used as winter cover crops to reduce soil erosion and improve soil quality (IAH, 2002). These crops also contribute nitrogen to the following crop, reducing fertilizer requirements. Grasses tend to have low seed costs and establish relatively quickly, but can impede cash crop development by drying out the soil surface or releasing chemicals during decomposition that may inhibit the growth of a following cash crop. Legumes take longer to establish, but are capable of fixing nitrogen from the atmosphere, thus reducing nitrogen fertilization required for the next cash crop. Legumes, however, are more susceptible to harsh winter environments and may not have adequate survival to offer sufficient erosion protection. Planting the cash crop in wet soil that is covered by heavy surface residue from the cover crop may impede emergence by prolonging wet, cool soil conditions. Cover crops should be killed off two or three weeks prior to planting the cash crop either by application of herbicide or mowing and incorporation, depending on the tillage practices used. Use of cover crops is illustrated in Figure 5-3.

(Photo Courtesy of NRCS)

Figure 5-3. Use of Cover Crops.

The NRCS provides additional information on cover crops at:
http://efotg.nrcs.usda.gov/references/public/IL/340.pdf

5.6.1 Effectiveness

The effectiveness of cover crops in reducing pollutant loading has been reported by several agencies. In addition to these benefits, the reduction in runoff losses will reduce erosion from streambanks, further reducing manganese loads and allowing for the establishment of vegetation and canopy cover. The reported reductions are listed below:

- 50 percent reduction in soil and runoff losses with cover crops alone. When combined with no-till systems, may reduce soil loss by more than 90 percent (IAH, 2002). Manganese reductions will likely be similar.
- 70 to 85 percent reduction in phosphorus loading on naturally drained fields (HRWCI, 2005).
- Reduction in fertilizer and pesticide requirements (OSUE, 1999).
- Useful in conservation tillage systems following low-residue crops such as soybeans (USDA, 1999).

5.6.2 Costs

The National Sustainable Agriculture Information Service recommends planting ryegrass after corn harvest and hairy vetch after soybeans (Sullivan, 2003). Both seeds can be planted at a depth of ¼ to ½ inch at a rate of 20 lb/ac or broadcast at a rate of 25 to 30 lb/ac (Ebelhar and Plumer, 2007; OSUE, 1990).

Researchers at Purdue University estimate the seed cost of ryegrass and hairy vetch at $12 and $30/ac, respectively. Savings in nitrogen fertilizer (assuming nitrogen fertilizer cost of $0.30/lb (Sample, 2007)) are $3.75/ac for ryegrass and $28.50/ac for hairy vetch. Yield increases in the following crop, particularly during droughts, are reported at 10 percent and are expected to offset the cost of this practice (Mannering et al., 1998). Herbicide application is estimated to cost $14.25/ac.

Accounting for the seed cost, herbicide cost, and fertilizer offset results in an average net cost of approximately $19.25/ac assuming that cover crop planting recommendations for a typical 2-year corn/soybean rotation are followed (Mannering et al., 1998). These costs do not account for yield increases which may offset the costs completely. Table 5-8 summarizes the costs and savings associated with ryegrass and hairy vetch.

Table 5-8. Costs Calculations for Cover Crops.

Item	Ryegrass	Hairy Vetch
Seed Costs	$12/ac	$30/ac
Nitrogen Fertilizer Savings	($3.75/ac)	($28.50/ac)
Herbicide Costs	$14.25/ac	$14.25/ac
Annual Costs	$22.50/ac	$15.75/ac
Average Annual Cost Assuming Ryegrass Follows Corn and Hairy Vetch Follows Soybeans: $19.25/ac		

5.7 Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. If topography allows, filter strips may also be used to treat effluent from tile drain outlets. For small dairy operations, filter strips may also be used to treat milk house washings and runoff from the open lot (NRCS, 2003).

Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005). A grass filter strip is shown in Figure 5-4.

(Photo Courtesy of NRCS)

Figure 5-4. Grass Filter Strip Protecting Stream from Adjacent Agriculture.

The NRCS provides additional information on filter strips at:
http://efotg.nrcs.usda.gov/references/public/IL/393.pdf

Filter strips also serve to reduce the quantity and velocity of runoff. Filter strip sizing is dependent on site specific features such as climate and topography, but at a minimum, the area of a filter strip should be no less than 2 percent of the drainage area for agricultural land (OSUE, 1994). The minimum filter strip width suggested by NRCS (2002a) is 30 ft. The strips are assumed to function properly with annual maintenance for 30 years before requiring replacement of soil and vegetation.

5.7.1 Effectiveness

Filter strips have been found to effectively remove pollutants from agricultural runoff. The following reductions are reported in the literature (USEPA, 2003; Kalita, 2000; Woerner et al., 2006):

- 65 percent reduction in total phosphorus
- 55 to 87 percent reduction in fecal coliform
- 11 to 100 percent reductions for atrazine

- 65 percent reductions for sediment (and likely manganese)
- Slows runoff velocities and may reduce runoff volumes via infiltration

5.7.2 Costs

Filter strips cost approximately $0.30 per sq ft to construct, and the system life is typically assumed to be 20 years (Weiss et al., 2007). Assuming that the required filter strip area is 2 percent of the area drained (OSUE, 1994), 870 square feet of filter strip are required for each acre of agricultural land treated. The construction cost to treat one acre of land is therefore $261/ac. The annualized construction costs are $13/ac/yr. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002c), for an additional cost of $8.70/ac/yr of agricultural land treated. In addition, the area converted from agricultural production to filter strip will result in a net annual income loss of $3.50. Table 5-9 summarizes the costs assumptions used to estimate the annualized cost to treat one acre of agricultural drainage with a filter strip.

Table 5-9. Costs Calculations for Filter Strips Used in Crop Production.

Item	Costs Required to Treat One Acre of Agricultural Land with Filter Strip
Construction Costs	$0.30
Annual Maintenance Costs	$0.01
Construction Costs	$261
System Life (years)	20
Annualized Construction Costs	$13
Annual Maintenance Costs	$8.70
Annual Income Loss	$3.50
Average Annual Costs	**$25/ac treated**

Filter strips used in animal operations typically treat contaminated runoff from pastures or feedlot areas or washings from the milk houses of small dairy operations (NRCS, 2003). The NRCS (2003) costs for small dairy operations (75 milk cows) assumes a filter strip area of 12,000 sq ft is required. For the pasture operations, it is assumed that a filter strip area of 12,000 sq ft (30 ft wide and 400 ft long) would be required to treat runoff from a herd of 50 cattle (NRCS, 2003). The document does not explain why more animals can be treated by the same area of filter strip at the dairy operation compared to the pasture operation.

For animal operations, it is not likely that land used for growing crops would be taken out of production for conversion to a filter strip. Table 5-10 summarizes the capital, maintenance, and annualized costs for filter strips per head of animal.

Table 5-10. Costs Calculations for Filter Strips Used at Animal Operations.

Operation	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Small dairy (75 milking cows)	$48 per head of cattle	$1.50 per head of cattle	$4 per head of cattle
Beef or other (50 cattle)	$72 per head of cattle	$2.50 per head of cattle	$6 per head of cattle

5.8 Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. A grassed waterway providing surface drainage for a corn field is shown in Figure 5-5.

(Photo Courtesy of NRCS)

Figure 5-5. Grassed Waterway.

The NRCS provides additional information on grassed waterways at:
http://efotg.nrcs.usda.gov/references/public/IL/412.pdf

5.8.1 Effectiveness

The effectiveness of grass swales for treating agricultural runoff has not been quantified. The Center for Watershed Protection reports the following reductions in urban settings (Winer, 2000):

- 30 percent reduction in total phosphorus
- 5 percent reduction in fecal coliform
- 68 percent reduction of total suspended solids (similar reduction likely for manganese)

In addition, grassed waterways that allow for water infiltration may reduce atrazine loads by 25 to 35 percent (Kansas State University, 2007).

5.8.2 Costs

Grassed waterways cost approximately $0.50 per sq ft to construct (USEPA, 2002c). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. The range is based on examples in the Illinois Drainage Guide, information from the NRCS Engineering Field Handbook, and a range of waterway lengths (100 to 300 feet). Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). The construction cost spread out over the life of the waterway is thus $2.25/yr for each acre of agriculture draining to a grassed waterway. Annual maintenance of grassed waterways is estimated at $0.02 per sq ft (Rouge River, 2001) for an additional cost of $1.75/ac/yr of agricultural land treated. Table 5-11 summarizes the annual costs assumptions for grassed waterways.

Table 5-11. Costs Calculations for Grassed Waterways Draining Cropland.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Square Foot	
Construction Costs	$0.50
Annual Maintenance Costs	$0.02
Costs to Treat One Acre of Agricultural Land (assuming 44 to 131 sq ft of filter strip)	
Construction Costs	$22 to $65.50
System Life (years)	20
Annualized Construction Costs	$1 to $3.25
Annual Maintenance Costs	$1 to $2.75
Annual Income Loss	$0
Average Annual Costs	**$2 to 6/ac treated**

Grassed waterways are primarily used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas. Table 5-12 summarizes the capital, maintenance, and annualized costs of this practice per head of cattle as summarized by NRCS (2003).

Table 5-12. Costs Calculations for Grassed Waterways Used in Cattle Operations.

Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
$0.50 to $1.50	$0.02 to $0.04	$0.05 to $0.12

5.9 Riparian Buffers

Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. The streamside forest slowly releases nutrients as twigs and leaves decompose. These nutrients are valuable to the fungi, bacteria, and invertebrates that form the basis of a stream's food chain. Tree canopies of riparian forests also cool the water in streams which can affect the composition of the fish species in the stream, the rate of biological reactions, and the amount of dissolved oxygen the water can hold. Channelization or widening of streams moves the canopy farther apart, decreasing the amount of shaded water surface, increasing water temperatures, and decreasing dissolved oxygen concentrations.

Preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer. A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure 5-6.

(Photo Courtesy of NRCS)

Figure 5-6. Riparian Buffer Between Stream Channel and Agricultural Areas.

The NRCS provides additional information on riparian buffers at:
http://efotg.nrcs.usda.gov/references/public/IL/390.pdf *and*
http://efotg.nrcs.usda.gov/references/public/IL/391.pdf

5.9.1 Effectiveness

Riparian buffers should consist of native species and may include grasses, grass-like plants, forbs, shrubs, and trees. Minimum buffer widths of 25 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. The following reductions are reported in the literature:

- 25 to 30 percent reduction of total phosphorus for 30 ft wide buffers (NCSU, 2002)
- 70 to 80 percent reduction of total phosphorus for 60 to 90 ft wide buffers (NCSU, 2002)
- 34 to 74 percent reduction of fecal coliform for 30 ft wide buffers (Wenger, 1999)
- 87 percent reduction of fecal coliform for 200 ft wide buffers (Wenger, 1999)
- 62 percent reduction in BOD_5 for 200 ft wide buffers (Wenger, 1999)
- 70 to 90 percent reduction of sediment (and likely manganese) (NCSU, 2002)
- 80 to 90 percent reduction of atrazine (USEPA, 2003)
- Increased canopy cover provides shading which may reduce water temperatures and improve dissolved oxygen concentrations (NCSU, 2002). Wenger (1999) suggests buffer width of at least 30 ft to maintain stream temperatures.
- Increased channel stability will reduce streambank erosion and manganese loads

5.9.2 Costs

Restoration of riparian areas costs approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms. Assuming a buffer width of 90 ft on either side of the stream channel and an adjacent treated width of 300 ft of agricultural land, one acre of buffer will treat approximately 3.3 acres of adjacent agricultural land. The cost per treated area is thus $30/ac to construct and $142.50/ac to maintain over the life of the buffer. Assuming a system life of 30 years results in an annualized cost of $59.25/yr for each acre of agriculture land treated (Table 5-13).

