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Flat Lake
Watershed Management Plan

Marshall County, Indiana

June 11, 2003

Poor Handmaids of Jesus Christ
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BMPs	Best Management Practices
CLP	Clean Lakes Program
CWA	Clean Water Act
ECBP	Eastern Corn Belt Plains
EI	Eutrophication Index
FSA	Farm Services Agency
FWA	Fish and Wildlife Area
FQI	Floristic Quality Index
HEL	Highly Erodible Land
HUC	Hydrologic Unit Code
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ISBH	Indiana State Board of Health
LARE	Lake and River Enhancement Program
MSL	Mean Sea Level
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PHJC	Poor Handmaids of Jesus Christ
RUSLE	Revised Universal Soil Loss Equation
STEPL	Spreadsheet Tool for the Estimation of Pollutant Load
SWCD	Soil and Water Conservation District
TSI	Trophic State Index
UWA	Unified Watershed Assessment
WCA	Wetland Conservation Area
WRAS	Watershed Restoration Action Strategy

FLAT LAKE
WATERSHED MANAGEMENT PLAN

1.0 INTRODUCTION

With funding from the U.S. Environmental Protection Agency through the Indiana Department of Environmental Management's (IDEM) Section 319 grant program, the Poor Handmaids of Jesus Christ (PHJC) initiated the development of this watershed management plan. The plan's geographic scope is the Flat Lake watershed. The Flat Lake watershed encompasses approximately 4,800 acres southwest of Plymouth, Indiana (Figures 1 and 2). The Flat Lake watershed is part of the larger Gunard Anderson-Carl Gjemre Ditches 14-digit watershed (07120001060070) which lies within the Kankakee River basin (07120001; Figure 3). This plan details the current and historical condition of the watershed. It documents the watershed stakeholders' concerns and vision for the future of the Flat Lake watershed and the waterbodies that lie in it. The plan also outlines the stakeholders' strategies and action items selected to achieve their vision. Finally, the plan includes methods for measuring stakeholders' progress toward achieving their vision and timeframes for periodic refinement of the plan.

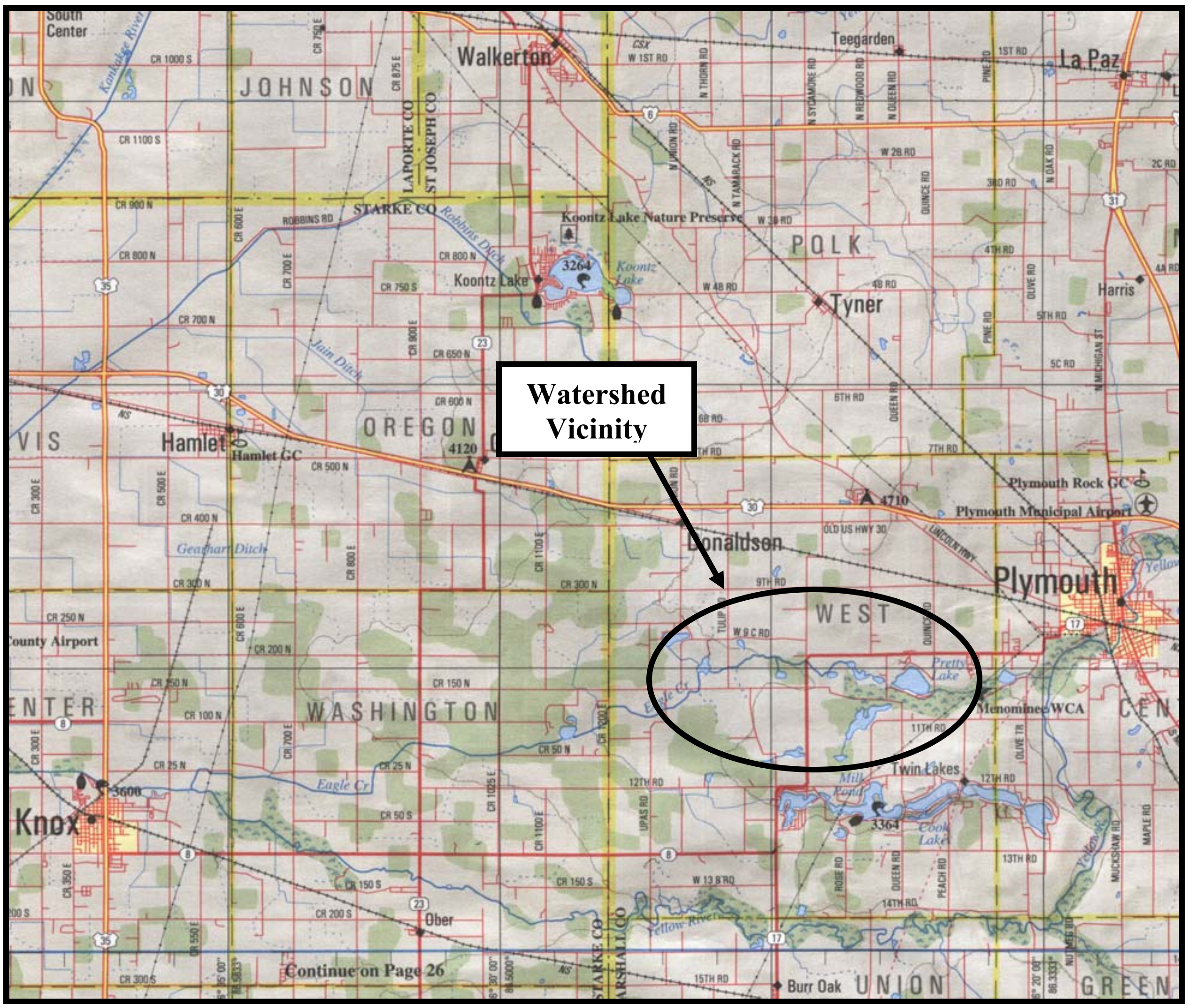

Figure 1. Location map. Source: DeLorme, 1998. Scale: 1"=approximately 2.5 miles.

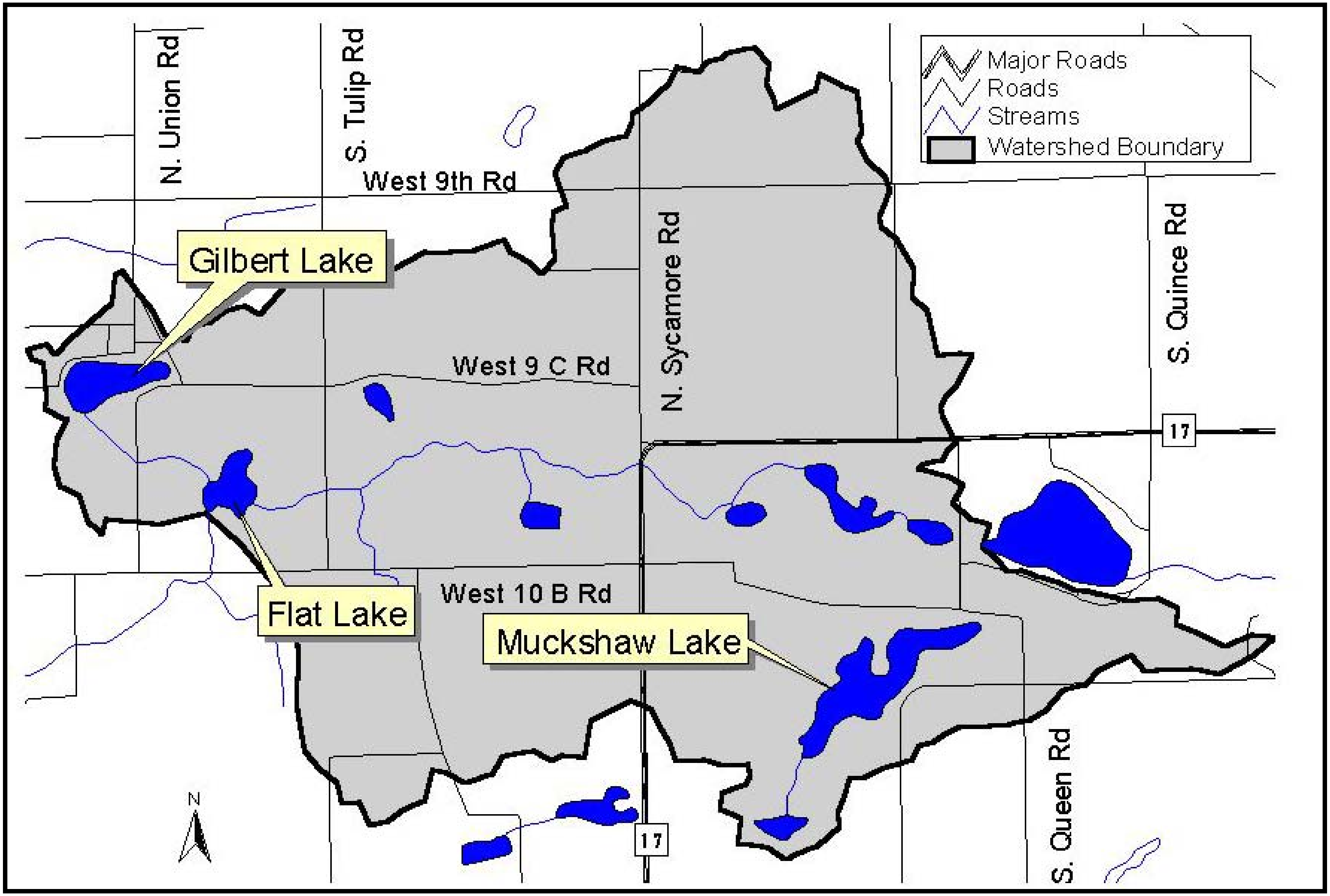

Figure 2. Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

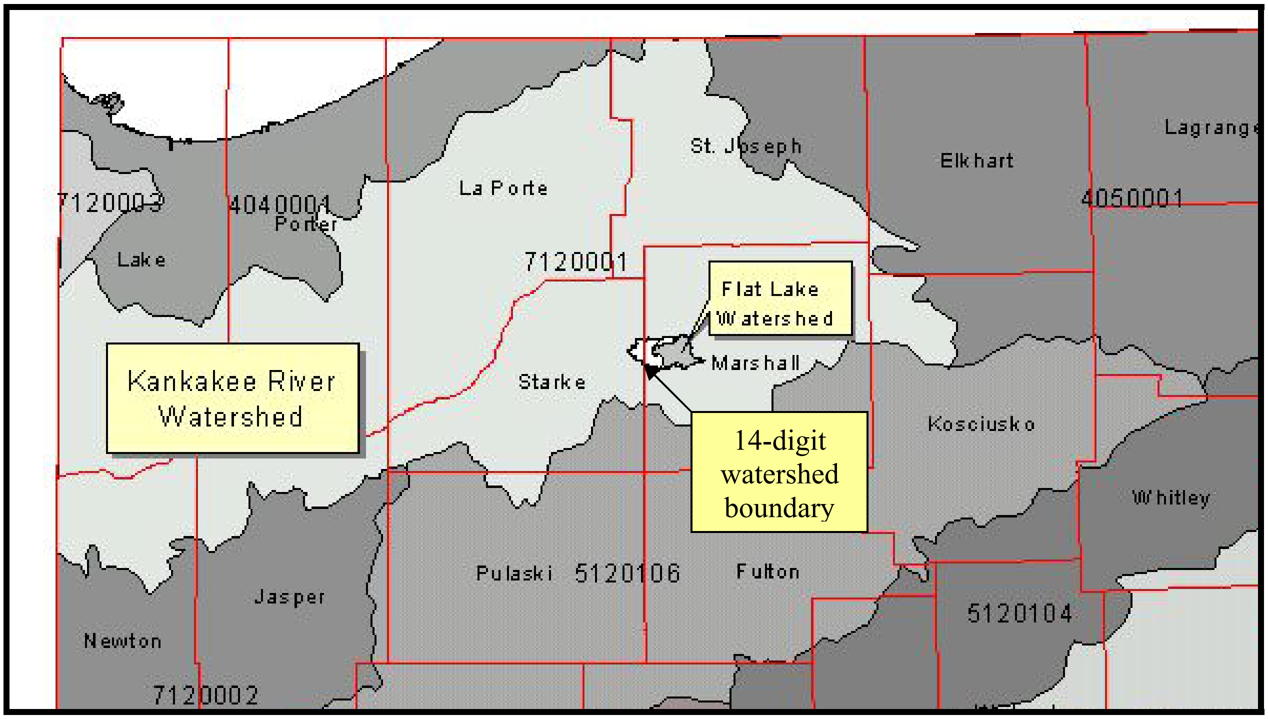

Figure 3. Kankakee River watershed. Source: See Appendix A.

1.1 History of the Watershed Management Plan Development

The PHJC initiated the development of this watershed management plan in response to concerns over the ecological health of Gilbert Lake and its watershed. Fish kills in the mid-1970's signaled a problem with the ecological balance of the lake and its watershed. Water quality testing conducted by IDEM in 1986 confirmed that there was a problem with Gilbert Lake. The results of that testing indicated that Gilbert Lake was hypereutrophic or overly productive. Gilbert Lake's Eutrophication Index (EI) score was 75, which is the worst possible score. Lakes with a score of 75 are often described as being similar to "pea soup" since severe algae blooms are the norm on these lakes. Later testing conducted by the Indiana Clean Lakes Program (CLP) in the mid to late 1990's found that water quality conditions in Gilbert Lake had improved, but still warranted concern.

Faced with this evidence, the PHJC began taking action to restore Gilbert Lake and its watershed. In the mid 1990's, the PHJC requested that the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program (LARE) conduct a study to help them better understand the condition of the lake and provide direction for its management. LARE staff conducted a preliminary diagnostic study on Gilbert Lake in 1997. With IDNR LARE Watershed Land Treatment funding, the PHJC completed a number of projects, many of which were recommendations from the diagnostic study. These projects include fencing cattle away from the lakeshore (1997); revegetating the east end of the lake (1997) and prohibiting mowing at the location; planting trees on the west end of the lake (1998); utilizing conservation tillage on all farmed acreage (since 1997); constructing a wetland above the inlet to Gilbert Lake (2000); installing a filter strip along the inlet to Gilbert Lake (2001); fencing livestock from the constructed wetland (2002); establishing a livestock watering facility (2003); implementing a conservation plan on all highly erodible land (HEL); and reducing the amount of fertilizers and herbicides used on the property. In addition to these Watershed Land Treatment projects, the PHJC also installed a wastewater wetland to treat the waste stream from the Earthworks facility located on the southern edge of Gilbert Lake. With funding from the same program that funded this management plan, the PHJC restored 12 acres of wetland around Gilbert Lake's outlet stream. This restoration included remeandering the outlet stream and fencing the wetland's perimeter to protect it from cattle grazing. Finally, the PHJC worked with state regulators to reroute the National Pollutant Discharge Elimination System (NPDES) permitted discharge from the PHJC wastewater lagoon from its original outlet to the lake to the restored wetland to provide additional post-discharge treatment for the wastewater. The PHJC are also currently working with the IDNR Division of Soil Conservation to install a grassed waterway upstream of Gilbert Lake.

While the PHJC is active in restoring Gilbert Lake and its watershed, they recognized the direct influence the condition of Gilbert Lake has on Flat Lake. Because of this connection, the PHJC broadened their efforts to include the landscape downstream of Gilbert Lake. The PHJC also recognized the need to include more people in the restoration efforts. This plan represents the collective effort of all the Flat Lake watershed stakeholders to make the watershed an ecologically healthy and attractive part of the landscape. All watershed property owners were invited to participate in development of this plan. Additionally, major stakeholders representing local, state, and federal natural resources agencies, including the IDNR Division of Soil Conservation Resource Specialist, the IDNR Menominee Wetland Conservation Area (WCA) Property Manager, Indiana Department of Environmental Management's Regional Watershed Coordinator; non-for-profit organizations such as Ducks Unlimited and the Sierra Club; and the local county planner were also invited to participate. (Appendix B contains a list of major stakeholders who are not property owners in the watershed.) Participation the plan's development was encouraged though the use of quarterly mailings to announce public meetings and summarize the discussion and decisions made at these meetings. The quarterly meetings formed the foundation of the plan's development. Stakeholders set goals, prioritized goals and decided on a course of action to achieve these goals in these public meetings.

1.2 <u>The Vision</u>

Over the course of discussion in the public meetings, some common themes began to emerge. These themes centered around stakeholders' desire to restore the lakes in the watershed to a condition that closely resembled their natural condition and to involve more people in the restoration process. Stakeholders agreed that these themes were their vision for the watershed. The goals stakeholders list in this document and the action plan designed to achieve these goals reflect their desire to realize this vision for the watershed. Ultimately, the Flat Lake watershed stakeholders hope this vision will serve as a guide for future management of the watershed. The following is the watershed stakeholders' vision:

The Flat Lake Watershed Stakeholders' Vision for the Flat Lake Watershed

Flat and Gilbert Lakes are moderately productive lakes capable of supporting a healthy, balanced biotic community and providing an attractive resource for citizens to enjoy. Watershed stakeholders are actively participating in the protection and improvement of the watershed's natural resources.

1.3 Roles and Responsibilities

Several parties played key roles in the development of the Flat Lake Watershed Management Plan. Collectively, the watershed stakeholders were responsible for the developing, reviewing, and agreeing upon the goals and action plan for the watershed. The PHJC coordinated the plan's development by hosting public meetings and workshops, writing press releases to advertise events associated with the plan's development, and reviewing the draft management plan. The PHJC also contracted with an ecological consulting firm, JFNew, to help with the plan's development. JFNew created a database of watershed stakeholders including all property owners in the watershed, distributed plan information and meeting announcements to all entities in the stakeholder database, facilitated public meetings, and drafted the watershed management plan based on the public meetings. The IDNR Division of Soil Conservation Resource Specialist and IDEM Project Manager provided reviews of the draft plan. The draft plan was also available via an ftp site giving watershed stakeholders the opportunity to review and comment on the draft plan. The PHJC will assume responsibility for updating the plan in the future.

2.0 WATERSHED CHARACTERISTICS

2.1 Climate

2.1.1 Indiana Climate

Indiana's climate can be described as temperate with cold winters and warm summers. The National Climatic Data Center summarizes Indiana weather in its 1976 Climatology of the United States document No. 60. "Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low-pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana" (National Climatic Data Center, 1976). Prevailing winds are generally from the southwest, but are more persistent and blow from a northerly direction during the winter months.

2.1.2 Marshall County Climate

The climate of Marshall County has the characteristic warm summers and cold and snowy winters described above. Winters in Marshall County typically provide enough precipitation, in the form of snow, to supply the soil with sufficient moisture to minimize drought conditions when the hot summers begin. Winters are cold, averaging 27º F, while summers are warm, averaging 71º F. The highest temperature ever recorded was 109º F on June 20, 1953. Mild drought conditions occur occasionally during the summer when evaporation is highest. Historic data from 1951-1974 suggest that the growing season (defined as days with an air temperature higher than 32º F) in Marshall County is typically 139 days long, although it can last as long as 164 days (Smallwood, 1980). The last day of freezing temperatures in spring usually occurs around May 6, while the first freezing temperature in the fall occurs around October 5 (Smallwood, 1980). During summer, average relative humidity differs greatly over the course of a day averaging 80 percent at dawn and dropping to an average of 60 percent in mid-afternoon. The average annual precipitation is 38.52 inches. In 2002, nearly 30 inches of precipitation (Table 1) was recorded at Plymouth, Indiana in Marshall County. Rainfall during 2002 was lower than the average precipitation by nearly 8.5 inches.

Table 1. Monthly rainfall data for year 2002 as compared to average monthly rainfall. Averages are based on available weather observations taken during the years of 1971-2000.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
2002	2.72	1.87	3.33	4.82	4.84	3.01	2.00	2.46	1.23	1.68	0.99	1.10	30.05
Average	1.92	1.84	2.87	3.87	3.79	4.20	4.10	3.33	3.62	3.02	3.03	2.93	38.52

Source: Purdue Applied Meteorology Group, 2003.

2.2 Geology and Topography

The advance and retreat of the glaciers in the last ice age shaped much of the landscape observed in Indiana today. As the glaciers moved, they laid thick till material over much of the northern two thirds of the state. This ground moraine left by the glaciers covers much of the central portion of the state. In the northern portion of the state, end moraines, formed by the layering of till material when the rate of glacial retreat equaled the rate of glacial advance, added topographical relief to the landscape. Several large, distinct end moraines are scattered throughout the northern portion of the state. As the glaciers melted, sand and gravel outwash plains formed along the meltwaters' drainage path.

The Flat Lake watershed lies within the Maxinkuckee Moraine. The Maxinkuckee Moraine is a crescent shaped moraine covering approximately 30 to 40 miles of western Marshall County and portions of western St. Joseph and Fulton Counties. The Maxinkuckee Moraine formed when the Huron-Saginaw Lobe of the last Wisconsian glacier stalled during its last northeasterly retreat (Wayne, 1966). Movement of the Lake Michigan Lobe from the northwest may have influenced the moraine's formation as well (IDNR, 1990).

Much of the Flat Lake watershed exhibits the knob and kettle topography that is characteristic of end moraines. High points (knobs) of over 850 and 840 feet above mean sea level (MSL) exist on the north and south sides of the watershed, respectively (Figure 4). Gilbert and Flat Lakes, which are kettle lakes, occupy low spots in the watershed at 746 and 734 feet above MSL, respectively. As with most watersheds, the steepest slopes exist in the upper watershed. Steep slopes occur around Muckshaw Lake and the unnamed ponds in the eastern inlet's headwaters. Flat Lake's eastern inlet possesses a topographical fall of approximately 60 feet over its course. Slopes bordering the northern bank of Flat Lake's eastern inlet tend to be steeper than the slopes bordering the southern bank, but in general, the inlet possesses a relatively wide valley. Flat Lake's western inlet drains relatively flat land between Gilbert and Flat Lakes. Historical maps and the hydric soil map suggest that the western inlet was historically wetland rather than a drainage channel.

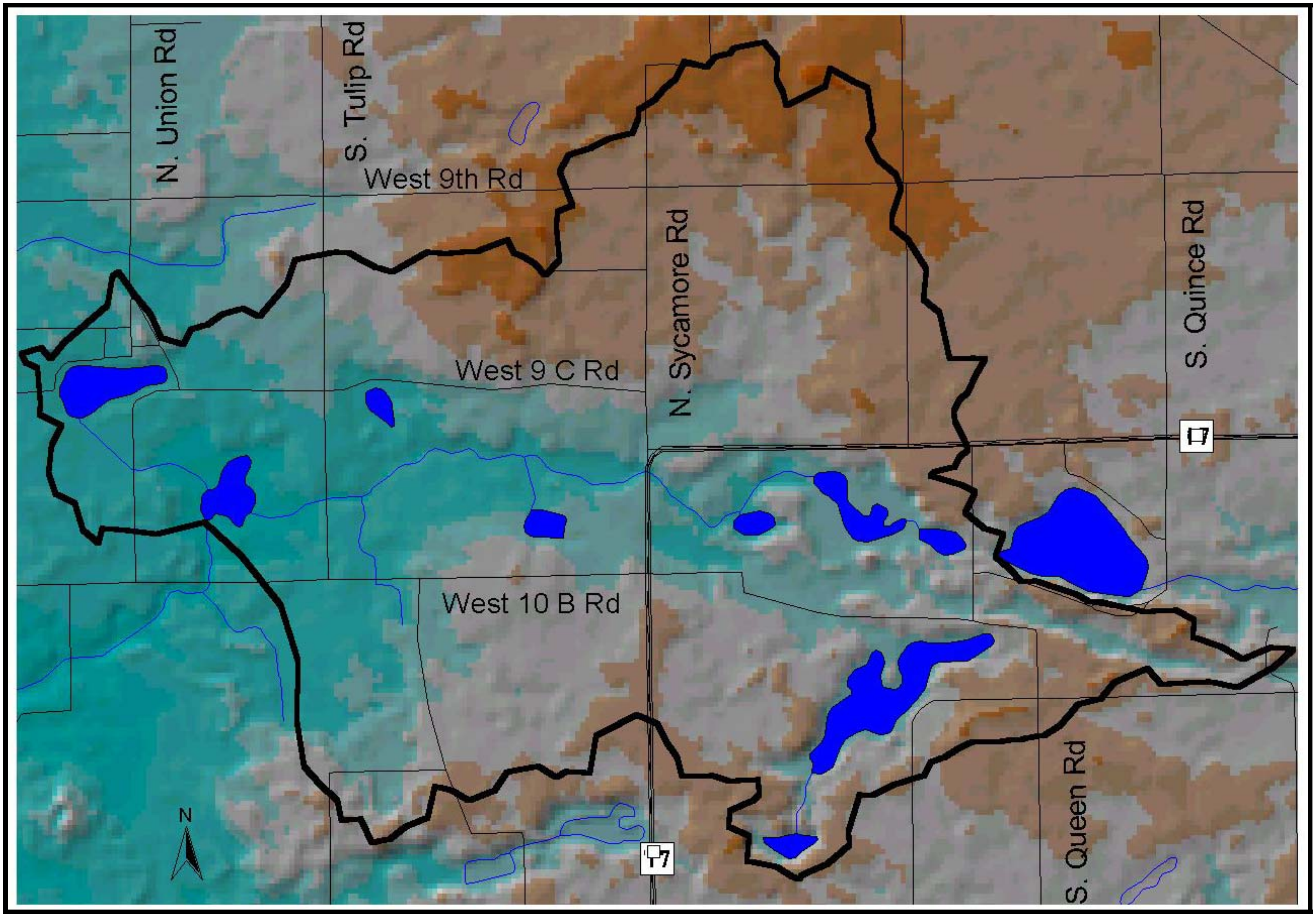

Figure 4. Topographical relief of the Flat Lake watershed. Source: See Appendix A. Scale: 1”=3,000’.

2.3 Soils

The soil types found in Marshall County are a product of the original parent materials deposited by the glaciers that covered this area 12,000 to 15,000 years ago. The main parent materials found in Marshall County are glacial outwash and till, lacustrine material, 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 of Marshall County today.

Smallwood (1980) maps two soil associations in the Flat Lake watershed: the Riddles-Metea-Wawasee association and the Plainfield-Chelsea-Tyner association. The Riddles-Metea-Wawasee association covers most of the watershed. This soil association is characteristic of morainal areas in Marshall County, such as the Maxinkuckee Moraine. Soils in this association developed from glacial till parent materials. In general, Riddles soils account for approximately 54% of the total soils in the association; Metea soils account for 22%, while Wawasee soils comprise 13% of the soil association. Much of the remaining portion of the soil association consists of hydric soil components lining drainageways. Riddles soils occupy moraine ridges. Metea soils occur on low knolls and sides of moraines. Like Riddles soils, Wawasee soils exist on moraine ridges. Woodlands and forested areas thrive on the Riddles-Metea-Wawasee association; however, the soils' strong slopes may limit agricultural productivity.

As the landscape encompassing the Flat Lake watershed transitions from the morainal formation of the Maxinkuckee Moraine to the outwash plan of the Kankakee River valley, the landscape's major soil associations transition from soil units consisting of till material to soil units consisting of courser textured materials (sand, gravel). Consistent with this geologic shift, the soil association covering the Flat Lake watershed shifts from a Riddles-Metea-Wawasee association to a Plainfield-Chelsea-Tyner association at the western edge of the watershed. Soils in the Plainfield-Chelsea-Tyner association developed from outwash parent materials. Plainfield soils account for approximately 32% of the total soils in the association; Chelsea soils account for 27%, while Tyner soils comprise 22% of the soil association. The remaining portion of the soil association consists of minor soil components. Plainfield soils occur on flats and knolls of outwash plains. Chelsea soils occupy gently rolling areas of outwash plains, while Tyner soils exist on more level areas of outwash plains. Smallwood (1980) classifies soils in the Plainfield-Chelsea-Tyner association as poor for agricultural production due to problems with slopes and drought.

In addition to shaping the type of vegetation that may be established in a certain area, soils, in particular their ability to erode or sustain certain land use practices, can impact the water quality of waterbodies in the watershed. For example, highly erodible soils are, as their name suggests, easily erodible. Soils that erode from the landscape are transported to waterways or waterbodies where they impair water quality and often interfere with recreational uses by forming sediment deltas in the waterbodies. In addition, such soils carry attached nutrients, toxins, and pathogens, which further impair water quality. Soils that are used as septic tank absorption fields deserve special consideration as well. The presence of highly erodible soils and the use of septic fields in the Flat Lake watershed are described in further detail below.

2.3.1 Highly Erodible Soils and Land

Different natural resource agencies categorize highly erodible soils and highly erodible land differently. Based on common soil characteristics such as slope and soil texture, the NRCS classifies soil units that are likely to erode from the landscape as highly erodible soils. The NRCS maintains a list of highly erodible soil units for each county. Table 2 lists the soil units in the Flat Lake watershed that the NRCS considers to be highly erodible. The county list or the one provided in Table 2 can be cross referenced with the county soil survey to locate highly erodible soils on the landscape. As Figure 5 indicates, potentially highly erodible soils cover a substantial portion (1,527 acres or nearly 32%) of the Flat Lake watershed. This acreage is spread throughout the watershed. Highly erodible soil exists in approximately 220 acres of the watershed most of which are located in the eastern portion of the watershed north of and around Muckshaw Lake.

Table 2. Highly erodible and potentially highly erodible soils units in the Flat Lake watershed.

Soil Unit	Soil Name	Detail	Soil Description
ChC	Chelsea fine sand	potentially highly erodible	6 to 12 percent slopes
FsB	Fox sandy loam	potentially highly erodible	2 to 6 percent slopes
FsC2	Fox sandy loam	potentially highly erodible	6 to 12 percent slopes, eroded
MeB	Martinsville silt loam	potentially highly erodible	2 to 6 percent slopes
MeC2	Martinsville loam	potentially highly erodible	6 to 12 percent slopes, eroded
MgC	Metea loamy fine sand	potentially highly erodible	2 to 6 percent slopes
OsB	Oshtemo loamy sand	potentially highly erodible	2 to 6 percent slopes
OsC	Oshtemo loamy sand	potentially highly erodible	6 to 12 percent slopes
OsD	Oshtemo loamy sand	highly erodible	12 to 18 percent slopes
PsC	Plainfield sand	potentially highly erodible	3 to 10 percent slopes
PsD	Plainfield sand	potentially highly erodible	12 to 18 percent slopes
RsB	Riddles sandy loam	potentially highly erodible	2 to 6 percent slopes
RsD	Riddles sandy loam	highly erodible	12 to 18 percent slopes
RsC2	Riddles sandy loam	potentially highly erodible	6 to 12 percent slopes, eroded

Source: Marshall County NRCS.

Highly Erodible Land (HEL) is a designation used by the Farm Service Agency (FSA). For a field or tract of land to be labeled HEL by the FSA, at least one-third of the parcel must be situated in highly erodible soils. Unlike the soil survey, these fields must be field checked to ensure the accuracy of the mapped soils types. Farm fields mapped as HEL are required to file a conservation plan with the FSA in order to maintain eligibility for any financial assistance from the U.S. Department of Agriculture. Figure 6 shows the location of HEL fields in the Flat Lake watershed. HEL comprises approximately 6% of the Flat Lake watershed (302 acres); much of this land is located in the northern portion of the watershed.

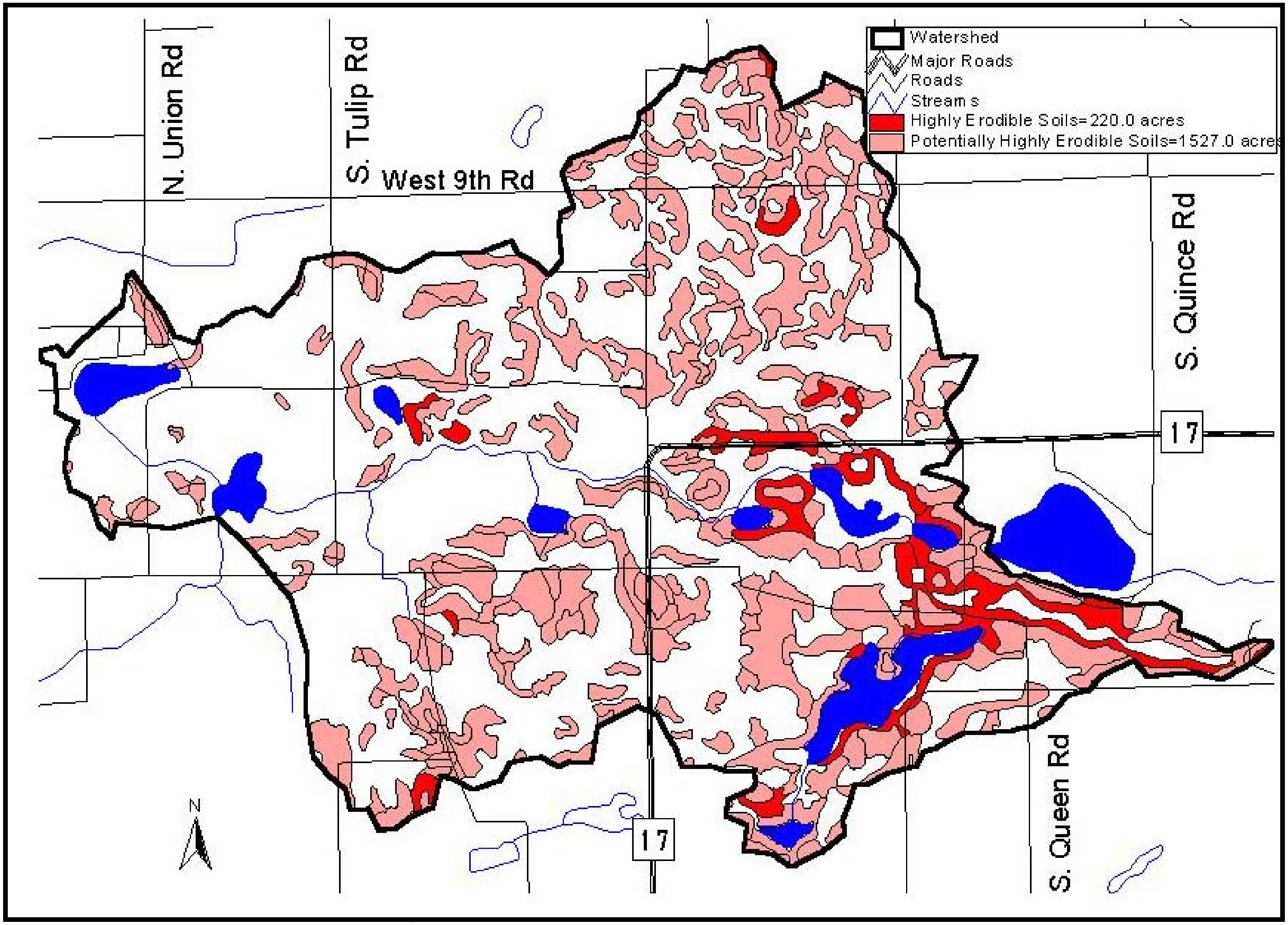

Figure 5. Highly erodible and potentially highly erodible soils in the Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

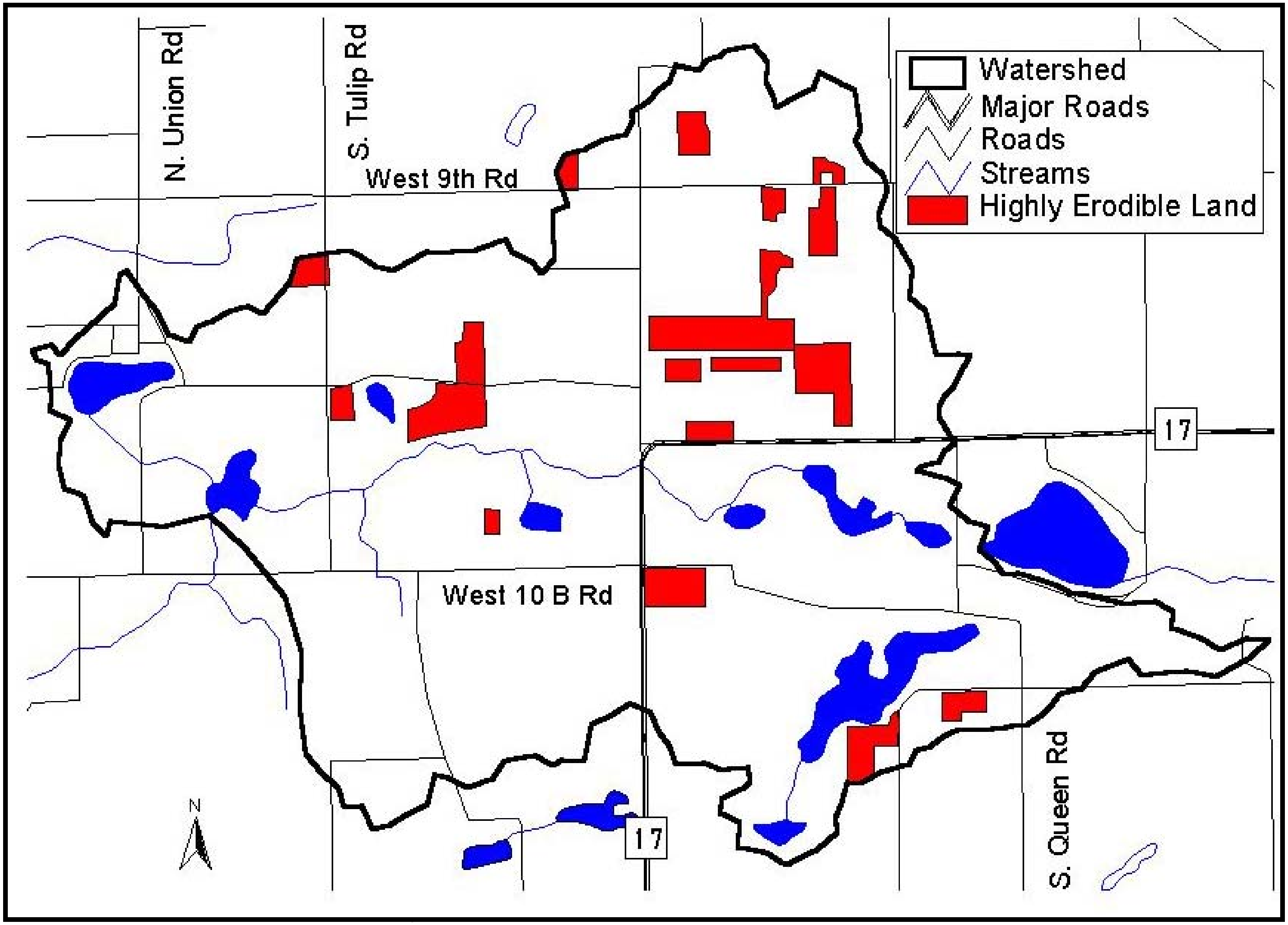

Figure 6. Tracts of highly erodible land in the Flat Lake Watershed. Source: See Appendix A. Scale: 1”=3,000’.

2.3.2 Septic System Use

As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment in the Flat Lake 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. Soil conditions such as slow permeability and high water table, coupled with poor design, faulty construction, and lack of maintenance reduce the average life span of septic systems in Indiana to 7-10 years (Jones and Yahner, 1994). Other factors affecting the effectiveness of effluent treatment include the position of the septic system in the landscape, the slope on which the septic leach field is placed, the soil texture, the soil structure of the septic leach field, the soil consistency, and the septic system's depth to limiting layers (Thomas, 1996).

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 adsorb 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 Flat Lake Watershed

The Natural Resources Conservation Service (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 soils series mapped in the Flat Lake watershed in terms of their suitability for use as septic tank absorption fields. Figure 7 displays the septic tanks absorption field suitability of soils mapped in the Flat Lake watershed.

Table 3. Soil types present in the Flat Lake watershed.

Symbol	Name	High Water Table	Suitability for Septic Tank Absorption Field
Ad	Adrian muck	+0.5-1.0 ft	Severe: ponding
AuA	Aubbeenaubbee sandy loam	1-3 ft	Severe: wetness
Bd	Brady sandy loam	1-3 ft	Severe: wetness, poor filter
BeA	Brems sand	2-3 ft	Severe: wetness, poor filter
BoA	Bronson loamy sand	2-3.5 ft	Severe: wetness, poor filter
Br	Brookston loam	+0.5-1.0 ft	Severe: ponding
ChB-ChC	Chelsea fine sand	>6 ft	Severe: poor filter
CtA	Crosier loam	1-3 ft	Severe: percs slowly, wetness
Ed	Edwards muck	+0.5-0.5 ft	Severe: ponding, percs slowly
FsA	Fox sandy loam	>6 ft	Severe: poor filter
Gf	Gilford sandy loam	+0.5-1 ft	Severe: ponding, poor filter
HdB	Hillsdale sandy loam	>6 ft	Moderate: percs slowly
Ho; Hp	Houghton muck	+2-1 ft	Severe: ponding, percs slowly
MeA-MeB	Martinsville loam	>6 ft	Slight
MgB-MgC	Metea loamy fine sand	>6 ft	Moderate: percs slowly, slope
Mn	Milford silty clay loam	+0.5-2 ft	Severe: ponding, percs slowly
Ne	Newton loamy fine sand	+1.5-1 ft	Severe: ponding, poor filter
OsA-OsD; OwA	Oshtemo loamy sand	>6 ft	Slight-Severe: slope
Pa	Palms muck	+0.5-1 ft	Severe: ponding
PsA; PsC-PsD	Plainfield sand	>6 ft	Severe: poor filter
Re	Rensselaer loam	+1.5-1 ft	Severe: ponding, poor filter
RsA-RsB; RsC2; RsD	Riddles sandy loam	>6 ft	Moderate-Severe: percs slowly, slope
TyA	Tyner loamy sand	>6 ft	Severe: poor filter
Ua	Udorthents, loamy	--	--
Wa	Wallkill loam	+0.5-0.5 ft	Severe: ponding
Wh	Washtenaw silty loam	+0.5-1 ft	Severe: ponding
WkB	Wawasee sandy loam	>6 ft	Slight
Wt	Whitaker loam	1-3 ft	Severe: wetness

Source: Smallwood, 1980.

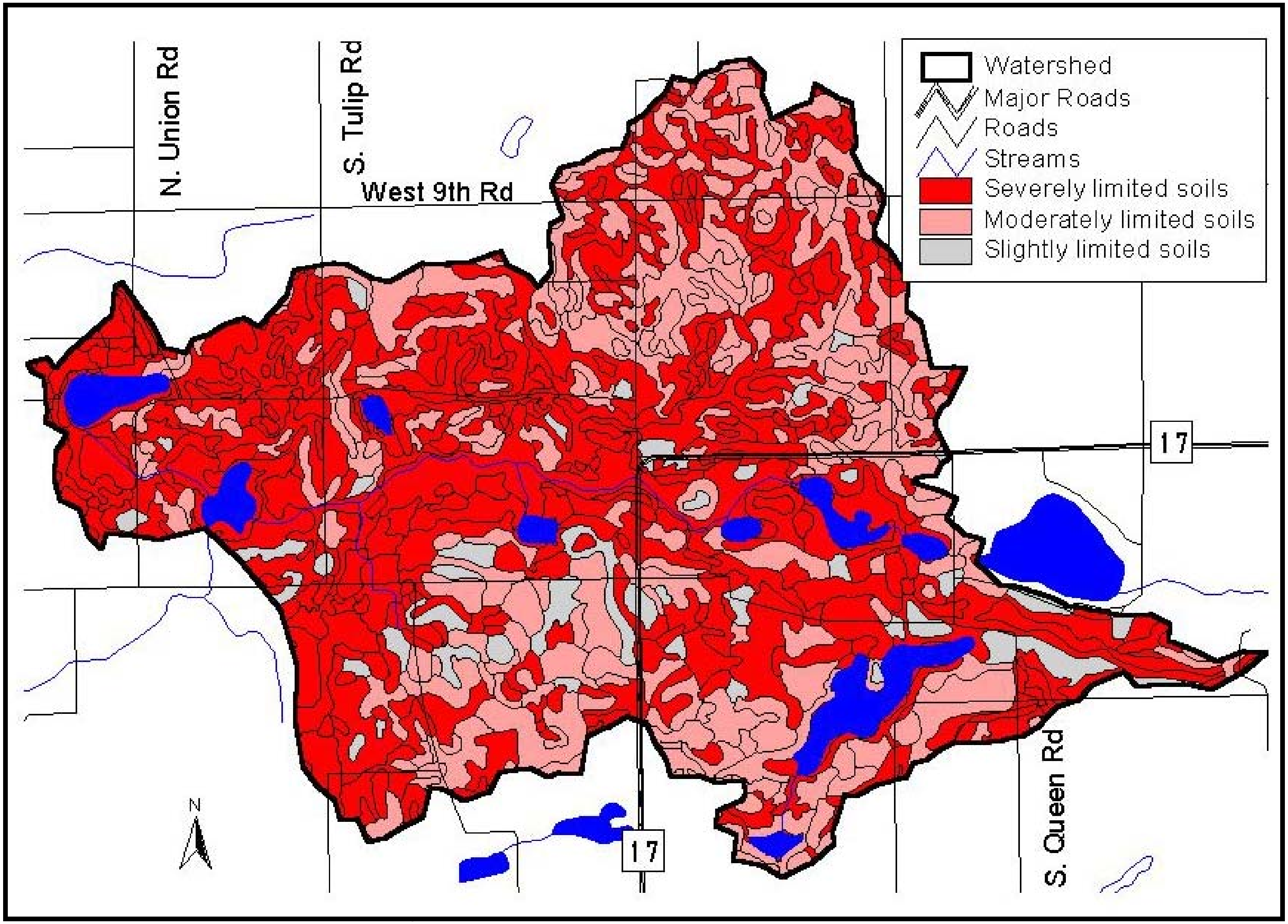

Figure 7. Soil series septic tank absorption field suitability. Source: See Appendix A. Scale: 1"=3,000'.

2.4 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, 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 Flat Lake watershed lies at or near the transition between two or more regions. For example, the watershed lies at the western boundary separating the Homoya's Northern Indiana Lakes Natural Area to the east from the Grand Prairie Natural Area to the west. Similarly, the Flat Lake watershed lies in Omernik and Gallant's Eastern Corn Belt Plains (ECBP) ecoregion, immediately south of the point where the ECBP ecoregion meets the Central Corn Belt Plains and Southern Michigan/Northern Indiana Till Plains ecoregions. As a result, the native floral community of Flat Lake watershed likely consisted of components of neighboring natural areas and ecoregions in addition to components characteristic of its own natural area and ecoregion.

Prior to European settlement, oak-hickory forest likely covered most of the upland portion of the Flat Lake 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; Omernik and Gallant, 1988). Sugar maple and beech undoubtedly grew in the watershed as well, but not to the extent observed in eastern Indiana. 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.

Wet habitat (lakes, marshes, swamps) intermingles with the upland habitat throughout the glaciated portion of the state. The hydric soil map and a 1876 map of Marshall County indicate wetland habitat existed around Flat and Gilbert Lakes, along the eastern inlet to Flat Lake, and southeast of Flat Lake. These wet habitats supported very different vegetative communities than the drier portions of the landscape. Swamp loosestrife, cattails, soft stem bulrush, marsh fern, marsh cinquefoil, pickerel weed, arrow arum, and sedges dominated the marsh habitat around the lakes and in the eastern inlet's corridor. Within the lakes themselves, common species likely included pondweeds, spatterdock, white water lilies, watershield, eel grass, and coontail. Swamp habitat likely covered the scattered shallow depressions at higher topographical elevations in the watershed. Typical dominant swamp species in the area included red and silver maple, green and black ash, and American elm (Homoya, 1985). Smallwood (1980) adds swamp white oak to the list of dominants in swamp habitat throughout the county. On the PHJC property, tamarack and willows were common wet tree species.

2.5 Hydrological Features

As is characteristic of much of the glaciated portion of the state, hydrological features, including streams, wetlands, ponds, and lakes, are important components of the Flat Lake watershed's landscape. Two major inlets flow into Flat Lake. Neither is named. For the purposes of this document, they will be called the eastern inlet to Flat Lake and the western inlet to Flat Lake. The eastern inlet to Flat Lake tributary is approximately 13,500 feet in length (excluding portions of stream channel that are ponded) while the western inlet is approximately 3,300 feet in length. Vegetated wetlands cover approximately 8% of the Flat Lake watershed (Figure 8). Several ponds lie along Flat Lake's eastern inlet and are scattered in other portions of the watershed. The ponds along the eastern inlet were formed by damming the eastern inlet in places. Two lakes, Gilbert Lake, and Flat Lake, exist in the Flat Lake watershed. (Muckshaw Lake is shown in some maps as a lake and other maps as a wetland. For the purposes of this report, it will be considered a wetland.) Flat Lake is approximately 26 acres in size and has a mean depth of 8 feet and a maximum depth of 21 feet. Gilbert Lake covers approximately 37 acres and possesses a mean depth of 13 feet and a maximum depth of 29 feet. Combined, wetlands, ponds, and lakes cover approximately 13% of the watershed (Table 4).

Table 4. Acreage and classification of wetland habitat in the Flat Lake watershed.

Wetland Type	Area (acres)	Percent of Watershed
Herbaceous	206.5	4.3
Lake*	137.2	2.8
Pond	118.5	2.4
Forested	112.3	2.3
Shrubland	48.6	1.0
Total	**623.1**	**12.9**

Source: USFWS National Wetland Inventory (NWI). *The NWI classification includes Flat and Gilbert Lakes as lacustrine wetlands. Subtracting their surface area yields a total wetland acreage of 565.1 acres. This figure will be utilized for approximating wetland loss in the Flat Lake watershed.

Humans have altered many of the watershed's natural hydrological features. As noted above, the eastern inlet to Flat Lake has been dammed to create deeper water ponds along the stream. Historical aerial photographs from the NRCS note the change is this hydrological feature over the past 50-75 years. The landscape has also 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 acreage of wetland (hydric) soils in the watershed (1,251.7 acres) to the acreage of existing wetlands (565.1 acres) suggests that nearly 55% of the original wetland acreage exists today. Compared to other watersheds in the northern Indiana, the Flat Lake watershed has experienced less wetland loss than typical for the region. Much of the loss occurred within the western and northern portions of the watershed. It is important to note, however, that there are ongoing efforts to restore wetland acreage and functionality in the Flat Lake watershed (Menominee Wetland Conservation Area, PHJC land).

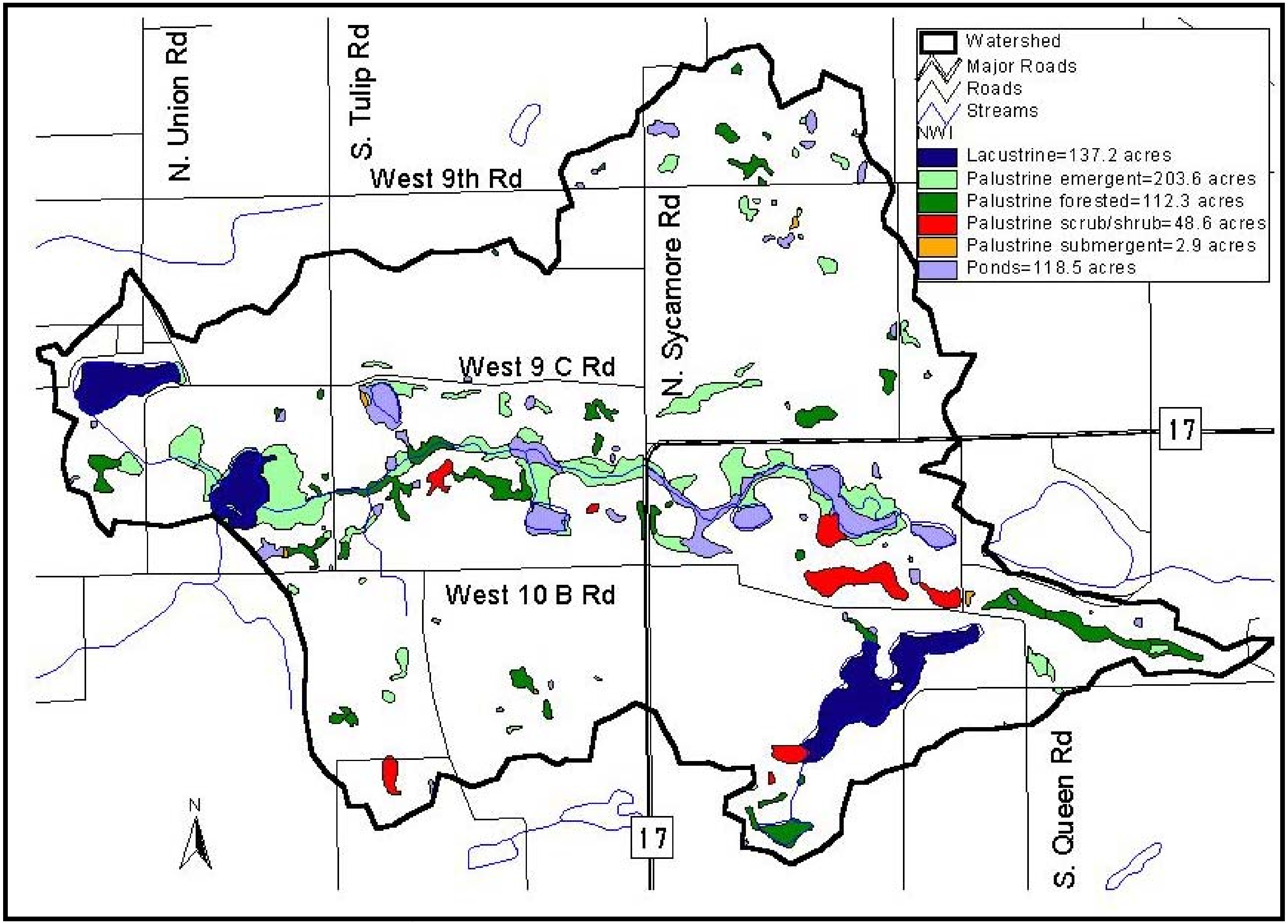

Figure 8. National wetland inventory map. Source: See Appendix A. Scale: 1”=3,000’.

