WATERSHED MANAGEMENT PLAN

Prepared for:

Upper Wabash River Basin Commission

July 2007

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CBBEL Project Number 05-331

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TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 WATERSHED BASED PLANNING 1
1.2 WATERSHED PARTNERSHIPS 4
1.3 PUBLIC PARTICIPATION 6
1.4 WATERSHED LOCATION 8
1.5 DESCRIPTION AND HISTORY 8
2.0 IDENTIFYING WATER QUALITY PROBLEMS AND CAUSES 14
2.1 STAKEHOLDER CONCERNS 14
2.2 WATER QUALITY BASELINE STUDIES 14
2.3 BASELINE WATER QUALITY: CONCERNS, PROBLEMS, AND CAUSES 25
3.0 IDENTIFYING POLLUTANT SOURCES 27
3.1 POTENTIAL POINT SOURCES OF POLLUTION 27
3.2 POTENTIAL NONPOINT SOURCES OF POLLUTION 30
4.0 IDENTIFYING CRITICAL AREAS 42
4.1 BENEFICIAL CRITICAL AREAS 42
4.2 CRITICAL AREAS AS POTENTIAL SOURCES OF POLLUTION 45
4.3 ESTIMATING POLLUTANT LOADINGS AND REDUCTIONS 49
5.0 GOALS AND DECISIONS 61
5.1 POTENTIAL IMPLEMENTATION TIMELINE 61
6.0 MONITORING EFFECTIVENESS 75

LIST OF TABLES

Table 1-1: Watershed Management Units 2
Table 1-2: UWRBC Voting Members 5
Table 1-3: Steering Committee Schedule 7
Table 1-4: Land Use 9
Table 1-5: Soil Associations 10
Table 1-6: HEL Soil Classifications 11
Table 1-7: UWRB Waterways & Tributaries 12
Table 2-1: TMDL Targets 15
Table 2-2:Pesticide Concentrations, MCLs, & Runoff % in the Upper Wabash River Basin 17
Table 2-3: Narrative Description of Chemical Monitoring Sites 17
Table 2-4:Comprehensive Water Quality Rankings, Upper Wabash River Basin 24
Table 3-1: NPDES Facilities in the UWRB 27
Table 3-2: CFO and CAFO Limits per Species 29
Table 3-3: NPS Pollution and Agriculture 32
Table 3-4: Adams, Jay, and Wells County Harvested Acres 33
Table 3-5: Estimate of Commercial Nutrient Application 34
Table 3-6: Percent of Crop Acres in Conservation Tillage 36
Table 4-1: Estimation of Long-term (1965-2006) Average Mean Annual Flow 51
Table 4-2: Targeted Phosphorus Load Reductions, Upper Wabash River Basin 51
Table 4-3: Targeted Nitrite & Nitrate Load Reductions, Upper Wabash River Basin 52
Table 4-4: Targeted *E. coli* Load Reductions, Upper Wabash River Basin 52
Table 4-5: Targeted Sediment Load Reductions, Upper Wabash River Basin 53
Table 4-6: Estimated Loadings Reductions, Septic Systems 55
Table 4-7: Estimated Load Reductions, Agricultural BMPs 57
Table 4-8: Estimated Load Reductions, Feedlots, Pastures, and Access Sites 57
Table 4-9: Estimated Load Reductions, Critical Area Management Measures 59
Table 5-1: Education Management Measures 63
Table 5-2: Flooding Management Measures 64
Table 5-3: Agricultural Management Measures 66
Table 5-4: Land Use/Development Management Measures 69
Table 5-5: *E. coli* Management Measures 72

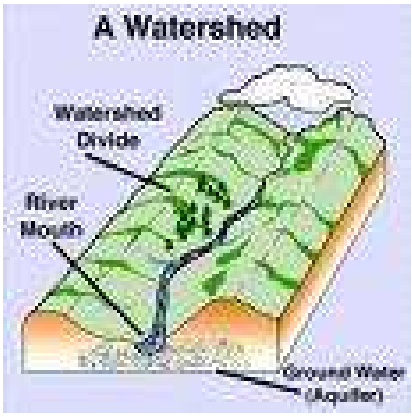
LIST OF EXHIBITS

Exhibit 1: Upper Wabash River Basin Site Location
Exhibit 2: Upper Wabash River Basin Land Use
Exhibit 3: Upper Wabash River Basin Potential Point Source Pollution Sites
Exhibit 4: Upper Wabash River Basin Flood Zones & USGS Stream Gages
Exhibit 5: Upper Wabash River Basin Critical Areas
Exhibit 6: Upper Wabash River Basin Beneficial Areas

1.0 INTRODUCTION

1.1 WATERSHED-BASED PLANNING

A watershed is an area of land that collects and drains water to a specific point. Similar to water poured into a bowl, a portion of the precipitation that falls on a watershed will move through the landscape, collecting and concentrating in low areas, wetlands, creeks, and streams, until it exits through an outlet point. All water, whether in the ground or traveling over the ground surface, moves from the highest to the lowest points in an area of land. Using this definition, watersheds can be defined for any location. For planning purposes, the watershed is a measurable and practical landscape feature that is based on how water moves, interacts with, and behaves on the landscape.



The diagram, developed by Kentucky Department of Natural Resources, depicts a schematic of a watershed. Water in the form of precipitation can take several paths once it has reached the earth. Some portion of the precipitation will never reach the ground; instead it is caught by vegetation and/or ground litter and evaporates. That portion of precipitation that does reach the ground can infiltrate the ground, becoming shallow or deep groundwater, travel through sub-surface tile systems, or travel over the surface as runoff. Runoff is excess rainfall that can not be absorbed or retained in the landscape. As water travels through the watershed by these pathways it interacts with the landscape, in a physical and chemical manner. That interaction determines the character of water quality in the receiving waterbody. Human activities alter the landscape and thus influence the physical and chemical interaction of water in a watershed. Recognition and an understanding of the hydrologic cycle in the context of human influence on watershed processes are fundamental to good watershed management planning.

Human interaction with the environment helps to define the characteristics of the watershed, and thus, the quality of the water. A logical way to approach water resource management is to use the watershed as the primary management unit. Since water collects and moves through the landscape via watersheds, the physical, chemical, and biological conditions of the water will be unique to each watershed. Therefore, planning and management would be most effective if the unique character and conditions of the watershed in question are addressed.

Watersheds and watershed management areas can be considered at a regional or very local level; where watersheds can be as small as a ¼ acre plot or as large as the Mississippi River Basin that covers millions of square miles. The Center for Watershed Protection classifies watersheds into five management units; these are catchment, sub-watershed, watershed, sub-basin, and basin and are listed in **Table 1-1**. The primary planning authority and suggested management focus for each of the five management units varies depending on the size of the watershed. According to this classification system the four 11-digit Hydrologic Unit Code (HUC) Upper Wabash River Basin watershed (approximately 251 square miles) would be considered a “Sub-basin” and is therefore best managed at the local, regional, and State level.

Table 1-1: Watershed Management Units

Watershed Management Unit	Typical Area (sq. mi.)	Primary Planning Authority	Suggested Management Focus
Catchment	0.05 - .050	Local property owner	Best Management Practices
Sub-watershed	1 - 10	Local Government	Stream Management & Classification
Watershed	10 - 100	Local or multi-local	Watershed-based Planning
Sub-basin	100 – 1,000	Local, regional, and State	Basin Planning
Basin	1,000 – 10,000	State, multi-state, federal	Basin Planning

(Schueler, 2003)

Watershed Planning

The Watershed Management Plan (WMP) is intended to benefit communities in the watershed by helping to improve the local economy, increase effectiveness of government, and preserve the environment through comprehensive water resource planning. Watershed planning can benefit the local economy by helping to protect drinking water supply, decrease losses related to floods, and increase property values by providing attractive and safe living and recreation areas. Good watershed planning can improve the effectiveness of government through more direct public involvement that earns the trust and support of the community and guarantees that all community interests are treated fairly. The planning effort also helps to ensure that current water quality in the community is preserved and that the community will not suffer significant financial losses due to loss of natural resource buffers and other natural resources.

The planning process is not without some complications as members of watershed communities can have competing desires for how water is used. For example, a large proportion of the Upper Wabash River Basin watershed is agricultural with many farming interests. A farmer may view water quality issues differently than will others in the community. However, the interests of that farmer must be taken into consideration if the WMP is to be a benefit to the whole community. Likewise, the homeowner that uses a well for their water supply has an interest in clean drinking water that is not polluted from other watershed users. Further complication of the planning process is realized when there are several governmental jurisdictions with different sets of ordinances and rules for water use. Nonetheless, it is imperative that the planning process formulate a workable WMP that is sensitive to the values and desires of all members of the community and is developed with the input and support of a good cross-section of the community. Input from the farmer, homeowner, government administrator, elected official, and others in the community will help to ensure that there is balanced and equitable distribution of responsibility for and benefits of good water quality in the watershed.

Watershed planning is especially important to help prevent future water resource problems, preserve watershed functions, and ensure future economic, political, and environmental health. Everyone in a watershed is involved in watershed management; however, there are not typically specific agreements on how water should be used and managed by all users in a community.

Many activities throughout the watershed have an impact on watershed users, but the efforts are not organized, and occasionally are counter-productive and may limit economic growth and value of land. However, a WMP can provide a better understanding of community values and watershed processes and can provide guidance toward the betterment of watershed management and living conditions in the community.

Context of Watershed Planning

Watershed management has been widely promoted by the Environmental Protection Agency (EPA) and other public and private organizations concerned with water quality. In fact, by developing WMPs, targeted areas become eligible for funding to implement a wide array of water quality related projects. Funding sources include, but are not limited to, the Indiana Department of Environmental Management (IDEM), the EPA, the Indiana Department of Natural Resources (IDNR), the U.S. Fish and Wildlife Service (FWS), and the United States Department of Agriculture (USDA).

Watershed planning can also be a response to regulatory interest in impaired water quality in the watershed. Section 303(d) of the Clean Water Act (CWA) requires states to identify waters that do not, or are not expected to, meet federal water quality standards. States are also required to develop a priority ranking for these waters taking into account the severity of the pollution and state defined designated uses of the waters. For those waters identified as having impaired water quality, the states are required to develop Total Maximum Daily Loads (TMDLs) in order to achieve compliance with federal water quality standards and the CWA.

According to the IDEM's 2004 303(d) impaired streams list there are 35 impairments on 9 waterbody segments listed for *E. coli*, Impaired Biotic Communities, and/or nutrients. A fish consumption advisory for Polychlorinated biphenyls (PCBs) has also been placed on 5 of these same segments. The severity ranking for the Wabash River is high and data has recently been collected as part of a TMDL development. The TMDL addresses *E. coli*, nitrate, and phosphorus in the Wabash River from the Indiana-Ohio state line to the Indiana-Illinois state line. Loads of pH and dissolved oxygen were not calculated but it is anticipated that the nutrient TMDLs will result in attainment of the water quality standards for these two parameters. The final TMDL was approved on September 22, 2006. A TMDL is also in development for the Limberlost Creek watershed, within the larger Upper Wabash River Basin. An effective watershed plan can help to address the water quality impairment identified by the IDEM. Furthermore, the WMP will help to demonstrate community involvement and commitment to address impaired water quality in the watershed.

Upper Wabash River Basin Watershed Management Plan

A WMP is a guiding document that examines the historical and current water resource issues in a particular watershed and presents specific actions to address those water resource issues based on the values and needs of the community. The intent of the WMP is to provide better living conditions, economic viability, and environmental health benefits for those who reside in the watershed and for communities downstream. Developers of the WMP are interested stakeholders who investigated prior and existing watershed conditions, identified watershed critical areas, and formulated strategies for implementing specific actions. The WMP document represents the earnest efforts of the community to understand, analyze, and be an integral part of the solution to improve impaired water quality in the watershed. Furthermore, active community involvement in the development of the WMP helps to ensure that there is commitment by the community to implement projects identified in the WMP.

The interest to prepare a WMP for the Upper Wabash River Basin watershed stems from the numerous known water quality problems in these watersheds and the fact that these watersheds are typical of the water quality problems facing many other rural watersheds throughout the State where agriculture is the primary activity. The combined drainage area for the project area is 161,080 acres and drains land in southern Adams County including discharges south of the City of Berne, northern and eastern Jay County, and southeastern Wells County. A small portion of the City of Berne (population 4,150) at its southern edge is included in the study area. Other smaller towns include Bryant (population 272), Geneva (population 1,368), and Vera Cruz (population 55). The total population of all of the towns and the City is approximately 5,800. **Exhibit 1** illustrates the project area location.

The land use in the City and surrounding towns is predominantly impervious (roads, parking lots, roof tops, etc.) which results in the discharge of untreated stormwater directly into various ditches that flow into the Wabash River Basin. The City of Berne's sewage treatment plant has an outlet to the Wabash River near Covered Bridge Road. This is an outlet for waters that have been processed by the series of lagoons utilized for wastewater treatment. While the Town of Monroe is geographically located out of the watershed, the combined sanitary and storm sewer flows to the City of Berne. The Town of Geneva and the Town of Vera Cruz are also located in close proximity to the Wabash River and may discharge untreated stormwater directly into the river.

Approximately 92% of the Upper Wabash River Basin watershed remain in agriculture use including livestock and crop production. The National Water Quality Inventory (NWQI), sponsored by EPA, reports that agriculture non-point source (NPS) pollution is the leading source of water quality impairments to surveyed rivers and lakes. Nutrients, pesticides, and sediment can migrate from agricultural lands to surface waters via runoff, sub-surface tile systems, and erosion.

The Upper Wabash River Basin WMP presents the overall watershed analysis and inventory conducted by Christopher B. Burke Engineering, Ltd. (CBBEL), the project Steering Committee, and the public, and offers recommendations for water quality improvement, preservation, and protection. During implementation of this WMP and associated practices, several Indiana Codes regarding surface water will need to be adhered to. This WMP meets the requirements of the IDEM's Watershed Management Plan Checklist.

1.2 WATERSHED PARTNERSHIPS

Partnerships among water resource professionals and interested citizens are essential to the successful development and implementation of the Upper Wabash River Basin WMP. This WMP is being prepared at two distinct levels - the local level using the resources of CBBEL and a Steering Committee as well as at the regional level since the Steering Committee is also the Upper Wabash River Basin Commission (UWRBC).

The Wabash River Heritage Corridor Commission, IDNR, National Park Service's Rivers, Trails, and Conservation Assistance Program held numerous meetings in 1995 and 1996 to develop a watershed management plan for the Upper Wabash River that addresses both water quantity and water quality issues. Local officials, many landowners in the Upper Wabash River Basin, and other interested citizens met to discuss the needs of the watershed. At the conclusion of many public meetings, the decision was made to establish a Commission to address the watershed issues of the Upper Wabash River Basin.

Upper Wabash River Basin Commission

In 2001, Indiana's legislature established the UWRBC under IC 14-30-4 as a separate municipal entity. The UWRBC consists of the three County Commissioners, the County Surveyor, and the chairman of the Soil and Water Conservation Districts (SWCD) of Adams, Jay, Wells, and Huntington Counties. The UWRBC has organized, elected officers, adopted by-laws, and has developed this formal WMP.

The efforts of the UWRBC are led by its voting members shown in **Table 1-2**. The UWRBC annually elects officers from among the voting members, which include a chairperson, a vice chairperson, a secretary, and a treasurer. An administrative secretary is contracted by the Commission to perform the daily administrative, secretarial, and financial duties.

Current elected officers of the UWRBC include:

- **Doug Bauman,** *Chairperson,* representing Adams County
- **Jay Poe**, *Vice Chairperson,* representing Huntington County
- **Ken Brunswick**, *Secretary*, representing the Jay County SWCD
- **Jarrod Hahn**, *Treasurer,* representing Wells County
- **Stacia Henderson,** *Administrative Secretary*

Table 1-2: UWRBC Voting Members

County	Member	Affiliation	Years of Service
Adams	Doug Bauman	Adams County Commissioner	2001-Present
	Ed Coil	Adams County Commissioner	2001-Present
	Steve Baumann	Adams County Commissioner	2001-Present
	John Friedt *Appt: E. Coil*	Adams County SWCD	2001-Present
	Paul Norr	Adams County Surveyor	2001-Present
	Rick Steiner	Adams County SWCD	2001-Present
Huntington	Richard Brubaker	Huntington County Commissioner	2001-Present
	Jerry Helvie	Huntington County Commissioner	2001-Present
	George Schul, II	Huntington County Commissioner	2001-2004
	Steve Updike	Huntington County Commissioner	2005-Present
	Troy Hostetler *Appt: J. Helvie*	Huntington County Surveyor's Office	2005-Present
	Steve Scher *Appt: S. Updike*	Huntington County Surveyor's Office	2005-Present
	Jay Poe	Huntington County Surveyor	2001-Present
	Kyle Lund	Huntington County SWCD	2001-Present
Jay	Milo Miller	Jay County Commissioner	2001-Present
	Mike Leonhard	Jay County Commissioner	2001-2004
	Faron Parr	Jay County Commissioner	2005-Present
	Gary Theurer	Jay County Commissioner	2001-Present
	Dwain Michael *Appt: G. Theurer; M. Leonhard*		2001-Present
	Brad Daniels	Jay County Surveyor	2001-Present
	Ken Brunswick	Jay County SWCD	2001-Present

Wells	Paul Bonham	Wells County Commissioner	2001-Present
	Scott Mossburg	Wells County Commissioner	2007
	Randy Plummer	Wells County Commissioner	2001-2006
	Kevin Woodward	Wells County Commissioner	2001-Present
	Jarrod Hahn	Wells County Surveyor	2005-Present
	John Studebaker	Wells County Surveyor	2001-2005
	Lynn Dettmer	Wells County SWCD	2001-2006
	Wayne Reinhard	Wells County SWCD	2007

The mission of the UWRBC is to provide regional leadership and promotion of flood prevention and control, soil and water conservation, and related resource management through a coordinated and comprehensive planning and implementing approach. Until recently, the focus of the UWRBC has been securing of funding by the State of Indiana to commission a comprehensive Stormwater Master Plan for the Upper Wabash River Basin that would address both drainage stormwater quantity and stormwater quality issues in the watershed. However, these efforts have not yet been successful.

In January of 2004, the UWRBC submitted a CWA Section 205(j) Water Quality Management Planning Program grant application to IDEM to develop a WMP for the portions of the Upper Wabash River Basin in Adams, Jay, and Wells Counties. The grant application was accepted and the UWRBC received $100,000 in October of 2004. The UWRBC retained CBBEL to serve as the Watershed Coordinator for the development of the WMP. The Watershed Coordinator facilitates stakeholder discussion, presents data and information about the watershed to the committee and the public through meeting updates and public workshops, as well as drafts the WMP.

1.3 PUBLIC PARTICIPATION

The UWRBC is made up of public officials and public participation is essential to maintaining the strength of the organization. Education and outreach efforts can effectively change the general public's behaviors and habits toward water quality and make a strong connection between land use and water quality and everyday decisions directly affect water quality. Information regarding the Commission is disseminated on behalf of the UWRBC through the Wells County SWCD webpage. Newspaper articles, workshop information, and newsletter articles are shared by the Adams, Huntington, Jay, and Wells County SWCDs for distribution to the public.

Steering Committee

The UWRBC met on a bi-monthly basis beginning in August 2005 through June 2007 where they utilized part of their regularly scheduled meetings to act as a Steering Committee for this project. CBBEL prepared and facilitated the Steering Committee portion of the meetings. **Table 1-3** outlines the meeting schedule and topics discussed. Each of these topics will be discussed in more detail in the following chapters of this Plan.

Table 1-3: Steering Committee Schedule

Meeting Date	Topic Discussed	
9-Aug-05	Introduction to Project	
11-Oct-05	**Water Quantity – Identify Critical Areas – Flooding & Streambank Restoration**	
13-Dec-05	Water Quantity – Dams & Logjams	
13-Dec-05	*Workshop - "Improving Open Streams Management"*	
14-Feb-06	Water Quantity – Recommendations & Implementation Projects	
11-Apr-06	**Agricultural Crop Production**	
13-Jun-06	Agricultural – Livestock Production	
13-Jun-06	*Workshop – "Improving Manure Management"*	
8-Aug-06	Agricultural – Recommendations & Implementation Projects	
10-Oct-06	**Urban – Development Practices**	
	Land Use Planning	Failing Septic Systems
	Stormwater	Wildlife and Pets
	Erosion & Sediment Control	Toxic Materials
	Impervious Areas	Lawn & Garden Chemicals
	Riparian Corridors	
12-Dec-06	**Urban – *E. coli* Reductions**	
12-Dec-06	*Workshop – "Reducing E. coli"*	
13-Feb-07	Urban Recommendations & Implementation Projects	
10-Apr-07	Present DRAFT Plan	
14-May-07	*Plan due to IDEM*	

As part of this planning process, information was gathered from the public during the UWRBC's regularly scheduled public meetings.

Water Quality Workshops

As part of this grant, three free workshops were held for the public on "Improving Open Streams Management", "Reducing E. coli", and "Improving Manure Management". The first in the series of workshops was held on December 13, 2005 at the Wells County 4-H Fairgrounds. In addition to the Commission members, there were nearly 25 in attendance. This workshop provided stakeholders with general information on the effects of log jams and other in-stream obstructions on water flow quantity as well as water quality. Several citizens were in attendance as George Bowman, the Assistance Director of the Division of Water at the IDNR gave a presentation outlining the various degrees of jams and the permitting requirements for each.

A second workshop entitled Improving Manure Management was held in the Geneva, Indiana Town Hall on June 13th, 2006. The purpose of the workshop was to inform stakeholders about on-farm measures to reduce the potential for runoff, and new technologies and programs for operators to achieve the most benefit from their manure and nutrient management practices.

The presenters for the workshop were Darrell Brown, Natural Resources Conservation Service District Conservationist for Adams and Wells Counties, Dennis Chenoweth, representing Livestock Engineering Solutions, Inc., and James Moffitt, a Certified Crop Advisor based in Fort Wayne.

The final workshop, entitled Reducing *E. coli* was held in Bluffton Indiana at the Wells County 4-H Fairgrounds on December 12, 2006. Presentations were provided by Denise Wright, an environmental scientist with the Indiana State Department of Health and L.A. Brown, a local septic installer and representative of the Indiana Onsite Wastewater Professionals Association. Several local Health Department representatives and soil scientists were in attendance to provide additional information as questions were posed. Over 20 stakeholders were present for the workshop.

Public Presentations

Once the draft WMP was completed, CBBEL posted it on the Wells County SWCD webpage and in the Berne, Bluffton, Geneva, and Portland Public Libraries. CBBEL presented an overview of the known water quality problems, goals, management measures, and action plan for improving water quality in the Upper Wabash River Basin Watersheds during the regularly scheduled bimonthly UWRBC meeting on February 13, 2007. Comments on the Draft WMP were collected from the UWRBC from April 17, 2007 through April 24, 2007. During the April 24, 2007 Special UWRBC meeting, comments from the Commission were discussed and suggested changes were approved as determined by the Commission.