Table 5-13. Costs Calculations for Riparian Buffers.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Acre of Riparian Buffer	
Construction Costs	$100
Maintenance Costs Over System Life	$475
Costs to Treat One Acre of Agricultural Land (assuming 0.3 ac of buffer)	
Construction Costs	$30
Maintenance Costs Over System Life	$142.50
System Life (Years)	30
Annualized Construction Costs	$1
Annualized Maintenance Costs	$4.75
Annual Income Loss	$53.50
Average Annual Costs	**$59.25/ac treated**

Restoration of riparian areas will protect the stream corridor from cattle trampling and reduce the amount of fecal material entering the channel. The cost of this BMP depends more on the length of channel to be protected, not the number of animals having channel access. The cost of restoration is approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Fecal coliform reductions have been reported for buffers at least 30 ft wide (Wenger, 1999). Large reductions are reported for 200 ft wide buffers. The costs per length of channel for 30 ft and 200 ft wide buffers restored on both sides of a stream channel are listed in Table 5-14. A system life of 30 years is assumed.

Table 5-14. Costs Calculations for Riparian Buffers per Foot of Channel.

Width	Capital Costs per ft	Annual Operation and Maintenance Costs per ft	Total Annualized Costs per ft
30 ft on both sides of channel	$0.14	$0.02	$0.03
60 ft on both sides of channel	$0.28	$0.04	$0.05
90 ft on both sides of channel	$0.42	$0.06	$0.07
200 ft on both sides of channel	$0.93	$0.13	$0.16

5.10 Constructed Wetlands

Constructed wetlands used to treat animal wastes are typically surface flowing systems comprised of cattails, bulrush, and reed plants. Prior to treating animal waste in a constructed wetland, storage in a lagoon or pond is required to protect the wetland from high pollutant loads that may kill the vegetation or clog pore spaces. After treatment in the wetland, the effluent is typically held in another storage lagoon and then land applied (USEPA, 2002a). Alternatively, the stored effluent can be used to supplement flows to the wetland during dry periods. Constructed wetlands that ultimately discharge to a surface waterbody will require a permit, and the receiving stream must be capable of assimilating the effluent during low flow conditions (NRCS, 2002b). Figure 5-7 shows an example of a lagoon-wetland system.

(Photo courtesy of USDA NRCS.)

Figure 5-7. Constructed Wetland System for Animal Waste Treatment.

The NRCS provides additional information on constructed wetlands at
http://efotg.nrcs.usda.gov/references/public/IL/656.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/NEH637Ch3ConstructedWetlands.pdf

5.10.1 Effectiveness

Wetland environments treat wastewater through sedimentation, filtration, plant uptake, biochemical transformations, and volatilization. Reported pollutant reductions found in the literature are listed below:

- 42 percent reduction in total phosphorus (USEPA, 2003)
- 59 to 80 percent reduction in BOD_5 (USEPA, 2002a)
- 92 percent reduction in fecal coliform (USEPA, 2002a)
- 53 to 81 percent reduction in total suspended solids (and likely manganese) (USEPA, 2002a)
- 50 percent reduction in atrazine in wetlands with a retention time of 35 days (Moore, 1999)

5.10.2 Costs

Researchers of the use of constructed wetlands for animal waste management generally agree that these systems are a lower cost alternative compared to conventional treatment and land application technologies. Few studies, however, actually report the costs of constructing and maintaining these systems. A Canadian study (CPAAC, 1999) evaluated the use of a constructed wetland system for treating milk house washings as well as contaminated runoff from the feedlot area and manure storage pile of a dairy operation containing 135 head of dairy cattle. The treatment system was comprised of a pond/wetland/pond/wetland/filter strip treatment train that cost $492 per head to construct. Annual operating and maintenance costs of $6.75 per head include electricity to run pumps, maintenance of pumps and berms, and dredging the wetland cells once every 10 years. Reductions in final disposal costs due to reduced phosphorus content of the final effluent were $20.75 per head and offset the costs of constructing and maintaining the wetland in seven years.

Another study evaluated the use of constructed wetlands for treatment of a 3,520-head swine operation in North Carolina. Waste removal from the swine facility occurs via slatted floors to an underlying pit that is flushed once per week. This new treatment system incorporated a settling basin, constructed wetland, and storage pond treatment system prior to land application or return to the pit for flushing.

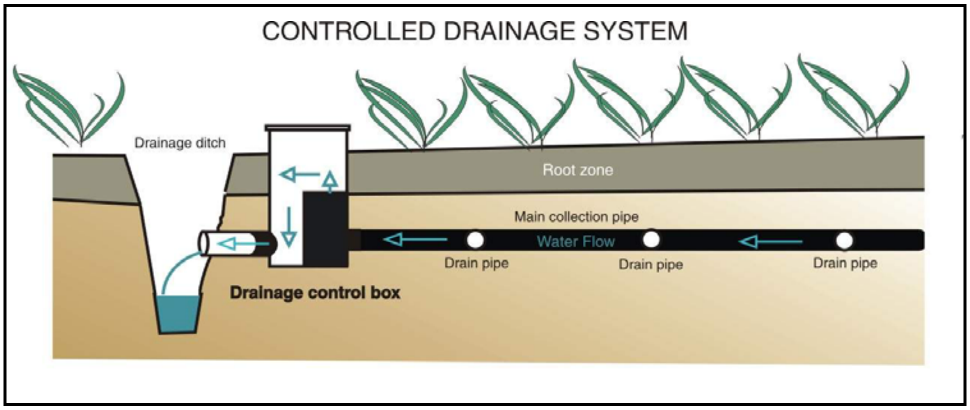
Capital and maintenance costs reported in the literature for dairy and swine operations are summarized per head in Table 5-15. No example studies including costs were available for beef cattle operations, which should generate less liquid waste than the other two operations. It would therefore be expected that constructing a wetland for beef cattle operation would cost less than for a dairy or swine operation.

Table 5-15. Costs Calculations for Constructed Wetlands.

Example	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Dairy farm	$492	-$14	$2.50
Swine operation	$103.75	$1.00	$4.50

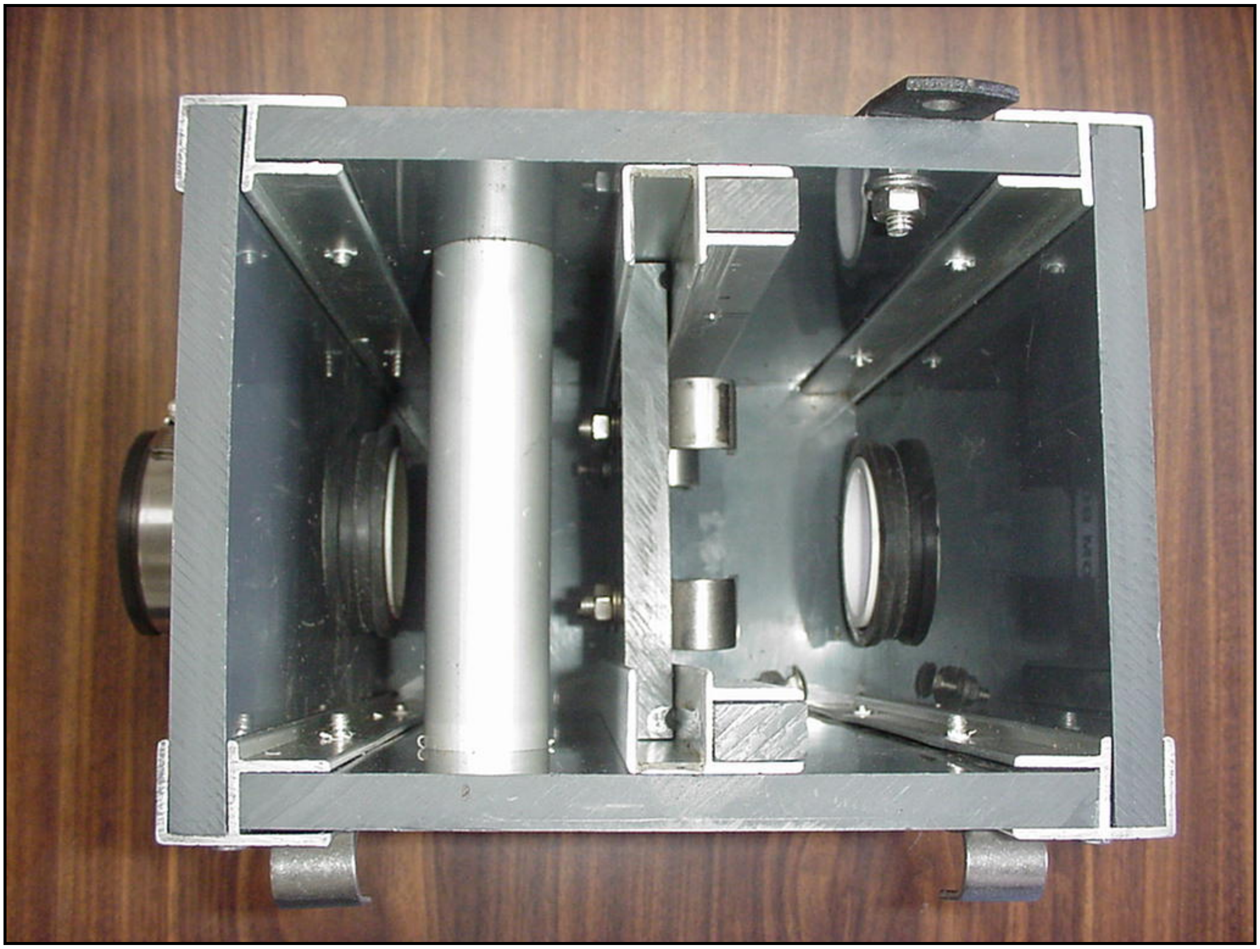
5.11 Controlled Drainage

A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 5-8 and Figure 5-9) allows for storage of the collected water to a predefined elevation. The stored water becomes a source of moisture for plants during dry conditions and undergoes biological, chemical, and physical processes that result in lower nutrient concentrations in the final effluent.



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 5-8. Controlled Drainage Structure for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 5-9. Interior View of a Drainage Control Structure with Adjustable Baffle Height.

The NRCS provides additional information on drainage management at:
http://efotg.nrcs.usda.gov/references/public/IL/554.pdf.

5.11.1 Effectiveness

Use of control structures on conventional tile drain systems in the coastal plains has resulted in reductions of total phosphorus loading of 35 percent (Gilliam et al., 1997). Researchers at the University of Illinois also report reductions in phosphorus loading with tile drainage control structures. Concentrations of phosphate were reduced by 82 percent, although total phosphorus reductions were not quantified in this study (Cooke, 2005). Going from a surface draining system to a tile drain system with outlet control reduces phosphorus loading by 65 percent (Gilliam et al., 1997).

Storage of tiled drained water for later use via subsurface irrigation has shown decreases in dissolved phosphorus loading of approximately 50 percent (Tan et al., 2003). However, accumulated salts in reuse water may eventually exceed plant tolerance and result in reduced crop yields. Mixing stored drain water with fresh water or alternating irrigation with natural precipitation events will reduce the negative impacts of reuse. Salinity thresholds for each crop should be considered and compared to irrigation water concentrations.

5.11.2 Costs

Tile mapping services are available in Illinois for approximately $2.25/ac using color infrared photography and can be used to assist farmers in identifying the exact location of their tile drain lines. Similar services are likely available through local vendors in the Little Wabash River II watershed. Cooke (2005) estimates that the cost of retrofitting tile drain systems with outlet control structures ranges from $20 to $40 per acre. Construction of new tile drain systems with outlet control is approximately $75/ac. The yield increases associated with installation of tile drain systems are expected to offset the cost of installation (Cooke, 2005). It is assumed that outlet control structures have a system life of 30 years. Cost assumptions for retrofitting and installation of new tile drain systems with outlet control devices are summarized in Table 5-16.

Table 5-16. Costs Calculations for Outlet Control Devices on Tile Drain Systems.

Item	Costs to Retrofit Existing Systems	Costs to Install a New System
Mapping Costs per Acre	$2.25	$0
Construction Costs	$20 to $40/ac	$75/ac
System Life (years)	30	30
Average Annual Costs	**$0.75 to $1.50/ac treated**	**$2.50/ac treated**

5.12 Proper Manure Handling, Collection, and Disposal

Animal operations are typically either pasture-based or confined, or sometimes a combination of the two. The operation type dictates the practices needed to manage manure from the facility. A pasture or open lot system with a relatively low density of animals (1 to 2 head of cattle per acre (USEPA, 2002a)) may not produce manure in quantities that require management for the protection of water quality. If excess manure is produced, then the manure will typically be scraped with a tractor to a storage bin constructed on a concrete surface. Stored manure can then be land applied when the ground is not frozen and precipitation forecasts are low. Rainfall runoff should be diverted around the storage facility with berms or grassed waterways. Runoff from the feedlot area is considered contaminated and is typically treated in a lagoon.