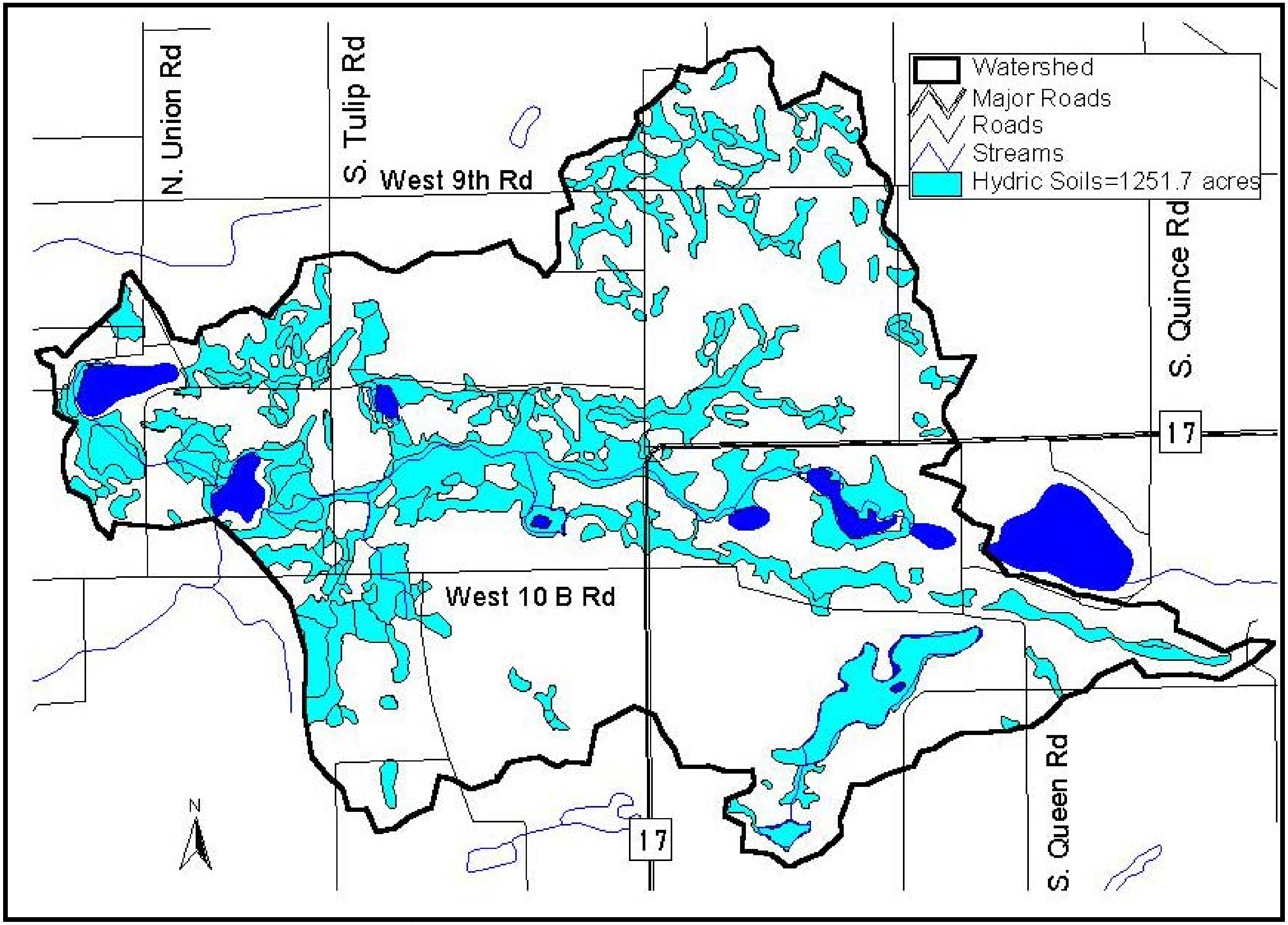

Figure 9. Hydric soils in the Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

2.6 Natural Communities and Endangered, Threatened, and Rare Species

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare 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 C presents the results from the database search for endangered, threatened, or rare species and high quality natural communities the Flat Lake watershed. (Appendix C also includes a listing of endangered, threatened, and rare species and high quality natural communities documented in Marshall County for additional reference.) According to the database, the Flat Lake watershed and the area immediately adjacent to the watershed supports only one endangered, threatened, or rare animal or plant. The listed animal is the state endangered American badger, which was found in Section 33, Township 34 North, Range 1 East. The last reported observation of this species occurred in 1985. The Flat Lake watershed also supports one high quality community: a wetland muck flat in Sections 8-10, Township 33 North, Range 1 East. This community is a state significant community.

Although they are not listed in the Natural Heritage Database, several other rare or diminishing species have been noted in the watershed. A watershed stakeholder has repeatedly observed the presence of a pair of red shouldered hawks (*Buteo lineatus*) on the PHJC property (Mary Baird, personal communication). Red shouldered hawks are species of special concern in Indiana. Baird also reports the possible sighting of an ornate box turtle (*Terrapene ornata*) and definite observation of nesting red headed woodpeckers (*Melanerpes erythrocephalus*). Ornate box turtles are state endangered species. As noted below, ornate box turtles do exist in Marshall County, so a sighting of one in the Flat Lake watershed is not unrealistic. Red headed woodpeckers are not rare, but their populations are diminishing.

The recently restored wetland immediately south of Gilbert Lake which supports a diverse population of native plant species is worth mentioning as well. A botanical survey conducted in the restored 12-acre wetland in August 2002 revealed the presence of over 120 native species. (Appendix C provides a listing of all the species found in the restored wetland.) These species included one state endangered plant, swamp smartweed (*Polygonum hydropepperoides* var. *setaceum*), and several very conservative species such as winged oval sedge (*Carex alata*), swamp thistle (*Cirsium muticum*), umbrella flat sedge (*Cyperus diandrus*), and swamp saxifrage (*Saxifraga pensylvanica*). Additionally, this restored wetland possessed a Floristic Quality Index (FQI) score of 49.9 and a mean conservatism value (mean c) of 4.7. Areas with FQI scores over 45 or mean c values greater than 4.5 are almost certain to have natural area potential (Swink and Wilhelm, 1994).

Marshall County supports a variety of endangered, threatened, and rare animals and plants. The listed animals include six reptiles: four turtles, the spotted turtle (*Clemmys guttata*), Kirtland's turtle (*Clonophis kirtlandii*), Blanding's turtle (*Emydoidea blandingii*), and the ornate box turtle, and two snakes, Butler's garter snake (*Thamnophi butleri*) and the eastern massasauga (*Sistrurus catenatus catenatus*). Eleven birds, including the great blue heron (*Ardea herodias*) and the sharp-shinned hawk (*Accipiter striatus*), and two mammals are also listed. Nearly all of the listed plants are hydrophytic plants, likely remnants from the original marshes that covered much of Marshall County. The county also supports five high quality communities, including mesic prairie, marl beach, acid bog, fen, and muck flat.

2.7 Early History and Land Use

Early settlers began arriving to the area over 200 years ago. Prior to European settlement, the Pottawatomie lived in the Flat Lake watershed. Smallwood (1980) notes that early surveyors platted the City of Plymouth in 1834. Settlers undoubtedly moved out from the city into the surrounding countryside soon after that. In 1954, county planners carved West Township, the township that encompasses the Flat Lake watershed, out of Center Township (Historic Landmarks Foundation, 1990). Surveyors had completely platted the county in 1878 (Smallwood, 1980). Glimpses of the watershed's early days can be seen in the historic landmarks that survive today. Figure 10 maps some of these notable landmarks, which include homes, farmsteads, and cemeteries dating back to the mid-1800's. The Ancilla Domini convent is also considered an outstanding historic landmark (Historic Landmarks Foundation, 1990).

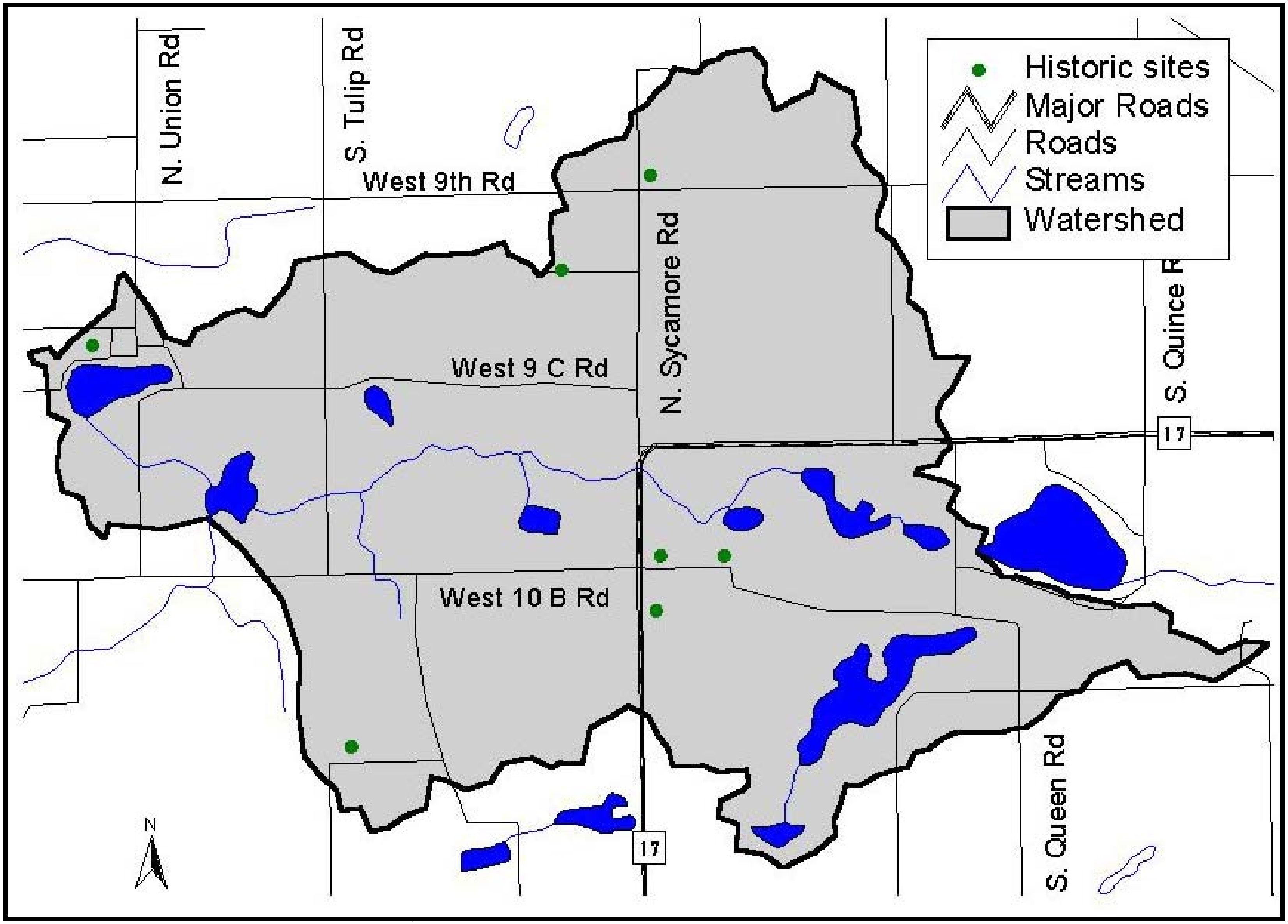

Figure 10. Historical structures and sites in the Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

As people settled the land, they began clearing forested uplands and draining wet lowlands to allow for agricultural production. One of the earliest (1876) maps of the area shows extensive wet habitat in the watershed. The 1922 plat map suggests some of this wet habitat had been drained. The 1948 plat map shows a distinct creek rather than wet or ponded habitat along much of Flat Lake's eastern inlet corridor. 1939 and 1951 aerial photography obtained from the NRCS lends further evidence to the hypothesis that early property owners drained portions of the wet corridor along the eastern inlet in an attempt to farm the property.

The aerial photography from the first half of the twentieth century also suggests that property owners may have given up trying to drain the wettest portion of the eastern inlet corridor. The 1951 photograph distinctly shows a dam across the eastern inlet immediately west of Pretty Lake, creating a small pond that exists today. This dam is not present in the 1939 photograph. Similarly, the 1951 photograph lacks a second pond located downstream of this first pond. Property owners must have constructed a second dam on the eastern inlet to create the second pond sometime after 1951. Both ponds lie in Houghton muck. The extremely poor drainage capacity of Houghton muck prevents its use as reliable farmland, unless extensive tiling and ditching assists with drainage. (High quality copies of the historical aerial photographs of the watershed could not be obtained for this document. Interested parties may contact the NRCS to review these photographs.)

Figure 11 and Table 5 present current land use information for the Flat Lake watershed. Land use data from the U.S. Geological Survey forms the basis of Figure 11. Agricultural land uses dominate the Flat Lake watershed. Row crop agricultural areas cover approximately half of the watershed. Pasture occupies an additional 19% of the watershed. The natural landscape remains on a smaller portion of the watershed. Forested land exists on approximately 22% of the watershed. Wetlands and open water cover nearly 12% of the watershed. (This number differs slightly from the one in the **Hydrological Features** Section since different data sources are utilized.) Most of the wetlands in the watershed lie in the eastern tip of the watershed (southeast of State Road 17) or border the eastern inlet to Flat Lake. Flat and Gilbert Lakes account for nearly half of the open water acreage; the remaining portion consists of ponds and Muckshaw Lake. (The 1936 Marshall County Plat Map identifies the body of water southwest of Pretty Lake as Muckshaw Lake.) Developed areas (Ancilla Domini Convent, Ancilla College, and residential properties) cover less than 1% of the watershed.

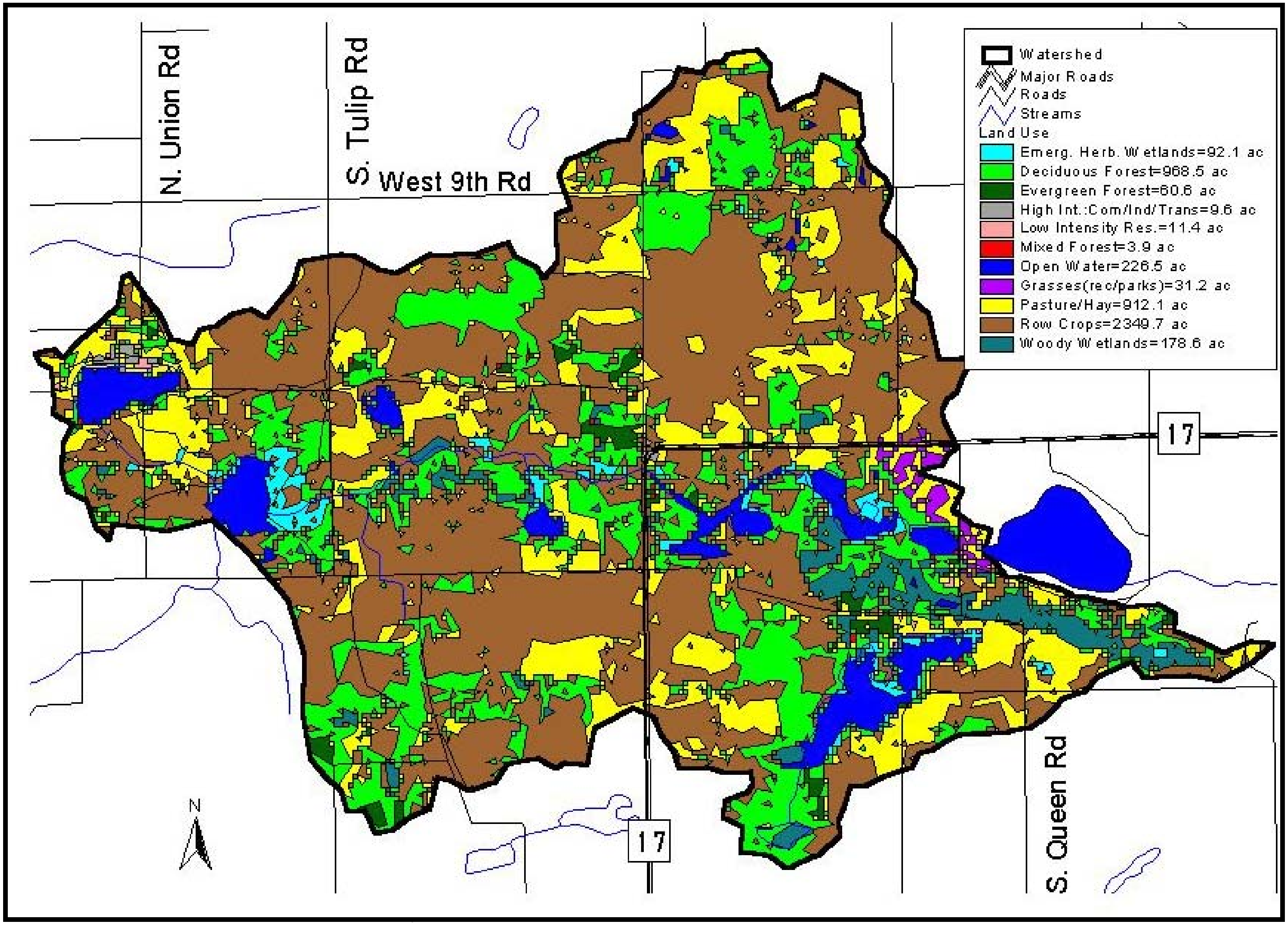

Figure 11. Land use in the Flat Lake watershed. Source: See Appendix A. Scale: 1'=3,000'.

Table 5. Detailed land use in the Flat Lake watershed.

Land Use	Area (acres)	Percent of Watershed
Row Crop Agriculture	2,349.7	48.5%
Deciduous Forest	968.5	20.0%
Pasture/Hay Agriculture	912.1	18.8%
Open Water	226.5	4.7%
Woody Wetlands	178.6	3.7%
Emergent Herbaceous Wetlands	92.1	1.9%
Evergreen Forest	60.6	1.3%
Recreational/Parks	31.2	0.6%
Low Intensity Residential	11.4	0.2%
High Intensity Commercial	9.6	0.2%
Mixed Forest	3.9	0.1%
Total	**4,844.2**	**100%**

Source: USGS Indiana Land Cover Data Set. Data set was corrected based on field investigations conducted in 2002.

2.8 Land Ownership

Figure 12 presents land ownership information for the Flat Lake watershed. Land ownership data from the Indiana Department of Natural Resources and the Poor Handmaids of Jesus Christ forms the basis of Figure 12. Nearly 10% of the Flat Lake watershed (489.2 acres) is owned by the Indiana Department of Natural Resources (Figure 12). This acreage comprises over half of the Menominee Wetland Conservation Area (WCA). Menominee WCA consists of eight tracts of land (830 acres) located west of Plymouth in Marshall County. The IDNR began purchasing land for creation of the Menominee WCA in 1977 and plans to continue to purchase additional acreage as tracts become available (Bean, unpublished). Habitat varies throughout Menominee WCA and includes arid, sandy uplands, oak/hickory woodlots, cattail marshes, and open water. Active management is limited to surveying, posting property boundaries, and periodic inspections (Bean, unpublished). Hunting, fishing, trapping, hiking, nature study, boating, and canoeing are all encouraged in the Menominee WCA (Despot, personal communication).

The Ancilla Domini sisters (Poor Handmaids of Jesus Christ or PHJC) originally purchased 65 acres of land in 1918. By the 1930's the sisters owned nearly 700 acres. Currently, the Poor Handmaids of Jesus Christ (PHJC) own approximately 982 acres of land in and around the northwest portion of the watershed (Figure 12). PHJC owns the entire shoreline of Gilbert Lake, which remains mostly undeveloped. The 37-acre lake, Provincial Motherhouse, Catherine Kasper Life Center, Lindenwood Conference/Retreat Center, Maria Center for Senior Retirement, Ancilla College, Earthworks, a beef/grain farm, four gas wells, and wastewater treatment facilities are all associated with and housed on PHJC property (Baird, unpublished). The wastewater treatment plant located on PHJC property is the only NPDES permitted discharge in the Flat Lake watershed. Other land uses on PHJC property consist of agricultural row crops, livestock pastures, woodlots, and five types of wetlands which include sedge meadow, open water, shallow shrub swamp, wet woodland, and shallow marsh (Baird, unpublished).

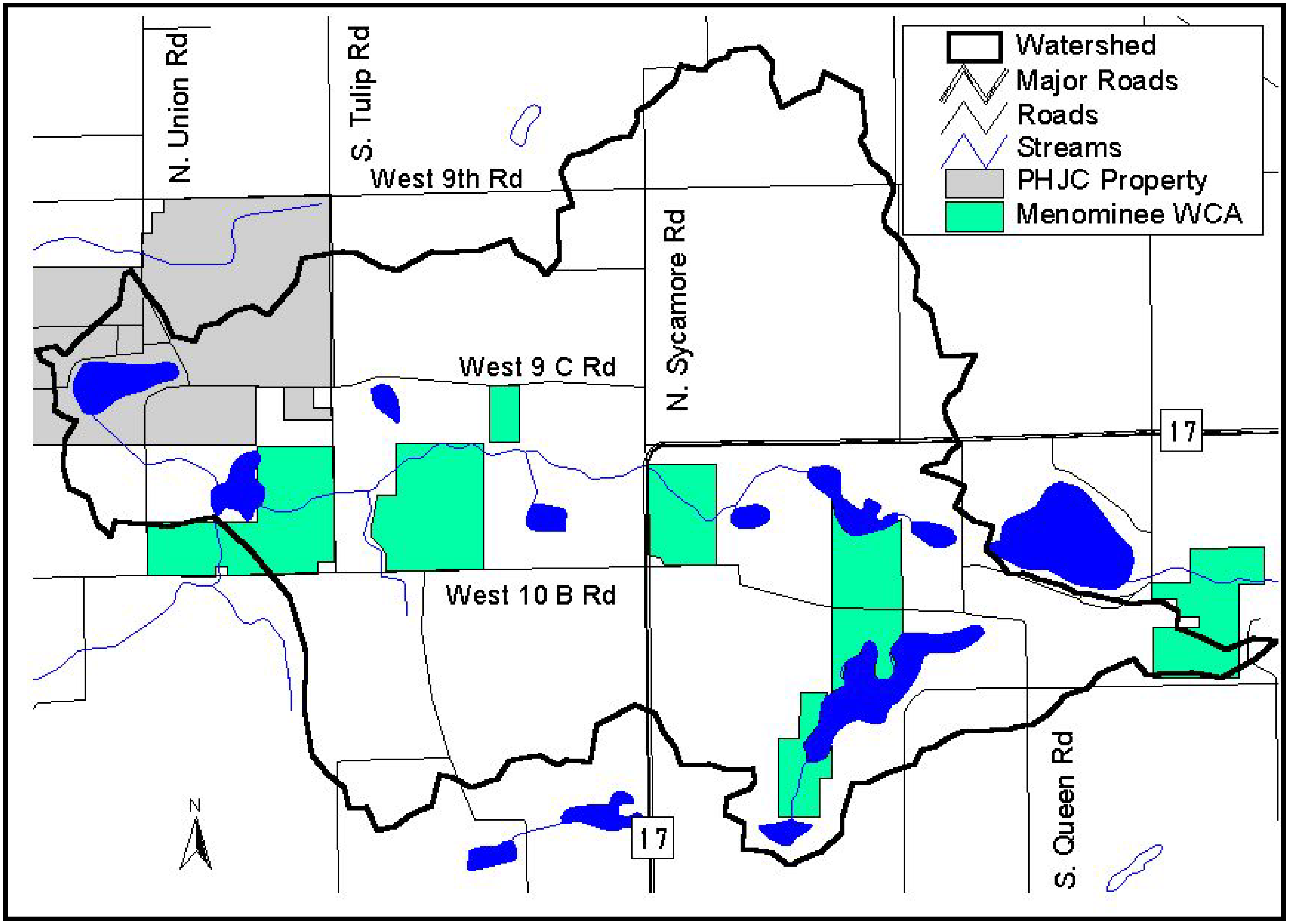

Figure 12. Tracts of land owned by the Indiana Department of Natural Resources (Menominee Wetland Conservation Area) and the Poor Handmaids of Jesus Christ. Source: See Appendix A. Scale: 1'=3,000'.

3.0 IDENTIFIED PROBLEMS

An array of water quality and related problems were identified during development of the Flat Lake Watershed Management Plan. Watershed stakeholders began compiling a list of problems during the first public meeting. JFNew expanded the problem list through a review of existing water quality and related reports from a variety of sources; conversations with representatives from local natural resource agencies; water quality assessment; and subwatershed modeling. The following sections list the key reference documents used to develop the list of water quality problems, outline the results of the water quality assessment conducted as a part of this plan's development, and suggest the sources of common pollutants causing the most problems in the watershed. Section 3.4 summarizes these items in a table format.

3.1 Key Reference Documents

Below is a list of key documents used in identifying water quality and related problems in the Flat Lake watershed and the larger Kankakee River basin. Although some of the documents listed below may not have been used directly in identifying water quality concerns, they are included below because they provide an excellent overview of water quality and related issues in the larger Kankakee River basin and may be useful in future planning efforts in the Flat Lake watershed. Additionally, Commonwealth Biomonitoring recently completed a master plan for the PHJC property. Recommendations made in this report should be considered in future versions of this watershed management plan.

- Baird, Sr. M. 2002. Ancilla Domini Land Design. This report details the historical and existing condition of the natural resources on the PHJC property. It also describes the natural resource assets on the property and highlights some problems that need to be addressed in the future.

- Indiana Clean Lakes Program. 2002. File data (1990, 1995, 1999). School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana. The Indiana Department of Environmental Management administers the Indiana Clean Lakes Program. Under contract from Indiana Department of Environmental Management, Indiana University's School of Public and Environmental Affairs assesses all lakes in Indiana on a five-year rotating basin system for the Indiana Clean Lakes Program. Data presented in the files included water chemistry data (temperature, pH, alkalinity, conductivity, dissolved oxygen concentration, and nutrient concentrations), water clarity data, light penetration data, and algal community data. The files also include the lakes' Indiana Trophic State Index score. Gilbert and Flat Lakes were both assessed in 1990, 1995, and 1999.

- Indiana Clean Lakes Program Volunteer Monitoring Program. 2002. File data (1990-1993). School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana. Under contract from Indiana Department of Environmental Management, Indiana University's School of Public and Environmental Affairs coordinates volunteer lake monitoring activities at more than 125 lakes throughout the state. Citizen volunteers primarily collected water clarity data. Both Gilbert and Flat Lake were assessed by volunteer lake monitors from 1990 to 1993.

- Indiana Department of Environmental Management. 1990. Macroinvertebrate sampling data files. The Indiana Department of Environmental Management Biological Surveys Section conducts macroinvertebrate surveys on streams in Indiana to evaluate whether or not the stream is meeting its aquatic life use designation. In 1990, the BSS conducted a survey in the eastern inlet to Flat Lake at Tulip Road. This sample site corresponds to Site 2 of the water quality survey conducted as part of the development of this watershed management plan.

- Indiana Department of Environmental Management. 1996. Indiana 305(b) Report 1994-1995. Office of Water Quality, Indianapolis, Indiana. 305(b) refers to Section 305(b) of the Clean Water Act. The 305(b) report is IDEM's biennial report to Congress outlining the conditions of the state's water resources and reporting on the progress the state has made toward achieving the goals of the Clean Water Act (i.e. that all waters are fishable and swimmable).

- Indiana Department of Environmental Management. 1999. Unified Watershed Assessment. Division of Water. Indianapolis, Indiana. Indiana Department of Environmental Management completed the "Unified Watershed Assessment". Local, state, and federal agencies and the public evaluated 15 water quality and related parameters (lake fisheries data, Eurasian water milfoil infestation data, aquatic life use support data, recreational use data, lake trophic scores, stream fisheries data, mussel diversity, critical biological resources data, aquifer vulnerability data, surface drinking water use, septic system density, urbanization statistics, livestock production, crop production, and mineral resource extraction data) to identify both healthy and impaired 11-digit watersheds.

- Indiana Department of Environmental Management. 2001. Kankakee River Watershed Restoration Action Strategy (WRAS). Office of Water Quality, Indianapolis, Indiana. Indiana Department of Environmental Management completed the "Kankakee River Watershed Restoration Strategy" to provide baseline background information. The WRAS documents water quality concerns and issues and recommends mechanisms for improving water quality throughout the 8-digit Kankakee River watershed.

- Indiana State Board of Health. 1975. Indiana Department of Environmental Management data files. In the early 1970's, Indiana State Board of Health surveyed all of Indiana's public lakes documenting many of the same parameters that the Indiana Clean Lakes Program documents today. Gilbert Lake was evaluated during this statewide lake evaluation effort.

- Indiana Department of Natural Resources. 1997. Preliminary Study of Galbraith Lake (Gilbert), Marshall County, Indiana. Indiana Department of Natural Resources. Lake and River Enhancement Program. Indianapolis, Indiana. The diagnostic study documents current and historical water quality issues within Gilbert Lake and its watershed. The report also lists management alternatives and restoration recommendations.

- Robertson, B. 1971. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, Indiana. In 1970, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and assessed basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake.

- Robertson, B. 1971. Flat (Mud) Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1970, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and assessed water quality within Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Flat Lake.

- Robertson, B. 1974. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1973, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake. This report documents the condition of the Gilbert Lake fish community following the fisheries renovation (rotenone treatment and restocking).

- Robertson, B. 1975. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1974, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and assessed basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake.

- Robertson, B. 1977. Flat (Mud) Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1976, Indiana Department of Natural Resources biologists surveyed the fish community and assessed water quality within Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Flat Lake.

- Robertson, B. 1977. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1976 and 1977, Indiana Department of Natural Resources biologists surveyed the fish community and assessed basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake. The report also documents the fish kill observed during the harsh winter of 1976-1977.

- Robertson, B. 1979. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1978, Indiana Department of Natural Resources biologists surveyed the fish community in Gilbert Lake. The report includes a

synopsis of the survey and provides general fisheries management recommendations for Gilbert Lake.

- Robertson, B. 1980. Flat (Mud) Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1979, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and assessed water quality within Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Flat Lake.

- Robertson, B. 1980. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1979, Indiana Department of Natural Resources biologists surveyed the fish and plant communities and assessed basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake.

- Robertson, B. 1992. Gilbert Lake, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana. In 1991, Indiana Department of Natural Resources biologists surveyed the fish community and assessed basic water quality (temperature, dissolved oxygen, pH, alkalinity, and water clarity) in Gilbert Lake. The report includes a synopsis of the surveys and provides general fisheries management recommendations for Gilbert Lake.

3.2 Water Quality Summary

The water quality in the major tributaries to Flat Lake was assessed by collecting water grab samples at three sites in the watershed (Table 6; Figure 13). The water samples were collected twice, once under base flow conditions and once following a storm event. Samples were analyzed for basic water quality parameters (temperature, dissolved oxygen, pH, and conductivity), nutrients (nitrogen and phosphorus), sediment, and *E. coli*. The following briefly describes the results of this sampling. Appendix D provides a complete report on the water quality assessment conducted as part of the plan's development. Appendix E contains the water quality assessment's Quality Assurance Project Plan.

Table 6. Detailed sampling location information for the Flat Lake watershed.

Site	Stream name	Road location	Place sampled
1	Unnamed Tributary (Gilbert Lake outlet)	within Poor Handmaids of Jesus Christ property	southern boundary of property upstream of fence
2	Unnamed Tributary (east inlet at Tulip Road)	South Tulip Road north of West 10B Road	downstream of road crossing
3	Unnamed Tributary (east inlet at State Road 17)	State Road 17 north of West 10B Road	downstream of road crossing

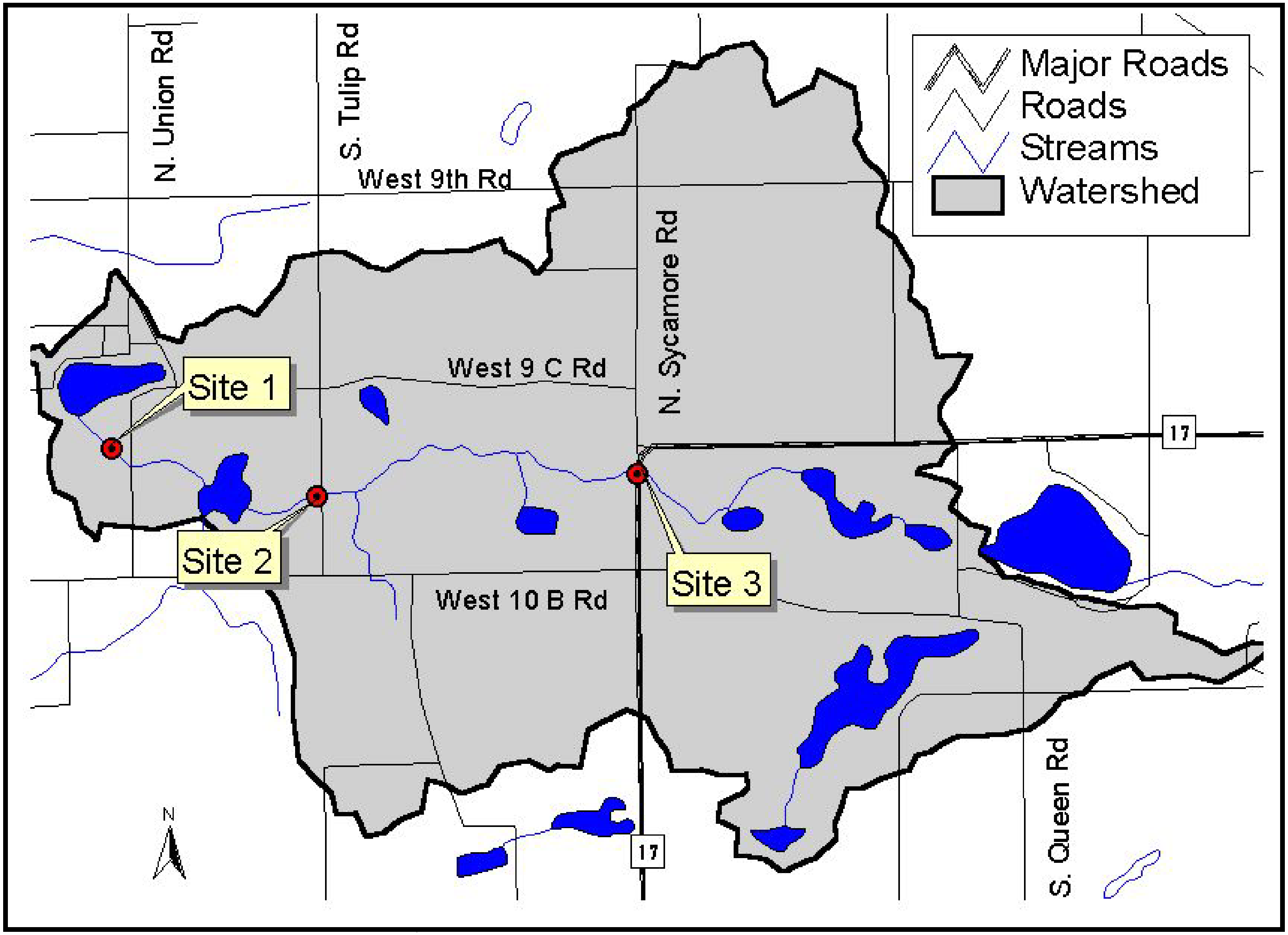

Figure 13. Flat Lake watershed sampling site locations. Source: See Appendix A. Scale: 1"=3,000'.

In general, physical and chemical parameter data collected from streams in the Flat Lake watershed indicate some evidence of water quality degradation when compared with ideal conditions. Dissolved oxygen levels were adequate in the east inlet to Flat Lake at Tulip Road (Site 2); however, one measurement recorded at the east inlet at State Road 17 and both measurements recorded at the Gilbert Lake outlet (Site 1) were below the state standard for dissolved oxygen. Low DO levels at these sites may be impairing the streams' biotic communities. Nitrate-nitrogen and ammonia-nitrogen concentrations in the watershed streams were generally low and within levels acceptable for aquatic life survival. All sites were near or lower than the USEPA's recommended nitrate-nitrogen criteria of 0.30 mg/L and all were lower than the Ohio EPA's nitrate-nitrogen standard of 1.0 mg/L. In contrast, total Kjeldahl nitrogen and total phosphorus levels were slightly elevated. Total phosphorus concentrations generally exceeded various recommendations/standards set to protect aquatic life (USEPA, 2000; Ohio EPA, 1999; Dodd et al., 1998). Despite this, total Kjeldahl nitrogen and total phosphorus concentrations were not unusually high for Indiana streams. The elevated total Kjeldahl nitrogen and total phosphorus levels may be impairing the aquatic biota in the watershed streams and may be contributing to the eutrophication of Flat Lake. *E. coli* concentrations were generally low compared to the typical Indiana stream suggesting recreational use of the waterbodies in the Flat Lake watershed is acceptable.

The exception to the many of the statements above is the Gilbert Lake outlet (Site 1). Dissolved oxygen levels were consistently low in this stream and were below levels necessary to sustain aquatic life. Pollutants concentrations, particularly during base flow, were very high. These high pollutant levels are likely impairing the stream's biotic community and may be affecting downstream communities. Additionally, these pollutants are likely contributing to the eutrophication of Flat Lake. Pollutant loading rates for some parameters (ammonia-nitrogen, total Kjeldahl nitrogen, and total suspended solids) measured during storm event sampling in the Gilbert Lake outlet (Site 1) were comparable and sometimes greater than pollutant loading rates observed in the east inlet at State Road 17 (Site 3), despite the fact that the flow rate at Site 3 was more than twice the flow rate at Site 1. These results indicate that watershed management efforts to improve Flat Lake and overall water quality in the watershed should focus on the watershed draining Site 1 (Figure 14).

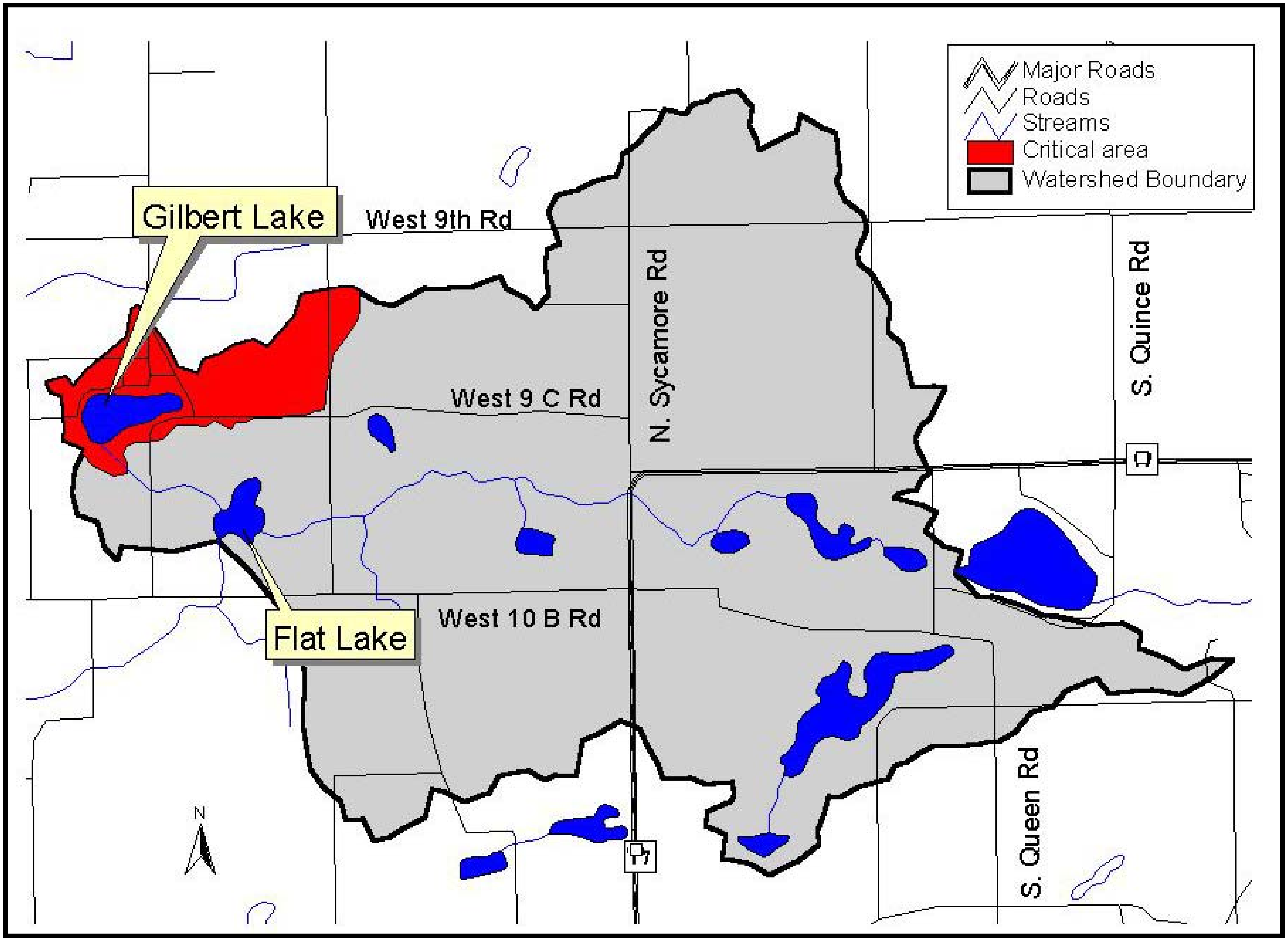

Figure 14. Critical areas targeted for improvement in the Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

3.3 Sources of Pollutants

Eutrophication was a common problem cited in many of the studies and key reference documents. Eutrophication, as defined by Cooke et al. (1993), is the excessive addition of nutrients and silt to lakes and streams causing an increase in biological productivity in the waterbody. The sampling conducted during the development of this watershed management plan also revealed high nutrient and sediment loads in some of the Flat Lake watershed streams. Understanding the sources of nutrients and sediment in the Flat Lake watershed is a critical component in developing an action plan to address the eutrophication problem in the watershed. The following summarizes the probable sources of these pollutants in the Flat Lake watershed.

Common sources of silt 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 silt 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. Of these sources, hardscape, a gravel road, and active farm fields exist in the Flat Lake watershed. A watershed tour did not reveal the presence of any active construction sites. Similarly observations made from road crossings and watershed maps indicate that the eastern inlet to Flat Lake, which accounts for most of the stream mileage in the watershed, has an intact riparian zone and little stream bank erosion. Most of the impervious surface in the watershed is concentrated on the PHJC property (Figure 12), while Tulip Road is the only public, gravel road. Management efforts to reduce sediment input from hardscape and gravel roads should focus on these two areas.

Figure 11 shows the location of farm fields in row crop in the Flat Lake watershed. It is important to note that not all farm fields are prone to erosion. Those fields that are actively farmed in row crop agriculture on highly erodible and potentially highly erodible soils are more likely to erode than areas where soils are not as erodible. Approximately 800 acres of land is farmed in row crop agriculture on highly erodible and potentially highly erodible soils in the Flat Lake watershed (Figure 15). To assist with planning efforts, Figure 15 also includes the location of large tracts in the Conservation Reserve Program (CRP). The use of CRP on highly erodible or potentially highly erodible soil eliminates water quality concerns associated with farming practices. Similarly the use of CRP as field buffers down gradient of farmed, highly erodible tracts also eliminates some of the water quality concerns associated with farming practices. Management efforts aimed at reducing erosion from farm fields such as the use of CRP or conservation tillage in the Flat Lake watershed should target those areas shown on Figure 15 that are not bordered by CRP. The largest of these tracts occur along West 10 B Road and State Road 17.

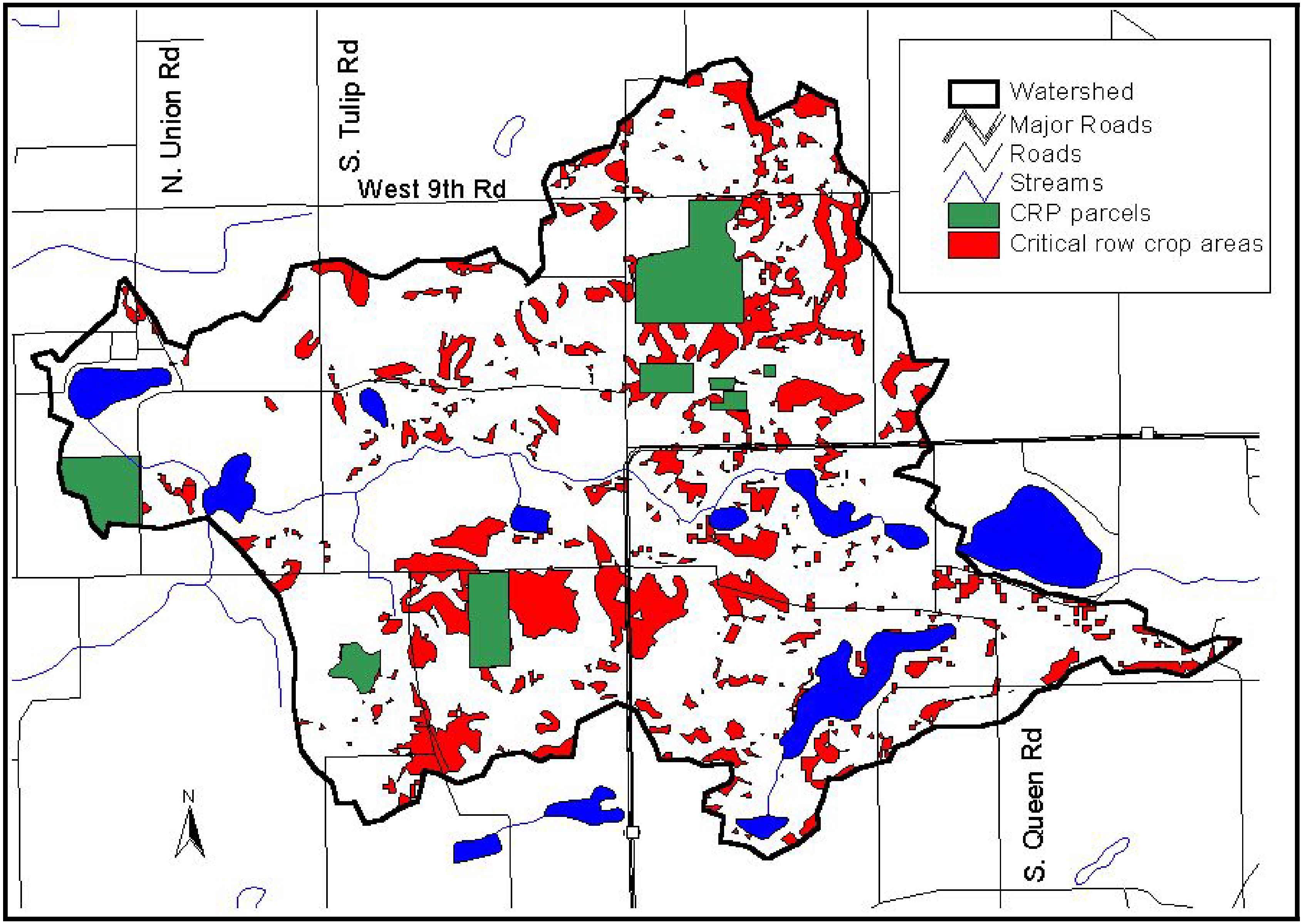

Figure 15. Critical row crop agricultural areas in the Flat Lake watershed. Source: See Appendix A. Scale: 1"=3,000'.

Nutrients are also a key stressor in the Flat Lake watershed. Common sources of nutrients include fertilizers, atmospheric deposition in rainwater, human and wildlife waste, yard waste and other plant material that reaches a waterbody, soil (nutrients are often attached to the soil), and hardscape. 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 lakes and streams in the watershed. Fertilizers are commonly used in variety of settings. Hot spots for the use of fertilizers in the Flat Lake watershed are the golf course in the eastern section of the watershed, residential property, and agricultural property (Figure 11). Nutrient input from human waste via septic systems may occur in the watershed. The most likely location(s) for this to occur is in areas where the soils are mapped as severely limited for use as a septic field (Figure 7). The PHJC waste water treatment facility is also a source of nutrients to Gilbert Lake. Cattle accessing Gilbert Lake and the Gilbert Lake outlet stream are a historical source of nutrients from animal waste. These areas have been fenced to prevent the cattle from accessing the waterbodies. Farmed areas on highly erodible soils contribute to nutrients to the watershed waterbodies when they contribute soil to the waterbodies. Impervious surfaces have been found to be a critical contributor of nutrients (Bannerman et al., 1993). Hardscape areas and areas where soil loss is prevalent in the Flat Lake watershed are noted above. Management efforts aimed at reducing nutrient loading to the watershed's waterbodies should target these sources.

Another source of nutrients may exist. Phosphorus may be released from the bottom of Flat and Gilbert Lakes via chemical reactions that occur when the lakes are stratified or under specific water chemistry conditions. In stratified lakes where the hypolimnion is anoxic, phosphorus bound to iron can be released. Similarly, when sediment with phosphorus bound to it is churned up by wind/wave action, phosphorus may be released if the pH of the water is high enough (approximately 9). Data collected by the Indiana Clean Lakes Program and the Indiana Department of Natural Resources, Division of Fish and Wildlife suggest that both types of internal phosphorus loading are likely occurring at least in Gilbert Lake. In lakes with a history of nutrient loading, such as Gilbert Lake, internal phosphorus loading can account for 70% or more of the total phosphorus budget. This source of phosphorus must be considered in management of the lake.

Some steps have already been taken to manage the sources of nutrients and sediment in the watershed. The PHJC is upgrading their waste water treatment facility. They have also installed a waste water wetland to treat the waste stream from Earthworks which is located along the southern shoreline of Gilbert Lake. The PHJC has fenced Gilbert Lake and the lake's outlet stream, preventing cattle from accessing the waterbodies. Several property owners in the watershed utilize the CRP program on or down gradient of highly erodible soils (Figure 15). Finally, all of the actively farmed acreage on the PHJC property uses conservation tillage. Management efforts should focus on the remaining hot spots and sources.

3.4 Identified Problems Summary

Tables 7 through 11 summarize the water quality and related problems identified through public meetings; review of existing water quality and related reports from a variety of sources; conversations with representatives from local natural resource agencies; and water quality assessments. The problems are separated into five groups: 1. problems affecting Flat Lake, 2.

problems affecting Gilbert Lake, 3. problems affecting Flat Lake watershed streams, 4. problems affecting the Flat Lake watershed, which includes problems associated with landscape processes that affect water quality, and 5. problems affecting the Kankakee River basin to provide a broader context for the problems faced in the immediate Flat Lake watershed. The tables list the concern on the far left side of the table. The center columns of the tables document the location of the problems and/or specific evidence of the problem. The final column in each table provides information on the implications of the problem on aquatic ecosystems and, where appropriate, lists sources or causes for the problem. Individuals should refer to the appendices for a complete documentation of the evidence for listing that concern (Appendix D: Water Quality Assessment).

Table 7. Identified issues affecting Flat Lake.