1.4 WATERSHED LOCATION

The 11-digit HUC watersheds addressed by this WMP (05120101010, 05120101040, 05120101050, and 05120101060) are located in portions of the Upper Wabash River Basin in Adams, Jay, and Wells Counties in Northeastern Indiana. For simplicity, these four watersheds will be referred to throughout this WMP as the Upper Wabash River Basin.

The combined drainage area for the project area is 161,080 acres and drains land in southern Adams County including discharges south of the City of Berne, northern and eastern Jay County, and southeastern Wells County. Exhibit 1 illustrates the project area location. There are approximately 330 miles of perennial streams and drainage ditches in the Upper Wabash River Basin Watersheds, eventually draining to the Wabash River.

1.5 DESCRIPTION & HISTORY

Natural History

The Bluffton Till Plain Section was one of the last areas of Indiana to be covered by glacial ice. The Wisconsin Glacier formed the present landscape of the Upper Wabash River Basin Watershed. The glacier left a characteristic series of moraines which give the landscape a mostly level to slightly rolling appearance. When the glacier receded it deposited as much as 20 to 100 feet of glacial till over the limestone bedrock. The soils found in the Upper Wabash River Basin Watershed are the result of direct glacial deposits or materials carried by the streams of melting ice and snow.

Prior to settlement in the mid-1800s, much of the Upper Wabash River Basin watershed was covered in wetlands and woods. The trees removed by the early settlers to make room for farming consisted of upland hardwood forest species characteristic of Maple-Beech and Oak-Hickory associations. Plant associations or communities are broad generalizations of

vegetation based on a geographic region. The upland areas of the Upper Wabash River Basin watershed were densely covered in sugar maple, oak, hickory, basswood, beech, yellow birch, American elm, ironwood, and red maple. Species such as silver maple, American elm, willow, basswood, sycamore, and ash were more abundant in the river corridors and low-lying marsh areas.

According to the 1992 Gap Analysis Program (GAP) datum, only 7% of the Upper Wabash River Basin watershed land use is wooded or wetland. Although nonnative and invasive species now dominate much of the understory of existing wooded areas, evidence of the native hardwood forest still prevails. Fragmentation of wooded and natural areas caused by increased human settlement as well as trapping and hunting has limited the number of wildcats, bears, foxes, and poisonous snakes that once were abundant in the Upper Wabash River Basin watershed.

Climate

According to Midwest Climate Data Center records, the average winter temperature is 38°F and the average daily minimum temperature is 19°F, while during the summer the average temperature is 76°F and the average daily maximum temperature is 82°F. Average annual precipitation in the area is 38.4 inches. Approximately 59% of the precipitation, or 23 inches, typically accumulates between April and September of any given year. The 2-year, 1-hour duration storm event is approximately 1.41 inches. The watershed receives an average seasonal snowfall of 31 inches and 9 days out of the year have at least 1 inch of accumulated snow on the ground. Tornadoes, hailstorms, and severe thunderstorms do occur in the area and typically affect the watershed in late spring and early summer.

Land Use

The land use of the Upper Wabash River Basin watershed began to significantly change from dense woods and wetlands to agriculture following settlement of the Europeans in the mid-1800s. Historically, the upland areas were cleared and drained to facilitate better crop production. As shown in **Table 1-4** and **Exhibit 2**, agricultural land uses continue to dominate the Upper Wabash River Basin watershed landscape today. Ninety-two percent of the watershed is in agricultural production. Row crops dominate the land use of the watershed with 132,812 acres (82%) in production.

Table 1-4: Land Use

Land Use	Acres	Percent
Row Crops	132811.79	82.46
Pasture/Hay	15303.96	9.50
Deciduous Forest	10036.31	6.23
Woody Wetlands	1709.88	1.06
Open Water	330.32	0.21
Low Intensity Residential	330.03	0.20
Evergreen Forest	186.12	0.12
Commercial/Industrial/Transportation	149.57	0.09
Emergent Herbaceous Wetlands	99.74	0.06
Transitional	43.24	0.03
High Intensity Residential	32.32	0.02
Mixed Forest	14.31	0.01
Urban/Recreational Grasses	12.86	0.01
Total	**161060.45**	**100.00**

(USGS, 2005)

The Wabash River is the main waterway in the watershed; the other waterways are primarily small headwater streams or drainage ditches. Approximately 2,140 acres (1%) within the watershed are classified as wetland or open water. The classification for land use is based on information provided by the Multi-Resolution Land Characteristic Consortium (MRLC) through the United States Geological Survey (USGS).

Very little of the watershed, approximately 512 acres (0.3%) has been converted for residential, commercial, and industrial land uses. The City of Berne is the largest urban area with an estimated population in July 2002 of 4,126 which reflected a population decrease (-0.7% change) from 2000. Land use in the watershed is anticipated to remain mostly rural and agricultural land uses due to the lack of industrial and commercial facilities in the area.

Soils

The soils of the Upper Wabash River Basin watershed formed from Wisconsin glacial till, glacial outwash, and recently deposited alluvium. According to the Soil Surveys for Adams, Jay, and Wells Counties and shown in **Table 1-5**, there are eleven predominant soil associations in the Upper Wabash River Basin watershed. In the low-lying, floodplain areas the Saranac and Sloan Association dominate, whereas in the upland areas, the Blount and Glynwood Association are more prevalent.

Table 1-5: Soil Associations

County	Soil Association	Characteristics
Adams	Blount-Pewamo	Deep, nearly level, somewhat poorly drained and very poorly drained, silty and clayey soils on till plains and moraines
	Glynwood-Blount	Deep, nearly level and gently sloping, moderately well drained and somewhat poorly drained, silty soils on till plains

County	Soil Association	Characteristics
	Saranac-Tice-Sloan	Deep, nearly level, very poorly drained and somewhat poorly drained, clayey, silty, and loamy soils on bottom lands
Jay	Saranac-Eel	Nearly level, very poorly drained and moderately well drained, clayey and loamy soils formed in alluvium; on flood plains
	Blount-Pewamo-Glynwood	Nearly level and gently sloping, poorly drained to moderately well drained, silty, clayey, and loamy soils formed in glacial till; on till plains and moraines
	Glynwood-Blount-Pewamo	Nearly level to moderately sloping, moderately well drained to poorly drained, loamy, silty, and clayey soils formed in glacial till; on till plains and moraines
Wells	Blount-Del Rey-Pewamo	Nearly level to gently sloping, deep, somewhat poorly drained and very poorly drained, medium textured and moderately fine textured soils formed in glacial till or in lacustrine sediments; on till plains and moraines
	Pewamo-Del Rey-Blount	Nearly level, deep, very poorly drained and somewhat poorly drained, moderately fine textured and medium textured soils formed in lacustrine sediments or in glacial till; on till plains and moraines
	Milford-Del Rey-Blount	Nearly level to gently sloping, deep, very poorly drained to somewhat poorly drained, moderately fine textured and medium textured soils formed in lacustrine sediments or in glacial till; on till plains and moraines
	Sloan-Shoals-Rensselaer	Nearly level, deep, very poorly drained and somewhat poorly drained, moderately fine textured and medium textured soils formed in alluvium and outwash; on flood plains and stream terraces
	Blount-Del Rey-Glynwood	Gently sloping, deep, somewhat poorly drained and moderately well drained, medium textured soils formed in glacial till and lacustrine sediments; on till plains and moraines

(USDA, 1986, 1992)

The Natural Resources Conservation Service (NRCS) has assigned a soil erodibility index to each soil type. This value is based on the soils chemical and physical properties, as well as climatic conditions. According to the SWCDs for Adams, Jay, and Wells Counties, there are highly erodible soils present in the Upper Wabash River Basin watershed. This information is described within **Table 1-6.** Overall, approximately 4,213 acres, or 2.6% of the watershed has been classified as highly erodible land (HEL). An additional 73,394 acres, or 48.7% has been classified as potentially highly erodible land (PHEL).

Table 1-6: HEL Soil Classifications

County	Map Unit Symbol	Component Name	HEL Classification
Adams	BcB	Blount	2
	GoB	Glynwood	2
	MoC2	Morley	1
	MoD2	Morley	1
	Na	Nappanee	2
	RdB	Rawson	2
	SaB2	St. Clair	2
Jay	BlA	Blount	2
	BlA	Glynwood	2
	EnB3	Eldean	2
	EnC3	Eldean	1
	GsB3	Glynwood	2
	GsC3	Glynwood	1
	MaB2	Martinsville	2
	MoD3	Morley	1
	Ud	Udorthents	2
Wells	BkB2	Blount	2
	BkB2	Del Rey	2
	EoB2	Eldean	2
	EpC3	Eldean	1
	EsB2	Eldean Variant	2
	GnB2	Glynwood	2
	GpB3	Glynwood	2
	MuB2	Morley	2
	MuE	Morley	1
	MvC2	Morley	1
	MxC3	Morley	2
	Py	Pitts	2
	RlB	Rawson Variant	2
	RlC	Rawson Variant	2
	TuB2	Tuscola	2
	Ud	Udorthents	2

(NRCS, SWCD; 1 classification is highly erodible, 2 classification is potentially highly erodible and the slope and slope length should be checked.)

Septic systems need well-drained soils to properly treat household wastewater. Nearly all of the soils in the Upper Wabash River Basin watershed have severe limitations for septic systems due to seasonal high water table and slow permeability.

Agriculture is the predominant land use in the Upper Wabash River Basin watershed and soil suitability can greatly affect agriculture production. The Blount-Pewamo, Glynwood-Blount, Blount-Pewamo-Glynwood, and Glynwood-Blount-Pewamo associations are soils in the Upper Wabash River Basin watershed that represent soils well suited for row crop production.

Topography

The topography of the Upper Wabash River Basin watershed varies slightly throughout the entire basin. Within Adams County glacial till plain is nearly level or gently sloping as the Wabash River flows from southeast to northwest and eventually enters Ohio. Little relief is observed within Jay County. However relief is greater with long slopes and gently to moderately sloping areas in areas near the moraines, and steeper yet along the rivers and major streams. Similar to the other Counties, Wells County has nearly level soils in the bottom lands, especially along the Wabash River. Steeply sloping, and even gently sloping areas are more susceptible to erosion and sedimentation of water courses, which may lead to increase nutrient loading and decreased water quality.

Hydrology

There are approximately 330 miles of waterways in the Upper Wabash River Basin watershed. The Wabash River is the largest waterway in Adams, Jay, and Wells Counties while other streams are primarily headwater streams and constructed agricultural drainage ditches. **Table 1-7** contains a listing of these main waterways and tributaries.

Table 1-7: UWRB Waterways and Tributaries

Anderson Ditch	Haskin Run	Pontius Ditch
Aspy Ditch	Henry Ditch	Powell Ditch
Barr Ditch	Houser Ditch	Priest Ditch
Bear Creek	Hunt Ditch	Rankin Lewis Ditch
Bills Creek	Jamstutz Ditch	Rice Ditch
Bloxsom Ditch	Johns Creek	Roth Ditch
Bockoven Ditch	Johns Ditch	Rupel Ditch
Bourne Williams Ditch	Jutte Run	Scherman Ditch
Breiner Joint Ditch	Karnes Ditch	Schott Ditch
Brewster Ditch	Leichty Ditch	Shirk Votaw Ditch
Bull Creek	Limberlost Creek	Shoemaker Ditch
Camp Run	Loblolly Creek	Simison Creek
Campbell Ditch	Longnecker Ditch	Sixmile Creek
Crampton Ditch	March Ditch	Strouble Ditch
Davidson Ditch	Markley Ditch	Sullivan Ditch
Deer Creek	May Ditch	Threemile Creek
Downing Ditch	Mc Allister Ditch	Tri Run
Egley Ditch	Metzner Ditch	Vandorn Ditch
Engle Ditch	Miller Ditch	Wabash River
Freemyer Ditch	Montgomery Ross Ditch	Warner Ditch
Glendenning Ditch	Moser Ditch	West Mortimore Ditch
Glentzer Perry Ditch	Myers West Ditch	Wheeler Ditch
Goss Switzer Ditch	Oakley Ditch	Wilson Creek
Green Run	Pape Haffner Ditch	Wilson Ditch
Grissom Ditch	Peden Ditch	Wolf Creek
Hartzel Ditch	Perry Ditch	Young Ditch

(IDEM, 2005)

Only 1% or approximately 330 acres of the watershed is classified as open water or wetland. Natural drainage in the Upper Wabash River Basin watershed is poor consisting of soils with high silty-clay content. Prior to settlement in the mid-1800s, marshes and swamps were common. As settlements arose and agricultural production became the mainstay of the area, subsurface drainage systems were installed as a necessity for crop production.

Land Ownership

The majority of land in the Upper Wabash River Basin watershed is privately owned. There are significant holdings of land by the State including Limberlost Swamp Wetland Preserve (531 acres) in Adams County, Loblolly Marsh Wetland Preserve (428 acres) in Jay County, and Ouabache State Park including Kunkel Lake (25 acres) in Wells County. These areas, along with several others will be discussed in further detail in later sections.

Endangered, Threatened, and Rare Species

In addition to a wide variety of native tree species, the Upper Wabash River Basin watershed are home to several unique plant and animal species. As shown in **Appendix 2**, there are a number of endangered, threatened, and rare plants and animals that have been identified in Adams, Jay, and Wells Counties. The Eastern Mississauga snake, the Indiana Bat, and the Barn Owl have been known to inhabit the tri-county area.

2.0 IDENTIFYING WATER QUALITY PROBLEMS AND CAUSES

As part of the watershed planning process, an inventory and assessment of the watershed and existing water quality studies relevant to the watershed must be conducted. Examination of previous work may show that data already gathered is sufficient for determining the magnitude and extent of water quality conditions, or it may indicate that additional studies are needed to characterize the water quality problems. In either case, assessing water quality information that has already been completed is part of the initial process of building a WMP and will help to guide the identification of water quality problems and links to pollution sources in the watershed. The following section provides a summary of past and current assessments of the Upper Wabash River Basin.

2.1 STAKEHOLDER CONCERNS

The individuals living, working, and playing in a watershed can prove themselves valuable by providing both current and historical insight to the issues of the area. These issues revolve around water quality, water quantity, and other associated natural resource concerns in the watershed. Concerns listed by the Steering Committee in the original grant application are identified below.

1) Failing manure management; poultry farm manure
2) Livestock access to open streams
3) Grain farming tilled to edge of streambank & nutrients/chemical application
4) Ohio-Mercer County (southern part) most concentrated livestock area in US
5) Urban lawns: fertilizer & chemicals
6) Parking Lot & Pavement Runoff
7) Increased water quantity and velocity; streams dredged w/o BMPs to keep sediment from re-entering streambank; erosion
8) Open streams: no filter strips or riparian corridor & livestock trample streams
9) Rural homes: failing septic, severely limiting soils
10) Wetlands, forest being cleared

The aforementioned concerns were consolidated by the Steering Committee to create 5 categories of concern regarding the Upper Wabash River Basin. These topics have further been addressed in public meetings and workshop settings with invited presenters.

1) Stakeholder education
2) Water quantity in regards to flooding control, streambank restoration, and log jam removal
3) Agricultural production in regards to crop production, livestock, and manure management
4) *E. coli* loadings to waterways in the watershed
5) Urban development and associated water quality and quantity issues

2.2 WATER QUALITY BASELINE STUDIES

The following section provides a summary of baseline water quality conditions present in the Upper Wabash River Basin as found in other plans, studies, and investigations.

Wabash River Nutrient and Pathogen TMDL Development

The severity ranking for the Wabash River is high and data has recently been collected as part of a TMDL development. The TMDL addresses *E. coli*, nitrate, and phosphorus in the Wabash

River from the Indiana – Ohio state line to the Indiana – Illinois state line. Loads of pH and dissolved oxygen were not calculated but it is anticipated that the nutrient TMDLs will result in attainment of the water quality standards for these two parameters. The Indiana portion of the *E. coli* and nutrient TMDLs were based on assumptions that Ohio's standard would be met at the state line. This theoretically ensures that each state is responsible for reducing loads that are generated within their boundaries. The targets utilized for the nutrient and *E. coli* TMDLs are provided in **Table 2-1** below.

Table 2-1: TMDL Targets

TMDL	IN targets	OH targets
Nutrients		
Nitrate + Nitrite	10 mg/L	1.5 mg/L
Phosphorus	0.30 mg/L	0.17 mg/L
E. coli	125 cfu/100 mL	126 cfu/100 mL

(Wabash River TMDL, 2006)

Water quality standards were assessed for several representative locations to facilitate the allocation process and the presentation of the results. For the area being studied as a part of this planning process, information obtained within the reach of the Wabash River at the inflow to J. Edward Roush Lake will be utilized. On average, the findings for *E. coli* were that between the months of April and October, approximately 95% of the *E. coli* loadings from non-point source pollution needs to be reduced. Total Phosphorus non-point source reductions range from 12% - 23%, and Nitrate reductions from non-point sources are not warranted per this study.

A public review draft of the Wabash River Nutrient and Pathogen TMDL Development was released in July of 2006. A final draft of the document was approved on September 22, 2006.

2006 Indiana Integrated Water Quality Report

The IDEM is the primary agency involved in surface water quality monitoring and assessment in the State of Indiana. In conjunction with the requirements of the CWA and the State's goals for protecting its natural and recreational resources, the IDEM operates several monitoring programs designed to monitor and assess the chemical, physical, and biological conditions of Indiana's rivers, streams, and lakes.

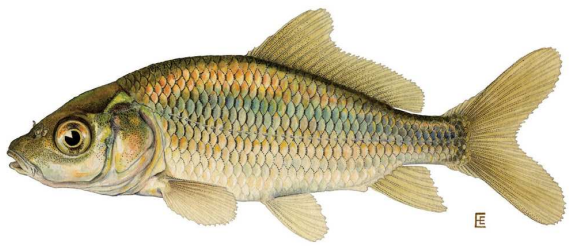
The IDEM's Office of Water Quality's surface water quality basin strategy is designed to describe the overall environmental quality of each major river basin in the state and to identify monitored water bodies that do not fully support designated uses. The IDEM's surface water monitoring was revised in 2001 to meet the goals of assessing all waters of the state within five years.

The 305(b) report provides a compilation and summary of all of the IDEM's water quality monitoring and assessment data (compiled from AIMS database and other datasets/reports within the IDEM). Each subwatershed is given a water quality rating relative to its streams status in meeting Indiana's Water Quality Standards (WQS). WQS are set at levels necessary for protecting a waterway's designated use(s), such as swimmable, fishable, or drinkable. Each subwatershed is given a rating of fully, partially, or not supportive of its designated uses.

Chapter 303(d) of the CWA requires states to identify waters that do not or are not expected to meet applicable water quality standards with technology based standards alone. States are also required to develop a priority ranking for these waters, taking into account the severity of the pollution and the designated use of the waters. Once this listing and ranking of waters is completed, States are required to develop TMDLs for these waters in order to achieve water quality standards. The Wabash River and tributaries were listed on both the 2002 and 2004 303(d) List of Impaired Waters due to *E. coli*, Nutrients, and Impaired Biotic Communities. In an attempt to ensure greater consistencies between the 305(b) report and 303d list, the two reports are now submitted together as an integrated report to U.S. EPA every two years. **Appendix 3** identifies the Upper Wabash River Basin's impairments as identified by the 2006 Integrated Water Quality report.

Fish Consumption Advisory (FCA)

Each year since 1972, three agencies have collaborated to create the Indiana FCA. These agencies include the IDEM, the IDNR, and the Indiana State Department of Health (ISDH). Each year, members from these agencies meet to discuss the findings of recent fish monitoring data and to develop the new statewide fish consumption advisory.



The 2004 FCA is based on levels of PCBs and mercury found in fish tissue. In each area, samples were taken of bottom-feeding fish, top-feeding fish, and fish feeding in between. Fish tissue samples were analyzed for PCBs, pesticides, and heavy metals. Of those samples, the majority contained some level of mercury. However, not all fish tissue samples had mercury at the levels considered harmful to human health. If the samples resulted in higher than normal levels of mercury, those waterbody segments were listed in the fish consumption advisory.

While there are seemingly few FCAs noted within the Upper Wabash River Basin, it should be realized that there is a statewide Fish Consumption Advisory for carp in all Indiana streams, the Indiana portion of Lake Michigan, and inland lakes due to the bioaccumulation tendencies of PCBs. More detailed information related to specific stream segments and the FCAs identified for those streams can be found in Appendix 3.

An Assessment of Pesticides in the Upper Wabash River Basin

In 1998, surface water samples from the Upper Wabash Basin were analyzed for 142 pesticides, pesticide degradation products, and urban chemicals. Atrazine, metolachlor, and acetochlor were the most represented pesticides during the study. Average concentrations for the three respective pesticides were 3.31ug/L, 2.17ug/L, and 1.04ug/L. The drinking water Maximum Contaminant Level (MCL) for atrazine is 3.0ug/L, 2.0ug/L for acetochlor, and there is no MCL for metolachlor. The study also utilized flow data and mathematical calculations to determine estimated loadings of each pesticide. Table 2-13 identifies the average concentration, Drinking Water MCL, and the percent runoff for each pesticide. Utilizing sampling results obtained at the USGS gaging station located on the Wabash River at Linn Grove, the pesticides Acetochlor and Atrazine were in exceedence of the MCL in 4 of the 11 samples taken between April 20, 1998 and July 29, 1998. The pesticide Metolachlor was not contained in the samples obtained from the Linn Grove sampling station.

Table 2-2: Pesticide Concentrations and MCLs in the Upper Wabash Basin

Pesticide	Average Concentration	Drinking Water MCL
Atrazine	3.31 ug/L	3.0 ug/L
Metolachlor	2.17 ug/L	N/A
Acetochlor	1.04 ug/L	2.0 ug/L

(IDEM, 2001)

The study also evaluated which tributary watersheds to the Upper Wabash River contribute the largest pesticide loadings. In general, it was determined that pesticide loadings were correlated with a watershed's contributing land use. Large watersheds tended to contribute larger pesticide loadings while smaller watershed tend to contribute smaller pesticide loadings. However, the correlation was not absolute, as factors such as soil composition, rainfall totals, the timing of sampling events, and land use all influence the pollutant loadings of a watershed.

The report concluded that identification of tributaries contributing the greatest pesticide loads was important and that priority should be given to federally funded Clean Water Act Section 319 grant projects within these basins to help alleviate pesticide runoff potential. Currently EPA requires a 66' setback for atrazine use; numerous county landowners are utilizing federal cost share dollars to implement filter strips in order to abide by this regulation.

Chemical Water Quality Assessment

In an effort to establish an expanded baseline of water quality conditions in the Upper Wabash River watershed, CBBEL partnered with JRM Environmental, Inc. to develop a chemical water quality monitoring program. Two water quality sampling events were conducted, one during a wet weather period and another event completed during a dry weather period. The first event (dry weather sampling) took place August 29 and 30, 2005, while the second sampling event (wet weather sampling) occurred on October 25 and 26, 2005. Twenty (20) sampling stations were established in the Upper Wabash River watershed, with sampling parameters including total phosphorus, nitrogen/nitrates/nitrites, total coliform, and *E. coli*. **Table 2-3** describes the water quality sampling sites located within the Upper Wabash River watershed. Duplicate field samples were also collected at sites 1 and 20 for validation purposes. **Appendix 4** provides the raw chemical and biological sampling data completed by JRM Environmental, Inc. for the purpose of this planning process.