Confined facilities (typically dairy cattle, swine, and poultry operations) often collect manure in storage pits located under slatted floors. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied or transported offsite.

Final disposal of waste usually involves land application on the farm or transportation to another site. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

An example of a waste storage lagoon is shown in Figure 5-10.

(Photo courtesy of USDA NRCS.)

Figure 5-10. Waste Storage Lagoon.

The NRCS provides additional information on waste storage facilities and cover at
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 313 and 367

and on anaerobic lagoons at
http://efotg.nrcs.usda.gov/references/public/IL/IL-365_2004_09.pdf
http://efotg.nrcs.usda.gov/references/public/IL/IL-366_2004_09.pdf

5.12.1 Effectiveness

Though little change in total phosphorus or organic content have been reported, reductions in fecal coliform as a result of manure storage have been documented in two studies:

- 97 percent reduction in fecal coliform concentrations in runoff when manure is stored for at least 30 days prior to land application (Meals and Braun, 2006).
- 90 percent reduction in fecal coliform loading with the use of waste storage structures, ponds, and lagoons (USEPA, 2003).

5.12.2 Costs

Depending on whether or not the production facility is pasture-based or confined, manure is typically deposited in feedlots, around watering facilities, and within confined spaces such as housing units and milking parlors. Except for feedlots serving a low density of animals, each location will require the collection and transport of manure to a storage structure, holding pond, storage pit, or lagoon prior to final disposal.

Manure collected from open lots and watering areas is typically collected by a tractor equipped with a scraper. This manure is in solid form and is typically stored on a concrete pad surrounded by three walls that allow for stacking of contents. Depending on the climate, a roof may be required to protect the manure from frequent rainfall. Clean water from rooftops or up-grade areas should be diverted around waste stockpiles and heavy use areas with berms, grassed channels, or other means of conveyance (USEPA, 2003). Waste storage lagoons, pits, and above ground tanks are good options for large facilities. Methane gas recovered from anaerobic treatment processes can be used to generate electricity.

The NRCS (2003) has developed cost estimates for the various tasks and facilities typically used to transport, store, and dispose of manure. Table 5-17 summarizes the information contained in the NRCS report and lists the capital and operating/maintenance costs reported per head of animal. Annual maintenance costs were assumed 3 percent of capital costs except for gutter downspouts (assumed 10 percent to account for animals trampling the downspouts) and collection and transfer (assumed 15 percent to account for costs associated with additional fuel and labor). The costs presented as a range were given for various sizes of operations. The lower values reflect the costs per head for the larger operations which are able to spread out costs over more animals.

The full NRCS document can be viewed at
http://www.nrcs.usda.gov/Technical/land/pubs/cnmp1.html

The useful life for practices requiring construction is assumed to be 20 years. The total annualized costs were calculated by dividing the capital costs by 20 and adding the annual operation and maintenance costs. Prices are converted to year 2004 dollars.

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head.

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Collection and Transfer of Solid Manure, Liquid/Slurry Manure, and Contaminated Runoff				
Collection and transfer of manure solids (assuming a tractor must be purchased)	All operations with outside access and solid collection systems for layer houses	$130.50 - dairy cattle $92.50 - beef cattle $0 - layer[1] $37.00 - swine	$19.50 - dairy cattle $13.75 - beef cattle $0.04 - layer $5.50 - swine	$26.00 - dairy cattle $18.25 - beef cattle $0.04 - layer $7.25 - swine
Collection and transfer of liquid/slurry manure	Dairy, swine, and layer operations using a flush system	$160 to $200 - dairy cattle $.50 - layer $5.75 to $4.50 - swine	$12.25 - dairy cattle $0.03 - layer $0.25 - swine	$20.25 to 22.25 - dairy cattle $0.05 - layer $0.50 - swine
Collection and transfer of contaminated runoff using a berm with pipe outlet	Fattened cattle and confined heifers	$4 to $9 - cattle	$0.12 to 0.25 - cattle	$0.25 to $0.75 - cattle
Feedlot Upgrades for Cattle Operations Using Concentrated Feeding Areas				
Grading and installation of a concrete pad	Cattle on feed (fattened cattle and confined heifers)	$35 - cattle	$1 - cattle	$2.75 - cattle
Clean Water Diversions				
Roof runoff management: gutters and downspouts	Dairy and swine operations that allow outside access	$16 - dairy cattle $2.25 - swine	$1.60 - dairy cattle $0.25 - swine	$2.50 - dairy cattle $0.50 - swine
Earthen berm with underground pipe outlet	Fattened cattle and dairy operations	$25.25 to $34.50 - cattle	$0.75 to $1.00 - cattle	$2 to $2.75 - cattle
Earthen berm with surface outlet	Swine operations that allow outside access	$1 - swine	$0.03 - swine	$0.08 - swine
Grassed waterway	Fattened cattle and confined heifer operations: scrape and stack system	$0.50 to $1.50 - cattle	$0.02 to $0.04 - cattle	$0.05 to $0.12 - cattle

[1] Costs presented by NRCS (2003) as operating and maintenance only.

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Storage				
Liquid storage (contaminated runoff and wastewater)	Swine, dairy, and layer operations using flush systems (costs assume manure primarily managed as liquid)	$245 to $267 - dairy cattle $2 - layer $78.50 to $80 - swine	$7.25 - dairy cattle $0.06 - layer $2.50 - swine	$19.50 to $20.50 - dairy cattle $0.16 - layer $6.50 - swine
Slurry storage	Swine and dairy operations storing manure in pits beneath slatted floors (costs assume manure primarily managed as slurry)	$104 to $127 - dairy cattle $15.50 to $19.50 - swine	$3.25 to $3.75 - dairy cattle $0.50 - swine	$8.25 to $10.25 - dairy cattle $1.25 to $1.50 - swine
Runoff storage ponds (contaminated runoff)	All operations with outside access	$125.50 - dairy cattle $140 - beef cattle $23 - swine	$3.75 - dairy cattle $4.25 - beef cattle $0.75 - swine	$10 - dairy cattle $11.25 - beef cattle $2 - swine
Solid storage	All animal operations managing solid wastes (costs assume 100% of manure handled as solid)	$196 - dairy cattle $129 - beef cattle $1 - layer $14.25 - swine	$5.75 - dairy cattle $3.75 - beef cattle $0.03 - layer $0.50 - swine	$15.50 - dairy cattle $10.25 - beef cattle $0.25 - layer $1.25 - swine

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Final Disposal				
Pumping and land application of liquid/slurry	Operations handling manure primarily as liquid or slurry.	Land application costs are listed as capital plus operating for final disposal and are listed as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. Pumping costs were added to the land application costs as described in the document.		$19.50 - dairy cattle $0.25 - layer $2.75 - swine
Pumping and land application of contaminated runoff	Operations with outside feedlots and manure handled primarily as solid	Pumping costs and land application costs based on information in NRCS, 2003. Assuming a typical phosphorus concentration in contaminated runoff of 80 mg/L to determine acres of land required for agronomic application (Kizil and Lindley, 2000). Costs for beef cattle listed as range representing variations in number of animals and manure handling systems (NRCS, 2003). Only one type and size of dairy and swine operation were included in the NRCS document.		$4 - dairy cattle $3.75 - beef cattle $4.50 - swine
Land application of solid manure	Operations handling manure primarily as solid	Land application costs are listed as capital plus operating for final disposal and are given as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. No pumping costs are required for solid manure.		$11 - dairy cattle $0.25 - layer $1.50 - swine $10.25 - fattened cattle

5.13 Composting

Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land. Like manure storage areas, composting facilities should be located on dry, flat, elevated land at least 100 feet from streams. The landowner should coordinate with local NRCS staff to determine the appropriate design for a composting facility based on the amount of manure generated. Extension agents can also help landowners achieve the ideal nutrient ratios, oxygen levels, and moisture conditions for composting on their site.

Composting can be accomplished by simply constructing a heap of the material, forming composting windrows, or by constructing one or more bins to hold the material. Heaps should be 3 feet wide and 5 feet high with the length depending on the amount of manure being composted. Compost does not have to be turned, but turning will facilitate the composting process (University of Missouri, 1993; PSU, 2005). Machinery required for composting includes a tractor, manure spreader, and front-end loader (Davis and Swinker, 2004). Figure 5-11 shows a poultry litter composting facility.

(Photo courtesy of USDA NRCS.)

Figure 5-11. Poultry Litter Composting Facility.

The NRCS provides additional information on composting facilities at
http://efotg.nrcs.usda.gov/references/public/IL/IL-317rev9-04.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/neh637c2.pdf

5.13.1 Effectiveness

Composting stabilizes the organic content of manure and reduces the volume that needs to be disposed of. In addition, the following reductions in loading are reported:

- 99 percent reduction of fecal coliform concentrations as a result of the heat produced during the composting process (Larney et. al., 2003).
- 56 percent reduction in runoff volumes and 68 percent reduction in sediment (and likely manganese) as a result of improved soil infiltration following application of composted manure (HRWCI, 2005).

5.13.2 Costs

The costs for developing a composting system include site development costs (storage sheds, concrete pads, runoff diversions, etc.), purchasing windrow turners if that system is chosen, and labor and fuel required to form and turn the piles. Cost estimates for composting systems have not been well documented and show a wide variation even for the same type of system. The NRCS is in the process of developing cost estimates for composting and other alternative manure applications in Part II of the document discussed in Section 5.12.2. Once published, these estimates should provide a good comparison with the costs summarized for the Midwest region in Table 5-17. For now, costs are presented in Table 5-18 based on studies conducted in Wisconsin, Canada, and Indiana.

Researchers in Wisconsin estimated the costs of a windrow composting system using four combinations of machinery and labor (CIAS, 1996). These costs included collection and transfer of excreted material, formation of the windrow pile, turning the pile, and reloading the compost for final disposal. The Wisconsin study was based on a small dairy operation (60 head). Costs for beef cattle, swine, and layer hens were calculated based on animal units and handling weights of solid manure (NRCS, 2003). Equipment life is assumed 20 years. The costs presented in the Wisconsin study are much higher than those presented in Table 5-18 for collection, transfer, and storage of solid manure. However, the Wisconsin study presented a cost comparison of the windrow system to stacking on a remote concrete slab, and these estimates were approximately four and half times higher than the values summarized by NRCS. It is likely that the single data set used for the Wisconsin study is not representative of typical costs.

Two studies have been conducted in Canada regarding the costs of composting. The University of Alberta summarized the per ton costs of windrow composting with a front end load compared to a windrow turner (University of Alberta, 2000). The Alberta Government presented a per ton estimate for a windrow system with turner: this estimate is quite different than the University of Alberta study. These per ton costs were converted to costs per head of dairy cattle, beef cattle, swine, and layer hens based on the manure generation and handling weights presented by NRCS (2003).

In 2001, the USEPA released a draft report titled “Alternative Technologies/Uses for Manure.” This report summarizes results from a Purdue University research farm operating a 400-cow dairy operation. This farm also utilizes a windrow system with turner.

Table 5-18 summarizes the cost estimates presented in each of the studies for the various composting systems. None of these estimates include the final costs of land application, which should be similar to those listed for disposal of solid manure in Table 5-17, as no phosphorus losses occur during the composting process.

Table 5-18. Costs Calculations for Manure Composting.

