Eel River-Tick Creek Watershed Management Plan

Cass County, Indiana

September 13, 2005

The Eel River-Tick Creek watershed and its water bodies are clean, stable, and treasured resources, where improved water quality supports recreation, agriculture, land-drainage, aquatic life and potable water. These resources preserved and strengthened through Cass County resident's civic pride, knowledge and stewardship

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EEL RIVER-TICK CREEK WATERSHED MANAGEMENT PLAN
CASS COUNTY, INDIANA

EXECUTIVE SUMMARY

The Eel River-Tick Creek watershed encompasses approximately 9,011 acres immediately northeast of Logansport, Indiana and lies at the downstream end of the larger Eel River basin in Cass County, Indiana. The watershed contains four main streams, Laird Ditch, Tick Creek, Shackelford Ditch, and Howard Ditch, one river, the Eel River, and one private, manmade lake, Lake Perry. With funding from the U. S. Environmental Protection Agency through the Indiana Department of Environmental Management's Section 319 grant program the Lake Perry Estates Corporation (LPEC) and the Cass County Soil and Water Conservation District (SWCD) initiated the development of a watershed management plan in an effort to improve water quality in the lake and streams in the Eel River-Tick Creek watershed.

The LPEC and Cass County SWCD, along with their consultant, held several public meetings, reviewed available historical water quality data, and conducted current water quality sampling to identify water quality concerns in the Eel River-Tick Creek watershed. Through the use of public notices and targeted mailings, all property owners in the watershed as well as representatives from local, state, and federal natural resource agencies, not-for-profit organizations, and local governments were invited to attend the public meetings. Several common themes began to surface during the public meetings. The three concerns emerged as the top concerns of the watershed stakeholders: 1. the streams and lake did not support multiple uses such as water quality, biological habitat, and aesthetic value; 2. water from the Eel River-Tick Creek watershed flows into the Eel River, which is the water source for the City of Logansport; and 3. watershed stakeholders do not understand the actions they could take to protect water quality.

As a first step toward addressing their three top concerns, the watershed stakeholders agreed on the following vision statement. The watershed stakeholders will use this vision to guide management efforts in the Eel River-Tick Creek watershed.

The Eel River-Tick Creek watershed and its water bodies are clean, stable, and treasured resources, where improved water quality supports recreation, agriculture, land-drainage, aquatic life and potable water—resource preserved and strengthened through Cass County resident's civic pride, knowledge and stewardship

Watershed stakeholders, along with their consultant, also identified the stressors associated with their top concerns and the sources of these stressors. High nutrient and sediment loads reaching the streams and lake are the primary stressors driving the eutrophication of the waterbodies. The second stressor identified by watershed stakeholders was lack of knowledge by property owners living in and around the watershed. Pathogenic contamination, as evidenced by high *E. coli* concentrations, was the third stressor identified by watershed stakeholders.

To reduce the identified stressors in the Eel River-Tick Creek watershed and address to other concerns identified by watershed stakeholders, the stakeholders developed six goals and developed an action plan for each of the goals. The goals in order of priority as agreed upon by the watershed stakeholders are as follows:

Goal 1: We want to increase participation by all stakeholders including local natural resources agencies/representatives, possibly resulting in the formation of a watershed group.

Goal 2: Within two years, each land owner within the watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Goal 3: We want to reduce the sediment load to the waterbodies within the Eel River-Tick Creek watershed by 50% over the next five years.

Goal 4: We want to repair and maintain existing drainage tiles to ensure property owners have full use of their land.

Goal 5: We want to reduce the nutrient load reaching Lake Perry by 50% over the next 10 years.

Goal 6: We want to reduce the concentration of E. coli within the waterbodies in the Eel River-Tick Creek watershed so that water within the streams and lake meets the state standard for E. coli within 10 years.

Where feasible, the goals list specific targets watershed stakeholders wish to reach. Additionally, the plan identifies who will assist with completing the plan and indicates what measures will be used to identify successful achievement of the plan’s goals and objectives.

ACKNOWLEDGEMENTS

The Eel River-Tick Creek Watershed Management Plan was made possible with funding from the Indiana Department of Environmental Management (IDEM) through the Section 319 Program and the Lake Perry Estates Corporation. The Eel River-Tick Creek Watershed Management Plan was completed by JFNew and their subcontractor, Indiana University School of Public and Environmental Affairs. Contributors to this project included Pete Riggle with the Lake Perry Estates Corporation, Judy Buttice with the Cass County Soil and Water Conservation District; Ruth Montgomery with the Cass County Natural Resource Conservation Service; Chuck Bell, Stacey Sobat, and Todd Davis with the IDEM Assessment Section; and Ron Helmich with the Indiana Department of Natural Resources Division of Nature Preserves. Special thanks to the dedicated stakeholders for their insight into the Eel River-Tick Creek watershed and their attendance at multiple meetings. Also thanks to Pete Riggle with the Lake Perry Estates Corporation and Judy Buttice for their initiative and assistance in getting this study completed and to Stan Williams with the Cass County/Logansport Planning Commission for his input on the vision statement. Authors of this report included Sara Peel, Marianne Giolitto, Joe Exl, and John Richardson at JFNew.

DISTRIBUTION LIST

All individuals attending any of the watershed planning meetings were sent a copy of the draft Eel River-Tick Creek Watershed Management Plan. A copy of the plan was provided to the Logansport Public Library to allow for community members not receiving the plan to comment. Additionally, multiple electronic copies were provided to the two sponsoring organizations in the care of Judy Buttice with the Cass County SWCD and Pete Riggle with the Lake Perry Estates Corporation. Other individuals and local and state entities receiving copies of the draft Eel River-Tick Creek watershed management plan are listed below:

- Judy Buttice, Cass County SWCD
- Ruth Montgomery, Cass County NRCS
- Pete Riggle, Lake Perry Estates Corporation
- Stan Williams, City/County Plan Commission
- Cass County Health Department
- Cass County Drainage Board
- Indiana Department of Environmental Management
- Indiana Department of Natural Resources

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BMP	Best Management Practice
cfu	colony forming unit
CLP	Clean Lakes Program
DC	District Conservationist
EPA	Environmental Protection Agency
ETR	Endangered, Threatened, or Rare
F	Farenheit
GIS	Geographic Information System
HES	Highly Erodible Land
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
ICLVMP	Indiana Clean Lakes Volunteer Monitoring Program
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
LPEC	Lake Perry Estates Corporation
mIBI	macroinvertebrate Index of Integrity
msl	mean sea level
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWI	National Wetland Inventory
PHES	Potentially Highly Erodible Land
QAPP	Quality Assurance Project Plan
QHEI	Qualitative Habitat Evaluation Index
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWA	Unified Watershed Assessment
WRAS	Watershed Restoration Action Strategy

EEL RIVER-TICK CREEK WATERSHED MANAGEMENT PLAN
CASS COUNTY, INDIANA

1.0 INTRODUCTION

This watershed management plan addresses non-point source pollution and other water quality concerns facing the Eel River-Tick Creek watershed. The Eel River-Tick Creek watershed (HUC 05120104070060) encompasses approximately 9,011 acres immediately northeast of Logansport, Indiana (Figures 1 and 2) and lies at the downstream end of the larger Eel River basin (05120104; Figure 3). The watershed contains four main streams, Laird Ditch, Tick Creek, Shackelford Ditch, and Howard Ditch, one river, the Eel River, and one private, manmade lake, Lake Perry. This watershed management plan documents the concerns watershed stakeholders have for the Eel River-Tick Creek waterbodies and describes stakeholders' vision for these waterbodies. The plan outlines the goals, strategies, and action items watershed stakeholders have selected to achieve their vision. Finally, the plan includes methods for measuring stakeholders' progress towards achieving their vision and timeframes for periodic refinement of the plan.

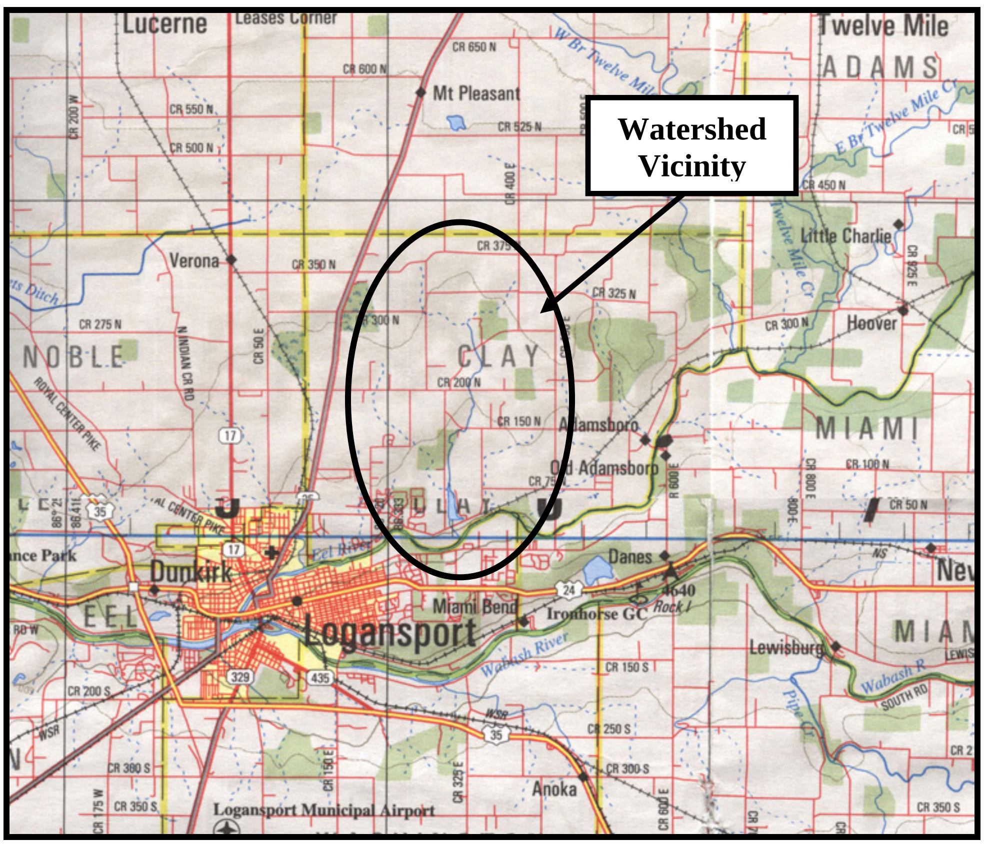

Figure 1. Eel River-Tick Creek watershed location map.
Source: DeLorme, 1998. Scale: 1"=approximately 2.5 miles.

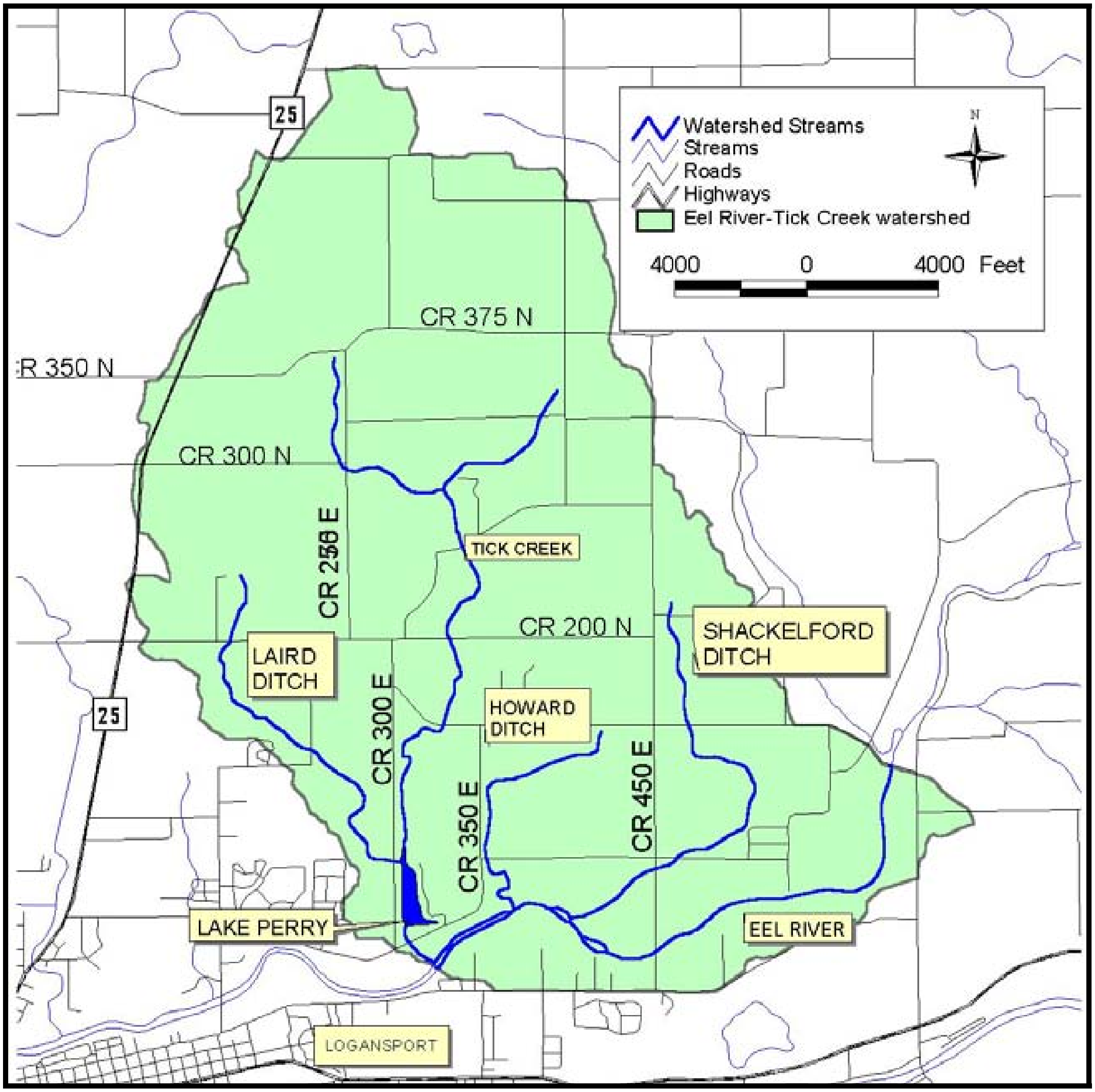

Figure 2. Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

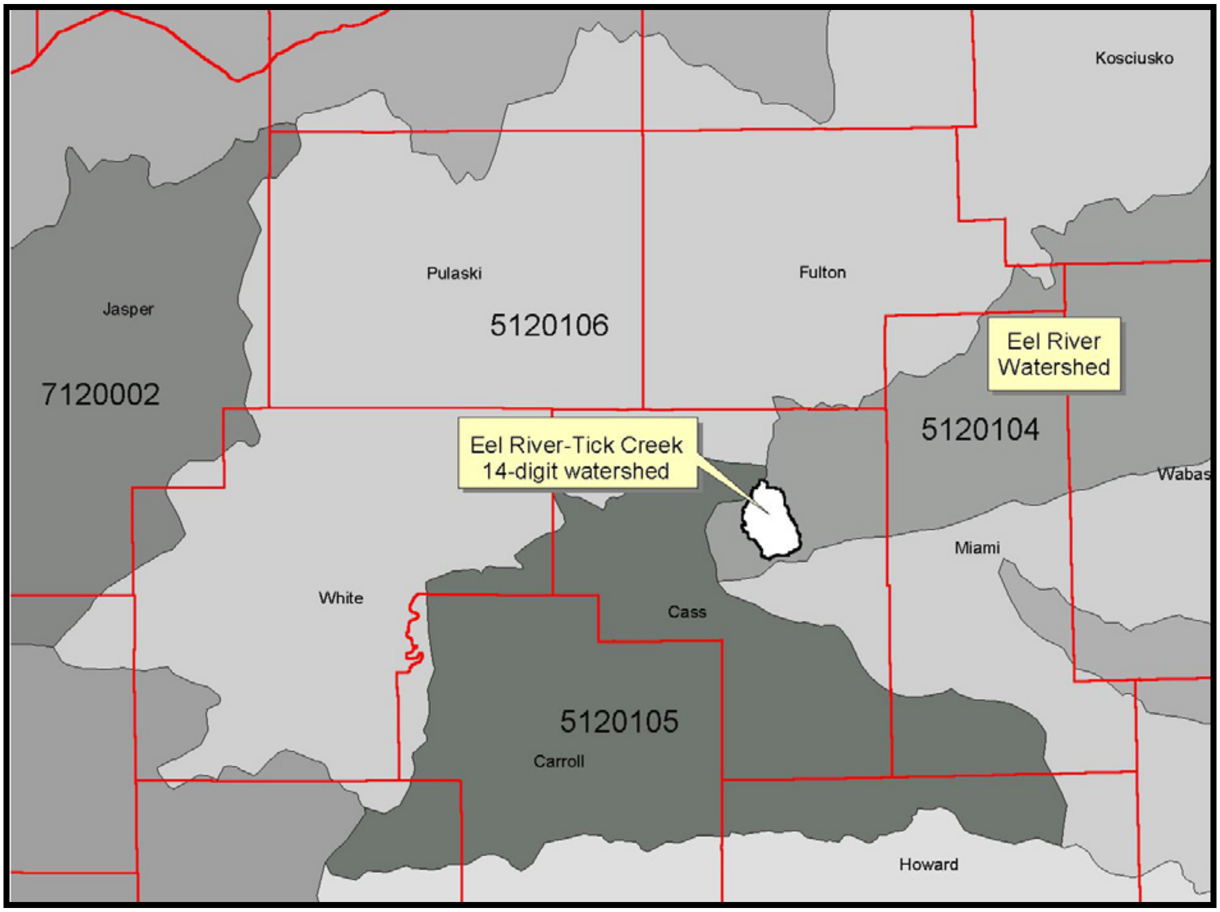

Figure 3. Eel River basin. Source: See Appendix A.

The Eel River-Tick Creek watershed management plan grew out of efforts by the Lake Perry Estates Corporation (LPEC), Natural Resources Conservation Service (NRCS), and an Indiana Department of Environmental Management (IDEM) regional watershed conservationist. In 1997, a small group of LPEC residents began to investigate some perceived problems in their lake (Steinberger and Wolf, 1997 correspondence to the LPEC Board of Directors). Maintenance concerns regarding the lake's outlet and sediment traps, poor water clarity, decreasing lake depth, poor sport fish community, and aquatic plant growth were among the perceived problems. The group's final report documented some of the perceived problems as unfounded or at least noted the lack of data necessary to verify the concern. The group confirmed other perceived problems such as a decrease in lake depth. Based on discussions with the engineer responsible for the lake's design and subsequent soundings of the lake bottom in 1997, the group estimated that the lake's maximum depth had decreased from 13 feet in the 1970s to 9.5 feet in 1997. The group recommended regular maintenance of the two sediment traps on the northern end of the lake and halting the aquatic plant treatment program.

In 1998, members of the LPEC asked the NRCS for assistance in determining sources of silt and sediment entering Lake Perry from the watershed. The NRCS District Conservationist (DC) completed an assessment of Lake Perry's watershed, which includes the area of land draining to Laird Ditch and the area of land draining to Tick Creek upstream of Lake Perry (Montgomery, unpublished). The District Conservationist found that many conservation practices were currently in use to reduce soil loss from the landscape. These included grassed waterways, wildlife and grassland set-asides, and conservation tillage methods. The DC also noted that in 1998 nearly 30% of Lake Perry's watershed was covered with land use types that limited erosion or helped control runoff. The DC concluded that siltation is a common problem for lakes with large watershed area to lake area ratios. (Lake Perry's watershed area to lake area ratio is approximately 245:1.) She recommended regular maintenance of Lake Perry's sediment traps and, if feasible, the construction of additional basins upstream of existing sediment traps.

In an effort to obtain more data on their lake's water clarity rather than relying on anecdotal evidence, the LPEC began monitoring Lake Perry's water clarity through the Indiana Clean Lakes Volunteer Monitoring Program (ICLVMP). From 2000 to 2003, water clarity, as measured with a Secchi disk, ranged from approximately 1.5 to 3.3 feet. The lake's average water clarity (1.8-2.3 feet) remained fairly stable over the four years. This relatively low average suggests water clarity in Lake Perry is poor, particularly when compared to other Indiana lakes. Of those lakes monitored through the ICLVMP, Lake Perry often rates among the lakes with poorest water clarity.

Under new leadership, the LPEC began working with a private consulting firm in 2002 to determine what steps they could take to address Lake Perry's poor water clarity. At the same time, the LPEC contacted IDEM's regional watershed conservationist for Cass County to enlist his services in building more effective partnerships with watershed landowners. Both the private consultant and the IDEM regional watershed conservationist encouraged the LPEC to develop a watershed management plan with input from the entire community since the process of the developing a plan is designed to help watershed stakeholders understand each stakeholder's concerns and find common ground in resolving these concerns. With this in mind, the LPEC and their partner, the Cass County Soil and Water Conservation District (SWCD), expanded the project scope to include the entirety of the Eel River-Tick Creek watershed and its four waterbodies, which all drain to the 303(d)-listed Eel River (*E. coli* and mercury). In 2004, the LPEC and SWCD successfully secured a Section 319 grant from the United States Environmental Protection Agency (EPA) through IDEM's Section 319 grant program to develop a watershed management plan.

Although efforts prior to the development of this watershed management plan focused primarily on the watershed draining to Lake Perry, the watershed management plan's geographical scope includes the entire 14-digit Eel River-Tick Creek watershed (05120104070060) not just the watershed draining to Lake Perry. This watershed includes four tributaries to and a portion of the Eel River mainstem, which is listed on Indiana's list of impaired waterbodies for pathogenic (*E. coli*) and mercury contamination. It was assumed during the grant application process that many of the same non-point source concerns facing stakeholders in the Lake Perry watershed were shared by stakeholders across the entire Eel River-Tick Creek watershed. Comments at the first several public meetings during the plan's development confirmed this assumption as many attendees expressed a concern for the water quality in the Eel River, which receives water from the Eel River-Tick Creek watershed. This is of specific concern since the City of Logansport obtains its drinking water from the Eel River and most watershed stakeholders will drink city water at some point in their lives, if not regularly.

1.1 Watershed Partnerships

The desire to build effective watershed partnerships to collectively address non-point source pollutions concerns facing the Eel River-Tick Creek watershed was one of the primary driving forces behind the LPEC's effort to initiate a watershed management plan. Because the Cass County SWCD works directly with many of the watershed's stakeholders, including many watershed landowners, forming a partnership with the SWCD was critical to linking the LPEC with other watershed stakeholders. The LPEC and the Cass County SWCD developed a partnership in which the Cass County SWCD served as the project's sponsor and the LPEC contributed the required matching funds for the project. The Cass County SWCD and LPEC contracted with JFNew, a private ecological consulting firm, to facilitate the planning process. JFNew also conducted water chemistry, biological, and habitat evaluations on each of the watershed's main waterbodies (Laird Ditch, Tick Creek, Shackelford Ditch, Howard Ditch, and Lake Perry) to provide additional data for guiding decision making during the planning process.

JFNew worked closely with the NRCS District Conservationist during the plan's development to understand the current condition of the watershed's landscape and existing conservation measures already in place. The local DC has invaluable information on the watershed in which he or she works, so working with this individual is particularly important during the land investigation portion of a watershed management plan's development. The NRCS District Conservationist toured the Eel River-Tick Creek watershed with a JFNew biologist. Additionally, both walked a portion of Laird Ditch to identify erosion concerns associated with the stream's banks.

The Cass County SWCD, LPEC, and JFNew developed a list of additional key stakeholders whose input would be important in the planning process. These stakeholders included Indiana Department of Natural Resources (IDNR) Division of Soil Conservation Resource Specialist, the Cass County 4-H, and the Cass County planner. A local developer and contractor were added to the list since residential development and its impacts with respect to water quality were noted as a concern during on of the first public meetings. Several individuals who own or operate agricultural land in the watershed were also included on the list to ensure representation of the agricultural community. All individuals on the list were sent a letter requesting their participation in the planning process. Regardless of their attendance at meetings, these individuals continued to receive outreach materials, including draft plans when available, for their review and comment.

1.2 Public Participation

The Eel River-Tick Creek watershed stakeholders and the public community at large drove the development of this watershed management plan. Early in the planning process, watershed stakeholders noted the connection between the Eel River-Tick Creek watershed and the drinking water for the City of Logansport. While recognizing that water from the Eel River-Tick Creek watershed comprises only a small portion of the river volume from which the city draws its drinking water, stakeholders felt that what they did in their watershed could affect the city's drinking water quality. Thus, stakeholders acknowledged the very public nature of their planning effort to improve water quality in the Eel River-Tick Creek watershed.

Public participation in the planning effort was encouraged through a series of quarterly public meetings. Outreach materials were developed to advertise the public meetings. Public meeting notices were published in the local paper prior to meetings. Additionally, meeting notices were provided to two local radio stations to announce meeting time and location. Flyers announcing the meetings were posted in conspicuous places around the community including at the SWCD office and the public library. Meeting announcements were mailed to all individuals on the key stakeholder list as well as those individuals who had attended previous project meetings. To further encourage public involvement, meetings were held in public spaces. The first meeting was held at the SWCD office, and subsequent meetings were held in the Logansport public library.

1.3 Concerns

During the beginning phases of the plan's development, the Eel River-Tick Creek watershed stakeholders identified several water quality related concerns in their watershed. Public meetings were the primary avenue for collecting concerns from stakeholders, although the project sponsor and facilitating consultant encouraged stakeholders to contact them with any concerns that stakeholders thought of outside of the meetings. The stakeholders' concerns broadly fit into various categories and are listed below. The order of the concerns listed below does not reflect any prioritization by the stakeholders.

Land Use

Watershed stakeholders had various concerns regarding how the land in the watershed was used in the past, is currently used, and may be used in the future.

- Stakeholders expressed a concern regarding the transition of land from old field land use to active agricultural land use and how that might affect soil erosion in those areas.
- Watershed stakeholders expressed a concern regarding an old dump in the watershed and how any runoff from the dump may be affecting water quality.
- Stakeholders noted there was a delay or time lag between site grading on the recently constructed recreational fields and establishment of grass on the fields. They expressed a concern over runoff from freshly graded areas.
- Stakeholders were concerned about site development techniques that involve grading an entire site for development rather than using a phased approach to minimize the amount of bare ground at any one time.
- Watershed stakeholders expressed concern over the effects of ditch cleaning on water quality and the adjacent habitat.

Flooding/Loss of Property

- Watershed stakeholders felt that silt and sediment clogging Howard and Shackelford Ditches was increasing flooding of land, rendering it unusable. The area near the intersection of County Road 450 East and County Road 150 North was noted as a particularly bad area.
- Stakeholders were concerned over the apparent disrepair of drainage tiles in some areas and how that can increase flooding and loss of property.
- Stakeholders questioned whether an open ditch would be better than tiles to prevent flooding and loss of property.

Education

- Watershed stakeholders generally agreed that there was a need for education among property owners and other stakeholders regarding water quality, techniques and land management to improve water quality, and who is already using such techniques to improve water quality.
- Watershed stakeholders indicated that there was a need to increase participation in the watershed planning process so that implementation efforts would be widespread.

Recreation

- Watershed stakeholders expressed a concern over the loss of recreational opportunities (swimming and aesthetic) due to poor water clarity from silt, particularly in Lake Perry.
- Stakeholders expressed concern over the loss of depth and consequently recreational opportunities resulting from sediment accumulation in Lake Perry. Stakeholders wondered about the natural age span of Lake Perry and what the natural rate of sedimentation is given the topography of the lake's drainage area.
- Stakeholders expressed a concern over the increase in rooted plants and algae in Lake Perry and how that is limiting swimming and boating opportunities on the lake. A stakeholder noted that the rooted plants now reach the top of the water column and suggested that it may be due to a loss in lake depth.

Health

- Watershed stakeholders expressed a desire for clean drinking water in the City of Logansport. (The City of Logansport receives it drinking water from the Eel River. Water from the Eel River-Tick Creek watershed drains to the Eel River immediately upstream of the city's drinking water intake.) Watershed stakeholders noted that while watershed property owners maintained individual wells for drinking water, nearly all stakeholders drank city water at some point in their lives. People who work, shop, dine, worship, and/or recreate in the city likely drink city water on a regular basis.
- Stakeholders expressed health and safety concerns over potential pollutants associated with the silt reaching Lake Perry. A stakeholder felt that more people used to swim in Lake Perry than now and wondered if concern for swimmers' health was preventing people from swimming in the lake.
- Stakeholders expressed concerns over bacteria (*E. coli*) concentrations that exceeded the state standard and how that could affect the health of those living near waterbodies with high levels of bacteria.