Problem	Evidence/symptoms	Identified By (Date)	Comments
Eutrophication	High nutrient levels	IDNR Fisheries Survey (1970)	Figure 16 presents a simplified schematic diagram of how high nutrients affect a lake ecosystem and the human community that utilizes the lake. Typical sources of nutrients include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches the lake. Internal cycling can also add to the nutrient load of a lake.
		ISBH (1975)	
		CLP (1995, 1999)	
	High chlorophyll *a* concentration	CLP (1995, 1999)	Chlorophyll *a* is the primary pigment in algae and is used as an indicator of algal density. Figure 16 details the impact of high algal density on a lake ecosystem and the human community that utilizes the lake.
Poor water clarity	Secchi disk 3-5 feet	IDNR Fisheries Survey (1976, 1979)	Algal or non-algal turbidity can decrease water clarity. Algal turbidity is a result of dense phytoplankton growth that blocks light penetration. Non-algal turbidity can result from sediment (dirt) resuspension within the lake, sediment introduction from the watershed via inlet drains or direct overland runoff, or shoreline erosion. While there are many sources of sediment and causes of erosion, active construction sites, unvegetated lake and stream banks, and poorly managed farm fields are the most common sources of sediment to a lake or stream. Figure 17 provides a simplified schematic diagram of the effect turbid water has on a lake ecosystem and the human community that utilizes the lake.
	Secchi disk transparency of 6.1-7.9 feet	CLP Volunteer Monitoring Program (1990-1991)	
	Secchi disk transparency of 3-4 feet in 1995 and 1999	CLP (1995, 1999)	
Low oxygen levels in the water column	No dissolved oxygen present 10-15 feet below the water surface.	IDNR Fisheries Survey (1970, 1976)	Bacterial decomposition of plant material (including algae) and other organic wastes in the hypolimnion can lead to anoxic conditions. Under anoxic conditions, phosphorus bound to the lake's sediment is converted to bioavailable phosphorus, adding to the lake's nutrient levels. See Figure 16 for an outline of how high phosphorus concentrations affect a lake ecosystem and the human community that utilizes the lake. Anoxic conditions also affect a lake's faunal community by limiting habitat availability. Potential results include a conversion of the fish population to one dominated by tolerant species or, if oxygen is extremely low, a fish kill can result. These results ultimately limit the fishing opportunities on the lake.
	The water column is anoxic 6-9 feet below the surface.	CLP (1990, 1995, 1999)	
Skewed fish community		IDNR Fisheries Survey (1970, 1976, 1979)	High populations of rough fish can reduce the quality of the game fishery by out-competing game fish for food resources and habitat. A dominance of rough fish can also be indicative of poor water quality.

Abbreviations: Indiana Department of Natural Resources (IDNR); Indiana Clean Lakes Program (CLP); Indiana State Board of Health (ISBH)

Table 8. Identified issues affecting Gilbert Lake.

Problem	Evidence/symptoms	Identified By (Date)	Comments
Eutrophication	Excessive hypolimnetic nutrients	CLP (1990, 1995, 1999)	High hypolimnetic nutrient concentrations indicate internal loading from nutrient reserves in the lake's sediment. Lakes with historically high nutrient loads often have significant nutrient reserves in their sediments. Figure 16 presents a simplified schematic diagram of how high nutrients affect a lake ecosystem and the human community that utilizes the lake.
		LARE (1997)	
	High total phosphorus concentration	IDNR Fisheries Survey (1970, 1976)	Phosphorus is often the limiting nutrient in aquatic systems. Refer to Figure 16 for an outline of how high phosphorus concentrations affect a lake ecosystem and the human community that utilizes the lake. Typical sources of nutrients include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches the lake. Internal cycling can also add to the nutrient load of a lake.
		ISBH (1975)	
		CLP (1990, 1995, 1999)	
		LARE (1997)	
	High chlorophyll *a* concentrations	CLP (1995, 1999)	Chlorophyll *a* is the primary pigment in algae and is used as an indicator of algal density. Figure 15 details the impact of high algal density on a lake ecosystem and the human community that utilizes the lake.
	Blue-green algal dominance	CLP (1990, 1995)	Blue-green algae are typically nuisance species capable of producing large blooms. Some blue green species also produce toxins (Figure 16).
	Oxygen supersaturation at the surface	LARE (1997)	Oxygen supersaturation indicates high algal productivity, since algae release oxygen during photosynthesis (Figure 16).
	High epilimnetic pH	IDNR Fisheries Survey (1970, 1973, 1974, 1976, 1979, 1991)	High epilimnetic pH indicates high algal productivity. Algae utilize carbon dioxide in the water column during photosynthesis raising the water's pH. Such a high pH can harm fish and other biota ultimately limiting fishing opportunities on the lake. Control of the algal populations via reduction in nutrients, particularly phosphorus, is necessary to control the pH in these cases. Refer to Figure 16 for an outline of how high pH affects a lake ecosystem and the human community that utilizes the lake.
		CLP (1995, 1999)	
		LARE (1997)	
	Poor Trophic State Index (TSI) Scores: TSI scores for Gilbert Lake indicate it is extremely eutrophic. Gilbert Lake scored the highest TSI possible (75) in 1975.	ISBH (1975)	The Clean Lakes Program and the agency responsible for the program (IDEM) use the Indiana Trophic State Index to measure eutrophication in Indiana lakes. IDEM considers lakes with scores ranging from 0 to 15 to be oligotrophic and lakes with scores ranging from 16 to 30 to be mesotrophic. IDEM classifies lakes with scores between 31 and 45 as eutrophic. IDEM considers lakes with scores above 45 to be hypereutrophic.

Table 8. Identified issues affecting Gilbert Lake.

Problem	Evidence/symptoms	Identified By (Date)	Comments
	Scores in the 1990's improved, but Gilbert Lake was still eutrophic (TSI's of 37-42).	CLP (1990, 1995, 1999)	
Poor water clarity	IDNR Fisheries Survey data includes Secchi disk depths of 1-2 feet in the 1970's and 4 feet in 1991.	IDNR Fisheries Survey (1970, 1973, 1974, 1976, 1979, 1991)	Algal or non-algal turbidity can decrease water clarity. Algal turbidity is a result of dense phytoplankton growth that blocks light penetration. Non-algal turbidity can result from sediment (dirt) resuspension within the lake, sediment introduction from the watershed via inlet drains or direct overland runoff, or shoreline erosion. While there are many sources of sediment and causes of erosion, active construction sites, unvegetated lake and stream banks, and poorly managed farm fields are the most common sources of sediment to a lake or stream. Channel modification also increase sedimentation downstream of the modification. Figure 17 provides a simplified schematic diagram of the effect turbid water has on a lake ecosystem and the human community that utilizes the lake.
	IDEM staff recorded a 1 foot Secchi disk depth.	IDEM (1986)	
	Clean Lakes Program data includes Secchi disk depths of 3-4 feet; light transmission at 3 ft is less than 30% (1995, 1999).	CLP (1990, 1995, 1999)	
	Secchi disk depths recorded by the Volunteer Monitoring Program average 2.5-3.75 feet. The greatest transparency measured was 4.5 feet while the poorest transparency was 1.5-2 ft.	CLP Volunteer Monitoring Program (1990-1993)	
		LARE (1997)	
	High turbidity	IDNR Fisheries Survey (1970)	
Low oxygen in the water column	No dissolved oxygen present 10-15 feet below the water surface.	IDNR Fisheries Survey (1970, 1973, 1974, 1976, 1991)	Bacterial decomposition of plant material (including algae) and other organic wastes in the hypolimnion can lead to anoxic conditions. Under anoxic conditions, phosphorus bound to the lake's sediment is converted to bioavailable phosphorus, adding to the lake's nutrient levels. See Figure 16 for an outline of how high phosphorus concentrations affect a lake ecosystem and the human community that utilizes the lake. Anoxic conditions also affect a lake's faunal community by limiting habitat availability. Potential results include a conversion of the fish population to one dominated by tolerant species or, if oxygen is extremely low, a fish kill can result. These results ultimately limit the fishing opportunities on the lake.
		ISBH (1975)	
	The water column is anoxic below 10 feet.	CLP (1995, 1999)	
	No dissolved oxygen below 12 feet.	LARE (1997)	

Table 8. Identified issues affecting Gilbert Lake.

Problem	Evidence/symptoms	Identified By (Date)	Comments
High surface water temperatures	The IDNR Fisheries Survey reports a surface water temperature of 82ºF (28ºC).	IDNR Fisheries Survey (1970)	High surface water temperatures increase algal growth (refer to Figure 16 for the implications of increased algal growth) and limit the water volume available to the fish community. High surface temperatures coupled with anoxic hypolimnetic waters can limit fish growth rates. This can limit the fishing opportunities on the lake. Lack of riparian vegetation along inlet streams and lack of shoreline vegetation can increase water temperatures.
	Surface water temperatures ranged from 75-80ºF (24-27ºC).	LARE (1997)	
High hypolimnetic pH	pH=10	IDNR Fisheries Survey (1976)	A pH of 10 is outside the range considered supportive of aquatic life. Such a high pH can harm fish and other biota ultimately limiting fishing opportunities on the lake. High levels of pH in a lake are often the result of high levels of algal photosynthesis. Control of the algal populations via reduction in nutrients, particularly phosphorus, is necessary to control the pH in these cases. Refer to Figure 16 for an outline of how high pH affects a lake ecosystem and the human community that utilizes the lake.
Fish kills	Summer fish kill	CLP Volunteer Monitoring Program (1990)	Fish kills typically occur in eutrophic lakes where large portions of the water column are anoxic. Decomposing plant material, including algae, and other organic wastes is the typical cause of anoxia in lakes. Fish kills can alter the lake's fish community shifting the community toward more tolerant species, which can in turn affect the rest of the lake's food web. Decomposing fish from a kill utilize oxygen and add nutrients to the water column. (See Figure 16 for implications of these consequences of a fish kill.) Ultimately, a fish kill reduces fishing and swimming opportunities and impairs the aesthetic value of the lake.
	Winter fish kill - Winter fish kills occurred during the winters of 1976-1979 and in the winter of 1990.	IDNR Fisheries Survey (1977, 1979)	
		LARE (1997)	
Skewed fish community structure	Large population of rough fish – particularly gizzard shad	IDNR Fisheries Survey (1970, 1976, 1979, 1991)	High populations of rough fish can reduce the quality of the game fishery by out-competing game fish for food resources and habitat. A dominance of rough fish can also be indicative of poor water quality.
	Bluegill and black crappie with below average growth rates	IDNR Fisheries Survey (1970, 1974)	Low growth rates and stunted fish can be indicative of an unbalanced food web or excessive plant growth. Stunted populations can lead to alterations in the game fish population and reduce the fishing opportunities on the lake.
	Dominance of tolerant fish species	IDNR Fisheries Survey (1974, 1976, 1979, 1991)	Tolerant fish species such as green sunfish and white suckers dominate when water quality is poor. These species reduce the quality of the game fishery, limiting fishing opportunities on the lake. Some tolerant fish, such as carp, contribute to nutrient recycling in the lake. (See Figure 16 for the implications of this on the lake ecosystem and the human community that utilizes the lake.)
		LARE (1997)	

Table 8. Identified issues affecting Gilbert Lake.

Problem	Evidence/symptoms	Identified By (Date)	Comments
Poor quality sport fishery		LARE (1997)	A poor quality sport fishery reduces the fishing opportunities on the lake.
Impaired Rooted Aquatic Plant Community	Curly-leaf pondweed	IDNR Fisheries Survey (1970, 1974)	Curly-leaf pondweed is an exotic invasive which forms dense canopies. Excessive growth of this species can limit fish habitat, stunt fish populations, and exclude more beneficial native rooted plant species from becoming established. This impairs fishing opportunities and the aesthetic value of the lake. Nuisance aquatic plant such as curly-leaf pondweed become established in a lake when introduced by a boater who did not carefully clean his boat after using it in an infested lake or stream.
	Poor aquatic rooted plant cover (rooted plants cover only approximately 5% of the lake's total surface area)	IDNR Fisheries Survey (1970, 1974, 1976, 1979, 1991)	Poor rooted plant coverage can have direct impacts on a lake ecosystem by limiting fish and invertebrate habitat which in turn limits fishing opportunities on the lake. Rooted aquatic plant communities improve water clarity by stabilizing sediments and preventing their resuspension, shading sunlight from algae, providing a refuge for zooplankton (algae's primary predator) and releasing alleopathic chemicals that discourage algae growth. Without rooted plants, these functions are lost resulting in decreased water clarity and increased algae growth. Figure 16 and 17 outline the implication of decreased water clarity and increased algae growth on a lake ecosystem and the human community that utilizes it.
		LARE (1997)	

Abbreviations: Indiana Clean Lakes Program (CLP); Lake and River Enhancement Program (LARE); Indiana Department of Natural Resources (IDNR); Indiana State Board of Health (ISBH); Indiana Department of Environmental Management (IDEM)

Table 9. Identified issues affecting Flat Lake watershed streams.

Problem	Location	Identified By (Date)	Comments
High *E. coli* concentrations	Western tributary to Flat Lake	Watershed stakeholders public meeting (2002)	*E. coli* indicates the presence of pathogenic organisms in the water. Pathogenic organisms can potentially harm the biota living in the stream. Such organisms can also make humans who some in contact with the water sick. Common sources of *E. coli* include human and wildlife wastes, fertilizers containing manure, previously contaminated sediments, septic tank leachate, and illicit connections.
	Western tributary to Flat Lake	JFNew base flow sampling (2002)	
	Eastern tributary to Flat Lake at Tulip Road	JFNew storm flow sampling (2002)	
Silt/High total suspended solid concentration	East inlet to Gilbert Lake	LARE (1997)	Silt in the inlet stream indicates an erosion problem in the watershed (current or historical) and/or streambank erosion. While there are many sources of silt and sediment, active construction sites, unvegetated stream and lake banks, and poorly managed farm fields area the most common. The addition of sediment to the stream system impairs habitat for the stream biota. Typically silt entering a stream has nutrients attached to it. These nutrients can impair the biota and ultimately the functioning of the stream ecosystem (see below). In addition, silty water presents aesthetic problems for human users of the system.
	Western tributary to Flat Lake	JFNew storm and base flow sampling (2002)	
	Eastern tributary to Flat Lake at Tulip Road	JFNew storm flow sampling (2002)	
	Eastern tributary to Flat Lake at SR 17	JFNew base flow sampling (2002)	
Low dissolved oxygen concentrations	East inlet to Gilbert Lake	LARE (1997)	Low gradient streams with high levels of organic material will typically have low dissolved oxygen levels. Low dissolved oxygen levels can limit the potential habitat for aquatic biota, ultimately limiting stream's ability to assimilate nutrients and perform other necessary functions. It also impairs the biological integrity of the stream.
	Western tributary to Flat Lake	LARE (1997)	
	Western tributary to Flat Lake	JFNew storm and base flow sampling (2002)	
	Eastern tributary to Flat Lake at SR 17	JFNew base flow sampling (2002)	
High phosphorus concentrations	Western tributary to Flat Lake	JFNew storm and base flow sampling (2002)	High total phosphorus concentrations alter a stream's biotic community by creating conditions that favor autotroph (algae) growth in a headwater stream where heterotrophs (macroinvertebrates) should dominate. This will impair a stream's ability to assimilate nutrients and perform other necessary functions. It also impairs the biological integrity of the stream. Common sources of phosphorus include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches the lake.
	Eastern tributary to Flat Lake at Tulip Road	JFNew storm flow sampling (2002)	
	Eastern tributary to Flat Lake at SR 17	JFNew base flow sampling (2002)	
High total Kjeldahl nitrogen (TKN) concentrations	Western tributary to Flat Lake	JFNew storm and base flow sampling (2002)	High TKN concentrations indicate the presence of organic matter in the stream. The decomposition of this matter can reduce the available oxygen which can impair the stream's biotic community.

Table 9. Identified issues affecting Flat Lake watershed streams.

Problem	Location	Identified By (Date)	Comments
	Eastern tributary to Flat Lake at Tulip Road	JFNew storm flow sampling (2002)	
	Eastern tributary to Flat Lake at SR 17	JFNew base flow sampling (2002)	
High ammonia concentration	Western tributary to Flat Lake	JFNew storm and base flow sampling (2002)	High ammonia concentrations indicate decomposition is occurring in the stream which can lower the oxygen available to the biotic community. Additionally because ammonia is the bioavailable form of nitrogen, high ammonia concentrations can promote the algae growth shifting the biotic community from one dominated by heterotrophs to one dominated by autotrophs. This will impair a stream's ability to assimilate nutrients and perform other necessary functions. It also impairs the biological integrity of the stream. At extreme concentrations ammonia can be toxic to aquatic fauna.
High pollutant loads	Eastern tributary to Flat Lake at Tulip Road	JFNew storm flow sampling (2002)	Loads are an indicative of the relative amount of each pollutant that each stream contributes to Flat Lake. During storm events, Flat Lake's eastern inlet delivered more pollutant mass to Flat Lake than the western inlet did. This is largely due to the greater flow (amount of water moving in the stream per unit of time) in the eastern inlet. Streams with greater flow are expected to carry more pollutants to a lake. Surprisingly, the total phosphorus and total suspended solid loads at base flow were lower in the eastern inlet at Tulip Road compared to the loads in the eastern inlet at SR 17. This suggests there is a sink somewhere between Tulip Road and SR 17 that is withdrawing pollutants from the system.
	Eastern tributary to Flat Lake at SR 17 (total suspended solids and total phosphorus)	JFNew base flow sampling (2002)	

Abbreviations: Lake and River Enhancement Program (LARE)

Table 10. Identified issues in the Flat Lake watershed.

Problem	Location	Identified By (Date)	Comments
Highly erodible land	See HEL Map	LARE (1997)	Soil and soil-attached pollutants (nutrients, toxins, and pathogens) easily erode from highly erodible lands. Soil in streams and lakes degrade habitat, impair biotic communities, and reduce the aesthetic and recreational value of the waterbody. Nutrients and other pollutants can have similar impacts. Refer to the tables detailing stream and lake issues for additional information on the impact of soil and other pollutants on receiving waterbodies.
		JFNew (2002)	
Pasturing cattle near waterbodies	South shore of Gilbert Lake; Unnamed Tributary to Flat Lake	LARE (1997)	Trampled banks damages buffer vegetation reducing its ability to perform critical water quality protection functions. The disturbance also alters the plant community favoring a dominance of tolerant species that often cannot perform these functions as well as a diverse community. Soil compaction by cows decreases the ability of runoff water to infiltrate the soils of the riparian zone; runoff water simply discharges to the adjacent waterway. The cattle increase bank sloughing adding sediment to adjacent waterbodies. Cattle also deposit waste material (nutrients and pathogens) directly or indirectly into the waterbodies. The lakes and streams issues tables outline the impact of sediment, nutrients, and pathogens on stream and lake ecosystems and the human community that utilizes these systems in greater detail.
		Watershed stakeholders public meeting (2002)	
Wetland loss	See Hydric Soils Map	LARE (1997)	Wetland loss and/or impairment reduces the ability of the landscape to perform the critical water quality functions. These functions include runoff storage, runoff filtering, groundwater recharge and discharge, and providing wildlife habitat. The loss of wetlands can lead to flooding downstream and degrade watershed water quality. Wetland loss typically is the result of development of the land for agricultural, residential, or commercial uses.
		JFNew (2002)	
Purple loosestrife	South shore of Gilbert Lake; Menominee State Wetland	LARE (1997)	Exotic invasives create monotypic stands of vegetation and lead to the loss of the natural wetland plant community and the functions associated with those communities (wildlife habitat, aesthetic value, ecosystem diversity, filtering and infiltration, etc.).
	Scattered throughout the entire watershed	JFNew (2002)	
	Menominee State Wetland	Watershed stakeholders public meeting (2002)	
Fish kills	Wetland upstream of State Road 17	Watershed stakeholders public meeting (2002)	Fish kills typically occur in productive waterbodies where large portions of the water column are anoxic. Decomposing plant material, including algae, and other organic wastes is the typical cause of anoxia in waterbodies. Fish kills can alter a waterbody's fish community, shifting the community toward more tolerant species, which can in turn affect the rest of the waterbody's food web.

Table 10. Identified issues in the Flat Lake watershed.

Problem	Location	Identified By (Date)	Comments
			Decomposing fish from a kill utilize oxygen and add nutrients to the water column. Refer to the lakes and streams issues tables for more information on the impact of increased nutrient loads and reduced dissolved oxygen in water bodies. A fish kill also reduces fishing opportunities in the waterbody in which the kill occurs and potentially in any downstream waterbodies.
Excess duckweed growth	Wetland upstream of State Road 17	Watershed stakeholders public meeting (2002)	Duckweed growth in a waterbody suggests the waterbody contains high nutrient levels, particularly in bioavailable forms (soluble reactive phosphorus, ammonia). Duckweed growth can be unsightly decreasing a waterbody's aesthetic value. In severe cases, duckweed can shade other rooted plants altering the waterbody's biotic community. A die-back of duckweed can lower oxygen levels and release nutrients back into the water body.
Large geese populations	Entire watershed	Watershed stakeholders public meeting (2002)	Large geese populations can add nutrients and pathogens to waterbodies. (The lakes and streams issues tables outline the impact of nutrients and pathogens on stream and lake ecosystems and the human community that utilizes these systems.) Geese can also be an aesthetic problem and interfere with recreational uses of a waterbody.
Flooding due to wetland restoration	Entire watershed	Watershed stakeholders public meeting (2002)	While there may not be an immediate water quality concern associated with flooding, flooding can prevent property owners from utilizing their land for agriculture and other uses requiring dry land.
Poor drainage	Intersection of North Union and Upas Roads	Watershed stakeholders public meeting (2002)	Again, a poorly functioning culvert may not have direct water quality impacts, but it could limit a property owner's land use.
Stormwater Drains	Ancilla College	LARE (1997)	Storm drains convey pollutants (sediment, nutrients, and pathogens) from impervious surfaces directly to waterbodies without any treatment. The lakes and streams issues tables outline the impact of sediment, nutrients, and pathogens on stream and lake ecosystems and the human community that utilizes these systems in greater detail. Given that commercial/institutional areas have the potential to release greater pollutant loads than agricultural lands, the presence of storm drains leading directly to Gilbert Lake is of concern.
National Pollutant Discharge Elimination System (NPDES) Facility	Gilbert Lake outlet	IDEM	The Poor Handmaids of Jesus Christ maintain a wastewater treatment plant which treats all wastewater from PHJC property. Once treatment occurs the plant discharges effluent to Gilbert Lake. The current wastewater treatment plant is not equipped to handle the current flow of waste from PHJC facilities. The current NPDES permit covers dissolved oxygen, total suspended solids, total phosphorus, ammonia-nitrogen, pH, and cBOD concentrations in the plants effluent. From January 2002 to February 2003 the plant was in violation of its permitted levels

Table 10. Identified issues in the Flat Lake watershed.

Problem	Location	Identified By (Date)	Comments
			for dissolved oxygen 64% of the time (9 months), total suspended solids and ammonia-nitrogen 7% of the time (1 month), and total phosphorus 14% of the time (2 months). (For more specific details on the impacts of low dissolved oxygen and high nutrient and sediment concentrations see Table 8.) A NPDES permit has been submitted for a new wastewater treatment plant. The plant will correct the two main issues with the current facility: it will be equipped for higher flow volumes and will bypass Gilbert Lake and discharge effluent into the restored wetland adjacent to Gilbert Lake's outlet stream.

Abbreviations: Lake and River Enhancement Program (LARE); Indiana Department of Environmental Management (IDEM)

Table 11. Identified issues in the Kankakee River basin.

Problem	Location	Identified By (Date)	Comments
Eurasian water milfoil infestation in area lakes	Lakes in the 11 digit watershed	UWA (1999)	Eurasian water milfoil (EWM) is an nuisance exotic species that can out-compete native plants forming a monoculture. EWM serves as poor habitat for the lakes' biota (fish and invertebrates) and can therefore impact the lakes' trophic structure, food web, and overall biological integrity. This in turn can affect fishing opportunities on the lakes. Dense EWM mats also impair the recreational and aesthetic value of the lakes. The spread of EWM from lake to lake is often the result of careless boaters who fail to clean their boats when going from infested to non-infested waters. Waterfowl can also spread the plant.
Relatively high density of septic systems	11 digit watershed	UWA (1999)	Failing, old, or poorly-sited/designed septic systems can leach nutrients and pathogens to nearby waterways and groundwater. The addition of these pollutants to water impair the water quality, alter the trophic structure of the water's biotic communities, and decrease the recreational and aesthetic value of waterways. Leaking septic systems also contaminate groundwater used for drinking water.
Relatively high Trophic State Index (TSI) scores	Lakes in the 11 digit watershed	UWA (1999)	High TSI scores are indicative of lake eutrophication. Eutrophic lakes support skewed biotic communities and may offer limited recreational and aesthetic opportunities. See the discussion points under the Gilbert Lake issues table for a more complete discussion on eutrophication.
Relatively high number of endangered species or critical habitat	11 digit watershed	UWA (1999)	This concern highlights the need to protect any listed species or special habitats in this 11 digit watershed.
Relatively high number of people using surface waters	11 digit watershed	UWA (1999)	This concern highlights the need in this 11 digit watershed to protect surface water from degradation since a relatively high number of people utilize surface water.
Relatively high density of livestock	11 digit watershed	UWA (1999)	Livestock can impact water quality, aquatic habitat, and biotic communities in a variety of ways. Livestock manure that reaches streams and lakes adds nutrients and pathogens to the waterbodies. Livestock accessing waterbodies for water can trample banks, adding sediment and any sediment-attached pollutants to the waterbodies. In riparian zones, overgrazing by livestock reduces the functionality of these zones in protecting water quality. On upland areas, overgrazing facilitates erosion adding sediment and sediment-attached pollutants to waterbodies. These various impacts can result in impaired biotic communities, recreational opportunities, and aesthetic value of the waterbodies.

Table 11. Identified issues in the Kankakee River basin.

Problem	Location	Identified By (Date)	Comments
Relatively high percentage of cropland	11 digit watershed	UWA (1999)	Agricultural practices can impact water quality, aquatic habitat, and biotic communities via the erosion and runoff of sediment and sediment-attached pollutants to nearby waterbodies. (It is important to note that urban land often exports more pollutants in runoff than well managed agricultural land.)
Non-support of recreational use (high *E. coli* measurements)	Gunnard Anderson Ditch	305 (b) Report (1994-1995)	High *E. coli* readings suggest pathogen contamination of the waterbody, making it unsafe for full-body contact (i.e. swimming). Common sources of *E. coli* include human and wildlife wastes, fertilizers containing manure, previously contaminated sediments, septic tank leachate, and illicit connections to stormwater drains or field tiles.
	Yellow River at Knox	305 (b) Report (1994-1995)	
	Yellow River at Knox	305 (b) Report (unpublished data from 2001 monitoring)	
	Yellow River at Knox	303 (d) list (2002)	
	Kankakee River (Lake and Laporte Counties)	303 (d) list (2002)	
Impaired biotic communities	Gunnard Anderson Ditch	IDEM macroinvertebrate sampling (1990)	Degradation of the biotic communities can impact a creek/river's ability to function—particularly its ability to absorb and sequester pollutants. Impaired macroinvertebrate communities can negatively impact fish community structure. Degraded biotic communities can also reduce recreational opportunities on the waterbody.
	Kankakee River (Lake and Laporte Counties)	303 (d) list (2002)	
Fish consumption advisory for polychlorinated biphenyls (PCBs) and mercury (Hg)	Kankakee River (Lake and Laporte Counties)	303 (d) list (2002)	Fish contamination can limit recreational opportunities on a waterbody. It can also impact the larger food web if fish are consumed by piscivorous birds.
	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	
Release of pollutants from Flat Lake	Downstream of Flat Lake	Watershed stakeholders public meeting (2002)	Pollutants released from the Flat Lake watershed can have many of the same impacts on downstream waterbodies as the impact these pollutants have on waterbodies in the Flat Lake watershed. Refer to the tables detailing stream and lake issues for additional information on the impact of pollutants on receiving waterbodies.
Obtaining data and targeting problems	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	This concern highlights the need for gathering data on a more local level. This watershed management plan will help achieve this.

Table 11. Identified issues in the Kankakee River basin.

Problem	Location	Identified By (Date)	Comments
Streambank erosion and stabilization	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	Eroding stream banks deposit soil and soil-attached pollutants (nutrients, toxins, pathogens) directly into waterways. Soil in streams and lakes degrade habitat, impair biotic communities, and reduce the aesthetic and recreational value of the waterbody. Nutrients and other pollutants can have similar impacts. Refer to the tables detailing stream and lake issues for additional information on the impact of soil and other pollutants on receiving waterbodies. Removal of streamside vegetation and straightening of streams are the most common causes of streambank erosion.
Failing septic systems and straight pipe discharges	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	Failing, old, or poorly-sited/designed septic systems or straight pipes can leach or deliver nutrients and pathogens to nearby waterways and groundwater. The addition of these pollutants to water impair the water quality, alter the trophic structure of the water's biotic communities, and decrease the recreational and aesthetic value of waterways. (See the lake and stream issues tables for more details on how these pollutants impact the waterbody ecosystems and the humans that utilize those systems.) Leaking septic systems also contaminate groundwater used for drinking water.
Water quality	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	This table and other tables in this section outline specific water quality concerns. Refer to these tables.
Nonpoint source pollution	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	This table and other tables in this section outline specific water quality concerns. Refer to these tables.
Point source pollution	8 digit Kankakee River watershed	IDEM Kankakee River WRAS (2001)	There is only one active point source discharger in the watershed with a NPDES permit (Ancilla WWTP). Potential pollutants discharged from the Ancilla WWTP include many of the same pollutants discussed in other tables (nutrients and pathogens). See these tables for the impact of these pollutants on receiving waterbodies and the human community that uses these waterbodies.

Abbreviations: Unified Watershed Assessment (UWA); Indiana Department of Environmental Management (IDEM); Watershed Restoration Action Strategy (WRAS)

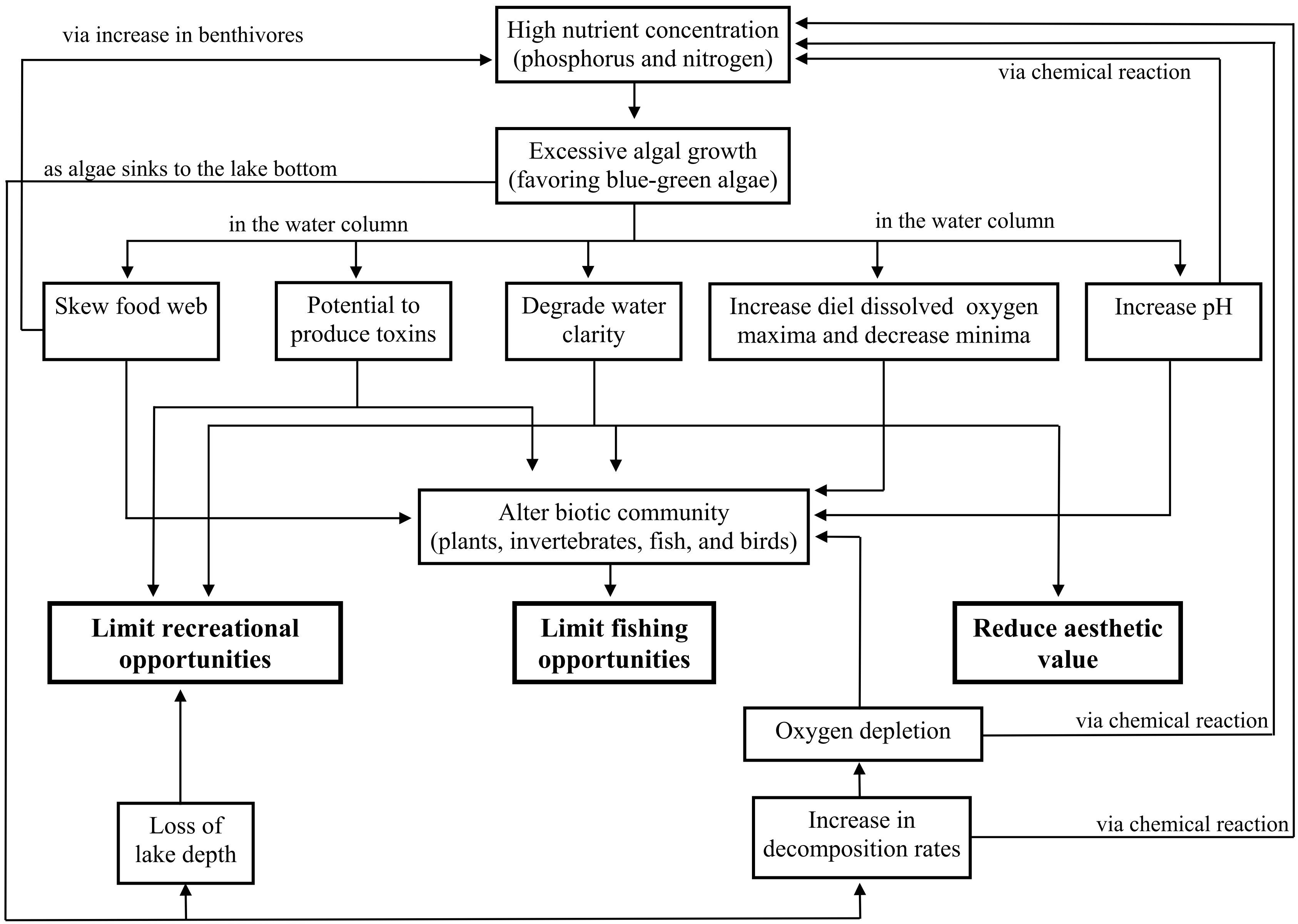

Figure 16. Potential nutrient impacts in a lake ecosystem.

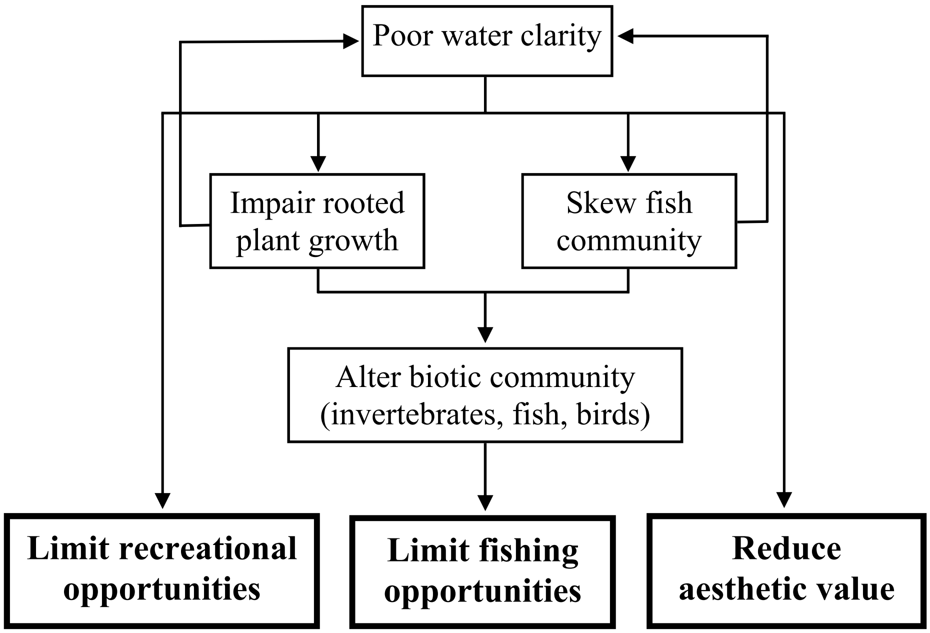

Figure 17. Influence of water clarity in a lake ecosystem.

4.0 GOALS AND DECISIONS

The following goals and action plan area a result of several public meetings. Once the watershed inventory and review of historical water quality reports was completed, watershed stakeholders met to identify those issues that were of greatest concern in the watershed and set goals to address those issues. Stakeholders identified three primary areas of concern: 1. the need to reduce eutrophication and improve water clarity in Flat and Gilbert Lakes, 2. the need to reduce purple loosestrife in the watershed, particularly around Flat Lake, and 3. the need to increase participation in the watershed planning and management processes.

The stakeholders wrote three goals addressing the need to reduce eutrophication and improve water clarity in Flat and Gilbert Lakes. The action plan to achieve those goals grew out of an understanding of the stressors and sources responsible for the increased eutrophication and decreased water clarity. Nutrients (phosphorus and nitrogen) and sediment (including sediment-attached nutrients) are the stressors responsible for the increase in eutrophication of the lakes and the reduction in water clarity. As noted in the previous section, sources of nutrients in the Flat Lake watershed include fertilizers, human and animal waste, atmospheric deposition in rainwater, yard waste or other plant material that reaches streams, and any of the above washed from hardscape. Gravel roads, hardscape, and actively farmed fields that are mapped in highly erodible or potentially highly erodible soils are sources of sediment and sediment-attached nutrients in the Flat Lake watershed. These sources are the ones targeted in the action plan. The plan includes measures to address sources in the agricultural community and sources coming from residential and institutional land. It also includes mechanisms to help identify and pinpoint additional sources (i.e measurement of storm drain releases). Finally, it provides a way to monitor future development in the watershed since active construction sites may be a source of sediment and sediment-attached pollutants in the watershed in the future.

The watershed stakeholders wrote one goal to address the need to reduce purple loosestrife and one goal to address the need for increased participation in watershed management. Neither of these problems has clearly defined stressors and sources. In the case of purple loosestrife, one "cause" of its spread is human beings. Because the species sports a pretty flower, some individuals may inadvertently spread the plant by transplanting it from the wild to their property. The following action plan includes an educational component to help increase awareness about the harm this species can cause in wetlands and prevent such spread of the species. Similarly, lack of awareness about the watershed is one of the "causes" of the lack of participation in watershed management. The action plan that will be undertaken to increase participation in watershed management includes actions that will raise awareness to the value of the natural resources in the Flat Lake Watershed.

The stakeholders prioritized the goals over the course of two public meetings. Each stakeholder prioritized the five 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 give the goal aimed at increasing participation in watershed management as 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 and sediment) to improve the environmental quality of the two major lakes in the watershed. The purple loosestrife goal recognizes that the invasion of this exotic nuisance species is a basin wide problem; stakeholders are attempting to do their part in managing this problem. 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 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 Flat Lake watershed.

The following are the prioritized goals and agreed upon action plan for the Flat Lake watershed:

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 time frame: Except for annual/continuous tasks, the goal should be reached by 2005.

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.

Objective notes: This core group, or a single contact from the core group, will provide progress reports on the plan's implementation to Sr. Margaret Anne Henns on a regular basis, possibly quarterly.

Actions:

- Contact possible core group members including the local IDNR conservation officer, local high school biology teacher, Ancilla College biology professors, Menominee WCA property manager, Waterfowl USA 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. Efforts to enlist participants for the group should include outreach to Ancilla College students and faculty.
- Hold regular meetings to discuss and address water quality issues in and around the Flat Lake 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 Flat Lake and its watershed and information on how stakeholders can participate in these efforts.

Objective 3: Organize and hold one annual field day highlighting the value of the streams and lakes in the Flat Lake watershed and how to protect the water quality and aquatic life in the watershed.

Actions:

- Work with NRCS and Soil and Water Conservation District (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. The local IDNR Resource Specialist, Beth Forsness, has already expressed an interest in assisting with this.
- Invite IDNR biologists or other experts to speak at field days, particularly concerning the value of Flat Lake and its watershed. Possible topics could include goose control, erosion control, exotic species control, volunteer water quality monitoring, water quality, conservation programs for local landowners, etc.

- Advertise the field days via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database.

Objective 4: Publicize the value of Flat Lake, its watershed, 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 and institutional land.
- Summarize the value of the waterbodies in the Flat Lake watershed 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 5: 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. (Students at Ancilla College would be a possible source of volunteers with oversight from a professor or mentor.)
- Identify landowners along Flat Lake 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 6: Participate in the Indiana Clean Lakes volunteer monitoring program.

Actions:
- Identify individuals that may be interested in participating in the Indiana Clean Lakes Program (CLP) Volunteer Monitoring Program. (Students at Ancilla College would be a possible source of volunteers with oversight from a professor or mentor.)
- Contact the CLP volunteer coordinator to schedule training for monitors on Flat and Gilbert Lakes.
- Advertise results of the work to the community through various forms of media mentioned in Objective 2.

Goal 2: In 10 to 20 years, we want to improve water clarity in Flat and Gilbert Lakes such that the lakes exhibit a growing season Secchi disk transparency mean of 6 feet.

Goal time frame: This is a long-term goal. The goal should be reached by 2013-2023.

Objective 1: Continue wetland restoration efforts in the headwaters of the eastern inlet to Gilbert Lake.

Objective notes:

- The PHJC constructed a wetland above the eastern inlet to Gilbert Lake in 2000 and adding fencing to exclude livestock from the wetland in 2002. This area could be planted with a diverse mix of wetland species to facilitate the wetland restoration and increase its water filtering ability. Some exotic/nuisance species control may also be useful in improving the wetland's filtering ability.
- Current research suggests that structural management practices such as wetlands may remove more than 80% of the sediment and approximately 45% of the nutrients (Winer, 2000; Claytor and Schueler, 1996: and Metropolitan Washington Council of Governments, 1992). Removal efficiencies depend upon site conditions and factors related to the structure's deign, 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.

Actions:

- Work with IDNR Resource Specialist to understand the expected hydrology in the constructed wetland and create a plan for vegetating the wetland.
- Select native plant species to vegetate wetland. A mix of emergent and floating species may be necessary depending upon the wetland's expected hydrology.
- Determine if a control of exotic/nuisance species is necessary and control with appropriate method (burning, herbicide, hand-pulling, etc.).
- Identify funding for planting and maintenance (exotic/nuisance species control).

Objective 2: Work with the NRCS, SWCD, and agricultural property owners in the watershed to promote water quality Best Management Practices (BMPs) usage in the watershed.

Objective notes:

- Many studies have shown a reduction in pollutant loads to waterbodies or improvement in waterbody trophic state due to implementation of BMPs on agricultural land. For example, Olem and Flock (1990) report 60 to 98 percent reductions in sediment loading and 40 to 95 percent reductions in phosphorus loading to waterways 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). With respect to Indiana lakes and the specific goals set by the Flat Lake watershed stakeholders, Jones (1996) found that ecoregions reporting higher percentages of cropland in the Conservation Reserve Program (CRP) had mean lower TSI scores (Goal 3). Similarly, Jones observed lower TSI scores in ecoregions with high percentages of conservation tillage. (Usually lakes with lower TSI scores have better water clarity as well.)

- Areas to be targeted are those areas shown as sources on Figure 15. Figure 15 highlights the portion of the watershed that is mapped in a highly or potentially highly erodible soil unit and row crop agricultural production. The largest tracts are located along West 10 B Road and State Road 17.
- Exact load reductions will depend upon the BMP utilized and acreage to which the BMP is applied. Appendix F presents an example load reduction calculation for converting a portion of a row cropped field to pasture (CRP). The example utilizes IDEM's pollutant load reduction workbook. Revised Universal Soil Loss Equation (RUSLE) parameters were taken from the U.S. Environmental Protection Agency's STEPL (Spreadsheet Tool for the Estimation of Pollutant Load) model. Using the IDEM pollutant load reduction model, converting 100 acres of row crop land to pasture will result in a reduction of 96 tons of sediment per year, 134 pounds of nitrogen per year, and 268 pounds of nitrogen per year.

Actions:

- Work with the NRCS and SWCD to identify which property owners in the Flat Lake 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. Increasing conservation tillage and the use of filter strips are stated goals of the Marshall County SWCD's Long Range Plan. Flat Lake watershed stakeholders should work with the SWCD to help them implement this goal.
- Work with NRCS and SWCD representatives to hold demonstration days 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. The local IDNR Resource Specialist has already expressed an interest in assisting with this. The local SWCD conducts such field days in the county.
- Attend local SWCD meetings.

Objective 3: Institute a program of regular street cleaning on the PHJC property.

Objective notes:

- The PHJC property contains the largest area of concentrated hardscape in the watershed. This area also has storm drains directly connected to the hardscape. Consequently this area is a source of silt and nutrients to the watershed's waterbodies.

Actions:

- Meet with facility groundskeeper to discuss regular cleaning schedule.
- Identify proper disposal areas for materials collected during cleaning.
- Identify which drains can be retrofitted with some type of sediment catch basin or filter. (Can be done in conjunction with Objective 6.)

Objective 4: Complete bridge/roadside erosion control project where Tulip Road crosses the unnamed eastern inlet to Flat Lake.

Objective notes:

- Sediment and gravel washed from Tulip Road into the unnamed eastern inlet to Flat Lake was identified as a problem during the watershed plan's development. Constructing a small levee or swale to direct road runoff away from the unnamed eastern inlet to Flat Lake and towards a small (20 square feet in size) filtration swale/area would help prevent the sediment and gravel from Tulip Road from entering the unnamed eastern inlet to Flat Lake.
- Filtration areas such as the one proposed here filter up to 80-90% of the sediment from stormwater that reaches the area. Any nutrients attached to filtered sediment will also be prevented from reaching the eastern inlet to Flat Lake.

Actions:

- Meet with County Highway Department to determine the feasibility of implementing an erosion control project at this site.
- Obtain property owners approval of the project.
- Depending upon size and exact location of the filtration swale/area, permits may be needed to construction these areas. If permits are needed, apply for federal (Army Corps of Engineers, Clean Water Act (CWA), Section 404), state (IDEM CWA Section 401 Water Quality Certification and IDNR Construction in a Floodway), and local (Marshall County Drainage Board) permits.
- Prepare "Request for Proposal" (RFP) package for contractors to design and construct the filtration swale/area. The RFP may include the permitting work. Funding source may dictate the form of the RFP.
- Select a contractor to design and construct the filtration swale/area

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

Objective notes:

- Figure 15 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:

- Meet with the Marshall 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 Ancilla College web site.

Objective 6: Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge from Poor Handmaids of Jesus Christ property to Gilbert Lake.

Objective notes: The 1997 IDNR Diagnostic Study completed for Gilbert Lake suggested that that storm drains from the Ancilla property may be contributing pollutants to the lake and increasing the eutrophication of the lake. These pollutant loads need to be identified and quantified in order establish the appropriate methods to abate this pollution and prioritization of abatement action. This objective is designed to provide stakeholders with the information needed to make such decisions. Decisions based on information obtained while achieving this goal should be included in future revisions of the watershed management plan.

Actions:
- Identify all storm drains entering Gilbert Lake. A portion of this might have already been completed during the building or updating of PHJC structures.
- Develop a spreadsheet/database containing the location of all storm drains to Gilbert Lake.
- Enter data/map or update maps of the storm drains. Attributes such as size of pipe, area of drainage, whether it carries water continuously or only during wet weather, and potential pollutants associated with it should be attached to the location information for each drain.
- Identify funding sources to support sampling efforts.
- Develop a plan to measure pollutant loads. Sampling protocol will have to be developed once the nature and location of storm drains is known (ie. some drains may not be accessible to sampling while others may only carry water during storm events). Sampling protocol will depend upon the funding available to sample identified storm drains.
- Develop spreadsheet/database to hold sampling results.
- Disseminate results of this sampling to watershed stakeholders in a watershed stakeholder meeting. Future versions of the watershed management plan should include methods for addressing storm drain pollutant loads, if necessary, and a prioritization of which drains should be addressed first.

Objective 7: Improve buffer around Gilbert Lake.

Objective notes:
- As noted above, 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).
- Planting trees around Gilbert Lake will also reduce internal cycling of phosphorus. Internal phosphorus loading was noted as a problem in the 1997 LARE diagnostic study. Wind action can stir shallow lakes enough to resuspend bottom sediments. If these sediments are high in phosphorus, the sediments could release the phosphorus under the right water chemistry conditions. This may be occurring in Gilbert Lake. Improving the buffer around the lake will reduce the internal loading problem.

Actions:

- Work with IDNR Resource Specialist to supplement previous efforts to plant trees along a portion of Gilbert Lake. Such a planting will help reduce wind mixing and the resuspension of sediment and sediment-attached nutrient that results from this wind mixing.
- Meet with appropriate officials to discuss feasibility of revegetating Gilbert Lake's shoreline and shallow water.
- Select appropriate site(s) and species for reforestation along the perimeter of Gilbert Lake; determine best areas for shoreline revegetation and plant species to be planted.
- Identify and apply for funding to purchase plants and conduct plantings. The funding required to complete this activity will depend upon the number, size, and variety of tree and plant species chosen for planting.
- Hold a volunteer field day to complete recommended plantings in and around Gilbert Lake.

Objective 8: Promote the usage of alternative fertilizers and/or the reduction in the use of fertilizer.

Objective notes: Fertilizers were identified as one of the sources of nutrients to the watershed waterbodies.

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 Ancilla College 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 Flat Lake watershed. If the market is available, future iterations of the watershed management plan should include methods for marketing phosphorus free fertilizer.

Objective 9: Work with the golf course managers to enroll the course in the Audubon International program.

Objective notes:

- The golf course was identified as one of the sources of fertilizers in the watershed.
- Audubon International is an educational program to assist golf courses in becoming environmentally friendly. The program offers information on six program goals, one of which is water quality management. Participating golf courses can become a certified Cooperative Sanctuary System course by completing tasks in each of the six categories.
- In a survey of program participants, Audubon International found that 63% of the survey respondents had decreased their fertilizer use as a result of participation in the program. Eighty three percent of the respondents increased their use of slow-release fertilizers (Audubon International, 2002).

Actions:

- Meet with the golf course superintendent to discuss the course's participation in the Audubon International program.

Objective 10: Work with Marshall County planning officials to increase awareness of any proposed development in the watershed.

Objective notes: Currently the Flat Lake watershed is not experiencing significant development pressure. However, establishing a good working relationship with Marshall County planning officials is recommended. This relationship will allow Marshall County planning officials to become familiar with the goals that stakeholders have developed to improve water quality in the watershed. It will also allow stakeholders to participate in any public comment processes associated with future development in the watershed.

Actions:

- Attend at least one Marshall County planning meeting annually.

Goal 3: In 50 years we want Gilbert and Flat Lakes to exhibit productivity levels that are characteristic of lakes right at the theoretical dividing line between mesotrophic and eutrophic categories.

Goal time frame: This is a long-term goal. The goal should be reached by 2053.

Goal notes: Efforts to improve water clarity (**Goal 2**) will reduce eutrophication as well; therefore, the only objective for this goal is regular monitoring to help track progress toward both goals. Additionally, promotion of water quality monitoring is one of the actions the Marshall County SWCD lists in its Long Range Plan. Monitoring Flat and Gilbert Lakes and advertising the results will assist Marshall County in completing this action item.

The lakes' trophic state will be measured using primarily the Carlson's TSI. Results obtained from the Indiana Clean Lakes Volunteer Monitoring Program (advanced or basic) will provide information to calculate Carlson's TSI. IDEM will calculate the Indiana Eutrophication Index (EI) using data it collects during the Indiana Clean Lakes Program rotating basin sampling that occurs every five years (approximately). Stakeholders can use this information in addition to their calculations of the Carlson TSI to track progress toward achieving this goal.

Objective 1: Monitor the trophic state of Flat and Gilbert Lakes.

Objective notes: There are a variety of ways to achieve this objective (i.e. purchase equipment and conduct the monitoring; hire a consultant to conduct the monitoring, etc.). However, the following actions are developed based on participation in the Indiana Clean Lakes Volunteer Monitoring Program. Participation in this program does not require a lot of money and will allow more stakeholders to be involved in implementing the management plan. The program also gives participants access to some technical assistance and equipment. Finally, it assists with statewide efforts to collect water quality data. As a result, participants will be able to compare their data collected for their lake to data collected by other volunteers across the state.

Actions:

- Identify individuals that may be interested in participating in the CLP Volunteer Monitoring Program. (Students at Ancilla College would be a possible source of volunteers with oversight from a professor or mentor.)
- Contact the CLP volunteer coordinator to schedule training for monitors on Flat and Gilbert Lakes. The CLP volunteer coordinator will provide the volunteer group with a Secchi transparency disk for measuring water clarity at the time of training. After one year in the program, the lakes may be eligible for advanced monitoring, which includes measuring total phosphorus and chlorophyll *a*. The program will provide the necessary equipment and training to conduct advanced monitoring as it does with the basic monitoring program.
- Record results of water clarity measurements in a spreadsheet to allow long-term tracking of the water clarity. Calculate the Carlson's TSI based on average Secchi disk transparency score. If advance monitoring is conducted, calculate the Carlson's TSI for total phosphorus and chlorophyll *a*.
- Advertise results of the work to the community via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database.

Goal 4: We want the dissolved oxygen level in Gilbert Lake's hypolimnion to be above 1 ppm (mg/L) at all times throughout the year except during mid to late summer (July and August).

Goal time frame: This is a long-term goal. The goal should be reached by 2013.

Goal notes: Efforts to improve water clarity (**Goal 2**) will increase hypolimnetic oxygen levels as well; therefore, the only objective for this goal is regular monitoring to help track progress toward both goals. Additionally, promotion of water quality monitoring is one of the actions the Marshall County SWCD lists in its Long Range Plan. Monitoring Gilbert Lake and advertising the results will assist Marshall County in completing this action item. Finally, this goal addresses Gilbert Lake first since it was identified as a critical area. Stakeholders will consider setting this goal for Flat Lake in future iterations of the watershed management plan.