Table 2-3: Narrative Description of Chemical Monitoring Sites

Site ID #	Waterbody	County	Location
1	Simison Creek	Jay	State Line Rd Bridge
2	Wabash River	Jay	State Line Rd Bridge
3	Wabash River	Jay	County Road 700E Bridge
4	Limberlost Creek	Jay	County Road 450E Bridge
5	Limberlost Creek	Jay/Adams	County Line Road Bridge
6	Loblolly Ditch	Jay	County Road 375W Bridge
7	Loblolly Ditch	Adams/Jay	County Road 300 W/50W Bridge
8	Wabash River	Adams	County Road 125 E Bridge
9	Loblolly Creek	Adams	County Road 1050 South west bank
10	Wabash River	Adams	Covered Bridge Road Bridge

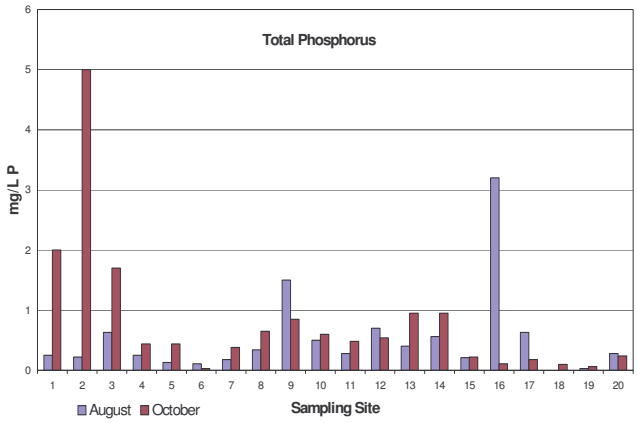
11	Wabash River	Adams	US Highway 27 S Bridge
12	Wabash River	Adams	County Road 400W Bridge
13	Wabash River	Adams	SR 218 West St Rt Bridges
14	Wabash River	Adams	CR 300S NE streambank
15	Wabash River	Wells	State Road 316 Bridge
16	Un-named Tributary	Wells	Elm Grove Road Bridge
17	Un-named Tributary	Wells	State Road 116 Bridge
18	Markley Ditch	Wells	State Road 116 Bridge
19	Six Mile Creek	Wells	State Road 116 Bridge at Six Mile Cemetery
20	Wabash River	Wells	County Road 450E Bridge

Nutrients

The term "nutrients" primarily refers to the two major plant macronutrients, phosphorus and nitrogen. These nutrients are common components of fertilizers, animal and human wastes, vegetation, and some industrial processes. Nutrients up to certain levels are both necessary and beneficial to water bodies. However, an overabundance of nutrients can stimulate the occurrence of algal blooms and excessive plant growth, which can result in the reduction of dissolved oxygen concentrations in surface water through respiration and the decomposition of dead algae.

Total Phosphorus

Nonpoint discharges are the major source of phosphorus in most watersheds. Phosphorus can be present as organic matter and can be either dissolved or suspended in the water column. Phosphorus may also occur in inorganic compounds released from various minerals, fertilizers, and detergents, which may also be either dissolved or suspended in the water column. Phosphorus is the primary nutrient associated with the production of algae and aquatic plants, as it is often a limiting nutrient in aquatic environments.



When referring to the chemical water quality sampling completed in 2005, guidelines were provided by DRAFT TMDL that total phosphorus levels equal to or above 0.3 milligrams per liter (mg/L) were an indication of poor water quality at the sampling sites. As shown from the sampling data, phosphorus loadings to the waterways within the Upper Wabash River watershed are an issue of concern and should be addressed. Of 20 samples, 10 samples, or 45%, resulted in levels of phosphorus higher than 0.3mg/L during the August collection event. Two of those ten samples had levels that exceeded 1.0 mg/L of total phosphorus.

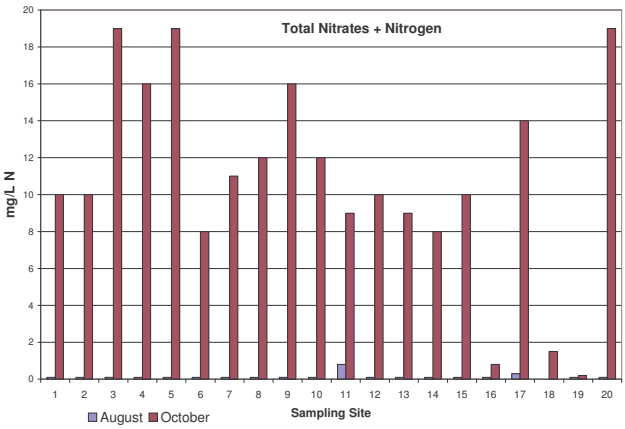
During the October collection event, 14 samples, 64%, indicated levels above 0.3mg/L, including 3 sites that resulted in levels above 1.0 mg/L. Seven sites (#3, 8, 9, 10, 12, 13 and 14) sampled had levels of total phosphorus that exceeded 0.3 mg/L during both the dry (August)

and the wet (October) collection events. This would seem to indicate a more continual phosphorus loading situation than had the exceedance occurred only during one event.

With approximately 92% of the land use in the Upper Wabash River watershed involved in agricultural production, it would seem highly likely that the main source of the phosphorus loadings to the sampled waterways are originating from associated agricultural practices. Situations such as conventional tillage, applied fertilizers and/or manure, failing septic systems usually located in more rural areas, and feedlot runoff should all be considered potential contributors of phosphorus.

Total Nitrogen/Nitrates/Nitrites

Point source discharges, such as Wastewater Treatment Plants (WWTP) can be a significant source of ammonia in surface waters; however, nonpoint discharges such as untreated effluent from septic systems, decaying organisms, and bacterial decomposition of organic waste from improper disposal or over-application of fertilizers in stormwater runoff can also contribute to the level of nitrogen in a waterbody.



Nitrogen is a significant factor in the water quality degradation of the Upper Wabash River, as shown by the 2005 sampling events. The guideline given by the DRAFT TMDL for total nitrogen was such that a value equal to or greater than 10 mg/L indicates poor water quality. Following this, in August, all samples collected were below 1.0 mg/L total nitrogen. However, 67% of the samples collected in October, or 14 of 20 samples resulted in levels above 10.0 mg/L of total nitrogen. Above those 14 samples, an additional 4 samples were valued at levels between 8.0 mg/L and 10 mg/L, indicating nearly 86% of the sampled sites have issues regarding nitrogen loadings.

As with phosphorus, all indications seem to focus on agricultural production activities as the main contributor to the water quality issues in the area. However, other potential sources, such as WWTPs, Combined Sewer Overflows (CSOs), and the application of residential or recreational fertilizers should not be overlooked. With the majority of the exceedences occurring during high flow events, it would seem to indicate that septic systems are not the main contributor of the usual rural nonpoint sources of pollution. More so, manure management practices such as storage and application, and agricultural fertilizer application should be further investigated, along with livestock access to tributary streams and feedlot management practices.

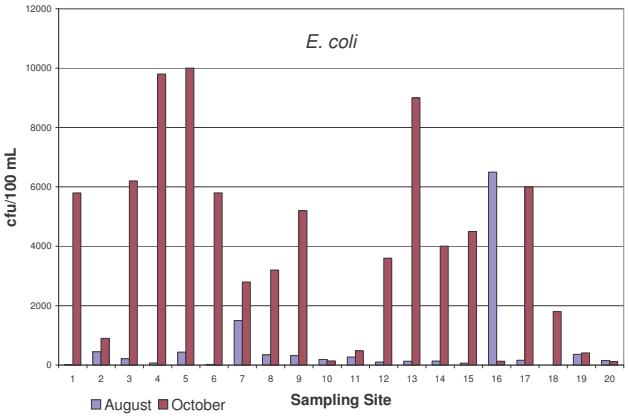
As the Wabash River Basin includes a significant drainage area within Ohio, it is important to become aware of the contributions regarding water quality, as well as water quantity. One of the chemical monitoring stations was located along the Ohio-Indiana State line. Site #1 captures water quality data as the Wabash River exits Ohio and enters Indiana. It can also be noted that while neither Ohio or Indiana have promulgated ambient water quality nutrient standards, targets utilized during the development of the Wabash River Nutrient and Pathogen TMDL Development are significantly varied. If the Ohio values were utilized, merely 6 of 40

samples or 15% are below the 0.17 mg/L target. With the same considerations regarding Nitrates + Nitrogen, approximately 50% of the samples collected are at or below the 1.5 mg/L target. Nearly all of the samples at or below the Nitrate + Nitrogen Ohio target were obtained during the August sampling event.

E. coli Bacteria

E. coli bacteria are associated with the intestinal tract of warm blooded animals and are widely used as an indicator of fecal pollution in water bodies. *E. coli* can enter surface waterbodies from nonpoint sources such as runoff from malfunctioning septic systems, straight pipe discharges from septic tanks, livestock, domestic pets, and wildlife. In addition, *E. coli* can also come from improperly treated or untreated discharges of domestic wastewater. Detection of *E. coli* in water bodies may indicate the presence of other microbes harmful to humans. Certain *E. coli* bacteria themselves may cause disease in humans and animals.

E. coli is also used as an indicator because it is easier and less costly to monitor for and detect than the actual pathogenic organisms such as *Giardia, Cryptosporidium,* and *Shigella*, which require special sampling protocols and sophisticated laboratory techniques in order to evaluate. The presence of waterborne disease causing organisms can cause outbreaks of diseases such as Typhoid Fever, dysentery, Cholera, and Chryptosporidosis.



Indiana WQS for *E. coli* have been established in order to ensure safe use of surface waters for recreation and drinking water. The state WQS for *E. coli* states that the E. coli bacteria, using membrane filter count, shall not exceed 125 colony forming units per 100 milliliters (cfu/100mL) as a geometric mean based on not less than 5 samples equally spaced over a 30 day period, nor exceed 235 cfu/100mL in any one sample in a 30 day period.

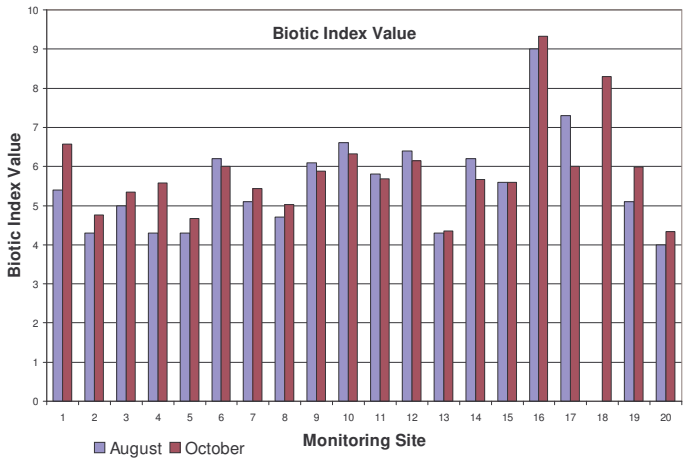
In all, for the first sampling event (August) there were 2 instances out of 20 where the levels were greater than 1,000 cfu/100mL mark, representing 10% of the samples taken. For August, when referencing the Indiana state WQS for *E. coli* (235 cfu/100mL) 8 of 20 samples or 40% were in violation. During the October sampling event, 80%, or 16 of 20 samples taken were in violation of the Indiana State WQS for *E. coli* (235cfu/100mL). Further 14 samples of 20 taken in October were indicative of excessive *E. coli* levels over 1,000 cfu/100mL.

Biological Water Quality Assessment

In addition to chemical water quality monitoring, CBBEL partnered with Commonwealth Bio-monitoring, Inc. to conduct habitat evaluations and macro-invertebrate monitoring at all sites utilizing both the Qualitative Habitat Evaluation Index (QHEI), and the biotic index. The purpose of these indices is to provide a measure of the stream habitat and riparian health which correspond to the physical factors affecting fish and other aquatic life. The QHEI values range from 100, or extremely good, to 0, or extremely poor while the Biotic Index Values range from 1 to 10, or extremely good to extremely poor, respectively.

The overall Biotic Index scores in the Upper Wabash River watershed ranged from 4.0 to 9.0, while the QHEI values were similar with respect to a range of 21 to 66. Taking the two indices

into consideration, an assessment was made regarding the overall water quality with only one site scoring in the "Very Good" range, 7 sites scoring in the "Good" range, 3 sites with a "Fair" rating, 5 sites with a "Fairly Poor" rating, 2 sites rated as "Poor" and 2 sites rated as "Very Poor". One of the assessed sites (site 18) was observed dry so no biological assessment could occur.



Priority sites were suggested and divided into two categories by those completing the assessment. Priority sites with relatively good habitat but with a relatively poor biotic index are Sites 10, 11 and 12. The priority site selected based on the biotic index value indicating obvious sewage-related pollution is Site 16.

IDEM Total Suspended Solids (TSS) Data

Sediment monitoring was completed throughout the Upper Wabash River Basin at 30 IDEM monitoring locations. The number of samples per site varied with some locations such as the Wabash River at the Ohio-Indiana State Line, Wabash River at US 27, and the Wabash River at Adams County Road 400 W with the longest sampling record (1991-2006) and the most number of individual samples. Two of these locations were sampled through USGS stream gages utilized in loading and reduction calculations later in this WMP; the Ohio-Indiana State Line and Linn Grove.

While a State WQS for TSS had not been established, a guideline target concentration of 80 mg/L TSS was set for this watershed in based on guidelines provided by Waters, 1995. For the three sampling sites with the greatest number of samples and the longest sampling period, the summary information is shown below in **Table 2-4**.

Table 2-4: IDEM TSS Data

Site Location	Length of Record	# Samples	Avg. TSS (mg/L)
Wabash River @ OH-IN State Line	2005-2006	32	95.9
Wabash River @ US 27	1991-2002	135	85.6
Wabash River @ Adams CR 400W	2003-2006	40	117.2

Water Quality Prioritization

In an effort to prioritize sampling sites based on data collected throughout the entire watershed, a water quality matrix was developed to rank and prioritize the overall aquatic ecological situation at each site. In **Table 2-5,** the average concentration of each parameter discussed above and its corresponding ranking is compared for each site within an 11-digit HUC and overall priority rankings are identified. While the data presented in the tables are averages, the raw data tables can be found in Appendix 4.

It can be shown by the sampling data that site 9, Loblolly Creek at State Road 116 near County Road 1100S, in the 0512010-040 watershed has the lowest overall water quality. This is further

described by looking at the individual parameters and the ranking of site 9: 4 of 5 for *E. coli*, Total Nitrogen and Total Phosphorus, and the lowest scores for the Biotic Index and the QHEI.

Regarding subwatershed 0512010-050, site 5, Limberlost Creek at the Jay/Adams County Line Road Bridge, resulted in the poorest water quality for the chemical components. However, this site scored the highest for this subwatershed for the Biotic Index and second highest for the QHEI. Total Nitrogen and *E. coli* samplings for this segment of Limberlost Creek were the poorest of this section. Similarly, the other site sampled on the Limberlost Creek, site 4, at the County Road 450E Bridge, was proven to have poor water quality as well, seemingly indicating an overall trend in the Limberlost Creek drainage area.

Sites 16 & 17, both unnamed tributaries to the Wabash River, West of Vera Cruz, tied for the poorest water quality observed in the 0512010-060 subwatershed of the Upper Wabash River watershed. These sites both were consistent in placing the lowest two or three rankings for all parameters. The exception to this being site 16's ranking as the second best result for Total Nitrogen in the subwatershed.

If the focus of watershed planning efforts is to be targeted on a broader level, the subwatershed 0512010-060 should be the primary focus of implementation efforts, education & outreach and other restoration activities. Ten sampling sites were located in this subwatershed, with 80% of those sites resulting in higher priority rankings than other sites in other subwatersheds.

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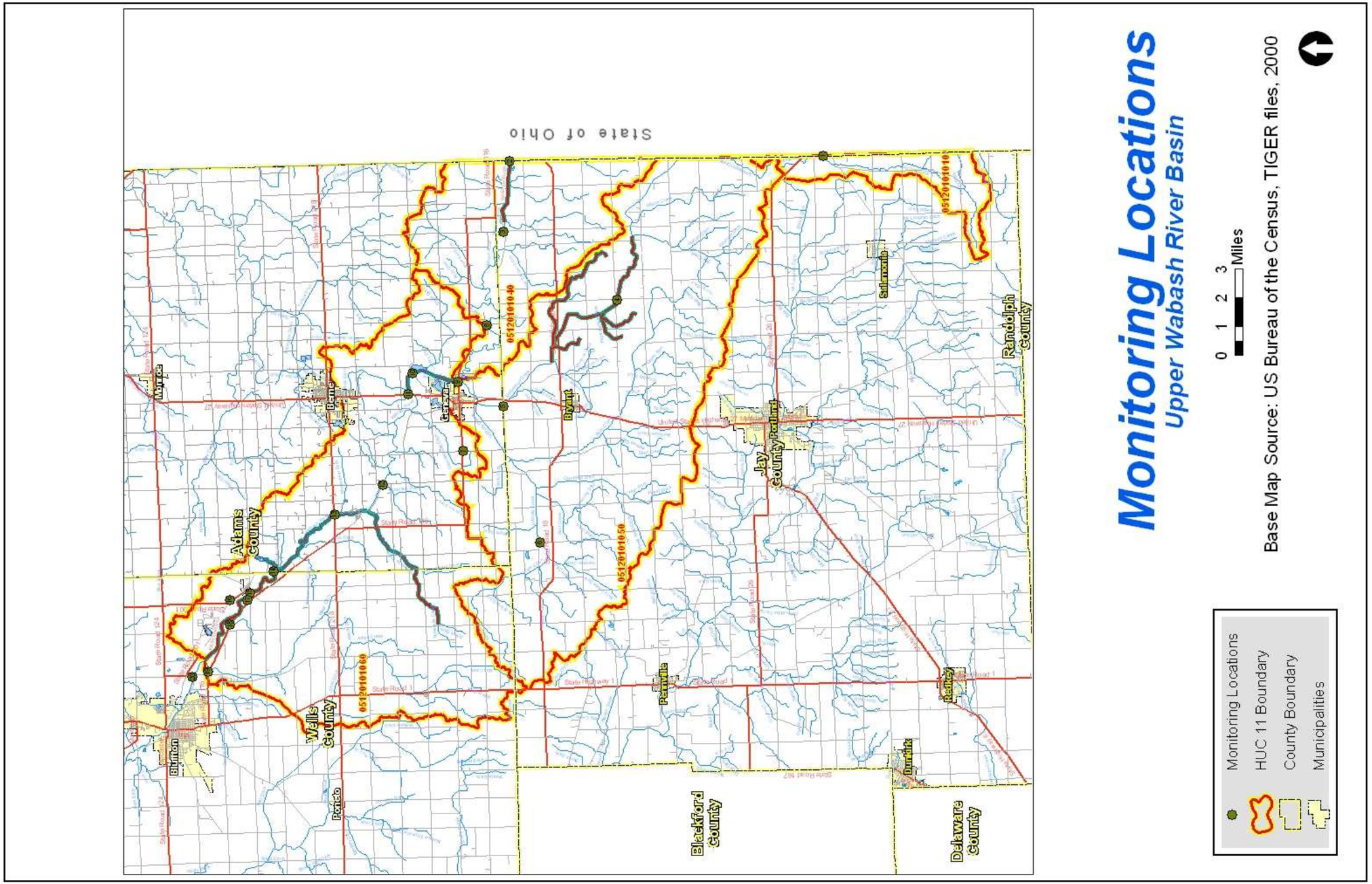

Monitoring Locations
Upper Wabash River Basin
Monitoring Locations
HUC 11 Boundary
County Boundary
Municipalities
0 1 2 3
Miles
Base Map Source: US Bureau of the Census, TIGER files, 2000
State of Ohio
Adams County
Wells County
Randolph County
Jay County
Blackford County
Delaware County
Bluffton
Berne
Geneva
Pennville
Redkey
Dunkirk
Salamonia
Bryant
Monroe
Pleasant
05120101040
05120101050
05120101060
05120101010

Table 2-5: Water Quality RankingUpper Wabash River watershed

11-digit HUC	Site #	Location	Total Phosphorus mg/L		Total N Nitrates + Nitrites mg/L		*E. coli* cfu/100mL		Biotic Index Value		QHEI Score		Final Rank	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Sum	Rank
05120101-040	1	Simison Creek – State Line Rd Bridge	1.13	2	5.05	1	1409	2	5.4	4	51	3	12	2
	2	Wabash River – State Line Rd Bridge	2.61	5	5.55	2	675	1	4.3	1	61	1	10	1
	3	Wabash River – CR 700E Bridge	1.17	3	9.5	5	3208	5	5.0	3	58	2	18	3
	8	Wabash River – CR 125E Bridge	0.50	1	6.0	3	1773	3	4.7	2	61	1	10	1
	9	Loblolly Creek – CR 1050 S (west bank)	1.18	4	8.0	4	2760	4	6.1	5	36	4	21	4
05120101-050	4	Limberlost Creek – CR450E Bridge	0.34	4	8.05	3	4937	3	4.3	1	52	1	12	3
	5	Limberlost Creek – County Line Rd bridge	0.29	3	9.5	4	5220	4	4.3	1	44	2	14	4
	6	Loblolly Ditch – CR 375W Bridge	0.07	1	4.0	1	2911	2	6.2	3	26	3	10	1
	7	Loblolly Ditch – CR300 W/50W Bridge	0.28	2	5.5	2	2150	1	5.1	2	24	4	11	2
05120101-060	10	Wabash River – Covered Bridge Rd Bdg	0.06	2	6.0	8	163	2	6.6	8	51	4	26	4
	11	Wabash River – US27 Bridge	0.38	5	4.9	6	374	3	5.8	5	51	4	23	3
	12	Wabash River – CR400W	0.62	7	5.0	7	1850	6	6.4	7	58	3	30	6
	13	Wabash River – SR218 Bridge	0.68	8	4.5	5	4564	11	4.3	2	66	1	27	5
	14	Wabash River – CR300S NE bank	0.76	9	4.0	4	2069	7	6.2	6	44	6	32	7
	15	Wabash River – SR316 Bridge	0.22	3	5.0	7	2282	8	5.6	4	50	5	27	5
	16	UNT – Elm Grove Rd Bridge	1.66	10	0.40	2	3314	10	9.0	10	21	9	41	8
	17	UNT – SR 116 Bridge	0.41	6	7.15	9	3083	9	7.3	9	38	8	41	8
	18	Markley Ditch – SR 116 Bridge	0.05	1	0.75	3	900	5	*		*			
	19	Six Mile Creek – SR 116 Bridge	0.05	1	0.10	1	386	4	5.1	3	43	7	16	1
	20	Wabash River – CR 450E Bridge	0.26	4	9.50	10	135	1	4.0	1	65	2	18	2

(5 = Higher Restoration Priority)

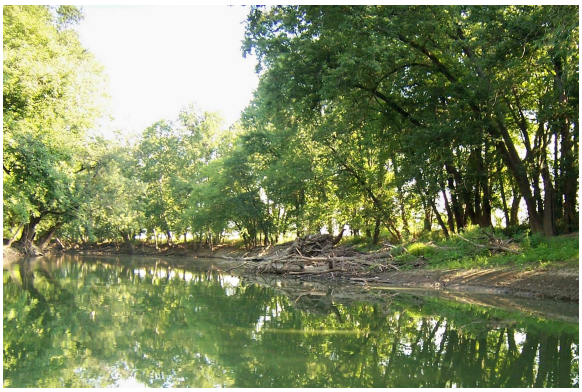
2.3 BASELINE WATER QUALITY: CONCERNS, PROBLEMS, AND CAUSES

Linking stakeholder concerns with known and discovered water quality issues in the watershed helps to validate initial observations and provides evidence to dismiss others. Thus, a review of historic water quality studies can help to guide the planning process toward management actions that are most appropriate and efficient for improving water quality conditions. The following descriptions detail water quality baseline conditions that have been established by prior studies as they relate to stakeholder concerns. These descriptions are organized by listed stakeholder concerns as shown in Section 2.1, and provide the foundations for the watershed management strategies identified in the WMP.