Equipment Used	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
2004 Costs Estimated from CIAS, 1996 – Wisconsin Study			
Windrow composting with front-end loader	$324.25 - dairy cattle $213.50 - beef cattle $1.75 - layer $23.75 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$196 - dairy cattle $129.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with bulldozer	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$193.25 - dairy cattle $127.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with custom-hire compost turner	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$215.25 - dairy cattle $141.75 - beef cattle $1.25 - layer $15.75 - swine	$228.75 - dairy cattle $150.50 - beef cattle $1.25 - layer $16.75 - swine
Windrow composting with purchased compost turner	$617 - dairy cattle $406.25 - beef cattle $3.50 - layer $45.25 - swine	$234.25 - dairy cattle $154.25 - beef cattle $1.25 - layer $17.25 - swine	$265.25 - dairy cattle $174.75 - beef cattle $1.50 - layer $19.50 - swine
2004 Costs Estimated from University of Alberta, 2000			
Windrow composting with front-end loader	Study presented annualized costs per ton of manure composted.		$23.75 to $47.50 - dairy cattle $15.75 to $31.25 - beef cattle $0.13 to $0.25 - layer $1.75 to $3.50 - swine
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$71.25 to $142.50 - dairy cattle $47.00 to $94.00 - beef cattle $0.50 to $0.75 - layer $5.25 to $10.50 - swine
2004 Costs Estimated from Alberta Government, 2004			
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$31.50 - dairy cattle $20.75 - beef cattle $0.25 - layer $2.25 - swine
2004 Costs Estimated from USEPA, 2001 Draft			
Windrow composting with compost turner	Study presented annualized costs per dairy cow.		$15.50 - dairy cattle $10.25 - beef cattle $0.09 - layer $1.25 - swine

5.14 Feeding Strategies

Use of dietary supplements, genetically enhanced feed, and specialized diets has been shown to reduce the nitrogen and phosphorus content of manure either by reducing the quantity of nutrients consumed or by increasing the digestibility of the nutrients. Manure with a lower nutrient content can be applied at higher rates to crop land, thus reducing transportation and disposal costs for excess manure.

Manure typically has high phosphorus content relative to plant requirements compared to its nitrogen content. Nitrogen losses due to ammonia volatilization begin immediately following waste excretion and continue throughout the stabilization process, whereas phosphorus remains conserved. In addition, most livestock animals are not capable of efficiently digesting phosphorus, so a large percentage passes through the animal undigested. Compounding the problem is over-supplementation of phosphorus additives relative to nutritional guidelines, particularly for dairy cattle (USEPA, 2002a).

5.14.1 Effectiveness

Most feeding strategies work to reduce the phosphorus content of manure such that the end product has a more balanced ratio of nitrogen and phosphorus. Reducing the phosphorus content of manure will result in lower phosphorus concentrations in runoff and stream systems. Feeding strategies will indirectly impact dissolved oxygen concentrations by reducing eutrophication in streams and lakes. The USEPA (2002a) reports the following reductions in phosphorus manure content:

- 40 percent reduction in the phosphorus content of swine manure if the animals are fed low-phytate corn or maize-soybean diets or given a phytase enzyme to increase assimilation by the animal.
- 30 to 50 percent reduction in the phosphorus content of poultry manure by supplementing feed with the phytase enzyme.

5.14.2 Costs

Several feeding strategies are available to reduce the phosphorus content of manure. Supplementing feed with the phytase enzyme increases the digestibility of phytate, which is difficult for animals to digest and is the form of phosphorus found in conventional feed products. Supplementing with phytase used to be expensive, but now is basically equivalent to the cost of the dietary phosphorus supplements that are required when animals are fed traditional grains (Wenzel, 2002).

Another strategy is to feed animals low-phytate corn or barley which contains more phosphorus in forms available to the animal. Most animals fed low-phytate feed do not require additional phosphorus supplementation; the additional cost of the feed is expected to offset the cost of supplements. The third strategy is to stop over-supplementing animals with phosphorus. Reducing intake to dietary requirements established by the USDA may save dairy farmers $25 per year per cow (USEPA, 2002a). Final disposal costs for manure will likely also decrease since less land will be required during the application process.

5.15 Alternative Watering Systems

A primary management tool for pasture-based systems is supplying cattle with watering systems away from streams and riparian areas. Livestock producers who currently rely on streams to provide water for their animals must develop alternative watering systems, or controlled access systems, before they can exclude cattle from streams and riparian areas. One method of providing an alternative water source is the development of off-stream watering using wells with tank or trough systems. These systems are often highly successful, as cattle often prefer spring or well water to surface water sources.

Landowners should work with an agricultural extension agent to properly design and locate watering facilities. One option is to collect rainwater from building roofs (with gutters feeding into cisterns) and use this water for the animal watering system to reduce runoff and conserve water use (Tetra Tech, 2006).

Whether or not animals are allowed access to streams, the landowner should provide an alternative shady location and water source so that animals are encouraged to stay away from riparian areas.

Figure 5-12 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 5-12. Centralized Watering Tank.

The NRCS provides additional information on these alternative watering components:

Spring development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-574.pdf,
Well development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-642.pdf,
Pipeline:
http://efotg.nrcs.usda.gov/references/public/IL/516.pdf,
Watering facilities (trough, barrel, etc.):
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 614

5.15.1 Effectiveness

The USEPA (2003) reports the following pollutant load reductions achieved by supplying cattle with alternative watering locations and excluding cattle from the stream channel by structural or vegetative barrier:

- 15 to 49 percent reductions in total phosphorus loading
- 29 to 46 percent reductions in fecal coliform loading.

Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Prohibiting access to the stream channels will also prevent streambank trampling, decrease bank erosion, protect bank vegetation, and reduce the loading of organic material to the streams. As a result, dissolved oxygen concentrations will likely increase and manganese loads associated with bank erosion will decrease.

5.15.2 Costs

Alternative drinking water can be supplied by installing a well in the pasture area, pumping water from a nearby stream to a storage tank, developing springs away from the stream corridor, or piping water from an existing water supply. For pasture areas without access to an existing water supply, the most reliable alternative is installation of a well, which ensures continuous flow and water quality for the cattle (NRCS, 2003). Assuming a well depth of 250 ft and a cost of installation of $22.50 per ft, the cost to install a well is approximately, $5,625 per well. The well pump would be sized to deliver adequate water supply for the existing herd size. For a herd of 150 cattle, the price per head for installation was estimated at $37.50.

After installation of the well or extension of the existing water supply, a water storage device is required to provide the cattle access to the water. Storage devices include troughs or tanks. NRCS (2003) lists the costs of storage devices at $23 per head.

Annual operating costs to run the well pump range from $9 to $22 per year for electricity (USEPA, 2003; Marsh, 2001), or up to $0.15 per head. Table 5-19 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 5-19. Costs Calculations for Alternative Watering Facilities.

Item	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Installation of well	$37.50	$0	$2
Storage container	$23	$0	$1
Electricity for well pump	$0	$0.15	$0.15
Total system costs	**$60.50**	**$0.15**	**$3.15**

5.16 Cattle Exclusion from Streams

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biological oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in Figure 5-13 and Figure 5-14.

Figure 5-13. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 5-14. Cattle-Induced Streambank Mass Wasting and Deposition of Manure into Stream.

An example of proper exclusion and the positive impacts it has on the stream channel are shown in Figure 5-15.

(Photo courtesy of USDA NRCS.)

Figure 5-15. Stream Protected from Sheep by Fencing.

The NRCS provides additional information on fencing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 382

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 5-16 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Photo courtesy of USDA NRCS.)

Figure 5-16. Restricted Cattle Access Point with Reinforced Banks.

The NRCS provides additional information on use exclusion and controlled access at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 472

5.16.1 Effectiveness

Fencing cattle from streams and riparian areas using vegetative or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. As a result, manganese (associated with eroded sediment) and BOD_5 loads will decrease. The USEPA (2003) reports the following reductions in phosphorus and fecal coliform loading as a result of cattle exclusion practices:

- 15 to 49 percent reductions in total phosphorus loading
- 29 to 46 percent reductions in fecal coliform loading.

5.16.2 Costs

The costs of excluding cattle from streams depends more on the length of channel that needs to be protected than the number of animals on site. Fencing may also be used in a grazing land protection operation to control cattle access to individual plots. The system life of wire fences is reported as 20 years; the high tensile fence materials have a reported system life of 25 years (Iowa State University, 2005). NRCS reports that the average operation needs approximately 35 ft of additional fencing per head to protect grazing lands and streams. Table 5-20 presents the capital, maintenance, and annualized costs for four fencing materials based on the NRCS assumptions.

Table 5-20. Installation and Maintenance Costs of Fencing Material.

Material	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Woven Wire	$43.50	$3.50	$5.75
Barbed Wire	$33.50	$2.75	$4.50
High Tensile (non-electric) 8-strand	$30.75	$1.75	$3.00
High Tensile (electric) 5-strand	$23.00	$1.50	$2.50

5.17 Grazing Land Management

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 5-17 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Photo courtesy of USDA NRCS.)

Figure 5-17. Example of a Well Managed Grazing System.

The NRCS provides additional information on prescribed grazing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 528A

And on grazing practices in general at:
http://www.glti.nrcs.usda.gov/technical/publications/nrph.html

5.17.1 Effectiveness

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. Increased ground cover will also reduce transport of sediment-bound manganese. Dissolved oxygen concentrations in streams will likely improve as the concentrations of BOD_5 in runoff are reduced proportionally with the change in number of cattle per acre.

The following reductions in loading are reported in the literature:

- 49 to 60 percent reduction in total phosphorus loading
- 40 percent reduction in fecal coliform loading as a result of grazing land protection measures (USEPA, 2003)
- 90 percent reduction in fecal coliform loading with rotational grazing (Government of Alberta, 2007).

5.17.2 Costs

The costs associated with grazing land protection include acquiring additional land if current animal densities are too high (or reducing the number of animals maintained), fencing and seeding costs, and developing alternative water sources. Establishment of vegetation for pasture areas costs from $39/ac to $69/ac based on data presented in the EPA nonpoint source guidance for agriculture (USEPA, 2003). Annual costs for maintaining vegetative cover will likely range from $6/ac to $11/ac (USEPA, 2003). If cattle are not allowed to graze plots to the point of requiring revegetation, the cost of grazing land protection may be covered by the fencing and alternative watering strategies discussed above.

5.18 Inlake Controls

For lakes experiencing high rates of phosphorus or manganese inputs from bottom sediments, several management measures are available to control internal loading. Hypolimnetic (bottom water) aeration involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic conditions at the sediment-water interface.

Hypolimnetic aeration effectiveness in reducing phosphorus concentration depends in part on the presence of sufficient iron to bind phosphorus in the oxygenated waters. A mean hypolimnetic iron:phosphorus ratio greater than 3.0 is optimal to promote iron phosphate precipitation (Stauffer, 1981). The iron:phosphorus ratio in the sediments should be greater than 15 to bind phosphorus (Welch, 1992). Aeration of bottom waters will also likely inhibit the release of manganese from bottom sediments in lakes.

Phosphorus inactivation by aluminum addition (specifically aluminum sulfate or alum) to lakes has been the most widely-used technique to control internal phosphorus loading. Alum forms a polymer that binds phosphorus and organic matter. The aluminum hydroxide-phosphate complex (commonly called alum floc) is insoluble and settles to the bottom, carrying suspended and colloidal particles with it. Once on the sediment surface, alum floc retards phosphate diffusion from the sediment to the water (Cooke et al., 1993).

Artificial circulation is the induced mixing of the lake, usually through the input of compressed air, which forms bubbles that act as airlift pumps. The increased circulation raises the temperature of the whole lake (Cooke et al., 1993) and chemically oxidizes substances throughout the water column (Pastorak et al., 1981 and 1982), reducing the release of phosphorus and manganese from the sediments to the overlying water, and enlarging the suitable habitat for aerobic animals.

5.18.1 Effectiveness

If lake sediments are a significant source of phosphorus or manganese in the Little Wabash River II watershed, then these inlake controls should reduce the internal loading significantly. Without data to quantify the internal load for each lake, it is difficult to estimate the reduction in loading that may be seen with these controls.

5.18.2 Costs

In general, inlake controls are expensive. For comparison with the agricultural cost estimates, the inlake controls have been converted to year 2004 dollars assuming an average annual inflation rate of 3 percent.

Hypolimnetic aerators may decrease internal loading of both phosphorus and manganese. The number and size of hypolimnetic aerators used in a waterbody depend on lake morphology, bathymetry, and hypolimnetic oxygen demand. Total cost for successful systems has ranged from $170,000 to $1.7 million (Tetra Tech, 2002). USEPA (1993) reports initial costs ranging from $340,000 to $830,000 plus annual operating costs of $60,000. System life is assumed to be 20 years.