Social

- Stakeholders expressed a desire to work with the county surveyor to ensure that ditch cleaning is done in a manner that is environmentally and economically justifiable.
- Stakeholders expressed a concern that Howard and Shackelford Ditches did not appear to be maintained regularly. There was a question over whether the ditch assessment fee was appearing on the property owners' taxes.
- Stakeholders felt there was a lack of cooperation among local agencies that address water resource issues.
- A stakeholder expressed a need for individuals to respect each other's property.

1.4 Vision for the Future

As the Eel River-Tick Creek watershed stakeholders listed concerns over the current state of water quality in their watershed, they concurrently described their vision for the streams and lake in the future. Several common themes began to surface during the public meetings. Nearly all stakeholders envisioned clean streams and lake that supported multiple uses. Stakeholders unanimously voiced support for a future in which the City of Logansport drinking water was clean and safe to consume. Stakeholders also envisioned a future where more individuals have a better understanding of actions they could take to protect water quality. The Eel River-Tick Creek watershed stakeholders summarized these themes in one overarching vision for the watershed:

The Eel River-Tick Creek watershed and its water bodies are clean, stable, and treasured resources, where improved water quality supports recreation, agriculture, land-drainage, aquatic life and potable water. These resources preserved and strengthened through Cass County resident's civic pride, knowledge and stewardship.

This vision serves as the foundation of the Eel River-Tick Creek watershed management plan. Watershed stakeholders selected and recorded in this document the goals and strategies that, over time, enable them to make this vision a reality.

2.0 THE EEL RIVER-TICK CREEK WATERSHED

2.1 Watershed Location

The Eel River-Tick Creek watershed encompasses approximately 9,011 acres immediately northeast of Logansport, Indiana (Figure 1). Specifically, the watershed is located in Bethlehem, Clay, and Eel Townships in Section 29 and 32-34 of Township 28 North, Range 2 East and Sections 3-11, 14-18, and 20-23 of Township 27 North, Range 2 East. The Eel River-Tick Creek watershed includes four perennial streams, Laird Ditch, Tick Creek, Shackelford Ditch, and Howard Ditch, and one private lake, Lake Perry (Figure 2). Laird Ditch and Tick Creek are tributaries to Lake Perry and cover the western portion of the watershed. The Laird Ditch subwatershed forms the western and southwestern boundaries of the watershed covering 973 acres. The Tick Creek subwatershed, including Lake Perry, drains approximately 4,660 acres. Water exits Lake Perry through Tick Creek and flows into the Eel River. The two remaining streams, Shackelford and Howard Ditches, are direct tributaries to the Eel River. Howard Ditch drains 860 acres, while the Shackelford Ditch subwatershed covers 1407 acres (Figure 4). The remaining 1,262 acres drain directly to the Eel River. Water flows from the Eel River into the Wabash River in Logansport and, ultimately, reaches the Ohio River in southern Illinois.

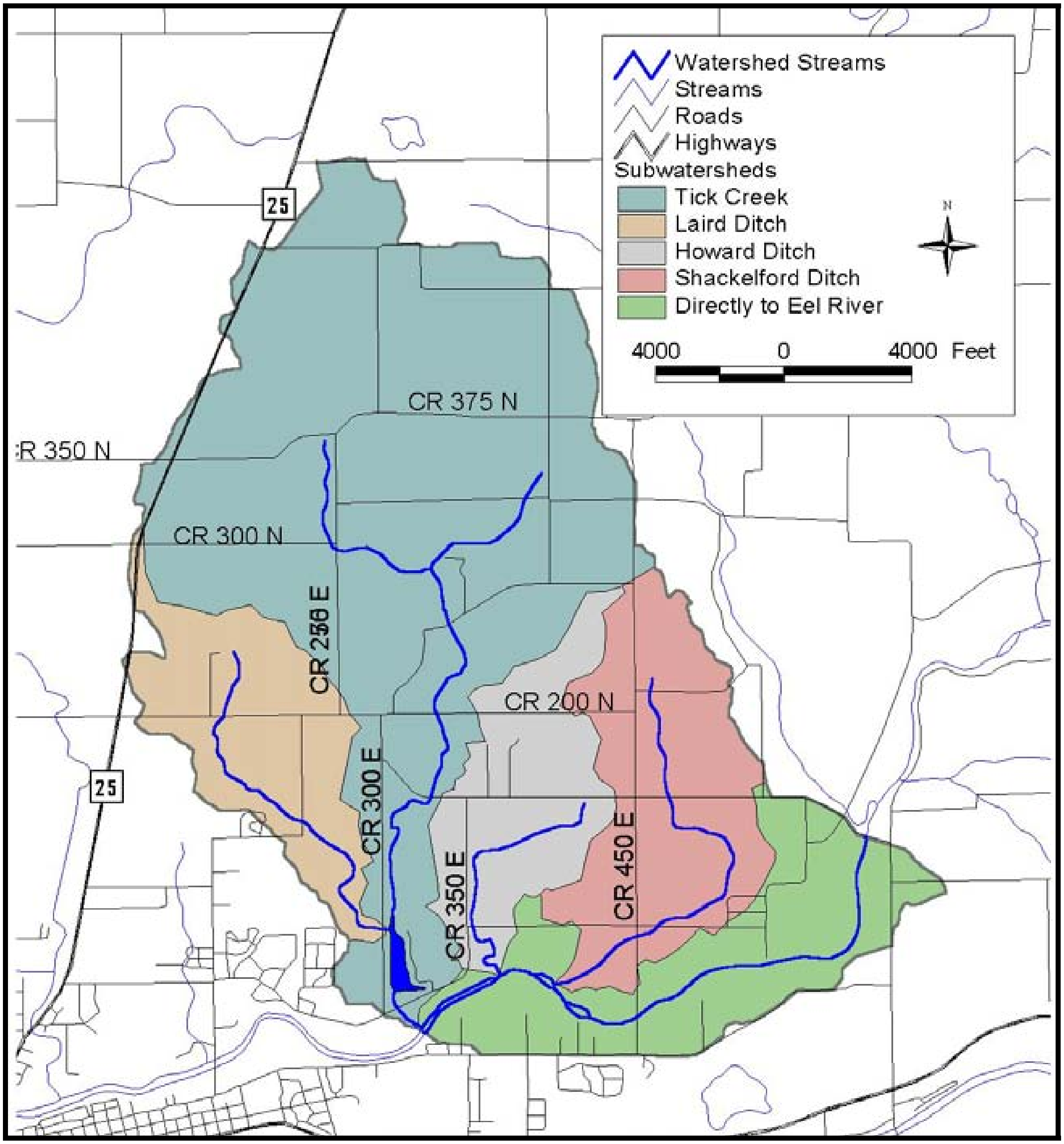

Figure 4. Subwatersheds of the Eel River-Tick Creek watershed.
Source: See Appendix A. Scale: 1"=4,000'.

2.2 <u>Climate</u>

As a whole, Cass County experiences cold winter months and warm summer months. In winter, the average temperature in Cass County is approximately 29° F. In summer, the average temperature is approximately 73° F. The record low is -25° F recorded on January 28, 1963, and the record high is 107° F recorded on July 14, 1954. Winter precipitation in Cass County is usually sufficient to minimize drought conditions for most soils during the summer months with annual snowfalls averaging nearly 21 inches. Approximately 60% of the total annual precipitation occurs between April and September, which corresponds to the growing season of most crops (Douglas, 1981). The average annual precipitation for Cass County is 38.48 inches (Table 1). In 2004, approximately 43.82 inches of precipitation was recorded in Logansport, Indiana. Rainfall during 2004 was approximately 5.5 inches more than the annual average. This was the primarily the result of a wetter than average summer (May through August).

Table 1. Monthly rainfall data (in inches) for 2004 compared to average monthly rainfall data (in inches) from 1971-2000 as recorded in Logansport, Indiana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	2.07	0.55	3.45	0.93	7.25	5.80	5.35	6.71	0.50	3.29	5.21	2.71	43.82
Average	2.10	1.82	2.81	3.39	4.03	4.33	3.92	3.92	3.53	2.82	3.08	2.73	38.48

Source: Purdue Applied Meteorology Group, 2004.

2.3 Geology and Topography

The repeated advance and retreat of glaciers in the last ice age shaped much of the landscape observed in Indiana today. Rather than blanketing the state as a single mass of ice from the north, distinct glacial lobes moved across the northern two thirds of the state on slightly different trajectories. At least three glacial lobes, the Lake Michigan Lobe, the Saginaw Lobe, and the Huron-Erie Lobe influenced the surficial geology in the northern two thirds of the state (Camp and Richardson, 1999). The Lake Michigan Lobe entered Indiana from the state's northwestern corner and moved southward along the Indiana-Illinois state line. The Saginaw Lobe entered the northeast corner of the state from southeastern Michigan and followed a southwesterly trajectory. The Huron-Erie Lobe entered Indiana from the east and pushed eastward and southward. These three lobes did not all move at the same time but rather through a series of staggered advances and retreats. The result is a mixture and layering of till, outwash, and drift materials across the northern two thirds of the Indiana.

The Eel River-Tick Creek watershed lies very near a junction point in Indiana surficial geology, suggesting each of the three glacial lobes mentioned above may have influenced the watershed's landscape. Fragments of the Packerton Moraine, one of the prominent end moraines left by the Saginaw Lobe extend into northeastern Cass County, just northeast of the Eel River-Tick Creek watershed (Hill, 1981). The Fair Oaks Dune Plain, which consists of wind blown outwash material from the Kankakee Outwash region, lies immediately to the west of the Eel River-Tick Creek watershed. The Kankakee Outwash and, consequently, the Fair Oaks Dune Plain were influenced by the activity of the Lake Michigan glacial lobe. The proximity of drift material from both the Saginaw and Lake Michigan Lobes to the Eel River-Tick Creek watershed suggests that such drift material may exist on the watershed's landscape as well.

Any influence of the Lake Michigan or Saginaw Lobes on the Eel River-Tick Creek watershed was, however, minor compared to the influence of the Huron-Erie Lobe. Till deposits left by the Huron-Erie Lobe cover much of the watershed (Hill, 1981; Gray, 1989). These till deposits consist primarily of sand and silt, giving the till a loamy to sandy loam texture (Hill, 1981; Gray, 1989). Two abandoned sand mines exist in the Eel River-Tick Creek watershed, confirming the prominence of sand in the glacial till (Hasenmueller, 2001). The depth of the glacial till ranges from less than 100 feet in the southern part of the watershed to close to 350 feet in the northern part of the watershed (Hill, 1981; Gray, 1983).

In addition to the ground-moraine till covering the Eel River-Tick Creek watershed's landscape, Hill (1981) maps four other groups of unconsolidated glacial materials in the watershed. In the southern portion of the watershed, valley train outwash materials (primarily sand and gravel) mark the floodplain of a glacial meltwater stream. These valley train outwash materials border the modern day Eel River. Alluvium deposits (sand, gravel and silt) line the riverbeds of Eel River and Tick Creek. A narrow band of wind blown sand dune deposits from western Cass County extends into the west central portion of the Eel River-Tick Creek watershed. Finally, Hill (1981) locates a muck deposit north of Tick Creek's headwaters.

This somewhat complex surficial geology covers a less complex bedrock foundation. Dolomite and limestone lies under the entire Eel River-Tick Creek watershed (Hill, 1981). This bedrock is from the Silurian Period (Gutschick, 1966; Gray et al., 1987; Hill, 1981).

The ground moraine left by the Huron-Erie Lobe created a gently rolling to nearly level topography across much of the watershed. Elevations north of County Road 375 North generally range from 760 feet above mean sea level (msl) to 790 feet msl. The landscape east of County Road 275 East between County Road 350 North and County Road 200 North also exhibit a gently rolling to nearly level topography. Elevations in this area generally range from 730 to 750 feet msl. Valley train deposits left in the southeastern portion of the watershed, primarily the Howard and Shackelford Ditch subwatersheds, suggest this area may have been at least part of a nearly level floodplain of a glacial meltwater stream. Elevations in the Howard and Shackelford Ditch subwatersheds generally range from 650 to 680 feet msl, with most of the area ranging between 670 and 680 feet msl.

The steepest topography in the Eel River-Tick Creek watershed lies along Tick Creek and Laird Ditch, particularly south of County Road 200 North. The steepest areas have grades of approximately 10%. These steep grades exist along both creeks near County Road 300 East.

The change in elevation along County Road 300 East illustrates the difference in topographic gradient between the northern and southern halves of the Eel River-Tick Creek watershed. From the intersection of County Road 300 East and County Road 200 North to the point where Laird Ditch crosses County Road 300 East and empties into Lake Perry (approximately 1.25 miles), the elevation drops approximately 100 feet. In contrast, from the intersection of County Road 300 East and County Road 200 North to the intersection of County Road 300 East and County Road 375 North (approximately 1.75 miles), the elevation rises only approximately 30 feet.

It is important to note that although the land adjacent to Tick Creek exhibits some of the steepest gradients in the watershed, Tick Creek itself does not possess the steepest gradient of the watershed streams. Over the course of the entire stream, Tick Creek drops approximately 30 feet per mile of stream. This is actually the lowest gradient of all the watershed streams. The gradient of Tick Creek north of County Road 200 North is less (27 feet per mile) than it is south of County Road 200 North (33 feet per mile). Laird Ditch possessed the steepest gradient dropping 41 feet per mile of stream. Howard and Shackelford Ditches drop 39 feet and 33 feet per mile of stream, respectively. Most of their gradient changes occur near their confluences with the Eel River.

2.4 Soils

The Eel River-Tick Creek watershed's geologic history described in the previous sections determined the soil types found in the watershed and is reflected in the major soil associations that cover the Eel River-Tick Creek watershed (Figure 5). The soil types found in the Eel River-Tick Creek watershed are a product of the original parent material deposited by the glaciers in this area 12,000 to 15,000 years ago. The main parent materials found in the watershed are glacial outwash and till, alluvium, and organic materials that were left as the glaciers receded. The interaction of these parent materials with the physical, chemical, and biological variables found in the area (climate, plant and animal life, time, landscape relief, and the physical and mineralogical composition of the parent material) formed the soils found in the Eel River-Tick Creek watershed today.

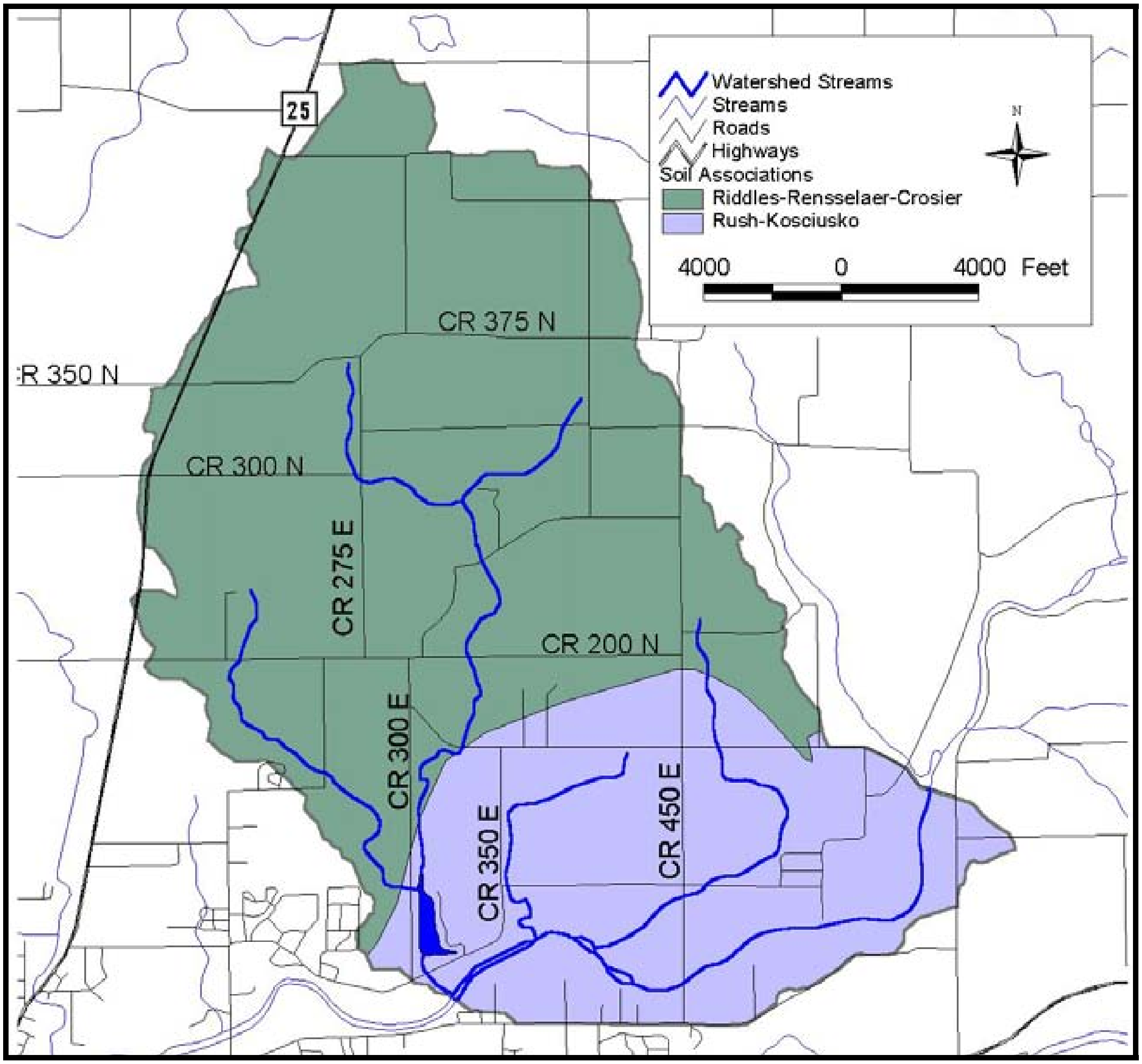

Figure 5. The major soil associations covering the Eel River-Tick Creek watershed.
Source: See Appendix A. Scale: 1"=4,000'.

Before detailing the major soil associations covering the Eel River-Tick Creek watershed, it may be useful to examine the concept of soil associations. Major soil associations are determined at the county level. Soil scientists review the soils, relief, and drainage patterns on the county landscape to identify distinct proportional groupings of soil units. The review process typically results in the identification of 8 to 15 distinct patterns of soil units. These patterns are the major soil associations of the county. Each soil association typically consists of two or three soil units that dominate the area covered by the soil association and several soil units (minor soils) that occupy only a small portion of the soil association's landscape. Soil associations are named for their dominant components. For example, the Rush-Kosciusko soil association consist primarily of Rush silt loam and Kosciusko silt loam. The following paragraphs provide more detailed information on each of the major soil association covering the Eel River-Tick Creek watershed. The discussion relies heavily on Douglas (1981) and readers should refer to that text for more information.

Douglas (1981) maps two soil associations in the Eel River-Tick Creek watershed: the Riddles-Rensselaer-Crosier soil association and the Rush-Kosciusko association (Figure 5). The Riddles-Rensselaer-Crosier soil association covers a majority of the Eel River-Tick Creek watershed including most of the Laird Ditch and Tick Creek subwatersheds and the headwaters of the Shackelford Ditch subwatershed. Soils in this association developed from glacial till parent materials. In general, Riddles soils account for 28% of the total soil association; Rensselaer soils account for 23%, while Crosier soils comprise 16% of the soil association. Riddles soils occupy side slopes along natural stream channels and on low rises. Within the Eel River-Tick Creek watershed, Riddles soils dominate the land adjacent to Laird Ditch and Tick Creek south of County Road 200 North. Rensselaer and Crosier soils are typically found in flat, low-lying or depressional areas. Rensselaer and Crosier soils are found scattered throughout the watershed north of County Road 200 North. Minor soil units in this association are also found in a variety of topographic locations. Miami soils are typically found in steep, eroded areas and Metea and Wawasee soils are typically located along ridge tops, while Houghton and Ackerman soils are typically found in poorly drained, depressional areas. Cultivated crops, such as corn, soybeans, small grains, and hay, thrive on soils of the Riddles-Rensselaer-Crosier association. Erosion, ponding, and wetness can limit use of these soils for both cultivation and urban development.

As the underlying geology of the Eel River-Tick Creek watershed transitions from the ground moraine covering most of the northern and western portion of the watershed to the outwash plain covering the southeast portion of the watershed, the watershed's soil units transition from soil units formed out of till parent material to soil units formed from glacial outwash. Consistent with this geologic shift, the soil association covering the Eel River-Tick Creek watershed shifts from the Riddles-Rensselaer-Crosier soil association in the northern and western portions of the watershed to the Rush-Kosciusko soil association in the southeastern portion of the watershed. Soils in the Rush-Kosciusko soil association developed from outwash parent material. Rush soils account for 33% of the association; Kosciusko soils comprise 18% of the association, while minor soil components account for the remaining 49% of the association. Rush soils occur on the top of high river terraces and along the sides of these terraces facing away from the river. Within the Eel River-Tick Creek watershed, Rush soils cover large areas around Howard and Shackelford Ditches. Kosciusko soils are found along small hills and on side slopes. Minor soils associated with this soil unit include Bloomfield loamy fine sand, Gessie Variant silt loam, Stonelick loamy fine sand, Sleeth silt loam, Shoals silty clay loam, and Gilford loam, gravelly substratum soils. Many of these minor soil units line the drainageways holding Howard and Shackelford Ditches. Douglas (1981) classifies soils in the Rush-Kosciusko association as generally well suited for agricultural production; however, erosion may limit productivity.

Soils in the watershed, in particular their ability to erode or sustain certain land use practices, can impact the water quality of lakes and streams in the watershed. The dominance of Riddles and Rush soils throughout the Eel River-Tick Creek watershed suggests that much of the watershed is prone to erosion; common erosion control methods should be implemented when the land is used for agriculture or during residential development to protect waterbodies in the Eel River-Tick Creek watershed. Similarly, several soil units within the Eel River-Tick Creek watershed are severely limited in their ability to serve as septic system leach fields. This needs to be considered as areas of the watershed are converted from agricultural use to residential use. More detailed discussions of highly erodible soils and soils used to treat septic tank effluent in the Eel River-Tick Creek watershed follow below.

2.4.1 Highly Erodible Soils

Soils that erode from the landscape are transported to waterways where they degrade water quality, interfere with recreational uses, and impair aquatic habitat and biotic health. In addition, such soils carry attached nutrients, which further impair water quality by increasing plant production and algal growth. Soil-associated chemicals, like herbicides and pesticides, can kill aquatic life and damage water quality.

Highly erodible and potentially highly erodible are classifications used by the NRCS to describe the potential of certain soil units to erode from the landscape. The NRCS examines common soil characteristics such as slope and soil texture when classifying soils. The NRCS maintains a list of highly erodible soil units for each county. Table 2 lists the soil units in the Eel River-Tick Creek watershed that the NRCS considers to be highly erodible. Figure 6 displays the locations of highly erodible and potentially highly erodible soils in the watershed.

Highly erodible and potentially highly erodible soil units cover much of the Eel River-Tick Creek watershed. The Cass County Soil Survey (Douglas, 1981) shows that that majority of the potentially highly erodible soils lie within the Tick Creek and Laird Ditch subwatersheds, along the lower portion of the Howard Ditch subwatershed, and in the Shackelford Ditch headwaters. Of the potentially highly erodible soils present within the watershed, Metea loamy fine sand (MkC), Rush silt loam (RtB), Riddles silt loam (RsB-RsC), and Wawasee sandy loam (WeB) soils are particularly dominant. Highly erodible soils are also present within the Eel River-Tick Creek watershed. The majority of the areas mapped as highly erodible soils are located along the State Road 25 corridor north and south of County Road 300 North, in the Tick Creek subwatershed east of County Road 275 East between County Road 200 North and County Road 325 North, and along the southeastern boundary of the watershed directly adjacent to the Eel River. Three other small areas of highly erodible soils are located in the immediate vicinity of or adjacent to Lake Perry (Figure 6).

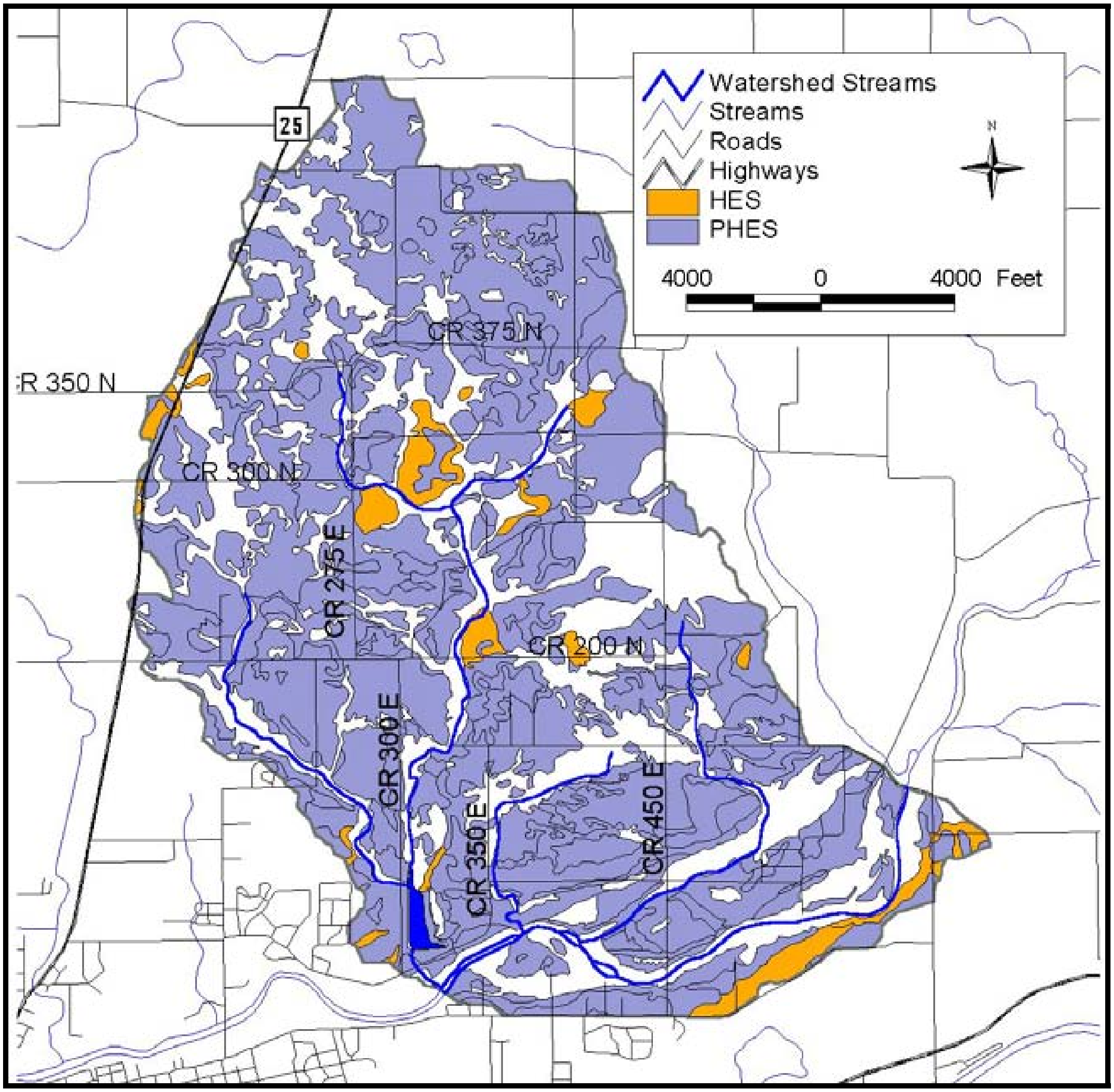

Figure 6. Highly erodible (orange) and potentially highly erodible (lavender) soils in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1”=4,000’.

Table 2. Highly erodible and potentially highly erodible soils units in the Eel River-Tick Creek watershed.

Soil Unit	Soil Name	Detail*	Soil Description
BmC	Bloomfield loamy fine sand	PHES	4 to 12 percent slopes
BnA	Blount silt loam	PHES	0 to 3 percent slopes
ChC	Chelsea loamy fine sand	PHES	4 to 12 percent slopes
GwB	Glynwood silt loam	PHES	2 to 6 percent slopes
HeE	Hennepin loam	HES	25 to 60 percent slopes
KoB	Kosciusko silt loam	PHES	2 to 6 percent slopes
KsC3	Kosciusko sandy clay loam	PHES	6 to 12 percent slopes, severely eroded
MkC	Metea loamy fine sand	PHES	3 to 10 percent slopes
MnB2-MnC2	Miami silt loam	PHES	2 to 12 percent slopes, eroded
MnD2	Miami silt loam	HES	12 to 18 percent slopes, eroded
MoC3	Miami clay loam	HES	6 to 14 percent slopes, severely eroded
MxC3	Morley clay loam	HES	6 to 12 percent slopes, severely eroded
NeB-NeC	NewGlarus silt loam	PHES	2 to 12 percent slopes
RsB-RsC	Riddles silt loam	PHES	2 to 12 percent slopes
RtB	Rush silt loam	PHES	2 to 6 percent slopes
RuB-RuC	Russell silt loam	PHES	2 to 6 percent slopes
WeB	Wawasee sandy loam	PHES	2 to 8 percent slopes

*PHES=Potentially Highly Erodible Soil; HES=Highly Erodible Soil
Source: Douglas, 1981; 1993 USDA/SCS Indiana Technical Guide II-C for Cass County.