Stakeholder Education – Public, local decision makers, organizations

The studies listed in Section 2.2 indicate that there are certainly water quality problems associated with the Upper Wabash River and its tributary streams. Those problems stem from elevated levels of nutrients and bacteria in the water system. These levels can directly be impacted by raising stakeholder awareness and modifying day-to-day behavior within the watershed. The results of the water quality studies support the idea that education and outreach will positively impact the water quality in this watershed.

Flooding – Flood control, streambank restoration, log jam removal



Stakeholders in the Upper Wabash River watershed have expressed great concern over the issue of water quantity. Interest is high in regard to flood control measures, streambank restoration, and log jam removal practices. Historic climate and disaster data does indicate a strong prevalence of high water events, carrying with them the ability to wash out valuable in-stream habitat, destruct streambanks, increase pollutant loadings to receiving waterbodies, and associated destruction of aquatic communities. Debris from infrastructure and buildings damaged by flood events, oils, grease, and toxins from submerged vehicles and septic systems, and common chemicals and solvents that are present in nearly every home and can all become mobile when flooding occurs.

Agricultural Impacts – Crop production, livestock & manure management,

The studies listed do indicate a potential impact on water quality by agricultural practices within the boundaries of the watershed. Pollutant loadings from agricultural sources can include pathogens, nutrients, and sediments. Elevated levels of phosphorus, nitrates, sediment, and pesticides have been observed during sampling sessions at locations in the Upper Wabash River watershed surrounded by agricultural land uses. *E. coli* impairments could likely be linked to land applied manure, livestock with direct access to waterways, and improper handling of manure and nutrients. Prior studies do indicate that the concerns raised regarding agricultural practices and the associated impact to water quality are supported by the data.

E. coli Loadings – Failing septic systems, land applied manure, wildlife

Referencing the 305(b) and 303(d) listings provided by IDEM and the chemical sampling completed in the fall of 2005, it can be witnessed that the levels of *E. coli* exceed the limits set for good water quality. The Steering Committee has expressed concern regarding this parameter specifically questioning the effects from failing septic systems. Another potential

source, wastewater treatment plant facilities within the watershed, should be further investigated to determine if these facilities are impacting the Upper Wabash River watershed. Import should be placed on this issue as it is a direct impairment not only to water quality, but also to human health.

Urban Development – Land use change, increased imperviousness

Point source and non-point source pollution has the potential to greatly increase proportionally to urban development. Increases in leaking underground storage tanks, impervious surfaces, household and yard waste, and even pet waste all contribute to the degradation of water quality. While there are no major urban areas in the Upper Wabash River watershed, the potential for growth is always accounted for. Planning needs to occur so that new construction and areas of development are required to implement measures to limit soil erosion and control stormwater runoff to reduce further degradation of the river and tributaries.

3.0 IDENTIFYING POTENTIAL POLLUTANT SOURCES

A number of substances, including nutrients, bacteria, metals, and toxic substances may cause water quality impairments. Sources of pollutants are divided into two broad categories: point sources and non-point sources. Prior sections of the WMP have identified stakeholder concerns, presented historic evidence of impairment, and discussed whether that evidence supports or negates those stakeholder concerns. This section attempts to present possible sources of pollution to the waterways that have been identified as issues or areas of concern. Where possible, the magnitude and extent of pollutant sources are supported by pollutant loading estimates. **Section 4** will provide greater detail regarding beneficial critical areas as well as critical areas that are a potential source of pollution.

3.1 POTENTIAL POINT SOURCES OF POLLUTION

Point source pollution refers to discharges that enter surface waters through a pipe, ditch, or other well-defined point of discharge, such as wastewater and stormwater discharges from a variety of sources. The primary pollutants associated with point source discharges are oxygen demanding wastes, nutrients, sediment, toxic substances, ammonia, and metals. It is important to identify that these permitted facilities exist within the watershed, but that identification is not intended to indicate that these facilities are negatively impacting water quality. Point source pollution was not specifically discussed as a primary concern by the Steering Committee. However, through the development of this WMP, point sources were identified to create a more comprehensive overview of the potential source of water quality degradation.

Potential Point Sources from Industrial Facilities

Wastewater point source discharges include municipal (city, town, or county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions, and individual homes. Stormwater point source discharges include stormwater discharges associated with industrial activities and stormwater discharges from Municipal Separate Storm Sewer Systems (MS4s) operated by municipalities and counties.

Industrial point source dischargers in Indiana must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program, which is delegated to IDEM by the US EPA. Within the boundaries of the Upper Wabash River watershed, there are 10 active NPDES permitted facilities outlined in **Table 3-1**, and **Exhibit 3** illustrates where in the watershed the facilities are located. Violations noted within Table 3-1, as identified by information provided by IDEM, were observed from August 31, 2002 through October 31, 2006.

Table 3-1: NPDES Facilities in the Upper Wabash River Watershed

Permit Number	Facility Name	City	Receiving Stream	NPDES Violations
IN0004839	Tomato Products, Inc. Geneva	Geneva	Loblolly Creek	BOD – 4 Nitrogen – 13 Oils & Grease - 1 Solids - 5
IN0039357	Geneva Municipal STP	Geneva	Loblolly Creek	Chlorine – 9 *E. coli* – 1 Nitrogen – 2

Permit Number	Facility Name	City	Receiving Stream	NPDES Violations
				pH - 2
IN0045004	Amishville USA, Inc, WWTP	Geneva	Liechty & Engle Ditch	None reported
IN0050211	Bearcreek Farms, Inc.	Bryant	Longnecker Ditch	BOD – 11 *E. coli* – 23 Nitrogen – 36 Solids - 25
IN0053121	Ouabache State Recreational Area	Bluffton	Wabash River	Chlorine - 10 Solids - 14
IN0055158	Bryant Municipal STP	Bryant	Perry Ditch	BOD – 15 Dilution Factor – 12 pH – 8 Solids - 7
ING490046	Mershberger Bros. Stone	Linn Grove, Berne	Rice Ditch	None reported
ING490053	Stoneco, Bryant Quarry, Plant 17	Bryant	Wabash River via Ditch	None reported
ING490060	Limberlost Sand & Gravel	Geneva	Loblolly Creek	None reported
INP000057	Elkhart Products Corporation	Geneva	Geneva STP to Loblolly Creek	None reported

(IDEM, 2006)

Potential Point Sources from Leaking Underground Storage Tanks

Another point source of pollution is the Underground Storage Tank (UST) used to store substances such as used oil, gasoline, gases, or even food products. Approximately 95% of the USTs contain some form of petroleum products and are placed underground to reduce the possibility of explosion. Other common uses include dry cleaning facilities for storage of chemicals, vehicle service stations for storage of used motor oil, and residences equipped with heating oil tanks either located in the basement or buried in the yard. Residential tanks are not regulated by IDEM but may pose a higher risk as heating oil systems are replaced by more modern heating systems. In many cases, the heating oil tanks are not removed and may continue to leak contents and residue with water table fluctuations.

Prior to 1998, many of the tanks and associated piping utilized were constructed of unprotected steel. Depending on the soil conditions, water table, and other groundwater conditions the underground systems began to show signs of rust and potential leaks after 10 years. Facilities with new tanks installed or replaced after 1998 were required to utilize liners composed of non-rusting materials. IDEM has prioritized Leaking Underground Storage Tank (LUST) areas into high, medium and low categories based on the risk posed to the general population, environmentally sensitive areas or other infrastructure. Those areas considered to be of a high priority include those where drinking water sources may be impacted, surface pooling of the substance is observed, utility lines (sewer) may be affected, environmentally sensitive areas are endangered or where vapors are

present in buildings in use. Moderate priority LUST areas are those where no aforementioned conditions exist and there is a potential for groundwater contamination due to leaking contents. Low priority areas are those where only the soil surrounding the LUST may become impacted.

According to IDEM's Office of Land Quality, there are currently 8 LUST sites within the Upper Wabash River Watershed. Within Adams County, there are 2 moderate and 2 low areas; Jay County has 1 moderate and 2 low sites listed; while Wells County has only 1 low prioritized area. Those LUSTs identified within the watershed boundaries are included in Exhibit 3.

Potential Point Sources from Confined Feeding Operations

Confined Feeding Operations (CFOs) are also considered to be a potential point source discharger and are required by IAC 16-2-5 to obtain an NPDES permit from IDEM's Office of Land Quality for operation. Livestock operations with at least 300 cattle, 600 swine, 600 sheep, or 30,000 fowl for at least 45 days within a 1 year period are designated as a CFO and must complete the permitting process prior to construction of the facilities. Furthermore, any existing operation with fewer animals but wishing to expand to the numbers listed above must apply for and obtain an NPDES permit. Smaller operations with a previous water quality violation may also be designated as a CFO. Larger operations also known as Confined Animal Feeding Operations (CAFOs) are also required to obtain an NPDES permit due to the number of animals present at the operation. CAFOs have at least 700 mature dairy; 1,000 veal calves; 1,00 beef cattle; 2,500 swine greater than 55 lbs.; 10,000 swine less than 55 lbs.; 500 horses; 10,000 sheep or lambs; 55,000 turkeys; 30,000 layers with a liquid manure system; 125,000 broilers with a solid manure system; 82,000 layers with a solid manure system; 30,000 ducks with a solid manure system; or 5,000 ducks with a liquid manure system present for at least 45 days within a 1 year period.

Table 3-2: CFO and CAFO Species Limits

	CFO	CAFO
Cattle	300	
Dairy		700
Veal Calves		1,000
Beef Cattle		1,000
Swine	600	
Swine >55 lbs.		2,500
Swine <55 lbs.		10,000
Horses		500
Sheep or Lambs	600	10,000
Fowl	30,000	
Turkeys		55,000
Layers (liquid)		30,000
Layers (solid)		82,000
Broilers (solid)		125,000
Ducks (liquid)		5,000
Ducks (solid)		30,000

(IDEM, 2007)

In order to successfully obtain the NPDES permit, a facility must prove the following: a minimum of 120 days storage for manure, adequate acreage for application of manure, minimum

distances from wells and surface waters, a Manure Management Plan has been completed and sufficient levels of record keeping regarding the facility and associated activities.

According to IDEM's records, there are 59 permitted facilities in the Upper Wabash River Watershed. It is important to note that based on evaluation of IDEM records, there have not been any major enforcement actions taken on these facilities, and they are believed to be in general compliance with their permit requirements. The concern surrounding these operations is the increased amount of manure and nutrient production yearly and the potential for leaching or overland runoff of those nutrients into nearby streams and tributaries. Manure contains nutrients such as nitrogen and phosphorus that are beneficial for crop production but in large quantities, are detrimental to water quality. These nutrients, if allowed to enter the water system will cause increased algal growth leading to increased turbidity and lower levels of dissolved oxygen as the algae and plants decompose.

Within the Upper Wabash River Watershed, there are currently 39 facilities with an active CFO status. Of these 39, 29 facilities or 74% are located in Jay County, while 8 facilities (21%) are located in Adams County, and the remaining 2 facilities (5%) are located in Wells County. CFOs within the boundaries of the watershed are included in Exhibit 3. It should be noted that in addition to the facilities mentioned above, there are a substantial amount of operations with numbers of horses, sheep, hogs, cattle, and/or poultry below the minimum extent of the permitting requirement. Without a complete livestock inventory of the entire watershed, it is difficult to determine the exact number of animals per species per operation.

To prepare an accurate representation of the amount of manure and selected nutrients generated in each 11-digit HUC, a more detailed livestock inventory will need to be completed. This inventory should include the number of animals of each species for appropriate weight or production classifications, the type of manure storage facility being utilized, and the location within the 11 or 14-digit HUC. To provide the best information possible, a future livestock inventory should also account for the amount of manure generated in other areas and applied within these specific watersheds. Similarly, manure generated within these watersheds and applied to acreage outside of the watershed boundaries should be accounted for.

3.2 POTENTIAL NON POINT SOURCES OF POLLUTION

NPS pollution refers to runoff that enters surface waters by stormwater runoff, contaminated groundwater, snowmelt, or atmospheric deposition. There are many types of common activities that can serve as a source of non-point source pollution due to the presence of impervious surfaces, including land development, construction, mining operations, crop production, animal feeding operations, subsurface drainage tiles, timber harvesting, failing septic systems, landfills, roads, and paved areas, and wildlife. These sources may contribute a single pollutant or a combination of pollutants such as *E. coli*, heavy metals, pesticides, oil and grease, nutrients, and any other substance that my be washed off the ground or removed from the atmosphere and carried into surface waters.

Potential Non Point Sources of Pollution from Flooding

Flooding and associated flood damage is most likely to occur during the spring because of heavy rains combined with melting snow. However, provided the right saturated conditions, intense rainfall of short duration during summer rain storms are capable of producing damaging flash flood conditions. Flooding events have been experienced routinely within this watershed, many of which result in significant property damages and pollutant loadings to streams and tributaries. These events are not only damaging to homes, but also to the agricultural community as well. Operators may need to replant crops that have been damaged by flooding, or the entire field could become inundated, zeroing out the productivity for that cropping season. Furthermore, livestock facilities that are located in the floodway or the 100-year floodplain are at a higher risk for loss of animals.

Flood Control

The standard index for flooding is a 1% chance of flooding or a 100-year flood. This is a benchmark used by the Federal Emergency Management Agency (FEMA) to establish a standard of flood protection in communities throughout the country. The 100-year flood is referred to as the "regulatory" or "base" flood. The term 100-year flood is often incorrectly used and can be misleading. It does not mean that only one flood of that size will occur every 100 years. What it actually means is that there is a 1% chance of a flood of that intensity and elevation happening in any given year. In other words, the regulatory flood elevation has a 1% chance of being equaled, or exceeded, in any given year and it could occur more than once in a relatively short period.

The southern third of Adams County provides drainage to the Wabash River, while the remaining area drains to the Maumee River Basin. Due to this drainage area, the Adams County Commissioners have elected to adopt the Maumee River Basin Commission's (MRBC) more restrictive floodplain ordinance requirements above and beyond the Indiana State requirements. This additional language requires No Adverse Impact (NOI) due to construction within floodplains. When any portion of the Special Flood Hazard Area (SFHA) is filled for the purpose of construction, this needs to be balanced by an equivalent volume of excavation within the same immediate watershed. This results in no net loss of floodplain storage post construction.

Along the main-stem of the Wabash River, both the floodway and the 100-year floodplain are meandering and quite expansive as allowed by the generally flat topography. Utilizing digital aerial photography of the watershed, structures within the floodway were estimated to include 26 residences, 34 agricultural structures, 1 large livestock facility, and 1 large industrial facility. These structures may realize damages to property, including crop losses, due to flooding on a frequent basis. Within the 100-year floodplain, an additional 27 residences and 31 agricultural structures are present. Floodways and 100-year floodplains associated for the streams and tributaries in the watershed are identified on **Exhibit 4**.

As high water events, both large scale and smaller scale floods, occur, there are many possibilities for pollutants to enter the stream systems. Debris from infrastructure and buildings damaged by flood events, oils, grease, and toxins from submerged vehicles and septic systems,

and common chemicals and solvents that are present in nearly every home can all become mobile when flooding occurs. These substances can be severely harmful to aquatic life, other wildlife, and humans that come into contact with the contaminated water, and can pose long term problems for saturated soils in the flood area.

Streambank Erosion/Log Jams
Streambank erosion often results from increased streamflows associated with heavy rainfall events. When stream flow rates exceed the resistance ability of nearby soils and vegetation, bank erosion occurs. Streambank erosion can have numerous negative impacts ranging from increased turbidity, loss of in-stream habitat, loss of conveyance volume, and damage to public infrastructure such as roads and bridges. Localized streambank problems, primarily in association with in-stream obstructions, have been identified as a water quality issue in the Upper Wabash River watershed that needs to be addressed in more detail.

Throughout the Wabash River Basin, areas along the mainstem of the Wabash River are sensitive to in-stream obstructions following high water events. These obstructions lead to destabilization of streambanks, increased sediment (TSS) loadings to the river, and increased damages and pollutant loadings associated with flooding in sensitive areas. Sedimentation of river systems depletes the integral pool-riffle-run systems; decreases habitat, spawning, and feeding areas for aquatic organisms; and increases turbidity of the water column. An increased rate of streambank erosion initiates the cyclical actions of destabilization-increased sedimentation-in-stream obstruction development-increased streambank erosion.

General damage debris, either from the destruction of buildings or from general washing away of materials on the ground can also have effect on the severity of the event. When materials are trapped in the stream, water is impeded and can potentially cause an enlarged area to become affected adding to the potential for pollutants to enter the water course and surrounding lands.

Potential Non Point Sources of Pollution from Agricultural Lands
In 2002, the NWQI, sponsored by the EPA, reports that agricultural nonpoint source pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, and a major contributor to ground water contamination and wetlands degradation.

NPS pollutants that commonly result from agricultural activities are nutrients, pesticides, bacteria, and sediment. These pollutants can migrate from the land to the surface and/or ground waters through overland runoff, erosion, and infiltration. It is important to note that these pollutants do not only originate from agricultural activities and can also be attributed to residential and urban lands as well. **Table 3-3** identifies common agricultural nonpoint source pollutants and their associated sources as identified by the EPA.

Table 3-3: NPS Pollution and Agriculture

Pollutants	Agricultural Sources
Nutrients	Commercial Fertilizers and Manure
Toxic Chemicals	Herbicides, Insecticides, Fungicides
Sediment	Sheet, rill, gully and streambank erosion, tillage methods
Animal Waste	Manure runoff from fields, pastures, and feedlots

(EPA, 2002)

There are a number of activities associated with agriculture that can serve as potential sources of water pollution.

1) Land clearing and conventional tillage makes soils susceptible to erosion, which can then cause stream and ditch sedimentation,
2) Pesticides and fertilizers (including synthetics and animal manures) can be washed from fields or facilities with inadequate storage facilities, and
3) Construction of drainage ditches and systematic subsurface tiling in poorly draining soils enhances the movement of oxygen consuming wastes, sediment, and soluble nutrients into ground and surface waters.
4) Flooding of agricultural lands increases sediment and nutrient loadings as flood waters inundate increased acreages and potentially cause holding ponds, lagoons, and other manure storage facilities to overflow.

Agriculture is the predominant land use in the Upper Wabash River Watershed. According to the National Agricultural Statistics Service (NASS), 2002 Census, approximately 95%, or 228,942 acres of land in Adams County is used for farming purposes, while 79% (195,357 acres) of land in Jay County, and 96% (226,294 acres) of land in Wells County is considered agricultural use.

Like most of Indiana, corn and soybeans dominate the crops grown in Adams, Jay, and Wells counties. Wells County ranks fourth in the state regarding soybean harvest, while Adams and Jay both rank among the top 20, at 12th and 19th respectively out of 92 Indiana counties. Wheat acres harvested, while less than the traditional corn and beans, places the three counties among the top 30 with Adams in 5th, Jay in 11th, and Wells in 29th of 92. **Table 3-4** shows the acres harvested and production amounts of the major crop commodities in these three counties.

Table 3-4: Adams, Jay and Wells County Harvested Acres

	Adams	Jay	Wells
Corn – grain			
Harvested	67,100 ac	77,200ac	69,800ac
Production	10,416,600bu	12,971,400bu	11,482,600bu
Soybeans			
Harvested	84,500ac	102,100ac	90,700ac
Production	4,568,800bu	5,399,200bu	4,839,100bu
Hay (dry) Tons			
Harvested	11,200ac	3,300ac	6,400ac
Production	40,500T	13,100T	25,000T
Wheat (all)			
Harvested	11,500ac	7,000ac	11,600ac
Production	804,600bu	508,100bu	779,200bu

(National Agricultural Statistics Service, 2002)
(ac=acres; bu=bushels)

Nutrients

Nutrients such as phosphorus (P) and nitrogen (N) in the form of commercial fertilizers, manure, land applied sludge, legumes, and crop residue are utilized to enhance crop production. In small amounts, N and P are beneficial and necessary to aquatic life. However, in excessive amounts, they can stimulate the occurrence of algal blooms and aquatic plant growth.

Algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and the decomposition of dead algae and other aquatic plants. This situation is accelerated by high temperatures and low flow conditions due to the reduced capacity of the water system to retain dissolved oxygen. When the dissolved oxygen levels reach severely low limits, fish kills occur and the aquatic ecosystem is disrupted.

The Office of Indiana State Chemist (OISC) annually publishes the total tonnages of commercial fertilizers sold in each Indiana County. The list includes single nutrient fertilizers, multi-nutrient fertilizers, as well as organic and micronutrient fertilizers. **Table 3-5** estimates the annual commercial nutrient application within the watershed. Total countywide application rates for Adams, Jay, and Wells counties were multiplied by the percent of each county's land area in the Upper Wabash River Watershed to estimate application within the boundaries of the watershed.

Table 3-5: Estimate of Commercial Nutrient Application

County	% of county in watershed	X	Total Nutrients (Tons)		X 2000 lbs/ton	Nutrients in watershed (lbs)	
			N	P_2O_5		N	P_2O_5
Adams	21.6	X	6,502.18	3,551.37	X 2000	2,808,941.76	1,534,191.84
Jay	32.4		4,694.71	2,376.35	X 2000	3,042,172.08	1,539,874.8
Wells	14.5		6,230.98	3,277.81	X 2000	1,806,984.2	950,564.9

(Derived from information provided by the ISCO)

The table shown above describes an estimate of the amount of fertilizer applied in the Upper Wabash River Watershed and is not intended to be an estimate of loading to waterways. It is expected that only a portion of the applied fertilizer nutrients would be mobilized to local waterways as a majority of the macronutrient would be utilized by the crop to which it was applied. According to the Steering Committee and individual stakeholders, applications of nutrients from custom spraying or from land application of livestock manure in close proximity to streams and tributaries has been observed throughout the watershed.