Alum treatments are effective on average for approximately 8 years per application and can reduce internal phosphorus loading by 80 percent. Treatment cost ranges from $290/ac to $720/ac (WIDNR, 2003).

Dierberg and Williams (1989) cite mean initial and annual costs for 13 artificial circulation projects in Florida of $440/ac and $190/ac/yr, respectively. The system life is assumed to be 20 years.

0 summarizes the cost analyses for the three inlake management measures. The final column lists the annualized cost per lake surface area treated. The costs of alum treatment for Fairfield Reservoir are not included because this lake is not listed for phosphorus.

Table 5-21. Cost Comparison of Inlake Controls.

Control	Construction or Application Cost	Annual Maintenance Cost	Annualized Costs $/ac/yr
Newton Lake (1,750 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$45 to $58
Alum Treatment	$508,000 to $1,260,000	$0	$36 to $90
Artificial Circulation	$770,000	$333,000	$212
Fairfield Reservoir (16 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$4,810 to $6,340
Artificial Circulation	$7,000	$3,000	$209

5.19 Atrazine BMPs

Several strategies exist to reduce atrazine migration from corn and grain applications. Similar to nutrient management planning, most of these BMPs rely on rates, methods, and timing of application. Researchers at Kansas State have found that 90 percent of atrazine losses occur in the dissolved form during runoff events (Kansas State University, 2007; University of Nebraska, 1996).

5.19.1 Effectiveness

The effectiveness of the atrazine control strategies are summarized below (Kansas State University, 2007):

- Incorporating atrazine into the top 2 inches of soil will reduce loading by 60 to 75 percent.
- Applying atrazine between November 1 and April 15 when rainfall events are less frequent and intense reduces loading by 50 percent.
- Post emergence applications of atrazine require 60 to 70 percent less applied product than application to soil and result in 50 to 70 percent reductions in atrazine loading. Post emergence applications are also more successful for weed control.
- Reducing the application rates of soil-applied atrazine by one-third may reduce loading by 33 percent. Use of other herbicides or weed control strategies may be necessary to control nuisance growth.
- Applying one-half to two-thirds of the application prior to April 15 and the remainder before or immediately following planting will reduce atrazine loads by 25 percent.
- Using non-atrazine herbicides will reduce atrazine in runoff by 100 percent.
- Integrated pest management strategies employing variable rate herbicide applications, crop rotation, pre-plant tillage, cover crops, row cultivation, hybrid selection, planting techniques, etc., may reduce atrazine loading by 0 to 100 percent.
- Band application of atrazine with ridge till cultivation may reduce loads by 50 to 67 percent.
- Riparian areas and filter strips that allow for water infiltration may reduce loads by 25 to 35 percent.
- Using proper mixing, application, and disposal practices will prevent additional environmental impacts.

5.19.2 Costs

The costs of implementing atrazine BMPs will vary for each farm based on the current application methods and the type of tillage system employed. The BMPs that allow for reduced application rates may lead to a net savings in herbicide costs. Splitting applications may or may not cost more depending on whether or not the savings from reduced application rates offsets the expense of additional trips to the field. Because atrazine typically costs less than other herbicides, offsetting application rates with other products may increase overall costs.

5.20 Streambank and Shoreline Erosion BMPs

Reducing erosion of streambanks and lake shore areas will reduce phosphorus and manganese loading and improve temperature and dissolved oxygen conditions by allowing vegetation to establish. The filter strips and riparian area BMPs discussed in Sections 5.7 and 5.9 and the agricultural BMPs that reduce the quantity and volume of runoff (Sections 5.5, 5.6, 5.8 5.10, and 5.11) or prevent cattle access (Section 5.16) will all provide some level of streambank and lake shore erosion protection.

In addition, the streambanks and lake shores in the watershed should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from runoff areas can be mitigated by infiltration in grassed waterways and passage of runoff through filter strips.

5.20.1 Effectiveness

Because the extent of streambank and lake shore erosion has not yet been quantified, the effectiveness of erosion control BMPs is difficult to estimate. The benefits of BMPs that offer stream bank protection and runoff control are therefore underestimated in this report.

5.20.2 Costs

Costs associated with the BMPs that offer secondary benefits to streambank and lake erosion are discussed separately for each BMP in Sections 5.5, 5.6, 5.7, 5.8, 5.9,5.10, 5.11, and 5.16.

5.21 Stream Restoration

Stream restoration activities usually focus on improving aquatic habitat, but can also be used to increase the amount of reaeration from the atmosphere to the water. A proper restoration effort will involve an upfront design specific to the conditions of the reach being restored. Stagnant, slow moving, and deep waters typically have relatively low rates of reaeration. Restorations aimed at increasing reaeration must balance habitat needs (which include pools of deeper water) with sections of more shallow, faster flowing water. Adding structures to increase turbulence and removing excessive tree fall may be incorporated in the restoration plan.

Stream restoration differs from riparian buffer restoration in that the shape or features within the stream channel are altered, not the land adjacent to the stream channel. Of course, a stream restoration may also include restoration of the riparian corridor as well.

The effectiveness and costs of stream restorations are site specific and highly variable. Watershed planners and water resource engineers should be utilized to determine the reaches where restoration will result in the most benefit for the watershed as a whole.

6.0 PRIORITIZATION OF IMPLEMENTATION

With the exception of total phosphorus, the water quality impairments in the Little Wabash River II watershed occur throughout the drainage area. This section of the plan will summarize the estimated loads for each impairment and the effectiveness of the BMPs discussed in Section 5.0. Finally, a prioritization of implementation will be discussed.

6.1 Summary of Pollutant Loads in the Little Wabash River II Watershed

6.1.1 Total Phosphorus

Phosphorus loads in the watershed were summarized for each major source in the Newton Lake watershed because that is the only waterbody in violation of the numeric standard. The estimated annual load of phosphorus in the watershed is summarized in Table 6-1. Of the loads that can be quantified, animal operations comprise approximately 90 percent with crop production making up most of the remainder. The sparse density of septic systems in the watershed results in a relatively low contribution from this source. Loads from point source dischargers cannot be quantified because monitoring for total phosphorus in discharge effluent is not currently required. Similarly, data are not available to estimate loads from streambank and lake shore erosion or resuspension from lake bottom sediments. Note that the loads presented in Table 6-1 are potential loads from each source and do not account for current management that may exist in the watershed.

Table 6-1. Potential Phosphorus Loads in the Newton Lake Watershed.

Source	Load (lb/yr)
Point source dischargers	Unknown
Onsite wastewater treatment systems	39 to 336
Crop production	8,825 to 26,475
Animal operations	204,215
Streambank and lake shore erosion	Unknown
Internal loading from lake bottom sediments	Unknown

6.1.2 Biological Oxygen Demand

The dissolved oxygen impairments in the Little Wabash River II watershed may be due to degradation of organic material, decreased canopy cover, high temperatures, low flows, or algal respiration during night time hours. The only quantifiable cause of impairment is the amount of degradable organic material in the system, which may be described by the five day biochemical oxygen demand (BOD_5). Table 6-2 summarizes the daily BOD_5 loads in the watershed. Again, animal operations are the most significant contributor to BOD_5 loads. Treatment of wastewater likely comprises the remainder of the load. Note that the load from animal operations represents the potential load from this source and does not account for management measures currently in place.

Table 6-2. Potential BOD_5 Loads in the Little Wabash River II Watershed.

Source	Load (lb/d)
Point source dischargers[1]	3,300
Onsite wastewater treatment systems	159 to 894
Animal operations	176,255

[1] The load from point source dischargers is based on permit data for a select number of dischargers in the watershed. Loads may be overestimated or underestimated because some facilities may discharge less than the permit limits and some facilities are not represented due to lack of specified permit limits.

6.1.3 Manganese

Manganese impairments occur throughout the Little Wabash River II watershed. Natural background loading and streambank and lake shore erosion likely contribute some of this loading, but crop production, which tends to increase rates of erosion over large land areas, is likely the main contributor. Under certain circumstances, release of manganese from lake bottom sediments may also add to the concentrations in lakes and streams downstream of water release structures. The only lake in this watershed impaired by manganese (Fairfield Reservoir) has a short residence time and shallow average depth. These conditions typically do not allow for excessive release of manganese from the sediments.

The only load that could be estimated for this parameter is the load from crop production. Estimating loads from the other potential sources will require an intensive sampling effort. The estimated daily loads are summarized in Table 6-3.

Table 6-3. Potential Manganese Loads in the Little Wabash River II Watershed.

Source	Load (lb/d)
Point source dischargers	Unknown
Onsite wastewater treatment systems	Unknown
Crop production	147 to 7,360
Animal operations	Unknown
Streambank and lake shore erosion	Unknown
Internal loading from lake bottom sediments	Unknown

6.1.4 Atrazine

Atrazine impairments occur throughout the Little Wabash River II watershed, and the only source is crop production. Estimating the loads from this source is not possible without detailed information concerning the rates, methods, and timing of application from each farm in the drainage area.

6.1.5 Fecal Coliform

Excursions of the fecal coliform water quality standard occur throughout the Little Wabash River II Watershed. Likely sources of fecal coliform include point source dischargers (both primary effluent and combined sewer overflows), onsite wastewater treatment systems, and animal operations. Additional sources may include wildlife and domesticated animals. Table 6-4 summarizes the loads from sources in this watershed. Based on the available data, most of the load is from animal operations; however, these estimates do not account for current management practices that may attenuate the delivery of loads to surface waters.

Table 6-4. Potential Fecal Coliform Loads in the Little Wabash River II Watershed.

Source	Load (cfu/d)
Point source dischargers	Unknown
Onsite wastewater treatment systems	2.96E+12 to 2.54E+15
Animal operations	9.34E+17

6.2 Summary of BMPs for Agricultural Operations

Based on the available data, crop production and animal operations contribute the majority of loading for each of the impairments in this watershed. The BMPs that are applicable to agricultural operations are summarized in Table 6-5 and include the percent reductions for each of the five parameters as well as additional information concerning streambank protection and additional impacts on dissolved oxygen. If a BMP is not expected to significantly reduce loading of a specific parameter, then the reduction is labeled not applicable (“na”). If a BMP is expected to reduce pollutant loading, but no studies were found to quantify the reduction, then the reduction is labeled “unknown.”

BMPs managing pollutant loads from other sources in the watershed are discussed individually in Section 5.0.

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Table 6-5. Summary of BMPs Reducing Impairments Due to Agricultural Operations.

BMP	Phosphorus Reduction (percent)	BOD_5 Reduction (percent)	Manganese Reduction (percent)	Atrazine Reduction (percent)	Fecal Coliform Reduction (percent)	Additional Benefits for Stream Health and Dissolved Oxygen Impairments
Nutrient Management Plans	20 to 50	na	na	na	na	Reducing nutrient loads to streams may reduce algal growth and related dissolved oxygen problems.
Conservation Tillage	68 to 76	na	50 to 90	67 to 90	na	Reduces runoff losses by 69 percent, which may reduce rates of streambank erosion.
Cover Crops	70 to 85	na	90	unknown	na	Reduces runoff losses by 50 percent, which may reduce rates of streambank erosion.
Filter Strips	65	unknown	65	11 to 100	55 to 87	Slows rates of runoff and may reduce volume via infiltration. May reduce rates of streambank erosion.
Grassed Waterways	30	unknown	68	25 to 35	5	Slows rates of runoff and may reduce volume via infiltration. May reduce rates of streambank erosion.
Riparian Buffers (30 ft wide)	25 to 30	unknown	70 to 90	80 to 90 (width not specified in study)	34 to 74	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Riparian Buffers (60 to 90 ft wide)	70 to 80	unknown	unknown		unknown	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Riparian Buffers (200 ft wide)	unknown	62	unknown		87	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Constructed Wetlands	42	59 to 80	53 to 81	50	92	Slows runoff and may reduce quantity via infiltration, evaporation, and transpiration.
Controlled Drainage (new tile system)	65	na	na	na	na	Reduces peak flow volumes and velocities by storing water; may allow for volume reduction via transpiration.
Controlled Drainage (retrofit tile system)	35	na	na	na	na	Reduces peak flow volumes and velocities by storing water; may allow for volume reduction via transpiration.

Table 6-5. (Cont.) Summary of BMPs Reducing Impairments Due to Agricultural Operations.