Objective 1: Monitor progress toward achieving **Goal 2** since achievement of **Goal 2** will help in achieving this goal.

Objective notes: There are a variety of ways to achieve this objective (i.e. purchase equipment and conduct the monitoring; hire a consultant to conduct the monitoring, etc.) However, for many of the same reasons listed in the objective notes for **Goal 3**, *Objective 1*, participation in the Indiana Clean Lakes Volunteer Monitoring Program is recommended.

Actions:

- Identify individuals that may be interested in participating in the CLP Volunteer Monitoring Program. (Students at Ancilla College would be a possible source of volunteers with oversight from a professor or mentor.)
- Contact the CLP volunteer coordinator to schedule training for monitors on Flat and Gilbert Lakes.
- Once in the program, volunteers can utilize dissolved oxygen equipment owned by the program. The nearest dissolved oxygen meter is stationed in Warsaw. The designated volunteer should check out the dissolved oxygen meter twice a month from May through September.
- Measure dissolved oxygen and temperature twice a month from May through September.
- Record results of dissolved oxygen and temperature measurements in a spreadsheet to allow long-term tracking of the dissolved oxygen goal. Create dissolved oxygen and temperature profiles for each sampling event.
- Advertise results of the work to the community via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database.

Goal 5: We want to reduce the coverage of purple loosestrife around Flat Lake on the IDNR property. Once we have reduced the purple loosestrife by achieving the objectives listed below, we will evaluate the growth of native species from the seed bank and, if necessary, supplement the native plant population with plugs and/or seeds.

Goal time frame: The goal should be reached by 2005.

Goal notes: Because of its low cost and use of volunteers, the 4-H program will be used to start reducing the purple loosestrife around Flat Lake. The program's protocol includes a pre-release survey of the purple loosestrife in the release area. The protocol also includes a post release survey. This will allow watershed stakeholders to set a target reduction percentage and measure their success in achieving that target reduction.

Objective 1: Participate in the 4-H biological control of purple loosestrife program.

Objective notes: This participation will involve a **one-time** beetle raising effort and release of raised beetles.

Actions:

- Establish a working relationship with the IDNR manager of the Menominee State Wetland Conservation Area (Tom Despot, Winamac FWA).
- Obtain permission from the IDNR to conduct the beetle release in the vicinity of Flat Lake on IDNR property.
- Identify individual(s) that may be interested in leading/serving as sponsor for a local 4-H control of purple loosestrife effort.

- Work with the Indiana 4-H program office (Natalie Carroll, Purdue University) and the Marshall County NRCS Extension Educator (Randy Dickson) to identify interested students.

Objective 2: Educate watershed stakeholders on the impact of purple loosestrife on aquatic ecosystems and ways to reduce infestation of the species.

Actions:

- Disseminate purple loosestrife literature produced by SeaGrant, IDNR, and other natural resource agencies to watershed stakeholders via a newsletter, email list, or if possible a link on the Ancilla College web site.
- Have information on purple loosestrife and its control available at field days organized by this watershed group or the local SWCD.

Table 12 summarizes the action plan and its time frame and presents important information on general cost estimates and potential funding sources for implementing the action plan. The first step of the plan is to generate more interest and participation in implementing the plan. A watershed stakeholder has agreed to spearhead the initial step toward generating more interest and participation. Once more participants are active in the plan's implementation, the potentially responsible parties column of Table 12 will be completed. Potential funding sources listed in Table 12 are simply a starting point for researching grant opportunities and other resources available to help fund the action plan. Additional funding sources and/or other resources are likely available for implementing the plan. Appendix G provides a summary of different funding sources and resources that ***may*** be available to help implement the Flat Lake Watershed Management Plan.

Table 12. Summary of potentially responsible parties, estimated costs, potential funding sources, sources of technical assistance, and time frames for each objective in the Flat Lake watershed action plan.

Goals/Objectives	Potentially Responsible Party	Estimated Cost$^+$	Potential Funding Sources/Technical Assistance*	Date to be Completed
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.				
Establish a core group of individuals willing to generate interest in the watershed management plan and coordinate and oversee the implementation of the plan.	Sr. Mary Baird	🕒		2003
Organize a watershed group to discuss the watershed management issues and water quality concerns in the watershed.		🕒 ¢	Education Grants☙	continuous
Organize and hold one annual field day highlighting the value of the streams and lakes in the Flat Lake watershed and how to protect the water quality and aquatic life in the watershed.		🕒 ¢	Education Grants	continuous
Publicize the value of Flat Lake, its watershed, and of ways to protect its water quality and aquatic life through various forms of media.		🕒 ¢	Education Grants	continuous
Participate in the Hoosier Riverwatch program.		🕒 ¢	Hoosier Riverwatch Equipment Grant; Hoosier Riverwatch Staff	continuous
Participate in the Indiana Clean Lakes volunteer monitoring program.	Joe Skelton; Tom Rzepka	🕒	Indiana CLP Volunteer Monitoring Coordinator	continuous
Goal #2: In 10 to 20 years, we want to improve water clarity in Flat and Gilbert Lakes such that the lakes exhibit a growing season Secchi disk transparency mean of 6 feet.				
Continue wetland restoration efforts in the headwaters of the eastern inlet to Gilbert Lake.		**$-$$**	LARE Program Grant; Section 319 Grant	2004-2005

Goals/Objectives	Potentially Responsible Party	Estimated Cost⁺	Potential Funding Sources/Technical Assistance*	Date to be Completed
Work with the NRCS, SWCD, and agricultural property owners in the watershed to promote water quality Best Management Practices (BMPs) usage in the watershed.		⊙ ¢	Education Grants	continuous
Institute a program of regular street cleaning on the PHJC property.		⊙	--	2006
Complete bridge/roadside erosion control project where Tulip Road crosses the unnamed eastern inlet to Flat Lake.		**<$-$**	LARE Program Grant; Section 319 Grant	2007
Work with county sanitarian to identify failing septic systems and promote proper septic system maintenance in the watershed.		⊙ ¢	Education Grants	continuous
Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge from Poor Handmaids of Jesus Christ property to Gilbert Lake.		⊙ **$-$$**	LARE Program Grant; Section 319 Grant	2008
Improve buffer around Gilbert Lake.		⊙ **<$-$**	Community Forestry Grant	2009
Promote the usage of alternative fertilizers and/or the reduction in the use of fertilizer.		⊙	--	continuous
Work with golf course managers to enroll the course in the Audubon International program.		⊙	--	2009
Work with Marshall County planning officials to increase awareness of any proposed development in the watershed.		⊙	--	continuous
Goal #3: In 50 years we want Gilbert and Flat Lakes to exhibit productivity levels that are characteristic of lakes right at the theoretical dividing line between mesotrophic and eutrophic categories.				
Monitor the trophic state of Flat and Gilbert Lakes.		⊙	Indiana CLP Volunteer Monitoring Coordinator	continuous

Goals/Objectives	Potentially Responsible Party	Estimated Cost⁺	Potential Funding Sources/Technical Assistance*	Date to be Completed
Goal #4: We want the dissolved oxygen level in Gilbert Lake's hypolimnion to be above 1 ppm (mg/L) at all times throughout the year except during mid to late summer (July and August).				
Monitor progress toward achieving **Goal 2** since achievement of **Goal 2** will help in achieving this goal.		◷	Indiana CLP Volunteer Monitoring Coordinator	continuous
Goal #5: We want to reduce the coverage of purple loosestrife around Flat Lake on the IDNR property.				
Participate in the 4-H biological control of purple loosestrife program.		◷ ¢	4-H Program	2005
Educate watershed stakeholders on the impact of purple loosestrife on aquatic ecosystems and ways to reduce infestation of the species.		◷ ¢	Education Grants	2005

⁺Each ◷ indicates an undetermined amount of personal time; each dollar sign ($) indicates an estimated cost of $10,000; a cent sign (¢) indicates an estimated cost of less than $2,500. Generally, ¢ notes the costs of supplies associated with hosting a field day or publishing a newsletter or brochure.
*Potential funding sources are listed based upon grant agency information in March 2003. Funding sources should be considered recommendations due to possible changes in funding agency goals and funds available. Funding sources identified during completion of the watershed management plan are listed in more detail in Appendix G. Other funding sources might be available in the future and should be considered.
☙Education Grants are considered those grants or granting organizations which generally fund community education programs including, but not limited to, the following: USEPA Education Grant; National Fish and Wildlife Foundation; Partners for Fish and Wildlife Program; NiSource Environmental Challenge Fund; IPALCO Golden Eagle Environmental Grant; Northern Indiana Community Foundation Grant.

5.0 MEASURING SUCCESS

Measuring stakeholders' success at achieving their goals and assessing progress toward realizing their vision for the Flat Lake 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. It also includes interim measures of success which will help stakeholders evaluate their progress toward their chosen goals. Finally, it outlines monitoring plans, where appropriate, to evaluate whether or not stakeholders have attained their goals. 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.

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 2004.)**

- Identification of a point person to lead the implementation of the plan.
- Flat Lake watershed group formed.
- Identification of potentially responsible parties to implement the plan (i.e completing Table 12 of the plan).
- Watershed group meetings held.
- Watershed group meeting minutes published.
- Watershed group newsletter published.
- Watershed group website developed.
- Property owners using conservation programs identified.
- Field days held.
- List of agricultural Best Management Practices developed.
- List of residential/institutional Best Management Practices developed.
- Hoosier Riverwatch volunteer training attended.
- Hoosier Riverwatch data collected and submitted.
- Clean Lakes Program volunteer training attended.
- Clean Lakes Program data collected and submitted.

Interim Measures of Success:

- Number of Flat Lake watershed group meetings held.
- Number of individuals attending watershed group meetings.
- Number of stakeholder mailings and/or newsletters distributed.
- Number of hits on the watershed group website.
- Number of individuals attending field days.
- Number of individuals receiving Best Management Practice lists.
- Number of individuals attending Hoosier Riverwatch training.
- Number of Hoosier Riverwatch sampling events conducted.
- Number of people involved in Hoosier Riverwatch sampling.
- Number of individuals attending Clean Lakes Program training.
- Number of Clean Lakes Program sampling events conducted.
- Number of people involved in Cleans Lakes Program sampling.

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 2: *In 10 to 20 years, we want to improve water clarity in Flat and Gilbert Lakes such that the lakes exhibit a growing season Secchi disk transparency mean of 6 feet.*

Milestones: **(Except for annual/continuous tasks milestones should be reached by the end of 2010.)**
- Property owners using conservation programs identified.
- Demonstration days held.
- Marshall County Soil and Water Conservation District (SWCD) meetings attended.
- Meeting with Marshall County Health Department held.
- List of Best Management Practices to control pathogen contamination developed.
- Gilbert Lake storm drains identified.
- Storm drain database developed.
- Storm drain map created.
- Storm drain sampling collection funding source identified.
- Storm drain sampling protocol developed.
- Sampling of storm drains completed.
- Revegetation of Gilbert Lake shoreline meeting held.
- Feasibility for planting trees along the shoreline of Gilbert Lake determined.
- Reforestation/revegetation sites selected.
- Reforestation/revegetation funding sources identified.
- Volunteer day for reforestation/revegetation of Gilbert Lake held.
- Information regarding impacts of fertilizers to water quality disseminated.
- Market potential for phosphorus-free fertilizer investigated.
- Meeting with golf course managers held.
- Marshall County planning meetings attended.

Interim Measures of Success:
- Wetland restoration project complete.
- Number of property owners using conservation programs identified.
- Number of demonstration days held.
- Increase in acreage of watershed in CRP.
- Increase in acreage of watershed using conservation tillage.
- Number of Marshall County SWCD meetings attended.
- Number of individuals receiving Best Management Practices to control pathogen contamination list.
- Number of failing septic systems identified.
- Bridge/roadside erosion control project completed.
- Establishment of pollutant loads from all storm drains.
- Reforestation/ revegetation project completed.
- Number of individuals participating in reforestation/revegetation volunteer day.
- Number of individuals receiving fertilizer information.
- Golf course enrolled in Audubon International program.
- Number of Marshall County planning commission meetings attended.

Goal Attainment:
The goal is attained when the growing season average water clarity is consistently greater than or equal to 6 feet as measured by a Secchi disk. The following outlines how to document progress toward goal attainment as well as actual attainment of the goal.
Indicator to be monitored: Water clarity.
Parameter assessed: Secchi disk transparency.
Frequency of monitoring: Bimonthly throughout the growing season – May-September. Sampling may also occur bimonthly in April and October depending upon the availability of volunteer completing the monitoring.
Location of monitoring: Each lake's deepest point.
Length of monitoring: The monitoring will be conducted for 10 to 20 years.
Protocol: Monitoring will be conducted according to the CLP Volunteer Monitoring Program protocol. This protocol is presented in Appendix H.
Monitoring equipment: Secchi disk, color chart, and data forms that are provided by the CLP Volunteer Monitoring Program. The monitor will also need a boat, oars, anchor, data sheets, clipboard, and pencil.
Data entry: Monitor will return data forms to the CLP Volunteer Monitoring Coordinator. Alternatively, the monitor may enter data directly via the CLP Volunteer Monitoring Program web site (see CLP Volunteer Monitoring protocol in Appendix H for instructions). Monitor should also keep a copy of the data forms in a three ring binder.
Data evaluation: The CLP Volunteer Monitoring Coordinator will evaluate the monitoring data as part of the Volunteer Monitoring Program. The data collected will be compared to data collected by other lake volunteer monitors across the state to provide some context. Data may also be evaluated by a consultant as needed. The IDEM lakes coordinator, the IDNR Lake and River Enhancement Program's aquatic biologist, and local SWCD or NRCS staff may also provide assistance in interpreting the data as needed.

Goal 3: *In 50 years we want Gilbert and Flat Lakes to exhibit productivity levels that are characteristic of lakes right at the theoretical dividing line between mesotrophic and eutrophic categories.*

Milestones: **(Training should be completed by the end of 2004. Data collection/submittal is a continuous task.)**
- Clean Lakes Program volunteer training attended.
- Clean Lakes Program data collected and submitted.

Interim Measures of Success:
- Number of individuals attending Clean Lakes Program training.
- Number of Clean Lakes Program sampling events conducted.
- Number of people involved in Cleans Lakes Program sampling.

Goal Attainment:
The goal is attained when the lake productivity level is near the dividing line between mesotrophic (moderately productive) and eutrophic (productive). Figure 18 provides a diagram for estimating productivity level based on Secchi disk transparency, total phosphorus, and chlorophyll *a*. Carlson's equations (Carlson, 1977) form the basis of this diagram. This

diagram suggests that to attain the goal the lakes' growing season average Secchi disk transparency should be greater or equal to 5 feet; they should have a growing season average chlorophyll a concentration of approximately 10 ppb (parts per billion or micrograms per liter); and they should have a growing season average total phosphorus concentration of 25 ppb.

```
                   Oligotrophic     Mesotrophic    Eutrophic   Hypereutrophic

                  20    25    30    35    40    45    50     55    60    65     70    75    80
Trophic State
    Index         +------------------------------------------------------------+

                 15    10  8 7  6    5    4     3     2  1.5     1          0.5     0.3
Transparency
(Meters)          +------------------------------------------------------------+


                    0.5       1      2      3  4  5   7   10  15  20   30  40  60 80 100 150
Chlorophyll-a
(µg/L or PPB)     +-------------------------------------------------------------+

 Total              3     5      7     10     15    20  25 30   40  50  60  80  100    150
 Phosphorus
(µg/L or PPB)     +------------------------------------------------------------+
```

Figure 18. Carlson's Trophic State Index

Indicator to be monitored: Trophic state (oligotrophic, mesotrophic, eutrophic, hypereutrophic)
Parameter assessed: Secchi disk transparency, total phosphorus, and/or chlorophyll *a*.
Frequency of monitoring: Monthly throughout the growing season – May-September.
Location of monitoring: Each lake's deepest point.
Length of monitoring: The monitoring will be conducted for 50 years.
Protocol: Monitoring will be conducted according to the CLP Volunteer Monitoring Program protocol. This protocol is presented in Appendix H.
Monitoring equipment: Secchi disk, color chart, chlorophyll *a* and total phosphorus sampling apparatus, and data forms that are provided by the CLP Volunteer Monitoring Program. The monitor will also need a boat, oars, anchor, data sheets, clipboard, and pencil.
Data entry: Monitor will return data forms to the CLP Volunteer Monitoring Coordinator. Alternatively, the monitor may enter data directly via the CLP Volunteer Monitoring Program web site (see CLP Volunteer Monitoring protocol in Appendix H for instructions). Monitor should also keep a copy of the data forms in a three ring binder.
Data evaluation: The CLP Volunteer Monitoring Coordinator will evaluate the monitoring data as part of the Volunteer Monitoring Program. The data collected will be compared to data collected by other lake volunteer monitors across the state to provide some context. Data may also be evaluated by a consultant as needed. The IDEM lakes coordinator, the IDNR Lake and River Enhancement Program's aquatic biologist, and local SWCD or NRCS staff may also provide assistance in interpreting the data as needed.

Goal 4: *We want the dissolved oxygen level in Gilbert Lake's hypolimnion to be above 1 ppm (mg/L) at all times throughout the year except during mid to late summer (July and August).*

Milestones: **(Training should be completed by the end of 2004. Data collection/submittal is a continuous task.)**

- Clean Lakes Program volunteer training attended.
- Clean Lakes Program data collected and submitted.

Interim Measures of Success:

- Number of individuals attending Clean Lakes Program training.
- Number of Clean Lakes Program sampling events conducted.
- Number of people involved in Cleans Lakes Program sampling.

Goal attainment:
The goal is attained when the Gilbert Lake's water column consistently has a dissolved oxygen concentration greater than 1 ppm (part per million or milligram per liter). Because Gilbert Lake is naturally at least a moderately productive lake, dissolved oxygen levels in the lake's hypolimnion at or less than 1 ppm are expected during mid to late summer (July and August). Low dissolved oxygen levels at these times would ***not*** be considered a failure in achieving the stated goal.
Indicator to be monitored: Presence of dissolved oxygen at concentrations greater than 1 ppm throughout the lake's water column.
Parameter assessed: Dissolved oxygen.
Frequency of monitoring: Monthly throughout the growing season – May-September. Sampling may also occur once in April and once in October depending upon the availability of volunteer completing the monitoring.
Location of monitoring: The lake's deepest point.
Length of monitoring: The monthly monitoring will be conducted for 10 to 20 years.
Protocol: Monitoring will be conducted according to the CLP Volunteer Monitoring Program protocol. This protocol is presented in Appendix H.
Monitoring equipment: Dissolved oxygen meter. The monitor may borrow a meter belonging to the CLP Volunteer Monitoring Program from the Kosciusko County SWCD in Warsaw. The monitor will also need a boat, oars, anchor, data sheets, clipboard, and pencil.
Data entry: Monitor will return data forms to the CLP Volunteer Monitoring Coordinator or the CLP Director. Monitor should also keep a copy of the data forms in a three ring binder.
Data evaluation: The CLP Volunteer Monitoring Coordinator or Director will evaluate the monitoring data as part of the Volunteer Monitoring Program. Data may also be evaluated by a consultant as needed. The IDEM lakes coordinator, the IDNR Lake and River Enhancement Program's aquatic biologist, and local SWCD or NRCS staff may also provide assistance in interpreting the data as needed.

Goal 5: *We want to reduce the coverage of purple loosestrife around Flat Lake on the IDNR property. Once we have reduced the purple loosestrife by achieving the objectives listed below, we will evaluate the growth of native species from the seed bank and, if necessary, supplement the native plant population with plugs and/or seeds.*

Milestones: **(Milestones should be reached by the end of 2005.)**

- Meeting with Indiana Department of Natural Resources manager of Menominee State Wetland Conservation Area held.
- Permission to conduct purple loosestrife beetle releases on DNR property granted.
- Individuals interested in leading 4-H purple loosestrife program identified.
- 4-H program enrollment completed.
- 4-H program student participants identified.
- Release site selected.
- Pre-release monitoring at release site conducted.
- Purple loosestrife beetles raised and released.
- Post-release monitoring completed (spring and fall).
- Purple loosestrife literature disseminated.

Interim Measures of Success:

- 4-H purple loosestrife monitoring program completed.
- Number of individuals receiving purple loosestrife literature.

Goal attainment:
The goal is attained when the purple loosestrife density is decreased and native wetland plant populations are increased. Biological control efforts may take 5 to 15 years before results are *observed.*
Indicator to be monitored: Purple loosestrife density and wetland plant community diversity.
Parameter assessed: Wetland plant community.
Frequency of monitoring: At a minimum, the wetland plant community should be evaluated once in the fall. One or possibly two additional monitoring visits may be beneficial and should be considered. A spring monitoring to assess the presence and quantity of biological control organisms (beetles) should also be conducted.
Location of monitoring: Location will depend upon where beetles are released.
Length of monitoring: The monthly monitoring will be conducted for 5 to 15 years. This is the timeframe in which one may expect to observe results from biological control efforts. Observing success with purple loosestrife control in heavily infested areas such as the area around Flat Lake has occurred as early as three years.
Protocol: Monitoring will be conducted according to the 4-H Biological Control of Purple Loosestrife program protocol. Data sheets for use with this protocol are presented in Appendix I. The complete protocol may be obtained from the Purdue Cooperative Extension Service (765-494-8422 or www.four-h.purdue.edu). The monitoring protocol includes a pre-release site inspection. This pre-release site inspection will be used to set a target for reduction and provide a measure against which success of the release will be measured. Volunteers that do not possess wetland plant identification skills may use this protocol. (Volunteers must learn how to identify purple loosestrife. Appendix J contains a brochure produced by the Ontario Federation of Anglers and Hunters and distributed by SeaGrant Great Lakes Network that provides tips on how

to identify purple loosestrife.) The Cornell University's Bernd Blossey, an expert in biocontrol of non-indigenous species, has created an alternative monitoring protocol for individuals with wetland plant identification skills. Use of this protocol may be considered if appropriate volunteers are available. The protocol may be obtained at www.invasiveplants.net/plants/purpleloosestrife.htm.

Monitoring equipment: For the first monitoring effort, the volunteer will need stakes to mark transects beginning and end points and thick rope/cord to establish permanent transects. The number of stakes and amount of cord will depend upon the number of transects established. Three are suggested by the protocol but more could be established if there are more than 9-10 students in the program. The transects should be 70 feet long so at least 210 feet of cord is needed. The stakes marking the transects should be at least 10 feet tall (before being anchored in the ground) since purple loosestrife can grow to be as tall as 6 feet. Placing surveying flagging at the top of the stakes will help volunteers easily spot the markers from year to year. Once the survey area is established, volunteers will need only data sheets, clipboard, pencil, calculator, and field guides (as needed).

Data entry: Monitors will keep a copy of the data forms in a three ring binder.

Data evaluation: The 4-H group leader will evaluate the data sheets in cooperation with the students. The group leader can obtain technical assistance from the Purdue Cooperative Extension Service (765-494-8422). Data may also be evaluated by a consultant as needed.

6.0 FUTURE CONSIDERATIONS

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

Beaver Dam at Flat Lake

Watershed stakeholders expressed concern over the beaver dam at the outlet to Flat Lake. Their concern revolved around what the ecological, social, and economical consequences would be if the dam failed. Stakeholders discussed the option of removing the dam and installing an artificial control structure in its place to ensure the lake level is maintained. JFNew and the IDNR Menominee WCA property manager inspected the dam in the spring of 2003. The dam appeared to be stable at the time of inspection. Because the dam is a natural construct and because it is likely that beavers would simply build a dam upstream of any artificial control structure, stakeholders agreed to postpone any action on the dam at this time. Watershed stakeholders may chose to revisit this issue in future revisions of the plan.

Internal Phosphorus Loading in Gilbert Lake

The action plan addresses many of the external sources of nutrients. However, many shallow lakes in Indiana also suffer from the internal release of phosphorus. This is particularly true for lakes that had historically high external phosphorus loads such as Gilbert Lake. In these lakes, internal sources can be the cause of more than 70% of the total phosphorus load to the lake. While it is important to address the external sources of phosphorus, complete restoration of the lake may not occur until the internal source of phosphorus is treated as well.

The action plan contains some one objective (**Goal 2, Objective 7**) that will help alleviate internal loading. This objective seeks to minimize wind mixing of the lake by enhancing the lake shoreline and planting trees along the lake's edge. Preventing or minimizing the mixing will help minimize the impact of internal loading.

In the future, more internal phosphorus control may be necessary. One of the most common and effective ways to treat internal phosphorus loading is through a strategy of phosphorus inactivation and precipitation (i.e., an alum treatment). Phosphorus precipitation and inactivation is designed to remove phosphorus from the water column and to prevent the release of phosphorus from the lake's bottom sediments. The treatment involves adding aluminum salts to the lake. These salts form a floc or an agglomeration of small particles. This floc acts in two ways: (a) it absorbs phosphorus from the water column as it settles, and (b) it seals the bottom sediments if a thick enough layer has been deposited. Phosphorus can also precipitate out as an aluminum salt. Alum treatments cost about $1,000-$1,600 per acre treated. Alum treatments should only be considered once all external sources of phosphorus are controlled. Stakeholders may consider such a treatment in the future is external phosphorus control is insufficient to achieve the goals outlined in the plan.

Permits, Easements, and Agreements:

Revegetation of wetland and lake perimeter: Permission to revegetate the constructed wetland above Gilbert Lake's inlet ditch (**Goal 2, Objective 1**) and to improve the buffer around Gilbert Lake (**Goal 2, Objective 7**) through supplemental tree plantings and shoreline/shallow water plantings must be obtained from the property owner (PHJC) before any plantings occur. The PHJC has granted permission to plant trees in the past.

Tulip Road erosion control project: Depending upon the size and exact placement of the filtration swale/area to treat the erosion problem where Tulip Road crosses the eastern inlet to Flat Lake (**Goal 2, Objective 4**), several permits may be required to complete the project. These permits may include federal (Army Corps of Engineers, Clean Water Act (CWA), Section 404), state (IDEM CWA Section 401 Water Quality Certification and IDNR Construction in a Floodway), and local (Marshall County Drainage Board) permits. Copies of the Army Corps of Engineers CWA Section 404 and IDEM CWA Section 401 Water Quality Certification permit applications are provided in Appendix K. Landowner permission or an easement agreement from the Marshall County Highway Department and/or private landowner (depending upon the size and location) will be necessary as well to complete the project.

Purple loosestrife control: The release of beetle to control of purple loosestrife (**Goal 5, Objective 1**) will require landowner permission. The Menominee WCA property manager has already responded positively to the proposed release. Registration of the species, number, and location of beetles being released is also required by the Indiana Department of Natural Resources Division of Nature Preserves.

Operation and Maintenance:

Tulip Road erosion control project: Any filtration area built to treat roadside erosion and prevent sediment loading to the eastern inlet to Flat Lake will require periodic maintenance. This maintenance simply involves removing any sediment accumulation that prevents proper filtration of the stormwater directed to the area. Sediment accumulation should be checked on an annual basis and actually removal of accumulation is expected to occur once every three to five years. The County Highway Department may be able to assist with this maintenance; however, maintenance responsibilities should be discussed with the Department during the initial scoping process to determine if the project is feasible.

Wetland Restoration: The PHJC have restored two wetlands on their property by restoring the area's natural hydrology. Additionally, they have fenced these areas to prevent disturbance by grazing cattle. 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. The PHJC has utilized or plans to utilize several of these management techniques to the wetland south of Gilbert Lake. This wetland was burned in the spring of 2003. It will be spot treated with a herbicide to kill the reed canary grass in the wetland and seeded and planted with native wetland species. 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. The wetland at the headwaters of the eastern inlet to Gilbert Lake might also benefit from such maintenance activities.

Monitoring: 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 PHJC will be responsible for holding and revising the Flat Lake 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 Register form provided in Appendix L. This form should be returned to the PHJC. The PHJC will keep completed action registers in three ring binder and review action register s to ensure tasks are being completed. The forms will also help document the success of actions taken in the watershed.

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APPENDICES

APPENDIX A:

Geographic Information Systems Map Data Sources

GEOGRAPHIC INFORMATION SYSTEM MAP DATA SOURCES

Figure 2. Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set.

Figure 3. Kankakee River watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road, stream, and county boundary coverages are from the U.S. Census Bureau TIGER data set. 8-digit and 14-digit watershed boundaries are from coverages created by the U.S. Geological Survey and Natural Resources Conservation Service in cooperation with Indiana Department of Environmental Management and Indiana Department of Natural Resources Division of Water.

Figure 4. Topographical relief of the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Relief coverage is the U.S. Geological Survey National Elevation Data set.

Figure 5. Highly erodible and potentially highly erodible soils in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Soils coverage is from the Natural Resources Conservation Service National Ssurgo Soils Database. Highly erodible and potentially soils criteria were set by the NRCS.

Figure 6. Highly Erodible Land in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Highly Erodible Land (HEL) acreage digitized from Marshall County NRCS map.

Figure 7. Soil series septic tank absorption field suitability.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Soils coverage is from the Natural Resources Conservation Service National Ssurgo Soils Database. Soil septic tank limitations were set by the NRCS.

Figure 8. National wetland inventory map.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for

accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Wetland location source is U.S. Fish and Wildlife Service National Wetland Inventory GIS coverage.

Figure 9. Hydric soils in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Soils coverage is from the Natural Resources Conservation Service National Ssurgo Soils Database. Hydric soil classifications were previously set by the NRCS.

Figure 10. Historical structures and sites in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Historic landmark sites digitized from Historic Landmarks Foundation of Indiana, 1990.

Figure 11. Land use in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Land use comes from the USGS Indiana Land Cover Data Set. The data set was corrected based on field investigations conducted in 2002.

Figure 12. Tracts of land owned by the Indiana Department of Natural Resources (Menominee Wetland Conservation Area) and the Poor Handmaids of Jesus Christ.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Land ownership information was provided by the Menominee Wetland Conservation Area property manager and by the Poor Handmaids of Jesus Christ.

Figure 13. Flat Lake watershed sampling site locations.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set.

Figure 14. Critical areas targeted for improvement in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set.

Figure 15. Critical row crop agricultural areas in the Flat Lake watershed.
Watershed boundaries generated using ArcView 3.3 Spatial Analyst with a hydrological modeling extension available from ESRI. Computer generated boundaries were field checked for accuracy. Road and stream coverages are from the U.S. Census Bureau TIGER data set. Land use comes from the USGS Indiana Land Cover Data Set. The data set was corrected based on

field investigations conducted in 2002. Soils coverage is from the Natural Resources Conservation Service National Ssurgo Soils Database. Highly erodible and potentially soils criteria were set by the NRCS. Critical row crop areas were overlayed with highly erodible and potentially highly erodible soils to determine critical agricultural areas.

APPENDIX B:

Flat Lake Watershed Major Stakeholders

MAJOR WATERSHED STAKEHOLDERS

Poor Handmaids of Jesus Christ
Contact: Sister Margaret Henns
P.O. Box 1
Donaldson, Indiana 46513

Indiana Department of Natural Resources
Division of Nature Preserves
Director of Winamac Fish and Wildlife Area
Contact: Tom Despot
1493 West 500 North
Winamac, Indiana 46996

Indiana Department of Environmental Management
Office of Water Management
Contact: Laura Bieberich
P.O. Box 6015
Indianapolis, Indiana 46206-6015

Indiana Department of Natural Resources
Division of Soil Conservation
Contact: Beth Forsness
2903 Gary Drive
Plymouth, Indiana 46563

Indiana Department of Natural Resources
Division of Nature Preserves
Contact: Rich Dunbar
5570 Fish Hatchery Road
Columbia City, Indiana 46725

Regional Watershed Conservationist
Natural Resources Conservation Service
Contact: Matt Jarvis
1523 N. US Highway 421, Suite 2
Delphi, Indiana 46923-9396.

Marshall County Planning Commission
Contact: Troy Kiefer
112 West Jefferson Street
Plymouth, Indiana 46563

Ducks Unlimited
Contact: Terry Jolly
15784 Menominee
Plymouth, Indiana 46563

Sierra Club
Contact: Bill Hayden
1010 South Dunn Street
Bloomington, Indiana 46701

Marshall County Farm Services
Contact: David Stults
2903 Gary Drive
Plymouth, Indiana 46563

U.S. Fish and Wildlife Service
Contact: Liz McCloskey
P.O. Box 2616
Chesterton, Indiana 46304

APPENDIX C:

Endangered, Threatened, and Rare Species

ENDANGERED, THREATENED AND RARE SPECIES,
HIGH QUALITY NATURAL COMMUNITIES, AND SIGNIFICANT NATURAL AREAS DOCUMENTED
FROM THE GILBERT LAKE-FLAT LAKE WATERSHED AREA, MARSHALL COUNTY, INDIANA

TYPE	SPECIES NAME	COMMON NAME	STATE	FED	LOCATION	DATE	COMMENT
DONALDSON							
Mammal	TAXIDEA TAXUS	AMERICAN BADGER	SE	**	T34NR01E 33	1987	
MENOMINEE WETLAND CONSERVATION AREA							
Wetland	WETLAND - FLAT MUCK	MUCK FLAT	SG	**	T33NR01E 10 SEQ SEQ	1985	

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

November 12, 1999

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM MARSHALL COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
VASCULAR PLANT					
ARMORACIA AQUATICA	LAKE CRESS	SE	**	S1	G4?
ASTER BOREALIS	RUSHLIKE ASTER	SR	**	S2	G5
COELOGLOSSUM VIRIDE VAR VIRESCENS	LONG-BRACT GREEN ORCHIS	ST	**	S2	G5T5
CYPRIPEDIUM CANDIDUM	SMALL WHITE LADY'S-SLIPPER	SR	**	S2	G4
ELEOCHARIS EQUISETOIDES	HORSE-TAIL SPIKERUSH	SE	**	S1	G4
GLYCERIA GRANDIS	AMERICAN MANNA-GRASS	SX	**	SH	G5
HYPERICUM PYRAMIDATUM	GREAT ST. JOHN'S-WORT	SE	**	S1	G4
PLATANTHERA ORBICULATA	LARGE ROUNDLEAF ORCHID	SX	**	SX	G5?
POA ALSODES	GROVE MEADOW GRASS	SR	**	S2	G4G5
POTAMOGETON STRICTIFOLIUS	STRAIGHT-LEAF PONDWEED	SE	**	S1	G5
VALERIANA EDULIS	HAIRY VALERIAN	SE	**	S1	G5
ZANNICHELLIA PALUSTRIS	HORNED PONDWEED	SE	**	S1	G5
MOLLUSCA: GASTROPODA					
CAMPELOMA DECISUM	POINTED CAMPELOMA	SSC	**	S2	G5
LYMNAEA STAGNALIS	SWAMP LYMNAEA	SSC	**	S2	G5
MOLLUSCA: BIVALVIA (MUSSELS)					
ALASMIDONTA VIRIDIS	SLIPPERSHELL MUSSEL	**	**	S2	G4G5
LAMPSILIS FASCIOLA	WAVY-RAYED LAMPMUSSEL	SSC	**	S2	G4
LIGUMIA RECTA	BLACK SANDSHELL	**	**	S2	G5
PLEUROBEMA CLAVA	CLUBSHELL	SE	LE	S1	G2
PTYCHOBRANCHUS FASCIOLARIS	KIDNEYSHELL	SSC	**	S2	G4G5
FISH					
COREGONUS ARTEDI	CISCO	SSC	**	S2	G5
ETHEOSTOMA PELLUCIDUM	EASTERN SAND DARTER	SSC	**	S2	G3
ICHTHYOMYZON BDELLIUM	OHIO LAMPREY	**	**	S2	G3G4
REPTILES					
CLEMMYS GUTTATA	SPOTTED TURTLE	SE	**	S2	G5
CLONOPHIS KIRTLANDII	KIRTLAND'S SNAKE	SE	**	S2	G2
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	S2	G4
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	SE	**	S2	G3G4T3T4
TERRAPENE ORNATA	ORNATE BOX TURTLE	SE	**	S2	G5
THAMNOPHIS BUTLERI	BUTLER'S GARTER SNAKE	SE	**	S1	G4
BIRDS					
ACCIPITER STRIATUS	SHARP-SHINNED HAWK	SSC	**	S2B,SZN	G5
ARDEA HERODIAS	GREAT BLUE HERON	**	**	S4B,SZN	G5
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	SE	**	S2B	G4
CERTHIA AMERICANA	BROWN CREEPER	**	**	S2B,SZN	G5

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

November 12, 1999

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM MARSHALL COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
CISTOTHORUS PALUSTRIS	MARSH WREN	SE	**	S3B,SZN	G5
DENDROICA CERULEA	CERULEAN WARBLER	SSC	**	S3B	G4
IXOBRYCHUS EXILIS	LEAST BITTERN	SE	**	S3B	G5
RALLUS ELEGANS	KING RAIL	SE	**	S1B,SZN	G4G5
RALLUS LIMICOLA	VIRGINIA RAIL	SSC	**	S3B,SZN	G5
WILSONIA CITRINA	HOODED WARBLER	SSC	**	S3B	G5
XANTHOCEPHALUS XANTHOCEPHALUS	YELLOW-HEADED BLACKBIRD	SE	**	S1B	G5
MAMMALS					
SPERMOPHILUS FRANKLINII	FRANKLIN'S GROUND SQUIRREL	SE	**	S2	G5
TAXIDEA TAXUS	AMERICAN BADGER	SE	**	S2	G5
HIGH QUALITY NATURAL COMMUNITY					
PRAIRIE - MESIC	MESIC PRAIRIE	SG	**	S2	G2
WETLAND - BEACH MARL	MARL BEACH	SG	**	S2	G3
WETLAND - BOG ACID	ACID BOG	SG	**	S2	G3
WETLAND - FEN	FEN	SG	**	S3	G3
WETLAND - FLAT MUCK	MUCK FLAT	SG	**	S2	G2

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

Site: Ancilla College Wetland
Locale: Marshall County, Indiana
Date: August 15, 2002 3.5 hours
By: Scott Namestnik, Mary Baird, John Richardson
File: f:\Environmental\99-08-24 Ancilla-WatershedPlan&WetlandRestoration\Wetland Restoration\species inventory.inv
Notes: Species Inventory

FLORISTIC QUALITY DATA	Native	112	77.8%	Adventive	32	22.2%
112 NATIVE SPECIES	Tree	7	4.9%	Tree	1	0.7%
144 Total Species	Shrub	6	4.2%	Shrub	1	0.7%
4.7 NATIVE MEAN C	W-Vine	1	0.7%	W-Vine	1	0.7%
3.7 W/Adventives	H-Vine	1	0.7%	H-Vine	0	0.0%
49.9 NATIVE FQI	P-Forb	59	41.0%	P-Forb	13	9.0%
44.0 W/Adventives	B-Forb	4	2.8%	B-Forb	4	2.8%
-3.0 NATIVE MEAN W	A-Forb	15	10.4%	A-Forb	1	0.7%
-2.0 W/Adventives	P-Grass	3	2.1%	P-Grass	8	5.6%
AVG: Fac. Wetland	A-Grass	0	0.0%	A-Grass	1	0.7%
	P-Sedge	10	6.9%	P-Sedge	2	1.4%
	A-Sedge	2	1.4%	A-Sedge	0	0.0%
	Cryptogam	4	2.8%			

ACRONYM	C	SCIENTIFIC NAME	W	WETNESS	PHYSIOGNOMY	COMMON NAME
ACARHO	0	Acalypha rhomboidea	3	FACU	Nt A-Forb	THREE-SEEDED MERCURY
ACERUB	7	Acer rubrum	0	FAC	Nt Tree	RED MAPLE
ACESAI	0	Acer saccharinum	-3	FACW	Nt Tree	SILVER MAPLE
ACHMIL	0	ACHILLEA MILLEFOLIUM	3	FACU	Ad P-Forb	YARROW
ACOCAL	7	Acorus calamus	-5	OBL	Nt P-Forb	SWEET FLAG
AGRPAR	7	Agrimonia parviflora	-1	FAC+	Nt P-Forb	SWAMP AGRIMONY
AGRREP	0	AGROPYRON REPENS	3	FACU	Ad P-Grass	QUACK GRASS
AGRALA	0	AGROSTIS ALBA	-3	FACW	Ad P-Grass	REDTOP
APIAME	7	Apios americana	-3	FACW	Nt P-Forb	GROUND NUT
APOCAN	4	Apocynum cannabinum	0	FAC	Nt P-Forb	INDIAN HEMP
ASCINC	4	Asclepias incarnata	-5	OBL	Nt P-Forb	SWAMP MILKWEED
ASCSYR	0	Asclepias syriaca	5	UPL	Nt P-Forb	COMMON MILKWEED
ASTPUP	8	Aster puniceus	-5	OBL	Nt P-Forb	BRISTLY ASTER
ASTSIS	3	Aster simplex	-5	OBL	Nt P-Forb	PANICLED ASTER
BARVUL	0	BARBAREA VULGARIS	0	FAC	Ad B-Forb	YELLOW ROCKET
BIDCER	5	Bidens cernua	-5	OBL	Nt A-Forb	NODDING BUR MARIGOLD
BIDCOM	5	Bidens comosa	-5	[OBL]	Nt A-Forb	SWAMP TICKSEED
BOECYC	2	Boehmeria cylindrica	-5	OBL	Nt P-Forb	FALSE NETTLE
BROINE	0	BROMUS INERMIS	5	UPL	Ad P-Grass	HUNGARIAN BROME
BROTEC	0	BROMUS TECTORUM	5	UPL	Ad A-Grass	DOWNY BROME
CALCAN	3	Calamagrostis canadensis	-5	OBL	Nt P-Grass	BLUE JOINT GRASS
CAMAPA	8	Campanula aparinoides	-5	OBL	Nt P-Forb	MARSH BELLFLOWER
CARPEN	4	Cardamine pensylvanica	-4	FACW+	Nt B-Forb	PENNSYLVANIA BITTER CRESS
CXALAT	10	Carex alata	-5	OBL	Nt P-Sedge	WINGED OVAL SEDGE
CXLURI	8	Carex lurida	-5	OBL	Nt P-Sedge	BOTTLEBRUSH SEDGE
CXSTRI	5	Carex stricta	-5	OBL	Nt P-Sedge	COMMON TUSSOCK SEDGE
CXTRIB	3	Carex tribuloides	-4	FACW+	Nt P-Sedge	AWL-FRUITED OVAL SEDGE
CXVULP	2	Carex vulpinoidea	-5	OBL	Nt P-Sedge	BROWN FOX SEDGE
		Carex species		OBL-UPL		SEDGE
CEPOCC	5	Cephalanthus occidentalis	-5	OBL	Nt Shrub	BUTTONBUSH
CHEGLB	8	Chelone glabra	-5	OBL	Nt P-Forb	TURTLEHEAD
CICMAC	6	Cicuta maculata	-5	OBL	Nt P-Forb	WATER HEMLOCK
CIRARV	0	CIRSIUM ARVENSE	5	UPL	Ad P-Forb	FIELD THISTLE
CIRMUT	10	Cirsium muticum	-5	OBL	Nt B-Forb	SWAMP THISTLE
CIRVUL	0	CIRSIUM VULGARE	4	FACU-	Ad B-Forb	BULL THISTLE
CONSEP	1	Convolvulus sepium	0	FAC	Nt P-Forb	HEDGE BINDWEED
COROBL	6	Cornus obliqua	-4	FACW+	Nt Shrub	BLUE-FRUITED DOGWOOD
CYPDIA	10	Cyperus diandrus	-5	[OBL]	Nt A-Sedge	UMBRELLA FLAT SEDGE
CYPESC	0	Cyperus esculentus	-1	[FAC+]	Nt P-Sedge	FIELD NUT SEDGE
CYPSTR	1	Cyperus strigosus	-3	FACW	Nt P-Sedge	LONG-SCALED NUT SEDGE
DACGLO	0	DACTYLIS GLOMERATA	3	FACU	Ad P-Grass	ORCHARD GRASS
DRYTHP	6	Dryopteris thelypteris pubescens	-5	[OBL]	Cryptogam	MARSH SHIELD FERN
ECHLOB	5	Echinocystis lobata	-2	FACW-	Nt H-Vine	WILD CUCUMBER
ELEOBT	3	Eleocharis obtusa	-5	OBL	Nt A-Sedge	BLUNT SPIKE RUSH
EPICOL	3	Epilobium coloratum	-5	OBL	Nt P-Forb	CINNAMON WILLOW HERB
EREHIE	2	Erechtites hieracifolia	3	FACU	Nt A-Forb	FIREWEED
ERIANS	0	Erigeron annuus	1	FAC-	Nt B-Forb	ANNUAL FLEABANE
ERICAN	0	Erigeron canadensis	1	FAC-	Nt A-Forb	HORSEWEED
EUPMAM	4	Eupatorium maculatum	-5	OBL	Nt P-Forb	SPOTTED JOE PYE WEED
EUPPER	4	Eupatorium perfoliatum	-4	FACW+	Nt P-Forb	COMMON BONESET
EUPSEM	0	Eupatorium serotinum	-1	FAC+	Nt P-Forb	LATE BONESET
FESELA	0	FESTUCA ELATIOR	2	FACU+	Ad P-Grass	TALL FESCUE
		Galium species		OBL-UPL		MADDER/BEDSTRAW

HIBPAL	9	Hibiscus palustris	-5	OBL	Nt P-Forb	SWAMP ROSE MALLOW
HYPMAJ	6	Hypericum majus	-3	FACW	Nt A-Forb	SAND ST. JOHN'S WORT
IMPCAP	3	Impatiens capensis	-3	FACW	Nt A-Forb	ORANGE JEWELWEED
JUNDUD	4	Juncus dudleyi	0	[FAC]	Nt P-Forb	DUDLEY'S RUSH
JUNEFF	7	Juncus effusus	-5	OBL	Nt P-Forb	COMMON RUSH
		Juncus species		OBL-FACU		RUSH
LACSER	0	LACTUCA SERRIOLA	0	FAC	Ad B-Forb	PRICKLY LETTUCE
		Lactuca species		FAC-UPL		LETTUCE
LATPAM	6	Lathyrus palustris myrtifolius	-3	FACW	Nt P-Forb	MARSH VETCHLING
LEEORY	4	Leersia oryzoides	-5	OBL	Nt P-Grass	RICE CUT GRASS
LEMMIO	5	Lemna minor	-5	OBL	Nt A-Forb	SMALL DUCKWEED
LOBSIP	6	Lobelia siphilitica	-4	FACW+	Nt P-Forb	GREAT BLUE LOBELIA
LUDALT	6	Ludwigia alternifolia	-5	OBL	Nt P-Forb	SEEDBOX
LUDPAA	5	Ludwigia palustris americana	-5	OBL	Nt P-Forb	MARSH PURSLANE
LUDPOL	6	Ludwigia polycarpa	-5	OBL	Nt P-Forb	FALSE LOOSESTRIFE
LYCAME	5	Lycopus americanus	-5	OBL	Nt P-Forb	COMMON WATER HOREHOUND
LYCVIR	9	Lycopus virginicus	-5	OBL	Nt P-Forb	BUGLE WEED
LYSTER	8	Lysimachia terrestris	-5	OBL	Nt P-Forb	SWAMP CANDLES
LYTSAL	0	LYTHRUM SALICARIA	-5	OBL	Ad P-Forb	PURPLE LOOSESTRIFE
MENARV	5	Mentha arvensis villosa	-5	[OBL]	Nt P-Forb	WILD MINT
MIMRIN	6	Mimulus ringens	-5	OBL	Nt P-Forb	MONKEY FLOWER
MONFIS	4	Monarda fistulosa	3	FACU	Nt P-Forb	WILD BERGAMOT
MORALB	0	MORUS ALBA	0	FAC	Ad Tree	WHITE MULBERRY
NYMTUB	7	Nymphaea tuberosa	-5	OBL	Nt P-Forb	WHITE WATER LILY
ONOSEN	8	Onoclea sensibilis	-3	FACW	Cryptogam	SENSITIVE FERN
OSMCIN	7	Osmunda cinnamomea	-3	FACW	Cryptogam	CINNAMON FERN
OSMRES	8	Osmunda regalis spectabilis	-5	OBL	Cryptogam	ROYAL FERN
OXAEUR	0	Oxalis europaea	3	FACU	Nt P-Forb	TALL WOOD SORREL
PEDLAN	9	Pedicularis lanceolata	-5	[OBL]	Nt P-Forb	FEN BETONY
PHAARU	0	PHALARIS ARUNDINACEA	-4	FACW+	Ad P-Grass	REED CANARY GRASS
PHLPRA	0	PHLEUM PRATENSE	3	FACU	Ad P-Grass	TIMOTHY
PHYAME	1	Phytolacca americana	1	FAC-	Nt P-Forb	POKEWEED
PILPUM	5	Pilea pumila	-3	FACW	Nt A-Forb	CLEARWEED
PLALAN	0	PLANTAGO LANCEOLATA	0	FAC	Ad P-Forb	ENGLISH PLANTAIN
PLAMAJ	0	PLANTAGO MAJOR	-1	FAC+	Ad P-Forb	COMMON PLANTAIN
PLAOCC	9	Platanus occidentalis	-3	FACW	Nt Tree	SYCAMORE
POAPRA	0	POA PRATENSIS	1	FAC-	Ad P-Grass	KENTUCKY BLUE GRASS
POLCOC	4	Polygonum coccineum	-5	OBL	Nt P-Forb	WATER HEARTSEASE
POLHYR	2	Polygonum hydropiper	-3	FACW	Nt A-Forb	WATER PEPPER
POLHYS	7	Polygonum hydropiperoides	-5	OBL	Nt P-Forb	MILD WATER PEPPER
POLPER	0	POLYGONUM PERSICARIA	1	[FAC-]	Ad A-Forb	LADY'S THUMB
POLSAG	8	Polygonum sagittatum	-5	OBL	Nt A-Forb	ARROW-LEAVED TEAR-THUMB
POPDEL	2	Populus deltoides	-1	FAC+	Nt Tree	EASTERN COTTONWOOD
POTNOR	0	Potentilla norvegica	0	FAC	Nt A-Forb	NORWAY CINQUEFOIL
POTREC	0	POTENTILLA RECTA	5	UPL	Ad P-Forb	UPRIGHT CINQUEFOIL
POTSIS	4	Potentilla simplex	4	FACU-	Nt P-Forb	COMMON CINQUEFOIL
PRUVLA	0	Prunella vulgaris lanceolata	3	[FACU]	Nt P-Forb	SELF HEAL
PYCTEN	7	Pycnanthemum tenuifolium	0	FAC	Nt P-Forb	SLENDER MOUNTAIN MINT
PYCVIR	5	Pycnanthemum virginianum	-4	FACW+	Nt P-Forb	COMMON MOUNTAIN MINT
QUEPAU	8	Quercus palustris	-3	FACW	Nt Tree	PIN OAK
RANSCE	6	Ranunculus sceleratus	-5	OBL	Nt A-Forb	CURSED BUTTERCUP
RORPAF	4	Rorippa palustris fernaldiana	-5	OBL	Nt A-Forb	MARSH CRESS
ROSMUL	0	ROSA MULTIFLORA	3	FACU	Ad Shrub	MULTIFLORA ROSE
ROSPAL	7	Rosa palustris	-5	OBL	Nt Shrub	SWAMP ROSE
RUBHIS	9	Rubus hispidus	-3	FACW	Nt Shrub	SWAMP DEWBERRY
RUMACE	0	RUMEX ACETOSELLA	3	[FACU]	Ad P-Forb	FIELD SORREL
RUMCRI	0	RUMEX CRISPUS	-1	FAC+	Ad P-Forb	CURLY DOCK
SALAMY	5	Salix amygdaloides	-3	FACW	Nt Tree	PEACH-LEAVED WILLOW
SALNIG	4	Salix nigra	-5	OBL	Nt Tree	BLACK WILLOW
SAMCAN	1	Sambucus canadensis	-2	FACW-	Nt Shrub	ELDERBERRY
SAXPEN	10	Saxifraga pensylvanica	-3	FACW	Nt P-Forb	SWAMP SAXIFRAGE
SCIATR	4	Scirpus atrovirens	-5	OBL	Nt P-Sedge	DARK GREEN RUSH
SCICYP	6	Scirpus cyperinus	-5	OBL	Nt P-Sedge	WOOL GRASS
SCIPUN	5	Scirpus pungens	-5	OBL	Nt P-Sedge	CHAIRMAKER'S RUSH
SCULAT	5	Scutellaria lateriflora	-5	OBL	Nt P-Forb	MAD-DOG SKULLCAP
SIUSUA	7	Sium suave	-5	OBL	Nt P-Forb	TALL WATER PARSNIP
SOLAME	0	Solanum americanum	4	FACU-	Nt A-Forb	BLACK NIGHTSHADE
SOLCAR	0	SOLANUM CAROLINENSE	4	FACU-	Ad P-Forb	HORSE NETTLE
SOLDUL	0	SOLANUM DULCAMARA	0	FAC	Ad W-Vine	BITTERSWEET NIGHTSHADE
SOLALT	1	Solidago altissima	3	FACU	Nt P-Forb	TALL GOLDENROD
SOLGIG	4	Solidago gigantea	-3	FACW	Nt P-Forb	LATE GOLDENROD
SOLGRN	3	Solidago graminifolia nuttallii	0	[FAC]	Nt P-Forb	HAIRY GRASS-LEAVED GOLDENROD
SOLPAT	9	Solidago patula	-5	OBL	Nt P-Forb	SWAMP GOLDENROD
SOLRUG	6	Solidago rugosa	-1	FAC+	Nt P-Forb	ROUGH GOLDENROD
SPAPEC	4	Spartina pectinata	-4	FACW+	Nt P-Grass	PRAIRIE CORD GRASS
SPIALB	7	Spiraea alba	-4	FACW+	Nt Shrub	MEADOWSWEET

STELON	8	Stellaria longifolia	-4	FACW+	Nt P-Forb	STITCHWORT
TAROFF	0	TARAXACUM OFFICINALE	3	FACU	Ad P-Forb	COMMON DANDELION
THADAD	5	Thalictrum dasycarpum	-2	FACW-	Nt P-Forb	PURPLE MEADOW RUE
TRAPRA	0	TRAGOPOGON PRATENSIS	5	UPL	Ad B-Forb	COMMON GOAT'S BEARD
TRIHYB	0	TRIFOLIUM HYBRIDUM	1	FAC-	Ad P-Forb	ALSIKE CLOVER
TYPANG	1	Typha angustifolia	-5	OBL	Nt P-Forb	NARROW-LEAVED CATTAIL
TYPLAT	1	Typha latifolia	-5	OBL	Nt P-Forb	BROAD-LEAVED CATTAIL
TYPGLA	1	Typha X glauca	-5	OBL	Nt P-Forb	HYBRID CATTAIL
URTPRO	2	Urtica procera	-1	FAC+	Nt P-Forb	TALL NETTLE
VERHAS	4	Verbena hastata	-4	FACW+	Nt P-Forb	BLUE VERVAIN
VERATA	5	Vernonia altissima taeniotricha	0	[FAC]	Nt P-Forb	HAIRY TALL IRONWEED
		Viola species		OBL-UPL		VIOLET
VITRIP	2	Vitis riparia	-2	FACW-	Nt W-Vine	RIVERBANK GRAPE
		Cyperaceae species		OBL-UPL		UNIDENTIFIABLE SEDGE
		Unidentifiable herbaceous		OBL-UPL		UNIDENTIFIABLE HERBACEOUS

Note: The species inventory was entered into the Chicago Region Database. Marshall County is technically not in the Chicago Region, however it is the first county to the southeast outside of the Chicago Region. Therefore, the numbers shown above should be fairly accurate.