Excess nutrient laden runoff may also stem from the numerous, non-regulated livestock operations throughout the watershed. Of the 39 regulated livestock operations, there are 20 swine operations, 3 dairy operations, 1 beef operation, 1 chicken/beef operation, 2 swine/beef operation, and 1 operation with swine, beef, and dairy livestock. The combined animals for the regulated facilities amounts to approximately 38,648 swine, 2.9 M chickens, 845 beef, and 995 dairy animals. According to information reported to the NASS, there are approximately 384 hog operations, 904 cattle, and 224 poultry operations in Adams, Jay, and Wells Counties above the regulated facilities. Regarding species not typically thought of as livestock, there are 33 farms reporting ducks, as well as 743 farms reported to own horses within the tri-county area. These totals are provided by county and therefore, not all of these facilities are within the boundaries of the watershed. Livestock farms may be included in one or more of the categories if, for example, there are both cattle and hogs present at the same farm. It becomes evident that the majority of the livestock operations in Adams, Jay, and Wells Counties are not regulated and

therefore, are not under the same restrictions as permitted facilities. This increases the risk for contamination of the nearby streams and rivers with potentially high levels of nutrients and bacteria as more stringent requirements such as inspections and reporting are not imposed on smaller facilities.

Pesticides

Pesticides include a broad array of chemicals used to control plant growth (herbicides), insects (insecticides), and fungi (fungicides). These chemicals have the potential to enter and contaminate water through direct application, runoff, wind transport, and atmospheric deposition. They can kill fish and wildlife, contaminate food and drinking water sources, and destroy the habitat that animals use for protective cover.

While some pesticides undergo biological degradation by soil and water bacteria, other pesticides are very resistant to degradation. Such non-biodegradable compounds may become "fixed" or bound to clay particles and organic matter in the soil. However, many pesticides are not permanently fixed by the soil, and instead they collect on plant surfaces and enter the food chain, eventually accumulating in wildlife such as fish and birds. Many pesticides have been found to negatively affect both humans and wildlife by damaging the nervous, endocrine, and reproductive systems or causing cancer (Kormandy, 1996). Further, the Steering Committee has observed the application of commercial pesticides within close proximity to streams and tributaries throughout the watershed and has identified this to be a potential source of water quality degradation.

The OISC does not track the overall pesticide sales within individual Indiana counties as it does with fertilizer sales. Water quality collection and sampling events in the Upper Wabash River Watershed to date have not been completed to analyze samples for pesticides. According to Indiana University Purdue University – Indianapolis (IUPUI) CEES, Atrazine and Triazine herbicides, which have health effects to both humans and wildlife, are widely utilized in corn production and are contaminants of concern for drinking water supplies both locally and nationally. Other herbicides and pesticides used on corn, soybeans, and for pest control on livestock also have the potential to impact surface water.

Erosion and Sedimentation

Erosion occurs when wind or water runoff carries soil particles from one area to another. Sedimentation occurs when these soil particles are deposited into a receiving waterbody, such as a stream or a lake. These mobilized soil particles may become suspended within the water column, clouding the water and reducing the amount of sunlight reaching aquatic vegetation, and obstructing the gills of aquatic organisms. Particles of silt and sand may eventually precipitate out of the water column, settling on the streambed effectively covering fish spawning areas, and smothering food supplies. Land clearing and conventional tillage makes soils more susceptible to erosion, which can then cause stream and ditch sedimentation.

Furthermore, pollutants such as phosphorus, pathogens, and heavy metals move through the landscape attached to microscopic soil and organic particles. These same microscopic particles may be easily transported via overland flow and are stored in and carried by streams throughout the watershed.

Areas with highly erodible soils, if not managed properly, can erode at an accelerated rate and may lead to excessive soil deposition within streams and ditches. HELs determinations are made based on a mathematical equation, USLE, the Universal Soil Loss Equation. This equation, and subsequent versions, considers the average rainfall, erodibility of the soil type, allowable loss for that soil type, and the length and the slope of the area. According to the USDA, the entire farm tract is considered HEL if at least one third of the tract has highly erodible soils present.

HEL erosion has been identified by the NRCS as a water quality problem throughout the watershed. Activities involving land disturbance such as conventional tillage methods, intensive livestock grazing with stream accessibility, and removal of wooded areas are likely to increase sediment loadings to the watershed. The HEL classified soils in the Upper Wabash River watershed are illustrated in Exhibit 5

Tillage Practices

Utilizing the 2003 Cropland Tillage Data obtained from Purdue University and from data provided by the Wells County SWCD, **Table 3-6** was created to compare various tillage methods utilized within Adams, Jay, and Wells Counties. While this information is provided on a county-wide basis, it is representative of the tillage types and percentages within the boundaries of the Wabash River watershed. No till refers to any direct seeding system including strip preparation with minimal soil disturbance. Mulch till refers to any tillage system leaving greater than 30% crop residue cover after planting, excluding no till. No till and mulch till are often collectively referred to as conservation tillage. It is clear that while no-till soybeans seem to be an accepted practice throughout the tri-county area, no-till corn has not been widely established. Resistance to utilizing conservation tillage in corn production can be attributed to several rationale including the needed acreage for manure application and associated incorporation methods, increased moisture attributed to the combination of poorly draining soils and excess fodder, the concern of inconsistent plant populations, and possible yield reductions. Reduced tillage, with 15%-30% crop residue remaining following the harvest and present during the critical erosion period, utilized for corn production does seem to be a more operator-accepted practice.

Table 3-6: Percent of Crop Acres in Conservation Tillage

County	Crop	% No Till (2003)	% Mulch Till	%Reduced Till	%Conventional Till	State Rank
Adams	Corn	5	4	32	60	54 of 92
	Soybeans	58	5	16	20	33 of 92
Jay	Corn	24	9	13	54	25 of 92
	Soybeans	67	5	9	19	22 of 92
Wells*	Corn	8	3	7	82	NA
	Soybeans	62	3	8	28	NA

(Purdue University, 2003)
(*Information provided by Wells County SWCD)

Increases in conservation tillage methods, including reduced till, mulch till, and no-till, for crop production has the potential to significantly reduce the sediment loads to streams and waterways in the Upper Wabash River watershed. The benefits of reducing sediment loss are numerous, not only in terms of water quality, but also in regards to drainage issues and overall soil health. When less sediment is delivered to the streams and ditches, routine maintenance or

dredging of these water systems may be lessened. This situation would help to maintain the designed flow capacity of the stream or drainage ditch. Sub-surface drainage tile mains and lateral lines may also be less likely to become choked with sediments, requiring less maintenance to repair tile "blow-outs".

Bacteria and Pathogens

Adams, Jay, and Wells Counties combine to create a significant concentration of livestock production within the state of Indiana. Adams County ranks 5th in the state for both hogs and horses with approximately 129,000 head and 3,250 head respectively and 6th in the state for ducks with nearly 31,000 head. Jay County nears the top of the state rankings, at 5th, for layers (2.3 million) and turkeys (200,000). Hogs and pigs are also numerous in Jay County with slightly over 91,000 head, placing them at 11th in the state. Wells County, while not disclosing specific numbers of specific species, does rank 18th for layers and 7th in Indiana for rabbit production.

Livestock generated manure, whether applied to agricultural fields for crop nutrition or the by-product of grazing near to streams and tributaries, is a water quality problem in the Upper Wabash River watershed as identified by the local SWCDs and farm operators within the watershed. The nitrogen and phosphorus that make the manure so productive in farm fields can create an over-fertilized "soup" when runoff enters nearby streams and drainage ditches, leading to increased algal blooms.

Land application of manure is often beneficial to the health of the soil, the health of the crop, and also serves as a useful method of disposal. Guidelines are provided by the NRCS in Standard 633 to assist landowners in reducing the potential for manure laden water to leave the field where it has been applied. Setbacks from streams and open waters, application rates, seasonal timing of the application, and various other techniques are outlined in this Standard. While this information cannot be considered a law or regulation, it does encourage landowners to demonstrate their stewardship for the watershed in which they operate.

Land application of manure is not the only agricultural source of bacteria entering waterways. Grazing livestock in pasture lands or livestock in feedlots can potentially provide a significant contribution of bacteria. If livestock are allowed unrestricted access to streams and creeks bisecting pasture lands; or if feedlots are located within close proximity to a stream, stormwater runoff or the direct deposit of manure will dramatically increase levels of potentially pathogenic bacteria in the water. Livestock with unrestricted access to streams and creeks have been observed throughout the watershed.

Pasture management can be an effective management measure to reduce impacts that livestock operations may have on water quality. Pasture management leads to better weed control, better soil structure, increased productivity over longer periods of time, and healthier animals. It also helps the soil absorb excess water, manure, nutrients and other pollutants, and ultimately protects water quality by reducing the amount of overland runoff by increasing the

infiltration of stormwater. Pastures can be grazed intensively during peak periods of growth, but they do need regular attention. A grazing rotation that allows 21 to 28 days of re-growth between grazing periods is usually needed. Pasturing too many animals on a given parcel of land or allowing them to graze for too long in the same area reduces plant vigor and compacts the soil, reducing absorption capacity and pasture recovery. Overgrazing, which has been observed throughout the watershed, can also lead to additional runoff and a poorer quality of runoff.

Unbuffered Stream Reaches

Conservation buffers are vegetated corridors with or without woody plants established along natural water courses and even constructed drainage ditches. Such buffers are an integral part of the form and function of a healthy water system. Although the appearance of conservation buffers differs between natural streams and drainage ditches, the functions remain the same – to improve water quality by filtering and trapping sediments and pollutants carried by overland runoff, to reduce the velocity of stormwater, and to create important aquatic and terrestrial wildlife habitats.

Based on visual inspection of digital aerial photography, it is estimated that 122 stream miles, or 37% of the 330 stream miles, have less than 30 feet of vegetated buffer on one or both of the streambanks. Many of these stream miles are centered in row crop land use. This analysis was completed utilizing visual inspection of digital aerial photography. With little to no protection and filtering capabilities, these streams have a greater risk potential of being subjected to overland runoff contaminated with excess nutrients, bacteria and soil particles. These unbuffered stream reaches are highlighted on **Exhibit 5**.

Conservation buffers along natural streams usually consist of a natural and dense network of grasses, shrubs, and/or trees. Conversely, buffers along agricultural drainage ditches usually consist of swaths of mowed grasses that are regularly maintained to prevent the establishment of woody plants. Funds are available through several programs within the USDA to assist with the implementation of a conservation buffer initiative. These programs function as cost share programs, providing funding for establishment of the buffer as well as annual payments for the life of the contract. These programs are accessible through the County SWCD and NRCS offices.

Subsurface Drainage Systems

Systematic drainage of agricultural fields through sub-surface tile may have negative, as well as positive effects on water quality. The installation of sub-surface drainage tile, as discussed by the Steering Committee is completed routinely throughout the watershed and should be considered a potential source of pollutants. Fields with good drainage systems show less surface runoff, erosion, and phosphorus loadings. However, fields with poorly installed or un-maintained subsurface systems can result in water quality degradation. As nitrate is soluble in water, it enters the subsurface tile relatively easily and is delivered to open ditches and streams. According to US EPA, concentrations of nitrate in tile drains are usually quite high, ranging from 10-40 mg/L. Pesticides applied to agricultural fields may also enter the tile system with ease. However, typical concentrations are very low and delivery may be reduced with subsurface tile compared to fields with surface runoff.

Potential Non Point Sources of Pollution from Urbanization

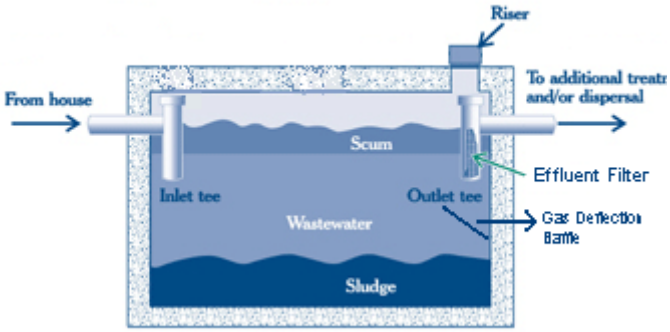
A change in land use, especially from field or forest to urban or residential development, has a significant impact on water quality and quantity. Not only is the permeability of the soil affected

by construction compaction and impervious coverage such as rooftops, driveways, and parking areas, but there is an increase of biological and chemical waste from human use. The sources of water quality pollution from urbanization focus on three main topics: human & domestic animal waste, household & yard waste, and development practices.

Failing Septic Systems

Septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, in Adams County, nearly 100% of the soils have been classified by NRCS as having severe limitations for conventional residential septic systems. Jay and Wells Counties show similar tendencies with 96% and 100% (respectively) of the soils classified by NRCS as being unsuitable to adequately treat household wastewater. High clay content within the soil structure does not allow adequate percolation of the wastewater through the underlying soil layers. Therefore, many of the bacteria, pathogens, and other waste components can not be effectively treated or removed from the effluent. In several instances, the contaminated wastewater will not drain in a downward fashion, but may rise to the surface or drain in a lateral pattern until it reaches an area suitable for percolation or an outlet such as a stream.

In rural areas such as the Upper Wabash River watershed, septic systems are often the primary mechanism utilized for residential wastewater treatment. Permitting procedures began to develop in the late 1960's and were not mandatory until early 1990 when the Indiana State Department of Health adopted a rule establishing statewide guidelines for construction and repair of septic systems. Information provided by Purdue University Extension gleaned from the 1990 Census, provides an estimated number of households with onsite wastewater disposal systems. Adams County is estimated to have 4,217 systems, Jay County is estimated to have 3,648 systems, and estimates for Wells County near 4,700. This information also suggests that there are more than 800,000 residential septic systems in the State of Indiana. Of those, it is estimated that approximately 200,000 of these systems are failing to properly treat household wastewater. Further estimates provide that from these failing systems, 15.3 billion gallons of raw sewage are discharged into local streams and rivers annually.



To further agitate the issue, homeowners may be largely unaware of the individual components of their particular system, how septic systems function, the location of the septic system, or how to properly maintain their system. In addition, many residential septic systems have been by-passed all-together and the effluent is directed into nearby agricultural drainage tiles with a direct route to a stream or open ditch. This by-pass may have seemed logical to the original homeowner as a means to avoid the on-going maintenance and the aforementioned potential problems associated with poorly draining soils. Elevated loadings of bacteria, nutrients, toxic substances, and oxygen consuming wastes are associated with improperly treated residential wastewater.

Wildlife and Pet Waste

Wildlife and pet wastes can contribute significantly to the concentrations of bacteria and organic matter in stormwater runoff. The presence of wildlife has been shown to result in elevated levels of ammonia, organic nitrogen, and *E. coli* bacteria. Recent studies have shown that domestic pet waste is among the top five sources of bacteria in contaminated waters and in some areas, more of a fecal coliform contributor than humans. Pet wastes can be partially controlled through municipal ordinances requiring the collection and removal of the wastes from curbsides, yards, parks, roadways and other areas where the waste can be washed directly into receiving waters and/or stormdrains. As the more urban areas within the watershed continue to grow in size and population, the impact of pet waste may become more of an issue and should be investigated further at that time.

Household & Yard Waste

Every home, regardless of size or age, has potential pollution sources that can impact ground and surface water quality and the Steering Committee feels that this potential source should be further identified as a contributor to water quality impairments. These may include the use, storage and disposal of pesticides, solvents, and petroleum products commonly used around the home. Cleaning solvents washed down the sink, motor oil leaking from vehicles, and common chemicals applied to flowerbeds and small gardens can have a major impact to local streams and tributaries.

Urban activities may create conditions that result in higher-than-normal concentrations of ammonia and phosphorus in water bodies downstream. While professional lawn and garden chemical applicators receive training and are required to maintain application records, the average homeowner does not. This often results in over-application of lawn and garden chemicals and contributes significant nutrient loads to adjacent waterbodies. It is advisable to have residential lawns sampled for available nutrient levels prior to application of additional fertilizers and/or nutrients. These samples will outline the specific needs of the lawn and will reduce the potential for over-application and contaminated runoff entering the local water courses.

Yard waste such as grass clippings, leaves, and dead plants are high in organic matter and if piled or dumped on nearby streambanks can result in the smothering of the vegetation that is naturally stabilizing the bank and preventing soil erosion. Depleted dissolved oxygen levels of nearby waterways as the vegetation decomposes can also be an outcome of improper disposal of lawn and brush clippings. Composting of the accumulated brush and lawn trimmings can be more valuable to the homeowner as a nutrient rich, organic material for flower beds and gardens and less damaging to the flora and fauna of the watershed.

Development Practices & Encroachment

Nationwide, more than 1.5 million acres of land are developed each year. Even though very little of that development seems to be occurring within the Upper Wabash River watershed, development practices and encroachment directly impact water quality and should be considered a potential source of pollution. Land Use Planning and development practices are effective methods to control not only where the development occurs but also the means by which it occurs, and the overall impact the development will have on the water quality for years to come.

Comprehensive Plans, Zoning Ordinances, and Subdivision Control Ordinances are documents that almost every community uses to guide growth and development within their jurisdictions.

These same documents can also be used to effectively protect natural resources and improve water quality. Comprehensive Plans were developed for Adams, Jay, and Wells Counties in the early 1990's and include brief descriptions regarding the preservation of natural resources and the environment. These plans should be updated to include land use changes that have occurred within the last 10 years, proposed management measures for protecting the Wabash River and tributary streams where applicable, and current long range planning measures for each municipality within the individual Counties and the watershed.

Soil erosion from construction activities contributes to the filling of nearby streams and ditches, affecting water quality, aquatic habitats, drainage, and recreational opportunities. There are a number of Best Management Practices (BMPs) including phased construction, silt fencing, and turf seeding, that when installed and maintained properly, can successfully limit sediment from leaving the site. None of the Counties or municipalities within the boundaries of the watershed are regulated under the Stormwater Phase II restrictions. However, these measures can be locally adopted and enforced to provide a proactive approach to reducing sediment loadings to the streams in the Upper Wabash River Watershed.

Impervious Areas

Many activities associated with urban or residential land uses can generate NPS pollution. In most urbanized areas, large quantities of impervious or hard non-porous surfaces such as roads, driveways, parking lots, and rooftops cause an increase in stormwater runoff resulting in flash floods and streambank erosion. Managing NPS pollution in urban areas typically includes practices for managing water quantity, as well as water quality. In urban environments, NPS pollutants typically include *E. coli* bacteria, sediments, nutrients, heavy metals, oil and grease, and pesticides.

In the Upper Wabash River watershed, there are less than 500 acres of land considered impervious (high intensity urban, low intensity urban and commercial, industrial and transportation), resulting in less than one half of 1% (0.31%) impervious land use. Based on data collected through the 2000 U.S. Census, Adams County Indiana experienced an 8% growth in population between 1990 and 2000. Within the same time frame, Wells County experienced a population growth of 6.4%, and Jay County reported an increase of 1.4%. It appears that while the Counties located in the watershed are experiencing growth, it is not occurring rapidly. This slow change in population may allow for better long-term planning as it relates to zoning, site impervious restrictions, stream buffers, and stormwater practices designed to protect current infiltration rates.

4.0 IDENTIFYING CRITICAL AREAS

Water quality data, trends in land use development, and comments from stakeholders in the watershed were utilized to identify critical areas within the Upper Wabash River watershed. Critical areas include areas that are of benefit to water quality and storage within the watershed, areas that are suspected of degrading water quality, and impeding the natural drainage and infiltration of the watershed. Areas that are considered to be beneficial to the Upper Wabash River watershed should be protected or enhanced, and those areas or activities suspected of degrading water quality or increasing the risk of flooding should be targeted for implementation of management measures.

4.1 BENEFICIAL CRITICAL AREAS

Identifying land uses and activities that have a negative impact on water quality or the assimilation of increased water quantity is often the primary focus of watershed planning. While managing the impacts of these activities can and does improve water quality and assimilation, it is equally important to identify the existing land use conditions and activities in a watershed that currently enhance or protect water quality and reduce the risk of flood related damages. As these areas are protected, the potential of further degradation will be reduced.

Buffered Stream Reaches

The term buffer includes those areas where permanent vegetation has been established with the intention of trapping pollutants and managing other natural resource concerns, such as field wind breaks, vegetated fence rows, filter strips, and riparian buffers. Buffered stream reaches can be beneficial to the watershed in many ways. Loadings of sediments, nutrients, and pesticides can be significantly reduced after passing though a vegetated buffer adjacent to the stream or ditch. These corridors are also important to the wildlife of the area as they provide habitat and food sources perhaps not found elsewhere. Overhanging vegetation, even if only tall grasses, allows the water course to be shaded in areas, creating a cooler environment, maintaining more consistent dissolved oxygen levels within the water, and providing a conducive habitat for aquatic organisms.

Within the Upper Wabash River watershed, there are approximately 330 miles of streams. Based on visual inspection of digital aerial photography, it has been estimated that approximately 208 stream miles, or 63% have 30 feet or more of vegetated buffer on one or both of the streambanks. Additionally, the mainstem of the Upper Wabash River appears to have a healthy riparian buffer system in excess of 75 feet of vegetation on either bank. These buffers provide a valuable water quality benefit and should be protected from encroaching development or neighboring land uses. Those stretches lacking sufficient cover should be revegetated. NRCS Practice Standard 393 suggests that with a minimum average flow length of 30 feet, reductions in the dissolved contaminants, nutrients, and suspended sediments in the overland runoff can be achieved. Healthy riparian buffers and/or corridors along the Wabash River and tributary streams may also provide flood control benefits, reductions in personal property damages, and increased retention and detention during high water events to allow for enhanced infiltration. Root systems associated with properly maintained and proportioned streambank vegetation such as tall grasses and woody vegetation also reduce the potential for streambank erosion and destabilization. When these root systems are removed or prohibited from growing, streambanks are more susceptible to sloughing and eventual collapse.

Areas of buffered stream reaches considered critical and in need of long-term protection include those reaches of the Wabash River main-stem with greater than 75 feet of riparian corridor.

Smaller streams and tributaries with greater than 50 feet of buffered streambank should also be provided protection. These areas not only provide habitat for land and aquatic species, they also provide crucial protection and enhancement capabilities for overall water quality, provide storage areas for high water events, and reduce potential monetary damages and injuries due to flooding.

A method for protecting these well buffered areas is to adopt a basin wide ordinance requiring a minimum of 75 feet setback along the Wabash River and tributaries, ensuring that the riparian area will be maintained and protected from encroachment. Other effective measures include developing a Greenways Plan, purchasing floodplain and/or conservation easements along the mainstem and other currently established riparian buffers, and continual outreach and educational efforts to inform individual landowners of the importance and overall value of riparian buffers.