BMP	Phosphorus Reduction (percent)	BOD_5 Reduction (percent)	Manganese Reduction (percent)	Atrazine Reduction (percent)	Fecal Coliform Reduction (percent)	Additional Benefits for Stream Health and Dissolved Oxygen Impairments
Proper Manure Handling, Collection, and Disposal	unknown	unknown	na	na	90 to 97	Reduces loads of nutrients and biodegradable organic material entering waterways which may improve dissolved oxygen concentrations.
Manure Composting	na	unknown	na	na	99	Stabilized manure that reaches waterbodies will degrade more slowly and not consume oxygen as quickly as conventional manure.
Application of Composted Manure	na	na	68	unknown	na	Application of composted manure improves soil infiltration and may reduce runoff volumes by 56 percent, potentially reducing rates of streambank erosion.
Feeding Strategies	30 to 50	na	na	na	na	Feeding strategies that reduce the phosphorus content of manure may improve dissolved oxygen conditions by reducing eutrophication in streams and lakes.
Alternative Watering Systems with Cattle Exclusion from Streams	15 to 49	unknown	unknown	na	29 to 46	Prevents streambank trampling and therefore decreases loads of manganese to the stream. Reduces direct deposition of manure into stream channel, which reduces loads of BOD_5, nutrients, and fecal coliform.
Grazing Land Management	49 to 60	unknown	unknown	na	40 to 90	Increased vegetative ground cover will reduce soil erosion and associated manganese and improve infiltration which should reduce runoff volumes. Improvements in dissolved oxygen concentrations should occur as a result of lower concentrations of BOD_5 in the runoff (reduced proportionally by the change in number of cattle per acre.)
Inlake Controls	variable	unknown	variable	na	na	May have impacts on dissolved oxygen balances downstream of water release structures.
Atrazine BMPs	na	na	na	0 to 100	na	Reducing atrazine loads to streams may improve stream health by lowering toxicity to aquatic animals.

6.3 Use of BMPs to Meet Water Quality Goals

The listed reaches in the Little Wabash River II watershed require varying degrees of reductions to meet water quality standards. This section briefly summarizes the required reductions for each segment and discusses the BMPs that will likely meet the water quality goals for the waterbody. Costs comparisons for each of the suggested BMPs are included at the end of the section. Where applicable, the watershed plan developed by the Upper Little Wabash River Ecosystem Partnership (ULWREP, 2007) is also discussed. The cutoff for this planning basin is just south of the boundary between Clay and Wayne counties. Appendix A includes a copy of this plan.

6.3.1 Newton Lake (RCR)

Newton Lake is impaired for phosphorus and requires a 61 percent reduction in loading to attain water quality standards. The majority of the loading likely originates from animal operations, particularly swine and cattle, and crop production areas. Achieving load reductions of at least 61 percent from animal operations can likely be attained by combining at least two of the following BMPs: animal feeding strategies, cattle exclusion from streams with alternative watering systems, or grazing land management.

Achieving at least a 61 percent load reduction from crop production areas can most easily be achieved by source reduction strategies such as conservation tillage or cover crops (cover crops may not achieve the reported reductions on artificially drained fields). Nutrient management planning would offer supplemental reductions (and possibly cost savings) but will likely not achieve the required reductions alone.

Treatment level BMPs such as filter strip, grassed waterways, constructed wetlands, and restoration of riparian buffers can mitigate phosphorus loads from both animal operations and crop production areas. These BMPs typically treat small drainage areas and are suggested as supplemental measures to be strategically located where needed.

The Newton Lake watershed is part of the Upper Little Wabash River Ecosystem Partnership. The subwatershed draining to the western arm of the lake was ranked among the top 10 (of 53) for having inadequately buffered streams and was prioritized for addressing point sources. The eastern subwatershed was ranked among the top 10 subwatersheds prioritized for comprehensive watershed improvements. The BMPs suggested above should improve conditions in these watersheds and help the partnership reach its goals.

6.3.2 Fairfield Reservoir (RCZJ)

Fairfield Reservoir is listed as impaired for manganese, and the TMDL requires a reduction in loading of 28 percent. The most likely source of manganese is crop production, though internal loading from bottom sediments may occur during anoxic conditions. If implemented widely throughout this watershed, conservation tillage practices could likely reduce manganese loading to levels protective of the water quality standard. Use of treatment level BMPs such as filter strips, grassed waterways, riparian buffers, and constructed wetlands, would also result in the required reductions if enough farmland drainage was treated. Fairfield Reservoir is not located in the Upper Little Wabash River Ecosystem Partnership.

6.3.3 Little Muddy Creek (CJA 02)

Segment CJA 02 of Little Muddy Creek is impaired for manganese. The TMDL reductions by flow regime are listed in Table 6-6; note that the load duration approach used to obtain these reductions is based on six water quality samples.

Table 6-6. TMDL Reductions for Impairments in Little Muddy Creek (CJA 02).

Parameter	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Manganese	No Data	25%	65%	94%	94%

The mostly likely source of manganese loading to this segment is crop production. Attaining the required reductions will likely require a combination of source reduction BMPs, such as conservation tillage, with treatment level BMPs such as filter strips, grassed waterways, riparian buffers, and constructed wetlands.

This drainage area is included in the Upper Little Wabash River Ecosystem Partnership, and has been targeted as a good candidate for expanding wetland areas due to the existing amount of wetlands available for connectivity and the percent of hydric soils in the subwatershed.

6.3.4 Elm River (CD 01)

Segment CD 01 of the Elm River is impaired by manganese, atrazine, and fecal coliform. Table 6-7 summarizes the required reductions for each parameter by flow regime.

Table 6-7. TMDL Reductions for Impairments in Elm River (CD 01).

Parameter	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Manganese	91%	94%	90%	96%	91%
Atrazine	No Data	68%	46%	15%	No Data
Fecal Coliform	98%	99%	98%	95%	2%

The manganese and atrazine impairments likely originate from crop production activities in the watershed. Reductions in atrazine loading can be attained by altering one or two of the application practices on each farm in the watershed. The manganese reductions, however, may require more than one BMP per farm to meet the targets. The most effective source reduction strategies for manganese are erosion control practices such as conservation tillage and cover crops. Cover crops are a more complicated BMP to implement and may not be as effective on farms that use artificial drainage systems.

Conservation tillage systems reportedly reduce sediment, and therefore associated manganese, by 50 to 90 percent. Treatment level BMPs will probably be needed to achieve the reductions required by the TMDL. These include filter strips, grassed waterways, riparian buffers, and constructed wetlands.

The fecal coliform reductions will likely require multiple BMPs to achieve. At animal operations, proper manure handling, collection, and disposal practices should be combined with composting manure, grazing land management, or alternative watering systems with cattle exclusion from streams. The following wastewater management practices are also suggested to meet the water quality standards in this segment: repairing or replacing failing onsite wastewater systems, disinfection of primary sewage treatment plant effluent at facilities that are not meeting permit requirements, and elimination of combined sewer overflows.

Segment CD 01 is not located in the Upper Little Wabash River Ecosystem Partnership.

6.3.5 Little Wabash River (C 22)

Segment C 22 of the Little Wabash River is listed for fecal coliform, which likely originates from animal operations, failing onsite wastewater systems, and sewage treatment plants. Obtaining the required reductions (Table 6-8) will require proper management of manure combined with composting practices, grazing land management, or cattle exclusion from streams with alternative water sources. In addition, some sewage treatment plants may need to be upgraded to include a disinfection step prior to discharge and should take all reasonable measures to reduce the volume and frequency of combined sewer overflows. Identifying and repairing or replacing failing onsite wastewater systems is also important.

The upper half of segment C 22 is located in the Upper Little Wabash River Ecosystem Partnership. This subwatershed has been prioritized for protection of species richness and expanding the area of wetland habitat.

Table 6-8. TMDL Reductions for Impairments in Little Wabash River (C 22).

Parameter	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Fecal Coliform	99%	>99%	76%	97%	0%

6.3.6 Little Wabash River (C 09)

Segment C 09 of the Little Wabash River is impaired for manganese, atrazine, and fecal coliform. TMDL reductions for these impairments are summarized in Table 6-9.

Table 6-9. TMDL Reductions for Impairments in Little Wabash River (C 09).

Parameter	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Manganese	76%	88%	74%	94%	83%
Atrazine	33%	60%	66%	0%	No Data
Fecal Coliform	76%	98%	0%	0%	0%

The manganese and atrazine impairments likely originate from crop production activities in the watershed. Altering one or two of the application practices for atrazine on each farm in the watershed will probably result in attainment of the water quality standard. The manganese reductions, however, will likely require more than one BMP per farm. It is suggested that conservation tillage be combined with strategically located treatment level BMPs such as filter strips, grassed waterways, riparian buffers, and constructed wetlands to meet these targets.

For this segment, the fecal coliform reductions are only required during moist conditions and high flows. Sources during these flow regimes may include manure wash-off from land surfaces, combined sewer overflows, primary sewage treatment plant effluent (with increased flow volumes due to infiltration), and effluent from failing onsite wastewater systems carried by increased volumes of groundwater. Meeting the fecal coliform reductions during these conditions might require upgrades at sewage treatment plants to disinfect primary effluent, repairing or replacing failing onsite wastewater systems, and properly managing manure from animal operations.

Segment C 09 is not located in the Upper Little Wabash River Ecosystem Partnership.

6.3.7 Little Wabash River (C 33)

Segment C 33 of the Little Wabash River is impaired for manganese and atrazine. Table 6-10 summarizes the TMDL reductions for these pollutants.

Table 6-10. TMDL Reductions for Impairments in Little Wabash River (C 33).

Parameter	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Manganese	No Data	52%	80%	92%	52%
Atrazine	No Data	57%	38%	37%	No Data

Manganese and atrazine loads to this segment likely originate from crop production. Attaining the manganese standards may be achieved by conservation tillage practices alone. If not, supplemental BMPs such as filter strips, grassed waterways, riparian buffers, and constructed wetlands will likely meet the target. Atrazine loads can easily be reduced by the required amounts by changing application methods, rates, and timing on fields that use this herbicide.

Segment C 33 is not located in the Upper Little Wabash River Ecosystem Partnership.

6.4 Implementation Strategy for Agricultural BMPs

The water quality impairments in the Little Wabash River II watershed can mainly be attributed to loading from animal operations, croplands, failing onsite wastewater treatment systems, and sewage treatment plants. This section discusses the most effective BMPs for each of these source categories in terms of effectiveness and costs. Because no TMDLs have been developed for dissolved oxygen, the BOD_5 reductions are not included in this discussion. All costs are presented in 2004 dollars as explained in Section 5.0.

6.4.1 Reducing Loads from Animal Operations

Managing pollutant loading from animal operations will likely be necessary to meet the TMDL requirements for reaches impaired by phosphorus or fecal coliform. The effectiveness of BMPs applicable to animal operations are summarized in Table 6-11. Cost data for poultry are omitted from this table since only 2 percent of pollutant loading is estimated to originate from this source. Data for poultry operations are included in the individual discussions of each applicable BMP presented in Section 5.0.

Table 6-11. BMPs for Animal Operations.

BMP	Phosphorus Reduction (percent)	Fecal Coliform Reduction (percent)	Annualized Costs
Proper Manure Handling, Collection, and Disposal	unknown	90 to 97	Varies by operation and waste handling system (see Table 5-17)
Manure Composting	na	99	$1.25 to $10.50 per head of swine $15.50 to $142.50 per head of dairy cattle $10.25 to $94 per head of beef or other cattle
Feeding Strategies	30 to 50	na	Variable – ranges from savings to net costs
Alternative Watering Systems with Cattle Exclusion from Streams	15 to 49	29 to 46	$5.50 to $9 per head of beef or other pastured cattle
Grazing Land Management	49 to 60	40 to 90	Variable – costs may be covered by fencing and alternative watering locations
Filter Strips	65	55 to 87	$4 to $6 per head of cattle
Grassed Waterways	30	5	$0.05 to $0.12 per head of cattle
Riparian Buffers (30 ft)	25 to 30	34 to 74	$0.03 per ft of channel
Riparian Buffers (60 to 90 ft)	70 to 80	Not reported	$0.05 to $0.07 per ft of channel
Riparian Buffers (200 ft)	Not reported	87	$0.16 per ft of channel
Constructed Wetlands	42	92	$2.50 per head of dairy cattle $4.50 per head of swine

None of the impaired waters in the Little Wabash River II watershed are listed for both phosphorus and fecal coliform. Management strategies at animal operations can therefore focus on the highest level of reduction for the pollutant of concern and the costs to implement. For operations in the Newton Lake watershed, the most cost-effective phosphorus BMPs (with known costs) are grassed waterways, filter strips, and constructed wetlands.