APPENDIX D:

Water Quality Assessment

Water Quality Assessment

Methods

Grab samples were collected from three sampling sites in the Flat Lake watershed (Table A; Figure A) two times during 2002. Water quality sample collection and analysis followed the methodologies outlined in the Flat Lake Watershed Quality Assurance Project Plan (Attachment A). The specifics of those methodologies will not be repeated here. The first sampling effort occurred on May 9, 2002 following one day of rain. Local monitoring stations reported precipitation totals of approximately 0.5 to 1 inch in Marshall County (Purdue Applied Meteorology Group, 2002). The hydrograph for the United States Geological Survey (USGS) Yellow River in Knox, Indiana gaging station indicated that discharge on May 9 was nearly twice the historical median discharge value (Figure B). (The historical median is based on 58 years worth of data.) Based on the hydrograph, the May 9 sampling effort documented storm flow conditions in the watershed streams. Following storm events, the increased overland water flow results in increased erosion of soil and nutrients from the land. In addition, precipitation washes pollutants from hardscape in the watershed. Thus, stream concentrations of nutrients and sediment are typically higher following storm events. In essence, storm sampling presents a "worst case" picture of watershed pollutant loading.

Table A. Detailed sampling location information for the Flat Lake watershed.

Site	Stream name	Road location	Place sampled
1	Unnamed Tributary (Gilbert Lake outlet)	within Poor Handmaids of Jesus Christ property	southern boundary of property upstream of fence
2	Unnamed Tributary (east inlet at Tulip Road)	South Tulip Road north of West 10B Road	downstream of road crossing
3	Unnamed Tributary (east inlet at State Road 17)	State Road 17 north of West 10B Road	downstream of road crossing

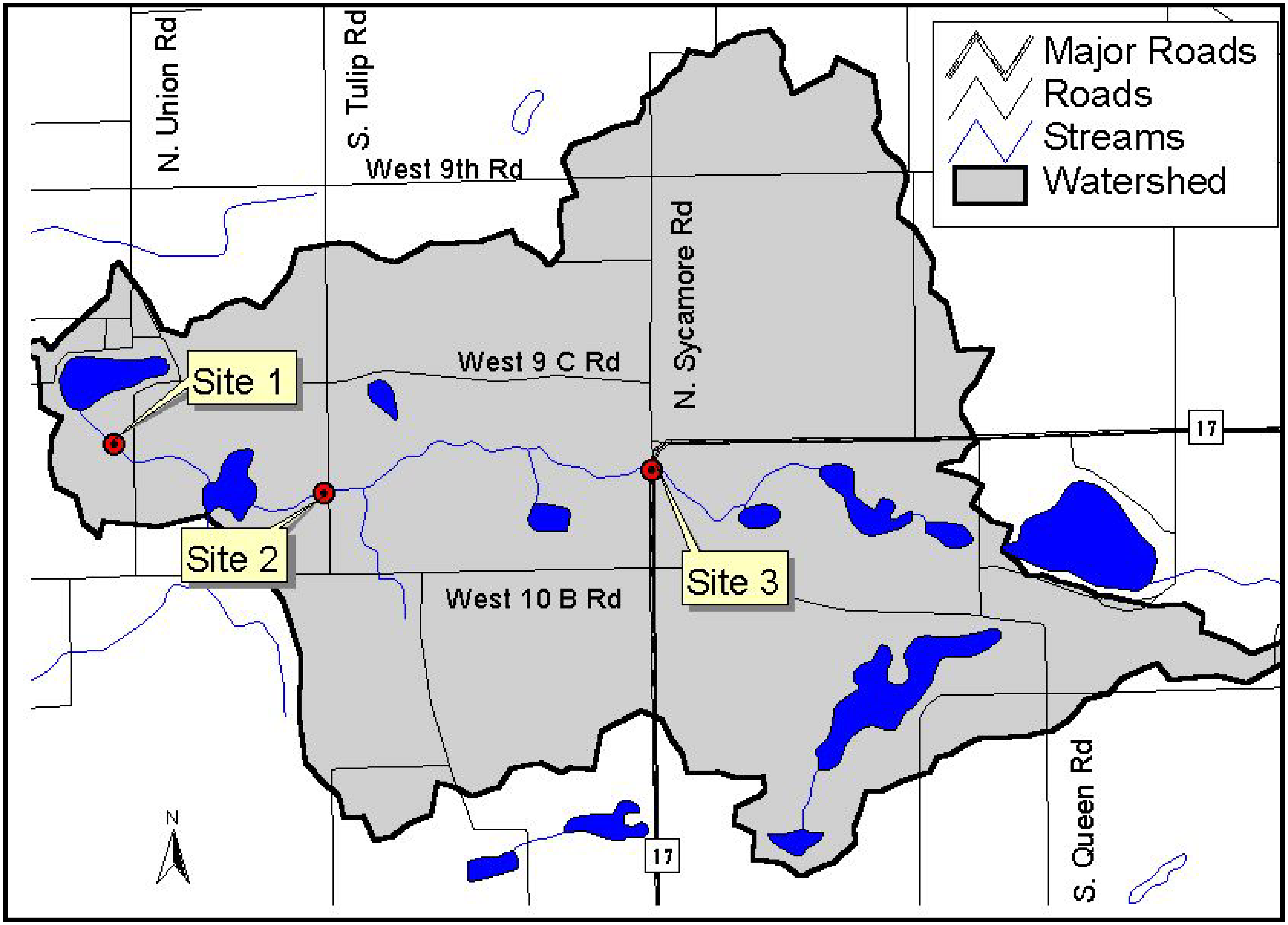

Figure A. Flat Lake watershed sampling site locations.

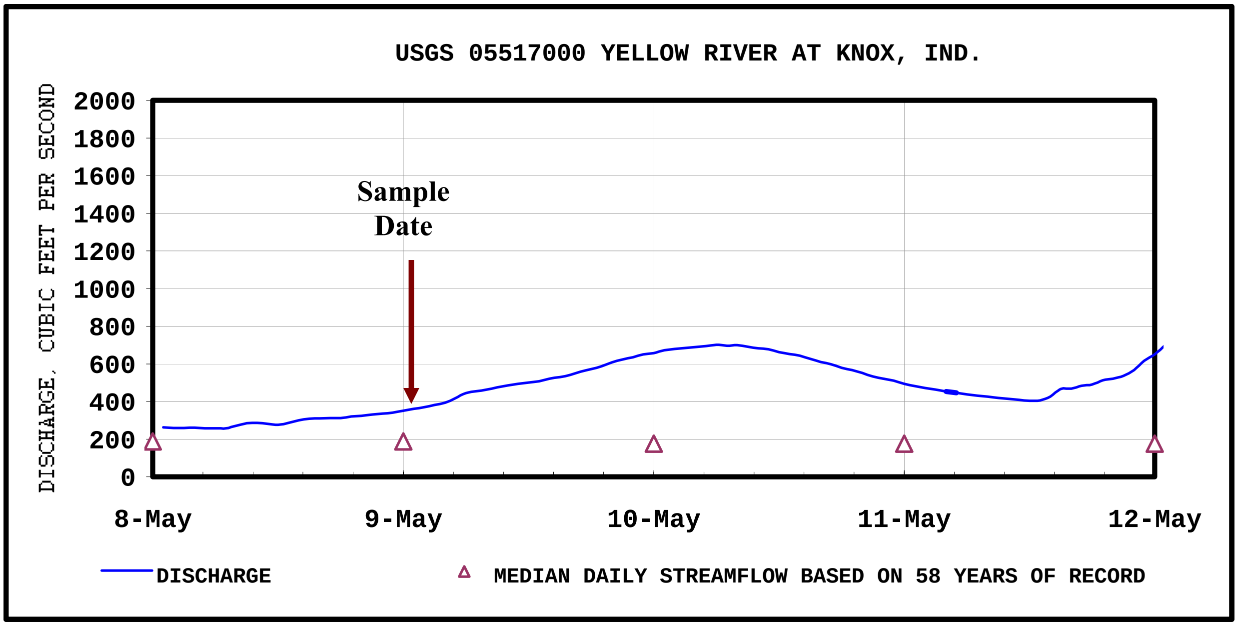

Figure B. Mean daily discharge for the Yellow River at Knox, Indiana. The arrow indicates the date of storm flow sampling. Discharge on the sampling date exceeded the 58-year median stream flow.

The second sampling effort occurred on July 16, 2002 following a period of little precipitation. The Yellow River in Knox, Indiana gaging station shows discharge at the gage was below the historical median discharge (Figure C). This data suggests streams in the watershed were at base flow conditions. Base flow sampling provides an understanding of typical conditions in streams.

Figure C. Mean daily discharge for the Yellow River at Knox, Indiana with base flow sampling date noted. Discharge on the sampling date was well below the 58-year median stream flow.

The water quality samples were analyzed for a variety of physical, biological, and chemical parameters. The following is a brief description of each of these parameters.

Temperature
Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For examples, water temperature affects the amount of oxygen dissolved in the water column. Likewise, water temperature regulates the species composition and activity of life associated with the aquatic environment. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (EPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits for Indiana streams. Temperatures should not exceed 26.7º C by more than 1.7 ºC during the month of May and 32.2º C during the month of July. (Water quality sample collection for this assessment occurred in these two months.) At no time should water temperatures exceed 32.2 ºC. In addition, the Indiana Administrative Code (IAC) states that "the maximum temperature rise at any time or place…shall not exceed 2.8 ºC in streams and 1.7 ºC in lakes and reservoirs."

Dissolved Oxygen
Dissolved oxygen (DO) is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3-5 mg/L of DO. The IAC requires that all waterbodies possess a daily dissolved oxygen average concentration of at least 5 mg/L and that at no time shall the DO concentration drop below 4 mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth, accompanied by high levels of photosynthetic activity, can over-saturate (greater than 100% saturation) the water with DO. Dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

pH
The pH of water describes the concentration of acidic ions (specifically H^+) present in water. The pH also determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6 to 9 pH units for the protection of aquatic life. pH concentrations in excess of 9 are acceptable only when occurring as daily fluctuations associated with photosynthetic activity.

Conductivity
Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the total concentration, mobility, and valence of ions in the water (APHA, 1995). At low discharge, conductivity of a stream is higher than it is following storm events because the water moves more slowly across or through ion-containing soils and substrates during base flow. Carbonates and other charged particles dissolve into the slow moving water, thereby increasing the conductivity of a water body.

Rather than setting a conductivity standard, the Indiana Administrative Code standard for conductivity is reported as 750 mg/L of dissolved solids. Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 µmhos per mg/L of dissolved solids roughly converts dissolved solid concentrations to specific conductance (Allan, 1995). Thus converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 μmhos per mg/L yields a specific conductance range of approximately 1000 to 1360 μmhos. Specific conductance was measured during this assessment rather than total dissolved solids.

Nutrients (Nitrogen and Phosphorus)

Nutrients are a necessary component of aquatic ecosystems. Ecosystem primary producers (i.e. plants) require nutrients for growth. Growth of the primary producers ultimately supports the remainder of the organisms in the ecosystem's food web. Insufficient nutrient levels in stream and lake water can limit the size and complexity of biological communities living in the stream or lake. In contrast, excessive levels of nutrients in lake or stream water alter biological communities by promoting nuisance species growth. For example, high concentrations of total phosphorus in lake water (>0.03 mg/L) create ideal conditions for nuisance algae growth. In extreme cases, lake algae growth can exclude rooted macrophyte growth and shift fish community composition.

In low order streams such as the unnamed tributaries to Flat Lake, aquatic plants exist primarily as periphyton (algae attached to substrate or other surfaces in the stream). Light availability and flow regime limit the establishment of rooted macrophytes and phytoplankton populations that are more common in lakes and large river systems. As small stream ecosystems' primary producers, periphyton support higher members of the stream food web (invertebrates, fish). Nutrients are one of the factors that limit periphyton growth in streams and thus are included in stream water chemistry analyses.

Phosphorus and nitrogen are common nutrients governing plant growth. (When diatoms dominate the periphyton or planktonic community, silica is also an important nutrient.) Sources of phosphorus and nitrogen include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches streams. Nitrogen can also diffuse from the air into streams. Atmospheric nitrogen is then "fixed" by certain algae species (cyanobacteria) into a usable form of nitrogen. Because of this readily available source of nitrogen (the air), phosphorus is usually the "limiting nutrient" in aquatic ecosystems.

Phosphorus and nitrogen exist in several forms in water. The two common phosphorus forms are soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus for growth. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), and total Kjeldahl nitrogen (TKN). Nitrate is a dissolved form of nitrogen that is commonly found in surface water where oxygen is readily available. In contrast, ammonia-nitrogen is generally found in water where oxygen is lacking. Ammonia-nitrogen, or more correctly the ionized form of ammonia-nitrogen (ammonium), is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the total organic nitrogen (particulate) and ammonia-nitrogen in the water sample.

Indiana possesses nitrate-nitrogen and ammonia-nitrogen standards for its water bodies. These standards apply to all state water bodies except those designated as Limited Use waters. The nitrate-nitrogen standard is 10 mg/L; nitrate-nitrogen concentrations exceeding 10 mg/L in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6). Because both temperature and pH govern the toxicity of ammonia for aquatic life, these factors are weighed in ammonia the standard. Depending on the temperature and pH range of the study streams maximum unionized ammonia-nitrogen concentrations should not exceed 0.084-0.164 mg/L.

Total suspended solids

Total suspended solids refer to all particles suspended or dissolved in stream water. Sediment, or dirt, is the most common solid suspended in stream water. The sediment in stream water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. In lakes and reservoirs, sediment accumulation limits boating opportunities and shortens the waterbody's lifespan. Similarly, few people are enthusiastic about having a picnic near a muddy creek or wading in silty water. Pollutants attached to sediment also degrade water quality.

Pathogens

Bacteria, viruses, and other pathogens are contaminants of concern in both rural and urban watersheds. Common sources of these pathogens include human and wildlife waste, fertilizers containing manure, previously contaminated sediments, septic tank leachate, and illicit connections to stormwater sewers or drainage tiles. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. Thus, pathogens can impair the recreational value of a stream. Some pathogens can also impair biological communities. Water quality researchers and monitoring programs utilize *E. coli* as an indicator for the presence of pathogens in water. According to the Indiana Administrative Code, *E. coli* concentrations should not exceed 235 colonies/100 mL in any one sample within a 30-day period.

Water Quality Results and Discussion

There are two useful ways to report water quality data in flowing water. *Concentrations* express the mass of a substance per unit volume, for example milligrams of total suspended solids per liter (mg/L). *Mass loading* describes the mass of a particular material being carried per unit time (kg/d). Loading is important when comparing among sites and among sampling dates because: 1) Flow can be highly variable; therefore, normalizing concentrations to flow eliminates variability. 2) Delivery of materials is important to consider. For example, a stream with high discharge but low pollutant concentration may deliver more of a pollutant to its receiving body than a stream with a higher pollutant concentration but lower discharge. It is the total amount of nutrients, suspended solids, and pathogens entering the stream that is of greatest concern when considering the effects of these materials downstream.

Selected Physical and Chemical Parameter Concentrations
Table B presents the physical parameter results measured during base flow and storm flow.

Table B. Selected physical and selected chemical parameter data collected from Flat Lake watershed sites.

Site	Date	Timing	Flow (cfs)	Temp (^oC)	DO (mg/L)	DO Sat (%)	Conductivity (μmhos/cm)	pH (SU)
1	5/9/02	storm	0.9	15.6	4.6	46.0	470	7.3
	7/16/02	base	0.0	27.5	0.9	11.7	400	7.6
2	5/9/02	storm	8.4	15.9	8.9	90.0	380	7.3
	7/16/02	base	0.12	22.5	8.1	94.1	400	7.2
3	5/9/02	storm	3.3	17.6	9.4	99.0	420	7.5
	7/16/02	base	0.07	23.0	4.8	57.1	400	7.2

Water temperature varied with season. As expected Flat Lake tributaries were warmer in July than in May. During base flow sampling, temperatures in the streams varied from 22.5º C at the east inlet at Tulip Road (Site 2) to 27.5º C at the Gilbert Lake outlet (Site 1). Water temperatures during storm flow varied from 15.6º C at the Gilbert Lake outlet (Site 1) to 17.6º C at the east inlet at State Road 17 (Site 3). The warmer water temperature measured at Site 1 during base flow conditions is likely due to the stream's shallow nature and slow flow; sunlight penetrating to the bottom of the small stream channel warms the entire water column. None of the sampling sites exhibited temperatures above the standard for the protection of aquatic life.

Dissolved oxygen concentrations varied from 0.9 mg/L (Site 1; May 9, 2002) to 9.4 mg/L (Site 3; July 16, 2002). DO in the east inlet at Tulip Road (Site 2) exceeded the Indiana state minimum standard of 5 mg/L indicating that oxygen was sufficient to support aquatic life during both storm and base flow sampling. However, low DO levels in the Gilbert Lake outlet (Site 1) during both base and storm flow and in the east inlet at State Road 17 (Site 3) during base flow may be impairing biota in these streams.

Since DO varies with temperature (cold water can hold more oxygen than warm water), it is also important to examine DO saturation values. DO saturation refers to the amount of DO dissolved in water compared to the total amount possible when equilibrium between the stream water and the atmosphere is maximized. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. The east inlet at Tulip Road (Site 2) was 90-94% saturated with oxygen during both sampling events suggesting this portion of the inlet stream is well oxygenated. In contrast, the Gilbert Lake outlet (Site 1) and the east inlet at State Road 17 (Site 3) during base flow exhibited low saturation (12% and 57%, respectively). DO saturation was also low in the Gilbert Lake outlet (Site 1) following the storm event. The low saturation is likely due to the two factors noted above: the consumption of oxygen during the decomposition of organic material in the stream and the relatively stagnant water limiting the entrainment of oxygen into the stream from the air.

In general, both conductivity and pH values fell within acceptable ranges. Conductivity values in Flat Lake watershed streams ranged from 380 to 470 μmhos during storm flow and measured 400 μmhos at all sites during base flow. All of the measurements fell below the lower end of the range obtained by converting the IAC dissolved solids standard to specific conductance. pH values in the Flat Lake tributaries ranged from 7.2-7.6. These pH values are within the range of 6-9 units established as acceptable by the Indiana Administrative Code for warm water aquatic life.

Chemical and Bacterial Parameter Concentrations
Table C lists the chemical and bacterial concentration data for the Flat Lake watershed streams by site. Figures D-I present concentration information graphically.

Table C. Nutrient, sediment, and bacterial parameter data from the Flat Lake watershed sites.

Site	Date	Timing	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100mL)
1	5/9/02	storm	0.05*	0.20	1.50	0.11	5	148
	7/16/02	base	0.10	3.60	100	14	5,900	10,000
2	5/9/02	storm	0.30	0.05*	1.60	0.16	17	340
	7/16/02	base	0.34	0.10	1.10	0.10	3	130
3	5/9/02	storm	0.05*	0.05*	0.52	0.05*	1*	69
	7/16/02	base	0.10	0.05*	1.80	0.21	35	220

*Method detection level.

Figure D presents the nitrate-nitrogen concentration data for both base and storm flow conditions. Nitrate-nitrogen concentrations during base and storm flow conditions were relatively low at all sites. Base flow concentrations ranged from 0.10 mg/L in the Gilbert Lake outlet (Site 1) and in the east inlet at State Road 17 (Site 3) to 0.34 mg/L in the east inlet at Tulip Road (Site 2), while storm flow nitrate-nitrogen concentrations ranged from below the detection limit (0.05 mg/L) in the Gilbert Lake outlet (Site 1) and the east inlet at State Road 17 (Site 3) to 0.30 mg/L in the east inlet at Tulip Road (Site 2). The east inlet at Tulip Road (Site 2) exhibited the highest nitrate-nitrogen concentration (0.34 mg/L), while the Gilbert Lake outlet (Site 1) and the east inlet at State Road 17 (Site 3) possessed the lowest nitrate-nitrogen concentrations (<0.05 mg/L). Nitrate-nitrogen concentrations were lower than median nutrient concentrations observed in Ohio streams (1.0 mg/L) known to support healthy warmwater habitats for aquatic life (Ohio EPA, 1999). Additionally, nitrate-nitrogen concentrations were close to or low than the EPA recommended nitrate-nitrogen level (0.30 mg/L) for streams in the Nutrient Ecoregion VII, which includes the Flat Lake Watershed (USEPA, 2000). Concentrations at all sites were well below 10 mg/L, the concentration set by the Indiana Administrative Code for safe drinking water.

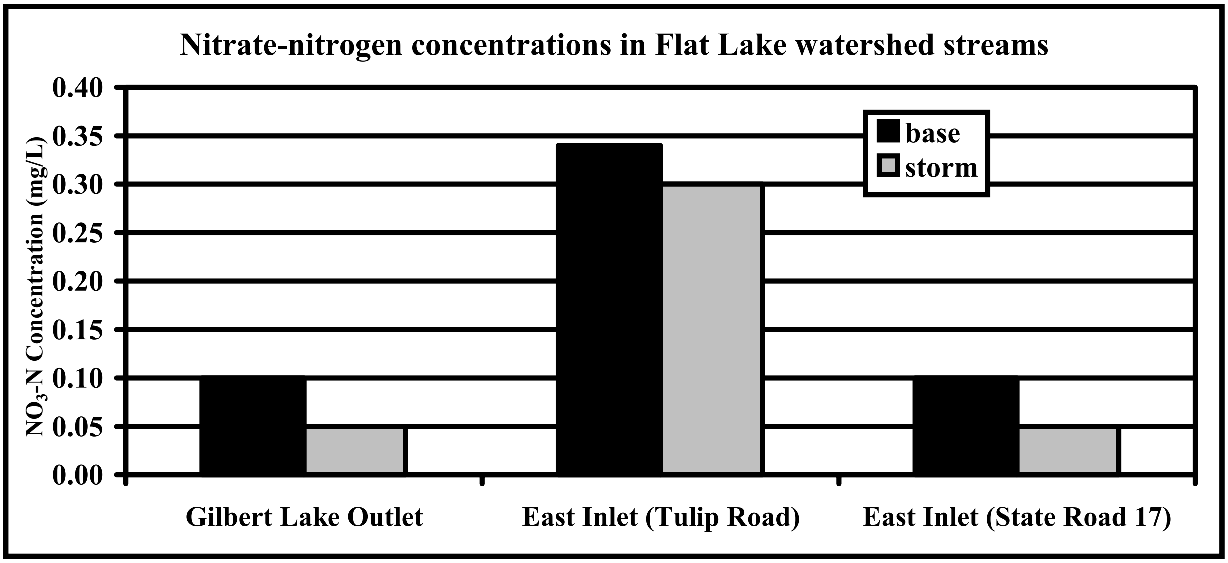

Figure D. Nitrate-nitrogen concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Ammonia-nitrogen concentrations were similarly low at most sites during base and storm flow sampling (Figure E). Ammonia-nitrogen concentrations measured during storm flow sampling were equal to or lower than concentrations measured in base flow samples at all sites. The base flow sample collected at the Gilbert Lake outlet (Site 1) during base flow exhibited the highest ammonia-nitrogen concentration (3.6 mg/L), while three samples, the east inlet at State Road 17 (Site 3) base and storm flow samples and the east inlet at Tulip Road (Site 2) storm flow sample, possessed concentrations below the detection limit (0.05 mg/L). None of the storm flow concentrations exceeded the IAC ammonia-nitrogen standard for the protection of aquatic life. Only one site, Gilbert Lake outlet (Site 1), sampled during the base flow event exceeded the IAC standard. Large populations of duckweed and filamentous algae present at this site provide further evidence of high nutrient concentrations; these species are typically observed in waters with high nutrient concentrations. The high ammonia-nitrogen concentration coupled with the low dissolved oxygen concentration suggests decomposition of organic matter is occurring in this stream. The high ammonia-nitrogen level at this site may also be impairing the tributary's aquatic life.

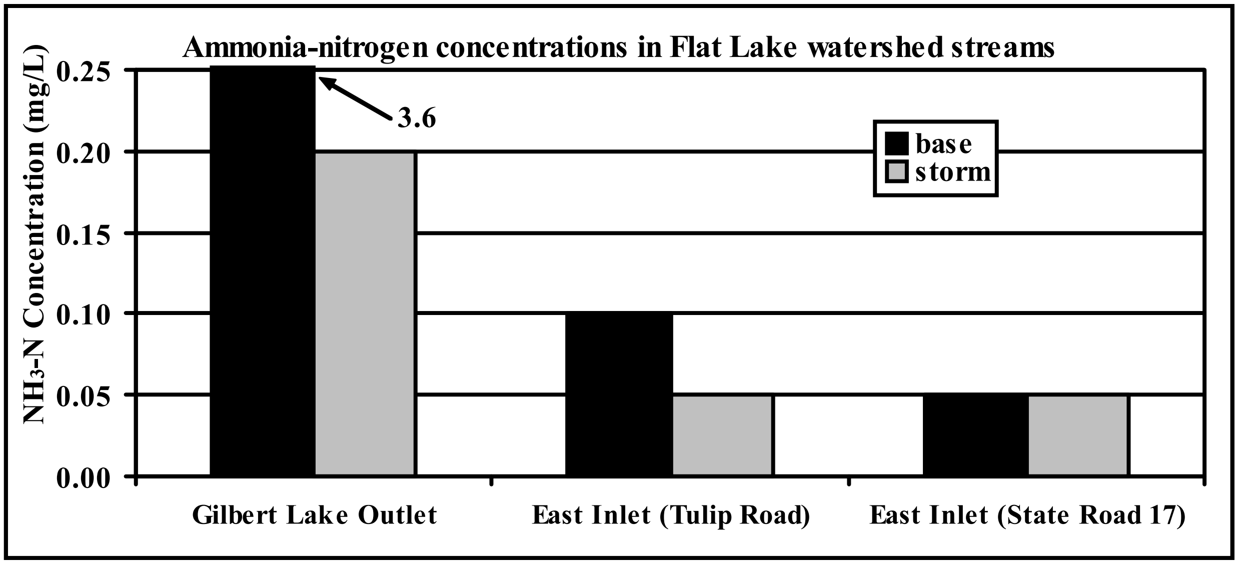

Figure E. Ammonia-nitrogen concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Compared to the dissolved parameters, many of the sites exhibited slightly elevated total Kjeldahl nitrogen (TKN) concentrations. Generally, TKN concentrations measured during base flow sampling exceeded the concentrations measured in storm flow samples (Figure F). As observed with the ammonia-nitrogen concentration, the Gilbert Lake outlet (Site 1) generally exhibited a higher concentration of TKN than the east inlet; during base flow the Gilbert Lake outlet possessed a TKN concentration of 100 mg/L. Although ammonia was also elevated at this site (Figure E), particulate organic nitrogen pollutants likely accounts for the high concentration here. A high TKN level was not surprising at this site given the observed accumulation of organic matter at this location. TKN levels exceeded USEPA recommended concentrations; however, except for the concentration observed in the Gilbert Lake outlet (Site 1) under base flow conditions, these TKN concentrations are typical of Indiana streams.

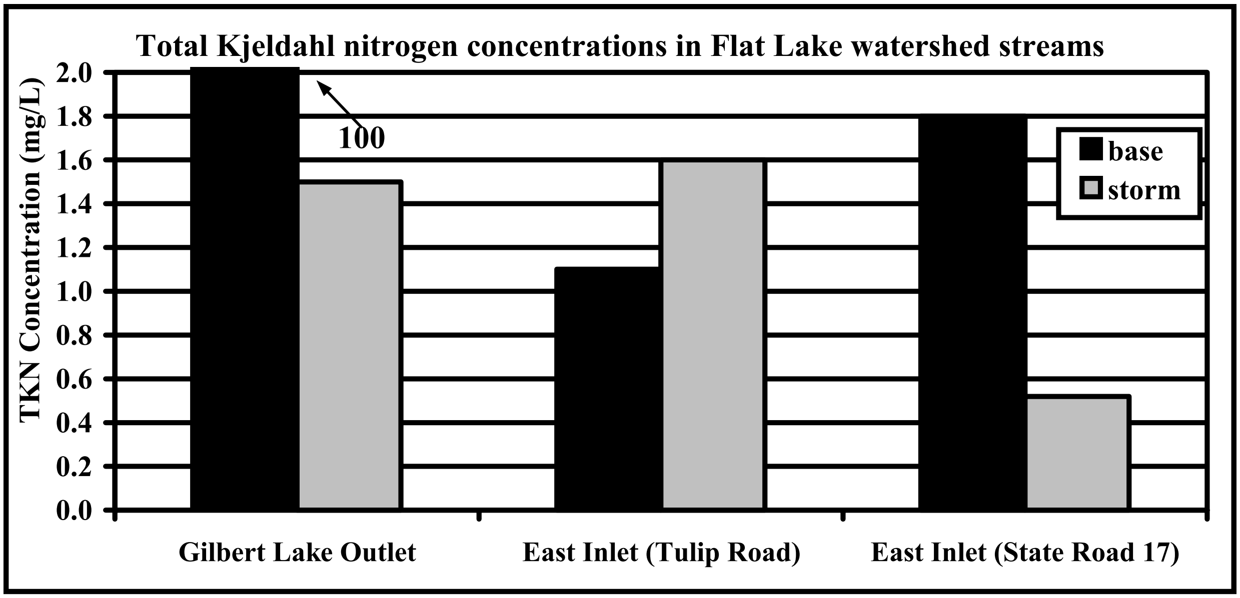

Figure F. Total Kjeldahl nitrogen concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Figure G shows the total phosphorus concentration data for the sampling sites. In contrast to the nitrogen parameters, total phosphorus levels in the Flat Lake watershed streams were elevated. The east inlet at State Road 17 (Site 3) during storm flow possessed the lowest total phosphorus concentration (<0.05 mg/L), while the Gilbert Lake outlet (Site 1) during base flow contained the highest total phosphorous concentration (14 mg/L). Total phosphorus concentrations in all of the streams except for the east inlet at State Road 17 (Site 3) during storm flow were at or above the Ohio EPA's numeric total phosphorus criteria set to protect aquatic life. (Indiana does not have numeric nutrient criteria.) The high total Kjeldahl nitrogen and total phosphorus concentrations observed at Site 1 lend further evidence to the hypothesis that organic matter may be accumulating at this site. The high total phosphorus concentrations and resultant productivity in the watershed streams may be altering their biotic community structure and impairing aquatic life.

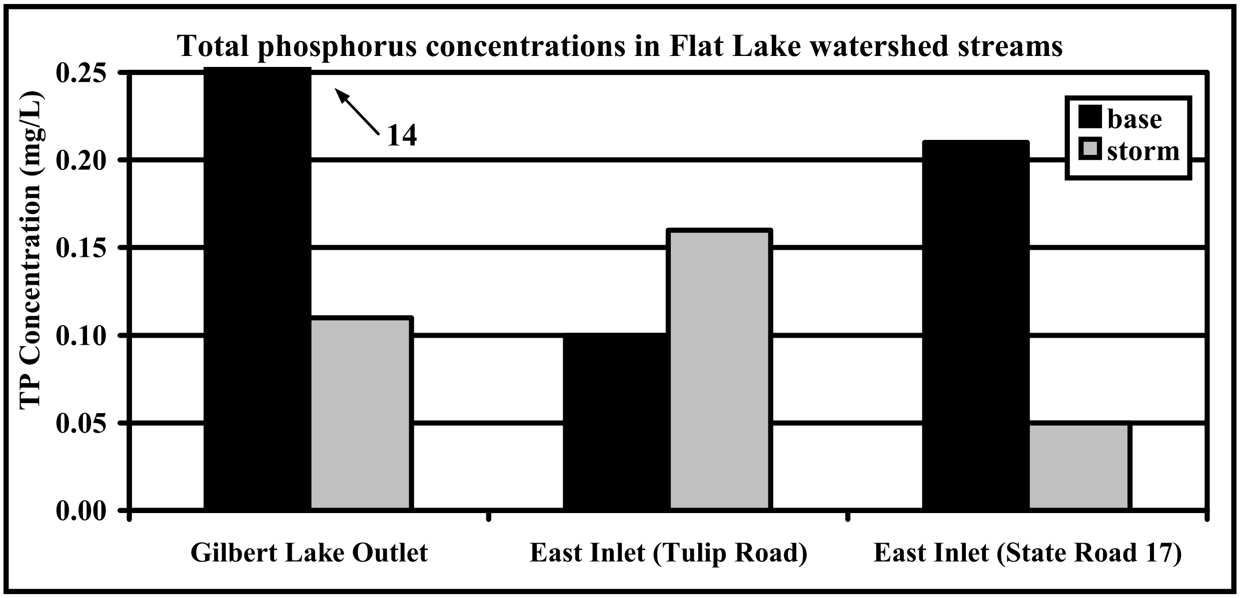

Figure G. Total phosphorus concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Figure H presents the total suspended solids concentration data for the study streams. Total suspended solids concentrations measured during base flow sampling exceeded concentrations measured in storm flow samples at Two of the three ample sites. Typically, higher overland flow associated with storm flow conditions result in an increase in soil erosion and sediment release to streams. Greater streambank and streambed erosion occurs during high flow as well. Therefore, higher concentrations of suspended solids are typically measured in storm flow samples. However, these typical results were observed at only one location, the east inlet at Tulip Road (Site 2). The relatively low flow observed during base flow in the Gilbert Lake outlet (Site 1) and the east inlet at State Road 17 (Site 3) may have influenced the TSS concentrations. The base flow sample collected at the east inlet at State Road 17 (Site 3) and the storm flow sample collected at the east inlet at Tulip Road (Site 2) contained elevated TSS concentrations (35 mg/L and 17 mg/L, respectively); the base flow sample collected in the Gilbert Lake outlet (Site 1) contained the highest total suspended solids concentration (5,900 mg/L). High TSS concentrations at Site 1 during base flow may be due to the high levels of plant materials observed in the stream. Base flow sample concentrations at this site were nearly 75 times the concentration found to be deleterious to aquatic life (80 mg/L; Waters, 1995).

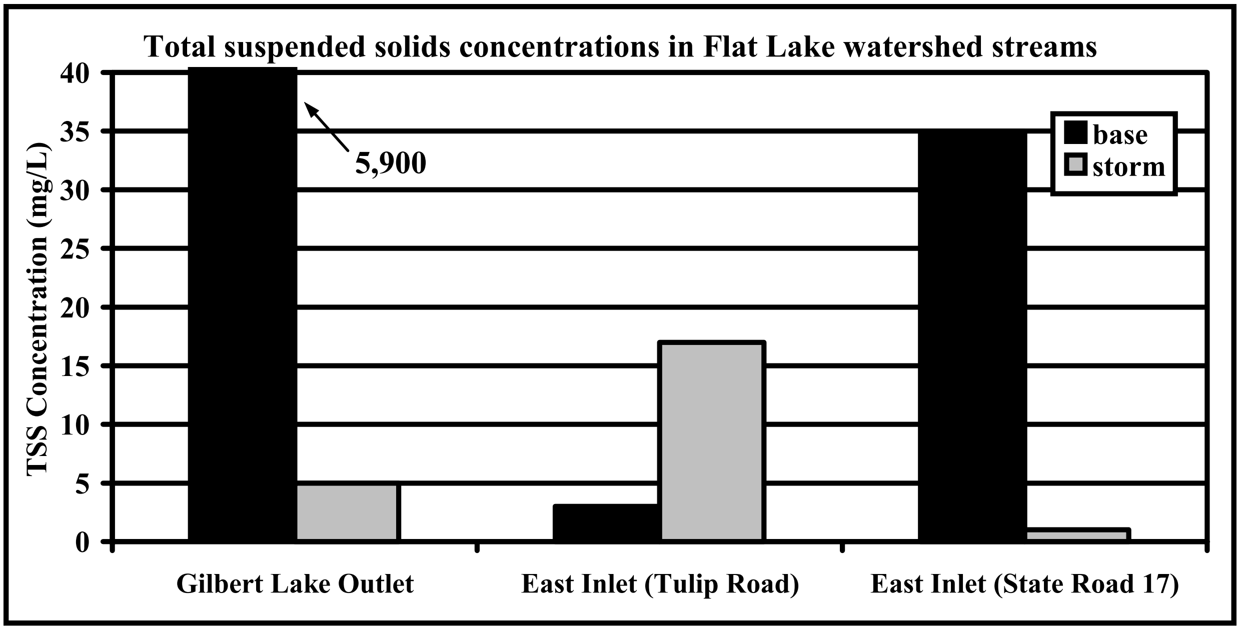

Figure H. Total suspended solids concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Figure I displays the *E. coli* concentration data for the two sampling events. The base flow sample collected in the Gilbert Lake outlet (Site 1) possessed the highest *E. coli* concentration (10,000 colonies/100 mL), while the storm flow sample from the east inlet at State Road 17 (Site 3) exhibited the lowest *E. coli* concentration (69 colonies/100 mL). Two sample sites, the Gilbert Lake outlet (Site 1) during base flow and the east inlet at Tulip Road (Site 2) during storm flow exhibited *E. coli* concentrations above the state standard (235 colonies/100 mL). *E. coli* concentration at the Gilbert Lake outlet (Site 1) severely violated the state standard. *E. coli* concentrations in the east inlet to Flat Lake were similar to or slightly lower than other streams in the state. White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 colonies/100 mL; only the *E. coli* concentrations measured in the Gilbert Lake outlet (Site 1) during base flow exceeded this average concentration.

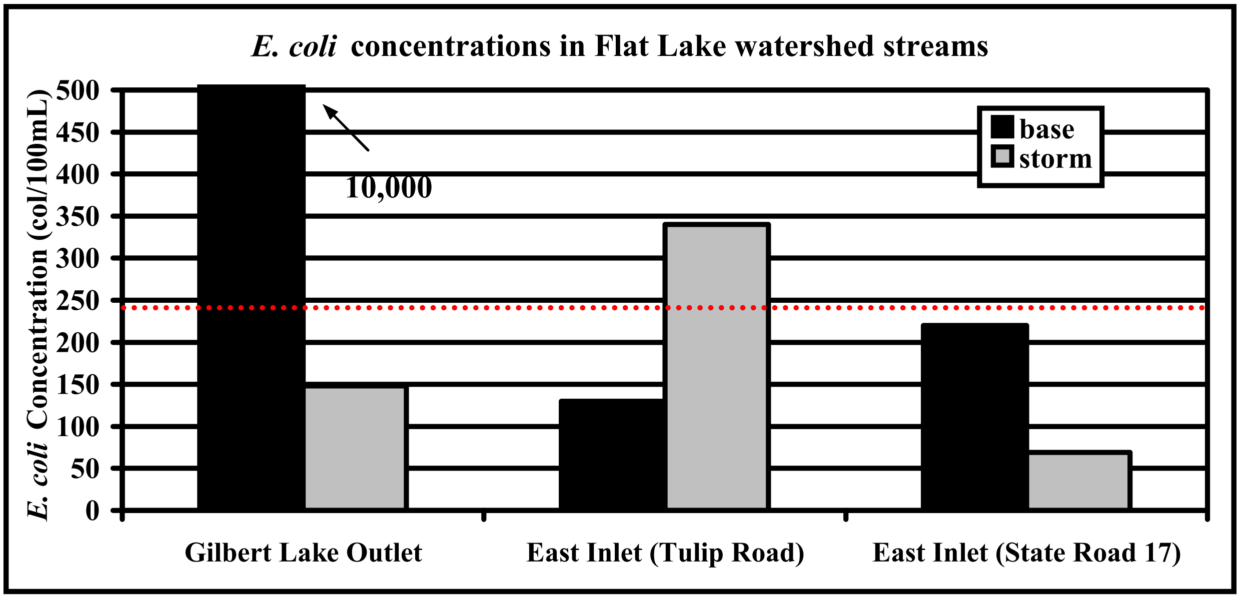

Figure I. *E. coli* concentrations measured in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002. The dashed line marks the Indiana state standard for grab samples of 235 colonies/100 mL.

Nutrient and Sediment Parameter Mass Loading

Table D lists the nutrient and sediment mass loading data in the Flat Lake watershed. Figures J-N present mass loading information graphically. Because water was stagnant (discharge = 0 cfs) in the Gilbert Lake outlet (Site 1) during base flow conditions, no mass loading could be calculated for this site during base flow conditions. Figures J-N reflect this.

Table D. Chemical and sediment loading data from Flat Lake watershed streams.

Site	Date	Timing	NO_3-N Load (kg/d)	NH_3-N Load (kg/d)	TKN Load (kg/d)	TP Load (kg/d)	TSS Load (kg/d)
1	5/9/02	storm	0.11	0.44	3.26	0.24	10.88
	7/16/02	base	0.00	0.00	0.00	0.00	0.00
2	5/9/02	storm	6.14	1.02	32.75	3.27	347.92
	7/16/02	base	0.10	0.03	0.32	0.03	0.87
3	5/9/02	storm	0.40	0.40	4.18	0.40	8.04
	7/16/02	base	0.02	0.01	0.30	0.04	5.90

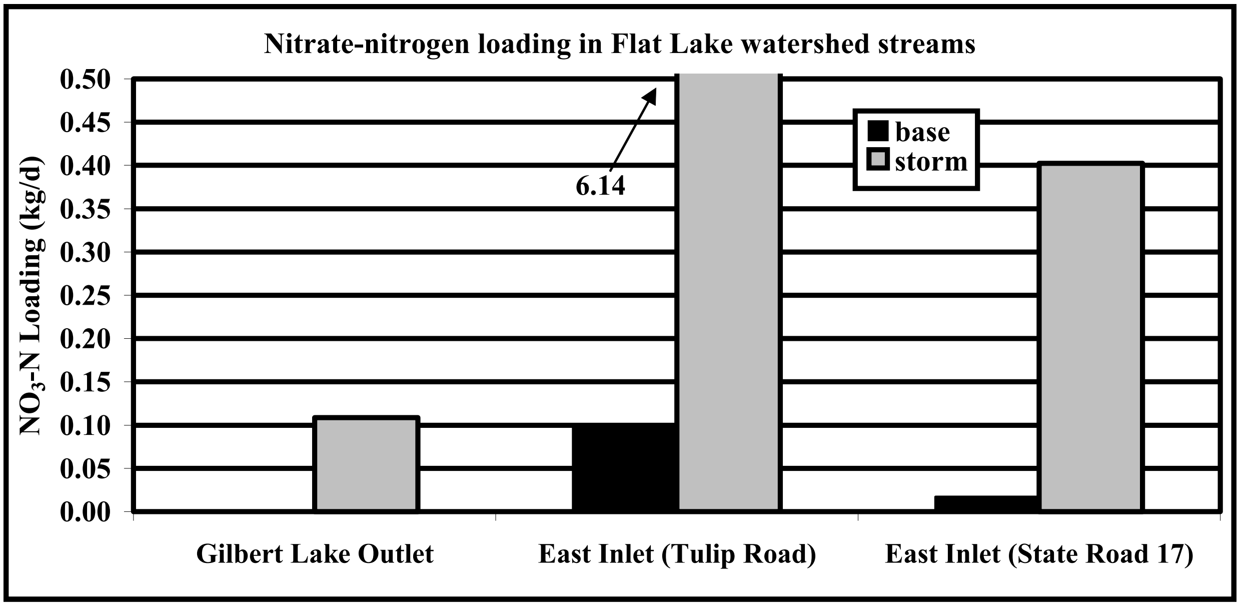

Figure J. Nitrate-nitrogen loading in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

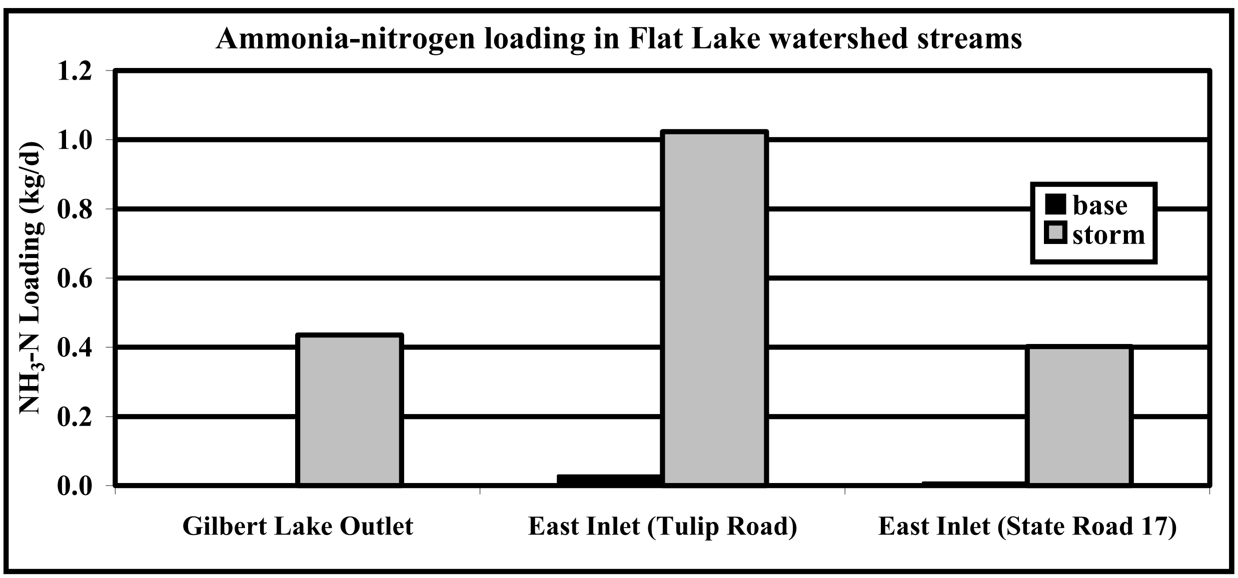

Figure K. Ammonia-nitrogen loading in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

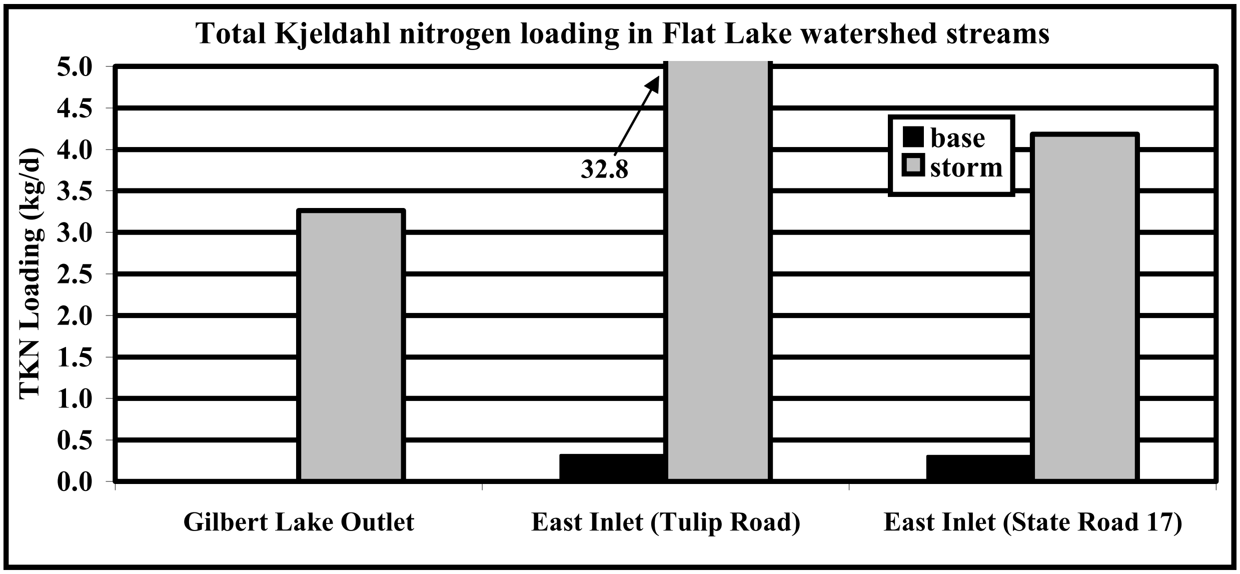

Figure L. Total Kjeldahl nitrogen loading in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

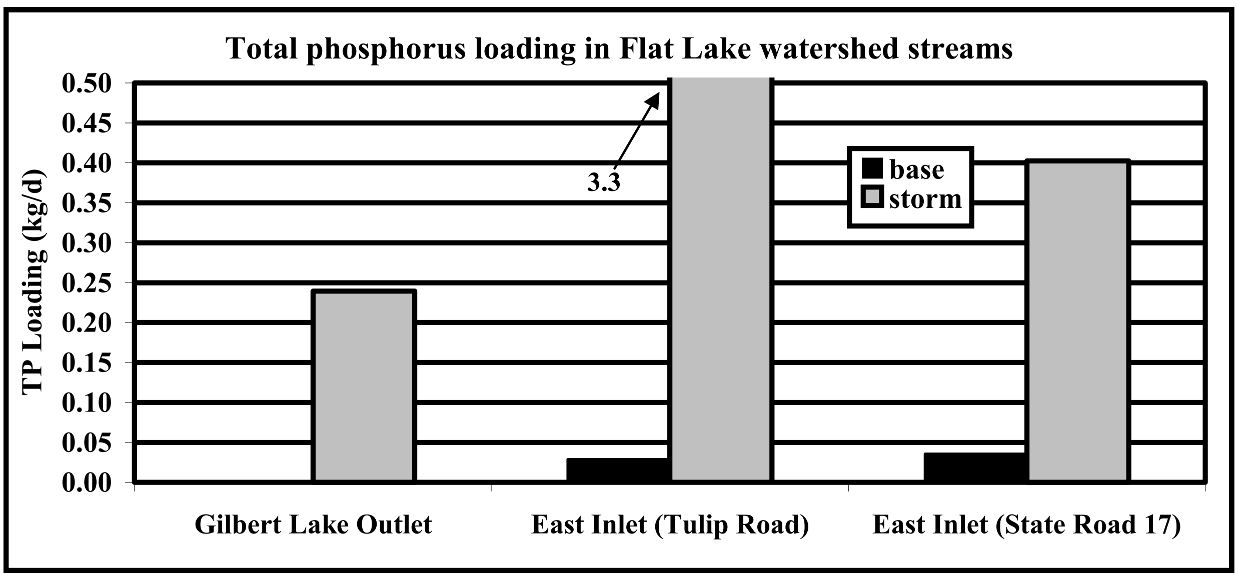

Figure M. Total phosphorus loading in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

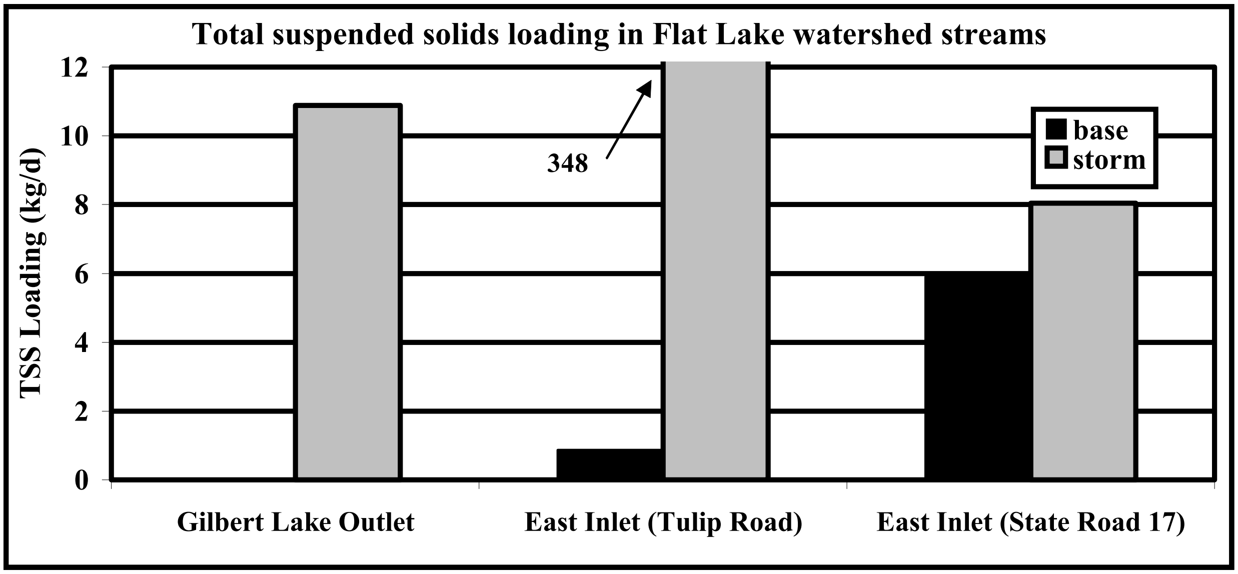

Figure N. Total suspended solids loading in Flat Lake water quality samples collected on 4/9/2002 and 7/16/2002.