2.4.2 Soils Used for Septic Tank Absorption Fields

As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment within the Eel River-Tick Creek watershed. This type of wastewater treatment system relies on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect surface and groundwater from contamination. The soil's ability to sequester and degrade pollutants in septic tank effluent (waste discharge) will ultimately determine how well surface and groundwater is being protected.

A variety of factors can affect a soil's ability to function as a septic absorption field. Seven soil characteristics are currently used to determine soil suitability for on-site sewage disposal systems: position in the landscape, slope, soil texture, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table (Thomas, 1996). The ability of soil to treat effluent depends on four factors: the amount of accessible soil particle surface area; the chemical properties of the surfaces; soil conditions like temperature, moisture, and oxygen content; and the type of pollutants present in the effluent (Cogger, 1989).

Many of the nutrients and pollutants of concern are removed safely if a septic system is sited correctly. Most soils have a large capacity to hold phosphate. On the other hand, nitrate (the end product of nitrogen metabolism in a properly functioning septic system) is very soluble in soil solution and is often leached to the groundwater. Care must be taken in siting the system to avoid well contamination. Nearly all organic matter in wastewater is biodegradable as long as oxygen is present. Pathogens can be both retained and inactivated within the soil as long as conditions are right. Bacteria and viruses are much smaller than other pathogenic organisms associated with wastewater; and therefore, have a much greater potential for movement through the soil. Clay minerals and other soil components may absorb them, but retention is not necessarily permanent. During storm flows, they may become resuspended in the soil solution and transported in the soil profile. Inactivation and destruction of pathogens occurs more rapidly in soils containing oxygen because sewage organisms compete poorly with the natural soil microorganisms, which are obligate aerobes requiring oxygen for life. Sewage organisms live longer under anaerobic conditions (without oxygen) and at lower soil temperatures because natural soil microbial activity is reduced.

The NRCS has ranked each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields in moderately or severely limited soils generally requires special design, planning, and/or maintenance to overcome the limitations and ensure proper function. Table 3 summarizes the soil series mapped in the Eel River-Tick Creek watershed in terms of their suitability for use as septic tank absorption fields. Figure 7 displays the location and extent of soils slightly, moderately, and severely limited for use as a septic tank absorption field.

Table 3. Soil types present in the Eel River-Tick Creek watershed and suitability for use as a septic tank absorption field.

Symbol	Name	High Water Table	Suitability for Septic Tank Absorption Field
Ad	Ackerman muck	+0.5-1.0 ft	Severe: ponding, poor filter
BmC	Bloomfield loamy fine sand	>6 ft	Severe: poor filter
ChC	Chelsea loamy fine sand	>6 ft	Severe: poor filter
CpA	Crosier loam	1-3 ft	Severe: wetness, percs slowly
Cy	Cyclone silt loam	+0.5-1.0 ft	Severe: ponding
Ge	Gessie Variant silt loam	>6 ft	Severe: floods, poor filter
Gf	Gilford sandy loam	+0.5-1.0 ft	Severe: ponding, poor filter
Gg	Gilford loam	+0.5-1.0 ft	Severe: ponding, poor filter
HeE	Hennepin loam	>6 ft	Severe: percs slowly, wetness
Hh	Houghton muck	+1-1.0 ft	Severe: ponding, percs slowly
KoB	Kosciusko silt loam	>6 ft	Severe: poor filter
KsC3	Kosciusko sandy clay loam	>6 ft	Severe: poor filter
MnD2	Miami silt loam	>6 ft	Severe: percs slowly, slope
MoC3	Miami clay loam	>6 ft	Severe: percs slowly
Ms	Millsdale silty clay loam	+1-1.0 ft	Severe: depth to rock, ponding, percs slowly
NeB	New Glarus	>6 ft	Severe: depth to rock, percs slowly
ObA	Oakville loamy fine sand	3-6 ft	Severe: wetness, poor filter
OsB	Ormas loamy fine sand	>6 ft	Slight
Po	Patton silty clay loam	+0.5-2.0 ft	Severe: ponding
Pp	Pits, gravel	--	--

Symbol	Name	High Water Table	Suitability for Septic Tank Absorption Field
Rn	Rensselaer loam	+0.5-1.0 ft	Severe: ponding, percs slowly
RsB-RsC	Riddles silt loam	>6 ft	Moderate: percs slowly, slope
RtA-RtB	Rush silt loam	>6 ft	Slight
Sh	Shoals silty clay loam	1.0-3.0 ft	Severe: floods, wetness
Sm	Sleeth silt loam	1.0-3.0 ft	Severe: wetness
St	Stonelick loamy fine sand	>6 ft	Severe: floods
WeB	Wawasee sandy loam	>6 ft	Slight

Source: Douglas, 1981.

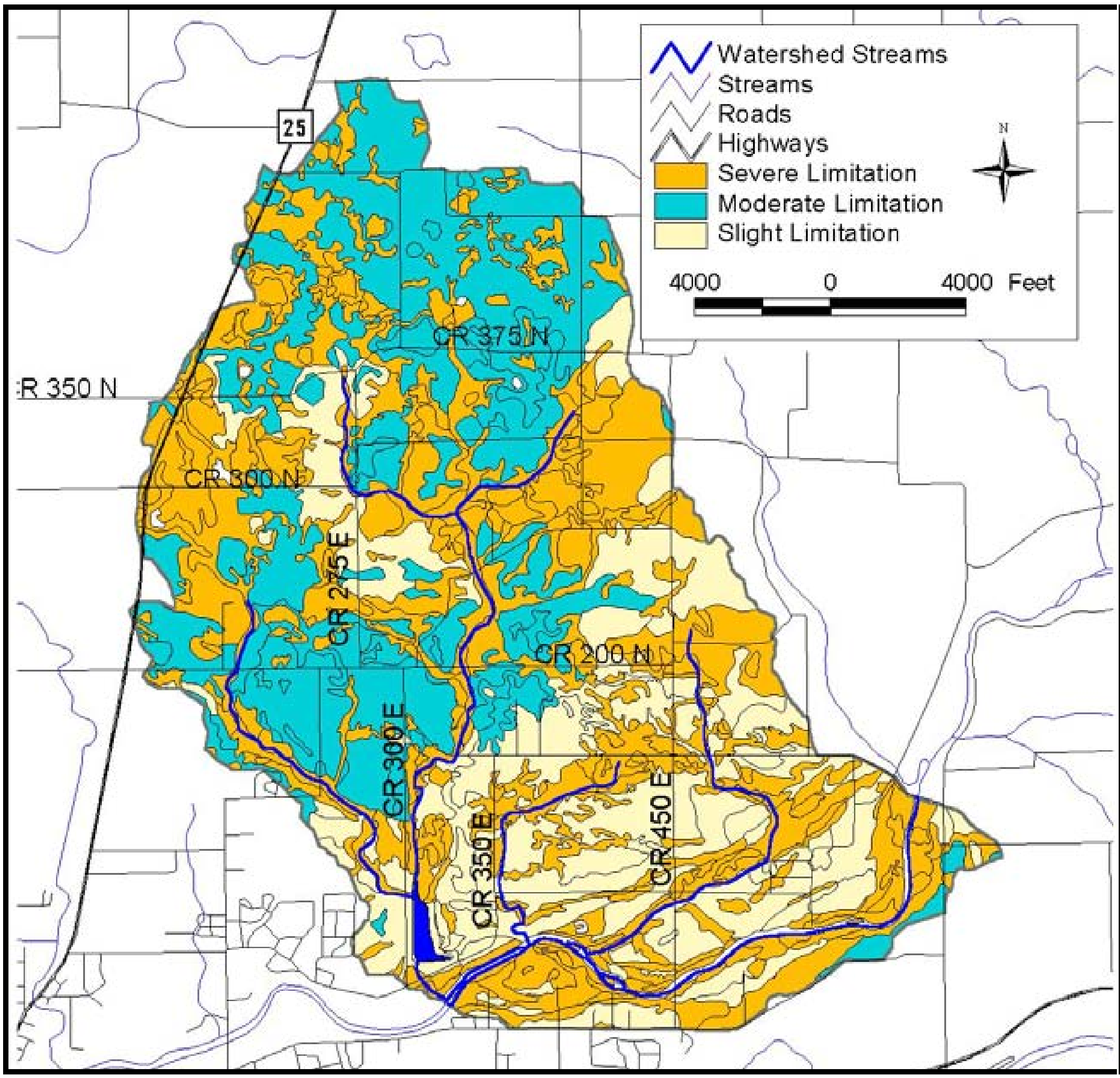

Figure 7. Soil septic field absorption suitability in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

2.5 Natural History

Geographic location, climate, geology, topography, soils, hydrology, and other factors play a role in shaping the native floral and faunal communities in a particular area. Various ecologists (Deam, 1921; Petty and Jackson, 1966; Homoya et al., 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geologic history, climate, topography, and soils. Because the groupings are based on factors that ultimately influence the type of vegetation present in an area, these natural areas or ecoregions tend to support characteristic native floral and faunal communities. Under many of these classification systems, the Eel River-Tick Creek watershed lies at or near the transition between two regions. For example, the northern portion of the watershed lies within Homoya's Northern Indiana Natural Lakes Area while the southern portion along the Eel River is part of the Bluffton Till Plain section of the Central Till Plain. Similarly, the watershed lies along the transition between the oak-hickory forest and the beech maple forest types in Lindsey et al.'s (1965) map of presettlement vegetation in Indiana. As a result, the native floral and faunal community of the Eel River-Tick Creek watershed likely consists of components of both natural areas.

Prior to European settlement, oak-hickory forest likely covered most of the Eel River-Tick Creek watershed, particularly in the northern, upland portion of the watershed. White oak was the dominant component of this forest with red oak, black oak, shagbark hickory, and bitternut hickory as subdominants (Petty and Jackson, 1966; Homoya et al., 1985). Petty and Jackson (1966) list pussy toes, common cinquefoil, wild licorice, tick clover, blue phlox, waterleaf, bloodroot, Joe-pye weed, woodland asters and goldenrods, wild geranium, and bellwort as common components of the forest under story in the watershed's region. In the southeastern portion of the watershed, the area that may represent the floodplain of a precursor to the Eel River, second bottom floodplain tree species may have dominated the plant coverage. Petty and Jackson describe a remnant, drier, second bottom floodplain near Logansport in their 1966 work. Hard maple (black and sugar) and beech dominate this remnant patch of forest, while American elm, hackberry, cork elm, Ohio buckeye, and slippery elm round out the community. It is likely that this may be similar to the native community in the southeast portion of the Eel River-Tick Creek watershed.

2.6 Endangered Species

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare (ETR) species, high quality natural communities, and natural areas in Indiana. The database was developed to assist in documenting the presence of special species and significant natural areas and to serve as a tool for setting management priorities in areas where special species or habitats exist. The database relies on observations from individuals rather than systematic field surveys by the Indiana Department of Natural Resources. Because of this, it does not document every occurrence of special species or habitat. At the same time, the listing of a species or natural area does not guarantee that the listed species is currently present or that the listed area is in pristine condition. The database includes the date that the species or special habitat was last observed in a specific location.

Appendix B presents the results from the database search for endangered, threatened, or rare species and high quality natural communities in the Eel River-Tick Creek watershed. (Appendix B also includes a listing of endangered, threatened, and rare species and high quality natural communities documented in Cass County for additional reference.) According to the database, the Eel River-Tick Creek watershed supports three ETR animals. The listed fish are the state endangered bluebreast darter, the state endangered greater redhorse, and the eastern sand darter, which is a state species of special concern. The listed animals were observed in the Eel River in Sections 14 and 20 of Township 27 North, Range 2 East. The two darter species were documented in 1941, while the greater redhorse was observed in 1992. No ETR species were documented elsewhere in the Eel River-Tick Creek watershed.

Cass County supports a variety of endangered, threatened, and rare animals and plants. The listed animals include fifteen aquatic species: ten freshwater mussels, including the state endangered Eastern fanshell pearlymussel, snuffbox, black sandshell, and rabbitsfoot, and five fish. One amphibian (the four-toed salamander) and two reptiles (the spotted turtle and the Eastern massasauga) are also listed. Two ETR birds, the great blue heron and the barn owl, have been noted in Cass County. Three mammals, the northern river otter, bobcat, and American badger, have also been identified in the county. More than thirty plant species, many of which are hydrophytic (wetland or aquatic species), are also included in the database for Cass County. The county also supports two high quality communities: mesic floodplain forest and cliff limestone.

2.7 Hydrology

As is characteristic of much of the glaciated portion of the state, hydrologic features including lakes, streams, wetlands, and ponds are important components of the Eel River-Tick Creek watershed's landscape. One lake, Lake Perry, lies within the Eel River-Tick Creek watershed. Lake Perry is a reservoir which was created in the 1970s by installing a water control structure within the Tick Creek channel (Pete Riggle, personal communication). The lake is approximately 20 acres in size and has a maximum depth of 20 feet. Three major inlets flow from the watershed into the Eel River. Tick Creek is the largest of these streams. Tick Creek has one main tributary, Laird Ditch, which enters Tick Creek from the west at Lake Perry. Laird Ditch forms the western boundary of the watershed. Tick Creek is approximately 26,257 feet in length (not including the length of Lake Perry), while Laird Ditch is approximately 12,413 feet in length. Portions of Laird Ditch and Tick Creek maintain some elements of their historic form; however, other portions have been impacted as land use changed in the watershed. Howard Ditch (8,869 feet) and Shackelford Ditch (14,463 feet) are located in the eastern portion of the watershed and flow directly to the Eel River. Both ditches were dug at least partly in historic wetland communities. The combined stream length of the four streams in the Eel River-Tick Creek watershed is approximately 62,000 feet. Additionally, nearly 5,714 feet of the Eel River are contained within the Eel River-Tick Creek watershed. Logansport's drinking water intake pipe is located downstream of the Eel River-Tick Creek watershed; therefore, all activities targeted at improving water quality within the Eel River-Tick Creek watershed should improve drinking water within the City of Logansport.

The United States Fish and Wildlife Service's (USFWS) National Wetland Inventory (NWI) Map (Figure 8) shows that wetlands cover approximately 446 acres or 5% of the Eel River-Tick Creek watershed. (Table 4 presents the acreage of wetlands by type according to the National Wetland Inventory.) Functioning wetlands filter sediments and nutrients in runoff, store water for future release, provide an opportunity for groundwater recharge or discharge, and serve as nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of the wetlands. As illustrated by Figure 8, wetland habitat is scattered throughout the watershed; however, several contiguous tracts of wetland habitat are located in the Laird Ditch and Tick Creek headwaters.

The Eel River-Tick Creek watershed has lost many of its wetlands. Figure 9 illustrates the extent of hydric soils in the watershed. Because hydric soils developed under wet conditions, they are a good indicator of the historical presence of wetlands. Comparing the total area covered by wetland (hydric) soils in the watershed to the area of existing wetland suggests that many of the wetlands in the Howard Ditch headwaters and along the mainstem of Shackelford Ditch have been converted to other land uses. Significant acreage in the northwest corner of the watershed has also been converted to other land uses.

Table 4. Acreage and classification of wetland habitat in the Eel River-Tick Creek watershed.

Wetland Type	Area (acres)	Percent of Watershed
Lacustrine	24.7	0.3%
Palustrine emergent	130.2	1.4%
Palustrine forested	120.5	1.3%
Palustrine scrub/shrub	54.2	0.6%
Palustrine submergent	0.5	0.0%
Ponds	22.7	0.3%
Riverine	92.9	1.0%
Total	**455.8**	**4.9%**

Source: USFWS National Wetland Inventory (NWI).

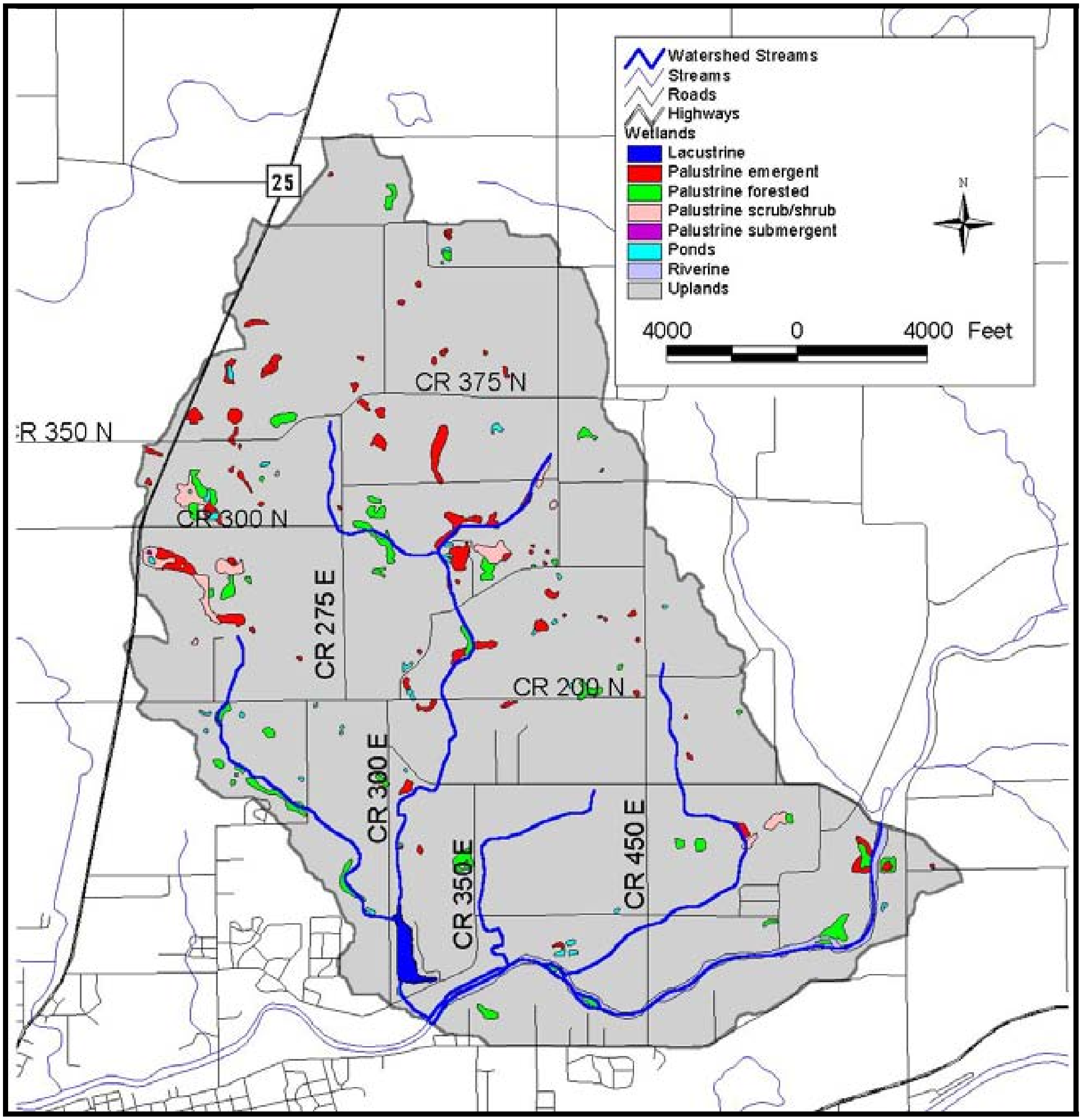

Figure 8. National wetland inventory map. Source: See Appendix A. Scale: 1"=4,000'.

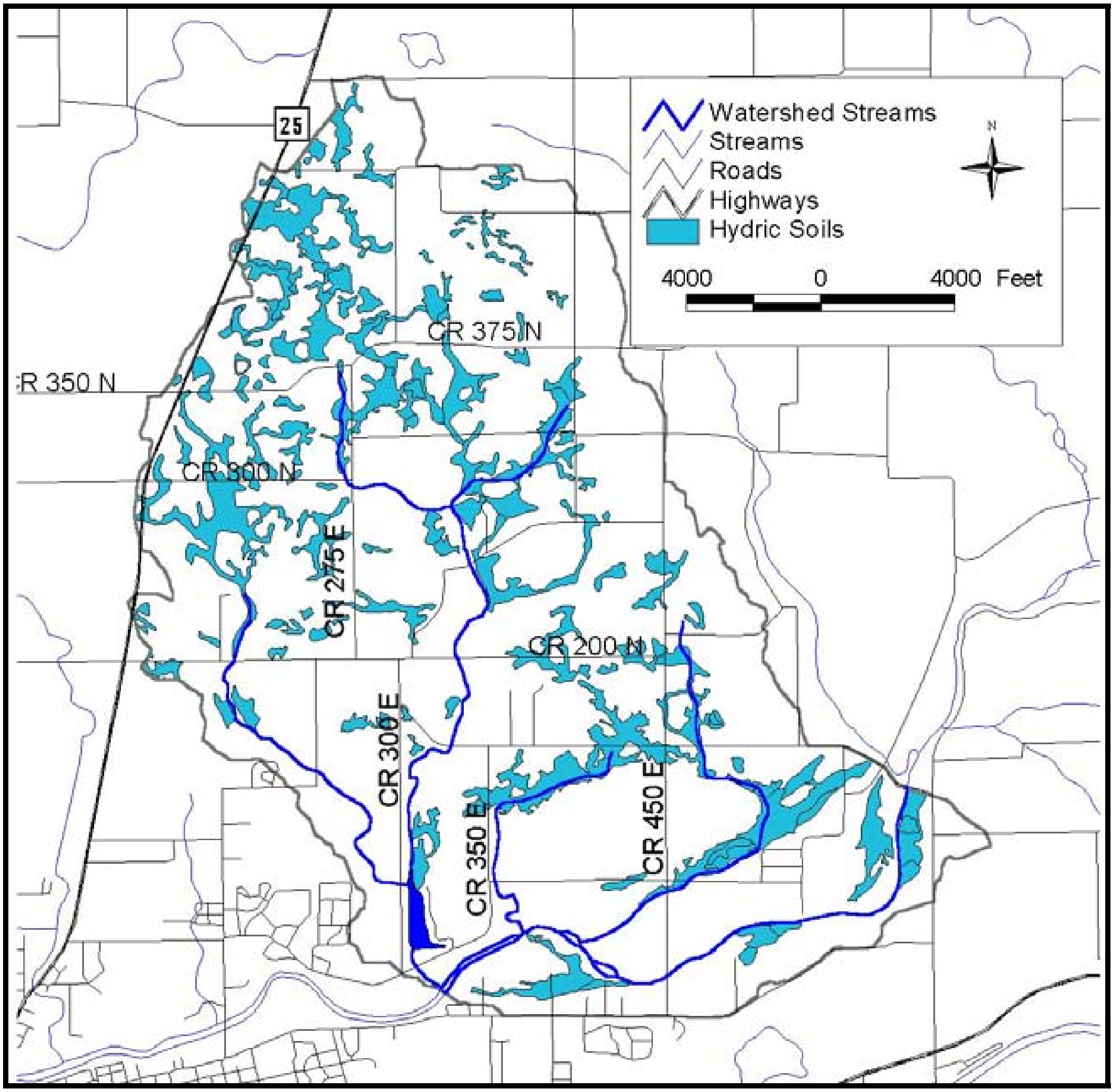

Figure 9. Hydric soils (blue) in the Eel River-Tick Creek watershed.

2.8 <u>Cultural Resources</u>

Prior to European settlement of Logansport and northern Cass County in 1826, the Eel River-Tick Creek watershed area was frequently visited by Native American tribes from other regions (Chamberlain, 1849). The Pottawatomie and Miami tribes called this area their home. Both tribes lived in this region year-around, frequently camping along the shores of the Eel and Wabash Rivers. Hunting, fishing, trapping, and gathering were a part of their culture; however, they also cultivated gardens for certain staple products. They sustainably harvested resources from the woods, wetlands, and prairies that dominated the land around them. Ultimately, as the pioneers entered the region, the majority of Pottawatomie and Miami tribes departed the region. By the mid-1830s, the tribes were relegated to their federally designated reservations in Kansas.

Logansport, the largest town in Cass County, was settled in the late 1820s. The first permanent settlers arrived in Cass County in 1826. These settlers built the first permanent structures and platted the city of Logansport in 1828 (Looker, 2004). Cass County was officially organized in 1829 (Chamberlain, 1849). Prior to being named Logansport, the Latin translation of "mouth of the Eel" and Logan were suggested. The town was eventually named after a Shawnee scout for the army, Logan, combined with "port" for the town's location along a navigable stream. In the late 1820's, General John Tipton, head of the Indian Agency at Fort Wayne, persuaded government officials in Washington D.C. to move the agency to Logansport. Subsequently, he played a major role in routing two heavily traveled thoroughfares through Cass County. Both the Michigan Road, which connected Madison, Indiana with Lake Michigan via Indianapolis, and the Wabash and Erie Canal, connecting Lake Erie in Toledo, Ohio with the Ohio River in Evansville, Indiana, established Cass County as an important hub for transportation (Looker, 2004). Automobile manufacturing, lumber production, and ultimately, the railroad, which operated a total of seven rail lines and employed over 4,000 people in the early 1920s, defined the town's location where it is today (State Legislature, 1938).

Settlers undoubtedly moved out from Logansport into the surrounding countryside soon after the city was platted. County commissioners established initial township boundaries early in 1829; however, these boundaries were revised many times. It was not until the 1840s that final township boundaries were determined (Historic Landmarks Foundation, 1984). Upon settling in the area, pioneers began altering the natural landscape. In an effort to cultivate the rich ground, forests were logged for their resources. Concurrently, prairies were cleared and plowed for cultivation and pastureland. Many of the streams were channelized and wetlands drained. Over time, wheat, small grain, hay, and corn production increased. In the early 1900s, nearly 95% of Cass County was farmed (Indiana Agricultural Statistics Service, 1999). Urbanization throughout the county also increased; this occurred primarily in and around Logansport, the area immediately southwest of the Eel River-Tick Creek watershed. Glimpses of the watershed's early history can be seen in the historic landmarks that survive today. Many historical structures are still present in the area. Figure 10 maps some of these notable landmarks, which include homes, churches, and farmsteads dating back to the early to mid-1800s.

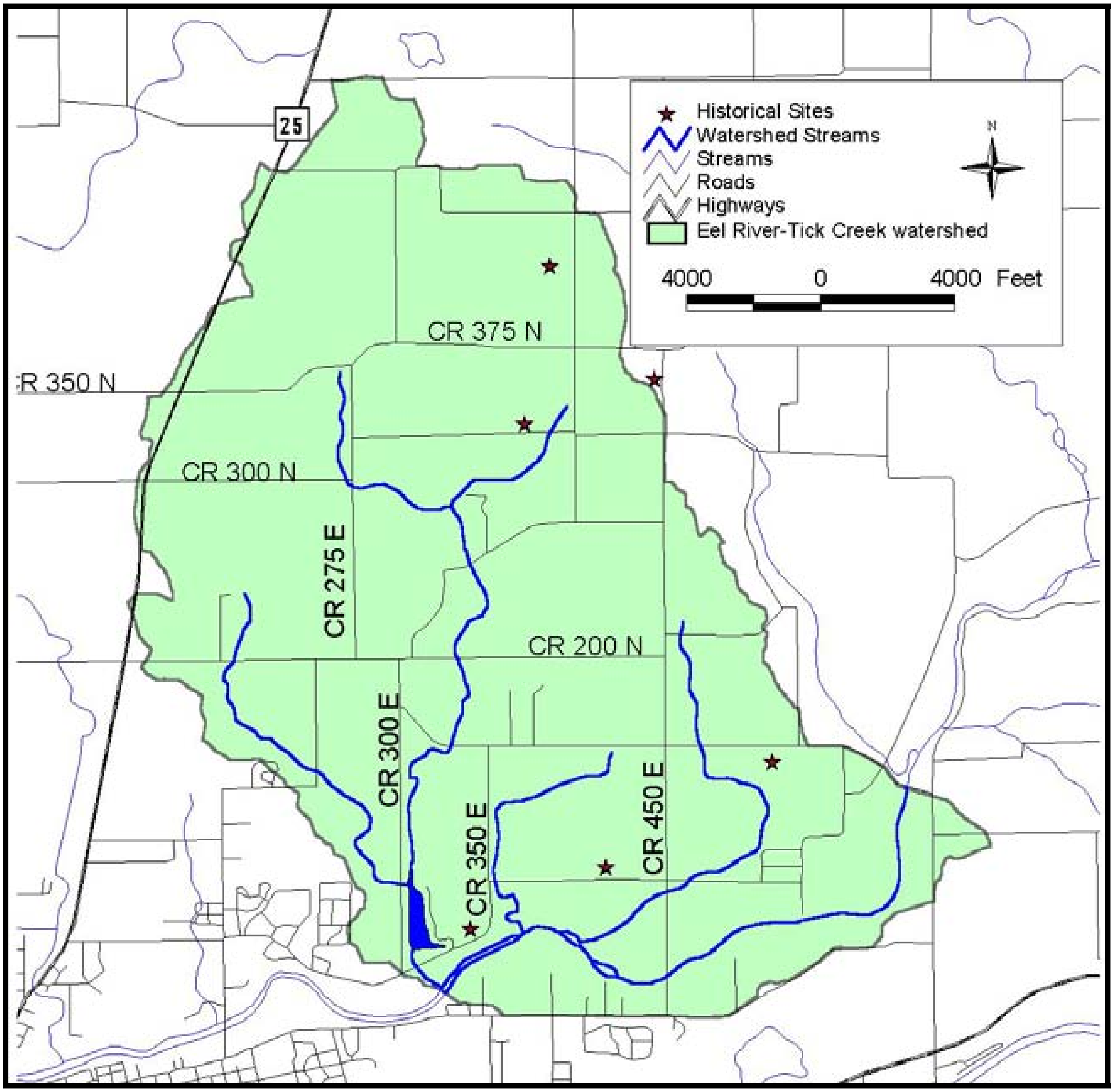

Figure 10. Historical structures and sites in the Eel River-Tick Creek watershed.
Source: See Appendix A. Scale: 1"=4,000'.