Operations located outside of the Newton Lake watershed should be more concerned with fecal coliform reductions. For swine and dairy operations, constructed wetlands offer cost-effective reductions. Filter strips are good choices for pastured cattle and milk house washings. Composting is highly effective, but generally more expensive than the other options.

The costs associated with grazing land management and feeding strategies are difficult to estimate, but may be covered by other costs (i.e., fencing) or result in net savings. Proper manure handling, storage, and disposal costs are highly variable depending on the waste handling system currently in place. Management practices associated with this BMP are required on large, permitted animal operations and should be strongly encouraged on smaller operations as well.

Riparian buffers offer excellent pollutant removal opportunities as well as stream protection benefits. These corridors should be restored or protected where feasible.

6.4.2 Reducing Loads from Crop Production

Lands used for crop production contribute phosphorus, manganese, and atrazine to the impaired waters. Table 6-12 summarizes the crop production BMPs that will most efficiently reduce loads from this source.

Table 6-12. BMPs for Crop Production.

BMP	Phosphorus Reduction (percent)	Manganese Reduction (percent)	Atrazine Reduction (percent)	AnnualizedCosts per Acre Treated
Nutrient Management Plans	20 to 50	na	na	$0.75 to $3.75
Conservation Tillage	68 to 76	50 to 90	67 to 90	$1.25 to $2.25
Cover Crops	70 to 85	90	Unknown	$19.25
Controlled Drainage (new)	65	na	na	$2.50
Controlled Drainage (retrofit)	35	na	na	$0.75 to $1.50
Altering Atrazine Applications, Methods, Timing	na	na	0 to 100	Ranges from net savings to costs
Filter Strips	65	65	11 to 100	$25
Grassed Waterways	30	68	25 to 35	$2 to $6
Riparian Buffers (30 ft)	25 to 30	70 to 90	80 to 90 (width not specified in study)	$20
Riparian Buffers (60 to 90 ft)	70 to 80	Not reported		$40 to $60
Riparian Buffers (200 ft)	Not reported	Not reported		$130

Conservation tillage practices offer the best reductions for all pollutants of concern and are among the least expensive options. Given that the impairments due to crop production occur throughout the watershed, encouraging conservation tillage practices should be a top priority. Other cost-effective measures that address all three pollutants include grassed waterways, cover crops, and filter strips. In addition, fertilizers and pesticides should be applied at proper rates when the chance of heavy rain is minimal. Incorporating or banding these chemicals will reduce transport off the field. Riparian buffers are highly effective but can only be used to treat a small drainage area near the stream channel.

6.4.3 Reducing Loads from Failing Onsite Wastewater Treatment Systems

Pollutants loads associated with failing onsite wastewater systems likely do not contribute to large scale impairments because the density is relatively low; however, localized impacts may be significant. Reducing the number of failing systems will require ongoing education of system owners, periodic inspections, regular maintenance, and replacing systems when needed. The costs associated with these measures were discussed in Section 5.3.2.

6.4.4 Reducing Loads from Sewage Treatment Plants

Sewage treatment plants may be contributing significant loads of phosphorus, BOD_5, and fecal coliform to the waterbodies in the Little Wabash River II watershed. It is not currently possible to estimate the loads from sewage treatment plants in the watershed because none of the facilities are required to monitor for total phosphorus and only about half monitor for fecal coliform. All facilities carry limits for BOD_5, so this parameter is monitored on a routine basis.

It is not likely that IEPA will require plants to upgrade beyond present treatment levels to reduce phosphorus and BOD_5 loading. The State may require facilities to submit fecal coliform data to determine if a disinfection exemption is still appropriate. The costs of disinfection were summarized in Section 5.1.2.

Sewage treatment plants may also be required to control combined sewer overflows through the nine minimum controls outline in Section 5.2. Relative to the cost of upgrading the sewage treatment plants to include a disinfection process, instituting the nine minimum controls for CSOs should be a minimal cost to each facility.

7.0 MEASURING AND DOCUMENTING PROGRESS

Managing impairments in the Little Wabash River II watershed will likely involve multiple agricultural BMPs to be used for crop production and animal operations. Continuing to monitor water quality in the waterbodies will determine whether or not managing the other sources of impairments, which may include failing onsite wastewater systems, point source discharges, oil mining operations, and inlake re-suspension, is necessary to bring the watershed into compliance.

The ULWREP (2007) is beginning to inventory BMPs in the northern half of the watershed. It is suggested that this effort be extended to the southern half as well. Tracking the implementation of BMPs while continuing to monitor water quality parameters will assist the stakeholders and public agencies in determining the effectiveness of this plan. If concentrations remain above the water quality standards, further encouragement of the use of BMPs across the watershed through education and incentives will be a priority. It may also be necessary to begin funding efforts for localized BMPs such as riparian buffer restoration.

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8.0 REASONABLE ASSURANCE

USEPA requires that a TMDL provide reasonable assurance that the required load reductions will be achieved and water quality will be restored. For this watershed, use of agricultural BMPs for crop production and animal operations are the primary management strategies to reach these goals. Participation of farmers and landowners is essential to improving water quality, but resistance to change and upfront cost may deter participation. Educational efforts and cost share programs will likely increase participation to levels needed to protect water quality.

Two of the incentive programs discussed below were administered under the 2002 Farm Bill, which expired September 30, 2007. The Conservation Reserve Program will continue to pay out existing contracts, but new enrollments will not be allowed until the bill is reinstated; no official date of reinstatement has been announced. Though the Environmental Quality Incentives Program was also part of the 2002 Farm Bill, it was extended beyond fiscal year 2007 by the Deficit Reduction Act of 2005 (Congressional Research Reports for the People, 2007).

8.1 Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to farmers and landowners who voluntarily implement resource conservation practices in the Little Wabash River II watershed. The most comprehensive is the NRCS Environmental Quality Incentives Program (EQIP) which offers cost sharing and incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands.

- The program will pay $10 for one year for each acre of farmland that is managed under a nutrient management plan (up to 400 acres per farmer).
- Use of vegetated filter strips will earn the farmer $100/ac/yr for three years (up to 50 acres per farmer).
- The program will also pay 60 percent of the cost to construct grassed waterways, riparian buffers, and windbreaks.
- Use of residue management will earn the farmer $15/ac for three years (up to 400 acres per farmer).
- Installation of drainage control structures on tile outlets will earn the farmer $5/ac/yr for three years for the effected drainage area as well as 60 percent of the cost of each structure.
- The program will pay 75 percent of the construction cost for a composting facility.
- Sixty percent of the fencing, controlled access points, spring and well development, pipeline, and watering facility costs are covered by the program.
- Waste storage facilities and covers for those facilities have a 50 percent cost share for construction.
- Prescribed grazing practices will earn the farmer $10/ac/yr for three years (up to 200 acres per farmer).

In order to participate in the EQIP cost share program, all BMPs must be constructed according to the specifications listed for each conservation practice.

The specifications and program information can be found online at:
http://www.il.nrcs.usda.gov/programs/eqip/cspractices.html.

8.2 Conservation Reserve Program (CRP)

The Farm Service Agency of the USDA supports the Conservation Reserve Program (CRP) which rents land converted from crop production to grass or forestland for the purposes of reducing erosion and protecting sensitive waters. This program is available to farmers who establish vegetated filter strips or grassed waterways. The program typically provides 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years.

More information about this program is available online at:
http://www.nrcs.usda.gov/programs/crp/

8.3 Conservation 2000

In 1995 the Illinois General Assembly passed the Conservation 2000 bill providing $100 million in funding over a 6-year period for the promotion of conservation efforts. In 1999, legislation was passed to extend the program through 2009. Conservation 2000 currently funds several programs applicable to the Little Wabash River II watershed through the Illinois Department of Agriculture.

General information concerning the Conservation 2000 Program can be found online at:
http://www.agr.state.il.us/Environment/conserv/

8.3.1 Conservation Practices Program (CPP)

The Conservation Practices Cost Share Program provides monetary incentives for conservation practices implemented on land eroding at one and one-half times or more the tolerable soil loss rate. Payments of up to 60 percent of initial costs are paid through the local SWCDs. Of the BMPs discussed in this plan, the program will cost share cover crops, filter strips, grassed waterways, no-till systems, and pasture planting. Other sediment control options such as contour farming and installation of stormwater ponds are also covered. Practices funded through this program must be maintained for at least 10 years.

More information concerning the Conservation Practices Program can be found online at:
http://www.agr.state.il.us/Environment/conserv/

8.3.2 Streambank Stabilization Restoration Program

Conservation 2000 also funds a streambank stabilization and restoration program aimed at restoring highly eroding streambanks. Research efforts are also funded to assess the effectiveness of vegetative and bioengineering techniques.

More information about this program is available online at:
http://dnr.state.il.us/orep/c2000/grants/proginfo.asp?id=20

8.3.3 Sustainable Agriculture Grant Program (SARE)

The Sustainable Agricultural Grant Program funds research, education, and outreach efforts for sustainable agricultural practices. Private landowners, organizations, educational, and governmental institutions are all eligible for participation in this program.

More information concerning the Sustainable Agricultural Grant Program can be found online at:
http://www.sare.org/grants/

8.4 Nonpoint Source Management Program (NSMP)

Illinois EPA receives federal funds through Section 319(h) of the Clean Water Act to help implement Illinois' Nonpoint Source (NPS) Pollution Management Program. The purpose of the Program is to work cooperatively with local units of government and other organizations toward the mutual goal of protecting the quality of water in Illinois by controlling NPS pollution. The program emphasizes funding for implementing cost-effective corrective and preventative best management practices (BMPs) on a watershed scale; funding is also available for BMPs on a non-watershed scale and the development of information/education NPS pollution control programs.

The maximum federal funding available is 60 percent, with the remaining 40 percent coming from local match. The program period is two years unless otherwise approved. This is a reimbursement program.

Section 319(h) funds are awarded for the purpose of implementing approved NPS management projects. The funding will be directed toward activities that result in the implementation of appropriate BMPs for the control of NPS pollution or to enhance the public's awareness of NPS pollution. Applications are accepted June 1 through August 1.

More information about this program is available online at:
http://www.epa.state.il.us/water/financial-assistance/non-point.html

8.5 Agricultural Loan Program

The Agricultural Loan Program offered through the Illinois State Treasury office provides low-interest loans to assist farmers who implement soil and water conservation practices. These loans will provide assistance for the construction, equipment, and maintenance costs that are not covered by cost share programs.

More information about this program is available online at:
http://www.state.il.us/TREAS/ProgramsServices.aspx

8.6 Illinois Conservation and Climate Initiative (ICCI)

The Illinois Conservation and Climate Initiative (ICCI) is a joint project of the State of Illinois and the Delta Pollution Prevention and Energy Efficiency (P2/E2) Center that allows farmers and landowners to earn carbon credits when they use conservation practices. These credits are then sold to companies or agencies that are committed to reducing their greenhouse gas emissions. Conservation tillage earns 0.5 metric tons (1.1 US ton) of carbon per acre per year (mt/ac/yr), grass plantings (applicable to filter strips and grassed waterways) earn 0.75 mt/ac/yr, and trees planted at a density of at least 250 stems per acre earn somewhere between 3.5 to 5.4 mt/ac/yr, depending on the species planted and age of the stand.

Carbon credits are currently selling at around $2.50 per mt. Current exchange rates are available online at http://chicagoclimatex.com. Administrative fees of $0.14/mt plus 8 percent are subtracted from the sale price.

Program enrollment occurs through the P2/E2 Center which can be found online at http://p2e2center.org/. The requirements of the program are verified by a third party before credits can be earned.