Wetlands

Within the Upper Wabash River Watershed, there are nearly 2,000 acres of woody or emergent herbaceous wetlands. There are approximately 70 acres within the 05120101-010 subwatershed, 430 acres of wetlands within the 05120101-040 subwatershed, 600 acres of wetlands within the 05120101-050 subwatershed, and within the 05120101-060 subwatershed an approximate 700 acres of wetlands exist. Areas identified as wetlands by the National Wetland Inventory (NWI) are located in **Exhibit 6**.

These wetlands have the ability to serve several functions in regard to the protection and enhancement of water quality. Water flowing into, or stored in a wetland may be retarded allowing increased time for the uptake of nutrients, settling of suspended solids, and evaporation or infiltration of excess water. If wetlands did not exist, this water would be directed to the nearest open water system; pollutants included. The ability to recharge the surrounding area with slowly released water helps provide a more consistent soil moisture level in an agricultural setting, while allowing for groundwater recharge at the same time. Wetlands also serve the watershed as wildlife habitat areas providing cover from predators while also serving as a food source. Several projects listed above involved restoration or protection of critical wetlands and these areas will be beneficial to the functioning of the natural landscape as well as the historical heritage of the area.

The individual County Comprehensive Plans have identified the importance of wetlands to the environmental and the need for protection of existing wetlands. The Adams County Comprehensive Plan of 1994 discusses the need to consider existing wetlands in reviewing development proposals, promote preservation of existing wetlands, and to encourage landowners to restore marginally productive farm land to wetland status. Jay County has stated that any development that will destroy or harm any environmentally sensitive areas, such as wetlands) should be discouraged. While the Wells County Comprehensive Plan does not specifically identify wetlands, it does state that an extensive system of conserved open space following the county's major watercourses has been proposed.

In order to provide the most benefit to the Upper Wabash River Basin, the 11-digit HUC prioritized for wetland protection should be the 05120101-060 subwatershed, while the 11-digit HUC prioritized for wetland construction or restoration efforts should be the 05120101-010 subwatershed. However, as none of the 11-digit subwatersheds have more than 2% of the land use classified as woody or emergent wetlands, protection, restoration, and construction efforts should be carried out watershed wide.

Protected Lands

Areas that are protected through the purchase of conservation easements carry with them obligations for perpetuity. These areas are often obtained as a measure of protection prior to land use alterations. However, it is possible, and successful to purchase a particularly sensitive area and restore the flora, fauna, and water quality benefits that had been removed or damaged. Areas maintained through a conservation easement have the ability to lessen pollutant loadings, provide habitat, reduce flood damages, and allow for protection of critical land uses.

Parks, recreational areas, and open space areas allow for the increased potential for infiltration of stormwater, uptake of nutrients, and entrapment of solids such as sediment, thus reducing the loadings to streams, rivers and ditches. These low development areas, if placed in sensitive locations can also reduce monetary damages caused by frequent flooding. Flood damages to the open space or recreational areas could be far lower than damages to residences or other structures routinely found along a water course.

The listing below identifies the nearly 2,800 acres of land protected by conservation easement or maintained as a natural area within the boundaries of the Upper Wabash River Watershed, or within close proximity.

- **Ouabache State Park -** This State Park is located in the south-east quadrant of Wells County and is bordered to the west by County Road 450E, to the north by County Road 100 S, and to the east by IND 301. The entire southern edge of the 1,104 acre park property abuts the Wabash River.
- **Ouabache State Park** - These 39.36 acres are adjacent to the park entrance and the Wabash River. This land provides potential for development of bike and hiking trails with Bluffton.
- **Rainbow Bend –** This area consists of 14 acre floodplain forest adjacent to the Wabash River.
- **Wabash River Greenway Trail** - This 6 acre parcel provides public access to the Wabash River as a part of The City of Bluffton Wetlands Restoration and Trail Project.
- **Bluffton Wetlands & Greenway**, Adjacent to the Ouabache State Park, and bordered on the south by the Wabash River, this 115.084 acres helps to conserve and preserve a natural wetland as part of the existing Wabash River Greenway trail.
- **Limberlost State Historic Site and Swamp Wetlands –** The following listing details over 1,400 acres of wetland areas in various stages of restoration within the watershed.
  - Original 12 acres of the Limberlost Bird Sanctuary established in 1947 contains 8 acres of flatwoods wetland and a 4-acre Nature Preserve forest.
  - 143 acres in the Loblolly Marsh in Jay County 1996 is a restored marsh with a wetland overlook and an Americans with Disabilities Act trail.
  - 45 acres in the Loblolly Marsh in Jay County 1996 – restored pothole has an Americans with Disabilities Act trail and boardwalk over a restored wetland.

- 240 acres in the Loblolly Marsh in Jay County 1997 – restored marsh and potholes to teach geology. The 25-acre woodland is arrayed with many native plants and several rare species.
- 38 acres in the Limberlost Swamp in Adams County 1998 – restored floodplain wetlands show nearly a decade of restoration regeneration.
- 152 acres in the Limberlost Swamp in Adams County 1999 – restored potholes and a swamp Nature Preserve. This property is very secluded and will provide a refuge for the wildlife in the area.
- 327 acres in the Limberlost Swamp in Adams County 2000 – partially restored
- 26 acres of the Limberlost Bird Sanctuary Addition 2000 – restored forest land shows 6 years of regeneration and a wildlife watering facility.
- 9 acres in the Limberlost Swamp in Adams County 2001 – partially restored
- 65 acres in the Wabash River Area in Adams County 2001 – restored floodplains has Americans with Disabilities Act trails to the Wabash River's edge, a canoe launch for river studies, an Americans with Disabilities Act trail to a restored oxbow wetland, Native American Indian restored historic trail and river ford.
- 24 acres in the Wabash River Area in Adams County 2001 – mature floodplain wetland forest with proposed Americans with Disabilities Act trail
- 8 acre oxbow island in the Wabash River Area in Adams County 2002 – Nature Preserve mature floodplain forest on an oxbow with Great Blue Heronry
- 27 acres in the Limberlost Swamp in Adams County 2003 – reforestation and emergent wetlands planned
- 20 acres in the Limberlost Swamp in Adams County 2005 – planning
- 39 acres of the Limberlost Bird Sanctuary Addition 2005 – restored
- 113 acres in the Limberlost Swamp in Adams County 2005 – planning
- 58 acres in the Limberlost Swamp in Adams County 2005 – planning
- 14 acres of the Limberlost Bird Sanctuary Addition 2006 – planning
- 15 acres of the Limberlost Bird Sanctuary Addition 2006 – Reforestation planned.
- 70 acres in early contractual purchase agreement during 2007-08 – future purchases will continually improve the water quality and reduce the intensity of the flooding losses.

Areas with Central Sewer or Other Treatment Facilities

Residential areas that are serviced by a centralized wastewater facility such as a WWTP or an operational package plant have reduced the potential for sewage or other household effluent to enter a nearby drainage ditch, stream or river. While there are risks and impacts associated with such services, the benefits far outweigh the detriments regarding the protection and enhancement of water quality. Treatment facilities have the ability to efficiently and effectively treat household wastewater while discharging significantly cleaner water into the receiving water bodies.

Areas serviced by centralized treatment facilities in the watershed include the Town of Geneva and the Town of Bryant. The City of Bluffton, the City of Portland and the Town of Berne are areas serviced by centralized treatment facilities, very near to the watershed boundaries. As these incorporated areas continue to grow in population, it may eventually become necessary to extend the service areas for the wastewater treatment plants. This may provide the opportunity for residences to abate their current on-site septic systems, thus reducing the overall potential for untreated household wastewater to enter the streams and tributaries in the Upper Wabash River watershed.

Critical service areas are those municipalities with separated storm and sanitary sewer utilities operating at less than or equal to half the design capacity. Feasibility studies need to be completed for these critical areas to determine the facility's operational ability and cost projections to extend services to those residents within 2 miles of the current service area.

4.2 CRITICAL AREAS AS POTENTIAL SOURCES OF POLLUTION

Critical areas identified below are considered by the UWRBC Steering Committee to be potential sources of pollution within the watershed. In order to minimize the water quality impacts associated with these areas, it will be important to target the implementation of management measures identified later in **Table 5-1, Table 5-2, Table 5-3, and Table 5-4** toward these critical areas.

Failing Septic Systems

A source of the elevated pathogen bacteria in the watershed may be associated with improperly functioning, failed, or non-existent residential septic systems. Many factors can lead to the failure of a residential septic system; the age of the system, lack of regular maintenance to the system, and heavy clay soils. Within the Upper Wabash River watershed, the unincorporated areas lack a centralized sewage disposal system, limiting homeowners to on-site septic systems. It is crucial that these homeowners are equipped with the necessary information and knowledge as to the proper maintenance of the system to prevent failure. As the more populated areas of the City of Berne, the City of Bluffton, the Town of Bryant, the Town of Geneva, and the City of Portland continue to grow in size, it will become more feasible to provide sanitary sewer services to those residences in close proximity to these areas. The importance to provide a centralized sanitary sewer system is underlined by information prepared by Purdue University Extension onsite regarding wastewater disposal in Indiana. Adams County, according to 1990 US Census data had an approximate 4,300 households utilizing onsite wastewater disposal systems. Soils in Adams County considered to be severely limited for proper septic system function based on NRCS criteria was estimated to be 100%. Similarly, within Jay and Wells Counties there are an estimated 3,700 and 4,700 households respectively utilizing onsite wastewater treatment systems. Further, in each of Jay and Wells Counties more than 96% of the soils are classified by NRCS as severely limited for septic systems.

Residential on-site sewage systems located within the floodway or 100-year floodplain are at a higher risk of discharging improperly treated effluent, bacteria, and pathogens into receiving waterbodies. As the soils become saturated due to rainfall, and the receiving streams are inundated, there is little to no treatment occurring within the soil absorption field. Routine flooding of those systems located in the floodplain may also have detrimental effects on the individual components of the system.

The most critical are those areas within the watershed is where a cluster of 20 or more rural homes with residential septic systems installed more than 10 years ago in soils with NRCS defined severe limitation for onsite wastewater disposal or treatment. Utilizing digital aerial photography, 8 clusters of septic systems as well as the Town of Linn Grove and the Town of New Corydon were identified and are shown on Exhibit 5. These clusters are all located near to the Wabash River or associated tributary streams and may provide concentrated loadings of nutrients and/or bacteria if several of these systems are failing to adequately treat the household wastes. Water quality monitoring should be initiated immediately upstream as well as immediately downstream of these areas to further assess the impact on water quality and macro-invertebrate communities.

Unbuffered Stream Reaches

Unbuffered streams and tributaries are highly exposed to overland runoff and the non-point source pollutants that are carried with it. Without the protection of several feet of vegetated buffer, pollutants such as sediment, nutrients and chemicals can be directly delivered to the stream system. In addition to reductions in pollutant loadings, vegetated buffers also provide a shading effect that can provide a more habitable environment for aquatic organisms regarding temperature and dissolved oxygen. Exhibit 5 highlights the areas of the streams and tributaries to the Upper Wabash River that have less than 30 feet of vegetation on either streambank. These areas were identified utilizing digital aerial photography of the watershed.

The most critical are those areas within the watershed where streams and tributaries have less than 30 feet of vegetated buffer and are bordered by agricultural fields utilizing conventional tillage methods during crop production. There are approximately 330 miles of streams within the watershed, and of that, it is estimated that approximately 122 miles, or 37%, of streams have less than 30 feet of vegetated buffer on one or both of the streambanks. The majority of such streambanks are located in the upland portions of the watershed surrounding headwater streams amid agricultural land uses. A more detailed assessment, including a tillage survey and buffer survey should be completed to provide a more accurate overview of the watershed.

Utilizing a visual inspection of digital aerial photography for the Upper Wabash River watershed, it is estimated that within the 05120101-040 subwatershed, approximately 23 stream miles have less than 30 feet of established vegetation on either streambank. In addition, it is estimated that 53 unbuffered stream miles are present in the 05120101-050 and 46 stream miles are present in the 05120101-060 subwatersheds. Based on the estimated number of unbuffered stream miles, the 05120101-050 subwatershed should be targeted for efforts to establish grassy or woody vegetation along the streambanks. The promotion of existing Federal Incentive programs such as Conservation Reserve Program (CRP), Conservation Security Program (CSP), and Environmental Quality Incentive Program (EQIP) can lead to the establishment of various forms of stream buffers providing benefits not only to the Upper Wabash River, but also to the individual landowners.

Areas Prone to Flooding

Areas prone to flooding can also be sensitive to other issues related to water or habitat quality degradation, as well as cumulative effects of increased water quantity within the stream system. Poorly managed floodplains where increased construction or other land use changes have occurred result in increased vulnerabilities to the new structures and to downstream areas as well. If water is not allowed to infiltrate the soil layers due to increased impervious surfaces, runoff volumes and downstream loadings will be increased. These increased volumes of water may mobilize trees and other near stream debris creating the potential for in-stream obstructions or log jams.

The term “log-jam” is defined by the Indiana Administrative Code as the accumulation of lodged trees, root wads, or other debris that impedes the ordinary flow of water through a waterway. As these log jams are created, areas of significant erosion and streambank destabilization are created further degrading water quality through sedimentation. Log jams may range in severity from leaning trees that need to be removed and utilized to stabilize the nearby streambank, to areas requiring large excavation equipment from both the land and within the stream for proper removal. With each degree of severity and corresponding workload, restrictions and guidelines provided by IDNR and the US Army Corps of Engineers (USACE) must be adhered to rigorously. Plans of work and permits are also required for more intensive situations. Some

areas in the Wabash River watershed are sensitive to log jams and associated debris deposition and/or increased streambank erosion. These areas, shown on Exhibit 5, were selected by the Adams, Jay, and Wells County Surveyors and are considered critical requiring constant observation and maintenance.

The risks to structural damages and watercourse damages can be decreased through preventative measures including detailed stream studies to establish floodways, floodplains, and base flood elevations. Utilizing the associated information will provide better knowledge regarding the stream and allow for proper floodplain management. Furthermore, the installation of United States Geological Survey (USGS) stream gages designed to monitor water quality, elevation, and flow will provide the necessary baseline information as well as information regarding low and high water events. Longevity of record for each gage is also important to monitor trends over several years. The combination of information obtained through detailed stream studies and long term monitoring can be valuable when proposing methods to prevent repeated flood events as well as reducing the impacts of flooding to water quality and personal property. Areas sensitive to repeated flooding, property damages, and the locations of existing are identified on Exhibit 4.

Livestock with Access to Stream

Livestock with access to the stream, or even feedlots and pastures bordering streams and tributaries can have a direct impact on water quality. Loadings of bacteria, such as *E. coli*, are directly deposited through fecal matter or delivered via stormwater runoff from the nearby feedlots and pastures. Sediment is delivered to the stream via erosion of worn livestock entrance paths and degraded streambanks. When livestock are excluded from the open streams and/or feedlots and pastures have been setback, it is important to establish a vegetated buffer to further reduce the potential of the above mentioned pollutants entering the stream system.

All areas where livestock have unrestricted access to open streams and tributaries, or where feedlots and pastures are within 500 feet of the open stream or tributary without a vegetated buffer are considered critical areas for the purpose of this plan. Furthermore, these areas would be considered extremely critical areas should they also be located in an area with HEL classified soils.

Conventionally Tilled Agricultural Fields

Conventional tillage of crop land allows the soil to remain exposed to the elements for extended periods of time. The majority of conventional tillage is completed following the crop harvest in the fall and no crop residue remains on the surface of the field. Thus the topsoil is exposed to the snow and more importantly during the spring snow melts and rain events. As the snow melts and the rain falls, the potential for soil erosion and the resulting sedimentation of receiving waters is greatly increased and nearly guaranteed.

Within the Upper Wabash River watershed, the primary tillage method for corn production remains to be conventional tillage. The percentage of conventional tillage is well over half in

both Adams County (60%) and Wells County (82%), while Jay County has been estimated at 54% conventional tillage. It does seem that soybean production has moved away from conventional tillage as the percentages are significantly lower in all three counties: Adams – 20%, Jay – 19% and Wells – 28%.

Fields utilizing conventional tillage for crop production on HEL soils within 500 feet of a stream or tributary are to be considered critical areas due to the increased erosion and pollution potential. For a more detailed view of these critical areas, a tillage inventory should be completed within the watershed and those results should be cross-referenced with NRCS HEL determinations.

Highly Erodible Lands

HEL determinations, made by NRCS, are based on a mathematical equation, USLE, the Universal Soil Loss Equation. This equation takes into account the rainfall factor, erodibility of the soil type, allowable loss for that soil type and the length and the slope of the area. Soil map units may also be classified as PHEL based on a varying range of length/slope values. In such instances, the final determination of erodibility must be made through an onsite investigation.

Within the Upper Wabash River watershed, there are approximately 4,200 acres (2.6% of the entire watershed) of HEL classified soils. Further, approximately 1,300 acres of HEL are located within the 05120101-040 subwatershed. An additional 78,400 acres (49% of the entire watershed) has been labeled as having characteristics similar to HEL soils and therefore are classified as potential HEL soils requiring individual field determinations. These soils, both HEL and PHEL, need proper management to reduce the increased potential for soil erosion. Thus, areas of HEL or PHEL soils currently in production and within 500 feet of a tributary stream of the Wabash River within the 05120101-040 are considered the most critical. These areas will need to be investigated in order to produce a conservation plan outlining potential BMPs and management techniques to reduce erosion. These areas are identified on Exhibit 5.

4.3 ESTIMATING POLLUTANT LOADINGS & REDUCTIONS

In order to determine the overall effectiveness of recommended management measures identified in this plan, it is important to have an understanding of the existing pollutant loads in the Watershed.

Pollutant Loadings

Flow data on the Wabash River was available for several USGS gaging stations, including Wabash River at New Corydon (OH-IN state line) for the period of 1951 through 1988; Wabash River at Linn Grove for the period of 1965 through 2006; Wabash River near Bluffton for the period of 2002 through 2005; and Wabash River at Bluffton for the period of 1931 through 1971. In order to determine the estimates of coincident long-term average mean annual flow at various points of interest, average mean annual flow was determined for various record periods that coincided with each of the stations. The ratio of long-term (1965-2006) average mean annual flow to average mean annual flow for each of these coincident periods at the Linn Grove station was determined and utilized for adjusting each station's average value for the respective coincident record period with the Linn Grove gaging station. Estimates of the long-term average mean annual flow for the intermediary area between the gaging stations were also determined by subtracting flow values at each upstream and downstream gaging station.

The above process to estimate the long-term average mean annual flow for various locations in the Upper Wabash River Basin based upon the Linn Grove Indiana gaging station is summarized in **Table4-1**.

The estimated long-term mean annual flow was then multiplied by the mean pollution concentrations for nitrate, phosphorus, and *E.coli* based samples collected near the 11-digit watershed outlets. These sampling stations were determined as a component of the IDEM, Clean Water Act – Section 205(j): Water Quality Planning Grant awarded to the UWRBC in 2004.

Target pollutant loads were then determined by multiplying the estimated long-term mean annual flow by a target concentration set for each pollutant. The targets utilized for this method were also utilized to develop the TMDLs for the Wabash River in both Ohio and Indiana. Target load reductions were then determined by subtracting the targeted loadings from the estimated existing loadings. Based on these calculations, the existing pollutant loads, targets, and target reductions were developed for Phosphorus, Nitrogen, *E.coli*, and TSS. Reductions needed to achieve attainment status in Indiana as well as Ohio are provided in **Tables 4-2, 4-3, 4-5, & 4-6**.

Table 4-1: Estimation of Long-Term (1965-2006) Average Mean Annual Flow

	Wabash River near New Corydon (USGS 03322500)		Wabash River at Linn Grove (USGS 03322900)		Wabash River near Bluffton (USGS 03322985)		Wabash River at Bluffton (USGS 03323000)
Area of Watershed Represented	Ohio Drainage	Intermediary Area	Entire Area upstream of Gaging station	Intermediary Area	Entire Area upstream of Gaging Station	Intermediary Area	Entire Area upstream of Gaging Station
Drainage Area (mi^2)	262	191	453	55	508	24	532
Period of Coincident Discharge Record with Linn Grove Long-Term Data	(1965-1988)		(1965-2006)		(2002-2005)		(1965-1971)
Avg. Mean Annual flow	208		413		671		349
Long term record Adjustment Factor	1.13		1.00		0.69		1.42
Adjusted flow (cfs)	235	178	413	50	463	33	496
Unit flow production (cfs/mi^2)	0.897	0.932	0.912	0.909	0.911	1.358	0.932
Estimated flow (cfs)	235.0	178.0	413.1	50.0	462.8	32.6	495.8

Table 4-2: Targeted Phosphorus Load Reductions for the Upper Wabash River Basin

Point of interest	Watershed of Interest	Drainage Area (Mi^2)	Unit Flow Production (cfs/mi^2)	Long-term Average Mean Annual Flow (cfs)	Existing Average Concentration (mg/L)	Estimated Existing Loadings (tons/year)	Target Concentration (mg/L)		Target Load Reduction (Tons/year)		Percent Reduction	
							IN	OH	IN	OH	IN	OH
Ohio-Indiana State Line	**Ohio Drainage Area + IN portion of 05120101010**	**262**	**0.897**	**235**	**2.6 mg/L**	**603.4**	**0.30**	**0.17**	**534.0**	**564.1**	**89.0%**	**94.0%**
Outlet of 05120101040 Just u/s of Loblolly Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Geneva)	296	0.901	267	1.18	310.0			231.4	265.3	74.6%	85.6%
Mouth of Loblolly Creek	**Entire Drainage area associated with 05120101050**	**110**	**0.932**	**103**	**0.55**	**55.7**			**25.3**	**38.5**	**45.5%**	**69.1%**
Outlet of 05120101060 Just d/s of Six Mile Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Bluffton)	506	0.911	461	0.26	117.9			Below Target	40.8	Below Target	34.6%

Table 4-3: Targeted Nitrate + Nitrogen Load Reductions for the Upper Wabash River Basin

Point of interest	Watershed of Interest	Drainage Area (Mi^2)	Unit Flow Production (cfs/mi^2)	Long-term Average Mean Annual Flow (cfs)	Existing Average Concentration (mg/L)	Estimated Existing Loadings (tons/year)	Target Concentration (mg/L)		Target Load Reduction (Tons/year)		Percent Reduction	
							IN	OH	IN	OH	IN	OH
Ohio-Indiana State Line	**Ohio Drainage Area + IN portion of 05120101010**	**262**	**0.897**	**235**	**5.6**	**1,295**	**10.0**	**1.5**	**Below Target**	**948**	**Below Target**	**73%**
Outlet of 05120101040 Just u/s of Loblolly Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Geneva)	296	0.901	267	8.1	2128			Below Target	1734	Below Target	81.5%
Mouth of Loblolly Creek	**Entire Drainage area associated with 05120101050**	**110**	**0.932**	**103**	**6.1**	**618**			**Below Target**	**466**	**Below Target**	**75.4%**
Outlet of 05120101060 Just d/s of Six Mile Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Bluffton)	506	0.911	461	9.6	4353			Below Target	3673	Below Target	84.4%

Table 4-4: Targeted *E. coli* Load Reductions for the Upper Wabash River Basin

Point of interest	Watershed of Interest	Drainage Area (mi^2)	Unit Flow Production (cfs/mi^2)	Long-term Average Mean Annual Flow (cfs)	Existing Average Concentration (cfu/100mL)	Estimated Existing Loadings (cfu/year)	Target Concentration	Target Load Reduction (cfu/year)	Percent Reduction
Ohio-Indiana State Line	**Ohio Drainage Area + IN portion of 05120101010**	**262**	**0.897**	**235**	**674.5**	**1.41E +15**	**235 cfu/100 mL**	**9.22E +14**	**65.2%**
Outlet of 05120101040 Just u/s of Loblolly Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Geneva)	296	0.901	267	2760	6.6E +15		6.0E +15	91.5%
Mouth of Loblolly Creek	**Entire Drainage area associated with 05120101050**	**110**	**0.932**	**103**	**163**	**1.50E +14**		**Below Target**	**Below Target**
Outlet of 05120101060 Just d/s of Six Mile Creek	Total Wabash River Watershed upstream of the point of interest (u/s of Bluffton)	506	0.911	461	135	5.6E +14		Below Target	Below Target

Table 4-5: Targeted Sediment Load Reductions for the Upper Wabash River Basin

Point of interest	Watershed of Interest	Drainage Area (Mi^2)	Unit Flow Production (cfs/mi^2)	Long-term Average Mean Annual Flow (cfs)	Existing Average Concentration (mg/L)	Estimated Existing Loadings (tons/year)	Target Concentration (mg/L)	Target Load Reduction (Tons/year)	Percent Reduction
Ohio-Indiana State Line	**Ohio Drainage Area + IN portion of 05120101010**	**262**	**0.897**	**235**	**95.9**	**22,170.6**	**80.0**	**3,675.8**	**16.6%**
Wabash River at Linn Grove	Entire area upstream of Gaging Station	453	0.912	413.1	114.4	46,491.3		13,979.9	30.1%

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Pollutant Reductions

Following the estimation of current pollutant loadings and the reductions needed to reach target levels of Total Phosphorus, Total Nitrogen and *E. coli*, various scenarios were developed to predict pollutant load reductions realized by implementing BMPs throughout the watershed. It should be noted that several BMPs may need to be implemented in combination to provide adequate reductions in loadings in order to meet Indiana target levels. A more long term goal would be to strive for pollutant loading reductions in order to meet Ohio target loadings for increased water quality improvements.