2.9 Land Use

Table 5 and Figure 11 present the land use information for the Eel River-Tick Creek watershed. Land use data from the U.S. Geological Survey (USGS) forms the basis of Figure 11. The USGS data for the watershed was updated by examining 2003 orthophotography in ArcView GIS. Portions of the watershed were also field checked. Like much of Cass County (Douglas, 1981), agricultural land uses dominate the landscape of the Eel River-Tick Creek watershed. Row crop agricultural areas cover nearly two-thirds of the watershed (63.8%). According to 2004 tillage transect data for Cass County, 83% of corn and 14% of soybean field (by acres) are in conventional tillage. Cass County ranks 71st for the use of no-till farming on corn fields (by acre) and 17th for soybean fields (IDNR, 2004). Pasture occupies an additional 12% of the watershed.

Forested land exists on approximately 15% of the watershed. Open water and wetlands cover nearly 2% of the watershed. (This number differs slightly from the **Hydrological Features** section since different data sources were utilized.) Most of the forested and wetland areas lie in the headwaters of Laird Ditch and along the mainstems of Laird Ditch and Tick Creek (Figure 11). Residential and commercial development account for more than 4% of the watershed land use. This percentage has increased over the past decade and will likely continue to do so in the next years as the population of Logansport grows and pushes out from the city center.

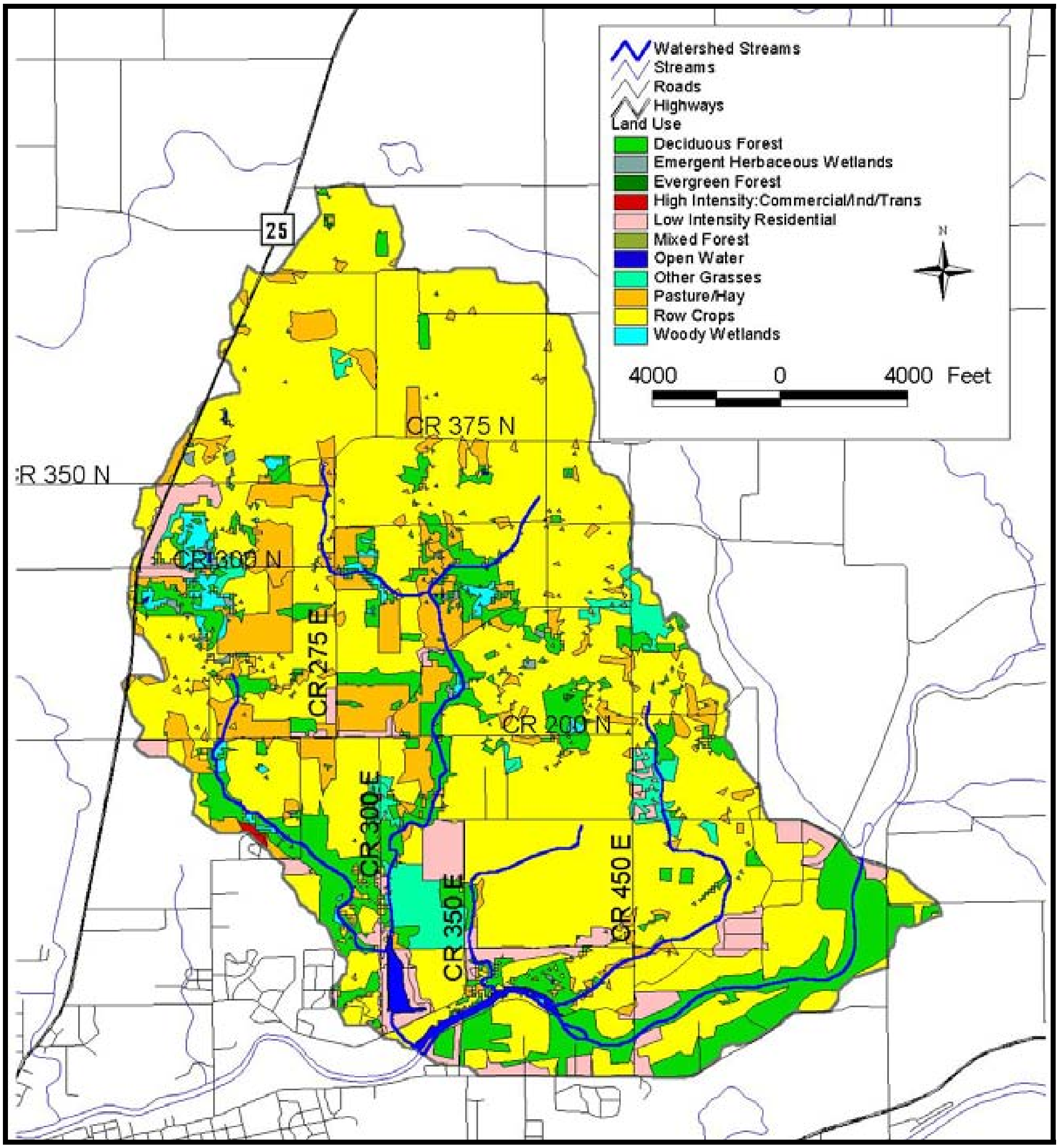

Figure 11. Land use in the Eel River-Tick Creek watershed.
Source: See Appendix A. Scale: 1"=4,000'.

Table 5. Detailed land use in the Eel River-Tick Creek watershed.

Land Use	Area (acres)	Percent of the Watershed
Row Crops	5755.7	63.9%
Deciduous Forest	1357.3	15.1%
Pasture/Hay	968.1	10.7%
Low Intensity Residential	470.8	5.2%
Other Grasses	263.1	2.9%
Woody Wetlands	107.5	1.2%
Open Water	49.5	0.5%
Emergent Herbaceous Wetlands	29.3	0.3%
High Intensity Commercial	6.8	0.1%
Evergreen Forest	2.8	0.0%
Mixed Forest	0.2	0.0%
Total	**9,011**	**100.0%**

2.10 Population

As the land use map (Figure X) suggests that the Eel River-Tick Creek watershed supports a relatively sparse population of people. Measuring and tracking population growth in the watershed is difficult since governmental and other agencies measuring this data often report their findings on a township, county, or census tract basis rather than by watershed. The reported data can, however, be utilized to estimate the current watershed population and track its growth over the past century. Table 6 presents the U.S. Census data for the Eel River-Tick Creek watershed area from 1890 to 2000. The entire Eel River-Tick Creek watershed lies in Clay Township, while the entirety of Logansport is located in Eel Township. Table 6 also provides data on Cass County for reference.

Table 6. U.S. Census data for Clay and Eel Townships and Cass County.

	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Cass County	**31,152**	**34,545**	**36,368**	**38,333**	**34,518**	**36,908**	**38,793**	**40,931**	**40,456**	**40,936**	**38,413**	**40,930**
Clay Township	838	765	745	683	681	671	635	1,386	1,943	2,779	2,878	2,890
Eel Township	14,052	17,237	20,239	21,905	18,895	20,760	21,772	21,901	20,275	18,890	17,746	20,115

Source: Stats Indiana, 2005.

Generally, both Clay and Eel Townships have shown steady growth over the past 110 years. Clay Township, within which lies the Eel River-Tick Creek watershed, experienced it greatest growth rate between 1950 and 1960 when the township's population grew by nearly 115%. Growth between 1960 and 1980 was also strong (approximately 40-45%). Conversely, Eel Township experienced its greatest growth rate between 1890 and 1900. This period of growth corresponds with heavy manufacturing growth within Logansport. Growth in Cass County also shows similar results; the greatest period of growth occurred from 1890 to 1900. Figure 12 details the population levels in the two townships and Cass County from 1890 through 2000.

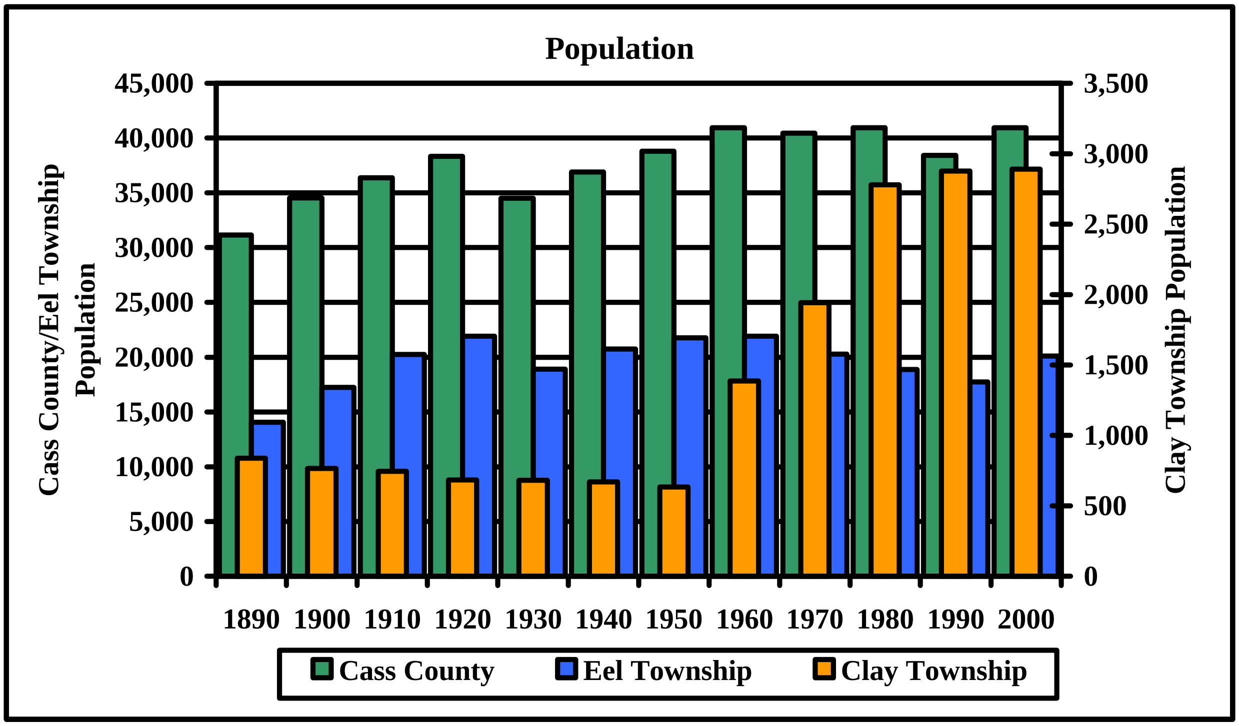

Figure 12. Populations of Clay Township (Eel River-Tick Creek watershed), Eel Township (City of Logansport), and Cass County from 1890 through 2000.

Population growth within the Eel River-Tick Creek watershed reflects that observed throughout Clay Township. In total, Clay Township supports approximately 80 people per square mile. A majority of these individuals are clustered around Lake Perry, along the State Road 25 corridor, and within subdivisions along the southern and eastern boundaries of the Eel River-Tick Creek watershed. In total, approximately 250 individuals own land within the Eel River-Tick Creek watershed (Judy Buttice and Pete Riggle, farm number records and Lake Perry Estates Corporation record search).

2.11 Land Ownership

Portions of two tracts of land owned by the Cass County Parks Department and the Cass County 4-H Program are located along the western watershed boundary of the Laird Ditch subwatershed (Figure 13). Both tracts are utilized for recreational activities including, but not limited to baseball diamonds, soccer fields, swing sets, animal barns, and open recreational areas. Individuals representing the Cass County Parks Department and the Cass County 4-H Program were contacted in regards to this project. Their input and opinions were solicited during the planning process through multiple mailings.

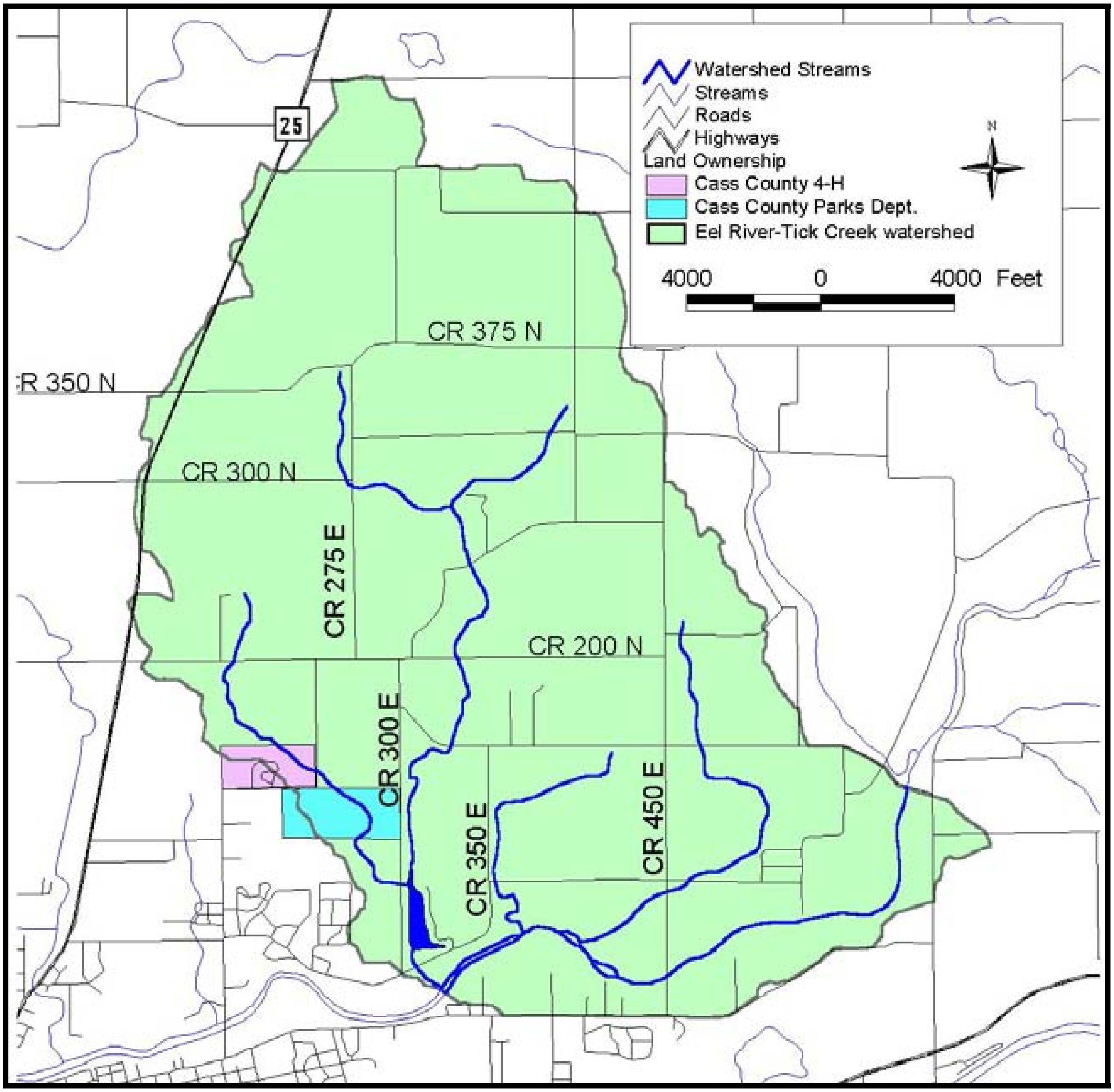

Figure 13. Tracts of land owned by public entities within the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

3.0 BASELINE WATER QUALITY CONDITIONS

Data contained in this section documents current water quality conditions in the four tributaries to the Eel River in the Eel River-Tick Creek watershed (Laird Ditch, Tick Creek, Howard Ditch, Shackelford Ditch, and Lake Perry). (These are referred to as the five major waterbodies in the Eel River-Tick Creek watershed throughout the remainder of this document.) Understanding the waterbodies' current conditions will help watershed stakeholders set realistic goals for future water quality conditions. This data will also serve as the benchmark against which future water quality conditions can be compared to measure stakeholder success in achieving their vision for the future of these waterbodies.

A variety of resources were reviewed to establish the existing or baseline water quality conditions within the five major waterbodies in the Eel River-Tick Creek watershed (Laird Ditch, Tick Creek, Howard Ditch, Shackelford Ditch, and Lake Perry). In general, few studies have been completed on the five waterbodies in the Eel River-Tick Creek watershed. The Indiana Department of Environmental Management assessed the water chemistry, biological communities, and physical habitat in Tick Creek and Laird Ditch in 1991, 1994, and 1998. The LPEC monitored Lake Perry's water clarity through the Indiana Clean Lakes Volunteer Monitoring Program from 2000 to 2004. JFNew collected additional data from each of the four major streams and Lake Perry during the summer of 2004 as part of this plan's development to supplement the existing data. The following paragraphs outline the findings of these assessments.

3.1 IDEM Assessments

The Indiana Department of Environmental Management's Biological Studies Section sampled both Tick Creek and Laird Ditch several times in the past 15 years. IDEM collected fish community data from Tick Creek, downstream of Lake Perry near its confluence with the Eel River in 1994 (Sobat, 2004). IDEM also collected macroinvertebrate community data from the same site in 1991 and 1998 (Davis, 2004). Because fish and macroinvertebrates live in the stream, the health of these biological communities provides an indication of the quality of the water in the stream. Concurrently with the macroinvertebrate collection, IDEM conducted an evaluation of the creek's physical habitat. This data is used to help determine whether habitat or water quality plays a larger role in influencing the health of the biological communities in the stream. In 1998, IDEM assessed the fish community, macroinvertebrate community, and water chemistry in Laird Ditch. Their sampling site on Laird Ditch was located at County Road 300 East. Appendix C contains the raw data from these assessments.

The biological community and habitat data from IDEM's assessment of Tick Creek indicate that the biota in the creek are at least moderately healthy and that IDEM would likely consider the creek to "support" its aquatic life beneficial use. (Under the Clean Water Act all waterbodies, with a few exceptions, must be capable of supporting aquatic life and recreational beneficial uses. In other words, waterbodies must be "*fishable and swimmable*". Indiana state law has similar requirements.) In 1994 Tick Creek received a fish Index of Biotic Integrity (IBI) score of 52 out of a possible 60, placing it in the "good" category (Table 7). The creek received a macroinvertebrate Index of Biotic Integrity (mIBI) score of 4.8 in 1991 and 4.4 in 1998 (out of a possible 8), placing it in the slightly impaired category (Table 8). The creek at this site scored 75 points in 1991 and 63 points in 1998 using the Qualitative Habitat Evaluation Index (QHEI). One hundred is the maximum possible QHEI score. The decrease in QHEI score between 1991 and 1998 resulted from a decrease in the in-stream cover and channel metric scores. IDEM considers scores below 51 to be non-supporting of the aquatic life beneficial use (Table 9). In general, Tick Creek's biotic scores suggest that the stream is supporting a healthy, balanced warmwater aquatic community and that it likely meets the state's standards for these biological parameters.

Table 7. Fish Index of Biotic Integrity scores and associated classification

Total IBI Score	Integrity Class	Attributes
58-60	Excellent	Comparable to the best situation without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant form; some species are present with less than optimal abundances or size distributions; trophic structure shows some sign of stress.
40-44	Fair	Signs of additional deterioration include the loss of intolerant forms, fewer species, highly skewed trophic structure (e.g. increasing frequency of omnivores and other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and conditions factors commonly depressed; hybrids and diseased fish often present.
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
0	No fish	Repeated sampling finds no fish.

Source: Simon and Dufour, 1998, adapted from Karr et al., 1986.

Table 8. Macroinvertebrate Index of Biotic Integrity scores and associated classification

Total mIBI Score	Integrity Class
6-8	Non-impaired
4-6	Slightly impaired
2-4	Moderately impaired
0-2	Severely impaired

Table 9. IDEM's criteria for aquatic life use support

Parameter	Fully Supporting	Partially Supporting	Not Supporting
Benthic aquatic macroinvertebrate Index of Biotic Integrity (mIBI)	mIBI $\geq$ 4	mIBI < 4 and $\geq$ 2	mIBI < 2
Qualitative habitat use evaluation (QHEI)	QHEI $\geq$ 64	QHEI < 64 and $\geq$ 51	QHEI < 51
Fish community (IBI) (Upper Wabash basin)	IBI > 34	IBI $\leq$ 34 and $\geq$ 32	IBI < 32

Source: IDEM, 2004f.

In the summer of 1998, IDEM assessed the biological communities, physical habitat, and water chemistry in Laird Ditch at County Road 300 East, upstream of the point where the creek discharges into Lake Perry (Davis, 2004; Sobat, 2004). The creek's biotic integrity scores were lower than those observed in Tick Creek. The creek received an IBI score of 38, placing it between the poor and fair categories, and a mIBI score of 3.6, placing it in the moderately impaired category. Despite being lower than the IBI score observed in Tick Creek, Laird Ditch's IBI score is high enough that IDEM would consider the creek fully supportive of its aquatic life beneficial use (IDEM, 2004f). The mIBI score, however, suggests IDEM might consider the creek only partially supportive of its aquatic life beneficial use. The creek's habitat may play some minimal role in limiting biotic life in the creek. Laird Ditch received a QHEI score of 60, which IDEM considers only partially supportive of the aquatic life beneficial use.

The water chemistry testing in Laird Ditch (Bell, 2004) included many common parameters such as dissolved oxygen, pH, and nutrients as well as numerous other parameters such as heavy metals and some organic chemical compounds. None of the concentrations of the measured parameters exceeded the state standards for water quality and most concentrations were below the laboratory detection limit. (It is important to note that Indiana does not have a state standard for each parameter measured by IDEM during this sampling event.) The concentrations of two parameters, turbidity and total phosphorus, were higher than desirable. The creek exhibited a turbidity of 36 NTU and a total phosphorus concentration of 0.12 mg/L. Indiana does not have numeric criteria for either of these parameters, but some potential management targets for ensuring stream health are 10 NTU for turbidity (USEPA, 2000) and 0.075-0.1 mg/L for total phosphorus (Dodd et al., 1998; EPA, 2000; Ohio EPA, 1999).

3.2 Indiana Clean Lakes Volunteer Monitoring Program

The LPEC monitored Lake Perry's water clarity through the Indiana Clean Lakes Volunteer Monitoring Program from 2000 to 2004. Citizen volunteers in the ICLVMP are trained by ICLVMP staff to collect water clarity data from individual lakes on a biweekly basis (if possible) throughout the summer months, typically from June through August. Water clarity data is measured by the volunteer with a Secchi disk using the standard methodology employed by most lake management professionals (Indiana Clean Lakes Volunteer Monitoring Program, 2001). On Lake Perry, the citizen volunteer typically monitored the lake four or five times throughout the summer.

The results of this testing indicate that the lake suffers from poor but relatively stable water clarity. Most of the Secchi disk measurements for the lake were between 1.8 and 2.8 feet, although in two instances readings better than 3 feet were obtained. The lake's July/August average Secchi disk depth ranged from a low of 1.9 in 2001 to a high of 2.5 in 2004. These averages are well below the median Secchi disk depth for Indiana lakes of 6.9 feet (Figure 14).

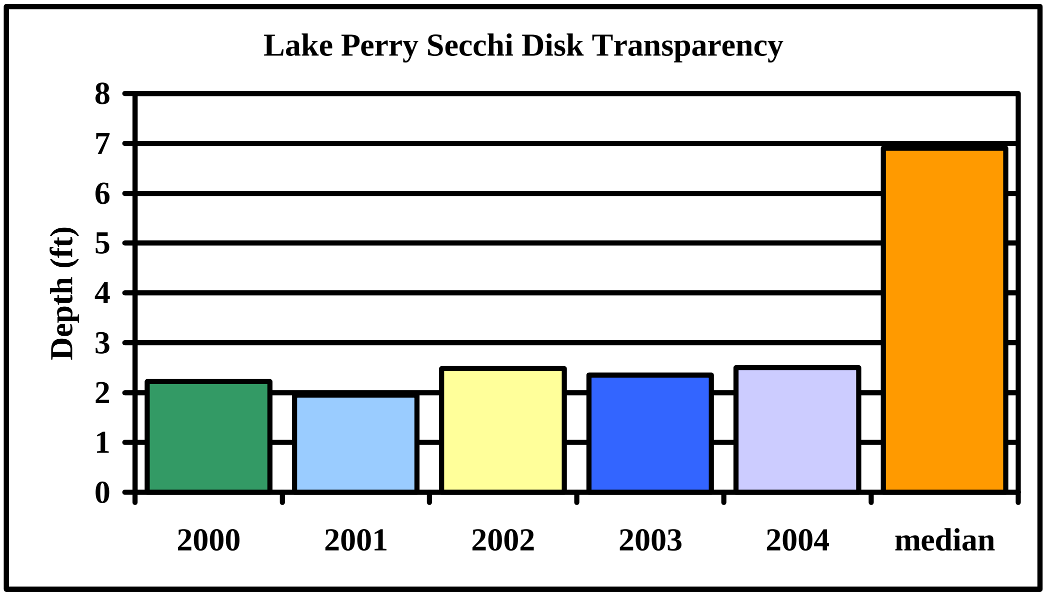

Figure 14. Water clarity in Lake Perry from 2000 to 2004. July/August Secchi disk averages for Lake Perry are compared to the median Secchi disk reading for Indiana lakes (based on Indiana Clean Lakes Program data).

3.3 JFNew Watershed Stream and Lake Sampling

To supplement the base of existing data, JFNew collected water chemistry, biological community, and physical habitat data from each of the four major watershed streams: Laird Ditch, Tick Creek, Howard Ditch, and Shackelford Ditch. One sampling station was located on each stream (Figure 15). Water chemistry samples were collected twice from each stream, once following a storm event to capture a runoff event and once following a period of little precipitation to serve as the "normal" stream condition. Each stream's biological community and physical habitat were assessed once in mid-late summer. To ensure comparability to data collected previously by IDEM, JFNew followed similar stream sampling protocols. Additionally, JFNew assessed the water quality in Lake Perry by examining water chemistry and biological parameters. Sampling followed the protocol utilized by the Indiana Clean Lakes Program to allow for comparison to data gathered for other Indiana lakes. The stream and lakes sampling and the appropriate quality assurance/quality control procedures are referenced in the project's Quality Assurance Project Plan (QAPP). Appendix D contains the project QAPP. Tables 10 through 12 present the raw water chemistry data, while Appendix E presents the raw data collected during the stream and lake assessments in tabular and graphical form. Sampling location coordinates are also contained in Appendix E.

Table 10. Physical parameter data collected during base and storm flow sampling events in the Eel River-Tick Creek watershed waterbodies on May 19, 2004 and July 20, 2004.

Site	Stream Name	Date	Event	Flow (cfs)	Temp (deg C)	DO (mg/L)	% Sat	pH	Turbidity (NTU)	TSS (mg/L)
1	Laird Ditch	5/19/04	storm	1.7	15.5	8.3	82.3	8.0	2.9	1.5
		7/20/04	base	0.5	18.5	8.2	98.7	8.0	4.3	14.5
2	Tick Creek	5/19/04	storm	8.3	14.3	9.6	93.7	8.1	2.5	2.3
		7/20/04	base	3.0	18.6	9.7	104.5	7.8	2.1	3.3
3	Howard Ditch	5/19/04	storm	1.6	14.8	9.0	88.5	7.9	2.8	5.0
		7/20/04	base	0.5	17.5	9.4	97.2	7.8	2.4	2.7
4	Shackelford Ditch	5/19/04	storm	2.1	14.0	7.5	73.4	7.9	6.3	26.0
		7/20/04	base	0.7	16.6	9.1	90.9	7.7	5.05	16.8

Table 11. Chemical and bacterial characteristics of the Eel River-Tick Creek watershed waterbodies as sampled on May 19, 2004 and July 20, 2004.