Under base flow conditions, the east inlet at Tulip Road (Site 2) exhibited a higher loading rate for nitrate-nitrogen, ammonia-nitrogen, and total Kjedahl nitrogen (Figures J-L) compared to the east inlet at State Road 17 (Site 3). This is to be expected. As the site located furthest downstream, the east inlet at Tulip Road receives the pollutants from the east inlet at State Road 17. In contrast, the east inlet at State Road 17 (Site 3) exhibited a higher load rate for total phosphorus and total suspended solids (Figures M-N) than the east inlet at Tulip Road (Site 2). The decrease in load observed between these sites suggests that sediment and sediment-attached phosphorus deposition may be occurring at some point between the upstream and downstream sites. Gilbert Lake outlet (Site 1) was not flowing during base flow sampling. Although concentrations measured at this location were extremely high, the pollutant loads carried by this stream during summer months are very low, or as observed during the July 17, 2002 sampling, zero.

Under storm flow conditions, the east inlet at Tulip Road (Site 2) possessed the greatest nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, total phosphorus, and total suspended solids loads (Figures J-N). Again, these observations are consistent with expectations. The east inlet at Tulip Road (Site 2) receives the pollutants from the east inlet at State Road 17 (Site 3). Additionally, the east inlet at Tulip Road (Site 2) possesses the largest watershed. Watershed size is typically directly proportional to pollutant loading rates; large watersheds often discharge more pollutants than smaller watersheds to their adjacent streams and the streams often possess greater flow rates, increasing pollutant loading rates (pollutant loading rate = pollutant concentration x flow rate).

Water Quality Summary

In general, physical and chemical parameter data collected from streams in the Flat Lake watershed indicate some evidence of water quality degradation when compared with ideal conditions. Dissolved oxygen levels were adequate in the east inlet to Flat Lake at Tulip Road (Site 2); however, one measurement recorded at the east inlet at State Road 17 and both measurements recorded at the Gilbert Lake outlet (Site 1) were below the state standard for dissolved oxygen. Low DO levels at these sites may be impairing the streams' biotic communities. Nitrate-nitrogen and ammonia-nitrogen concentrations in the watershed streams were generally low and within levels acceptable for aquatic life survival. All sites were near or lower than the USEPA's recommended nitrate-nitrogen criteria of 0.30 mg/L and all were lower than the Ohio EPA's nitrate-nitrogen standard of 1.0 mg/L. In contrast, total Kjeldahl nitrogen and total phosphorus levels were slightly elevated. Total phosphorus concentrations generally exceeded various recommendations/standards set to protect aquatic life (USEPA, 2000; Ohio EPA, 1999; Dodd et al., 1998). Despite this, total Kjeldahl nitrogen and total phosphorus concentrations were not unusually high for Indiana streams. The elevated total Kjeldahl nitrogen and total phosphorus levels may be impairing the aquatic biota in the watershed streams and may be contributing to the eutrophication of Flat Lake. *E. coli* concentrations were generally low compared to the typical Indiana stream suggesting recreational use of the waterbodies in the Flat Lake watershed is acceptable.

The exception to the many of the statements above is the Gilbert Lake outlet (Site 1). Dissolved oxygen levels were consistently low in this stream and were below levels necessary to sustain aquatic life. Pollutants concentrations, particularly during base flow, were very high. These high pollutant levels are likely impairing the stream's biotic community and may be affecting downstream communities. These pollutants are likely contributing to the eutrophication of Flat Lake. Pollutant loading rates for some parameters (ammonia-nitrogen, total Kjeldahl nitrogen, and total suspended solids) measured during storm event sampling in the Gilbert Lake outlet (Site 1) were comparable and sometimes greater than pollutant loading rates observed in the east inlet at State Road 17 (Site 3), despite the fact that the flow rate at Site 3 was more than twice the flow rate at Site 1. These results indicate that watershed management efforts to improve Flat Lake and overall water quality in the watershed should focus on the watershed draining Site 3.

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APPENDIX E:

Quality Assurance Project Plan

Quality Assurance Project Plan
For
Flat Lake Watershed Management Plan
in
Marshall County, Indiana

A305-1-00-211

Prepared by:

J.F. New & Associates, Inc.

Prepared for:

Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

April 8, 2002

Approved By:

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SECTION 1: PROJECT DESCRIPTION

Historical Information

The Flat Lake watershed occupies the eastern half of the Gunnard Anderson-Carl Gjemre Ditches 14-digit watershed (HUC 07120001060070) within the larger Kanakakee Rver Basin (HUC 07120001) (Figure 1). The watershed encompasses approximately 4800 acres or 7.5 square miles. Drainage from the watershed flows into Flat (Mud) Lake, a 26 acre natural lake near the city of Donaldson, Indiana. Flat Lake flows discharges to the Gunnard Anderson Ditch. Water in Gunnard Anderson Ditch flows through Eagle Lake and Eagle Creek, eventually reaching the Yellow River. The Yellow River is a tributary of the Kankakee River.

While state/local agencies have conducted relatively few water quality studies that specifically focus on waterbodies in the Flat Lake watershed, those studies that exist indicate water quality is impaired in the watershed. In 1997, the Indiana Department of Natural Resources (IDNR) completed a diagnostic study on Gilbert Lake, one of the lakes in the Flat Lake watershed. The study found that cattle grazing along the lakeshore, poor wastewater management practices, and nutrient inputs from the lake's agricultural watershed have impaired the lake's ability to support swimming, fishing and boating opportunities (IDNR, 1997). IDNR fisheries surveys of Gilbert and Flat Lakes show rough fish, or non-game species avoided by anglers such as carp, shad, and quillback, dominate these lakes (Robertson, 1980; Robertson, 1992). A dominance of rough fish typically occurs in lakes with high levels of nutrients. Additionally, Indiana's 1994-1995 305 (b) Report lists the Gunnard Anderson Ditch, the watershed's outlet, as only partially supportive of recreational uses (IDEM, 1996). The bacteria *Escherichia coli* (*E. coli*) is the cause to this recreational impairment.

Following the 1997 diagnostic study, the Poor Handmaids of Jesus Christ (PHJC) began several projects to restore the ecological health of Gilbert Lake and the land immediately adjacent to it. These projects include restoration of a wetland at the lake's main inlet and installation of a wastewater treatment cell to treat wastewater from the Earthworks facility. The PHJC also intends to restore at least a portion of the wetland located south of Gilbert Lake. Recognizing the need to include the entire Flat Lake watershed in their ecological restoration efforts, the PHJC plan to expand their work to encompass the Flat Lake watershed. To this end, the PHJC will develop a watershed management plan for the Flat Lake watershed. Once completed, the plan will help prevent further ecological degradation of the watershed and guide future watershed management efforts to ensure the area's ecological health.

Project Objectives

The goal of this project is to document the physical, biological and chemical conditions of the Flat Lake Watershed from which a watershed management plan can be developed. Data collected during the project will be used to make broad management decisions on a watershed scale. More specifically, data collected during the study will be used to identify "hot spots" in the watershed that may be contributing more nonpoint source pollutants to Flat Lake relative to other spots in the watershed; to suggest appropriate Best Management Practices (BMPs) to curb current ecological degradation in the watershed; and to guide future land management efforts in the watershed. The data collected during this study will also serve as baseline data to track changes in conditions of the watershed due to development. Additionally, the data may be used as baseline data to track the success in any restoration project undertaken as a result of the management plan.

The project goals will be accomplished by:

- Collecting historical data and documenting the conditions of the watershed such as land use, soils (Highly Erodible Land), and stream habitat.
- Collecting and analyzing water quality data.
- Assisting the community through watershed management plan development.
- Documenting the community's goals, efforts, and action items in a written watershed management plan.

To achieve the goal of evaluating and ranking "hot spots" in the watershed relative to one another and thus assisting the prioritization of management efforts, emphasis will be placed on maintaining standard procedures at each water quality sampling station. Consistencies in protocol will ensure sampling stations can be compared to one another, enabling the Project Manager to determine which sites are most degraded relative to others in the watershed.

Project Site

The 4800-acre Flat Lake watershed lies in the eastern half of the Gunnard Anderson-Carl Gjemre Ditches 14-digit watershed (HUC 07120001060070) in northwestern Marshall County (Figure 2). The project site is a subwatershed of the larger Kankakee River Basin (HUC 07120001). Because the project's goal is to document the physical, biological, and chemical conditions in the watershed and guide management of the watershed, the study will examine/identify the following parameters.

1. Land use current and proposed
2. Topography
3. Soils
4. Significant natural areas
5. Biological communities including the location of endangered, threatened, and rare species (ETR)
6. Water quality

Parameters 1-5 are general parameters that will be examined on a watershed scale (i.e. no specific sampling sites). Much of this data has already been collected by several natural resources governmental agencies following specific protocols. The project will utilize this existing data rather than conducting field investigations for these parameters. This existing data has been collected and verified in a manner sufficient to achieve the goals of this project (i.e. development of a watershed management plan).

Parameter 6 is site specific. Water quality sampling sites were selected based on location in the watershed and accessibility. Preliminary site selection was based on map analysis. The Flat Lake watershed is a relatively small watershed. Flat Lake itself has two primary inlet streams: an unnamed ditch (the western inlet) connecting Gilbert Lake to Flat Lake and an unnamed perennial stream (the eastern inlet) flowing west from Flat Lake's headwaters, through predominantly wetland habitat and discharging to the eastern edge of Flat Lake. Two sampling sites (Sites 1 and 2) were selected to provide information on each of the main inlets to Flat Lake and thus allow a comparison of inputs from the two main subwatersheds of Flat Lake (Figure 3). To provide more detailed information about Flat Lake's eastern subwatershed, a third sample site was selected. Site 3 is located in the headwaters of Flat Lake's eastern subwatershed. Site 4 was selected to provide data on the quality of water leaving the watershed. Each site was field checked by the Project Manager to ensure site accessibility. Appendix A provides a more detailed description of each sampling site. Landowners at the selected sampling stations will be contacted to obtain permission to conduct sampling in those areas. Should permission be denied, the situation will be discussed with the IDEM Quality Assurance Manager. Any changes in sampling locations will be submitted as an addendum to this QAPP.

<u>Sampling Design</u>
General parameters collected at the watershed scale (Parameters 1-5 under Project Site) will be collected throughout the course of the study. An effort will be made to collect the majority of this data in the initial project stages to allow for any adjustments in site-specific selection (water quality) as necessary. General parameters will be collected from sources required to follow specific and reviewed protocols such as state and federal natural resources agencies or peer reviewed scientific journals. All data (except water quality data) obtained from these secondary sources will be accepted a priori and will be appropriately cited in the Watershed Management Plan. Anecdotal data will be noted as such, if included at all in the data set.

Parameter 6, water quality, will be sampled twice during the project period (Table 1). Figure 2 shows the proposed sampling site locations. Water quality samples will be collected once under base flow conditions and once under storm flow conditions. For the purposes of this project, storm flow conditions are those following a rain event of approximately one or more inches within a 24-hour time span. This timing allows collection under varying climatic conditions that may impact water quality. Again, the goal of the project is to collect data on a watershed scale from which broad management decisions can be made. Collection of water quality from this variety of situations will enable an overview of water quality in the watershed under varying conditions while staying within the project budget.

Historical water quality data for the study area will be collected as well. All data collected will be reviewed. Some, or possibly all, of the data may not be comparable to data collected using the sampling regime outlined above. Such data will be incorporated into the final product; however, non-analogous data will be cited as such in the Watershed Management Plan.

Water quality parameters to be sampled include pH, temperature, dissolved oxygen, conductivity, flow, *E. coli*, ammonia-nitrogen, nitrate+nitrite-nitrogen, total Kjeldahl nitrogen, total phosphorus, and total suspended solids. pH, temperature, dissolved oxygen, conductivity and discharge will be analyzed in situ with field equipment. Discharge measurements will allow loading calculations and therefore comparison of relative contributions of the tributaries. EIS Analytical Services, Inc. (EIS) in South Bend, Indiana will analyze the remaining parameters at their laboratory.

Table 1. Parameters studied

	Type of Sample/Parameter	Number of Samples/Sampling Event/Sampling Station*	Sampling Event Frequency	Sampling Period
General Data	Land uses, soils, ETR, etc.	N/A	N/A	Spring/Summer 2002
Chemical	Water Quality	1	2	March 2002-March 2003

*Number does not include quality assurance samples/measurements taken to determine precision and accuracy.

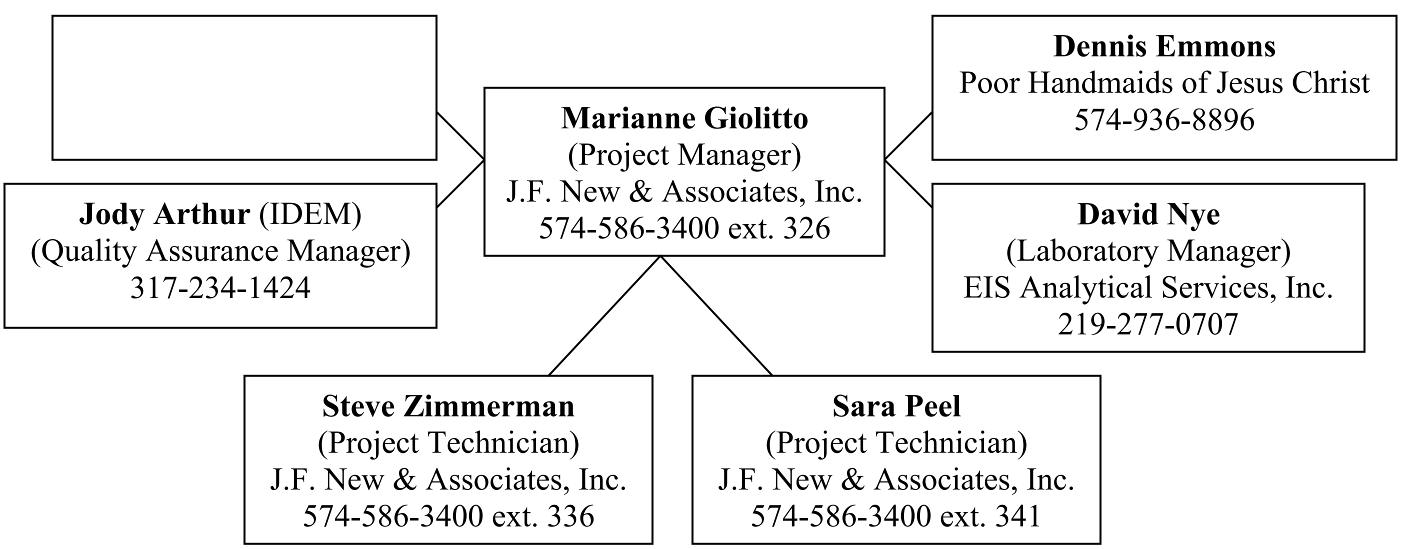
The water quality sampling schedule is flexible to prevent sampling during inappropriate weather or when equipment is not working.

<u>Project Schedule</u>

Project schedule is outlined in Table 1. General data collection will occur in Spring/Summer 2002. Results of this collection will be presented verbally at a public meeting in Summer 2002. These results will also be included in the final project document which is expected to be complete in March 2003. Water quality collection will likely occur in Spring/Summer 2002. As discussed previously, this will depend upon weather conditions. The laboratory will likely provide a report of the analysis within three weeks following their receipt of the samples (David Nye, personal communication). Water quality will be presented verbally at a public meeting in Summer 202. The data and analysis of the data will be included in the final project document, which is expected to be complete in March 2003.

SECTION 2: PROJECT ORGANIZATION AND RESPONSIBILITY

J. F. New & Associates will be responsible for the planning, execution, analysis of water quality sample collection, providing forums for public input and documenting the public's concerns an goals, and overall project management. The water-testing lab (EIS Analytical Services, Inc.) will be responsible for chemical water quality analysis. Indiana Department of Environmental Management (IDEM) will provide the overall project guidance and assistance.



Chain of Authority

- Project Technicians report to Project Manager
- Project Manager coordinates with EIS Analytical Services, IDEM Quality Assurance Manager, IDEM Project Manager, and Poor Handmaids of Jesus Christ

Duty List

Project Technician is responsible for

- QAPP development
- Collection of general watershed parameters
- Collection of historical water quality data
- Water quality sampling
- Entering water quality sampling results from the laboratory
- Analysis of collected information

Project Manager is responsible for

- Oversight of Project Technician's duties listed above
- Selection of sampling site locations
- Review water quality field data sheets prior to leaving sampling site
- Implementation of QAPP
- Water quality sampling
- Review water quality data entry for completeness and accuracy
- Analysis of collected information

SECTION 3: DATA QUALITY OBJECTIVES

Like any project, this project has financial and temporal constraints. The project goal is to document the ecological conditions of the watershed with special emphasis on water quality from which a watershed management plan can be developed. The project's data quality goals are based on this overall project goal. Based on this, the general data quality objectives are to gather representative information on the ecosystem's to make broad conclusions, and perform collection by accepted protocols to ensure the effort can be repeated in the future.

General Parameters

Because of time and financial constraints, existing data will be utilized rather than collecting original data for land use, soils (Highly Erodible Land), and natural areas (ETR) locations. Precision, accuracy, and representativeness of these data will be ensured by only using data from local, state or federal agencies and peer or similarly reviewed publications. If anecdotal data is included in the plan, it will be noted as such. Due to the time frame available to collect this data and the availability of the data, 100% completeness should be achieved.

Water Quality Parameters

The contracted laboratory will implement Quality Assurance/Quality Control (QA/QC) measures to ensure data quality (Appendix B). The laboratory standards are sufficient to meet the stated goals of this project. Table 2 summarizes the data quality objectives for the water quality parameters.

Table 2. Data Quality Objectives for Field and Laboratory Methods.

Parameter	Method	Precision	Accuracy	Completeness
pH	Hach Pocket Pal pH Meter	RPD<5%	± 0.1 at 20°C	50%
Temperature	YSI Model 55D	RPD<5%	± 2%	50%
Dissolved Oxygen	YSI Model 55D	RPD<5%	± 2%	50%
Conductivity	Orion QuiKcheK Model 118	RPD<5%	± 2%	50%
Flow	Global Water Flow Meter Model FP201	RPD <5%	±0.05% at .5 ft/sec ±0.02%at 1 ft/sec ±0.03% at 5 ft/sec	50%
E. coli	Standard Method 9213D	See Standard Methods Reference	See Standard Methods Reference	50%
Ammonia	EPA Method 350.1	See EPA Reference	See EPA Reference	50%
Nitrate+nitrite	EPA Method 353.2	See EPA Reference	See EPA Reference	50%
Total Kjeldahl Nitrogen	EPA Method 351.2	See EPA Reference	See EPA Reference	50%
Total Phosphorus	Standard Method 4500-P F	See Standard Methods Reference	See Standard Methods Reference	50%
Total Suspended Solids	Standard Method 2540 D	See Standard Methods Reference	See Standard Methods Reference	50%

Completeness

In the event that some catastrophic event (i.e. weather anomaly, chemical spill, or other event that would prohibit access to sampling sites) were to take place, the first action taken would be to delay the sampling to a later time that year, in hopes that sampling would occur under more representative conditions. There is flexibility built into the project schedule to allow sampling to occur during favorable conditions, preserving data quality.

One hundred percent (100%) collection of water quality samples is expected. Sampling locations have been field checked to ensure sampling access and proper sampling hydrology is present at each site. However, climatic or other changes beyond the project's control may alter conditions in the watershed. Refusal of landowners to grant access to the property may also limit the sample collection. Loss of the samples obtained at Site 3, the Flat Lake headwaters, and site 4, the Flat Lake outlet would not prevent the project from attaining its goal of developing a watershed management plan. Sites 1 and 2 provide the data necessary to compare Flat Lake's two main subwatersheds, and thus fulfill the project's objectives. Based on this 50% completeness (see equation below) will be acceptable for completion of the project.

$$\%\ \text{completeness} = \frac{(\text{number of valid measurements}) \times 100\%}{(\text{number of valid measurements expected})} = \frac{4 \times 100\%}{8} = 50\ \%$$

Representativeness

Representativeness is the most important data quality metric in the project since the project objective is to provide watershed scale data. Representativeness of sampling sites was achieved by performing a desktop review of potential sampling sites. All tributaries to Gilbert and Flat Lakes will be sampled by this project. Potential sites were selected based on accessibility (proximity to a road) and location in the watershed (ensuring that the main stream in each of the two major subwatersheds is sampled). Potential sites were then field checked by the Project

Manager to ensure accessibility to sampling stations. Landowner permission will confirm potential sampling locations usability as sampling sites.

<u>Comparibility</u>

Water quality parameters are expected to be comparable to other studies if sampling and laboratory protocols are similar and data quality objectives are similar. Results of this study can be compared to other studies that use this protocol and similar data quality objectives. As noted in the Sampling Design section, any non-analogous historical data (data collected under a different protocol with different data quality objectives) used in the study will be cited as such in the final product.

SECTION 4: SAMPLING PROCEDURES

The sampling methods and equipment are summarized in Table 2.

<u>Water Quality Sampling</u>

Water quality sampling will be taken at each station to test the parameters listed in Table 2. Temperature, dissolved oxygen, pH, conductivity, and flow measurements will be made in the field using the following instruments: YSI Model 55D dissolved oxygen/temperature meter, Hach pH meter, Orion QuiKcheK Model 118 conductivity meter, Global Water flow meter. All measurements will be taken according to the standard operating procedures provided by the manufacturer of the equipment. Width and depth measurements of the stream channel or culvert at the sampling station will be made to obtain a cross-sectional area of the stream channel or culvert. This cross-sectional area will be used, along with flow measurements, to calculate discharge at the sampling station.

Grab samples will be collected for the remaining water quality parameters. Samples will be placed in plastic containers supplied by EIS Analytical in South Bend, Indiana. EIS will provide the appropriate preservative in the pre-packaged containers as necessary. Sample collection will proceed in a manner similar to that outlined in *EPA Volunteer Stream Monitoring: A Methods Manual* (1997). One member of the field crew will wade to the center of the stream/creek thalweg to collect the water sample. The crew member will invert a clean sample bottle (an extra one, not one used for sample storage) from the laboratory into the stream's thalweg. At a depth of approximately 8 to 12 inches below the water surface, the crew member will turn the bottle into the current to allow for collection of water. (If the stream at the sampling station is shallower than 16 inches, water collection will occur mid-way between the water's surface and the stream bottom.) Once the bottle is full the crew member will scoop the bottle up toward the surface. Water in this bottle will be poured into the sample container. The sample container will be labeled as outlined in the proceeding section, stored on ice and transported in the laboratory for analysis. Water quality samples will be transported immediately to the lab. Required chain of custody procedures as outlined in the laboratories QA/QC plan (Appendix B) will be followed. Water quality samples will be processed at the lab using standard operating protocol (see Table 2). Analytical results from the water quality lab will be based on their schedule but are anticipated within 2-3 weeks of sample collection.

SECTION 5: CUSTODY PROCEDURES

The field crew consisting of the Project Technician and Project Manager (or two Project Technicians or the Project Manager and a PHJC volunteer) will collect the water quality samples using the procedure outlined in Section 4. Samples will be labeled with the sampling location, sample number (same as "Field ID" on the laboratory Chain of Custody Record), date and time of collection, sample parameters, and sampler name(s). This information along with the project name and project number will be recorded on the laboratory Chain of Custody Record (Appendix C). Appendix C contains a blank Chain of Custody Record and one showing which fields will be entered by the field crew. Samples will be stored on ice and transported within 6 hours to EIS Analytical. The Chain of Custody Record will be signed by the Project Manager (or Project Technician if the Project Manager is not a member of the field crew) in the presence of the laboratory technician when samples are released to the laboratory. The report from EIS Analytical is expected within three weeks of sampling.

SECTION 6: CALIBRATION PROCEDURES AND FREQUENCY

Calibration measures will be performed on all field equipment to be used based upon the manufacturers recommendations as spelled out in the users manual for each individual piece of equipment. Field equipment that cannot be calibrated, such as a tape measure, will not be calibrated. Calibration will be performed the day of each sampling prior to use of equipment in the field. See Appendix B for EIS Analytical calibration procedures and frequency.

SECTION 7: ANALYTICAL PROCEDURES

Table 3 summarizes the analytical procedures for each water quality parameter. The laboratory has the capability, as shown in their Quality Assurance document (Appendix B), to analyze the water samples according to the procedures listed in Table 3.

Table 3. Analytical Procedures

Matrix	Parameter	Method	Detection Limits	Holding Time	Volume Collected
Water	pH	Hach pH meter	0.1	N/A	N/A
Water	Temperature	YSI Model 55D	1°C	N/A	N/A
Water	Dissolved Oxygen	YSI Model 55D	0.1 mg/l	N/A	N/A
Water	Conductivity	Orion QuiKcheK Model 118	0.10 mS/cm	N/A	N/A
Water	Flow	Global Water Flow Meter Model FP201	0.1 ft/s	N/A	N/A
Water	*E. coli*	Standard Method 9213D	N/A	24 hours*	120 ml
Water	Ammonia	EPA Method 350.1	0.05 mg/l	28 days	1000 ml
Water	Nitrate+nitrite	EPA Method 353.2	0.1 mg/l	28 days	1000 ml
Water	Total Kjeldahl Nitrogen	EPA Method 351.2	0.1 mg/l	28 days	1000 ml
Water	Total Phosphorus	Standard Method 4500-PF	0.05 mg/l	28 days	1000 ml
Water	Total Suspended Solids	Standard Method 2540 D	1 mg/l	7 days	1000 ml

*This value refers to the maximum time between sample collection and analysis, not the holding time from the time the sample arrives at the lab. That holding time is 2 hours.

SECTION 8: QUALITY CONTROL PROCEDURES

In summary, quality control will be achieved by strict adherence to written protocol. Quality control in the field will be obtained by adherence to standard operation protocols. To achieve precision in field measurements, replicate measurements will be taken. Replicate measurements for each field parameter sampled will be taken at one of the four sampling sites for each sampling event. Fieldwork will be performed by the same crew at each site. The Project Manager or Lead Project Technician will ensure consistency in sample collection and fieldwork. These quality control procedures will allow for comparisons to be made among sampling sites and thus achieve the project goals of identifying hot spots within the watershed for more targeted intensive management.

Quality control of lab water quality analysis will be performed as outlined in the lab's QA/QC plan (Appendix B). This quality control includes use of lab duplicates, split samples, reference standards, and method blanks where appropriate. This level of quality control is sufficient to achieve project goals.

SECTION 9: DATA REDUCTION, REVIEW, AND REPORTING

Field data sheets will be inspected for completeness and signed by the Project Manager or Lead Project Technician before leaving the site. The Project Manager or Lead Project Technician will calculate the RPD before leaving the site to ensure the precision data quality objectives for the field measurements are met. It will be assumed that accuracy data quality objective of field measurements are met if there is no problem with equipment calibration. The field sheet contains fields showing whether the RPD met the data quality objective, calibration was completed, if the measurement was taken (completeness), and if protocol was followed (comparability).

Water samples given to EIS Analytical will contain data sheets similar to the one shown in Appendix C. This data sheet will be filled out by the Project Manager or Lead Project Technician and hand delivered along with the samples to EIS in South Bend, Indiana. EIS will review sample labels and remove from the data set any that cannot be attributed to specific samplers, have not been properly preserved, or that exceed the maximum holding time. The laboratory manager will also sign-off on lab bench sheets after all checks have been completed. Any data reduction done in the lab will be done as per the methods indicated in Tables 2 and 3.

The Project Technician will enter all data into a computerized spreadsheet/database program designed for this project and compatible with hardware and software used by J.F. New & Associates, IDEM, and the Poor Handmaids of Jesus Christ. The Project Manager will review data entry for completeness and errors. Discharge and loadings will be calculated w=using the spreadsheet to minimize errors involved with performing hand calculations. Once the raw data has been reviewed by the Project Manger, discharge will be calculated using the following formula

$$\text{Discharge} = \frac{(\Sigma d_i)}{(n+1)}\, w*v$$

where d equals stream depth, n equals the number of streams depths measured, w equals the width of the stream and v equals the velocity of the stream. This equation has been modified from EPA (1997). See EPA (1997) for a full explanation of the equation. Once discharge has been calculated, the pollutant load will be calculated by multiplying the specific site discharge by the concentration of a pollutant found at that site. Pollutant loads among sites will be compared to identify which sites provide the greatest load of pollutant to Flat Lake.

The final water quality analysis report will be produced and delivered no later than June 2003. The Project Manager will be responsible for report production and distribution. Assistance in these tasks will be provided by the Project Technicians. The report will contain the data results, interpretation of the data, Best Management proposals for existing watershed conditions, a compilation of watershed stakeholders' concerns and goals, and proposals for future development in the watershed.

SECTION 10: PERFORMANCE SYSTEM AUDITS

Specific audits such as those conducted on the contracting laboratory by outside auditors are not applicable to this type of project. Such audits are not necessary to achieve the project goals given the scope of this study and the intended use of the data. However, the following checks and oversight will be utilized to ensure data quality:

- The Project Manager will provide oversight to all technical staff ensuring strict adherence to all protocols.
- Field data sheets will be reviewed for completeness prior to leaving the field.

EIS Analytical has built in audits (Appendix B). The Project staff is open to IDEM's audits upon IDEM's request. The Project Manager will conduct a system audit following the first sampling event and at the end of the project to ensure data quality objectives are met.

SECTION 11: PREVENTATIVE MAINTENANCE

A conductivity meter (Orion QuiKcheK Model 118), dissolved oxygen meter/thermometer (YSI Model 55D), tape measure, and flow meter (Global Systems Model FP201) will be utilized for water quality sampling by J.F. New & Associates, Inc. To keep these instruments in proper working order, all maintenance will be performed as outlined in the users manuals provided with the equipment where appropriate. Additional batteries for the dissolved oxygen meter, a separate thermometer, and replacement dissolved oxygen membranes will be present in the field to prevent easily fixable equipment failure (i.e. dead battery). Preventative maintenance in the laboratory is covered in Appendix B.

SECTION 12: DATA QUALITY ASSESSMENT

As stated in the Project Objectives portion of **SECTION 1**, the goal of the project is to document the physical, biological, and chemical condition of the Flat Lake Watershed. Collected data will be utilized to identify "hot spots" in the watershed that may be contributing more non-point source pollutants to Flat Lake. Data quality controls outlined in the sections above will be sufficient to meet the objectives of the project. Data quality assessments conducted by the contracting laboratory will be sufficient to meet the objectives of the project (Appendix B). All QA/QC measures for each run of the samples will be included with the lab's final data analysis and will be included as an appendix in the final report.

Additionally, the project has built into it several measures to provide continuous review of data to ensure completeness and allow modification of the project if necessary. For example, the

Project Manager will review field data sheets before leaving the site to check for completeness (**SECTION 9**). See above Sections for details on other built in reviews to ensure completeness.

Due to flexibility in scheduling of sampling events, 50-100% completeness is anticipated. If for some reason (such as ones outlined in previous sections) 100% collection of samples is not possible, the data will be evaluated to determine whether the watershed has been sufficiently represented in the data collection to date. Meeting the goal of representation is of primary importance since it is one of the study's data objectives. Data will be evaluated for representativeness based primarily on the following criteria: all sampling stations have been sampled at least once and samples have been collected during storm and base flow events. Those criteria are listed in order of importance. The first one listed will have more importance in deciding whether the project is complete despite not having collected 100% of the samples. Any decisions to deem the project complete without 100% collection of data will be made by the Project Manager. The IDEM Project Manager will be included in all such decisions.

SECTION 13: CORRECTIVE ACTION

Should extraordinary events occur that may adversely affect the collection of accurate, representative data (extreme climatic conditions, chemical spill, etc.) testing shall be rescheduled during the same year when conditions are more favorable. The data can then be analyzed so that reports can be written. Since water quality sampling is to be done only twice, it is feasible to schedule sampling at a time when conditions permit within the project's timeframe. If, for reasons beyond the project's control, samples cannot be collected during the project's timeframe, the prohibitive conditions will be noted and discussed with the IDEM Project Manager.

EIS Analytical corrective actions that will be taken for the chemical water quality analysis are noted in Appendix B. Although it is not anticipated, should data received from EIS be unusable given the project's data objectives, another sampling will occur to replace effected data. Assurance from EIS that similar problems in data quality will not be repeated will be obtained prior to submission of any samplings.

SECTION 14: QUALITY ASSURANCE REPORTS

Quarterly reports will be written and submitted starting in Winter 2001. Any problems that are found with the data will be documented in the quarterly reports. Quality assurance issues that may be addressed in the quarterly report include, but are not limited to the following:

- Assessment of such items as data accuracy and completeness
- Significant QA/QC problems and recommended solutions
- Discussion of whether the QA objectives were met and the resulting impact on decision making
- Limitations on use of the measurement data

If no QA/QC problems arise, this will be noted in the report.

REFERENCES CITED

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U.S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79/020.

U.S. Environmental Protection Agency. 1997. Volunteer Stream Monitoring: A Methods Manual. EPA-841-B-97-003.

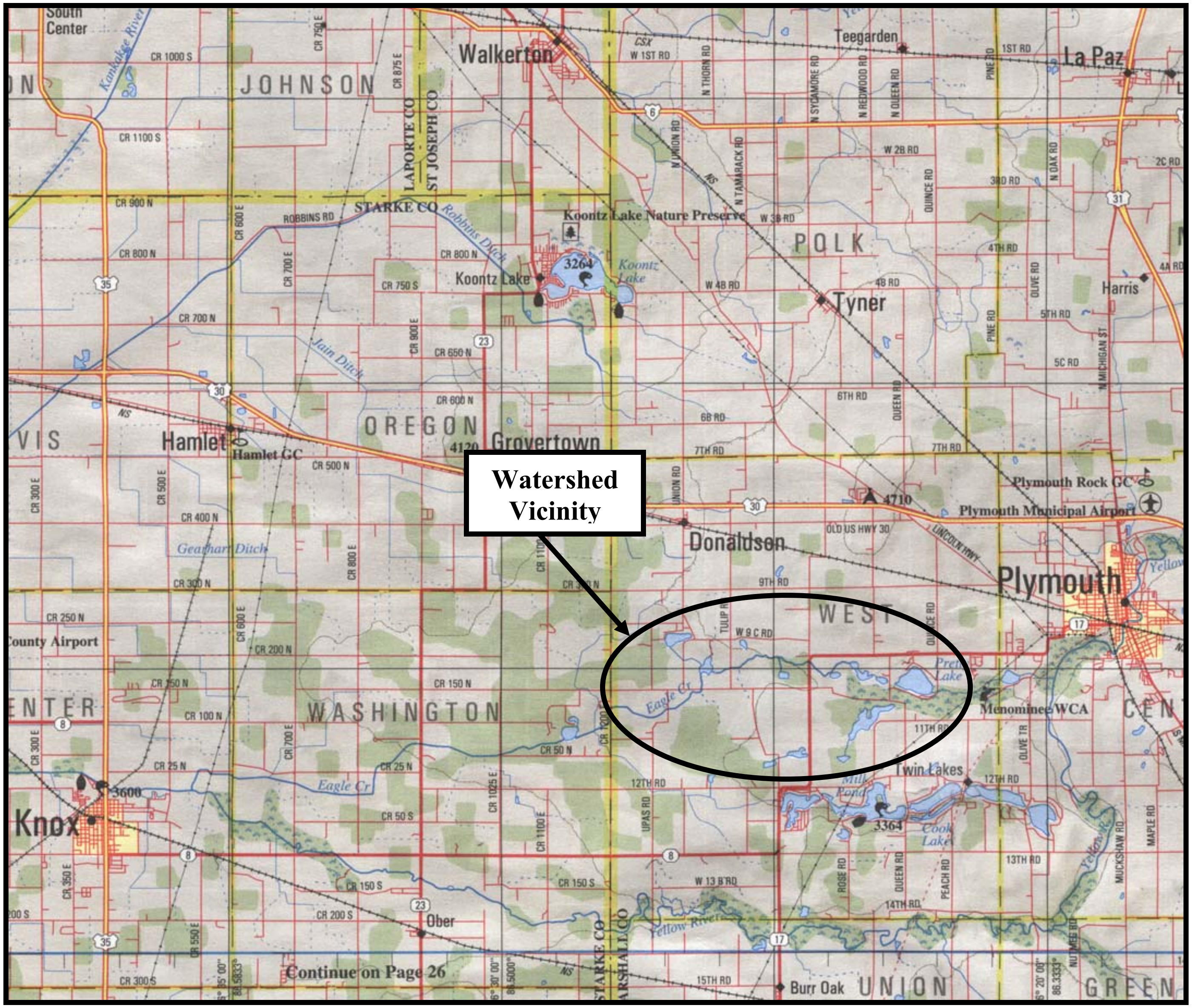


Figure 1. Location map.

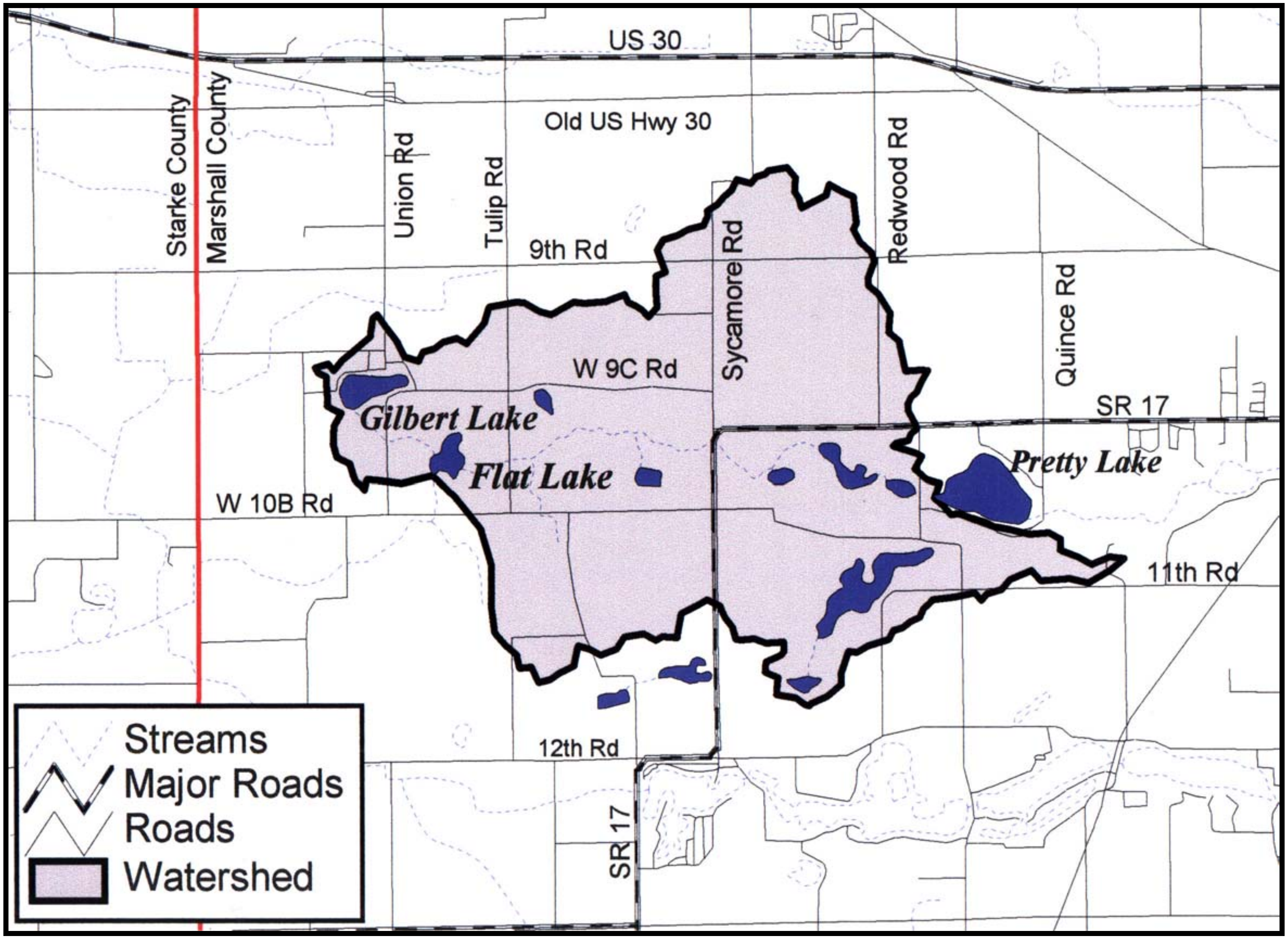


Figure 2. Flat Lake Watershed.

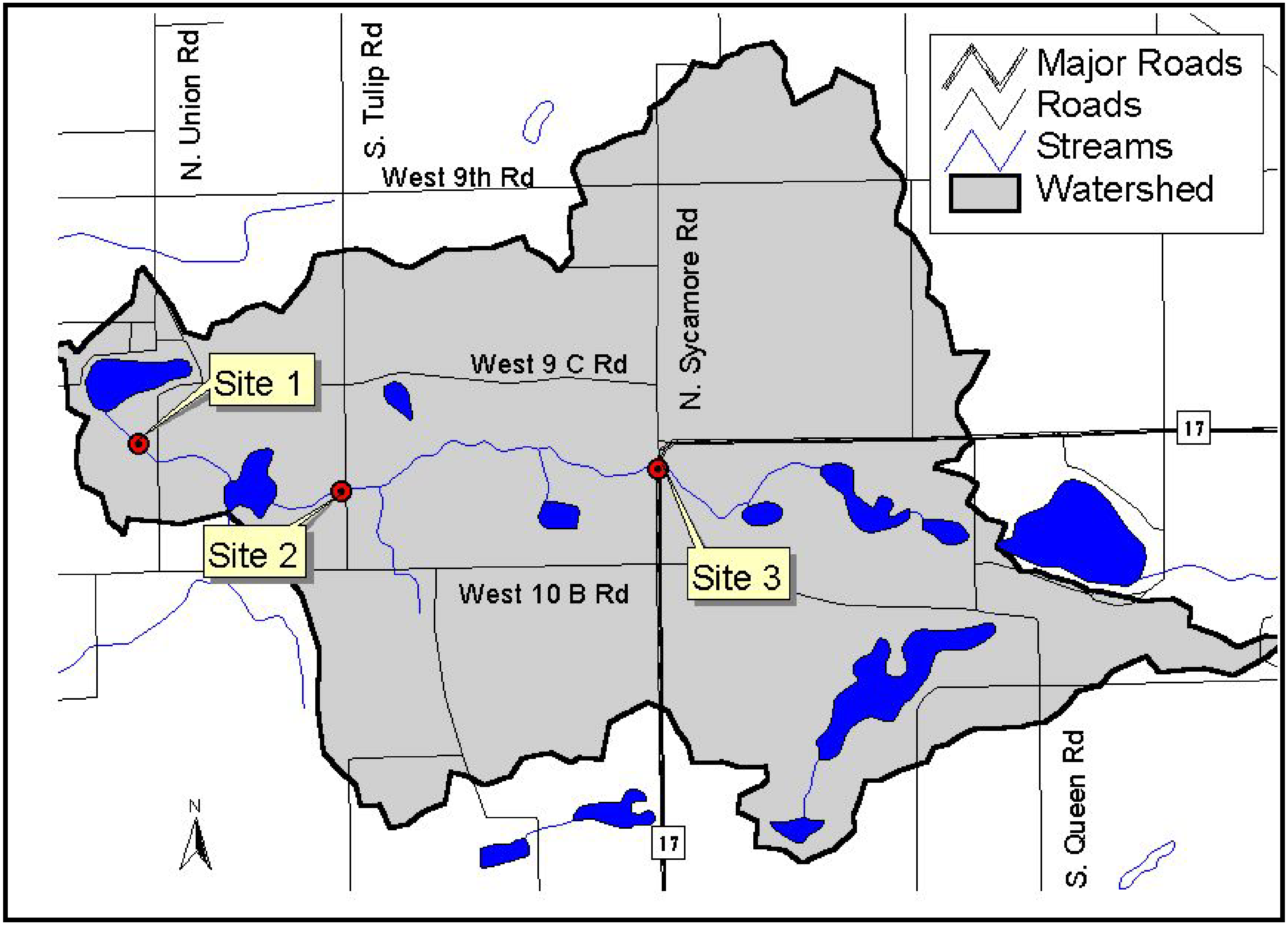


Figure 3. Flat Lake Watershed and Sampling Sites.

APPENDIX A

SAMPLING STATION LOCATIONS

PROPOSED SAMPLING SITES

Site 1

Site 1 provides information on Flat Lake's western watershed. Samples will be collected at an unnamed ditch downstream of Gilbert Lake where the ditch exits the Poor Handmaids of Jesus Christ property. The ditch flows through a degraded wetland at Site 1. Reed canary grass dominates the plant community in the wetland. Ditch banks are low, measuring approximately 1-2 feet in height. Stream substrate consists of sand and silt. The Poor Handmaids of Jesus Christ have granted permission to access the ditch on their property.

Site 2

Site 2 is located on South Tulip Road between West 9C Road and West 10B Road. The stream channel at Site 2 is 3 to 5 feet in width and less than three feet deep. The substrate consists mainly of sand, silt, and organic muck. Stream banks at Site 2 are approximately six feet high, with steep slopes. A narrow, wooded riparian corridor borders the north and south stream bank upstream of the bridge. Maintained lawns border the wooded riparian zone. Downstream of the bridge, the unnamed tributary flows through a low floodplain wetland prior to entering Flat Lake. Landowner permission is currently being sought for this site.

Site 3

Site 3 is located on State Road 17 north of West 10B Road and south of West 9C Road. Site 3 is located on an unnamed tributary to Flat Creek. This tributary drains Flat Creek's eastern subwatershed east of Site 2. The unnamed tributary flows through a floodplain wetland both upstream and downstream of the State Road 17 Bridge. The stream channel is approximately two feet wide and three feet deep at the sampling point. The substrate type consists of silt, sand, and organic muck. Canopy closure is almost non-existent at this location. The stream banks are low, measuring approximately three feet in height on the north and south banks with steeper slopes and higher banks around and under the bridge. Samples will be collected at the bridge where the stream is confined to a concrete box culvert. Landowner permission is being sought for this site. Site 3 is accessible due to its location along the road.

Site 4

Site 4 is located along Gunnard Anderson Ditch on West 10B Road east of South Union Road. Site 4 lies immediately downstream of the outlet to Flat Lake. Samples collected at Site 4 provide information on the quality of water leaving the Flat Lake watershed. Gunnard Anderson Ditch has a width of approximately five feet as it exits Flat Lake. The channel's width expands to approximately 20 feet closer to the West 10B Road bridge. Water in the ditch flows from the north side of the West 10B Road bridge to the south side via a 2-foot diameter culvert. Water discharged from the culvert on the south side of the road ponds near the bridge. Approximately 15 feet south of the West 10B Road bridge the ditch channel narrows to a width of approximately 3 feet. Near the West 10B Road bridge the banks are approximately 5 feet high and steep (1:1). Canopy closure is approximately 20% upstream of the bridge due to channel width. Downstream of the bridge, channel cover is 65-85%. Landowner permission to access the property will determine the exact location of sample collection.

APPENDIX B

EIS LABORATORY QA/QC PLAN

A copy of the EIS QA/QC Plan can be obtained from JFNew, EIS, or the Indiana Department of Environmental Management.

APPENDIX C

LABORATORY CHAIN OF CUSTODY DATA SHEET

WATER QUALITY SAMPLING FIELD LOG SHEET

DATE: ______________________ PROJECT NAME: ____________________________

TIME: _______________

SAMPLERS: _____________________________________

SAMPLE SITE: ___________________________________

WEATHER CONDITIONS: ____

OTHER OBSERVATIONS: ____

EQUIPMENT CALIBRATION (Date): _______________________

FIELD PARAMETERS	REPLICATE (if taken)	
pH: _____________	pH: ____________	RPD = _______
Temperature: ________________	Temperature: ____________	RPD = _______
Dissolved Oxygen: ____________	Dissolved Oxygen: _______	RPD = _______
Conductivity: ________________	Conductivity: _________	RPD = _______
Flow: ______________	Flow: ________	RPD = _______

LAB PARAMETERS

E. Coli: ____

Ammonia: ____

Nitrate: ____

Kjeldahl Nitrogen: ____

Total Phosphorus: ____

Total Suspended Solids: ____

STREAM MEASUREMENTS

Width: __________

Depth(s): ____

Field Crew Leader Signature: ______________________

APPENDIX F:

Load Reduction Spreadsheet

Agricultural Fields and Filter Strips

Please fill in the gray areas below. Once you have successfully estimated
the sediment and nutrient load reductions, please print two (2) copies of this worksheet.
Attach both copies to the 319A or 319U cost-share form.
If you have any questions, please contact Jim Dunaway (317/233-8490).

		Example
IDEM Project Manager:		**WWS**
Project ARN:		**95-992**
Landowner Initials:		**HJK**
Date practices completed:		**8/8/1999**

These may include:
Prescribed Grazing
Residue Management, Mulch Till
Conservation Crop Rotation
Conservation Cover
Cover and Green Manure
Critical Area Planting
Stripcropping, Contour
Stripcropping, Field
Filter Strips

Please check which BMPs apply:

☑ Agricultural Field Practices
☐ Filter Strips

RUSLE	Before Treatment	After Treatment	Example **Before Treatment**	Example **After Treatment**
Rainfall-Runoff Erosivity Factor (R)	160	160	**120**	**120**
Soil Erodibility Factor (K)	0.254	0.254	**0.35**	**0.35**
Length-Slope Factor (LS)	0.266	0.266	**0.44**	**0.44**
Cover Management Factor (C)	0.207	0.04	**0.7**	**0.5**
Support Practice Factor (P)	1	1	**0.775**	**0.11**
Predicted Avg Annual Soil Loss (ton/acre/year)	2.24	0.43	**10.03**	**1.02**

		Example
Contributing Area (acres)	100	**14**

The portion of the treated field which contributes eroded soil to the waterbody. The contributing area is defined by the runoff flowpath and by topography and may differ in size from the actual treated field.