Utilizing information found in Schueler's "The Practice of Watershed Protection", calculations to determine phosphorus and nitrogen loadings and potential load reductions were also produced utilizing estimated septic system inputs from household wastewater per person, per day, using an estimate of the number of households within the watershed. According to 1990 data from Purdue University, all of Adams County had an approximate 4,200 homes with onsite wastewater systems. Likewise, all of Jay County had an approximate 3,600 systems, and Wells County was estimated to have nearly 4,700 homes utilizing septic systems. County estimates were then altered to show the estimated percentage of those systems within the Upper Wabash River Basin. Estimates were then produced to determine septic system outputs for systems that are failing, or non-existent, as well as systems that are efficiently and effectively treating the household wastewater. These estimates assume that routine maintenance and cleaning of the septic system components is occurring. These values are identified in **Table 4-6**. It can be further estimated that with septic system pumping, routine maintenance, and system replacements, 3.6 – 4.7 tons of phosphorus per year and 15.0 – 19.6 tons per year of nitrogen can be reduced.

Table 4-6: Estimated Loadings and Reductions for Septic Systems within the Upper Wabash River Basin

County	Est. number of on-site systems	Est. failing systems (25%)	Est. Phosphorus reduction (Tons/year)	Est. Nitrogen reduction (Tons/year)
Adams	1,218	305	1.2	5.1
Jay	1,764	441	2.0	7.4
Wells	987	247	0.9	4.1
TOTAL	**3,969**	**993**	**4.1**	**16.6**

Existing and Target Row Crop Sediment Loads

Sediment monitoring was completed throughout the Upper Wabash River Basin at IDEM fixed-site monitoring locations. Two of these locations were sampled through USGS stream gages utilized in earlier loading and reduction calculations; the Ohio-Indiana State Line and Linn Grove. Considering all samples for these locations, average concentrations of TSS were obtained and multiplied by the calculated Long-Term average mean flow found in Table 4-1. The estimated average annual loading at the Linn Grove site is 47,259 Tons/year, above the target loading of 32,511 Tons/year. Similarly, the estimated average annual loading at the Ohio-Indiana State Line is 22,170 Tons/year, above the target loading of 18,494 Tons/year. This can be utilized to indicate the need for management measures to be implemented in the Ohio drainage area. Management measures should also be taken within the Indiana drainage area to reduce the potential sediment loadings to the watershed since conventional tillage practices are still being widely utilized. The individual, 100 acre farm load reduction for sediment described below could be utilized to determine a target goal for the watershed.

Load Reduction on an Individual, 100 acre Farm for Sediment, Phosphorous, and Nitrogen

Load reduction spreadsheets (Region 5 Model) accepted by IDEM, Ohio Department of Natural Resources (ODNR), Michigan Department of Environmental Quality (MDEQ), and the Illinois Environmental Protection Agency (IEPA), along with the RUSLE2 predicted annual soil loss (ton/year) were utilized to produce estimated load reductions for sediment, phosphorus, and nitrogen as a result of implementing agricultural field practices and/or filter strips on a 100 acre farm in 2 different soil types. This spreadsheet is better utilized with field specific information, but is beneficial in this application as it provides estimates of how various BMPs can reduce pollutant loadings. The Region 5 Model assumes that all of the runoff from the 100 acres is being treated by the BMPs used in the calculation.

The NRCS RUSLE2 Worksheet Erosion Calculation Record was utilized with general local information provided by the Wells County NRCS District Conservationist and these records can be found in **Appendix 5**. RUSLE2, the Revised Universal Soil Loss Equation, is a mathematical equation which considers a rainfall factor, erodibility of individual soil types, allowable loss for that soil type and the length and the slope of the area.

Regarding the Upper Wabash River watershed, 82.5% of land use, or 132,808 acres, is classified as row crop production occurring predominantly in Blount and Pewamo soils. The assumption can be made that with high agricultural, row crop land use, significant load reductions should be achieved by implementing agricultural BMPs, such as conservation tillage and filter strips, throughout the watershed. Based on information derived from local sources and spreadsheets mentioned, the estimated reductions in phosphorus loadings by implementing conservation tillage and filterstrips on a single 100 acre, row crop farm would range from approximately 31 lbs/year to 158 lbs/year. In regard to nitrogen, the reductions range from approximately 58 lbs/year to 300 lbs/year. **Table 4-7** was produced outlining these findings and demonstrates the potential reductions based on 2 different soil types. The Region 5 Model Worksheets to produce these findings can be found in Appendix 5. The Region 5 Model assumes that all 100 acres would have conservation tillage and filterstrips.

Livestock with direct access to a nearby stream or drainage way can provide significant inputs of nutrients and bacteria. Pasture lands or feedlots without a proper filter strip, within 500 feet of a tributary stream or open ditch may also provide considerable amounts of excess nutrients and bacteria. Following the estimation of current pollutant loadings and the reductions needed to reach target levels of Total Phosphorus, Total Nitrogen and *E. coli*, various scenarios were developed to predict pollutant load reductions realized by implementing BMPs throughout the watershed. It should be noted that several BMPs may need to be implemented in combination to provide adequate reductions in loadings in order to meet Indiana target levels.

Calculations within the load reduction spreadsheets previously mentioned were utilized to determine potential load reductions associated with installation of livestock exclusion fencing and/or filterstrips along feedlot and pasture areas. These estimated reductions will vary based on species or combinations of species per operation, number of operations implementing livestock exclusion and/or feedlot setbacks. The animal unit estimates are values below permitting levels. Values ranging from 8 lbs/year phosphorus reductions through 1,061 lbs/year phosphorus reductions per operation are identified in **Table 4-8**. The Region 5 Model Worksheets to produce these findings can be found in Appendix 5. No BMP efficiency data was available for nitrogen removal through livestock exclusion and/or feedlot setbacks.

Table 4-7: Estimated Loadings and Reductions, Ag BMPs

EST. LOAD REDUCTIONS per 100 ac farm	PEWAMO			BLOUNT B		
	Ag Field Practices	Filter Strips	TOTAL	Ag Field Practices	Filter Strips	TOTAL
Sediment (Tons/yr)	2	10	**12 T/yr**	26	69	**95 T/yr**
Phosphorus (lbs/yr)	4	27	**31 lbs/yr**	33	126	**159 lbs/yr**
Nitrogen (lbs/yr)	8	50	**58 lbs/yr**	65	234	**300 lbs/yr**

(IDEM Region 5 Model, April 2007)

Table 4-8: Estimated Loadings and Reductions, Feedlots, Pastures and Access Areas

Species	Average Animals	Est. Phosphorus Loadings without Filterstrip (lbs/yr)	Est. Phosphorus Loadings with Filterstrip (lbs/yr)
Beef	275	1,248	187
Dairy	299	1,248	187
Horse	5	10	1
Sheep	400	109	16
Swine	599	734	110

(IDEM Region 5 Model, April 2007)

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Based on these estimates, the implementation of these management measures at specific sites would greatly reduce the pollutant loadings potentially meeting the targeted phosphorus load reductions for the watershed as indicated in Tables 4-2 and 4-4. All target load reduction numbers for nitrogen were below reduction target values, as shown in Table 4-3, so theoretically no management measures for nitrogen would even need to be implemented in the watershed.

Table 4-9 identifies the predicted load reductions associated with implementing some of the management measures discussed above.

Table 4-9: Potential Load Reductions, Critical Area Management Measures

Management Measure	Total Phosphorous Reduction	Total Sediment Reduction	Total Nitrogen Reduction
Septic System Improvements (systems)	1: 14 lb/yr 993: 13,902 lb/yr	N/A	1: 34 lb/yr 993: 33 762 lb/yr
Implementation of Filter/Buffer Strips (miles)	1: 0.2-1.2 T/yr 122 : 24.4-146.4 T/yr	1: 125.6-1,716.3 T/yr 122: 15,323.2-209,352.0 T/yr	1: 0.3- 2.3 T/yr 122: 36.6-280.6 T/yr
Implementation of Agricultural Conservation Measures (100 acre farm)	1: 4.0-33.0 lb/yr 1,328: 5,312.0-43,824.0 lb/yr	1: 2.0-26.0 lb/yr 1,328: 2,656.0-34,528.0 lb/yr	1: 8.0-65.0 lb/yr 1,328: 10,624.0-86,320.0 lb/yr
Streambank Stabilization/Restoration (per each 250 feet long X 10 high streambank with a recession rate of 0.2 feet per year*)	1: 10 lb/yr 10: 100 lb/yr	1: 10 lb/yr 10: 100lb/yr	1: 20 lb/yr 10: 200 lb/yr

(*Region 5 Model example, see Appendix 5)

While the above calculations indicate reductions in pollutant loads, it is difficult to estimate the percentage of these reductions per subwatershed. However, it can be assumed that with the implementation of these BMPs, the Upper Wabash River Watershed will move towards attainment of the Indiana target concentrations for Phosphorus, Nitrogen, and sediment. In the individual subwatersheds where the existing concentrations are currently estimated to fall below the target concentrations, implementation of BMPs should also be promoted as a method to further reduce the pollutant loadings and achieve a great water quality benefit. It can be assumed that as the Upper Wabash River and tributaries progress through the watershed, the cumulative effects of BMPs implemented will have a positive effect on water quality. Thus it would seem that the water quality would be greater leaving the watershed versus the quality of the water entering the watershed from Ohio.

Water quality sampling events, USGS gaging stations, and the information obtained through the IDEM fixed site sampling locations seem to indicate a great amount of pollutant concentrations stemming from the Ohio Wabash River drainage area. While the Indiana Wabash River drainage area should not be held responsible for reducing these loadings as well, it does highlight the inherent need to operate and implement on a watershed-wide scale without State divisions.

It is important that the established pollutant reduction targets be utilized as reference points and not as hard and fast indicators through which to evaluate the long term success of this watershed management plan. Both existing pollutant loadings and pollutant reduction targets are subject to a wide variety of assumptions, and are based on the best data currently available. The overall success of the watershed management plan should not only be evaluated by whether or not target load reductions or instream standards are achieved, but also on the basis of whether or not water quality improves as a result of implementing the watershed management plan. If existing pollutant loads are estimated too high, achieving target pollutant load reductions may not result in achieved in-stream pollutant concentrations. Alternatively, if existing pollutant loadings are estimated too low with goals that are easily achieved, in-stream target concentrations may be fulfilled prior to reaching target pollutant load reductions resulting in an inadequate number of BMPs to effectively improve overall water quality.

5.0 GOALS AND DECISIONS

Setting realistic and measurable goals is key to the successful implementation of this Watershed Management Plan. A goal is the desired change or outcome as a result of the watershed planning effort. Depending on the magnitude of the problem, goals may be general, specific, long-term or short-term. The goals in this plan focus on improving water quality through the implementation of a variety of management measures. IDEM suggests watershed groups focus on developing goals, management measures, action plans, resources, and legal matters as part of the watershed planning process.

According to IDEM, management measures describe what needs to be controlled or changed in order to achieve the goal. The anticipated timeline for implementing individual management measures is identified in this section. In order to successfully implement this plan, resources such as people, programs, and money need to be identified. It is important to have the support of individuals identified as resources to successfully execute the goals of the plan. Successful implementation may require some legal matters such as obtaining permits, purchasing easements, or the adoption of an ordinance. The UWRBC has decided to focus on goals that improve both water quality issues and water quantity issues in the Upper Wabash River watershed. The topics of concern and the goals outlined by the Commission are described below. Responsibility for implementing tasks will vary with agency initiatives, directives, staffing, and funding opportunities.

Education Goal: *Improve water quality to meet Indiana water quality targets and reduce damages associated with water quantity in the Wabash River watershed through education and outreach efforts that focus on changing stakeholder's habits and behaviors.*

Flooding Goal: *Reduce in-stream and private property damages, nearly $1.6 million since 1978, associated with increased water quantity through collaborative efforts basin-wide, including the Ohio drainage area.*

Agricultural Goal: *Promote application and participation to implement BMPs throughout the watershed in an effort to remove 303(d) segment listings and impairments within the Upper Wabash River Basin.*

Land Use/Future Development Goal: *Improve water quality to meet Indiana water quality targets and reduce damages associated with water quantity in the Wabash River watershed through basin-wide land use planning and ordinance development for the protection of agricultural activities and floodplain management.*

***E. coli* Reduction Goal:** *Remove 303(d) segment listings and impairments within the Upper Wabash River Basin due to E. coli and nutrient concentrations through proper agricultural nutrient management and on-site household wastewater treatment systems.*

5.1 POTENTIAL IMPLEMENTATION TIMELINE

Management measures identified as high priorities are likely to provide the greatest long term benefit to water quality in the watershed. However, these activities are not always the easiest measures to implement. Likewise some of the measures that may be considered moderate or low priorities may be relatively easy to implement. Therefore, implementation of certain moderate priority measures may occur prior to certain high priority measures, and implementation of certain low priority measures may occur prior to certain medium priority

measures. Additionally, new information or changes in political and economic circumstances may result in a change in the implementation schedule shown below.

Tables 5-1, 5-2, 5-3, 5-4, and 5-5 located on the following pages identify management measures, action plans, resources/cost, legal matters, and progress indicators associated with addressing education, flooding, agriculture, land use planning, and the reduction of *E. coli (respectively)* in the Upper Wabash River Basin. "Local Resources" in the tables are intended to provide a list of local organizations that could potentially provide support, advice, or consultation on a particular management measure. These lists are not intended to be comprehensive and are not intended to exclude non-listed organizations from participating in the development or implementation of a particular management measure. Lead agencies will vary with program directives, funding, and staffing abilities. Other non-listed organizations are encouraged to participate as available.

Proposed management measures were discussed and prioritized by the UWRBC into High, Moderate, and Low priority categories. Estimated costs in the tables are identified as Low, Moderate, or High. Those activities, materials, or programs estimated to cost between $1,000 and $10,000 are considered low cost. Activities, materials and programs that are estimated to cost between $10,000 and $50,000 are considered moderate cost, while those projects estimated to cost over $50,000 were considered to be a high cost. Anticipated timeline dates are provided as a reference for estimated start dates for the individual management measures proposed.

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Table 5-1: Education Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
Improve communication and coordinate activities with OH & IN Upper Wabash River Communities. **High Priority**	• Create a working partnership between UWRBC and GLWWA. • Explore newsletter mailing lists and contact information to ensure that all communities are included. • Create an At-Large position on each Board, devote agenda time for updates.	• UWRBC • Adams, Jay, and Wells County SWCDs • Local media outlets (print, TV, and radio) for information transfer • Mercer County (OH) SWCD • Low Cost	• Amendments to By-Laws or other provisions may need to occur to create an At-Large position on each representative Board.	• Members from each respective Board are coordinating water quality and water quantity efforts utilizing a Basin-wide approach. **Anticipated Timeline** 2008-2010
Formation of Joint OH & IN Wabash River Basin Commission **High Priority**	• Create an Interstate Wabash River Basin Commission to ensure information, projects, proposals and efforts are conducted for the benefit of the entire Basin.	• UWRBC • GLWWA Joint Board • Low Cost	• Amendments to By-Laws, State Legislation, or other provisions may need to occur to create a Joint Board representative of the entire Basin, including Ohio.	• A Joint Board representative of the entire Basin, including Ohio has been created. **Anticipated Timeline** 2011
Install Pilot/Demonstration project highlighting 2-stage ditch design methods. **Moderate Priority**	• Explore various methods of drainage ditch design, construction, and maintenance. • Determine feasibility of innovative methods in specific locations within the watershed. • Determine best technique and best location for the Pilot project or demonstration project. • Monitor area for beneficial or detrimental results, compile results and distribute to interested stakeholders.	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County SWCD/NRCS offices. • Purdue Extension • IDNR • Moderate Cost	• Permits may need to be obtained prior to onset of work. • Conservation or Construction and Maintenance Easements may need to be purchased to complete work and monitor results.	• Pilot/Demonstration project has been constructed and regularly monitored for results. **Anticipated Timeline** 2010

Prepare and distribute an educational brochure regarding proper septic system operation and maintenance.
 	
Moderate Priority
	• Distribute educational brochure on proper septic system operation and maintenance to 25% of the watershed population.
	• Target known areas in the watershed with existing septic systems.
		• Local Resources
		  • Adams, Jay, and Wells County Health Departments
		  • Area Plan Commissions
		• Low cost
			NA	• Follow up contact indicates that stakeholders receiving brochures have changed their behaviors and/or practices.
				
				Anticipated Timeline
				2008

Submit bi-annual articles and updates to newspapers and other community organizations in the Upper Wabash River Watershed.
 	
Moderate Priority
	• Biannual submissions beginning in 2006.	• Local Resources
		  • Local media outlets.
		  • Adams, Jay, and Wells County SWCD Newsletters and Mailings
		  • Farm Service Agency Newsletters
		  • Purdue Extension
		• Low cost
			NA	• Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed.
				
				Anticipated Timeline
				Ongoing

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Conduct a septic system demonstration project to promote onsite wastewater treatment systems resulting in improved water quality.
 	
Low Priority
	• Explore feasibility of implementing an alternative treatment system demonstration project.
	• Locate one or more landowners with currently failing septic systems willing to participate in a demonstration.
	• Conduct an onsite wastewater treatment system demonstration project with regular system monitoring.
		• Local Resources
		  • Adams, Jay, and Wells County Health Departments
		  • ISDH
		• Section 319 grant
		• High cost
			• Proper permit will need to obtained from local, and possibly State Health Departments.	• Future water quality sampling indicates a reduction of *E.coli* concentrations in the Upper Wabash River Watershed.
				• Awareness of proper installation, operation and maintenance of residential septic systems is increased.
				
				Anticipated Timeline
				Ongoing

Prepare educational displays and participate in at least four community events annually.
 	
Low Priority
	• Identify 2 events per year providing best results to improve awareness of water quality issues.
	• Identify contact persons for respective events.
	• Develop and maintain a display that can easily be updated (i.e. impacts of residential land use such as car washing, dog waste, and lawn care at the county fair).
		• Display board, laminated images, brochures, flyers, etc.
		• Local Resources
		  • Purdue Extension
		  • Adams, Jay, and Wells County SWCDs
		• Low cost
			NA	• Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed.
				
				Anticipated Timeline
				Ongoing

Survey watershed stakeholders in order to determine their awareness of water quality issues and to identify localized water quality problems. **Low Priority**	• Distribute surveys to landowners along creeks and ditches. • Repeat distribution of survey annually	• Local Resources • Upper Wabash River Watershed Commission • Low cost	NA	• Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed. **Anticipated Timeline** Ongoing
Promote and encourage participation in Waste District Tox-Drop and Recycling Programs. **Low Priority**	• Distribute materials at 2 local events and workshops per year.	• Local Resources • Solid Waste Districts • Low cost	NA	• Future surveys indicate changes in stakeholder attitudes and behaviors as they relate to pollution prevention. **Anticipated Timeline** Ongoing

Table 5-2: Flooding Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
Conduct detailed flood protection studies for focused flooding problem areas, leading to basin wide Flood Control Master Plan **High Priority**	• Secure funding for flood protection studies to develop Flood Control Master Plan • Select appropriate author for Flood Control Master Plan. • Implement proposed projects in Flood	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County Commissioners • Area Planning Commissions • Municipal Governments	• Adoption of Flood Control Master Plan and inclusion into basin-wide Comprehensive Plans, Ordinances and Zoning will need to be completed.	• Funding secured, Flood Control Master Plan completed and adopted by County and Local Governments and included in existing plans and ordinances.