Site	Stream Name	Date	Event	NH_3-N (mg/L)	NO_3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	BOD (mg/L)	*E. coli* (col/100 mL)
1	Laird Ditch	5/19/04	storm	0.065	1.614	0.817	0.052	0.081	<2	390
		7/20/04	base	0.067	2.127	0.475	0.040	0.088	<2	490
2	Tick Creek	5/19/04	storm	0.116	6.661	0.963	0.032	0.081	<2	690
		7/20/04	base	0.018	4.222	0.486	0.025	0.063	<2	1,000
3	Howard Ditch	5/19/04	storm	0.087	3.751	0.559	0.053	0.080	<2	870
		7/20/04	base	0.018	4.316	0.349	0.026	0.081	<2	545
4	Shackelford Ditch	5/19/04	storm	0.113	3.770	0.724	0.071	0.137	<2	3,150
		7/20/04	base	0.053	3.028	0.468	0.036	0.101	<2	1,240

Table 12. Chemical loading data for the Eel River-Tick Creek watershed waterbodies as sampled on May 19, 2004 and July 20, 2004.

Site	Stream Name	Date	Event	NH_3-N Load (kg/d)	NO_3-N Load (kg/d)	TKN Load (kg/d)	SRP Load (kg/d)	TP Load (kg/d)	TSS Load (kg/d)	*E. coli* Load (mil col/d)
1	Laird Ditch	5/19/04	storm	0.264	6.606	3.345	0.213	0.332	6.140	15963
		7/20/04	base	0.088	2.777	0.620	0.052	0.115	18.933	6398
2	Tick Creek	5/19/04	storm	2.373	135.793	19.637	0.652	1.651	45.866	140656
		7/20/04	base	0.132	31.044	3.572	0.184	0.460	23.896	73525
3	Howard Ditch	5/19/04	storm	0.334	14.500	2.160	0.205	0.309	19.329	33632
		7/20/04	base	0.024	5.646	0.456	0.034	0.106	3.551	7129
4	Shackelford Ditch	5/19/04	storm	0.586	19.623	3.766	0.370	0.713	135.451	163978
		7/20/04	base	0.093	5.324	0.823	0.063	0.178	29.447	21800

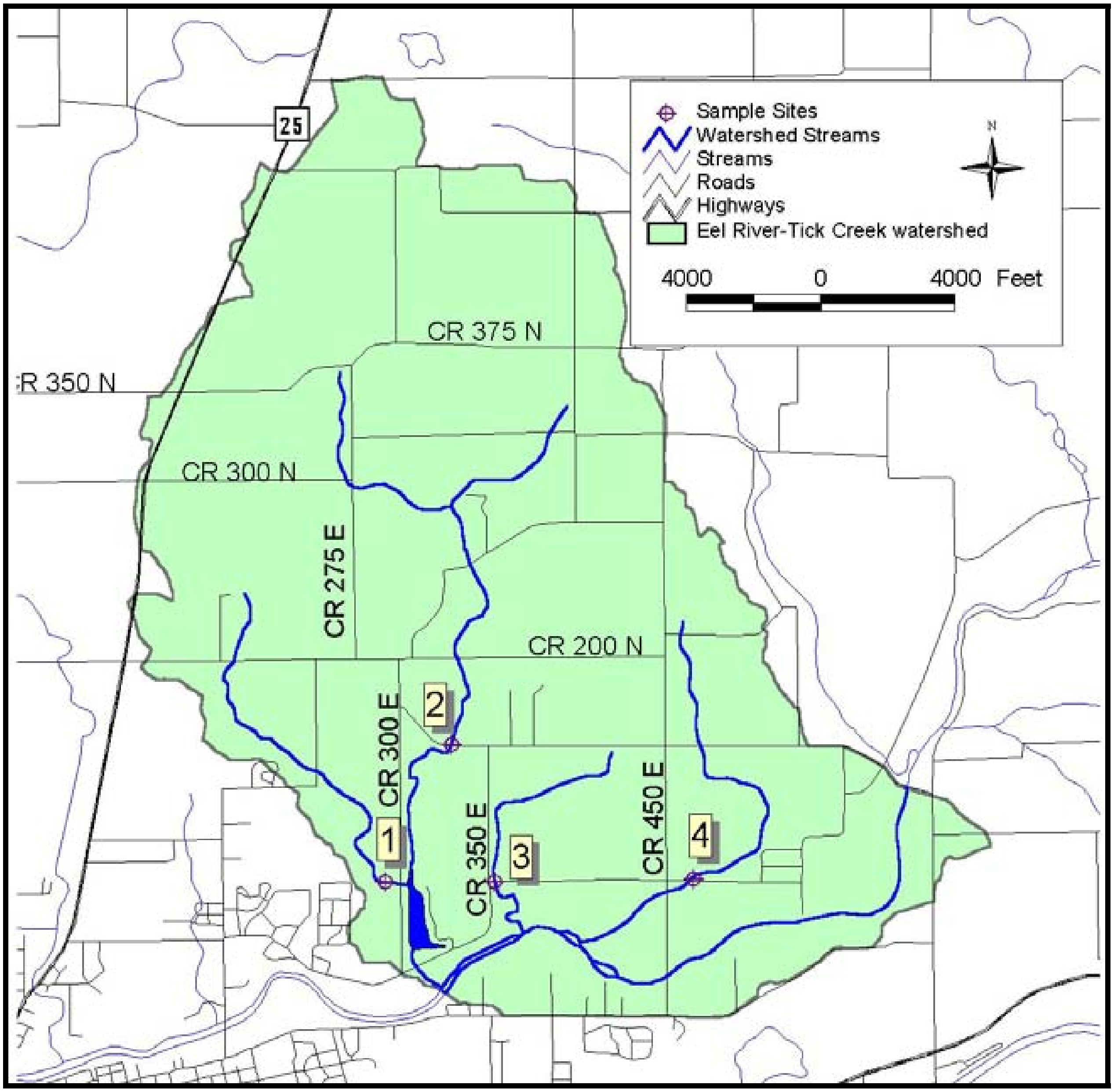

Figure 15. Stream sampling locations. Source: See Appendix A. Scale: 1"=4,000'.

3.3.1 Laird Ditch

In general, water quality was relatively good in Laird Ditch, although some parameters were of concern. During both base flow and storm flow conditions, none of the samples violated the Indiana state standards for temperature, dissolved oxygen, pH, nitrate-nitrogen, or ammonia-nitrogen concentrations. These results are consistent with the findings from IDEM's 1998 assessment of the ditch. The evaluation of Laird Ditch's biological community and physical habitat indicated that the ditch fell just short of the thresholds at which IDEM typically considers a stream to be "fully supportive" of its aquatic life use. The ditch received a mIBI score of 3.6 placing it in the moderately impaired category. (This score was identical to the score obtained by IDEM in 1998.) Laird Ditch had a QHEI score of 63, which was a few points higher than the score calculated by IDEM in 1998.

The 2004 sampling of Laird Ditch highlighted a few areas of concern. First, the ditch exhibited *E. coli* concentrations above the Indiana state standard of 235 cfu/100mL during both the storm flow and base flow sampling events. While exceeding the state standard is of concern, the concern should be tempered by the fact that the *E. coli* concentrations observed in Laird Ditch were below the average *E. coli* concentration found in Indiana streams. In reviewing ten years worth of data from Indiana fixed monitoring stations, White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 cfu/100mL. Also of concern is Laird Ditch's nitrate-nitrogen concentration. While the concentration does not exceed the state standard, the concentration under both storm and base flow conditions was above the concentration recommended by the Ohio EPA to protect aquatic life. In a study correlating nutrient concentrations to biotic health, the Ohio EPA (1999) recommended keeping nitrate concentrations below 1.0 mg/L in most streams. Finally, although the pollutant loads in Laird Ditch were low compared to the other watershed streams, Laird Ditch exhibited the second highest total suspended solids areal loading rate during storm flow. (Areal loading rate is the pollutant loading rate divided by drainage area. This allows for a comparison of loading rates in different sized drainages. Normally, pollutant loading rates in larger drainages are expected to be higher than the pollutant loading rates in smaller drainages.) The high (relative to other watershed streams) total suspended solids areal loading rate suggests that the stream may carry a significant suspended solid load and/or stream erosion during storm flow may be a considerable source of sediment in the ditch (Figure 16).

Figure 16. Typical stream bank erosion observed along Laird Ditch during a walking tour of the ditch.

3.3.2 Tick Creek

Like Laird Ditch, for many of the parameters measured, Tick Creek exhibited relatively good water quality. None of the temperature, dissolved oxygen, pH, nitrate-nitrogen, or ammonia-nitrogen measurements violated Indiana state standards. The creek's biological community and physical habitat exhibited the best health compared to the other watershed streams. Tick Creek received a mIBI score of 4.2, placing it in the slightly impaired category. This score however is high enough to be considered fully supportive of its aquatic life beneficial use. Similarly, the creek possessed a QHEI score of 71, which is well above the threshold at which IDEM considers habitat to be supportive of aquatic life beneficial use.

Despite these good biological integrity and physical habitat scores, Tick Creek exhibited a few characteristics of concern. For example, the stream's nitrate-nitrogen concentrations during both base and storm flow were high. Following a storm event, the creek's nitrate-nitrogen concentration was 6.7 mg/L and its nitrate-nitrogen concentration under base flow conditions was 4.2 mg/L. (Appendix E contains the raw data for the 2004 stream and lake sampling.) These concentrations are well above the 1.0 mg/L level, which the Ohio EPA recommends as a standard for protecting aquatic life. Additionally, they are above the 3-4 mg/L concentration at which the Ohio EPA found a definite correlation with impaired biotic health (Ohio EPA, 1999). Tick Creek also exhibited relatively high *E. coli* concentrations. The *E. coli* concentrations following a storm event (690 cfu/100mL) and during base flow conditions (1000 cfu/100mL) exceeded both the state standard and the average *E. coli* concentration in Indiana streams. Finally, Tick Creek possessed the highest pollutant loading rates of the four watershed streams for all pollutants measured except total suspended solids, for which the creek possessed the second highest loading rate. This finding is not surprising since Tick Creek's drainage area is three to six times larger than the drainage areas of the other watershed creeks. Creeks with larger drainage areas typically possess high pollutant loading rates. When drainage size is normalized by dividing pollutant loading rates for each stream by drainage size, Tick Creek still generally exhibits the highest loading rates for the nitrogen parameters (nitrate-nitrogen, ammonia-nitrogen, and total Kjeldahl nitrogen). This suggests the Tick Creek subwatershed may be a hot spot or critical source for nitrogen based pollutants.

3.3.3 Howard Ditch

The water chemistry conditions in Howard Ditch were fairly similar to those observed in Laird Ditch and Tick Creek. None of temperature, dissolved oxygen, pH, nitrate-nitrogen, or ammonia-nitrogen measurements taken in Howard Ditch during either the storm event or under base flow conditions violated Indiana state standards. The ditch received a mIBI score of 3.9, placing the ditch's biological community in the moderately impaired category. This score is just short of the 4.0 threshold IDEM considers when determining whether a waterbody meets its aquatic life beneficial use.

Characteristics of concern within Howard Ditch include its high nitrate-nitrogen concentration, high *E. coli* concentration, high phosphorus and total suspended solids loading rates during storm flows relative to the ditch's drainage size, and poor habitat score. Howard Ditch exhibited a nitrate-nitrogen concentration of 3.8 mg/L and 4.3 mg/L during storm flow and base flow conditions, respectively. These concentrations are within the range found by the Ohio EPA to be correlated with biotic community impairment. Thus, high nitrate-nitrogen concentrations could be negatively impacting the fauna within Howard Ditch. Howard Ditch also possessed *E. coli* concentrations during both sampling efforts that exceeded the state standard of 235 cfu/100mL. When drainage size is normalized, Howard Ditch had the second highest total phosphorus and total suspended solid loading rates following a storm event. This suggests runoff related issues should be focused on when targeting management actions in this subwatershed. Finally, Howard Ditch received a low QHEI score (42). IDEM considers streams with QHEI scores under 51 to be non-supportive of its aquatic life beneficial use. Unlike Laird Ditch and Tick Creek which appear to be natural drainages, Howard Ditch is primarily a manmade or highly modified feature so its low QHEI score is expected.

3.3.4 Shackelford Ditch

Shackelford Ditch exhibited the worst water quality of the four watershed streams. The ditch generally possessed the highest pollutant concentrations during each sampling effort. Of particular concern were the ditch's nitrate-nitrogen, total phosphorus, and *E. coli* concentrations. During each sampling effort, Shackelford Ditch exhibited nitrate-nitrogen concentration above 3.0 mg/L. High nitrate-nitrogen levels may be impairing the ditch's biotic community. Total phosphorus concentrations in the ditch exceeded 1.0 mg/L during each sampling effort. The *E. coli* concentrations in Shackelford Ditch were five to thirteen times higher than the state standard and two to five times greater than the average *E. coli* concentration in Indiana streams. Additionally, Shackelford Ditch exhibited relatively high pollutant loading rates. Shackelford Ditch possessed the highest phosphorus and suspended solids areal loading rates during base and storm flows. Finally, the biological and physical habitat assessments indicated impairment of these components of the ecosystem. Shackelford Ditch received a mIBI score of 1.6, placing it in the severely impaired category. Its QHEI score was 24.

3.3.5 Lake Perry

Lake Perry is best classified as a being on the border between a eutrophic and hypereutrophic lake. Eutrophic lakes often exhibit poor water clarity and elevated nutrient concentrations. The high nutrient concentrations feed algal populations, resulting in periodic algal blooms, and occasional scum formation, throughout the summer. During the summer, blue-green or nuisance algae typically dominate the algal populations in eutrophic lakes. Conditions are typically worse in hypereutrophic lakes. These lakes have higher nutrient concentrations than eutrophic lakes and experience more and longer algal blooms. In severely hypereutrophic lakes, algal blooms are so bad, the lake often appears the color of pea soup.

Lake Perry's nutrient concentrations were comparable to nutrient concentrations found in other eutrophic lakes (Vollenweider, 1975 and Carlson, 1977). Lake Perry's chlorophyll *a* (an indicator of algae) concentration, however, was comparable to chlorophyll *a* concentrations found in other hypereutrophic lakes (Carlson, 1977). Similarly, Lake Perry's water clarity was poorer than that found in many eutrophic lakes suggesting the lake may be hypereutrophic in nature.

While the data above suggest the lake is in poor shape, a comparison of data collected from Lake Perry with selected water quality data from other Indiana lakes suggests Lake Perry is certainly not atypical. Table 13 presents a comparison of Lake Perry data to data collected from 1994 through 2004 by the Indiana Clean Lakes Program. The CLP data summarized in the table are minimum, maximum, and median values obtained by averaging the epilimnetic (surface water) and hypolimnetic (bottom water) pollutant concentrations from each of the 456 lakes. At the time of sampling, Lake Perry was not stratified (i.e. there was no distinction based on temperature between surface and bottom water in the lake); consequently only one sample was collected from the midpoint in the water column.

Table 13. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program compared to data collected from Lake Perry on July 21, 2004.

	Secchi Disk (ft)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chlorophyll *a* (μg/L)
Minimum	0.3	0.01	0.004	0.230	0.01	0.01	0.013
Maximum	32.8	9.4	22.5	27.05	2.84	2.81	380.4
Median	6.9	0.275	0.818	1.66	0.12	0.17	12.9
Lake Perry	**0.8**	**1.67**	**0.06**	**0.97**	**0.013**	**0.09**	**34.28**

In general, Lake Perry exhibits slightly lower nutrient concentrations than the typical (median) Indiana lake. The lake's ammonia-nitrogen, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus concentrations were all lower than the median concentration for Indiana lakes. Lake Perry's nitrate-nitrogen concentration, however, was higher than the median concentration for Indiana lakes. As noted above, elevated nitrate-nitrogen concentrations were observed in Tick Creek and Laird Ditch which empty into Lake Perry. While Lake Perry's nutrient concentrations were lower than those in a typical Indiana lake, they were still high enough to support algal blooms. (Total phosphorus concentrations greater than 0.03 mg/L and inorganic nitrogen concentrations greater than 0.1 mg/L are known to support algal blooms.) The lake's high chlorophyll *a* concentration suggests the lake was experiencing an algae bloom at the time of sampling. Watershed stakeholders may want to reduce nutrient concentrations below the thresholds listed above to decrease likelihood of algae blooms.

3.4 Indiana Geological Survey

Data layers within the Indiana Geological Survey's GIS (Geographical Information Systems) Atlas for Indiana were reviewed to identify any additional water quality data or threats. A review of the data layers revealed that no known or permitted confined feeding operations, corrective action sites, construction demolitions waste sites, industrial waste sites, leaking underground storage locations, National Pollution Discharge Elimination System facilities or pipe locations, open dump sites, restricted waste sites, septage waste sites, solid waste landfills, Superfund sites, underground storage tank sites, or voluntary remediation program sites exist within the Eel River-Tick Creek watershed (IDEM, 2002a-b; IDEM, 2004a-e; IDEM, 2004g-q). At least two open waste sites that are not known to IDEM were identified by watershed stakeholders during public meetings. The content of these sites is unknown.

3.5 Other Sources

A variety of other sources were reviewed to assist in establishing baseline water quality conditions in the waterbodies of the Eel River-Tick Creek watershed. The current and historical 305(b) reports were studied (IDEM, 1994; IDEM, 1996; IDEM, 2000; IDEM, 2004f). No data specific to the tributaries of the Eel River within the Eel River-Tick Creek watershed were found in these reports. However, these reports indicate that the Eel River mainstem possesses as light concern for mercury contamination and a moderate concern for pathogenic (*E. coli*) contamination (IDEM, 2004f). None of the tributaries within the Eel River-Tick Creek watershed are listed on the 2004 303(d) list; however, the Eel River immediately upstream of its confluence with the Wabash River is listed for *E. coli* and mercury contamination (IDEM, 2004f). This portion of the Eel River is slated for Total Maximum Daily Load (TMDL) development from 2013 to 2018. The Watershed Restoration Action Strategies (WRAS) for the Eel–Wabash Watershed (Whitman Hydro Planning Associates, Inc., 2002) and the Unified Watershed Assessment (UWA) (IDEM, 1999) do not contain data specific to the Eel River-Tick Creek watershed. Without providing specific data, the WRAS suggests that streambank erosion and stabilization, failing septic systems and straight pipes, non-point source pollution (including lack of education on non-point source pollution), point source pollution, and data management are water quality issues of concern within the larger Eel River Basin (HUC 05120104). The UWA suggests aquifer contamination and the high percent of agricultural land use may be water quality issues of concern within the eleven digit watershed containing the Eel River-Tick Creek watershed. Again, neither the WRAS nor the UWA contain specific watershed data confirming the validity of these concerns within the Eel River-Tick Creek watershed.

4.0 BASELINE WATERSHED CONDITIONS

Identifying areas of concern and selecting sites for future water quality improvement projects were the goals for this visual and watershed inspection. The Eel River-Tick Creek watershed was toured multiple occasions throughout the completion of the watershed management plan. Inspections and tours included a stream crossing survey completed in February 2004, a walking tour completed in November 2004, and additional observations completed during stream and lake sampling trips in May and July of 2004.

4.1 Stream Crossing Survey

In general, the stream crossing survey provided a basis for selecting water quality sampling sites. This assessment was designed to identify the best possible water quality sampling sites on the basis of stream accessibility. In addition to fulfilling its primary duty, this process allowed for the identification of a number of areas where water quality improvement projects could be implemented. Specific areas are mapped in Figure 17. Table 14 lists the sites in the Eel River-Tick Creek watershed where various concerns were observed during the stream crossing survey. Additionally, the table lists possible options for land management actions that could improve water quality within the Eel River-Tick Creek watershed. Appendix F contains photographs of each of the stream crossings as observed in February 2004.

Table 14. List of locations where the application of best management practices would improve water quality in the Eel River-Tick Creek watershed as identified during the stream crossing survey.

Site	Concern	Suggested Management Practice
S1	Steep streambanks; streambank sloughing	Streambank stabilization
S2	Steep streambanks	Streambank stabilization
S3	Natural vegetation has been removed	Restore riparian buffer
S4	Land appears to be grazed	Livestock fencing; Restore riparian buffer

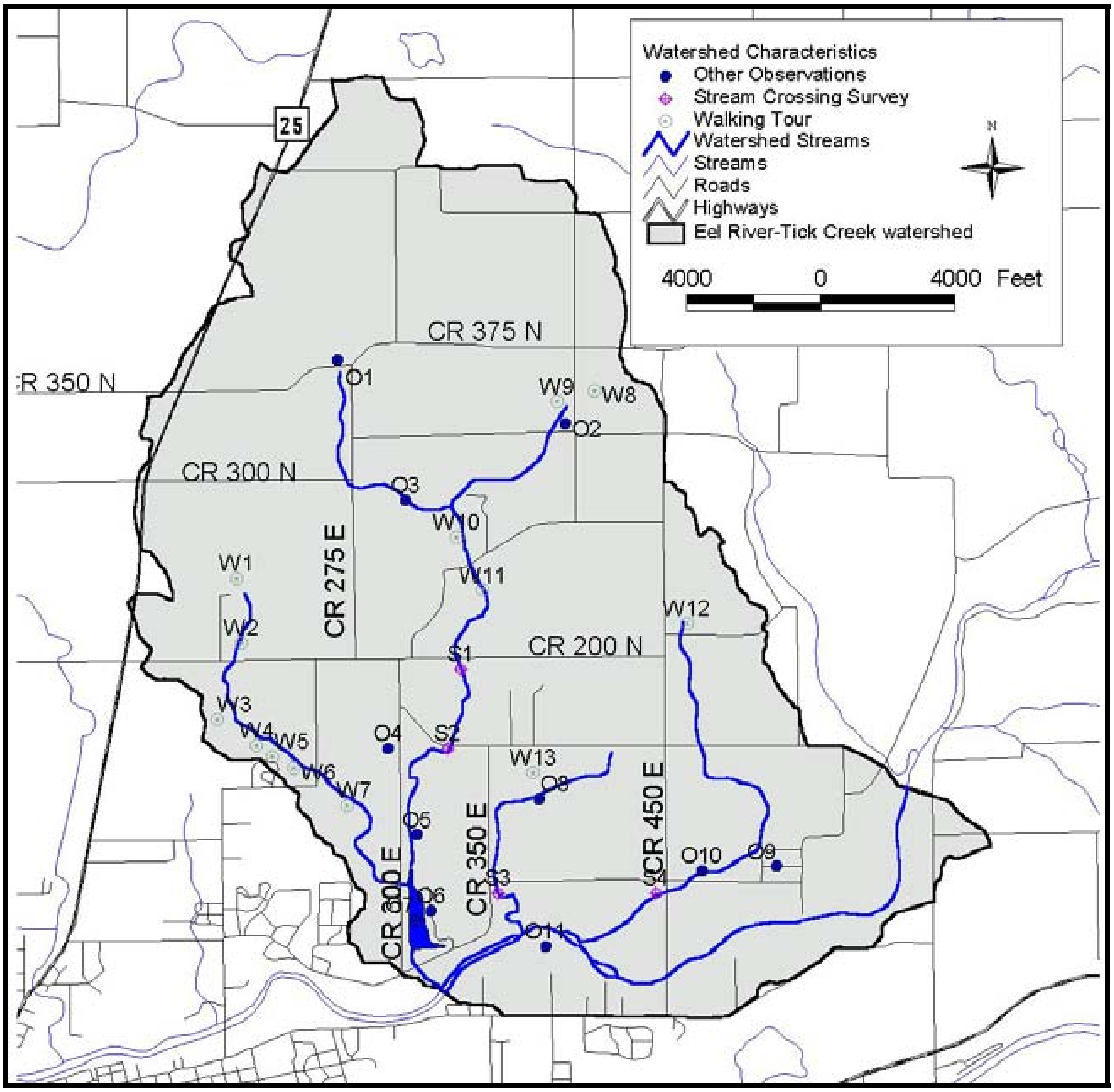

Figure 17. Watershed concerns identified during various watershed surveys in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1”=4,000’.

4.2 Walking Survey

In general, the stream crossing survey focused on the Laird Ditch and Tick Creek watersheds as these areas offered the greatest source of water quality improvement projects compared with the Howard and Shackelford Ditch subwatersheds. The walking tour consisted of individuals from JFNew and the Cass County NRCS District Conservationist walking the lengths of Laird Ditch and Tick Creek. These individuals recorded all potential watershed concern areas along the length of these two streams. Additional areas within the Eel River-Tick Creek watershed were also toured via a driving tour and are included herein. All areas of concern were noted during both the walking and driving tours and are listed in Table 15. Locations of these observations are also included in Figure 17. Appendix F contains photographs of each of the areas as observed in November 2004.

Table 15. List of locations where the application of best management practices would improve water quality in the Eel River-Tick Creek watershed as identified during the walking survey.

Site	Concern	Suggested Management Practice
W1	N/A	Wetland restoration is possible
W2	Land appears to be grazed	Livestock fencing; Restore riparian habitat; Filter strip installation
W3	Ravines are eroding	Stabilize ravines; Restore riparian habitat
W4	Soil/manure pile	Create filtration; Post signs and move manure pile away from stream
W5	Barn drainage piped to stream	Install vegetated filter or rain garden
W6	Banks are eroding	Stabilize streambanks; Restore riparian habitat
W7	Banks are eroding	Stabilize streambanks; Restore riparian habitat
W8	Potential pollution source	Investigate on-the-ground options for water quality improvement
W9	N/A	Wetland restoration is possible
W10	Land appears to be grazed	Livestock fencing; Restore riparian habitat; Filter strip installation
W11	Land appears to be grazed	Livestock fencing; Restore riparian habitat; Filter strip installation
W12	N/A	Wetland restoration is possible
W13	Natural vegetation has been removed	Restore riparian habitat; Stabilize streambanks as necessary

4.3 Other Observations

Observations of water quality concern areas were recorded throughout the completion of the watershed management plan. These areas were identified through information from watershed stakeholders during meetings and during stream and lake water quality assessment events. All observations identified through methods other than the stream crossing survey or the walking tour are included in this section and listed in Table 16. Specific areas are also mapped in Figure 17. Appendix F contains photographs of each of some of these areas observed during the completion of the watershed management plan.

Table 16. List of locations where the application of best management practices would improve water quality in the Eel River-Tick Creek watershed as identified during the completion of the watershed management plan.

Site	Concern	Suggested Management Practice
O1	Land appears to be grazed	Livestock fencing; Restore riparian habitat; Filter strip installation
O2	Tile disrepair	Work with landowner(s) to identify specific solution
O3	Banks are eroding	Stabilize streambanks; Restore riparian habitat
O4	Potential pollution source	Investigate on-the-ground options for water quality improvement
O5	N/A	Wetland restoration is possible
O6	Potential pollution source	Investigate on-the-ground options for water quality improvement
O7	Potential pollution source	Investigate on-the-ground options for water quality improvement
O8	Natural vegetation has been removed	Restore riparian habitat; Stabilize streambanks as necessary
O9	Natural vegetation has been removed	Restore riparian habitat; Stabilize streambanks as necessary
O10	Natural vegetation has been removed	Restore riparian habitat; Stabilize streambanks as necessary
O11	N/A	Wetland restoration is possible

5.0 CLARIFYING OUR PROBLEMS

5.1 Linking Concerns to the Existing Data

Throughout the planning process watershed stakeholders were invited to share their concerns for the Eel River-Tick Creek watershed, its waterbodies, and their water quality. All of the stakeholder's concerns identified during the planning process are detailed in the Concerns Section of the Introduction (Section 1.3). The project sponsor and facilitating consultant developed a group of broad categories within which the stakeholder's concerns could fit. These same categories were used throughout the planning process to develop problem statements, identify priority areas, and set goals for watershed and water quality improvement. Table 17 reflects the stakeholder's concerns, any existing data identified that supports or refutes those concerns, and identifies the problem statement developed for that particular concern.

Table 17. Linking watershed stakeholders' concerns with existing data to develop problem statements.