Please select a gross soil texture:

○ Clay (clay, clay loam, and silt clay)
◉ Silt (silt, silty clay loam, loam, and silt loam)
○ Sand (sand, sandy clay, sandy clay loam, sandy loam, and loamy sand)
○ Peat

Estimated Load Reductions for Agricultural Field Practices

	Treated	Example
Sediment Load Reduction (ton/year)	96	**85**
Phosphorus Load Reduction (lb/year)	134	**100**
Nitrogen Load Reduction (lb/yr)	268	**200**

Estimated Additional Load Reductions through Filter Strips

	Filter Strips	Example
Sediment Load Reduction (ton/year)	15	**92**
Phosphorus Load Reduction (lb/year)	37	**114**
Nitrogen Load Reduction (lb/yr)	69	**227**

Total Estimated Load Reductions

	Total	Example
Sediment Load Reduction (ton/year)	111	**177**
Phosphorus Load Reduction (lb/year)	171	**214**
Nitrogen Load Reduction (lb/yr)	337	**427**

APPENDIX G:

Potential Funding Sources

FUNDING SOURCES AND WATERSHED RESOURCES

Funding and other resources are important for the actual implementation of recommended management practices in a watershed. Several cost share and grant programs are available to help offset costs of watershed projects. Additionally, both human and material resources may be available in the watershed.

Funding Sources

There are several cost-share grants available from both state and federal government agencies specific to watershed management. Lake associations and/or Soil and Water Conservation Districts (SWCDs) can apply for the majority of these grants. The main goal of these grants and other funding sources is to improve water quality though the use of specific BMPs. As public awareness shifts towards watershed management, these grants will become more and more competitive. Therefore, any association interested in improving water quality through the use of grants must become active soon. Once an association is recognized as a "watershed management activist" it will become easier to obtain these funds repeatedly. The following are some of the possible major funding sources available to lake and watershed associations for watershed management.

Lake and River Enhancement Program (LARE)

LARE is administered by the Indiana Department of Natural Resources, Division of Soil Conservation. The program's main goals are to control sediment and nutrient inputs to lakes and streams and prevent or reverse degradation from these inputs through the implementation of corrective measures. Under present policy, the LARE program may fund lake and watershed specific construction actions up to $100,000 for a specific project or $300,000 for all projects on a specific lake or stream. Cost-share approved projects require a 0-25% cash or in-kind match, depending on the project. LARE also has a "watershed land treatment" component that can provide grants to SWCDs for multi-year projects. The funds are available on a cost-sharing basis with farmers who implement various BMPs. The watershed land treatment program is highly recommended as a project funding source for the Flat Lake Watershed.

Clean Water Act Section 319 Nonpoint Source Pollution Management Grant

The 319 Grant Program is administered by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Watershed Management Section. 319 is a federal grant made available by the Environmental Protection Agency (EPA). 319 grants fund projects that target nonpoint source water pollution. Nonpoint source pollution (NPS) refers to pollution originating from general sources rather than specific discharge points (Olem and Flock, 1990). Sediment, animal and human waste, nutrients, pesticides, and other chemicals resulting from land use activities such as mining, farming, logging, construction, and septic fields are considered NPS pollution. According to the EPA, NPS pollution is the number one contributor to water pollution in the United States. To qualify for funding, the water body must meet specific criteria such as being listed in the state's 305(b) report as a high priority water body or be identified by a diagnostic study as being impacted by NPS pollution. Funds can be requested for up to $300,000 for individual projects. There is a 25% cash or in-kind match requirement.

Section 104(b)(3) NPDES Related State Program Grants
Section 104(b)(3) of the Clean Water Act gives authority to a grant program called the National Pollutant Discharge Elimination System (NPDES) Related State Program Grants. These grants provide money for developing, implementing, and demonstrating new concepts or requirements that will improve the effectiveness of the NPDES permit program that regulates point source discharges of water pollution. Projects that qualify for Section 104(b)(3) grants involve water pollution sources and activities regulated by the NPDES program. The awarded amount can vary by project and there is a required 5% match.

Section 205(j) Water Quality Management Planning Grants
Funds allocated by Section 205(j) of the Clean Water Act are granted for water quality management planning and design. Grants are given to municipal governments, county governments, regional planning commissions, and other public organizations for researching point and non-point source pollution problems and developing plans to deal with the problems. According to the IDEM Office of Water Quality website: "The Section 205(j) program provides for projects that gather and map information on non-point and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and implement watershed management plans. No match is required. For more information on the 319, 104(b)(3), and 205(j) grants, please see the IDEM website http://www.in.gov/idem/water/planbr/wsm/Section205j_main.html.

Other Federal Grant Programs
The USDA and EPA award research and project initiation grants through the US National Research Initiative Competitive Grants Program and the Agriculture in Concert with the Environment Program.

Watershed Protection and Flood Prevention Program
The Watershed Protection and Flood Prevention Program is funded by the U.S. Department of Agriculture (USDA) and is administered by the Natural Resources Conservation Service (NRCS). Funding targets a variety of watershed activities including watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in small watersheds (250,000 or fewer acres). The program covers 100% of flood prevention construction costs or 50% of construction costs for agricultural water management, recreational, or fish and wildlife projects.

Conservation Reserve Program
As already discussed, the Conservation Reserve Program (CRP) is funded by the USDA and administered by the Farm Service Agency (FSA). CRP is a voluntary, competitive program designed to encourage farmers to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. The program targets farmed areas that have a high potential for degrading water quality under traditional agricultural practices or areas that might make good wildlife habitat if they were not farmed. Such areas include highly erodible land, riparian zones, and farmed wetlands. Currently, the program offers continuous sign-up for practices like grassed waterways and filter strips. Participants in the program receive

cost share assistance for any plantings or construction as well as annual payments for any land set aside.

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is funded by the USDA and is administered by the NRCS. WRP is a subsection of the Conservation Reserve Program. This voluntary program provides funding for the restoration of wetlands on agricultural land. To qualify for the program, land must be restorable and suitable for wildlife benefits. This includes farmed wetlands, prior converted cropland, farmed wet pasture, farmland that has become a wetland as a result of flooding, riparian areas which link protected wetlands, and the land adjacent to protected wetlands that contribute to wetland functions and values. Landowners may place permanent or 30-year easements on land in the program. Landowners receive payment for these easement agreements. Restoration cost-share funds are also available. No match is required.

Partners for Fish and Wildlife Program

The Partners for Fish and Wildlife Program (PFWP) is funded and administered by the U.S. Department of the Interior through the U.S. Fish and Wildlife Service. The program provides technical and financial assistance to landowners interested in improving native habitat for fish and wildlife on their land. The program focuses on restoring wetlands, native grasslands, streams, riparian areas, and other habitats to natural conditions. The program requires a 10 year cooperative agreement and a 1:1 match.

North American Wetland Conservation Act Grant Program

The North American Wetland Conservation Act Grant Program (NAWCA) is funded and administered by the U.S. Department of Interior. This program provides support for projects that involve long-term conservation of wetland ecosystems and their inhabitants including waterfowl, migratory birds, fish, and other wildlife. The match for this program is on a 1:1 basis.

National Fish and Wildlife Foundation (NFWF)

The National Fish and Wildlife Foundation is administered by the U.S. Department of the Interior. The program promotes healthy fish and wildlife populations and supports efforts to invest in conservation and sustainable use of natural resources. The NFWF targets six priority areas which are wetland conservation, conservation education, fisheries, neotropical migratory bird conservation, conservation policy, and wildlife and habitat. The program requires a minimum of a 1:1 match. More information can be found at http://www.nfwf.org/about.htm.

Community Forestry Grant Program

The U.S. Forest Service through the Indiana Department of Natural Resources Division of Forestry provides three forms of funding for communities under the Community Forestry Grant Program. Urban Forest Conservation Grants are designed to help communities develop long term programs to manage their urban forests. UFCG funds are provided to communities to improve and protect trees and other natural resources, projects that target program development, planning, and education are emphasized. Local municipalities, non-for-profit organizations, and state agencies can apply for $2,000-20,000 annually. The second type of Community Forestry Grant Program, the Arbor Day Grant Program, funds target activities which promote Arbor Day and the planting and care of urban trees. $500-1000 grants are generally awarded. Tree Steward

Program is an educational training program that involves six training sessions of three hours each. The program can be offered in any county in Indiana and covers a variety of tree care and planting topics. Generally, $500-1000 is available to assist communities in starting a county or regional Tree Steward Program. Each of these grants requires an equal match.

Wildlife Habitat Incentive Program

The Wildlife Incentive Program (WHIP) is funded by the USDA and administered by the NRCS. This program provides support to landowners to develop and improve wildlife habitat on private lands. Support includes technical assistance as well cost sharing payments. Those lands already enrolled in WRP are not eligible for WHIP. The match is 25%.

Forestry Incentives Program

The NRCS Forestry Incentives Program (FIP) provides cost-share dollars for forestry conservation activities like tree planting and timber stand improvement on privately-owned forest land. The program will share up to 65% of the cost of these and other related practices up to $10,000 per landowner per year. To be eligible for FIP, a particular parcel of land must be: smaller than 1,000 acres, be privately owned and non-industrial, be suitable for land management practices like reforestation, or stand improvement, and be of sufficient productivity to yield marketable timber crops.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is a voluntary program designed to provide assistance to producers to establish conservation practices in target areas where significant natural resource concerns exist. Eligible land includes cropland, rangeland, pasture, and forestland, and preference is given to applications which propose BMP installation that benefits wildlife. EQIP offers cost-share and technical assistance on tracts that are not eligible for continuous CRP enrollment. Certain BMPs receive up to 75% cost-share. In return, the producer agrees to withhold the land from production for five years. Practices that typically benefit wildlife include: grassed waterways, grass filter strips, conservation cover, tree planting, pasture and hay planting, and field borders. Best fertilizer and pesticide management practices are also eligible for EQIP cost-share.

Farmland Protection Program

The Farmland Protection Program (FPP) provides funds to help purchase development rights in order to keep productive farmland in use. The goals of FPP are: to protect valuable, prime farmland from unruly urbanization and development; to preserve farmland for future generations; to support a way of life for rural communities; and to protect farmland for long-term food security.

Debt for Nature

Debt for Nature is a voluntary program that allows certain FSA borrowers to enter into 10-year, 30-year, or 50-year contracts to cancel a portion of their FSA debts in exchange for devoting eligible acreage to conservation, recreation, or wildlife practices. Eligible acreage includes: wetlands, highly erodible lands, streams and their riparian areas, endangered species, or significant wildlife habitat, land in 100-year floodplains, areas of high water quality or scenic value, aquifer recharge zones, areas containing soil not suited for cultivation, and areas adjacent or within administered conservation areas.

Non-Profit Conservation Advocacy Group Grants
Various non-profit conservation advocacy groups provide funding for projects and land purchases that involve resource conservation. Ducks Unlimited and Pheasants Forever are two such organizations that dedicate millions of dollars per year to projects that promote and/or create wildlife habitat.

U.S. Environmental Protection Agency Environmental Education Program
The USEPA Environmental Education Program provides funding for state agencies, non-profit groups, schools, universities to support environmental education programs and projects. The program grants nearly $200,000 to projects throughout Illinois, Indiana, Michigan, Minnesota, Wisconsin, and Ohio. More information is available at http://www.epa.gov/region5/ened/grants.html.

NiSource Environmental Challenge Fund
The Environmental Challenge Fund is an employee-driven, non-for-profit corporation created by NiSource. The corporation provides funds to stimulate local efforts to preserve, protect, and enhance the environment in the service area of NiSource subsidiaries. Since its inception the Environmental Challenge Fund has provided funding for over 100 projects totaling more than $280,000. More information is available at http://www.nisource.com/enviro/ecf.asp

Indianapolis Power and Light Company (IPALCO) Golden Eagle Environmental Grant
The IPALCO Golden Eagle Grant awards grants of up to $10,000 to projects that seek improve, preserve, and protect the environment and natural resources in the state of Indiana. The award is granted to approximately 10 environmental education or restoration projects each year. Deadline for funding is typically in January. More information is available at http://www.ipalco.com/ABOUTIPALCO/Environment/Golden_Eagle.html

Nina Mason Pulliam Charitable Trust (NMPCT)
The NMPCT awards various dollar amounts to projects that help people in need, protect the environment, and enrich community life. Prioritization is given to projects in the greater Phoenix, AZ and Indianapolis, IN areas, with secondary priority being assigned to projects throughout Arizona and Indiana. The trust awarded nearly $20,000,000 in funds in the year 2000. More information is available at www.nmpct.org

Northern Indiana Community Foundation (NICF)
The NICF is a publicly supported philanthropic foundation that provides assistance to human services, education, revitalization, social, art, and cultural endeavors in Fulton, Miami, and Starke Counties. NICF administers fund that relate to educational development in and around the Flat Lake watershed such as the Ancilla College Endowment Fund, the Oregon-Davis Elementary Academic Enhancement Fund, The Palmer Fund, and the Swanson Family Fund.

Watershed Resources

An important but often overlooked factor in accomplishing goals and completing projects in any watershed is resources within the watershed itself. These resources may be people giving of their time, local schools participating in projects, companies giving materials for project construction, or other donations. This study documents some of these available resources for the Flat Lake Watershed. It is important to note that this list is not all-inclusive, and some groups and donors may have been missed.

Watershed Coordinator

IDEM and the USDA cosponsor three regional watershed conservationist positions. The watershed conservationist is an advocate for watershed level work in the region. Watershed conservationists can help direct actions of groups and stakeholders who are interested in working together to address problems in their watershed. They can help with everything from structuring public meetings to assisting with the compilation of a Watershed Management Plan. Their wealth of knowledge includes ideas about how to work with and respect all stakeholders in order to find the best plan for natural resource conservation within your watershed. Matt Jarvis is the regional watershed conservationist for the northern third of Indiana and has an office in Delphi, Indiana. His contact information is: Matt Jarvis, Regional Watershed Conservationist, Natural Resources Conservation Service, 1523 N. US Highway 421, Suite 2 Delphi, Indiana 46923-9396. He can also be contacted via phone at (765) 564-4480 or email at matt.jarvis@in.usda.gov.

Coordinated Resource Management

The Coordinated Resource Management (CRM) process is an organized approach to the identification of local concerns, evaluation of natural resources, development of alternative actions, assistance from technical specialists, implementation of a selected alternative, evaluation of implementation activities, and involvement of all interested parties who wish to participate in watershed action. The goal of the CRM process is the development of an effective Watershed Management Plan. Further CRM information and its complementary Watershed Action Guide can be downloaded from the USDA/NRCS website at http://www.in.nrcs.gov. The CRM gives guidance on how diverse groups of people can plan to maximize benefits to the greatest number of individuals while enhancing or maintaining the natural resource.

Hoosier Riverwatch

The Hoosier Riverwatch Program was started in 1994 by the State of Indiana to increase public awareness of water quality issues and concerns. Riverwatch is a volunteer stream monitoring program sponsored by the IDNR Division of Soil Conservation in cooperation with Purdue University Agronomy Department. Any citizen interested in water quality may volunteer to take a short training session held from May through October. Water monitoring equipment may be supplied to nonprofit organizations, schools, or government agencies by an equipment grant. Additionally, many SWCD offices (including the Marshall County SWCD) have loaner equipment that can be borrowed. The Bremen Conservation Club, Knox High School, Plymouth Wastewater Treatment Plant Staff, and Potato Creek State Park employees and volunteers currently participate in the program. Because the Flat Lake watershed has not been monitored through the Hoosier Riverwatch Program, more participation should be advocated within the watershed especially since loaner equipment is readily available. More detailed information is available via the Hoosier Riverwatch web site at http://www.state.in.us/dnr/soilcons/riverwatch/.

Indiana Department of Natural Resources

Tom Despot, the Winamac Fish and Wildlife Area Manager, could offer assistance and management recommendations as conservation projects are built in the area. Mr. Despot also manages the Menominee State Wetland. He can be contacted at: 1493 West 500 North, Winamac, Indiana or at (574) 946-4422.

Volunteer Groups

Volunteer groups can be instrumental in planning projects, implementing projects, and monitoring projects once they are installed. Although no streams in the study watershed have been monitored by Hoosier Riverwatch participants, both the Rensselaer Central Middle School and South Newton High School have participated in the program. The two schools are located in Rensselaer and Brook and are close to the study watershed. Involving the people living in the watershed, especially school-age children, is a good way to promote natural resource awareness and a good way to get data collected and projects completed. Oftentimes, data collected by volunteer groups may be the only available data for a watershed. This data is very valuable in helping to establish baseline trends with which to compare future samples.

APPENDIX H:

Clean Lakes Program
Volunteer Monitoring Program Protocol

Indiana Volunteer Lake Monitoring Program

Expanded Monitoring Handbook

April 2001

Background

Indiana has over 1,100 lakes. These lakes offer Hoosiers tremendous recreational opportunities, whether they are used for boating, fishing, swimming, or quiet enjoyment. The lakes also offer habitat for waterfowl and other wildlife. Many lakes are used for drinking water supplies and flood control. In short, Indiana lakes are an integral part of our lives.

Because they are so important, we all must insure that our lakes maintain their beauty and water quality. Unfortunately, keeping close track of the water quality of each lake would be a costly and difficult undertaking.

The time and expense of monitoring the water quality of all our publicly owned lakes has encouraged the Indiana Department of Environmental Management (IDEM) to sponsor the Volunteer Lake Monitoring Program as a part of its Clean Lakes Program. Through this program, you can learn more about your lake and other lakes in Indiana while helping to monitor your lake's water quality. The Volunteer Lake Monitoring Program is modeled closely after the successful citizen monitoring program in Wisconsin. Other states, including Illinois, Minnesota, Ohio, and New York, have similar citizen programs.

Who Runs the Program?

The Volunteer Lake Monitoring Program is a cooperative effort by three groups: the volunteers, IDEM, and Indiana University's School of Public and Environmental Affairs (SPEA).

You, as a representative of the volunteers, are the crucial link in the operation of the Volunteer Lake Monitoring Program. You probably know your lake better than either of the other two groups. You know where the best fishing is, what birds visit the lake, and where the weeds are causing problems. You volunteered because of your concern for the lake. By collecting the data for your lake, you can help IDEM and SPEA understand more about your lake and we can help you increase your understanding how your lake "works."

SPEA will assemble the data that you collect and will enter it into a computer data base. At the end of the sampling season, SPEA will send you a summary of your measurements and a summary of other volunteers' lakes. The statewide summary will allow you to compare the water quality of your lake to others. It will be presented in easy-to-understand graphs and written comments. The annual summaries will allow IDEM to closely monitor water quality changes and identify management needs at the participating lakes.

What is the Lake Monitoring Program All About?

Begun in 1989, the Volunteer Lake Monitoring Program now includes over 100 Indiana lakes. More lakes are added to the program each year. Citizen volunteers like you donate about one hour of their time every two weeks to collect the necessary data. Your efforts provide a number of benefits not only for IDEM, but also for you. Here's how:

1) As a volunteer you will learn more about lake science (*limnology*).

2) You will learn not only about taking Secchi disk transparency readings, and possibly collecting total phosphorus and chlorophyll *a* samples, but also about other water quality tests. However, the data you collect will be valuable *only* if you take the readings carefully and according to set procedures.

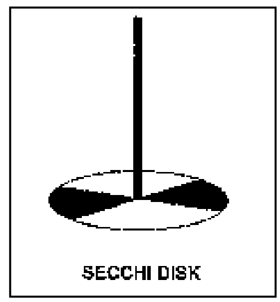
3) By analyzing your samples and summarizing the information that you collect, we will be able to assess the changes in water quality at your lake. This is particularly important for lakes where little information has been gathered in the past.

4) After we have summarized the data, we will be able to compare the water quality of lakes around the state. This information will allow us to better understand our Indiana lakes.

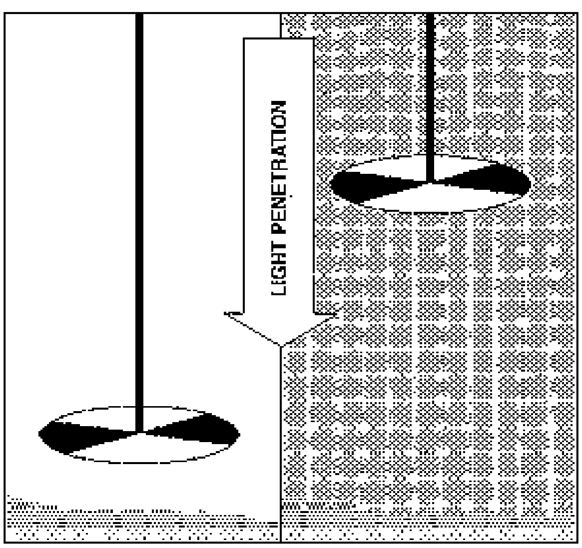
5) Once we have several seasons' worth of data for a particular lake, we can begin to assess the long-term trends in the lake's water quality. Five years' worth of Secchi disk data will provide an indication if the lake is being degraded, is improving, or staying the same. One season of sampling is not enough to establish long-term trends.

6) This assessment can identify which lakes should receive more intensive management and/or monitoring.

What Do These Measurements Say About Water Quality?



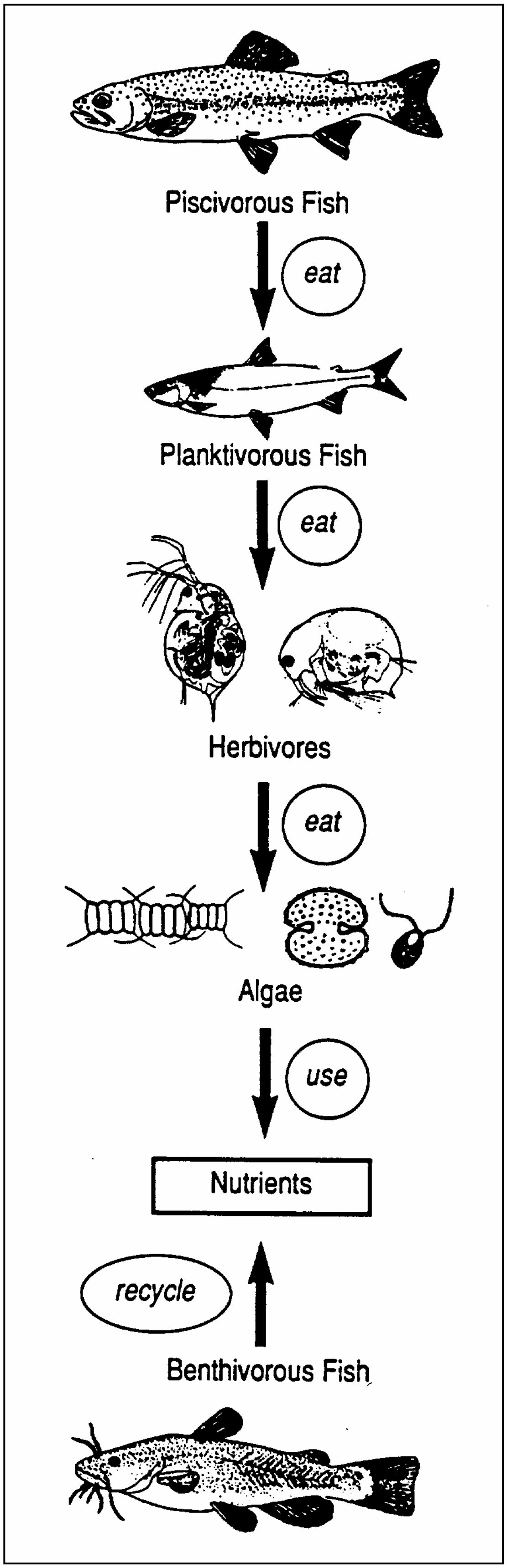
The Secchi disk that you received as part of your volunteer package is used to measure water clarity or transparency. It is one of the oldest and most basic tools used by limnologists around the world. The Secchi disk is an eight-inch diameter disk painted black and white in alternating quarters. It is attached to a fiberglass measuring tape marked in **tenths** of feet. Look at the tape carefully to see that the markings are NOT in inches! (Earlier Secchi disks used in this program were attached to nylon cords marked in one-foot intervals.)



Clear Lake **Turbid Lake**

Secchi disk measurements of water clarity can tell a great deal about the water quality of lakes. Water clarity is affected by two factors: algae and suspended sediments. Sediments may be introduced into the water by either runoff from the land or from sediments already on the bottom of the lake. Many activities may introduce sediments to lakes via runoff: examples include erosion from construction sites, agricultural lands, and riverbanks. Bottom-feeding fish such as carp may resuspend bottom sediments, or in shallow lakes, sediments may be suspended by motor boats or strong winds.

Algae are a natural component of the food chain in lakes. They are food for microscopic animals (zooplankton), which are, in turn eaten by fish. We



AQUATIC FOOD CHAIN

are usually only aware of algae when they become overly abundant. Algae are microscopic plants, which grow like plants do; they need sufficient light and nutrients to survive. When there are too many nutrients in the lake, the algae multiply enough to cause a decrease in water clarity. The decrease will be seen when you take the Secchi disk transparency reading.

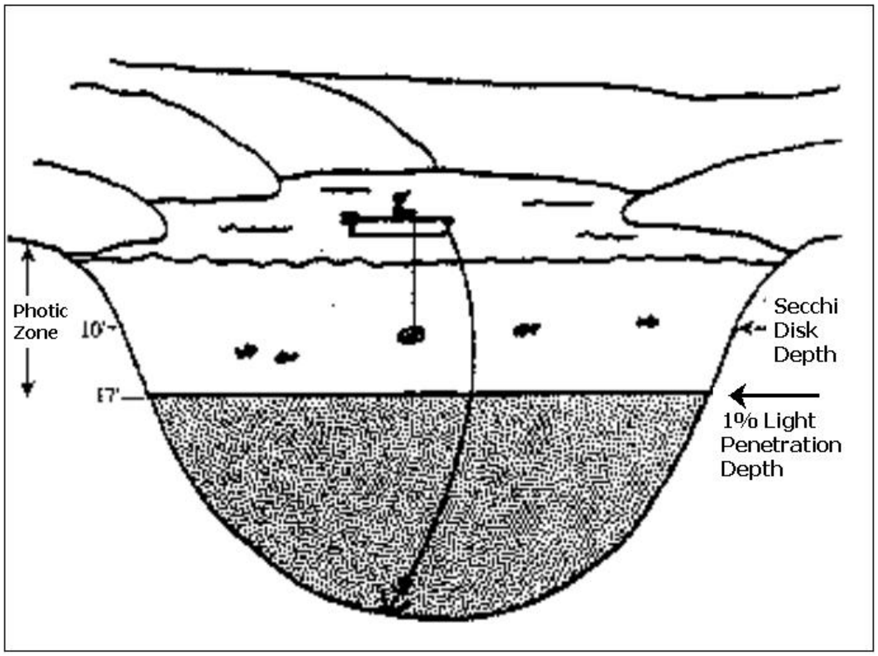
Of course, algae and suspended sediments are not the only factors that will affect your Secchi disk reading. Other factors that may affect your reading will be the color of the water, wind, waves, sunlight, and even your eyesight. Some lakes have a natural brown color. The color is not an indication of pollution or suspended sediments, but of tannic acids produced by decaying plants. Light does not penetrate as deeply in these darkened waters, so these brown lakes will generally have fewer algae that clear lakes.

Secchi disk transparency readings can also give a rough estimate of the depth to which oxygen can support fish and other aquatic life. Generally the Secchi disk depth times 1.7 is the depth to which light can penetrate. For example, if your Secchi disk reading was 10 feet, then light can penetrate to a depth of approximately 17 feet. If light can penetrate this far, then there is enough light to support an algal population. The *photic zone* is defined as the vertical depth of a lake that has enough light to support plant growth. Algae use the light to produce energy through a process called photosynthesis. Oxygen is released by the algae as a by-product of photosynthesis. The oxygen is in turn used by the fish that live in the deeper waters of the lake.

When to Take a Reading

The weather is another factor that will affect your ability to read the Secchi disk. Try to take your readings on days when the lake is calm and the sky is clear. The angle of the sun will affect your ability to see the disk, so take readings between 10 a.m. and 4 p.m. Winds creating high waves will adversely affect your ability to read the disk.

The goal of our program is to have transparency monitored *once every two weeks*. Try to make the sampling a regular part of your activities. If you are



able to take a reading every week, great! Total phosphorus and chlorophyll samples should be taken *once per month during the summer months*.

Water transparency following intense rainstorms or heavy boating activity is often lower than other times. This is to be expected. For example, many of our volunteers report worse transparencies on Saturdays, Sundays, and Mondays than on other days of the week. We encourage you to vary the day of the week that you make your Secchi disk transparency measurement. This will help cover the entire range of conditions common on your lake. We especially encourage you to make a measurement after a heavy storm runoff. Use the comment section of the data card to indicate if there was a recent heavy rain or other event that could affect your reading. We analyze your data according to day of the week measured and according to any special conditions you note.

If you are unable to take your scheduled reading, do not worry about it. Take it as soon as you are able. If for some reason you are unable to continue to sample during the sampling season, please do not hesitate to contact SPEA. In this event, it would be extremely helpful to the program if you could provide us with the name of another lake resident interested in volunteering to take the readings.

Other Information to Collect

After you make each Secchi disk transparency measurement, we'd like you to also record the (a) water color, (b) recreation potential of the lake, and (c) physical appearance of the water.

Water Color
A lake's water color can give us insight into whether transparency is affected by algae (green color) or suspended sediments (brownish color) or even what kind of algae (green, blue-green, yellow-brown…). Water color can be determined by lowering your Secchi disk into the water to about one-half the Secchi disk depth. Look at the water color against the white background of the disk. Compare the water color to one of the 19 colors represented on your color chart. Record this color number on the data card.

Recreational Potential
We would also like to get your opinion of your lake's "recreational potential" and "physical appearance" at the time you take your Secchi disk measurement. This helps us relate Secchi disk transparency to the use and appearance of your lake. Remember, this should be <u>your</u>

opinion on the condition of your lake. For the “recreational potential”, if everything looks great, circle “beautiful” on the date card. If the water looks really scummy and you personally wouldn’t want to swim in the lake, circle “no swimming”. If swimming isn’t allowed in your lake, we’d still like you to consider “recreational potential” as if swimming was allowed.

Similarly, circle the condition that you feel best represents the lake’s physical appearance.

Expanded Monitoring

Total Phosphorus: A Measure of Nutrient Enrichment

Phosphorus is often the key nutrient in determining the amount of phytoplankton (algae) in a lake. In comparison to other nutrients, phosphorus is usually the first element to limit biological productivity. Most of the phosphorus in lakes occurs in two forms: dissolved phosphorus and particulate phosphorus. The determination of dissolved phosphorus is a measure of the inorganic form of phosphorus *available* to algae. The determination of total phosphorus is a measure of all forms of phosphorus *potentially available* to algae.

Phosphorus enters a lake from rainfall, incoming streams, overland runoff, groundwater, and direct discharges. Phosphorus is also contributed to lakes from decomposition of organic matter and the erosion of soils. Phosphorus in the lake sediments may be released into the water under anoxic (no oxygen) conditions. Phosphorus is contributed to a lake by human activity in the watershed, direct discharge of wastes, runoff from agriculture, or poorly maintained septic systems.

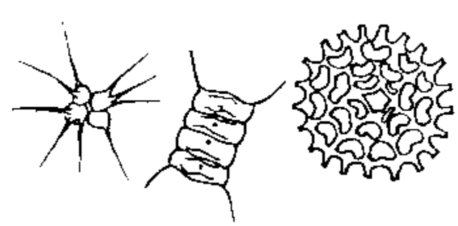
Phosphorus is often the *limiting nutrient* in freshwater systems because it is unavailable from the atmosphere and rapidly recycled and converted to forms unavailable to algae. As the limiting nutrient, any addition of phosphorus can stimulate more algae growth.

To sample for total phosphorus, a water sample is collected every month throughout the growing season in a specially cleaned bottle and then analyzed in the laboratory.

Chlorophyll *a*: A Measure of Lake Productivity

Chlorophyll *a* is the photosynthetic pigment that causes the green color in algae and plants. The concentration of chlorophyll *a* present in the water is directly related to the amount of algae living in the water. Excessive concentrations of algae give lakes an undesirable “pea soup” appearance.

Some representative algae



The water quality characteristics of a lake largely determine which types of algae will be present. Lakes with high nutrient enrichment will tend to support larger numbers of algae than lakes with low nutrient enrichment. Other factors such as water temperature, depth, pH, and alkalinity also influence the species and numbers of algae found in a lake.

To measure chlorophyll *a* concentration, you will take an integrated water sample from the lake every month throughout the growing season. The water sample is "integrated" because it represents a sample of the water column from the surface to a depth of 6 feet. The integrated sample allows us to examine the water column where phytoplankton live (i.e. the part of the water column with enough sunlight for photosynthesis to occur). Then, a certain volume of this integrated sample is filtered. All of the algae (and other suspended particles) in the water will collect on the filter paper, which is then analyzed in the laboratory for chlorophyll *a* concentration.

Sampling Checklist

Before going out on the lake to make your Secchi disk reading and/or collect your water samples, make sure that you have everything you need and the weather conditions are okay for sampling!! Please confirm everything on this checklist and, if you are collecting water samples, make certain that you have all the equipment pictured at the top of the next page as well.

Weather:

- ❑ Sunny/partly sunny/partly cloudy
- ❑ Winds calm to breezy (NO WHITECAPS!!)

Date and time of day:

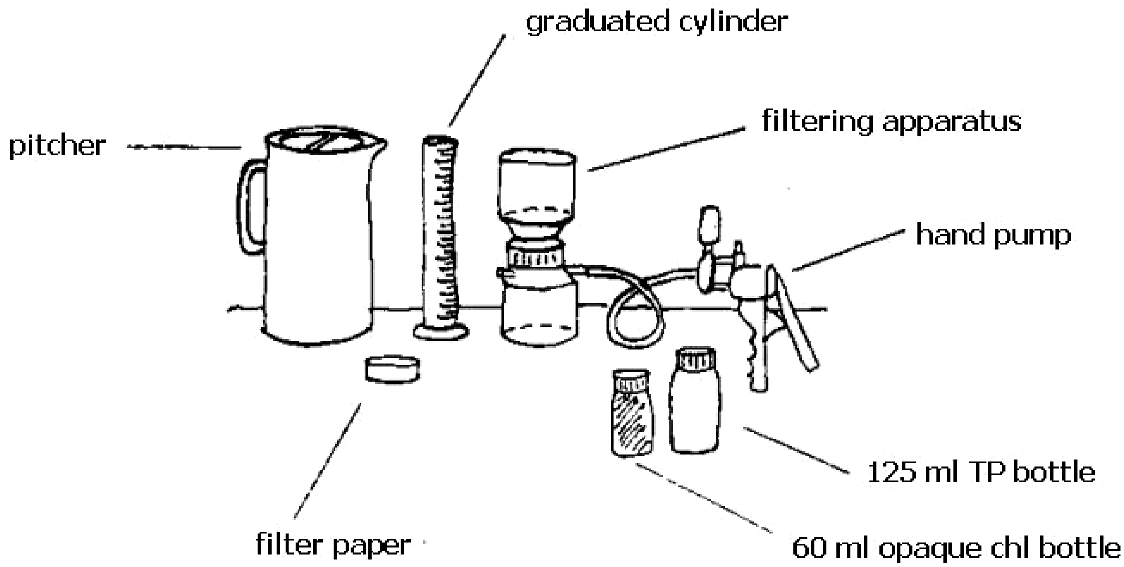
- ❑ Between 10 a.m. and 4 p.m.

Do you have:

- ❑ Secchi disk?
- ❑ Boat anchor?
- ❑ Color chart?
- ❑ Sampling instructions?
- ❑ Data forms?
- ❑ Something to write with?

Equipment for Chlorophyll *a* and Total Phosphorus Sample Collection:

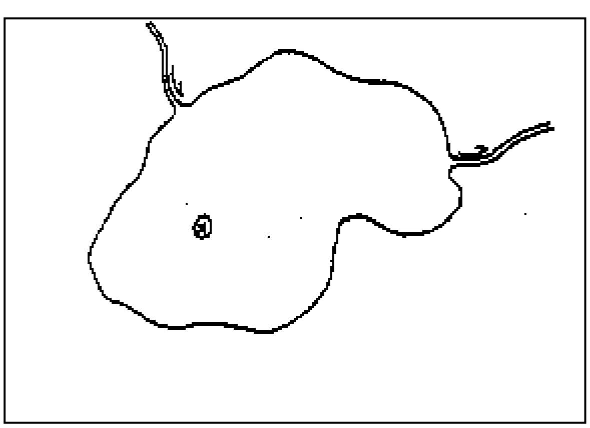
- ❑ Filtering apparatus ~ cap, upper chamber, filter support plate & receiver
- ❑ Pitcher
- ❑ 250 milliliter graduated cylinder
- ❑ 4.7 cm filter paper (in plastic case) with Tweezers
- ❑ Hand-operated pump with clear tubing
- ❑ PVC pipe (for sample collection)
- ❑ Sample bottles ~ 1--6 ml opaque (chlorophyll *a*) & 1-- 125 ml clear (total phosphorus)
- ❑ Styrofoam mailer



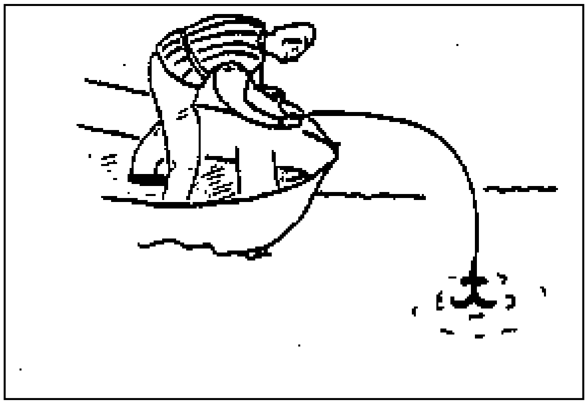
Chlorophyll a sampling gear

HOW TO TAKE A SECCHI DISK READING

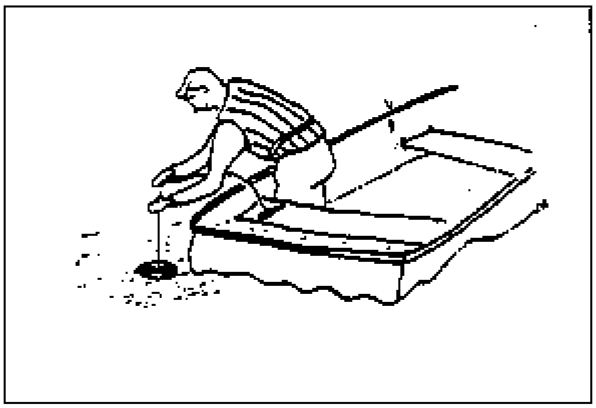
When taking the Secchi disk readings and water samples be sure to follow the instructions. Remember, do not feel guilty about missing a scheduled reading, do it when you have the time. **NEVER** make up data. We would rather have no data than invalid data. Most of all enjoy your time in the boat and on the lake.



1. Use the map of your lake and its marked sampling site and proceed to the site. Always take your Secchi disk measurements from this same general location.



2. Anchor the boat at the sampling site. Remove your sunglasses.

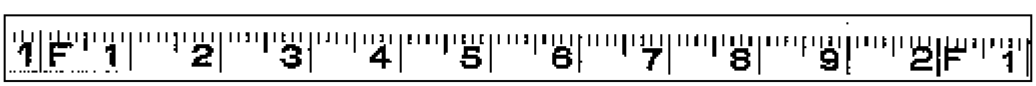


3. Lean over the **shady** side of the boat and slowly lower the Secchi disk into the water until it can no longer be seen.

4. Note the depth that the Secchi disk disappears from site. **Remember:** the marks on the measuring tape are in tenths (1/10) of a foot <u>NOT</u> inches.

5. Lower the disk a few more feet into the water. Slowly raise the disk. When the disk reappears, note this depth. Record the mean depth between where the disk disappeared and reappeared as the Secchi disk transparency depth.

Measuring Tape Markings



6. *Tape Measure:* Carefully read off the depth to the nearest **tenth** of a foot.

7. Record the measurement on the date card and/or data log (see pages 9 & 10 for examples).

Secchi Disk/Expanded Data Log

Volunteer Name: ____

Lake Name: _______________ County: ____________________

Date/Time	*Secchi Depth (feet)*	*Water Color (number)*	*Recreation Potential (number)*	*Physical Appearance (number)*	*Amount Filtered (mls)*

Your Name: ____________________

Lake Name: ____________________

County: ____________________

Sample Date: __________ Sample Time: __________

SECCHI DISK TRANSPARENCY: (Record to nearest 1/10 foot)

Depth: __________ Did it hit bottom? *(circle one)* NO YES

WATER COLOR: *(select one from color chart)* __________

RECREATION POTENTIAL:	PHYSICAL APPEARANCE:
1. Beautiful	1. Crystal Clear
2. Minor Aesthetic Problems	2. Some Algae
3. Swimming Impaired	3. Definite Algae
4. No Swimming	4. High Algae
5. No Recreation	5. Severe Algae

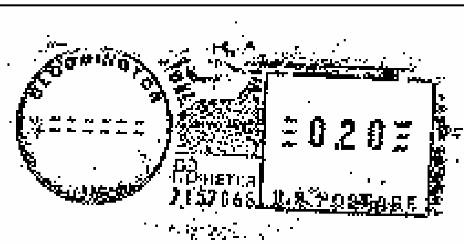
(Circle the condition that most applies in each category.)

OTHER COMMENTS:

Sample Data Card

8. To determine the water color, lower the Secchi disk into the water to about ½ the Secchi disk depth and observe the water color against the white background. Record your observation.

9. Consider the water quality condition of the lake and circle one answer for "Recreation Potential" and one answer for "Physical Appearance."



No postage stamp necessary. Postage has been prepaid by:

Bill Jones
Clean Lakes Program
SPEA 347
Indiana University
Bloomington, IN 47405

10. If you are taking water samples, proceed with the expanded program directions. If you are monitoring more than one site or lake, proceed to the next location and repeat steps 1-9.

11. Once on shore, check to see that the data card is completely filled out. Mail it as soon as you can.

- OR -

12. Log onto the Indiana Clean Lakes Program web site and enter your data **on line!** See page 11.

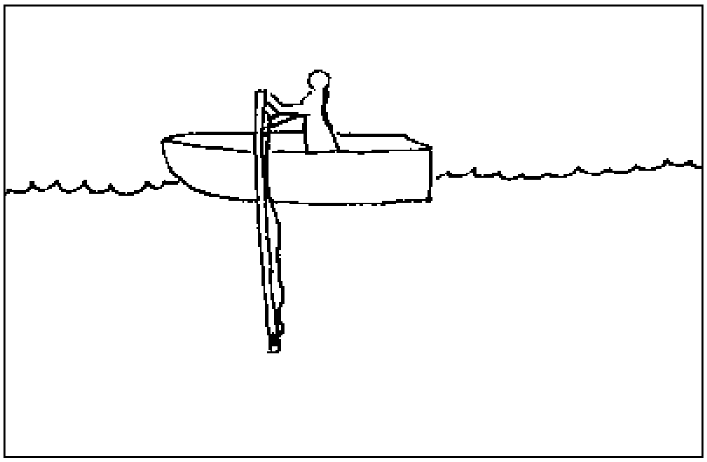
After taking your Secchi disk reading, be sure to:

- ❑ Store your Secchi disk, color chart and equipment in a dry place.
- ❑ Go over the data form and make sure it's complete.
- ❑ Carefully copy the data onto the SPEA postcard. Make sure all the blanks are filled. Mail the postcard to SPEA in Bloomington.
    - o **–OR-**
- ❑ Log onto the Indiana Clean Lakes Program web site at: http://www.spea.indiana.edu/clp/ and enter your data onto our electronic data entry form.

Instructions for Entering Data Using the Clean Lakes Program Web Page

1. Log onto the Internet using your web browser.
2. Type in our web site address: http://www.spea.indiana.edu/clp/ (save this address in your 'Favorites')
3. From the CLP home page, click on the link that reads **Volunteer Monitoring**
4. Click on the link that reads **Data Entry Form**
5. Now just enter information requested in all the blanks. Use the **TAB** key to advance to the next box. Do **NOT** use the 'Return' or 'Enter' key. We have drop-down menus from which you can select your county, lake name, recreational potential and physical appearance.
6. **IMPORTANT!** Check your data entries very carefully. Once you are satisfied that everything is correct, click on the button reading **Submit Form**
7. This transmits your data to us in Bloomington and automatically enters it into our volunteer monitoring database. This saves us from having to re-enter your data from the data cards.
8. If you wish to delete all your data from the form and not submit it, click on the button that reads: **Reset Form** will bring up another blank form for you to use.

HOW TO COLLECT CHLOROPHYLL *a* AND TOTAL PHOSPHORUS SAMPLES



1. Rinse the pitcher with lake water twice by simply dipping the pitcher into the lake.

2. Rinse the pipe by slowly lowering the end of the pipe into the water so that the 6 foot mark on the pipe is 2 feet below the lake surface. The ball valve needs to be open during this step.

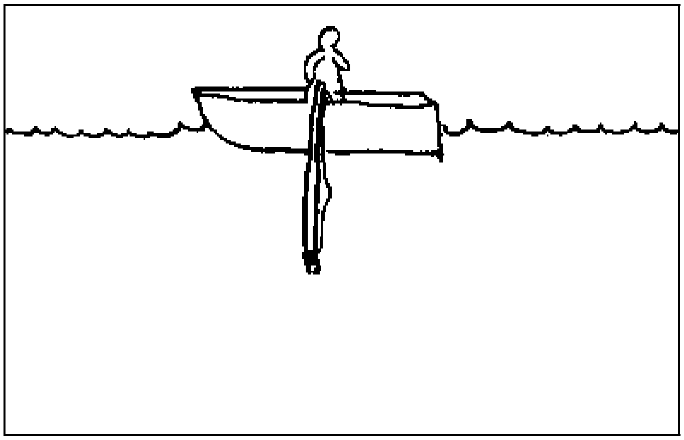
3. Slowly pull the sampling pipe back up and into the boat. Repeat.

**Don't have an integrated pipe sampler?? Contact us or see Appendix A (page 26) for instructions on making one.

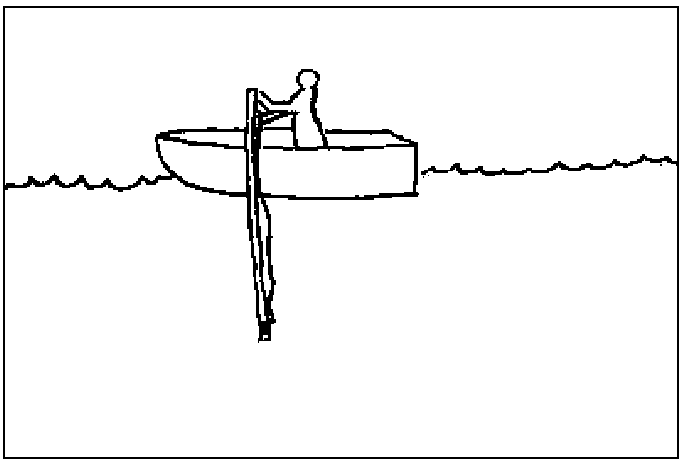
TABLE 1

Secchi Depth	Vol of Water to Filter
< 1 ft	50 mls
1 – 1.5 ft	100 mls
>1.5 – 2.5 ft	200 mls
>2.5 – 3.5 ft	300 mls
>3.5 – 6 ft	500 mls
>5 ft – 9 ft	800 mls
>9 ft – 16 ft	1000 mls
>16 ft	1500 mls
">" means	"greater than"

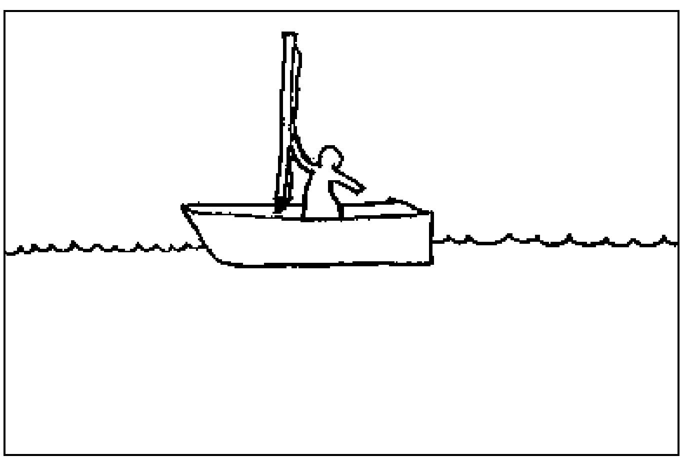
4. Take a Secchi disk reading if you have not done so already. Refer to Table 1 and determine the amount of water required for chlorophyll-a filtration. For example, if your Secchi depth was 10 feet you would need to filter <u>at least</u> 1000 ml of water for chlorophyll *a*, plus collect 125 ml for your total phosphorus bottle. Each integrated sample delivers about 1000 ml so you would need to collect 2 samples of lake water in the pitcher before filtering or filling any bottles.



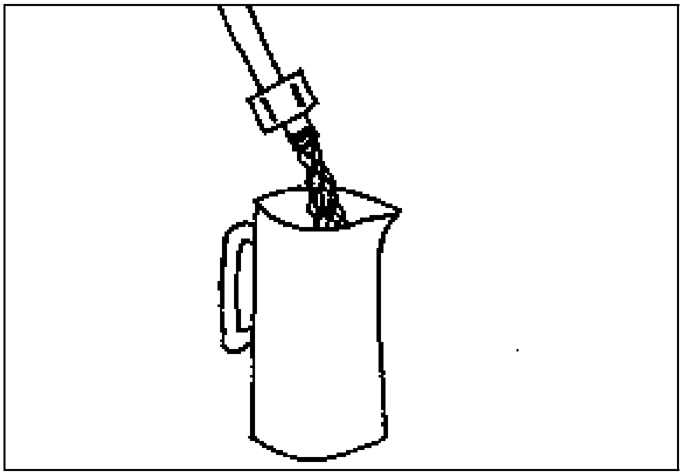
5. Your goal is to filter enough water to make the filter green (like #1 on your color chart). This will give us enough pigment to analyze in the lab. Table 1 above provides a starting point – **you will likely have to filter more than what the chart indicates**. Be certain to keep track of all the water you filter.



6. To take the integrated water sample, slowly and evenly lower the end of the pipe into the water until the 6-foot mark on the pipe is even with the surface of the water.



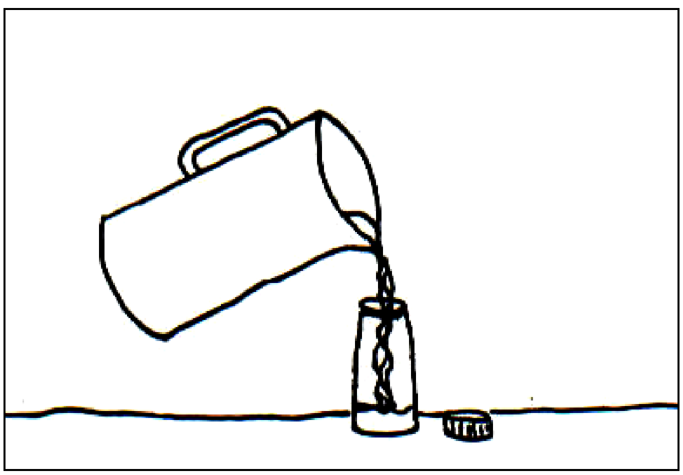
7. Pull the rope on the pipe to close off the valve at the bottom of the sampler. Hold the open end out of the water, keeping the pipe perpendicular to the water's surface



8. Hold the end of the pipe over the pitcher. In order to prevent contamination, be careful not to let the coupling on the end of the pipe touch anything (your hands, the pitcher, the water that you will empty into the pitcher).

9. Slowly release the valve in the pipe.

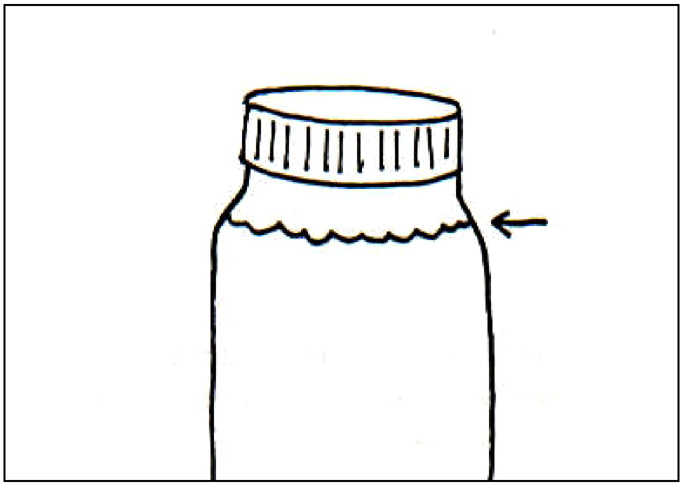
10. Allow the entire sample to drain from the pipe before continuing.



11. Once the pipe is empty, check to see if you need to take another sample (see step 4). If you do, repeat the procedure again in steps (4) to (10) until you have the correct amount of water.