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
	Control Master Plan.	• High Cost		**Anticipated Timeline** As funding allows
Conduct research on Grand Lake spillway including evaluating design, educational outreach, and open a dialog with affected parties. **High Priority**	• Obtain designs, elevations and O&M procedures for current Spillway. • Participate in forum with Designers, Operators and downstream residents as to the information obtained.	• OH DNR & IN DNR • Grand Lake/Wabash Watershed Alliance • UWRBC • Adams, Jay, and Wells County Surveyor's Offices • Mercer County Engineer's Office • Low Cost	• Ongoing litigation involving Mercer County Landowners and Ohio Department of Natural Resources • Plans and project proposals to be adopted by County and Local Governments and Planning Commissions.	• Transfer of valid information regarding the Grand Lake Spillway to all parties in Ohio and Indiana. • Working partnership developed between Ohio and Indiana Wabash drainage areas. **Anticipated Timeline** 2009
Inventory log jams and streambank erosion areas of concern. **High Priority**	• Inventory locations prone to log jams and streambank erosion • Determine need for DNR permit for mitigation activities at each site • Prioritize areas and obtain funding for removal or stabilization activities	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay and Wells County SWCDs • Property owners along River and tributaries. • Moderate Cost	• Easements or agreements need to be obtained for private property entrance. • Funding mechanisms may include ditch assessments, maintenance fees or other means involving public input.	• Inventory and GIS mapping of logjams and destabilized streambanks utilized to determine areas in greatest need. • Various sources of funding identified, landowners in aware of the issues. **Anticipated Timeline** 2008
Increase frequency of drainage ditch maintenance and/or number of miles maintained using appropriate BMPs. **High Priority**	• Update inventory and prioritization annually. • Inspect new areas and add to inventory. • Determine personnel needs to adequately address the maintenance needs of the area. • Explore partnership options with other County or Municipal offices.	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County Commissioners • NRCS • Low Cost unless additional personnel are required.	• Work will need to be completed as outlined by the County Drainage Board and the County Surveyor.	• Inventory of areas in need is updated annually and utilized as a fluid document. • Personnel needs have been addressed. • Increased maintenance, either visual or mechanical, is occurring. **Anticipated Timeline** 2008
Conduct detailed studies of unnumbered Zone A streams (approximately 42 miles) **Moderate Priority**	• Prioritize areas in need of study • Secure funding for appropriate studies • Acquire local and Federal adoption of the detailed studies.	• Adams, Jay, and Wells County Surveyors • FEMA • High Cost	• FEMA and local approval will need to be obtained to finalize and adopt the studies.	• Prioritized areas have completed studies. • Remaining areas are prioritized for future studies. • Adequate local support is provided. **Anticipated Timeline** 2010
Participate in National Floodplain Insurance Program's Community Ratings System (CRS) program. **Moderate Priority**	• Secure funding, prepare, and adopt Multi-Hazard Mitigation Plans for Jay and Wells Counties. • Prepare CRS applications for all interested communities. • Implement management measures outlined in MHMPs and needed items in the CRS application to ensure best	• Jay and Wells County EMAs • Area Planning Commissions • County and Local Governments within the River Basin. • Adams, Jay and Wells County Surveyor's Offices • NFIP Communities within the watershed	• Adoption of Completed MHMPs and CRS applications will need to be completed by County and Local Governments.	• Each County and/or Community involved has developed and adopted a specific Multi-Hazard Mitigation Plan. • Interested communities have become CRS participants and received associated Flood Insurance discounts.

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
	rating possible for each community.			**Anticipated Timeline** 2010
Maintain existing and increase the overall number of gaging stations in the watershed that monitor flow data **Moderate Priority**	• Determine activity levels of stream gages currently in the watershed. • Determine locations of active and inactive stream gages. • Explore steps to re-activate 3 discontinued gages. • Maintain central repository or electronic database for all stream gages in the watershed.	• United States Geological Survey • Indiana Geological Survey • Adams, Jay, and Wells County Surveyor's Offices • UWRBC	• O&M contracts may be needed to discuss funding, responsible entity, and longevity matters.	• Number of stream gages increased due to local interest and efforts. • Data from gages utilized to guide land use decision making in Adams, Jay and Wells Counties and Local Communities within those counties. **Anticipated Timeline** 2009
Stream gaging station on Ohio/Indiana line needs to remain active and permanent. **Moderate Priority**	• Determine existence of stream gage located on the state line. • Explore steps to have gage installed if not present; re-activate and/or made a permanent structure.	• United States Geological Survey • Indiana Geological Survey • Ohio Department of Geological Survey • Adams, Jay, and Wells County Surveyor's Offices • UWRBC	• O&M contracts may be needed to discuss funding, responsible entity, and longevity matters.	• Stream gage on Ohio – Indiana state line has been installed/re-activated or made permanent and data is continuously obtained and utilized for decision making processes. **Anticipated Timeline** 2008

Implement streambank stabilization techniques that utilize a combination of vegetation, bioengineering, and structural systems.
 	
Moderate Priority
	• Inventory 2nd and 3rd order waterways for erosion problems.
	• Distribute educational materials on streambank stabilization.
	• Identify funding sources to assist with stabilizing eroded banks.
	• Develop economic incentive program to conduct streambank stabilization projects.
		• Local Resources
		  • Adams, Jay and Wells County SWCDs
		  • NRCS
		  • DNR
		  • Adams, Jay and Wells County Surveyor's Office
		• 319 Grant
		• High cost
			• Construction and maintenance easements may need to be obtained to complete necessary work.
			
			• Permits may also need to be obtained for instream work.
				• Future water quality sampling indicates a reduction of sediment, phosphorus, and nitrogen loadings and concentrations, within the Upper Wabash River Watershed.
				
				Anticipated Timeline
				2009

Table 5-3: Agricultural Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Establish vegetated buffer along natural streams and artificial drainage ditches. A total of 122 stream miles need buffered.
 	
High Priority
	• Identify landowners adjacent to natural waterways.
	• Conduct a workshop and/or develop educational materials on benefits of riparian buffers and filter strips.
	• Encourage participation in existing federal programs.
	• Develop economic incentive program for landowners ineligible for Federal funding.
	• Indicate buffers using GIS
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • Adams, Jay, and Wells County Surveyor's Office
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension Service
		  • Nature Conservancy Easements
		  • Land Trust Organizations
		• Federal incentive programs
		• High cost
			• Development of easements, deed restrictions and/or contractual management agreements.	• Future water quality sampling indicates a reduction in nutrient concentrations and loadings in the Upper Wabash River Watershed.
				• Conducive habitats for aquatic life: more consistent temperature ranges and dissolved Oxygen levels due to overhanging vegetation.
				
				Anticipated Timeline
				Ongoing

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Increase the number of acres utilizing conservation tillage methods.
 	
High Priority
	• Provide educational materials at SWCD annual meetings, Ag Days, County Fairs
	• Research and promote incentive programs to improve participation in conservation tillage practices by 20%.
	• Develop economic incentive program to assist landowners with implementing conservation tillage.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension Service
		  • Adams, Jay, and Wells County Surveyor's Office
		• CTIC/CORE 4 programs
		• Federal incentive programs
		• 319 Grant
		• Moderate cost
			NA	• Future surveys, tillage transects, and correspondence indicate that stakeholders have changed behaviors and/or practices.
				
				Anticipated Timeline
				Ongoing

Increase nutrient management and pest management practices among crop producers.
 	
High Priority
	• Identify 100 landowners and evaluate current manure, nutrient, and /or pest management practices.
	• Conduct a workshop and/or develop brochure addressing manure, nutrient, and pest management and highlighting NRCS standards.
	• Develop economic incentive program to provide land-owners with assistance in developing and implementing nutrient and pest management plans.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		  • Adams, Jay, and Wells County Surveyor's Office
		• CTIC/CORE 4 programs
		• Federal incentive programs
		• Section 319 Grant
		• Low cost
			N/A	• Follow up contact indicates that stakeholders attending workshops have changed behaviors and/or practices.
				
				• Future water quality sampling indicates a reduction in *E.coli*, phosphorus, and ammonia concentrations in the Upper Wabash River Watershed.
				
				Anticipated Timeline
				Ongoing

Promote use of winter cover crops to reduce erosion and sedimentation within the watershed.
 	
High Priority
	• Target 50 fall plowed fields within the watershed.
	• Provide informational materials regarding benefits to water quality and soil health through establishing winter cover crops.
	• Obtain funding and provide economic incentives to landowners incorporating winter cover crops.
	• Complete pre and post implementation load reductions based on spreadsheets provided by IDEM and RUSLE 2 calculations.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		• CTIC/Core 4 programs
		• Federal incentive programs
			NA	• Reduced sediment loadings to nearby streams and waterways
				• Enhanced water quality in stream segments near to participants.
				
				Anticipated Timeline
				Ongoing

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Promote use of grassed waterways, concentrated flow areas, and critical seedings to reduce erosion and sedimentation within the watershed.
 	
High Priority
	• Provide informational materials regarding benefits to water quality and soil savings through establishing grassed waterways, concentrated flow areas, and critical seeding areas.
	• Obtain funding and provide economic incentives to 25 landowners to stabilize areas of concern.
	• Complete pre and post implementation load reductions based on spreadsheets provided by IDEM and RUSLE 2 calculations.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		• CTIC/Core 4 programs
		• Federal incentive programs
			NA	• Reduced sediment loadings to nearby streams and waterways
				• Enhanced water quality in stream segments near to participants.
				
				Anticipated Timeline
				Ongoing

Explore benefits of Wetland/Reservoir Sub-Irrigation Systems in the Upper Wabash River watershed.
 	
Moderate Priority
	• Research existing systems for efficiency, benefits to both water quality and crop production and cost/benefit.
	• Determine best location(s) for 2 demonstration projects.
	• Develop monitoring program for water quality as well as crop productivity.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		• Federal incentive programs
		• Section 319 Grant
		•
			NA	**Anticipated Timeline**
				2009

Secure funding for livestock and crop producers to implement conservation BMPs.
 	
Low Priority
	• Research funding sources and develop economic incentives to implement BMPs on 25 operations.	• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • DNR
		  • Purdue Extension
		• Federal incentive programs
		• 319 Grant
		• High cost
			• Requirements of funder must be followed and necessary reports completed and submitted.	• Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Upper Wabash River Watershed.
				
				• Increased watershed wide participation in conservation programs.
				
				Anticipated Timeline
				Ongoing

Table 5-4: Land Use/Development Management Measures

Management Measure	Action Plan	Resources/Cost	Legal Matters	Process Indicators
Limit development in 100 & 500 year floodplains. **High Priority**	• Determine critical areas and prioritize them for focused efforts and expenditures. • Determine limitations to be proposed based on type of development, amount of development, current and proposed land use changes. • Investigate utilizing Conservation and Development Right easements to obtain land in floodplains. • Author ordinances for the limitation of development within the 100-year and 500-year floodplains.	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay and Wells County Commissioners • Area Planning Commissions • Low Cost	• Proposed ordinances will need to be adopted by County and Municipal Governments. • Contractual agreements for easement purchase/lease and management procedures	• Ordinances are developed and adopted by all County and Local Governments. • Floodplain for the Upper Wabash River and tributary streams is protected. **Anticipated Timeline** 2010
Coordinate with Federal NRCS/FSA programs and land use conversion programs to reduce flood damages. **High Priority**	• Create ad hoc committee to investigate correlations of needs and opportunities. • Determine critical areas based on previous flooding, land uses within the 100 year floodplain, and repetitive loss properties. • Utilize combined effort to inform landowners of programs and funding available for proposed activities.	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County SWCD/NRCS • Local media outlets (print, TV, and radio) for information transfer • Low Cost	• Guidelines set forth by Federal Entities must be followed and operations must be eligible for participation.	• Increased application and participation in Federally funded agricultural incentive and enrollment programs. **Anticipated Timeline** Ongoing
Evaluate urban areas subject to repetitive flooding for existing structural relocation, buy out and flood-proofing. **High Priority**	• Investigate repetitive loss properties. • Determine critical areas based on previous flooding and land uses within the 100 year floodplain. • Inform landowners of programs and funding mechanisms available • Create upland storage areas and develop passive land uses that would experience little monetary damage if flooded	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County SWCDs • Adams, Jay, and Wells County EMA Directors • IDHS	• Contractual agreements for purchase or private properties.	• Repetitive Loss properties mitigated to reduce future flood damages. **Anticipated Timeline** 2008
Wetland preservation, restoration and enhancement activities. **Moderate Priority**	• Identify critical areas for wetland construction or preservation • Inform landowners existing Federal funding programs	• Adams, Jay, and Wells County Surveyor's Offices • Adams, Jay, and Wells County SWCD/NRCS offices. • Local Land Trust Organizations • Moderate to High Cost	• It may be necessary to purchase conservation easements prior to construction of wetlands. Contractual agreements will need to be obtained.	• 50 acres of constructed or restored wetlands are providing additional storage capacity in critical areas of the watershed. Flooding damages have been reduced due to this project. **Anticipated Timeline** Ongoing

Incorporate water quality BMPs into future construction and flood control projects designed and implemented in the watershed.
 	
Moderate Priority
	• Update existing Comp Plans, Zoning Ordinances, and Subdivision Control Ordinances.	• Local Resources
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Adams, Jay, and Wells County SWCDs
		• Moderate Cost
			• Approval and adoption of updated planning documents and ordinances.	• Updated ordinances and comprehensive plans address water quality issues.
				
				Anticipated Timeline
				2010

Minimize soil erosion and sedimentation of waterways with better construction management and practices.
 	
Moderate Priority
	• Update Adams, Jay and Wells Counties existing ordinances to require ESC from sites disturbing greater than or equal to one acre of land.
	• Implement an educational program on the benefits of implementing ESC measures.
	• Create and distribute a handbook identifying appropriate BMPs.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Local Builders Associations
		  • Purdue Planning with POWER
		• Moderate cost
			• Approval and adoption of updated planning documents and ordinances.
			
			• Enforcement methods of existing fines for construction violations.
				• Post construction practices implemented in 100% of developments greater than or equal to one acre in the Upper Wabash River Watershed.
				
				Anticipated Timeline
				Ongoing

Develop and adopt a Greenways Plan to maintain a system of healthy riparian/aquatic buffers along the Upper Wabash River.
 	
Moderate Priority
	• Work with landowners, planners, SWCD staff, and interested group to develop a basin-wide Greenways Plan.	• Local Resources
		  • Area Plan Commissions
		  • Adams, Jay, and Wells County SWCDs
		  • Wabash River Corridor Heritage Commission
		  • Local Land Trust Organizations
		  • Secure additional funds to pay for study writing, and distribution of plan.
		• Moderate cost
			• Amendments to the Zoning Ordinance and Comprehensive Plan, and adoption of those amendments may be necessary.	• Greenway Plan developed and riparian buffers maintained.
				
				Anticipated Timeline
				Ongoing

Minimize the water quality impacts associated with transportation corridors.
 	
Moderate Priority
	• Work with INDOT to implement hydrocarbon removing BMPs along US Hwy 27 roadside ditches.
	• Encourage state and local Highway Departments to utilize a substitute for road salt along stretches of US Hwy 27 near the Wabash River and its tributaries.
		• Local Resources
		  • Adams, Jay, and Wells County Highway Departments
		  • INDOT
		• Medium cost
				• Implementation of BMPs, and change in salt/sand application policies.
				
				Anticipated Timeline
				2010

Update current Comprehensive Plans, Zoning Ordinances, and Subdivision Control Ordinances to address water quality issues including:
• Wetland protection
• Riparian corridor protection
• Tree preservation/protection
• Setbacks and buffer protection
• Limiting impervious areas
• Conservation design
• Drainage (ROW) easements
• Treatment of sewage (septic/sewer)
• Flexible development standards
 	
Low Priority
	• Participate in future updates of the Comprehensive Plans for Adams, Jay and Wells Counties.
	• Participate in future updates of Zoning Ordinances, Subdivision Control Ordinances, and Floodplain Ordinances.
	• Update Flood Insurance Rate Maps.
	• Develop digital zoning maps.
		• Model ordinances.
		• Local Resources
		  • Local Builders Association
		  • Area Plan Commissions
		  • Adams, Jay, and Wells County SWCDs
		  • Adams, Jay, and Wells County Surveyor's Offices
		  • Purdue Extension
		• Moderate cost
			• Approval and adoption of updated planning documents and ordinances.	• Updated ordinances and comprehensive plans address water quality issues.
				
				Anticipated Timeline
				2010

Use GIS to assist with establishing future land use and zoning districts based on appropriateness for development, agriculture, and open space.
 	
Low Priority
	• Develop watershed wide GIS layer to assist in future planning and decision making efforts.	• Digital soil, property, and drainage layers
		• Local Resources
		  • Information Technology Departments
		  • Area Plan Commissions
		  • Adams, Jay, and Wells County SWCDs
		  • Adams, Jay, and Wells County Surveyor's Office
		• Moderate cost
			• Interested offices and agencies must be granted full or limited access to the information.	• Watershed wide GIS layer developed and utilized in future land use decisions.
				
				Anticipated Timeline
				Ongoing

Improve water quantity and quality management through effective storage and treatment of urban, suburban, and rural stormwater runoff including:
• On-site stormwater treatment
• Bioretention
• Rain Gardens
• Constructed wetlands
• Detention/retention ponds
• Infiltration basins/trenches
• Vegetated filters strips/swales
• Stream buffers
• Limit impervious areas
• Tree conservation/protection
 	
Low Priority
	• Review existing drainage ordinances and make recommendations for improvement to the Drainage Boards and Town Councils.
	• Implement educational program focusing on benefits of stormwater BMPs in new development.
	• Distribute handbook identifying appropriate stormwater BMPs.
	• Develop economic incentive to developers implementing stormwater BMPs.
		• List of definitions suggested language, and model ordinances.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Local Builders Associations
		• 319 Grant
		• High cost
			• Approval and adoption of updated planning documents and ordinances.	• Post-construction practices implemented in 100% of developments greater than or equal to one acre in the Upper Wabash River Watershed.
				
				Anticipated Timeline
				2009

Table 5-5: *E. coli* Reduction Management Measures

Management Measure	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Improve the planning process to minimize impacts of residential septic systems on water quality.
 	
High Priority
	• Ensure Health Departments continue to participate in review and approval process.
	• Create GIS layer identifying land suitable for septic systems.
	• Include language in updated Comprehensive Plans addressing impacts of septic systems on water quality.
	• Promote existing assistance programs for homeowners replacing and repairing inadequate septic systems.
	• Require documentation of properly functioning system prior to real estate transfer.
		• Local Resources
		  • Adams, Jay, and Wells County Commissioners
		  • Adams, Jay and Wells County Health Departments
		  • Purdue Extension Service
		  • USDA RCAP
		  • Local Realtors
		• Secure additional funds to provide economic incentives for repairing failing septic systems.
		• Moderate cost
			• Will need to gain legal authority to require landowners to provide documentation that their septic systems are working properly prior to selling their property.	• Secure funding for low-income landowners that may need financial assistance in installing, repairing, or operating and maintaining their septic systems.
				
				• Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Upper Wabash River Watershed.
				
				Anticipated Timeline
				Ongoing

Increase detection and enforcement of illicit discharges.
 	
High Priority
	• Create GIS database to track operational status of septic systems in Adams, Jay and Wells Counties.
	• Conduct dye testing to identify failing systems and illicit connections.
	• Require septic system contractors, inspectors, and haulers be certified.
	• Develop County wide Long Range Plan for IDDE actions
		• Local Resources
		  • Adams, Jay, and Wells County Health Departments
		  • Adams, Jay, and Wells County Commissioners
		  • Purdue Extension
		• Secure additional funds to develop and amend a watershed wide GIS database.
		• Moderate-High cost
			• Develop and adopt an ordinance requiring homeowners to document proof of septic system maintenance.
			• Provide necessary enforcement actions and authorities.
			• Certification procedures for contractors, haulers and inspectors approved by Indiana State Department of Health.
				• Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Upper Wabash River Watershed.
				• 50 residential septic system upgrades/replacements within 5 years.
				• Ordinance for septic maintenance in place.
				• Certification process in place.
				
				Anticipated Timeline
				2009

Secure funding or cost-share assistance to assist interested landowners with connecting to local wastewater treatment plants.
 	
High Priority
	• Work with Regional Sewer Districts to identify priority landowners.
	• Secure funds to provide support to landowners to connect to local wastewater treatment plants.
	• Develop and conduct an education and marketing campaign on the benefits of connecting to wastewater treatment plants.
		• Local Resources
		  • Adams, Jay, and Wells County Commissioners
		  • Regional Sewer District
		  • Adams, Jay, and Wells County Health Departments
		  • USDA RCAP
		• State Revolving Loan Funds.
		• High cost
			• Requirements of funder must be followed and necessary reports completed and submitted.	• Secure funding to assist interested landowners with connecting to local wastewater treatment plants and proper septic system abandonment procedures.
				
				Anticipated Timeline
				2011

Secure funding for landowners installing, repairing, or operating and maintaining residential septic systems.
 	
High Priority
	• Research and secure funds for addressing septic systems issues including sewer extensions and private WWTP.	• Local Resources
		  • Adams, Jay, and Wells County Health Departments.
		  • Purdue Extension
		  • USDA RCAP
		• High cost
			• Requirements of funder must be followed and necessary reports completed and submitted.	• Funding for septic improvements and maintenance secured.
				• Septic systems are being repaired/upgraded and/or increased amount of sewer connections where possible.

				Anticipated Timeline 2011

Improve pasture management techniques including rotational grazing, livestock exclusion fencing and/or alternative watering sources.
 	
Moderate Priority
	• Create educational materials for livestock producers about pasture management and limiting access to waterways.
	• Develop economic incentive for exclusion fence and provide alternative watering mechanisms.
		• Local Resources
		  • Adams, Jay, and Wells County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		• Federal incentive programs
		• Section 319 Grant
		• High cost
			NA	• Future water quality sampling indicates a reduction in *E.coli* and phosphorus concentrations in the Upper Wabash River Watershed.
				• Increase in participants in Federal Programs, such as exclusion fencing.
				
				Anticipated Timeline
				Ongoing

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6.0 MONITORING EFFECTIVENESS

Progress indicators are used to gauge the progress and success of the watershed planning effort. Indicators may be administrative, such as language added to an ordinance, or programmatic, indicating the total acreage added to a filter strip program. Assigning dates to progress indicators is an effective method to ensure that the implementation of the WMP remains on target. Thus, monitoring describes how the aforementioned indicators will be evaluated to determine the level of success reached toward achieving the goal. Monitoring progress can be general, or very specific, such as increasing the number of participants at quarterly meetings or through improvements observed in biological and/or chemical measurements. Maintaining a list of successful programs and policies as a result of this WMP will help keep the momentum of the planning effort moving forward.

Goal Monitoring

For each goal, it is suggested that progress toward meeting each indicator (reduction of pollutant loadings, reduction of social, physical, and economic damages associated with flooding, and changes in stakeholders awareness and behaviors) listed in Tables 5-1 through 5-5 be documented on a biannual basis by the UWRBC. Biannual tracking of progress for each milestone will help to maintain focus on goal objectives and progress, but also to troubleshoot issues where it is clear that tasks may need to be adjusted or modified in order to achieve the goal objective. Responsibility for implementing tasks will vary with agency initiatives, directives, staffing, and funding opportunities.

Plan Evaluation

The UWRBC will be responsible for the regular review and update of the Upper Wabash River Watershed Management Plan. This plan should be evaluated on a biannual basis to document and celebrate progress; assess effectiveness of efforts; modify activities to better target water quality issues; and keep implementation of the plan on schedule. The plan should be revised as needed to better meet the needs of the watershed stakeholders and to meet water quality goals.

Routine Monitoring

Every three years, monitoring of water quality, both biological and chemical, should occur at the sites utilized for the development of this plan. The data gathered through subsequent monitoring events will be utilized in order to evaluate the beneficial impact of implementation of BMPs throughout the watershed. It is anticipated that water quality will increase as loadings of sediment, nutrients and bacteria are decreased.

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