Concern	Existing Data	Problem Statement
Land Use		
Increase in erosion due to transition of old field habitat to active agriculture	No data from the watershed were available to verify this; however, research on pollutant runoff suggests that sediment loss rates are greater on active agricultural land than old field habitat.	1
Effect of old dump on water quality	No data were available to confirm or refute the concern.	
Increase in erosion during site development, particularly when there is a delay in establishing ground cover	No data from the watershed were available to verify this; however, research on pollutant runoff suggests significant erosion occurs on active construction sites.	1
Negative effect of ditch cleaning on water quality and habitat.	An assessment of ditch cleaning within the watershed was not available; however, Howard and Shackelford Ditch possessed the poorest habitat scores of the four watershed streams. Shackelford Ditch generally possessed the worst water quality (water chemistry and biological integrity).	1
Flooding/Property Loss		
Flooding due to tile damage and/or clogging drainage ditches	During the watershed land inventory, flooding and a concurrent loss of property for agricultural use were observed. Discussions with local natural resource agencies confirm that a damaged tile prevents drainage from the flooded land to Shackelford Ditch. The land inventory and stream habitat assessment confirmed that sediment has accumulated in Shackelford Ditch. The substrate metric of the habitat score was extremely poor.	2
Open drains should replace drainage tiles to increase drainage	No data from the watershed was available to establish which drainage system drains land faster or more efficiently.	
Education		
Stakeholders need to be better informed with respect to water quality and how to manage the watershed to improve water quality	Discussions with the education coordinator for the SWCD and with individual landowners confirm that stakeholders could be better educated with respect to water quality and how to manage the watershed to improve water quality.	3
Stakeholders need to participate more in the planning process	A core group of individuals attended all of the watershed planning meetings. Attendance fluctuated, but generally remained at levels similar to the number of individuals attending the first meeting.	4
Recreation		
Lake Perry suffers from poor water clarity	Water clarity sampling by volunteer monitors and JFNew indicate that the lake's water clarity is poorer than most Indiana lakes.	1

Concern	Existing Data	Problem Statement
Lake Perry has lost depth	Water depth measured by JFNew suggests the lake is approximately 5-6 feet shallower at its deepest point than the lake was designed to be. No as-builts are available to confirm that the lake was constructed according to its design.	1
Natural age of Lake Perry	The natural age of Lake Perry could be, but has not been, estimated at this point.	
The rooted plants and algae populations are too dense in Lake Perry	No quantitative data was available on the rooted plant population. The lake has elevated levels of nutrients to support dense algal populations; however the lake's turbidity (poor clarity) may be limiting algal growth. The lake's chlorophyll *a* concentration was 34.28 μg/L.	5
Health		
Existence of pollutants associated with silt in Lake Perry	No data was available on whether pollutants other than nutrients and silt are in Lake Perry. IDEM tested the water in Laird Ditch, one of Lake Perry's inlets, for a wide range of chemical constituents in 1998. None of the pollutants tested exceeded the state standards, and most pollutant concentrations were below the laboratory detection limits.	
High levels of bacteria in watershed streams and effect of this on residents	All of the watershed streams, both during base flow and following a storm event, possessed *E. coli* concentrations that exceeded the state standard of 235 cfu/100mL.	6
Social		
Ditch assessment for property owners on Howard and Shackelford Ditches	Watershed stakeholders are investigating whether or not property owners on Howard and Shackelford Ditches are being assessed a fee for ditch maintenance.	
The remaining social concerns are not concerns for which data can be collected to confirm or refute the concern. They are simply expressions of a desire for better conditions in the future.		

5.2 <u>Developing Problem Statements</u>

Problem statement development occurred throughout the planning process in an effort to tie watershed stakeholders' concerns with existing data to develop a clear pathway for future work in the Eel River-Tick Creek watershed. The problem statements reflect information gathered throughout the watershed planning process. Details regarding stressors, pollutant sources, and identified hot spots are listed for each problem statement. It should be noted that many of the critical areas are located within the Lake Perry drainages which include Laird Ditch and Tick Creek subwatersheds. It is likely that other critical areas are located within the watershed as the watershed touring process was not exhaustive.

Problem Statement 1: Silt and sediment are degrading and filling the watershed waterbodies and limiting their use for recreation, drainage, and aesthetic purposes. Poor water clarity (poorer than most lakes in Indiana) and elevated turbidity and total suspended solids concentrations document sediment issues within the Eel River-Tick Creek watershed. In total, waterbodies in the Eel River-Tick Creek watershed deliver approximately 1,410 tons of sediment to the Eel River annually. A review of the scientific literature and data collected during the land inventory of the watershed suggest streambank/ravine erosion and land use/land use changes (including active construction sites and areas converted from old field habitat to agricultural land) are likely sources of silt and sediment in the Eel River-Tick Creek watershed. Additional sources of sediment in streams and lakes include unvegetated landscapes such as unvegetated stream banks, active farm fields, and active construction sites. Although not intuitive at first, hardscape (impervious surfaces) such as streets and parking lots can also be contributors of sediment to waterways (Bannerman et al., 1993). Dirt on these surfaces often washes directly to storm drains. Gravel roads can also add sediment to nearby waterways. Specific sources identified within the Eel River-Tick Creek watershed are listed below and displayed in the following figures. Management efforts to reduce sediment input from the Eel River-Tick Creek watershed should focus on the critical areas identified during the watershed tour (Figures 18 and 19).

Stressor: Silt/sediment

Source: Streambank erosion (Figures 20 and 21)
Ravine erosion
Active construction sites
Current land use (lack of buffers)
Changes in land use (future development)
Hydrological changes in watershed (loss of wetlands)
Row crop agricultural areas (especially those farmed on Highly Erodible Soils)
Livestock access locations

Hot spots/Critical areas: Laird Ditch and some ravines between County Road 250 East and County Road 300 East (Figure 20)
Tick Creek south of County Road 200 North (Figure 21)
Residential areas along County Road 300 East
Future residential development sites

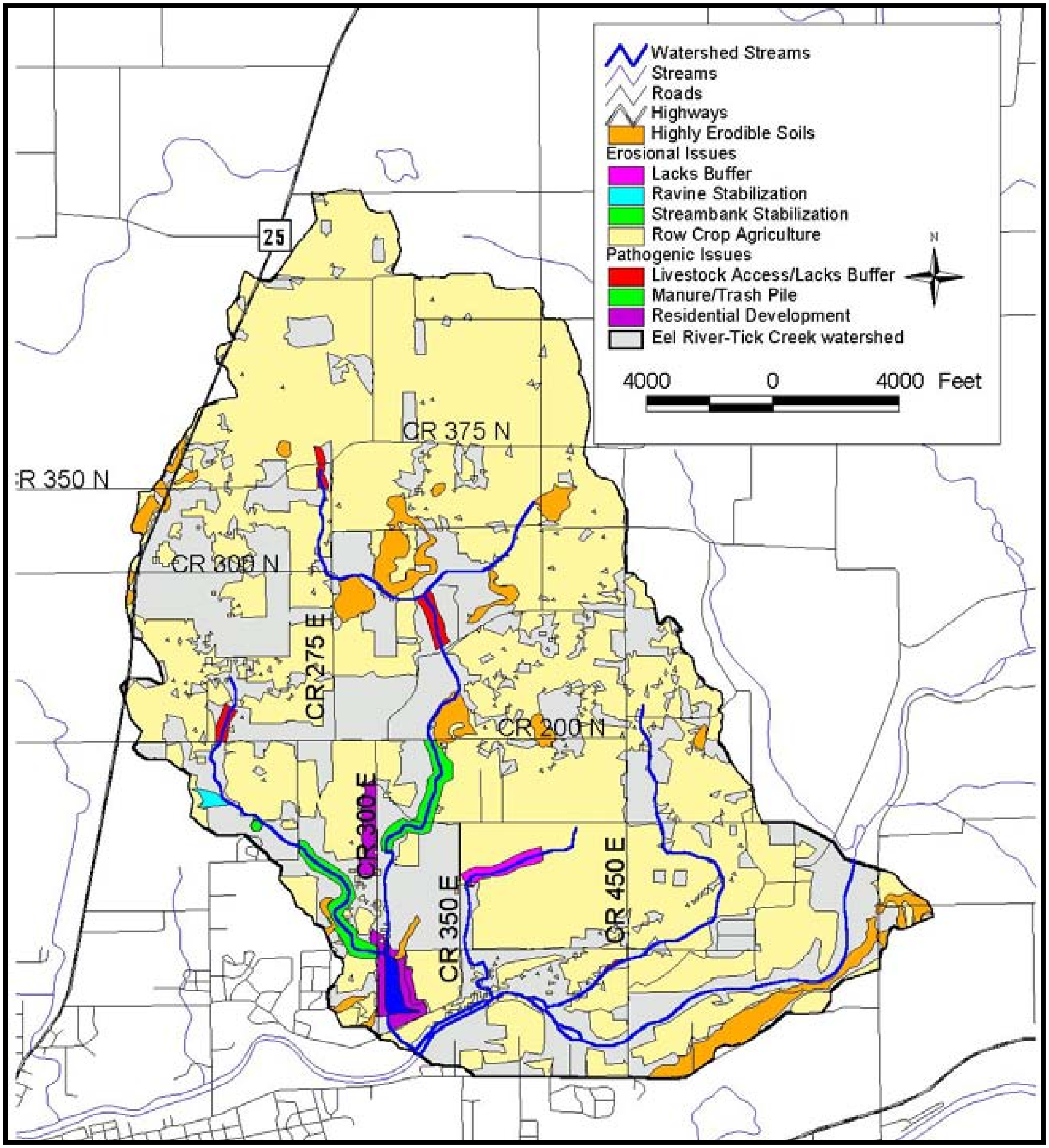

Figure 18. Critical areas targeted for sediment loading reduction in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

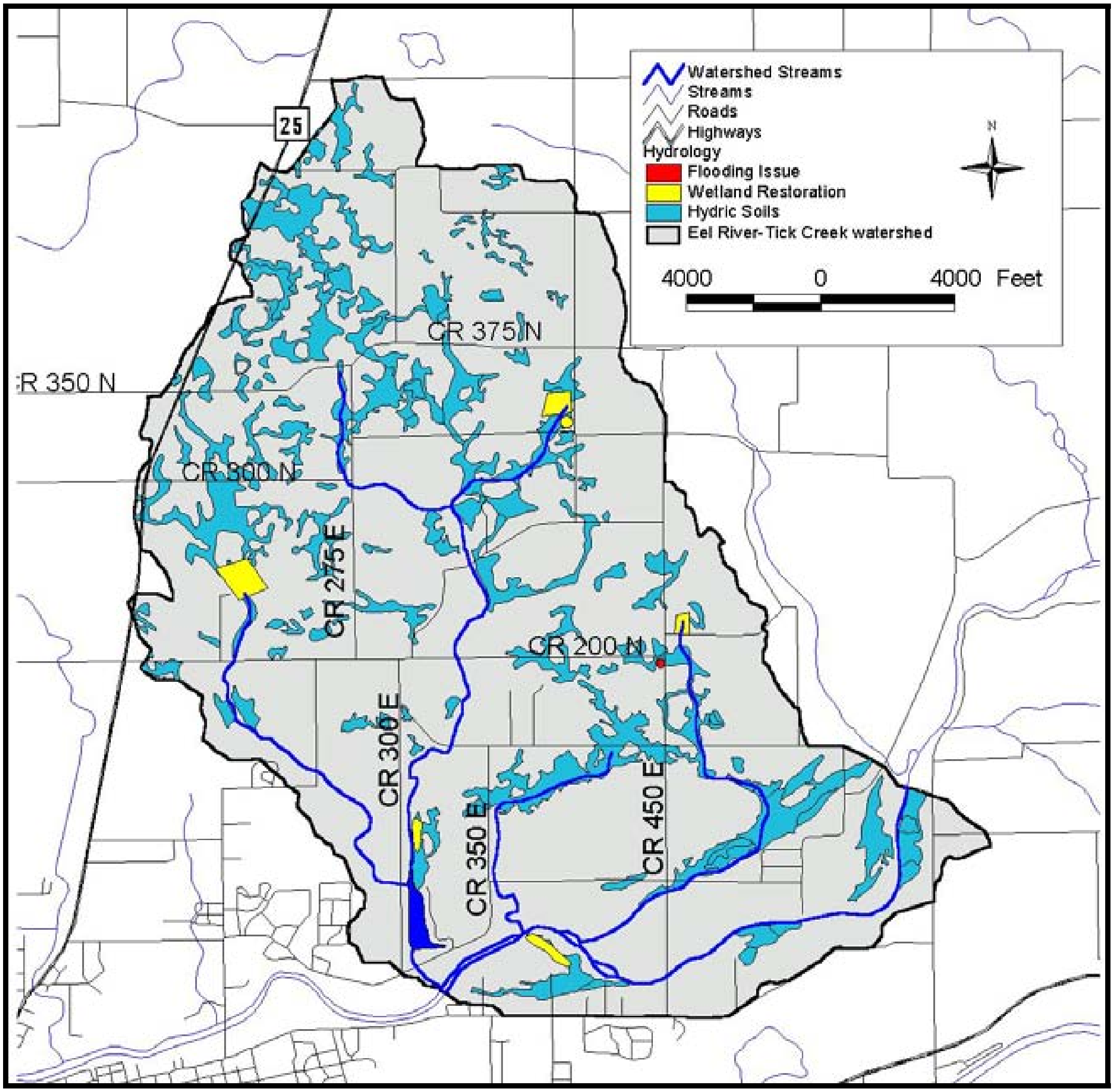

Figure 19. Critical areas targeted for wetland restoration and flood control in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

Figure 20. Streambank erosion along Laird Ditch between County Road 250 East and County Road 300 East.

Figure 21. Streambank erosion along Tick Creek south of County Road 200 North.

Problem Statement 2: Flooding is preventing some landowners from fully utilizing their property. Damaged tiles that have not received proper care and maintenance are the primary cause for the flooding.

Stressor: Flooding

Source: Disrepair of tiles

Hot spots/Critical areas: Near the intersection of County Road 200 North and County Road 450 East (Figure 19)

Problem Statement 3: Many watershed stakeholders lack important knowledge regarding how to manage their individual properties to protect or improve water quality of nearby waterbodies.

Stressor: Lack of knowledge

Source: A specific watershed location cannot be identified as a source for this problem statement.

Hot spots/Critical areas: Residential property owners
Agricultural property owners not currently working with NRCS

Problem Statement 4: Many watershed stakeholders are unaware of the planning process or lack the knowledge of the existence of the watershed group.

Stressor: Lack of knowledge

Source: A specific watershed location cannot be identified as a source for this problem statement.

Hot spots/Critical areas: Residential property owners
Agricultural property owners
Cass County employees and officials

Problem Statement 5: Dense algal populations are limiting the recreational and aesthetic use of Lake Perry. Poor Secchi disk transparency (poorer than most lakes in Indiana), elevated chlorophyll *a* concentrations (three times higher than more than most lakes in Indiana), and dominance by blue-green algae provide evidence of algal populations within Lake Perry. Furthermore, nitrate-nitrogen and total phosphorus concentrations present within the inlet streams exceed levels identified by the Ohio EPA as levels at which biotic impairment occurs (Ohio EPA, 1999). Additionally, total phosphorus concentrations present within the lake and inlet streams exceed the level at which the waterbodies are considered eutrophic (Carlson, 1977; Dodd et. al, 1998, respectively). The primary cause of this problem is high levels of nutrients in the lake's water column. Likely sources of these pollutants include fertilizers, human and animal waste, organic materials, yard waste and other plant material that reaches the waterbody, soil (nutrients are often attached to the soil), hardscape, internal lake processes, and atmospheric deposition. A tour of the watershed and mapping of the watershed revealed that all of these sources as well as some others may contribute to the eutrophication of the lake and streams in the watershed. Fertilizers are commonly used in variety of settings. Specific hot spots or critical areas were identified throughout the planning process (Figure 22). Management efforts aimed at reducing nutrient loading to the watershed's waterbodies should target these sources.

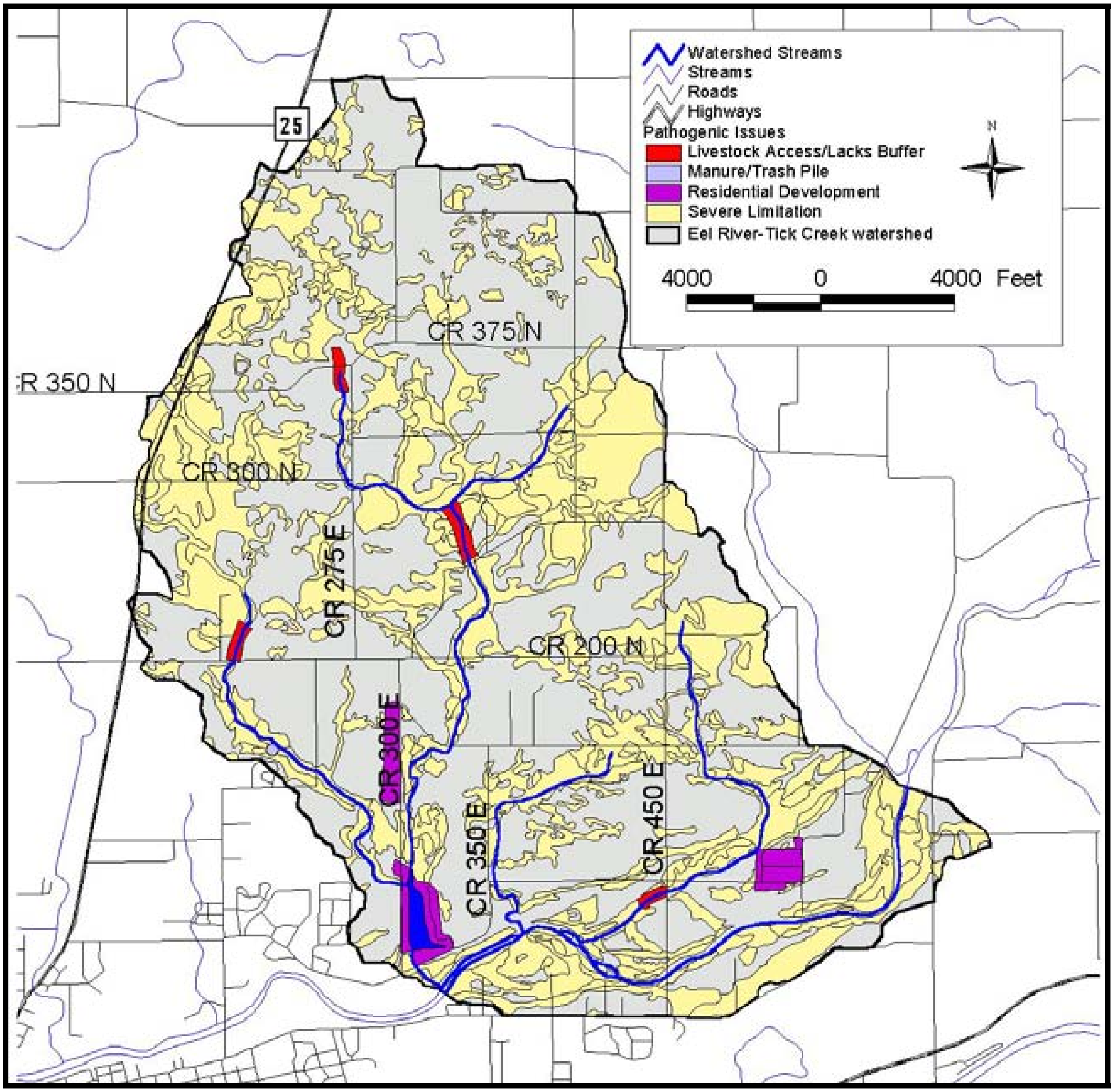

Figure 22. Critical areas targeted for nutrient loading and pathogen concentration reduction in the Eel River-Tick Creek watershed. Source: See Appendix A. Scale: 1"=4,000'.

Stressor: Nutrients

Source: Fertilizers
Human and animal waste
Organic materials
Soil erosion

Hot spots/Critical areas: Residential land – particularly immediately adjacent Lake Perry or its two inlets (Laird Ditch and Tick Creek)
Manure disposal behind 4-H
Failing septic systems – particularly any adjacent to watershed waterbodies (Mapped in Figure 22 as soils with Severe Limitation)
Livestock access points (Figure 23)
Improper disposal of yard waste
Future residential development sites

Figure 23. Representative location where livestock have access to waterbodies within the Lake Perry subwatershed.

Problem Statement 6: Pathogen levels in the watershed streams are high enough to be a human health concern. *E. coli* indicates the presence of pathogenic organisms in the water. *E. coli* concentrations measured in the watershed waterbodies exceed the Indiana state standard at all sites during both base and storm flow events. Pathogenic organisms can potentially harm the biota living in the stream. Such organisms can also make humans who come in contact with the water sick. Currently, none of the watershed streams meet the state standard for *E. coli*, an indicator for pathogens. Common sources of *E. coli* include human and wildlife wastes, fertilizers containing manure, previously contaminated sediments, septic tank leachate, and illicit connections. The potential sources of pathogens in the Eel River-Tick Creek watershed include failing or poorly sited/maintained septic systems and wildlife, livestock, and domestic animal waste. Specific hot spots or critical areas were identified throughout the planning process (Figure 22). Management efforts aimed at reducing nutrient loading to the watershed's waterbodies should target these sources.

Stressor: *E. coli* (pathogens)

Source: Human and animal (domestic, livestock, wildlife) waste

Hot spots/Critical areas: Livestock access to streams (Figure 24)
Manure disposal behind 4-H
Failing septic systems – particularly any adjacent to watershed waterbodies (The Cass County Health Department has not documented any failed septic systems within the Eel River-Tick Creek watershed (personal communication).)

Figure 24. Representative location where livestock have access to waterbodies within the Shackelford Ditch subwatershed.

5.3 Identifying Potential Goals

For each of the problem statements developed throughout the planning process, a potential goal was developed and potential technique identified to assist in the reaching the goal. During the identification stage, goals were listed (see below) following the same pattern as that identified during the problem statement development stage. During the March 8, 2005 public meeting, watershed stakeholders reviewed and refined the goals, then prioritized the goals based on order of importance. From a discussion that occurred during the June 7, 2005 public meeting, a sixth goal was developed. This goal targets the inclusion of more watershed stakeholders and community members in the planning and implementation process. The goals and potential techniques listed below were refined, then utilized as a basis for the goals, objectives, and action items that were developed later in the planning process. The goals are listed below in the order that they were developed; hereafter goals are listed as prioritized by watershed stakeholders.

Potential Goal 1: We want to reduce the sediment load to the waterbodies within the Eel River-Tick Creek watershed by 50% over the next five years.

Potential Techniques:
a. Streambank stabilization (biolog installation, Palmiter techniques, soil encapsulated lifts)
b. Ravine and gully stabilization (check dams, rip rap, filter cloth, vegetation)
c. Erosion control ordinance
d. Ditch buffers/grassed waterways
e. Open space ordinance
f. Wetland restoration (to reduce stress on stream bed and banks)

Potential Goal 2: We want to repair and maintain existing drainage tiles to ensure property owners have full use of their land.

Potential Goal 3: Within two years, each land owner within the watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Potential Techniques:
a. Outreach (Newsletters, newspaper column, field days, web site, demonstration projects)

Potential Goal 4: We want to reduce the nutrient load reaching Lake Perry by 50% over the next 10 years.

Potential Techniques:
a. Lakeside land management (develop lake side buffers, use phosphorus free fertilizers, proper yard and pet waste disposal, restricting car washing)
b. Address 4-H problem
c. Residential land management (use phosphorus free fertilizers, proper yard and pet waste disposal)
d. Wetland restoration immediately upstream of Lake Perry
e. Some of the same techniques listed under Goals 1 and 5

Potential Goal 5: We want to reduce the concentration of *E. coli* within the waterbodies in the Eel River-Tick Creek watershed so that water within the streams and lake meets the state standard for *E. coli*.

Potential Techniques:
a. Address 4-H problem
b. Replace failing septic systems; Connect with city sewer lines
c. Restrict livestock access to streams
d. Proper disposal of pet waste

Potential Goal 6: We want to increase participation by all stakeholders including local natural resources agencies/representatives, possibly resulting in the formation of a watershed group.

Potential Techniques:
a. Outreach (Newsletters, newspaper column, field days, web site, demonstration projects)

6.0 SETTING GOALS AND MAKING DECISIONS

The following goals and action plan are a result of several public meetings. Once the watershed inventory was completed and the baseline water quality data was reviewed, watershed stakeholders met to identify those issues that were of greatest concern in the watershed, develop problem statements, identify sources of water quality and watershed impairment, and set goals to address those issues. The sources identified through this process are the ones targeted in the action plan. The plan includes measures to address each of the identified sources in the agricultural community and from residential and county-owned land. The plan also includes mechanisms to help identify and pinpoint additional sources where not enough existing data could be identified.

As noted above, the stakeholders prioritized the goals over the course of two public meetings. Each stakeholder prioritized the goals individually. The results of the individual prioritizations were combined to achieve a final prioritization order. Stakeholders almost unanimously saw the need for increased participation in watershed management as critical to implementing the plan. The relatively small number of stakeholders who participated in the watershed plan's development was not enough to implement the plan. Thus, stakeholders elected to write an additional goal aimed at increasing participation in watershed management and give this goal the number one priority. All watershed management efforts will focus on achieving this goal before focusing on efforts to achieve the other plan goals.

Stakeholders considered the environmental, economic, and social impacts of their actions. As noted above the action plan was designed to target the specific stressors of concern (nutrients, sediment, flooding, *E. coli*) to improve the environmental quality of the streams and lake in the watershed. Stakeholders took economic concerns into consideration by designing a management plan that for the most part could be implemented by active volunteers. Additionally, the monitoring of the success of the plan could also be completed by volunteers. (See the MEASURING SUCCESS Section.) Most of the actions items that cannot be completed by a volunteer work force can potentially qualify for funding from a known source. This funding might be used to hire a consultant to complete the work that volunteers cannot undertake. The social impact of the plan was considered in the first goal. Stakeholders agreed increased stakeholder involvement in watershed management was of primary importance. The action plan also includes a number of action items designed to increase the public's awareness of the value of the natural resources in the Eel River-Tick Creek watershed.

The following are the prioritized goals and agreed upon action plan for the Eel River-Tick Creek watershed:

Goal 1: We want to increase participation by all stakeholders including local natural resources agencies/representatives, resulting in the formation of a watershed group.

Goal time frame: Except for annual/continuous tasks, the goal should be reached by Fall 2006. Objectives and action items required to meet Goal 1 are listed in Table 18.

Table 18. Goal 1 objectives and action items.

Objective	Action Item
Establish a group to generate interest in the plan and implementation	Contact possible core group members including the local IDNR conservation officer, local high school biology teacher, Lake Perry Estates Corporation members, Cass County Planning Commission representatives, Cass County SWCD representatives, local IDNR resource specialist, regional IDNR fisheries biologist, and Ducks Unlimited
Organize a watershed group to discuss issues and concerns	Advertise the formation of the group via the local newspapers and mailings
	Hold regular meetings
	Invite resource professionals to attend watershed group meetings
	Publish meeting minutes via an email list, newsletter, and/or web site posting
Participate in the Hoosier Riverwatch program	Identify groups that may be interested in participating in Riverwatch
	Identify landowners that would be willing to allow a group to conduct Riverwatch sampling on their property
	Attend a Riverwatch training session
	Advertise results of the work to the community through various forms of media
Participate in the Indiana Clean Lakes volunteer monitoring program	Continue working through the Lake Perry Estates Corporation to maintain a lake monitoring volunteer for Lake Perry
	Advertise results of the work to the community through various forms of media

Goal notes: As a small group of individuals have attended all of the watershed planning meetings to date, these individuals will likely be charged with maintaining the current attendance standard and will need to work with other community members to boost interest and participation in project implementation phase of this project. The core group of individuals working on planning in the Eel River-Tick Creek watershed should always contain a representative from the Lake Perry Estates Corporation and from the Cass County SWCD. Meeting this goal requires that a core group of individuals begin implementation of this plan and that these individuals meet at least on a quarterly basis.

Associated cost: With the exception of time costs, there are no real costs associated with this goal. The Cass County SWCD maintains a set of Hoosier Riverwatch sampling equipment, which the Eel River-Tick Creek watershed group could borrow for use during stream monitoring. The Indiana Clean Lakes Program provides lake monitoring equipment to the Lake Perry Estates Corporation free of charge.

Estimated load reduction: A load reduction cannot be attributed to this goal or any of its objectives or action items.

Potential targets: This goal targets the entirety of the Eel River-Tick Creek watershed and all of the individuals which live within it. This goal is designed to bring together community members, county officials, and individuals living in the Eel River-Tick Creek watershed. Their work towards forming a cohesive group directed at improving water quality and way of life within the Eel River-Tick Creek watershed will provide longevity for the Eel River-Tick Creek Watershed Management Plan.

With no action: If the Eel River-Tick Creek watershed group does not continue to meet, then there will be no checks or balances on any of the activities identified as part of this plan. Likewise, individual's completing work items through this plan will not have a forum to discuss successes or failures. Additionally without an established watershed group, a mechanism to implement projects related to this plan or to review and update the plan will not be in place.

Objective 1: Establish a core group of individuals willing to generate interest in the watershed management plan and coordinate and oversee the implementation of the plan.

Actions:

- Contact possible core group members including the local IDNR conservation officer, local high school biology teacher, Lake Perry Estates Corporation members, Cass County Planning Commission representative, Cass County SWCD representative, local IDNR resource specialist, regional IDNR fisheries biologist, and Ducks Unlimited.