More information about carbon trading can be found online at:
http://illinoisclimate.org/

8.7 Upper Little Wabash River Ecosystem Partnership

The Upper Little Wabash River Ecosystem Partnership (ULWREP) has committed itself to helping farmers and landowners obtain grants for the implementation of BMPs that will improve stream and water quality as well as habitat (ULWREP, 2007). Several of the BMPs discussed in this plan will be eligible for funding through the ULWREP for areas located in a priority watershed:

- $100,000 may be used in each subwatershed prioritized for improving water quality to implement no till, reduced till, and cover crop usage by 25 percent.
- $250,000 has been allocated for each priority subwatershed to construct approved animal waste systems.
- $250,000 is allocated for each priority subwatershed to construct approved rotational grazing systems.
- $150,000 has been allocated for subwatersheds prioritized for water quality and livestock improvements to provide $75 to $100 per acre to farmers or land owners who convert acres of marginal cropland into permanent cover.
- $250,000 is allocated for water quality critical subwatersheds to improve eroding streambanks.

Stakeholders may contact the ULWREP to determine eligibility for these programs.

Table 8-1 and Table 8-2 summarize the cost share programs available for BMPs in the Little Wabash River II watershed. Table 8-3 lists the contact information for each local soil and water conservation district (SWCD).

Table 8-1. Summary of Assistance Programs Available for Farmers in the Little Wabash River II Watershed.

Assistance Program	Program Description	Contact Information
NSMP	Provides grant funding for educational programs and implementation of nonpoint source pollution controls.	Illinois Environmental Protection Agency Bureau of Water Watershed Management Section, Nonpoint Source Unit P.O. Box 19276 Springfield, IL 62794-9276 Phone: (217) 782-3362
Agricultural Loan Program	Provides low-interest loans for the construction and implementation of agricultural BMPs. Loans apply to equipment purchase as well.	Office of State Treasurer Agricultural Loan Program 300 West Jefferson Springfield, Illinois 62702 Phone: (217) 782-2072 Fax: (217) 522-1217
ULWREP	Provides funding for implementation of BMPs and land improvement projects to farmers and landowners within the partnership.	IDNR Region 4 Office 4521 Alton Commerce Parkway Alton, IL 62002 Phone: 618-462-1181 Fax: 618-462-2424
NRCS EQIP	Offers cost sharing and rental incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands. Applies to nutrient management plans, filter strips, grassed waterways, riparian buffers, and conservation tillage.	Contact local SWCD (Table 8-3)
FSA CRP	Offsets income losses due to land conversion by rental agreements. Targets highly erodible land or land near sensitive waters. Provides up to 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years for converted land.	
Conservation 2000 CPP	Provides up to 60 percent cost share for several agricultural BMPs: cover crops, filter strips, grassed waterways.	
Conservation 2000 Streambank Stabilization Restoration Program	Provides 75 percent cost share for establishment of riparian corridors along severely eroding stream banks. Also provides technical assistance and educational information for interested parties.	
SARE	Funds educational programs for farmers concerning sustainable agricultural practices.	
Local SWCD	Provides incentives for individual components of nutrient management planning, use of strip tillage, and restoration of riparian buffers.	
ICCI	Allows farmers to earn carbon trading credits for use of conservation tillage, grass, and tree plantings.	

Table 8-2. Assistance Programs Available for Agricultural BMPs.

BMP	Cost Share Programs and Incentives
Education and Outreach	Conservation 2000 Streambank Stabilization Restoration Program SARE NSMP Local SWCD ULWREP
Nutrient Management Plan	EQIP: $10/ac for one year, 400 ac. max. Local SWCD: up to $30/ac for one year ULWREP: contact agency for individual resource allocations
Conservation Tillage	EQIP: $15/ac for three years, 400 ac. max. ICCI: earns 0.5 mt/ac/yr of carbon trading credit ULWREP: contact agency for individual resource allocations
Cover Crops	CPP: cost share of 60 percent ULWREP: contact agency for individual resource allocations
Filter Strips	EQIP: $100/ac for three years, 50 ac. max. CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Grassed Waterways	EQIP: 60 percent of construction costs CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Land Retirement of Highly Erodible Land or Land Near Sensitive Waters	CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted ULWREP: contact agency for individual resource allocations
Restoration of Riparian Buffers	EQIP: 60 percent of construction of costs CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted ULWREP: contact agency for individual resource allocations

Note: Cumulative cost shares from multiple programs will not exceed 100 percent of the cost of construction.

Table 8-3. Contact Information for Local Soil and Water Conservation Districts.

Organization Name	Address	Contact Numbers
Clay County SWCD	155 Route 45 North Louisville, IL 62858	Phone: 618/665-3327 (Ext. 3) Fax: 618/665-3385
Edwards County SWCD	90 West Pine Street Albion, IL 62806	Phone: 618/445-3615 Fax: 618/445-3838
Effingham County SWCD	2301 Hoffman Drive Effingham, IL 62401	Phone: 217/347-7107 (Ext. 3) Fax: 217/342-9855
Jasper County SWCD	1403 Clayton Avenue Newton, IL 62448	Phone: 618/783-2319 (Ext. 3) Fax: 618/783-2374
Richland County SWCD	821A S. West Street Olney, IL 62450	Phone: 618/392-7141 (Ext. 3) Fax: 618/392-4325
Wayne County SWCD	23 Industrial Drive Fairfield, IL 62837	Phone: 618/842-7602 (Ext. 3) Fax: 618/842-3332
White County SWCD	1105 West Main Street Carmi, IL 62821	Phone: 618/382-2213 (Ext. 3) Fax: 618/382-5801

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9.0 IMPLEMENTATION TIMELINE

This implementation plan for the Little Wabash River II watershed defines a phased approach for achieving the water quality standards (Figure 9-1). Ideally, implementing control measures on nonpoint sources of loading will be based on voluntary participation which will depend on 1) the effectiveness of the educational programs for farmers, landowners, and owners of onsite wastewater systems, and 2) the level of participation in the programs. In addition, point source dischargers operating under a disinfection exemption are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. Facilities with year-round disinfection exemptions may be required to provide the Agency with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions. This section outlines a schedule for implementing the control measures and determining whether or not they are sufficient to meet the water quality standards.

Phase I of this implementation plan should focus on education of farm owners concerning the benefits of agricultural BMPs on crop yield, soil quality, and water quality as well as cost share programs available in the watershed. It is expected that initial education through public meetings, mass mailings, TV and radio announcements, and newspaper articles could be achieved in less than 6 months. As described in Section 8.0, assistance with educational programs is available through the following agencies: the Illinois Department of Agriculture Conservation 2000 Streambank Stabilization Restoration Program, the Illinois Department of Agriculture Sustainable Agriculture Grant Program (SARE), the Illinois Environmental Protection Agency Nonpoint Source Management Program (NSMP), the Upper Little Wabash River Ecosystem Partnership (ULWREP), and the local Soil and Water Conservation Districts. During this phase, the sewage treatment plants may be asked to submit fecal coliform data to IEPA to determine if a disinfection exemption is still appropriate. In addition, all facilities with CSOs should begin to institute the nine minimum controls.

Phase II of the implementation schedule will involve voluntary participation of farmers in BMPs such as proper management of manure, fertilizers, and pesticides and use of filter strips, composting, constructed wetlands, conservation tillage, and grassed waterways. The local Natural Resources Conservation Service office will be able to provide technical assistance and cost share information for these BMPs. In addition, initial inspections of all onsite wastewater treatment systems and necessary repairs may begin. Continued monitoring of water quality in the watershed should continue throughout this phase, which will likely take one to three years.

If pollutant concentrations measured during Phase II monitoring remain above the water quality standards, Phase III of the implementation plan will be necessary. The load reduction achieved during Phase II should be estimated by 1) summarizing the areas where BMPs are in use, 2) calculating the reductions in loading from BMPs, and 3) determining the impacts on pollutant concentrations measured before and after Phase II implementation. If BMPs are resulting in decreased concentrations, and additional areas could be incorporated, further efforts to include more stakeholders in the voluntary program will be needed. If the Phase II BMPs are not having the desired impacts on pollutant concentrations, or additional areas of incorporation are not available, supplemental BMPs, such as restoration of riparian areas and stream channels will be needed. If the nine minimum controls are not mitigating the fecal coliform load from CSOs, the more expensive, long-term measures should be implemented. In addition, sewage treatment plants may be required to add a disinfection process if fecal coliform standards in receiving and downstream segments are not being met. If required, this phase may last five to ten years.

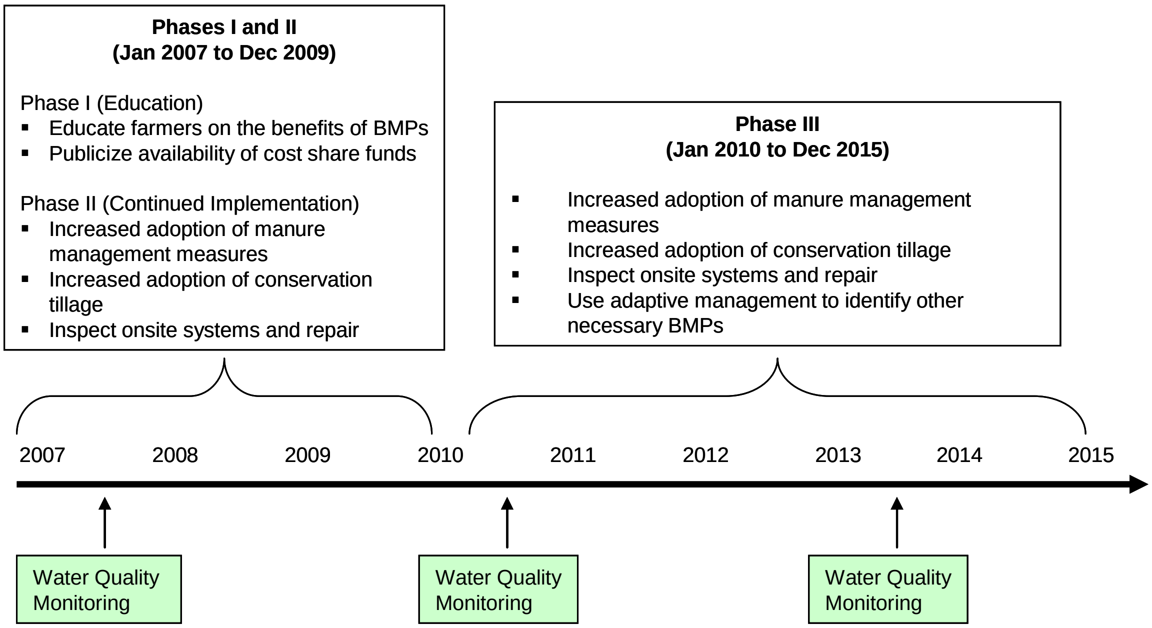

Figure 9-1. Timeline for the Little Wabash River II TMDL Implementation Plan.

10.0 CONCLUSIONS

With the exception of total phosphorus, the water quality impairments addressed in the TMDL report occur throughout the Little Wabash River II watershed. The majority of loading likely originates from animal operations, croplands, failing onsite sewage treatment systems, and sewage treatment plants that operate under disinfection exemption.

The implementation of BMPs in this watershed will occur in a phased approach. Phase I of this implementation plan will provide education and incentives to farmers in the watershed to encourage the use of BMPs. Phase II will occur during and following Phase I and will involve voluntary participation of farmers in the watershed, implementation of the nine minimum controls for CSOs, and submittal of fecal coliform data for the STPs in the watershed. Future water quality monitoring will determine whether or not these BMPs are capable of reaching the water quality goals in the watershed.

Whether or not Phase III will be required depends on the results of future water quality sampling. If the water quality standards are not being met after implementation of the Phase II BMPs, then regional BMPs (such as restoration of stream channels and riparian areas) may be needed. Additional sewage treatment plant upgrades and long-term control measures for CSOs may also be considered.

As agricultural BMPs are implemented, water quality in the watershed should improve accordingly. Measuring the effectiveness of these BMPs will require continued sampling of water quality over the next several years.

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APPENDIX A. THE UPPER LITTLE WABASH RIVER ECOSYSTEM PARTNERSHIP STRATEGIC WATERSHED PLAN

APPENDIX B. STRATEGIC SUB-WATERSHED IDENTIFICATION PROCESS (SSIP)