Objective 2: Organize a watershed group to discuss the watershed management issues and water quality concerns in the watershed.

Actions:

- Advertise the formation of the group via the local newspapers and mailings to stakeholders using the existing stakeholder database.
- Hold regular meetings to discuss and address water quality issues in and around the Eel River-Tick Creek watershed.
- Biannually, invite local, regional, and state natural resource professionals to attend watershed group meetings. Have the invited speakers speak on local and state efforts/events to improve water quality (including regulatory efforts) and resources available to help watershed groups.
- Publish meeting minutes via an email list, newsletter, and/or web site posting. These publications should include information detailing current and future efforts for improving water quality and the aesthetic value of Lake Perry and its watershed and information on how stakeholders can participate in these efforts.

Objective 3: Participate in the Hoosier Riverwatch program.

Actions:

- Identify groups (local schools, girl/boy scouts, girls and boys club, 4-H, etc.) that may be interested in participating in Riverwatch.
- Identify landowners along Eel River-Tick Creek watershed tributaries that would be willing to allow a group to conduct Riverwatch sampling on their property. Target property owners at sites sampled during development of the watershed management plan.
- Attend a Riverwatch training session.
- Advertise results of the work to the community through various forms of media mentioned in Objective 2.

Objective 4: Participate in the Indiana Clean Lakes volunteer monitoring program.

Actions:

- Continue working through the Lake Perry Estates Corporation to maintain a lake monitoring volunteer for Lake Perry.
- Advertise results of the work to the community through various forms of media mentioned in Objective 2.

Goal 2: Within two years, each land owner within the watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Goal time frame: Except for annual or continuous tasks, the goal should be reached by 2007. Objectives and action items required to meet Goal 2 are listed in Table 19.

Table 19. Goal 2 objectives and action items.

Objective	Action Item
Organize one annual field day highlighting lake and stream values and protection	Identify members of the agricultural community that currently implement conservation projects
	Invite local experts to speak at field day
	Advertise the field day via newsletters, press release, and watershed stakeholders
Publicize the value of the watershed and ways to protect water quality and aquatic life	Develop list of BMPs for agricultural land
	Develop list of BMPs for residential land
	Summarize value of the watershed and watershed group
	Publish annual newsletter highlighting this information
	Develop a website highlighting this information
Work with NRCS, SWCD, and agricultural property owners to promote BMP's	Identify property owners using conservation land programs.
	Hold one agricultural demonstration day annually to highlight landowners
	Attend one local SWCD meeting annually
Work with NRCS, SWCD and residential property owners to promote BMP's	Develop a list of activities that residential property owners can do
	Hold one demonstration day annually on residential property
	Develop list of grants for residential water quality projects
Establish and maintain a watershed and water quality table at the Cass County Fair	Talk to fair representatives to establish a table or booth
	Develop program materials and handouts
	Develop group to manage table or booth during fair

Goal notes: This goal is targeted at educating individual stakeholders within the Eel River-Tick Creek watershed. The actual implementation of the practice or technique will be handled by the landowner themselves. Specific grants or cost-share programs may be available for the implementation of these practices or techniques. However, as all of the objectives and action items target education, associated costs for this goal also target education not implementation.

Associated costs: All of the tasks associated with this goal will utilize personnel time. Actual dollar costs associated with newsletter production, stakeholder database maintenance, website development, and booth space rental at the Cass County Fair are low; likely total less than $5,000 over the next two years.

Estimated load reduction: There is no exact load reduction that can be calculated for this goal. As this goal deals specifically with education, pollutant load reduction is not the ultimate goal. However, as many of the implementation tasks will result in a reduction in pollutant loads and the volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented, the following information sources provide a range of pollutant load reduction values. Current research suggests that the installation of structural management practices, such as wetland restoration or streambank stabilization, may remove more than 80% of the sediment and approximately 45% of the nutrients (Winer, 2000; Claytor and Schueler, 1996; Metropolitan Washington Council of Governments, 1992). Olem and Flock (1990) report 60 to 98% reduction in sediment loading and 40 to 95% reduction in phosphorus loading as a result of utilizing conservation tillage methods. Buffer strips can reduce up to 80% of the sediment and 50% of the phosphorus in runoff according to the Conservation Technology Information Center (2000). Removal efficiencies depend upon site conditions and factors related to the structure's design, operation, and maintenance. Nutrient removal efficiencies differ depending upon the form of the nutrient measured. For example, total phosphorus removal efficiencies are often greater than ammonia-nitrogen removal efficiencies.

Potential targets: The entire watershed and all of the watershed landowners (residential and agricultural) are targeted by this goal.

With no action: With no additional education, watershed landowners will continue to be informed by the Lake Perry Estates Corporation and by the Cass County SWCD and NRCS offices. However, it is unlikely that each and every landowner within the watershed will learn and/or implement a water quality improvement project as they will not all be exposed to the educational materials. Without the installation of water quality improvement projects, it is unlikely that water quality within the Eel River-Tick Creek watershed will improve.

Objective 1: Organize and hold one annual field day highlighting the value of the streams and lakes in the Eel River-Tick Creek watershed and how to protect the water quality and aquatic life of the watershed.

Actions:

- Work with the NRCS and SWCD representatives to identify members of the agricultural community in the watershed who are participating in a conservation program or utilizing conservation tillage. Work with those individuals to hold demonstrations on their properties.
- Invite IDNR biologists or other experts to speak at field days, particularly concerning the value of the waterbodies of the Eel River-Tick Creek watershed.
- Advertise the field days via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database and SWCD contacts.

Objective 2: Publicize the value of the Eel River-Tick Creek watershed, its waterbodies, and of ways to protect its water quality and aquatic life through various forms of media.

Actions:

- Develop a list of "Best Management Practices" that protect water quality in nearby waterways for agricultural land.
- Develop a list of "Best Management Practices" that protect water quality in nearby waterways for residential land.
- Summarize the value of the Eel River-Tick Creek watershed and the Eel River-Tick Creek watershed group in language understood by a non-technical audience.
- Publish an annual newsletter containing information outlined in the first three action items of this objective.
- Develop a web site containing information outlined in the first three action items of this objective.

Objective 3: Work with the NRCS, SWCD, and agricultural property owners in the watershed to promote water quality Best Management Practice in the watershed.

Actions:

- Work with the NRCS and SWCD to identify which property owners in the Eel River-Tick Creek watershed are using conservation tillage methods and/or land conservation programs. Where possible or appropriate, assist the NRCS and SWCD in encouraging agricultural property owners not using conservation tillage or not participating in conservation programs to utilize these programs.
- Work with NRCS and SWCD representatives to hold one demonstration day annually on properties where landowners are implementing conservation tillage methods and/or land conservation programs. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Attend local SWCD meetings.

Objective 4: Work with the NRCS, SWCD, and residential property owners in the watershed to promote residential water quality Best Management Practices in the watershed.

Actions:

- Work with the NRCS and SWCD to develop a list of potential activities that residential property owners can do to improve water quality within the Eel River-Tick Creek watershed.
- Work with NRCS and SWCD representatives to hold one demonstration day annually on residential properties where landowners are implementing water quality improvement projects. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Locate and develop a list of potential grant monies for residential water quality improvement project implementation.

Objective 5: Establish and maintain a watershed and water quality education table at the Cass County Fair.

Actions:

- Talk with fair representatives to determine the feasibility of establishing a table or booth at the Cass County Fair to target watershed and water quality education.
- Work with the NRCS, SWCD, and IDEM Project Manager to develop program materials and handouts for the table or booth.
- Establish a core group of individuals to manage the table or booth during the fair and provide educational information to attendees on the watershed, water quality, and the watershed management planning process.

Goal 3: We want to reduce the sediment load to the waterbodies within the Eel River-Tick Creek watershed by 50% over the next five years.

Goal time frame: Except for annual or continuous tasks, the goal should be reached by 2010. Objectives and action items required to meet Goal 3 are listed in Table 20.

Associated costs: Many of the tasks associated with this goal will utilize personnel time. Actual dollar costs associated with education of watershed stakeholders, local developers, and county employees and officials are quite low. Cost estimates for streambank stabilization total $60,000, while final cost estimates for the wetland restoration and buffer installation projects are included as an action item for those objectives.

Estimated load reduction: Estimated load reductions can be calculated for only two of the seven objectives associated with this goal. For the remaining objectives and action items, an exact load reduction cannot be calculated. As mentioned above, the volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented. Estimates for potential sediment load reduction associated with wetland restoration, conservation tillage, and buffer/filter strips are detailed above. As detailed above, removal efficiencies will depend upon site conditions and factors related to the structure's design, operation, and maintenance. The expected load reductions associated with those objectives for which loads can be calculated are listed under each of the objectives.

Potential targets: Specific targets associated with this goal include two areas of streambank/ravine stabilization along Laird Ditch and Tick Creek as indicated in Figure 18. Two potential wetland restoration projects were identified during the watershed planning process. Those areas, as well as all of the hydric soils, are potential wetland restoration sites. These areas are also mapped in Figure 19. All other objectives target the entirety of the Eel River-Tick Creek watershed in some way.

Table 20. Goal 3 objectives and action items.

Objective	Action Item
Implement stabilization techniques along Laird Ditch and Tick Creek	Contact landowners regarding using their land
	Apply for funding for Laird Ditch stabilization
	Apply for funding for Tick Creek stabilization
	Hire engineer to complete designs
	Hire contractor to install stabilization design
Reduce erosion from active construction sites	Become familiar with erosion control practices
	Work to require erosion control on all construction sites
	Implement strict erosion control ordinances
	Work to ensure that Rule 5 is being implemented at all applicable sites
	Develop recognition for county builders implementing erosion control practices
Implement soil conservation practices in rural and agricultural areas	Identify agricultural producers using conservation practices
	Host annual demonstration day targeting conservation practice implementation
	Apply for cost-share funding to install practices
	Conduct on annual field day to demonstrate conservation practices
Restore the watershed's wetlands	Work to understand hydrology in a wetland
	Contact landowners to re: feasibility
	Develop a restoration plan for the wetlands
	Design the wetland restorations
	Determine necessity of species control
	Identify and apply for funding
Improve the buffer around Lake Perry	Educate homeowners about shoreline buffers
	Develop a planting plan for Lake Perry
	Discuss the feasibility of improving the buffer
	Select appropriate demonstration project sites
	Apply for funding to conduct planting
	Hold a volunteer field day to plant buffer
	Develop recognition system
Increase awareness of development in the watershed	Establish a good working relationship with county officials
	Attend one Cass County planning meeting annually
Encourage county officials to maintain buffers along legal drains	Meet with Cass County Surveyor to determine the maintenance schedule for legal drains within the watershed
	Attend one Cass County Drainage Board meeting annually
Monitor sediment load in the watershed streams and water clarity in Lake Perry.	Identify individuals to complete monitoring training.
	Complete monitoring on a monthly or quarterly basis.
	Maintain a water quality sampling database
	Compare results from sampling.
	Publish sampling results

With no action: If water quality improvement projects, such as streambank or ravine stabilization, wetland restoration, buffer enhancement along Lake Perry and watershed streams, or soil erosion reduction practices, are not implemented it is anticipated that sediment loading will likely remain at its current levels or increase as erosion continues throughout the watershed. Based on load reduction calculations for streambank or ravine stabilization alone, it is anticipated that 100s of tons of sediment enter the Eel River-Tick Creek watershed. If stabilization is not completed, it is likely that erosion and sediment transport will continue from these and other sites within the Eel River-Tick Creek watershed.

Objective 1: Implement streambank/ravine stabilization techniques along Laird Ditch and Tick Creek.

Estimated load reduction: The current sediment load carried by Laird Ditch as estimated by two field samplings (base and storm flow) is 12.5 kg/d (5 tons/yr). Using IDEM's load reduction worksheet (Steffen, 1982), it is estimated that stabilizing half of the streambanks along the approximately 5,200 lineal feet of Laird Ditch identified for stabilization will result in a sediment load reduction of approximately 4 tons/yr or reduce sediment loading by greater than 50%. Stabilizing larger portions of the streambank or ravine will likely result in a larger sediment loading reduction. Similarly, the current sediment load as estimated by Tick Creek is 34.8 kg/d (14 tons/yr). Using IDEM's load reduction worksheet, it is estimated that by stabilizing half of the streambanks along the approximately 4,700 lineal feet of Tick Creek will result in a sediment load reduction of 12.6 tons/yr; a reduction of nearly 90% of the sediment loading within Tick Creek. As mentioned for Laird Ditch above, stabilizing larger portions of the streambank will likely result in a greater reduction. It should be noted that the measured total suspended solids is an estimate of the annual load rather than a calculation of it. It was estimated from the two sampling events. Consequently there is likely error associated with the estimate. Regardless, it is reasonable to expect a reduction in total suspended solids if the banks along the eroding portions of Laird Ditch and Tick Creek are stabilized.

Estimated cost: The total cost for streambank stabilization along Laird Ditch and Tick Creek will depend upon the specific technique implemented. The specific technique implemented will depend upon the specific location and degree of erosion at that location. Cost estimates are provided for installation through a cost-share grant program with the Cass County SWCD using volunteer labor and for installation through a contractor. The following list details estimated costs per lineal foot for each bank stabilization technique as estimated by JFNew (2005): Palmiter methods-$45/foot without volunteer labor, $10/foot with volunteers; coir fiber logs (with plants)-$55/foot without volunteer labor, $20/foot with volunteers; willow staking, fascines, or mats-$35/foot without volunteer labor, $5/foot or less with volunteers; bank reshaping, erosion control blanket and seeding-$25/foot without volunteer labor, $10/foot with volunteers; and soil encapsulated lifts-$75/foot without volunteer labor, $35/foot with volunteers. In total, it is estimated that the stabilization of the entire length of the two project reaches is $60,000-160,000.

Actions:

- Contact the respective landowners to determine their willingness to allow streambank/ravine stabilization projects.
- Apply for Indiana Department of Environmental Management Section 319 Supplemental funds or Indiana Department of Natural Resources Lake and River Enhancement Program funds to implement streambank stabilization techniques along Tick Creek.
- Apply for Indiana Department of Environmental Management Section 319 Supplemental funds or Indiana Department of Natural Resources Lake and River Enhancement Program funds to implement ravine stabilization techniques along Laird Ditch.
- Once funding is obtained, hire an engineer to complete stabilization designs.
- Once the project is designed, hire a contractor to complete structural stabilization technique installation.

Objective 2: Reduce erosion from active construction sites.

Objective notes: This objective deals with the both the education of the watershed group and of developers in the area. As such, specific on-the-ground implementation tasks are not a part of this objective. Future iterations of the Eel River-Tick Creek Watershed Management Plan should account for any potential implementation practices and associated costs and sediment load reduction as information becomes available.

Actions:

- Become familiar with typical erosion control practices used at both small (1 acre) and large (>5 acres) construction sites.
- Work with county officials to require erosion control on all construction sites regardless of whether it is required by the state under Rule 5.
- Work with county officials to implement strict erosion control ordinances that include provisions requiring site clearing to be done in phases, eliminating the possibility of complete site clearing.
- Work with state and county officials to ensure that Rule 5 is being adhered to at all sites under which it is applicable.
- Develop a system of recognition for county builders actively implementing erosion control practices on active construction sites.

Objective 3: Implement soil conservation practices in rural and agricultural areas of the Eel River-Tick Creek watershed including conservation tillage, grassed waterways, vegetated stream buffers, and other structural Best Management Practices, as necessary and needed.

Objective notes: As indicated under Goal 2, the specific items that are identified and subsequently implemented will determine the implementation cost and sediment load reduction. As this objective is again targeted at cataloging and educating stakeholders rather than the specific implementation of practices, there is no load reduction associated with this objective.

Actions:

- Identify agricultural producers who are using no-till and other conservation practices.
- Facilitate interaction between those producers using conservation practices and other landowners interested in adopting conservation practices by hosting one demonstration day annually.
- Apply for cost-share funding to install practices.
- Conduct one annual field day to demonstrate practices for agricultural producers and watershed residents.

Objective 4: Restore the watershed's wetlands, if feasible.

Objective notes: In general, restoring wetlands, where feasible, will increase the storage potential of the watershed. In addition to storing sediment, wetlands serve as groundwater recharge sites and allow the watershed to regain its natural hydrological regime. This helps prevent bed and bank erosion in adjacent streams, since water is stored in wetlands during high flows, thereby protecting the streams from the energy associated with high flows. Two potential wetland restoration projects were identified during the planning process. Individual landowners have expressed a desire to restore wetlands on their properties. However, additional wetland restoration sites may be located throughout the watershed. As such, all of the hydric soils (soils which developed under wetland conditions) are mapped in Figure 19 as target areas. It should be noted that the primary areas targeted by this objective are the wetland restoration sites mapped in Figure 19; however, additional wetland restoration opportunities mentioned above are not being ruled out for restoration opportunities.

Estimated load reduction: No model is available to predict a reduction in sediment loading by restoring wetlands in the watershed. The estimated load reduction notes (above) list general research on pollutant removal rates through wetland restoration. As specifics of wetland restoration opportunities are not yet determined for the Eel River-Tick Creek watershed, load reductions using these values were not calculated as part of this plan.

Estimated cost: Restoring wetlands can range from several thousand dollars to remove tile or upwards of $5,000 per acre if additional excavation is required and/or the area seeded to promote the growth of native species. As exact plans have not been developed for the identified wetland restoration projects, final cost estimates have also not been developed. Therefore, final cost estimates are included as an action item for this objective.

Actions:

- Work with the NRCS District Conservationist to understand the expected hydrology in a restored or constructed wetland.
- Contact landowners where potential wetland restoration and/or creation sites are located to determine their willingness for restoration or creation to occur on their property.
- Work with the IDNR, NRCS, and/or SWCD to develop a restoration plan and cost estimates for the wetlands.
- Design the size, placement, and construction methods required for creating or restoring wetlands in the Eel River-Tick Creek watershed.
- Determine if control of exotic/nuisance species is necessary and control those species with the appropriate method (burning, herbicide, hand pulling, etcetera).
- Identify and apply for funding for restoration or creation of wetlands.
- Obtain permits and landowner permission and hire contractors to restore or create wetlands.

Objective 5: Improve the buffer around Lake Perry.

Estimated load reduction: The sediment load originating from shoreline properties adjacent to Lake Perry was not calculated as part of this project. As such, an estimate of the anticipated load reduction which will occur through the implementation of this objective can not be accurately calculated. However, current literature indicates that shoreline buffers can reduce up to 80% of the sediment and 50% of the phosphorus in runoff (CTIC, 2000).

Cost estimate: Typical costs for installing shoreline buffers range from $5 per lineal foot for emergent plant installation to $50 per lineal foot for more extensive planting and shoreline restoration.

Actions:

- Educate Lake Perry Estates Corporation homeowners about the need for shoreline buffers and their impact on water quality within Lake Perry.
- Work with the NRCS/SWCD to develop a planting plan for the shoreline of Lake Perry. A forested buffer would be best as it would help reduce wind mixing and resuspension of sediments that results from this mixing. However, an herbaceous buffer would also improve on the existing conditions.
- Meet with the appropriate individuals and lake shore owners to discuss the feasibility of improving the buffer around Lake Perry.
- Select appropriate sites to serve as demonstration projects and determine the appropriate buffer improvement technique and plants to be planted.
- Identify and apply for funding to purchase plants and conduct planting.
- Hold a volunteer field day to complete the recommended plantings in and around Lake Perry.
- Develop a system of recognition for Lake Perry residents participating in the shoreline buffer installation program.

Objective 6: Work with Cass County officials to increase awareness of any proposed development within the Eel River-Tick Creek watershed.

Actions:

- Currently, the Eel River-Tick Creek watershed is not experiencing significant development pressure. However, establishing a good working relationship with Cass County planning officials is recommended. Therefore, watershed residents should attend at least one Cass County planning meeting annually.

Objective 7: Encourage county officials to maintain vegetated riparian buffer along legal drains and to reduce the use of chemical applications along Eel River-Tick Creek waterbodies.

Actions:

- Meet with the Cass County Surveyor to determine the maintenance schedule for legal drains within the Eel River-Tick Creek watershed.
- Attend one Cass County Drainage Board meeting annually.

Objective 8: Monitor the sediment load of each of the four Eel River-Tick Creek watershed streams and water clarity (Secchi disk transparency) in Lake Perry.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:

- Identify individuals to complete the Hoosier Riverwatch and Indiana Clean Lakes Program Volunteer Monitoring Program training.
- Complete Hoosier Riverwatch and ICLVMP monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results to allow comparison.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 1) and in the local newspaper.

Goal 4: We want to repair and maintain existing drainage tiles to ensure property owners have full use of their land.

Goal time frame: This is a long-term goal. Watershed stakeholders should continue to work with the associated landowners over the next 10 years. This task should be considered concluded or be reevaluated for other possible solutions in 2015. Objectives and action items required to meet Goal 4 are listed in Table 21.

Table 21. Goal 4 objectives and action items.

Objective	Action Item
Work with landowners to determine solutions to the drainage tile issue	Examine the ecological and economic impact of the existing hydrologic condition
	Propose possible alternative solution and determine methods to address the problem
	Identify and apply for grants
	Complete design and construction
Work with landowners to identify and maintain existing drainage tiles	Identify all existing drainage tiles with the watershed
	Map the existing drainage tile
	Monitor and maintain existing tiles if they break or fall into disrepair

Associated costs: At this time, it is anticipated that a majority of the work associated with this goal includes personnel time. Real dollar cost estimates will need to be determined as individuals work through the objectives and action items associated with this goal. As such, the development of these cost estimates is included as an action item.

Estimated load reduction: This goal predominantly deals with a single flooding and drain maintenance issue. As such, an estimated sediment or nutrient load reduction is not associated with this goal.

Potential targets: Specific targets associated with Objective 1 include a single area near the intersection of County Road 200 North and County Road 450 East in the Shackelford Ditch subwatershed. All landowners within the Eel River-Tick Creek watershed are potential targets for work completed under Objective 2. However, a large portion of the targets for Objective 2 are likely those owners of the watershed's agricultural land. As such, these areas and associated property owners should be targeted prior to work being completed in more populated areas of the watershed.

With no action: If this issue is not resolved, it is anticipated that flooding will continue to occur on the properties identified through Objective 1 (Figure 19). Additionally, the associated landowners will not be able to fully appreciate the use of their property if this goal is not met. It is anticipated that all other landowners would maintain their existing tile; however, assistance from the watershed group in doing so may be welcomed by these individuals. Additionally, it is possible that these tiles will not be maintained and only through work with the watershed group will any maintenance activity occur.

Objective 1: Work with landowners near County Road 200 North and County Road 450 East to determine the current condition and possible solutions to the drainage tile issue in the Shackelford Ditch subwatershed.

Actions:
- Conduct a study examining the ecological and economic impact of the existing hydrologic conditions.
- Propose possible alternative solutions and determine cost-effective methods for addressing the drainage problem.
- Identify and apply for available grant monies to complete the recommended action.
- Complete design and construction for the recommended action including obtaining permits, landowner permission, and easements and hiring contractors.

Objective 2: Work with landowners throughout the Eel River-Tick Creek watershed to identify and maintain existing drainage tiles.

Actions:
- Work with the Cass County Surveyor's office to identify all existing drainage tiles within the Eel River-Tick Creek watershed.
- Map the existing tiles on the watershed maps.
- Work with landowners to monitor and maintain existing tiles if they break or fall into disrepair.

Goal 5: We want to reduce the nutrient load reaching Lake Perry by 50% over the next 10 years.

Goal notes: All objectives and actions completed as listed under Goals 1 and 2 should also improve the likelihood of meeting Goal 5. Those objectives and actions are not listed here again. Please refer to Goals 1 and 2 for additional methods to reduce nutrient loading to Lake Perry. Objectives and action items required to meet Goal 5 are listed in Table 22.

Goal time frame: Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2015.

Associated costs: All of the tasks associated with this goal will utilize personnel time. Actual dollar costs associated with educational tasks are low; likely total less than $5,000 over the next ten years. Livestock restriction is estimated to cost $2 per lineal foot. Posting signage at the 4-H Property should cost approximately $300-500, while installing a vegetated filter could cost $3,000-10,000, and hosting a volunteer day is estimated to cost $2,500. Sediment trap maintenance costs will be determined following the next assessment of their capacity.

Table 22. Goal 5 objectives and action items.

Objective	Action Item
Educate lakeshore residents about what they can do to reduce nutrient loading to the lake	Identify techniques that residents can use to improve water quality.
	Locate or develop educational materials for shoreline BMPs
	Host one annual demonstration day highlighting lakeshore activities
Work with Cass County 4-H program to educate users and reduce sediment, nutrient, and manure loading to Laird Ditch	Post signs at all animal barns regarding manure disposal
	Investigate and obtain funding to install a vegetated filter
	Host a volunteer day to complete planting of the vegetated filter
	Construct a vegetated swale and/or rain garden to filter manure runoff
Restores the watershed's wetlands and maintain the existing or construct additional sediment traps upstream of Lake Perry on Laird Ditch and Tick Creek	Determine amount of sediment in existing sediment traps
	Establish an annual assessment plan
	Remove sediment from the traps
	Determine necessity of additional traps
	Identify grant funding
Promote the usage of alternative fertilizers and/or the reduction in use of fertilizer	Disseminate fertilizers' impact on water quality literature
	Investigate the market potential of phosphorus free fertilizer
Work to identify any failing septic systems and promote proper septic system maintenance in the watershed	Identify any failing septic systems in the watershed
	Develop list of BMPs to reduce pathogenic contamination
	Disseminate BMP information
Restrict livestock access to watershed streams	Identify a feasible solution to restrict livestock access to Tick Creek
	Identify an alternative watering source for the livestock
	Obtain funding for restriction
	Complete the fence installation
Monitor nutrient load in the watershed streams	Identify individuals to complete monitoring training.
	Complete monitoring on a monthly or quarterly basis.
	Maintain a water quality sampling database
	Compare results from sampling.
	Publish sampling results

Estimated load reduction: Existing nutrient loading calculations were completed using phosphorus export coefficients developed by Reckhow and Simpson (1980). It is estimated that the current phosphorus load to Lake Perry is approximately 5,800 kg/ha-yr. As land use changes within the watershed and individuals implement water quality improvement projects, the nutrient load can be re-estimated and the load reduction calculated. Most of the objectives listed under this goal are education and assessment related. As landowners become more educated and implementation plans are developed from the anticipated assessments, it is likely that actual load reduction calculations can be developed. Objectives and action items listed for other goals, specifically Goals 1 and 2, possess associated load reductions, if applicable. Refer to these objectives for the anticipated reduction in nutrient loading to Lake Perry.

Potential targets: Specific targets associated with this goal include educating of lakeshore residents on their contribution to nutrient loading and the use of phosphorus free fertilizer, educating Cass County 4-H volunteers and participants about the use of their manure pile and its impact to the Eel River-Tick Creek watershed, monitoring of the existing sediment traps and assessing future need for additional sediment trap construction, identifying and educating individuals about failing septic systems, and restricting livestock access to Tick Creek as indicated in Figure 22. Essentially, all watershed residents and user groups are targeted by this goal.

With no action: If water quality improvement projects, such as sediment trap maintenance, manure pile usage at the 4-H Fairgrounds, or livestock fencing upstream of Lake Perry and along watershed streams are not implemented it is anticipated that sediment and nutrient loading will likely remain at its current levels or increase as erosion continues throughout the watershed. If work is not completed, it is likely that erosion and sediment transport will continue from these and other sites within the Eel River-Tick Creek watershed.

Objective 1: Educate lakeshore residents about what they can do to reduce nutrient loading to the lake.

Actions:

- Identify potential techniques that individual lakeshore residents can do personally to improve water quality within Lake Perry. Potential techniques include, but are not limited to, establishing shoreline buffers, utilizing phosphorus-free fertilizer, establishing a protocol for yard and pet waste disposal, and encouraging residents to wash cars away from existing drains which flow directly to the lake.
- Work with the SWCD and IDEM Project Manager to locate or develop educational materials addressing shoreline Best Management Practices.
- Host one annual demonstration day highlighting activities that lakeshore residents can complete on their own.

Objective 2: Work with the Cass County 4-H Program to educate users and reduce sediment, nutrient, and manure loading to Laird Ditch.

Objective notes: It is likely that, once implemented, the educational action items identified for this objective will sufficiently reduce sediment, nutrient, and manure loading to Laird Ditch. The status of the use of the current manure pile should be evaluated prior to designing or constructing a vegetated swale or rain garden to treat runoff. If the pile is no longer is use, then construction of neither a swale nor a rain garden will be necessary. As education efforts should be sufficient to meet this goal, estimated load reductions were not completed during the planning process.

Actions:

- Post signs at all animal barns regarding the use of the compost pile as the appropriate disposal site for manure on the 4-H property.
- Investigate and obtain funding to install a vegetated filter between the existing manure pile and Laird Ditch.
- Host a volunteer day to complete planting of the vegetated filter.
- Identify funding, complete a design, and construct a vegetated swale and/or rain garden system to collect and filter runoff from the existing manure pile before it enters Laird Ditch.

Objective 3: Restore the watershed's wetlands and maintain existing or construct additional sediment traps upstream of Lake Perry on Laird Ditch and Tick Creek.

Objective notes: Goal 3, Objective 4 details the actions necessary to restore the watershed's wetlands; therefore, this objective only list actions required to maintain the existing or construct additional sediment traps along Laird Ditch and Tick Creek. This objective targets restoration of any and all wetlands within the Eel River-Tick Creek watershed. See Goal 3, Objective 4 for more details on wetland restoration possibilities within the Eel River-Tick Creek watershed.

Estimated load reduction: As specific sediment trap locations have not been identified, a specific load reduction cannot be attributed to the installation of these practices. Estimates for sediment and nutrient load reductions associated with wetland restoration are detailed under Goal 3 Objective 4. Additionally, the current sediment traps are designed to reduce sediment loading to Lake Perry. Maintenance of these traps will neither increase nor decrease sediment loading to the lake; it will, however, increase the longevity of these sediment traps.

Cost estimate: An assessment of the current status of the sediment traps will likely be completed with volunteer labor. After the assessment is completed, the group will then need to determine whether the sediment traps require maintenance. As such, a local contractor should be able to provide a cost estimate for any required maintenance or cleaning. Therefore, a cost estimate is not included at this time for maintenance or cleaning of the existing sediment traps.

Actions:
- Work with the Lake Perry Estates Corporation to determine the amount of sediment in the existing sediment traps and to establish a means of cleaning the sediment traps.
- Establish an annual assessment plan to determine the amount of sediment present in each of the sediment traps.
- If necessary, obtain a sediment disposal site and hire a contractor to remove sediment from the existing traps.
- Work with the landowner along Laird Ditch and Tick Creek to determine the feasibility of establishing additional sediment traps.
- Identify potential grant funding available for the creation of the trap(s).
- Obtain the necessary permits, landowner permission, and design plans and hire a contractor to build the trap(s).

Objective 4: Promote the usage of alternative fertilizers and/or the reduction in use of fertilizer.

Estimated load reduction: No actual measurements of soil phosphorus were completed during the planning process. As such, an exact estimate of phosphorus load reduction is not possible. However, Garn (2002) estimated that the use of phosphorus free fertilizer could reduce phosphorus runoff from near shore lawns by as much as 57%.

Actions:

- Disseminate information explaining how fertilizers impact water quality and the importance of reducing fertilizer usage in the watershed via a newsletter, email list, or if possible as a link to the Cass County SWCD web site. Residential watershed stakeholders should be provided information on how to test their soils to determine the need for phosphorus in residential fertilizer applications and how to obtain phosphorus free fertilizer. (The local SWCD can provide soil testing information.)
- Investigate the market potential of phosphorus free fertilizer within the vicinity of the Eel River-Tick Creek watershed. If the market is available, future iterations of the watershed management plan should include methods for marketing phosphorus free fertilizer.

Objective 5: Work with county sanitarian to identify any failing septic systems and promote proper septic system maintenance in the watershed.

Objective notes: Figure 7 suggests much of the watershed is mapped in a soil unit that is considered moderately to severely limited for use as a septic system. The areas mapped in the severely limited soil unit and those closest to the watershed's waterbodies should be targeted first.

Actions:

- Work with the Cass County Health Department to identify any failing septic systems in the watershed, targeting the areas noted above first.
- Develop list/summary of "Best Management Practices" available to reduce the risk of pathogenic contamination of watershed waterbodies. The list should include management techniques that address contamination from all sources, including domestic and wild animals, in the watershed. Additionally, the list should be written in language that is understood by a non-technical audience.
- Disseminate the list/summary of "Best Management Practices" available to reduce the risk of pathogenic contamination of watershed waterbodies via an email distribution list, newsletter, or if possible a link on the Cass County SWCD's web site.

Objective 6: Restrict livestock access to watershed streams.

Estimated load reduction: An exact estimate of sediment and phosphorus loading was not completed for the livestock currently pastured adjacent to Laird Ditch or Tick Creek. As such, it is difficult to estimate a reduction in sediment and phosphorus loading that will result from restricting livestock access to these streams. Using IDEM's load reduction worksheet (Steffen, 1982), it is estimated that livestock access to two areas within the Lake Perry portion of the Eel River-Tick Creek watershed results in and annual loading of 119 pounds of phosphorus to the entire watershed. By fencing livestock out of these three areas, the load reduction worksheet estimates that phosphorus loading would decrease to 36 lbs/yr. This would result in approximately 70% lower phosphorus loading to the Eel River-Tick Creek watershed. Using the same worksheet, it is estimated that livestock access at these locations produces 949 pounds of nitrogen per year. Restricting the livestock from these areas would result in a nitrogen load of 522 pounds per year, or approximately 55% less nitrogen entering the stream from these locations.

Estimated cost: It is estimated that livestock fencing will cost approximately $2 per lineal foot of fencing installed. Additional potential costs include seeding, gate installation, and watering hole construction. Cost estimates for these items are not listed here as associated costs will depend upon the landowner's preference.

Actions:
- Work with the NRCS and the landowner along Tick Creek north of County Road 300 North and east of County Road 275 East to identify a feasible solution to restrict livestock access to Tick Creek.
- Identify an alternative watering source for the livestock.
- Obtain funding to construct the alternative watering source, if necessary, and to install fencing along Tick Creek.
- Hire a contractor to complete the fence installation.

Objective 7: Monitor the nutrient load of each of the Lake Perry tributary streams.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:
- Identify individuals to complete the Hoosier Riverwatch training.
- Complete Hoosier Riverwatch monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 1) and in the local newspaper.

Goal 6: We want to reduce the concentration of *E. coli* within the waterbodies in the Eel River-Tick Creek watershed so that water within the streams and lake meets the state standard for *E. coli* within 10 years.

Goal time frame: This is a long-term goal. The goal should be reached by 2015. The tasks associated with TMDL development are subject to the development schedule of IDEM. This portion of the Eel River is slated for TMDL development from 2013 to 2018. Objectives and action items required to meet Goal 6 are listed in Table 23.

Goal notes: Many of the objectives included for Goals 2, 3, and 5 will also help to reduce the concentration of *E. coli* within the waterbodies of the Eel River-Tick Creek watershed. Completing specific tasks targeting maintenance or management of the manure pile at the Cass County 4-H property; identification of failing septic systems and/or the promotion of proper septic maintenance; establishment of shoreline buffers along Lake Perry and buffer strips adjacent to watershed streams; and livestock restriction from watershed water bodies will increase the likelihood of meeting this goal as well. Other potential tasks should target education of watershed residents and participation in development of the *E. coli* Total Maximum Daily Load (TMDL) for the Eel River watershed.

Table 23. Goal 6 objectives and action items.

Objective	Action Item
Learn more about identifying the sources of *E. coli* from the Total Maximum Daily Load development process for the Eel River	Attend and participate in the Total Maximum Daily Load development process for the Eel River.
	Create and distribute TMDL meeting minutes to watershed stakeholders
Publicize Best Management Practices available to reduce pathogenic contamination of the Eel River-Tick Creek watershed waterbodies	Meet with the Cass County Health Department to discuss BMPs available to maintain septic systems
	Develop a list of BMPs to reduce the risk of pathogenic contamination
	Publish a newspaper article targeting the list or summary of BMPs
Monitor *E. coli* load in the watershed streams and water clarity in Lake Perry.	Identify individuals to complete monitoring training.
	Complete monitoring on a monthly or quarterly basis.
	Maintain a water quality sampling database
	Compare results from sampling.
	Publish sampling results

Associated costs: All of the tasks associated with this goal will utilize personnel time. Actual dollar costs associated with educational tasks are low, totaling less than $5,000 over the next ten years.

Estimated load reduction: As this is an educational goal and all implementation projects are included as part of Goals 2, 3, and 5. Additionally, this goal deals with a reduction in concentration not load. As such, a reduction in load cannot be calculated for this goal.

Potential targets: Specific targets associated with this goal include the entire Eel River-Tick Creek watershed and all of its stakeholders.

With no action: If water quality improvement projects, such as manure pile usage at the 4-H Fairgrounds or livestock fencing upstream of Lake Perry and along watershed streams are not implemented it is anticipated that *E. coli* concentrations will likely remain at their current levels or increase as erosion continues and population levels increase throughout the watershed.

Objective 1: Learn more about identifying the sources of *E. coli* from the Total Maximum Daily Load development process for the Eel River. (The Eel River is on the 303(d) list for *E. coli* contamination.)

Actions:
- Attend and participate in the Total Maximum Daily Load development process for the Eel River.
- Create and distribute TMDL meeting minutes to watershed stakeholders.

Objective 2: Publicize Best Management Practices available to reduce pathogenic contamination of the Eel River-Tick Creek watershed waterbodies.

Actions:

- Meet with the Cass County Health Department to discuss Best Management Practices available to maintain properly functioning septic systems.
- Develop a list or summary of Best management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies. The list should include management techniques that address contamination from all sources, including domestic and wild animals in the watershed.
- Publish a newspaper particle targeting the list or summary of Best Management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies.

Objective 3: Monitor the *E. coli* load of each of the four Eel River-Tick Creek watershed streams.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:

- Identify individuals to complete the Hoosier Riverwatch training.
- Complete Hoosier Riverwatch monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 1) and in the local newspaper.

7.0 MEASURING SUCCESS

Measuring stakeholders' success at achieving their goals and assessing progress toward realizing their vision for the Eel River-Tick Creek watershed is a vital component of the plan. The following describes concrete milestones for stakeholders to reach and tangible deliverables produced while they work toward each goal. Interim measures or indicators of success, which will help stakeholders evaluate their progress toward their chosen goals, are included in the Action Register contained in Appendix G. Monitoring plans, where appropriate, to evaluate whether or not stakeholders have attained their goals are also included below. Because several of the goals are long-term goals (i.e. it will take more than 5 years to attain), regular monitoring is essential to ensure the actions stakeholders take are helping achieve those goals. Monitoring will allow stakeholders to make timely adjustments to their strategy if the monitoring results indicate such adjustments are needed. Finally, potential funding sources for implementing these projects are included in Appendix H.

Goal 1: We want to increase participation by all stakeholders including local natural resources agencies/representatives, possibly resulting in the formation of a watershed group.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2006.)

- Identification of a point person to lead the implementation of the plan.
- Eel River-Tick Creek watershed group formed.
- Watershed group meetings held.
- Watershed group meeting minutes published.
- Watershed group newsletter published.
- Watershed group website developed.
- Website updates noting new members and participants.
- Hoosier Riverwatch volunteer training attended.
- Hoosier Riverwatch data collected and submitted.
- Clean Lakes Program volunteer training attended.
- Clean Lakes Program data collected and submitted.

Goal Attainment: This goal lacks a specific water quality target similar to that which the other goals possess. Rather than being attained this goal will be a continual effort by watershed stakeholders.

Goal 2: Within two years, each land owner within the watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2007.)

- Property owners implementing conservation projects identified.
- Local experts invited to speak at field days.
- Field days advertised and held.
- List of agricultural Best Management Practices developed.
- Value of the watershed and watershed group summarized and promoted.
- Annual newsletter published.
- Group website developed.
- Property owners using conservation land programs identified.
- Agricultural demonstration day held.
- Local SWCD meeting attended.
- List of residential Best Management Practices developed.
- Residential demonstration day held.
- List of grants for residential water quality projects developed.
- Program materials and handouts regarding the watershed group and water quality developed.
- Table or booth established at Cass County Fair.
- Conservation practices implemented.

Goal Attainment: The goal is attained when each landowner learns about and implements one water quality improvement project or technique on his or he property. This does not involve a specific water quality target. Like Goal 1, this goal will be a continual effort by watershed stakeholders. A list of all individuals living within the Eel River-Tick Creek watershed was developed as part of the planning process. This list will be updated to include information on individual's conservation practice history. Additionally, the Eel River-Tick Creek watershed group will use the list to track conservation practice implementation throughout the watershed.

Goal 3: We want to reduce the sediment load to the waterbodies within the Eel River-Tick Creek watershed by 50% over the next five years.

Milestones: (Except for annual or continuous tasks, this goal should be reached by 2010.)

- Landowners contacted regarding streambank stabilization opportunities.
- Funding for streambank stabilization along Laird Ditch obtained.
- Funding for streambank stabilization along Tick Creek obtained.
- Streambank stabilization completed.
- Construction site erosion control practices identified.
- Erosion control ordinances implemented.
- Recognition program for county builders developed.
- Annual conservation program demonstration day held.
- Cost-share funding identified for conservation program implementation.
- Annual field day held.
- Wetland restoration sites identified.
- Wetland restoration designed.
- Funding for wetland restoration obtained.
- Shoreline buffer education provided.
- Planting plan for Lake Perry's shoreline developed.
- Volunteer buffer planting day held.
- Planning commission meeting attended.
- Drainage board meeting attended.

Goal Attainment: The goal is attained when the sediment load in each of the waterbodies in the Eel River-Tick Creek watershed is only half of the current load. This can be measured using either total suspended solids (TSS) or turbidity.
Indicator to be monitored: Sediment loading measuring half of current sediment load within each waterbody.
Parameter assessed: Total suspended solids (streams); water clarity (lake)
Frequency of monitoring: Monthly during the growing season (May-September); Quarterly throughout the remainder of the year.
Location of monitoring: Each stream's sampling point as indicated in Figure 15.
Length of monitoring: The monitoring will be conducted for 5 years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix D) or utilizing the Hoosier Riverwatch protocol for measuring turbidity (Crighton and Hosier, 2004). Lake clarity will be measured using the Indiana Clean Lakes Program Volunteer monitoring protocol (ICLVMP, 2001).
Monitoring equipment: Equipment required for TSS and discharge analysis following the QAPP protocol is identified in Appendix D. For equipment requirements for turbidity measurements using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).

Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter TSS, turbidity, and flow measurements in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 4: We want to repair and maintain existing drainage tiles to ensure property owners have full use of their land.

Milestones: Watershed stakeholders should continue to work with the associated landowners over the next 10 years. (This task should be considered concluded or be reevaluated for other possible solutions in 2015.)

Interim Measures of Success:
- Economic and ecological impact of tile disrepair evaluated.
- Alternative solutions to tile repair proposed.
- Grant opportunities identified.
- Existing tile drains identified.
- Existing tile drains mapped.

Goal attainment: This goal lacks a specific water quality target similar that the other goals possess. Rather than being attained this goal will be a continual effort by watershed stakeholders.

Goal 5: We want to reduce the nutrient load reaching Lake Perry by 50% over the next 10 years.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2015.)
- Techniques that can be used by residents to improve water quality identified.
- Educational materials for shoreline Best Management Practices developed.
- Annual demonstration day (shoreline) held.
- Manure management signs posted at the 4-H ground.
- Vegetated filter designed and funding applied for.
- Volunteer day hosted.
- Vegetated swale constructed.
- Sediment traps assessed.
- Sediment traps cleaned, if necessary.
- Phosphorus free fertilizer promoted.
- Market for phosphorus free fertilizer assessed.
- Failing septic systems identified.
- List of pathogenic Best Management Practices developed.
- Livestock restricted from watershed waterbodies.

The goal is attained when the nutrient load to Lake Perry is reduced by half of its current load.
Indicator to be monitored: Phosphorus and nitrogen loads of less than half the current load for each waterbody.

Parameter assessed: Total phosphorus and nitrate+nitrite, ammonia-nitrogen, and total Kjeldahl nitrogen.
Frequency of monitoring: Monthly during the growing season; Quarterly the remainder of the year.
Location of monitoring: Each stream's sampling point as indicated in Figure 15.
Length of monitoring: The monitoring will occur for five years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix D) or utilizing the Hoosier Riverwatch protocol for measuring total phosphorus and nitrate+nitrite (Crighton and Hosier, 2004).
Monitoring equipment: Equipment required for total phosphorus, nitrate+nitrite, ammonia-nitrogen, total Kjeldahl nitrogen, and discharge analysis following the QAPP protocol is identified in Appendix D. For equipment requirements for total phosphorus and nitrate+nitrite, ammonia-nitrogen, and total Kjeldahl nitrogen measurements using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter total phosphorus, nitrate+nitrate, and flow measurements in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 6: We want to reduce the concentration of *E. coli* within the waterbodies in the Eel River-Tick Creek watershed so that water within the streams and lake meets the state standard for *E. coli* within 10 years.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2015.)

- Total Maximum Daily Load development meetings attended.
- Meeting minutes distributed.
- Meeting with health department held.
- List of pathogenic Best Management Practices developed.
- Newspaper article published.

Goal attainment: The goal is attained when the *E. coli* concentration in each of the watershed waterbodies meets the state standard (235 colonies/100 ml).
Indicator to be monitored: *E. coli* concentration less than 235 colonies/100 ml for each watershed waterbody.
Parameter assessed: *E. coli* concentration
Frequency of monitoring: Monthly during the growing season.
Location of monitoring: Each stream's sampling point as indicated in Figure 15.
Length of monitoring: The monitoring will occur for ten years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix D) or utilizing the Hoosier Riverwatch protocol for measuring *E. coli* (Crighton and Hosier, 2004).
Monitoring equipment: Equipment required for *E. coli* analysis following the QAPP protocol is identified in Appendix D. For equipment requirements for *E. coli* measurement using the

Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter *E. coli* concentrations in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

8.0 FUTURE CONSIDERATIONS

There are several considerations stakeholders should keep in mind as they implement the Eel River-Tick Creek Watershed Management Plan. Many of these considerations are noted in the proceeding sections of this text, but due to their importance, they warrant reiteration.

<u>Permits, Easements, and Agreements</u>
Revegetation of Lake Perimeter: Permission to improve the buffer around Lake Perry (**Goal 3, Objective 5**) through supplemental tree plantings and shoreline/shallow water plantings must be obtained from the property owners before any plantings occur.

<u>Operation and Maintenance</u>
Wetland Restoration: Two wetland restoration projects were identified in the watershed. In the long term, these areas will provide water quality benefits while requiring little maintenance. In the short term, certain management activities may be employed to help these areas recover faster than they would if they were left alone. Such activities included prescribed burns, spot herbicide treatments, and supplemental plantings. These maintenance activities which are designed to increase the plant diversity of the wetland will also increase functionality of the wetland. They also increase the pace of wetland restoration. Additional burns, herbicide spot treatments, and plantings may further increase the wetland's recovery. As wetland recovery progresses, additional maintenance activities may be deemed necessary in the future.

Vegetated Swale: The need for a vegetated filter to filter runoff from the 4-H Fairgrounds was identified as a need in the watershed. Any filtration area built to treat erosion and prevent sediment loading to Laird Ditch will require periodic maintenance. This maintenance simply involves removing any sediment accumulated that prevents proper filtration of the stormwater directed to the area. Sediment accumulation should be checked on an annual basis and actual removal of accumulation is expected to occur once every three to five years.

<u>Monitoring</u>
Monitoring is an important component of this watershed management plan. Without monitoring, stakeholders will not know when or whether they have achieved their goals; or worse, they will not make timely refinements to their actions to ensure the actions they are taking will achieve their goals. The **MEASURING SUCCESS** Section details how stakeholders will monitor their progress toward achieving the goals set in this watershed management plan.

Plan Revisions

This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as other stakeholders become more active in implementing the plan. The LPEC will be responsible for holding and revising the Eel River-Tick Creek Watershed Management Plan as appropriate based on stakeholder feedback. To assist with record keeping and to ensure action items outlined in the plan are being completed, stakeholders should complete the simple Action Tracker form provided in Appendix I. This form should be returned to the LPEC. The LPEC will keep completed action registers in three ring binder and review action registers to ensure tasks are being completed. The forms will also help document the success of actions taken in the watershed.

9.0 LITERATURE CITED

Bannerman, R., R. Dodds, D. Owens, and P. Hughes. 1992. Sources of Pollutants in Wisconsin Stormwater. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Bell, C. (January 29, 2004). [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

Camp, M. and Richardson, G. 1999. Roadside Geology of Indiana. Mountain Press Publishing Company. Missoula, Montana.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22(2): 361-369.

Chamberlain, E. 1849. Cass County Retrospective. In: Branson, R. 2004. Cass County. [web page] Crossroads of America: Early Indiana History. http://www.countyhistory.com/cass [Accessed April 22, 2004]

Claytor, R. A. and T.R. Schueler. 1996. Design of Stormwater Filter Systems. Center for Watershed Protection, Ellicott City, Maryland.

Cogger, C.G. 1989. Septic System Waste Treatment in Soils. Washington State University Cooperative Extension Department. EB1475.

Conservation Technology Information Center. 2000. Conservation Buffer Facts. [web page] http://www.ctic.purdue.edu/core4/buffer/bufferfact.html [Accessed March 3, 2000].

Crighton, L. and J. Hosier. 2004. Hoosier Riverwatch Training Manual. Indiana Department of Natural Resources, Division of Soil Conservation, Indianapolis, Indiana.

Davis, T. (January 29, 2004). [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

Deam, C.C. 1921. Trees of Indiana. Department of Conservation. Indianapolis, Indiana.

DeLorme. 1998. Indiana Atlas and Gazetteer.

Dodd, W. K., J.R. Jones, and E. B. Welch. 1998. Suggested classification of stream trophic state: Distributions of temperate stream types by chlorophyll, total nitrogen, and phosphorus. Wat. Res. 32:1455-1462.

Douglas, W. 1981. Soil Survey of Cass County, Indiana. USDA Soil Conservation Service and Purdue Agricultural Experiment Station.

Garn, H.S. 2002. Effects of lawn fertilizer on nutrient concentrations in runoff from lakeshore lawns, Lauderdale Lakes, Wisconsin. U.S. Geological Survey, Water-Resources Investigation Report 02-1430.

Gray, H. H. 1983. Map of Indiana showing thickness of unconsolidated deposits. Miscellaneous Map 37, Indiana Geological Survey.

Gray, H.H. 1989. Quaternary Geologic Map of Indiana, Indiana Geological Survey Miscellaneous Map 49.

Gray, H.H., Ault, C.H., and Keller, S.J. 1987. Bedrock Geologic Map of Indiana, Indiana Geological Survey Miscellaneous Map 48

Gutschick, R.C. 1966. Bedrock Geology. In: Linsey, A.A. (ed.) Natural Features of Indiana. Indiana Academy of Science, Indiana State Library, Indianapolis, Indiana, p. 1-20.

Hasenmueller, W. A., 2001, Preliminary database of abandoned sand and gravel pits, Coal and Industrial Minerals Section Memorandum Report 98, Indiana Geological Survey, Bloomington, 3 p., and a CD-ROM.

Hill, J. 1981. Some Environmental Geologic Factors as Aids to Planning in Cass County, Indiana. Department of Natural Resources, Geological Survey Special Report 22. pp.30.

Historic Landmarks Foundation. 1984. Cass County Interim Report: historic sites and structures inventory. Indianapolis, Indiana.

Homoya, M.A., B.D. Abrell, J.R. Aldrich, and T.W. Post. 1985. The Natural Regions of Indiana. Indiana Academy of Science. Vol. 94. Indiana Natural Heritage Program. Indiana Department of Natural Resources, Indianapolis, Indiana.

Indiana Agricultural Statistics Service. 1999. Indiana Farm Land Use History, Cass County, Indiana. [web page] U.S. Census of Agriculture. http://www.nass.usda.gov/in [Accessed April 8, 2004]

Indiana Clean Lakes Program. 2001. Indiana Volunteer Lake Monitoring Program Expanded Monitoring Handbook. Bloomington, Indiana.

Indiana Department of Environmental Management. 1994. 1992-1993 305(b) Report. Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana..

Indiana Department of Environmental Management. 1996. 1994-1995 305(b) Report. Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2000. Indiana Water Quality Report. Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana. IDEM/34/02/001/2000.

Indiana Department of Environmental Management. 1999. Unified Watershed Assessment. Division of Water. Indianapolis, Indiana.

Indiana Department of Environmental Management. 2002a. Facilities in the National Pollutant Discharge Elimination System with Assigned UTM Coordinates in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2002b. Pipe Locations in the National Pollutant Discharge Elimination System with Assigned UTM Coordinates in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004a. Active Permitted Solid Waste Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004b. Composting Facilities in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004c. Confined Feeding Operation Facilities in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004d. Construction and Demoliton Waste Facilities in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004e. Corrective Action Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management, 2004f. Indiana Integrated Water Quality Monitoring and Assessment Report. Indiana Department of Environmental Managemetn, Office of Water Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004g. Industrial Waste Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004h. Leaking Underground Storage Tanks in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004i. Open Dump Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004j. Restricted Waste Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004k. Septage Waste Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004l. Superfund Program Facilities in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004m. Treatment. Storage, and Disposal Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004n. Underground Storage Tanks in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004o. Voluntary Remediation Program Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004p. Waste Tire Sites in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004q. Waste Transfer Stations in Indiana (Point Shapefile). Indiana Department of Environmental Management, Office of Land Quality, Indianapolis, Indiana.

Indiana Department of Natural Resources. 2004. Cass County Tillage Transect Data. [web page] http://www.in.gov/dnr/soilcons/publications/tillagereports/cass.html [Accessed August 29, 2005]

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Natural History Survey, Special Publication 5.

Lindsey, A. A., W. B. Crankshaw, and S. A. Qadir. 1965. Soil relations and distribution map of the vegetation of presettlement Indiana Bot. Gaz. 126:155-163. Cited in: Lindsey, A.A. (ed.) Natural Features of Indiana. Indiana Academy of Science, Indiana State Library, Indianapolis, Indiana, p. 264-296.

Looker, B. 2004. Early Cass County History. [web page] Cass County Historical Society. http://casscountyin.tripod.com/index.htm [Accessed April 22, 2004]

Metropolitan Washington Council of Governments. 1992. Design of Stormwater Wetland Systems: Guidance for Creating Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region. Anacostia Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C.

Montgomery, R. unpublished. Lake Perry Watershed memo to Walter Wolf, 24 June 1998.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. U. S. Environmental Protection Agency, Corvallis, Oregon. EPA/600/3-88/037.

Ohio EPA. 1999. Association between nutrients, habitat, and aquatic biota in Ohio rivers and streams. Ohio EPA Technical Bulletin MAS/1999-1-1, Columbus.

Olem, H. and G. Flock, eds. 1990. Lake and Reservoir restoration guidance manual. 2nd edition. EPA 440/4-90-006. Prepared by NALMS for USEPA, Washington, D.C.

Petty, R.O. and M.T. Jackson. 1966. Plant communities. In: Lindsey, A.A. (ed.) Natural Features of Indiana. Indiana Academy of Science, Indiana State Library, Indianapolis, Indiana, p. 264-296.

Purdue Applied Meteorology Group. 2004. Department of Agronomy. Indiana Climate Page. [web page] No date. http://shadow.agry.purdue.edu/sc.index.html [Accessed January 10, 2005]

Reckhow, K.H. and J.T. Simpson. 1980. A procedure using modeling and error analysis for the prediction of lake phosphorus concentration from land use information. Can. J. Fish. Aquat. Sci., 37:1439-1448.

Simon, T.P. and R.L. Dufour. 1998. Development of Index of Biotic Integrity Expectations for the Ecoregions of Indiana V. Eastern Cornbelt Plain. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Branch, Chicago. IL. EPA 905/R-96/004.

Sobat, S. (January 29, 2004). [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

State Legislature. 1938. Cass County Retrospective. In: Branson, R. 2004. Cass County. [web page] Crossroads of America: Early Indiana History. http://www.countyhistory.com/cass [Accessed April 22, 2004]

Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision. Michigan Department of Environmental Quality, Surface Water Quality Division, Nonpoint Source Unit, Lansing, Michigan. EQP 5841 (6/99).

Steinberger and Wolf, 1997. Correspondence to the Lake Perry Estates Corporation Board of Directors.

Thomas, J.A. 1996. Soil Characteristics of "Buttermilk Ridge" Wabash Moraine, Wells County Indiana. Notes for the IU/PU (Ft. Wayne) Soils Course: Characteristics of Fine-Grained Soils and Glacial Deposits in Northeastern Indiana for On-Site Wastewater Disposal Systems.

United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient Criteria Rivers and Streams in Nutrient Ecoregion VI. United States Environmental Protection Agency, Office of Water, Washington, D.C. EPA 822-B-00-017.

Vollenweider, R.A. 1975. Input-output models with special reference to the phosphorus loading concept in limnology. Schweiz Z. Hydrol, 37(1):53-84.

White, G. Unpublished. Typical ranges of nine chemical tests. Adapted from Indiana Department of Environmental Management records.

Whitman Hydro Planning Associates, Inc. 2002. Watershed Restoration Action Strategies for the Eel–Wabash Watershed. Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, Indiana.

Winer, R.R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2nd Edition. Center for Watershed Protection, Ellicott City, Maryland.