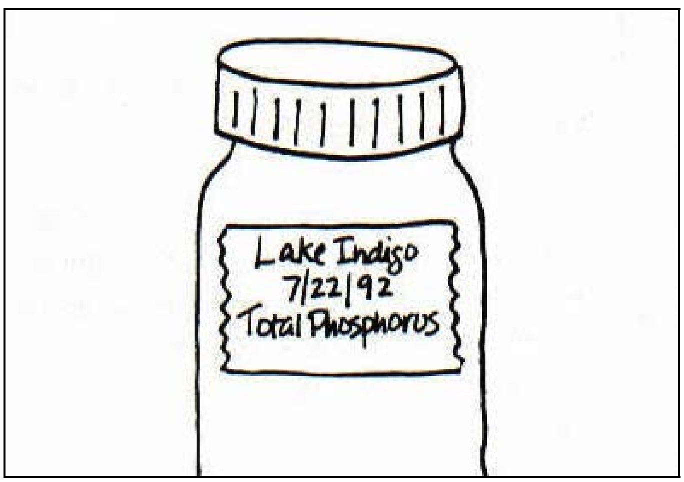
12. Swirl the pitcher to thoroughly mix the water.

13. Carefully pour the water from the pitcher into the Total Phosphorus bottle (clear bottle). (The bottle has been specially washed so do not rinse it out prior to filling). Be careful not to let the mouth of the Total Phosphorus bottle touch the pitcher or anything else.



14. Fill the bottle up to the bottom of the neck in order to allow for expansion of the water when you freeze it.

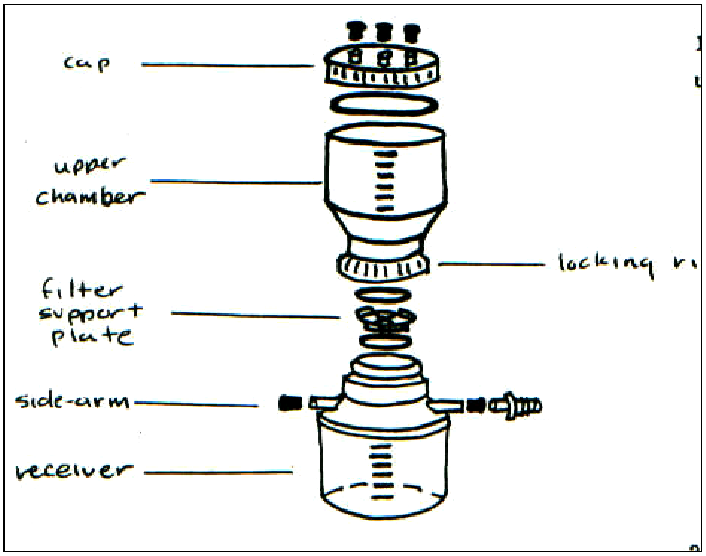
15. Securely screw the cap onto the bottle.



16. Label the Total Phosphorus bottle on the tape with the "Sharpie" pen. Be sure to include lake name and the date sampled.

HOW TO FILTER CHLOROPHYLL *a*

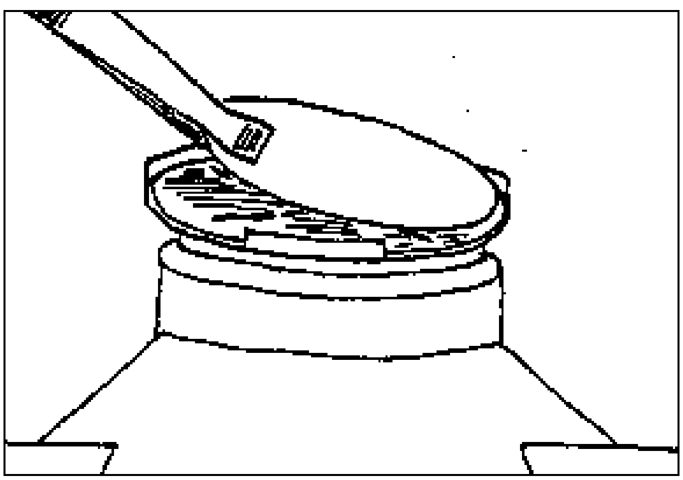
***NOTE: The chlorophyll* a *filtration procedure should be conducted out of direct sunlight. Exposure to direct sunlight promotes the degradation of chlorophyll* a. *Try to keep the filtration apparatus out of direct sunlight whenever possible*.**



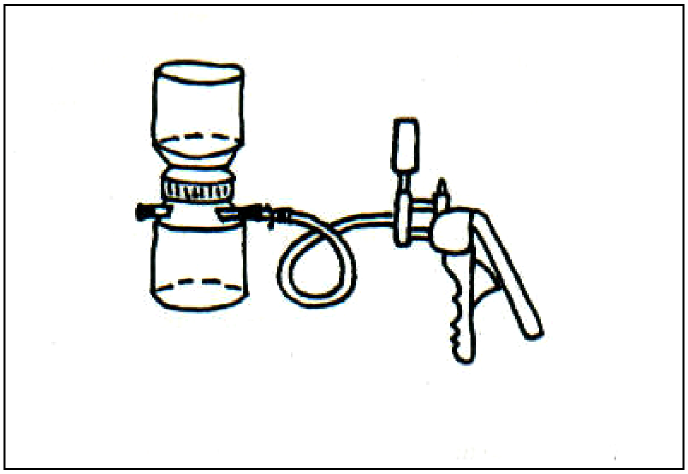
1. Separate the chlorophyll-a filtration apparatus by unscrewing the upper chamber from the receiver.

2. Pick up one of the 4.7 cm filters with tweezers and place the filter on the filter support plate on top of the receiver.

3. Carefully place the upper chamber back on top of the filter support and receiving flask.



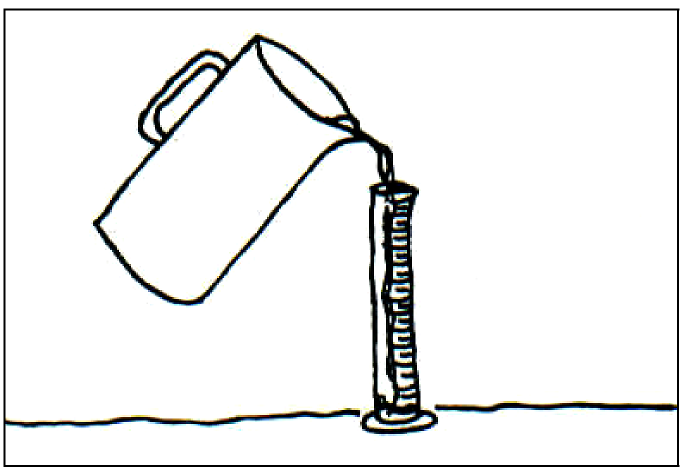
4. While holding the upper chamber piece stationary, tighten the locking ring until the upper chamber is firmly seated on the receiver. (Do not over tighten the locking ring or allow the upper chamber to rotate while tightening because this may tear the filter paper.)



5. Connect the tubing from the hand pump to one of the two side-arms on the side of the receiver. (The other side-arm must have a black cap on it in order for a vacuum to form).

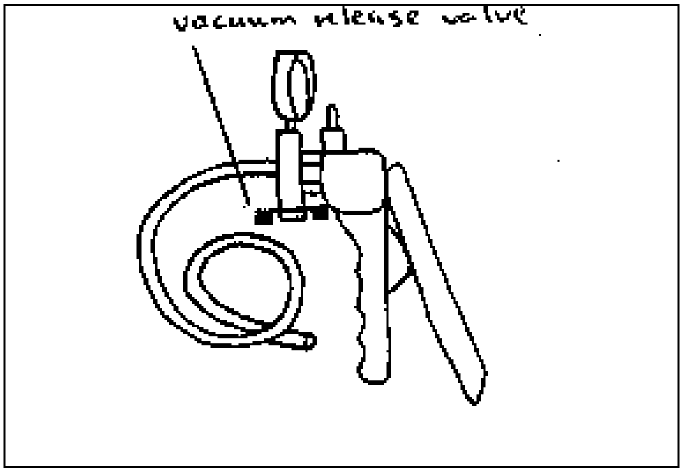
6. Using your previously measured Secchi depth, refer again to Table 1 to determine the amount of water to filter. [example: if the Secchi depth was 7 feet, then you would measure out 500 ml (2 x 250 ml contained in graduated cylinder) of water from the integrated sample in the pitcher].

** **Remember** – Table 1 gives you the amount of water to start with. If the filter is not green, then add more water, 100 ml at a time until the filter is a nice, green color. Be careful! Too much water will clog the filter and then you will have to start over.



7. Pour water from graduated cylinder into upper chamber. Squeeze the vacuum pump until the pressure on the dial reaches 15 on the outer scale of the dial. Do not exceed 15 psi or the pressure may damage the filter. Over time the pressure will decrease so you will need to periodically squeeze the hand pump to maintain pressure.

8. Note that the upper chamber and receiver only hold 500 ml each. If you are required to filter more than 500 ml, you must disassemble the filtering apparatus and empty out the receiver according to the following procedure outlined in steps (9) to (16). If you do not need to filter more than 500 ml, proceed to step (17).



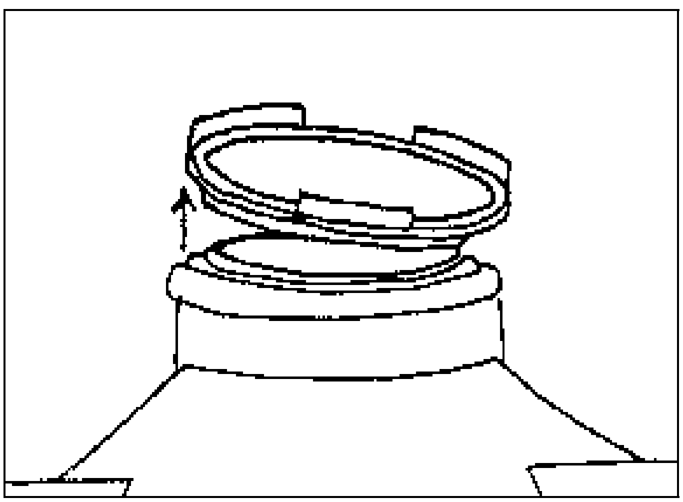
9. Has all of the sample water passed through the filter? Squeeze the vacuum pump several extra times to remove as much water as possible from the filter.

10. Release the pressure of the vacuum pump by rotating the vacuum release valve to the right.

11. Hold the upper chamber stationary while unscrewing the locking ring.

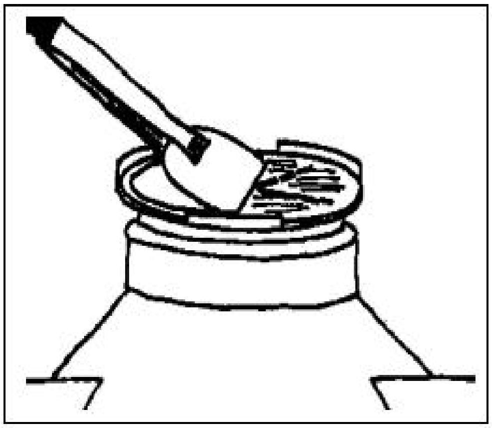
12. Carefully remove the upper chamber by lifting directly upwards. The filter support plate should now be exposed on the top of the receiver.

13. Grasp the filter support plate by its edges and lift directly upwards. The filter support plate should snap out of the receiver.



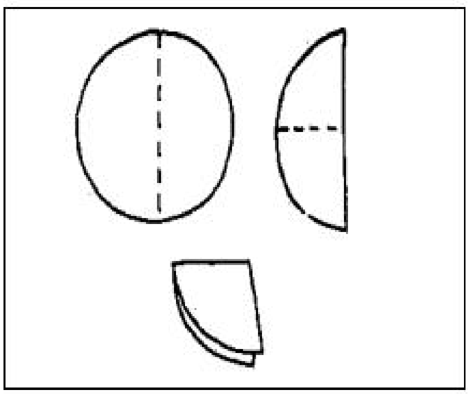
14. Carefully empty the water in the receiver into the lake. Remember, we are only interested in what is left on the filter paper, not the filtered water. Be sure not to dump water down the plastic tubing that connects the hand pump to the receiver.

15. After emptying the flask, return the filter support plate with the "green" filter containing algae and particulate matter to the receiver by snapping it back on the top of the receiver. (Be sure not to touch the filter).

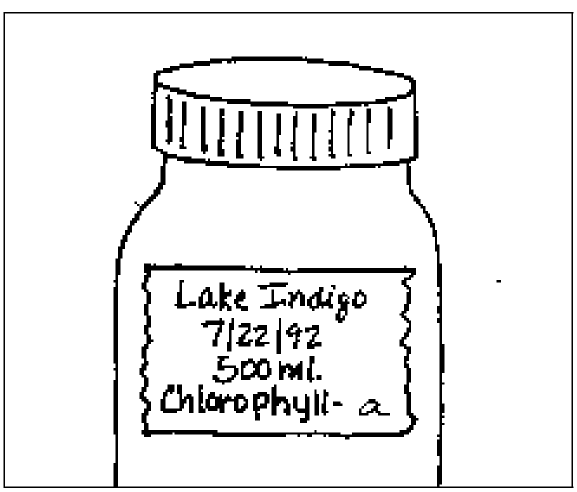


16. Reconnect the upper chamber as instructed in step (3) and (4) and proceed filtering the remainder of your sample as indicated by the Secchi depth. (Remember you already filtered 500 mls!)

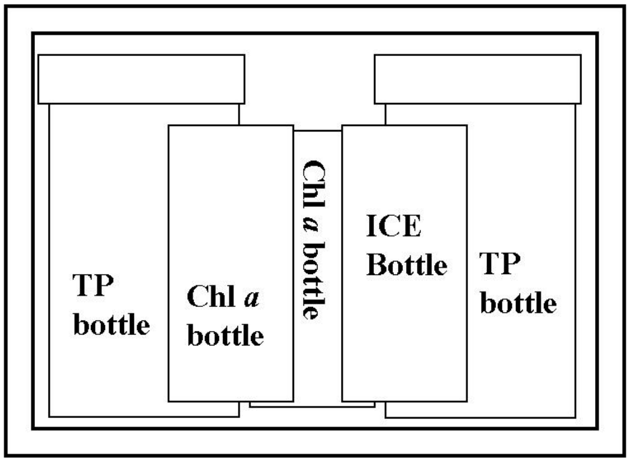
17. When you are done filtering the recommended amount of lake water, remove the upper chamber as directed in steps (9) through (12).



18. Using the tweezers, carefully pick up the edge of the filter and fold it in half on top of the filter support plate. (All of the algae and other particles are trapped on top of the filter paper, therefore this "green," top side of the filter must always be on the inside of the fold). Make sure that all of your folds are crisp to ensure that the "green" stays inside and is not lost during transfer to or from the bottle.



19. Place the folded filter paper into the opaque amber chlorophyll sample bottle and label the bottle with a "Sharpie." Include the lake name, date and number of milliliters of sample water filtered. Also record this information on your data log sheet.



20. Place both the chlorophyll and the total phosphorus bottles in the styrofoam mailer and put the mailer in the freezer. Samples must be frozen immediately. If the styrofoam mailer will not fit in your freezer, put the loose samples in freezer but be careful not to lose them!

21. Once you have collected two total phosphorus samples and two chlorophyll *a* samples, mail frozen samples.

22. Pack styrofoam cooler as shown to the left. Seal with tape. Place sealed cooler in mailing bag and affix the pre-printed and posted mailing label. Take package to the Post Office close to the time when packages go out so your sample doesn't sit in a warm room or truck for too long.

Clean-up and Storage of Equipment

1. Rinse all of the sampling equipment [pitcher, hose, filter apparatus (be sure to remove hand pump), graduated cylinder, tweezers] with tap water. IN ORDER TO PREVENT CONTAMINATION, DO NOT USE ANY TYPE OF DETERGENT ON THE EQUIPMENT.

2. Let the equipment air dry.

3. Once equipment is dry reassemble the filter apparatus and reconnect the hose ends in order to prevent any contamination from entering the hose.

4. Return the equipment to the storage bucket. Place the bucket in a safe, dry place until next month.

TEMPERATURE & DISSOLVED OXYGEN MONITORING

Beginning in 1999, all volunteers will be able to borrow an electronic instrument that measures water temperature and dissolved oxygen. The instrument includes a submersible probe and a digital readout with easy-to-use controls. Generally, temperature and dissolved oxygen are measured from just below the water surface down to just off the bottom in one-meter increments. The instrument's cable is marked in one-meter increments to facilitate this.

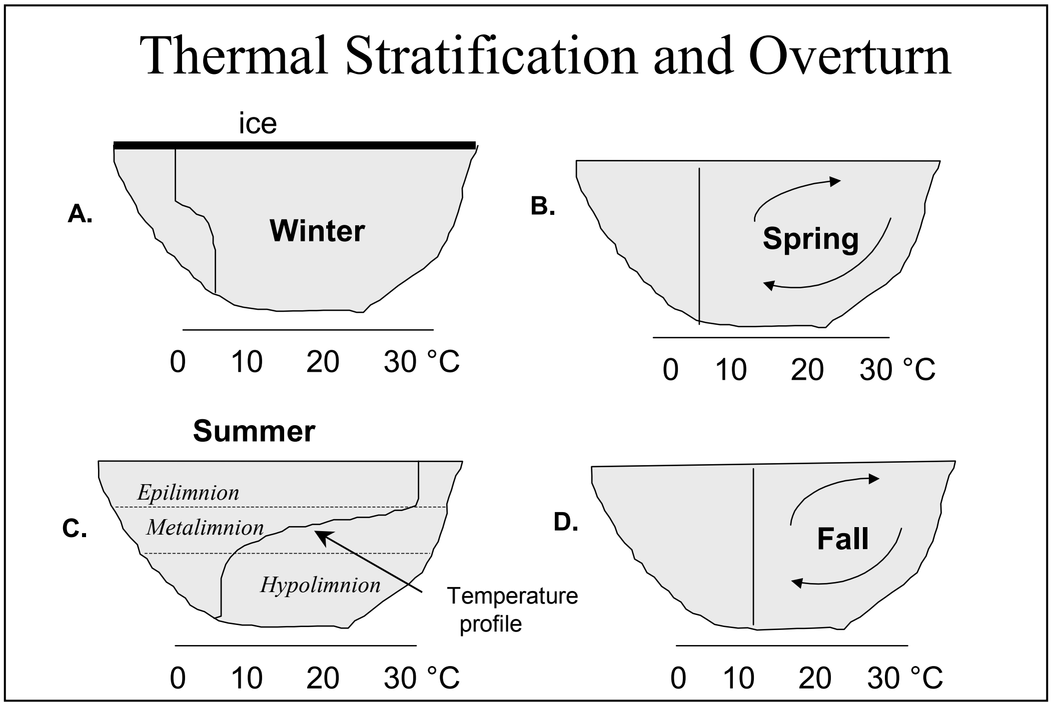
Temperature and oxygen profiles of lakes can yield very useful information. For example, the temperature profile indicates: a) if the lake is thermally stratified or unstratified (mixing), b) if stratified, the depth of the epilimnion or hypolimnion, c) the position of the metalimnion (fish often hang out at the top of the metalimnion). The dissolved oxygen profile indicates: a) how much of the lake has sufficient oxygen for fish, b) if the hypolimnion has no oxygen, and c) the potential for nutrient release from bottom sediments (this may occur when the hypolimnion is anoxic).

How Lakes Change With the Seasons

As the spring sun rises higher in the sky and air temperatures become warmer, the surface water of lakes warms as well. This warm water is less dense than the cold, heavy water on the lake bottom. The wind does not have enough energy to overcome these density differences and completely mix the lake, so only the surface water (***epilimnion***) is mixed during the summer in deeper lakes (5-7 meters deep). Thus, the bottom waters in the ***hypolimnion*** are isolated from the air at the surface. The narrow zone of water separating the epilimnion and hypolimnion is called the ***metalimnion***. This temperature and density layering in lakes is called ***thermal stratification***.

Dissolved oxygen in the hypolimnion is consumed by bacteria decomposing organic matter (dead algae, leaves, etc.) on the sediments. This lost oxygen is not replaced during stratification because the hypolimnion is not in contact with the atmosphere (the major source of oxygen to lake water) and photosynthesis (which produces oxygen as a by-product) cannot take place in the dark waters. As a result, oxygen concentrations are often lower in the hypolimnion of stratified lakes - the lower the hypolimnetic oxygen concentration, the more productive (***eutrophic***) the lake is. Low oxygen in the hypolimnion can prevent the use of the area by fish and aquatic macroinvertebrates. Fish need at least 3-5 ppm (mg/L) of dissolved oxygen to survive. If no oxygen is present in the hypolimnion, phosphorus can separate from compounds in the sediments and re-dissolve in the water. Ammonia can also accumulate in the hypolimnion as a result of bacterial decomposition of organic material in the sediments.

In the fall, cooler air temperatures gradually cool the lake's surface water until it is nearly the same temperature as the bottom water. Because all the water now has similar density, a light wind can cause the lake to mix completely down to the bottom. This is called ***fall overturn***. Nutrients released into the hypolimnion from the sediments during summer stratification can now mix with the surface water and this may cause a fall algae bloom in some lakes.



Measuring Temperature and Dissolved Oxygen

Getting information about the characteristics and magnitude of the seasonal cycles described above provides limnologists with important information needed to diagnose the lake condition. We have placed five YSI Model 95 temperature and dissolved oxygen meters in Soil and Water Conservations District (SWCD) offices around Indiana for participants in the Volunteer Lake Monitoring Program to use on their lakes. Because both temperature and dissolved oxygen change with the seasons, volunteers are encouraged to take several of these profile measurements on their lake – ideally once per month.

Each meter is expensive ($1,000) and fragile. Please use with care. You will be trained by SWCD or SPEA staff before you are allowed to borrow a meter. If you are uncertain about features of the meters or how to use them after you've been trained, please call for refresher instructions.

Here is the procedure for borrowing the meters:

1. Call the nearest SWCD office or SPEA to reserve the meter for a specific date (addresses and telephone numbers are given following). Arrange a time when you can pick up the meters.

2. The local SWCD or SPEA staff will train you on proper use and care of the meter during your first visit. This training will take approximately 30 minutes.

3. You will have to sign for the meter on a standard form.

4. Take the meter home and make the measurements on your lake (measurement instructions are on a separate sheet and enclosed in the meter case).

5. Return the meter to the SWCD office or SPEA the same or next day. We can only allow you 1-2 days at a time with the meter so that it is available for others to use.

Where to Sign Out a Meter

Kosciusko County SWCD
217 E. Bell Drive
Warsaw, IN 46582
(219) 267-7445 ext 3
Contact: Julie Harrold

Noble County SWCD
100 East Park Drive
Albion, IN 46701-9797
(219) 636-7682 ext 3
Contact: Kent Tracey

LaGrange County SWCD
910 South Detroit Street
LaGrange, IN 46761-2235
(219) 463-3166 ext 3
Contact: Mark Diehm

Steuben County SWCD
Peachtree Plaza 200
1220 N. 200W
Angola, IN 46703-8901
(219) 665-3211 ext 3
Contact: Mark Diehm

School of Public and Environmental Affairs
Indiana University
1315 East 10th Street
Bloomington, IN 47405-1701
(812) 855-4556
Contact: Bill Jones

INSTRUCTIONS FOR TAKING TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS

Temperature and oxygen profiles should generally be made from the deepest water depths in your lake. You will have to anchor your boat – otherwise drift will cause inaccurate depth measurements.

1. Turn on meter and calibrate according to instructions. **The meter must be turned on for 20 minutes prior to calibration to allow the electronics to stabilize.

2. Once calibrated, remove probe from calibration/storage chamber.

3. Lower probe into water to desired depth.

(Always start measurements with the probe at just below the water's surface. Then make measurements at one-meter intervals, for example, 1m, 2m, 3m, 4m, etc. The cord is marked with tape at these intervals. Be careful to not let probe hit the bottom sediments.)

4. Press MODE button until meter is in "dissolved oxygen % air saturation" mode.

5. Allow temperature to stabilize (about 30 seconds).

6. Record temperature on data sheet (see example data sheet on page 14).

7. Raise and lower the probe gently (about 2 inches per second) until % air saturation stabilizes. Record this percentage.

8. Press UP ARROW button once so dissolved oxygen is displayed in "mg/L". Again raise and lower the probe until stable. Record this value.

9. Lower probe to next depth.

10. Press the UP ARROW button to return to "% air saturation" mode. Repeat steps 5 – 9 as necessary.

11. When finished, rinse probe with distilled water from the squirt bottle. Place probe in storage chamber. Turn off meter.

REMEMBER: Never hold the meter over the water. Keep it securely inside the boat. Put **only** the probe over and into the water.

Send completed data sheet to:
Bill Jones, SPEA 347, Indiana University, Bloomington, IN 47405

Report any difficulties to SWCD staff.

VOLUNTEER LAKE MONITORING PROGRAM

- Temperature/D.O. Data Sheet -

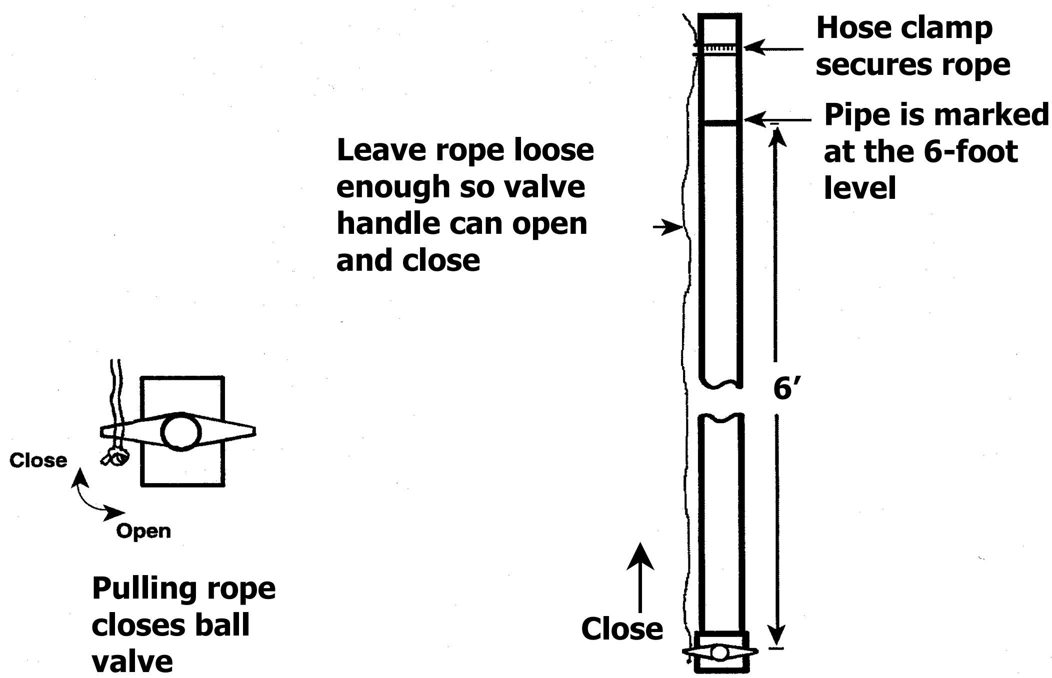
Lake: ________________________ Date: __________

Volunteer: ____________________ Time: _________

DEPTH (m)	TEMP. (^{o}C)	D.O. (%)	D.O. (ppm)
Surface			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

APPENDIX A

Construction of an integrated pipe sampler



APPENDIX I:

4-H Biological Control of Purple Loosestrife Monitoring Forms

Biological Control of Purple Loosestrife

Release Form

1. Name of 4-H Club: ____________________________ County: ________________

2. Adult: _____________________________________ Phone: _________________

3. Extension Educator: ___________________________ Phone: _________________

4. Number of youth involved: ____________________ Number of plants with beetles delivered to the release site. ____________

5. Number of beetles received to raise: _____________ Note: All plants and beetles must be released at one site.

6. Average Diversity Index (before beetles were released): _______________

7. Number of beetles released into the wetland (approximate): _______________

8. <u>Location</u> of the purple loosestrife infestation and <u>Release site</u> (specific area in the wetland where beetles were released. You may sketch the wetland and close cross roads on the back of this form.):

   ____

   ____

9. Property Owner: ______________________________ Phone: _________________

10. Approximate area affected (in acres or fraction of acres): ________________ acres

11. Approximate percent of the area infested with purple loosestrife: __________%

12. Intended dates of follow-up monitoring (approximate):

    ________________________________ ____________________________________

    ________________________________ ____________________________________

Please give this form to your Extension Educator after beetle release (by September 15, 2001). **Extension Educators:** Please copy this form for your records and send to Natalie Carroll, State 4-H Office, by October 1, 2001. Thank You!

Biological Control of Purple Loosestrife

Fall Sampling Report Form

1. Name of 4-H Club: ____________________________ County: ________________

2. Adult: _____________________________________ Phone: _________________

3. Extension Educator: ___________________________ Phone: _________________

4. Date of Survey: _________________________________

5. Number of youth participating in the Fall Survey: ____________________

6. Average Diversity Index (before beetles were released): _______________

7. Location of the purple loosestrife infestation and Release site (specific area in the wetland where beetles were released. You may sketch the wetland and close cross roads on the back of this form.):

   ____

   ____

8. Property Owner: ______________________________ Phone: _________________

9. Average Diversity Index today: _________________

10. Any additional information that you would like to share (your thoughts and comments, youth comments, how this project worked, what the youth learned, etc.):

Please take/mail this form to your County Extension Educator as soon as possible after your Fall Survey. This information is very important to the Indiana DNR, the Sea Grant College Program, and Purdue Extension.

Extension Educators: Please copy this form for your records and send to Natalie Carroll, State 4-H Office, as soon as possible (Fax or mail). Thank You!

Biological Control of Purple Loosestrife

Spring Sampling Report Form

1. Name of 4-H Club: ____________________________ County: ________________

2. Adult: _____________________________________ Phone: _________________

3. Extension Educator: ___________________________ Phone: _________________

4. Date of Survey: _________________________________

5. Number of youth participating in the Spring Survey: ____________________

6. Average Diversity Index (before beetles were released): _______________

7. Location of the purple loosestrife infestation and Release site (specific area in the wetland where beetles were released. You may sketch the wetland and close cross roads on the back of this form.):

   ____

   ____

8. Property Owner: ______________________________ Phone: _________________

9. Average Diversity Index today: _________________

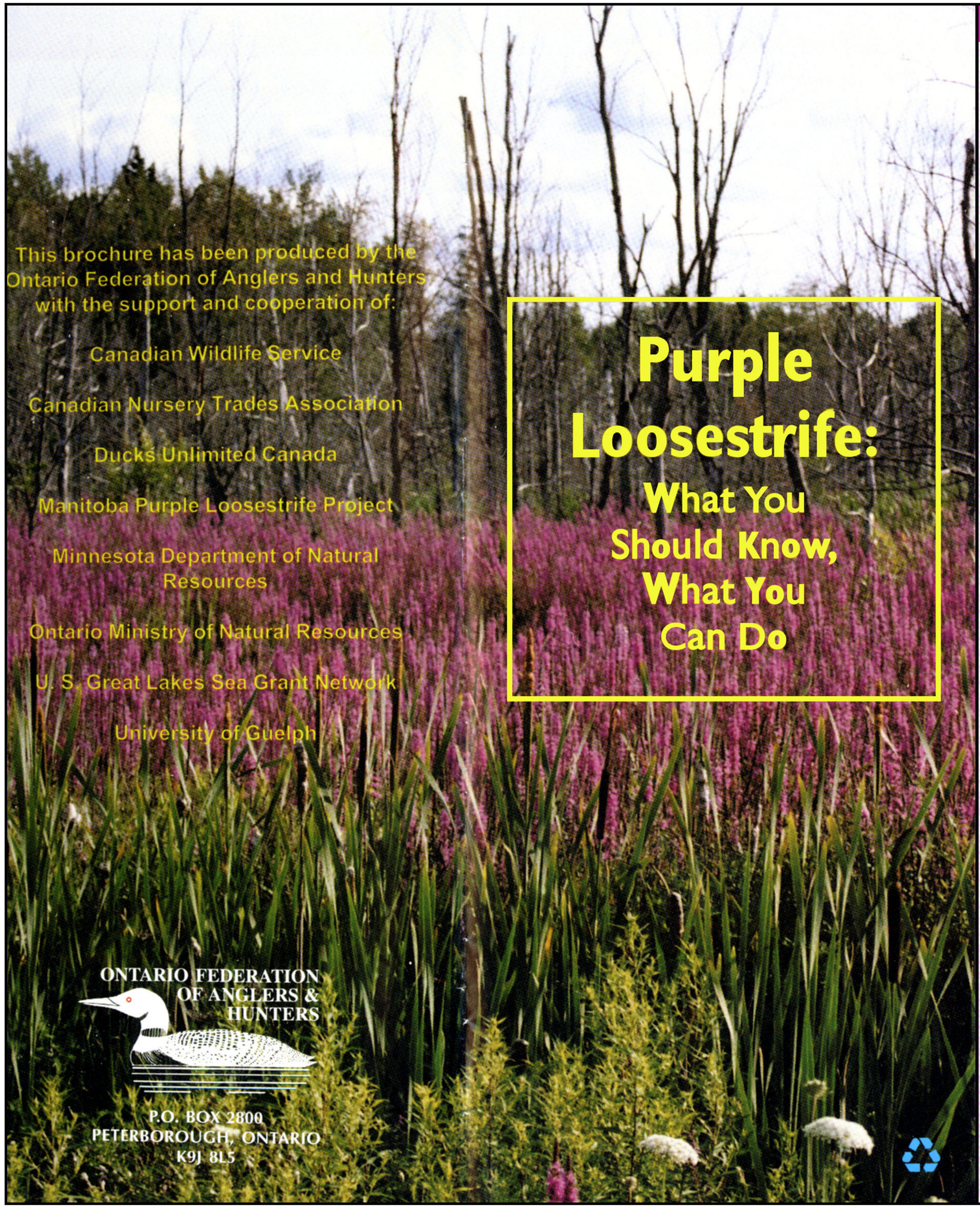
10. Any additional information that you would like to share (How the beetles & plants survived the winter, your thoughts and comments, youth comments, how this project worked, what the youth learned, etc.):

Please take/mail this form to your County Extension Educator as soon as possible after your Fall Survey. This information is very important to the Indiana DNR, the Sea Grant College Program, and Purdue Extension.

Extension Educators: Please copy this form for your records and send to Natalie Carroll, State 4-H Office, as soon as possible (Fax or mail). Thank You!

APPENDIX J:

SeaGrant Purple Loosestrife Identification Brochure



This brochure has been produced by the Ontario Federation of Anglers and Hunters with the support and cooperation of:

Canadian Wildlife Service

Canadian Nursery Trades Association

Ducks Unlimited Canada

Manitoba Purple Loosestrife Project

Minnesota Department of Natural Resources

Ontario Ministry of Natural Resources

U. S. Great Lakes Sea Grant Network

University of Guelph

ONTARIO FEDERATION OF ANGLERS & HUNTERS

P.O. BOX 2800
PETERBOROUGH, ONTARIO
K9J 8L5

Purple Loosestrife: What You Should Know, What You Can Do

PURPLE LOOSESTRIFE

THE ARRIVAL

Purple loosestrife *(Lythrum salicaria)*, a beautiful but aggressive invader, arrived in eastern North America in the early 1800's. Plants were brought to North America by settlers for their flower gardens, and seeds were present in the ballast holds of European ships that used soil to weigh down the vessels for stability on the ocean. Since it was introduced, purple loosestrife has spread westward and can be found across much of Canada and the United States.

THE PROBLEM

Purple loosestrife is a very hardy perennial which can rapidly degrade wetlands, diminishing their value for wildlife habitat. Wetlands are the most biologically diverse, productive component of our ecosystem. Hundreds of species of plants, birds, mammals, reptiles, insects, fish and amphibians rely on healthy wetland habitat for their survival.

However, when purple loosestrife gets a foothold, the habitat where fish and wildlife feed, seek shelter, reproduce and rear young, quickly becomes choked under a sea of purple flowers. Areas where wild rice grows and is harvested, and where fish spawn, are degraded. An estimated 190,000 hectares of wetlands, marshes, pastures and riparian meadows are affected in North America each year, with an economic impact of millions of dollars.

Purple loosestrife also invades drier sites. Concern is increasing as the plant becomes more common on agricultural land, encroaching on farmers' crops and pasture land.

THE CHALLENGE

Many organizations throughout North America have taken action to control the spread of purple loosestrife. Their response has been characterized by unparallelled cooperation. National wildlife services, state/provincial natural resource and environment agencies, universities, nursery trades associations, and conservation and community organizations have responded to the purple loosestrife invasion by raising awareness of the threat posed by this invasive plant, and how to prevent its spread.

Individuals, resource managers and community groups can make a valuable contribution to conserving our wetlands for future generations by acting on the information in this brochure. Contact the organizations listed on page seven for additional information.

GUIDELINES FOR PURPLE LOOSESTRIFE CONTROL

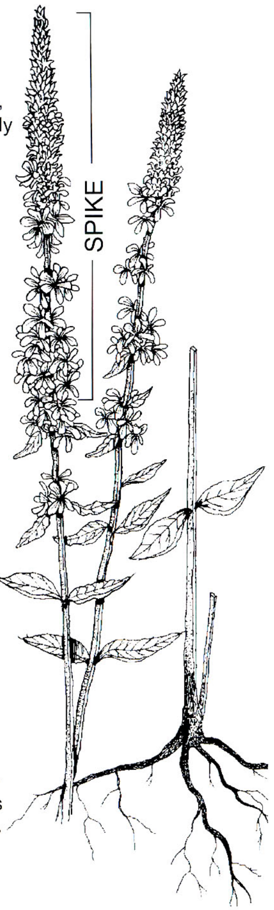
HOW TO IDENTIFY PURPLE LOOSESTRIFE

Before control activities begin, use the following diagram to be sure you are correctly identifying purple loosestrife.

Flower: Individual flowers have five or six pink-purple petals surrounding small, yellow centers. Each flower spike is made up of many individual flowers.

Seed Capsule: As flowers begin to drop off, capsules containing many tiny seeds appear in their place. Depending on where you live, plants may go to seed as early as late July.

Seed: Each mature plant can produce up to 2.7 million seeds annually. As tiny as grains of sand, seeds are easily spread by water, wind, wildlife and humans. Germination can occur the following season, but seeds may lay dormant for several years before sprouting.



Leaves: Leaves are downy, with smooth edges. They are usually arranged opposite each other in pairs which alternate down the stalk at 90° angles, however, they may appear in groups of three.

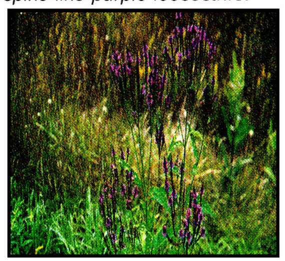
Stalk: Stalks are square, five- or six-sided, woody, as tall as 2m (6+ ft.) with several stalks on mature plants.

Perennial Rootstock: On mature plants, rootstocks are extensive and can send out up to 30 to 50 shoots, creating a dense web which chokes out other plant life.

DON'T BE FOOLED BY THESE LOOK-ALIKES

***Swamp Loosestrife**: Individual flowers ring the stem above leaf pairs. They do not form a flower spike like purple loosestrife.*

***Fireweed**: The conical flower spike is 10-13 cm (4-5 inches) wide at the base. Stem is round and leaves alternate.*



***Blue Vervain**: Small purple flower spikes; edges of leaves are toothed.*

***Winged Loosestrife**: Leaves alternate with small stems attaching to main stem.*

Photo by M.J. Oldham

HOW TO CONTROL PURPLE LOOSESTRIFE

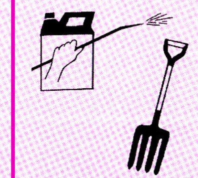
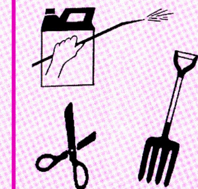
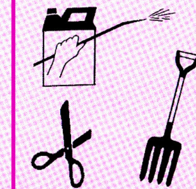
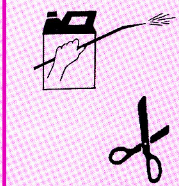
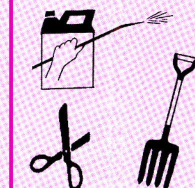
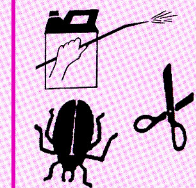
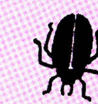
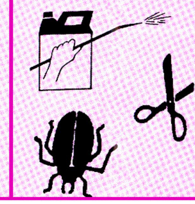
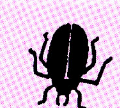
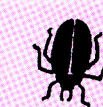
Controlling the spread of purple loosestrife is crucial to protecting vital fish, wildlife and native plant habitat! Purple loosestrife can easily spread if improper control methods are used. The following simple guidelines will ensure that your efforts to control the spread of purple loosestrife are effective.

Estimate the size and density of the infestation, and use the following chart to choose one or more appropriate loosestrife control options.

In areas too heavily infested to pull, cut or dig plants, these control techniques can still be used to control plants that may sprout as a result of seeds escaping the area. Watch drainage ditches or streams leading from heavily infested areas, as new purple loosestrife colonies are likely to become established there. Pulling, cutting or digging plants in these more manageable infestations will limit the spread of purple loosestrife beyond the area of heavy infestation.

SIZE OF INFESTED AREA

DENSITY OF INFESTED AREA

	Isolated plants	Small less than 1 acre (0.1 - 0.5 hectares)	Medium up to 4 acres (0.5 - 2 hectares)	Large more than 4 acres (more than 2 hectares)
Low Density 1 to 50 plants (1 - 25% of the area)				
Medium Density 50 to 1,000 (25 - 75% of the area)				
High Density more than 1,000 (75 to 100% of the area)				

KEY TO CHART SYMBOLS

Digging & Hand Pulling

Pulling purple loosestrife by hand is easiest when plants are young (up to two years) or when in sand. Older plants have larger roots that can be eased out with a garden fork. Remove as much of the root system as possible, because broken roots may sprout new plants.

Biological Control

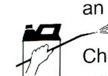
In areas of severe purple loosestrife infestation, manual and chemical control efforts are ineffective and may in fact contribute to the problem. However, the use of specially selected insects that feed on purple loosestrife is being studied to determine the effectiveness of this method for long-term control in these higher density areas. Biological control is discussed in more detail in a following section.

Cutting

Removing flowering spikes will prevent this year's seeds from producing more plants in future years -- remember each mature plant can produce over 2 million seeds per year. Also, remove last year's dry seed heads, as they may still contain seeds. Finally, cut the stems at the ground to inhibit growth.

Chemical Control

If an infestation is in a dry, upland area, and on your own property, an approved herbicide can be applied to individual plants by selective hand spraying. Broadcast spraying is not recommended as it kills all broad-leaved plants, leaving the area open to further invasion from nearby sources of purple loosestrife. This also provides an opportunity for seeds present in the soil to sprout.



Chemical control is used in the United States to control purple loosestrife near or in water, however, as of 1996, no herbicide has been approved for this type of application in Canada. **NOTE:** In the U.S. a permit is required; call a state natural resource agency for more information.

THINGS TO KEEP IN MIND

The best time to control purple loosestrife is in late June, July and early August, when it is in flower, plants are easily recognized, and before it goes to seed. Once flower petals start to drop from the bottom of the spike, the plant begins to produce seed. Control activities can continue during this time, but require greater care so seeds are not shaken from the plant. At sites where plants have gone to seed, remove all of the flowering spikes first by bending them over a plastic bag and cutting them off into the bag. Further cutting of stems or pulling can now take place without fear of spreading the tiny seeds.

Proper disposal of plant material is important. Put all plant pieces in plastic bags (vegetation rots quickly in plastic) and take the bags to a sanitary landfill site. Be sure the landfill site doesn't require bags to be broken open for composting. Composting is not advised, as purple loosestrife seeds may not be destroyed and the thick, woody stem and roots take a long time to decompose. If facilities exist in your area, incineration is an effective way to dispose of plant material.

Be aware that your clothes and equipment may transport the small seeds to new areas. Thoroughly brush off your clothes and equipment before leaving the site.

Keep site disturbance to a minimum. Wetlands provide habitat for many native song birds, waterfowl, mammals, amphibians, and fish which depend on native wetland vegetation. Wetlands are also home to many rare and delicate plants. Take care not to trample or damage native vegetation when controlling purple loosestrife.

BIOLOGICAL CONTROL

WHY BIOLOGICAL CONTROL?

When a plant from one continent is introduced to another, it usually leaves behind the natural enemies that help prevent population explosions where it normally grows. The purpose of biological control (biocontrol) is to reunite a plant with its natural enemies. Complete eradication is unlikely; the goal of biocontrol is to reduce numbers of the target plant to lessen its ability to displace native vegetation.

The aggressive spread of purple loosestrife across North America prompted the consideration of biological control in the battle against this invader.

Obviously, extreme caution must be taken when introducing one organism to control another. Prior to any introduction of a biological control agent, intensive testing is conducted to ensure that a safe and effective agent is selected.

SELECTION AND SCREENING PROCEDURES

Before approval is granted to release biological control agents in Canada or the U.S., years of testing are required to determine host specificity and ecological specificity.

Testing is usually done in Europe by the International Institute of Biological Control in collaboration with Canadian and U.S. scientists. This enables controlled laboratory testing and natural field testing to be conducted in the insects' native home, eliminating the high cost of meeting the requirements of working in North American quarantine to avoid the risk of a foreign species escaping.

Once testing is completed, a report is written for submission to a Canadian Advisory Committee and a U.S. Technical Advisory Group. If both the Canadian and U.S. representatives are satisfied that the benefits outweigh the risks, they recommend the release of biological control agents.

Once approved for release in Canada or the U.S., insects must pass through national quarantine facilities to ensure that they are the correct species and are free of disease and parasites. A limited number of insects are imported for use as brood stock, to reproduce and supply additional insects for release.

BIOLOGICAL CONTROL

FINDING BIOLOGICAL CONTROLS

In the mid-1980's, biologists began to conduct a search for biological control agents of purple loosestrife. Of the more than 100 insects that feed on purple loosestrife in Europe, several species were thought to have had excellent potential. Testing began in Europe and was completed in North America between 1987 and 1991 prior to the insects being approved for release. Included in the tests were "feeding trials" which exposed the insects to approximately 50 species of plants including wetland species native to North America, and important commercial and agricultural species.

Following the rigorous testing process and evaluation of the test results, five species of beetles received approval for release in North America, first from the United States government, and then from the Canadian government in 1992.

The following five species of beetles were selected for purple loosestrife to be introduced without fear of negative impacts to native North American plants. *Galerucella pusilla* and *G. calmariensis* are leaf-eating beetles which seriously affect growth and seed production by feeding on the leaves and new shoot growth of purple loosestrife plants. *Hylobius transversovittatus* is a root-boring weevil that deposits its eggs in the lower stem of purple loosestrife plants. Once hatched, the larvae feed on the root tissue, destroying the plant's nutrient source for leaf development, which in turn leads to the complete destruction of mature plants. Finally, two flower-eating beetles, *Nanophyes brevis* and *N. marmoratus*, severely reduce seed production of purple loosestrife.

RELEASE AND MONITORING PROTOCOL

Since the initial importation of these insects into North America for the biological control of purple loosestrife, three of the control agents have been released in Canada, including *H. transversovittatus*, *G. pusilla*, and *G. calmariensis*; the United States has released these as well as *N. marmoratus*. The other flower-eating beetle has yet to be released in North America.

As of 1996, insects have been released for the control of purple loosestrife in 25 U.S. states and in seven Canadian provinces.

At the time of insect release, site characteristics including habitat and soil type, size of infestation and water levels are recorded. Follow-up visits to the site occur later in that season, and in subsequent years, so that survival and establishment of the beetles can be assessed and their impact on the plant population evaluated.

BIOLOGICAL CONTROL

THE IMPACT OF BIOLOGICAL CONTROL ON PURPLE LOOSESTRIFE

Scientists expect that once established at initial release sites, insect populations will increase, effectively reducing the density of purple loosestrife by reducing shoot growth, preventing or delaying flowering, and reducing seed production. When the number of loosestrife plants on a site dwindles, the beetles will move to other loosestrife stands to feed. Since the control agents will never completely eradicate loosestrife populations, there will be a food source for remaining insect populations.

In North America, it is hoped that the impact of the biological control agents will result in reductions of purple loosestrife abundance of approximately 80%. However, this is a long-term goal. It is estimated that it will be 10 to 20 years after the insect populations become established before their densities will be high enough to result in this reduction.

In the meantime, it is important that we work together to control the spread of purple loosestrife to new areas by using the guidelines outlined previously.

Before

After

Insect photos courtesy Don Hamilton, University of Guelph.
Before & after photos courtesy of Minnesota Dept. of Natural Resources

IS PURPLE LOOSESTRIFE GROWING IN YOUR GARDEN?

In some states and provinces, noxious weed laws or other state/provincial laws make it illegal to plant purple loosestrife (*Lythrum salicaria*) and its cultivars. However, it is still legally available for sale at some locations. **DO NOT BUY IT!** Also, purple loosestrife seeds are present in some wildflower seed mixes--**check the label before you buy any seed packages.**

Garden varieties of loosestrife, which were once thought to be sterile, have been proven to cross-pollinate with wild purple loosestrife to produce viable seed. Gardeners can help control the spread of this plant and protect our environment from its harmful impacts by not planting purple loosestrife or the following cultivars:

- *Atropurpureum*
- Brightness
- Columbia Pink
- Dropmore Purple
- Firecandle
- Flashfire
- Floralie
- Florarose
- Gypsy Blood
- Happy
- Lady Sackville
- Morden Gleam
- Morden Pink
- Morden Rose
- Pink Spires
- Purple Dwarf
- Purple Spires
- Robert
- Rose Gleam
- Rose Queen
- *Roseum superbum*
- Rosy Gem
- Rosy Glow
- The Beacon
- The Rocket
- *Tomentosum*

ALTERNATIVE PLANTINGS FOR PURPLE LOOSESTRIFE

If you currently have purple loosestrife or a cultivar growing in your garden, it could contribute to the loss of fish and wildlife habitat. Please remove it (roots and all) or at least cut off the flower tops before they begin to form seed. For proper disposal, please see "Things to Keep in Mind" on page four of this publication.

The Canadian Nursery Trades Association has discouraged the sale of purple loosestrife by its members. As a result, many garden centres and seed distribution companies have responded to the purple loosestrife epidemic by voluntarily refusing to sell purple loosestrife and its cultivars, and by providing an alternative selection of environmentally-friendly perennials to landscapers and home gardeners.

Several species of garden perennials display characteristics similar to purple loosestrife, yet they pose no threat to our natural environment. The following plants are an example of some of the environmentally-friendly species available at garden centres and nurseries.

BLAZING STAR, GAY FEATHER *(Liatris spicata)*

There are several species of *Liatris* that are native to North America. Plants grow flowering spikes of blue, pink or purple. Availability and appropriateness of the *Liatris* species and their varieties will vary in the different geographic areas of North America.

DELPHINIUM *(Delphinium spp.)*

This traditional perennial grows up to 2m (6') tall producing a brilliant spike of blue to purple flowers. Individual flowers are about 5-7.5cm (2-3") with a single or double ring of petals. *Delphinium* grows best in full sun.

FALSE SPIREA *(Astilbe arendsii)*

Astilbe grow 0.75-1m (2-3') tall and form 20 to 30cm (8 to 12") spikes of tiny flowers ranging in colour from purple to pink and crimson. *Astilbe* grows in moist but well-drained soil and in light shade where it will not dry out too quickly during the summer months.

LUPINE *(Lupinus)*

This spectacular perennial provides flowers in a variety of colours ranging from blue to pink and yellow. The flowers form large 0.5m (2') spikes along the 1-1.75m (3-5') stem. *Lupines* grow best with full sun and in well-drained, neutral or slightly acidic soils.

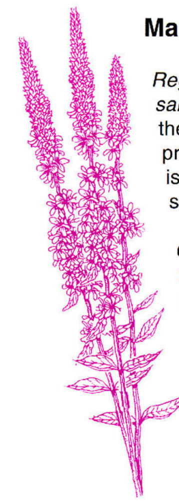
LOBELIA *(Lobelia cardinalis)*

A wildflower of wet areas in North America. This plant has spikes of scarlet-red flowers in summer. Excellent beside a pond or stream.

SALVIA *(Salvia superba)*

Salvia is a hardy perennial that is drought resistant and somewhat bug-proof. Most *Salvia* have blue to violet flowers, appearing as spikes during June and August. Plants grow 0.75-1m (2-3') tall, preferring full sun and good garden soil.

For more information ...



Management in Minnesota

Regulations - Purple loosestrife (*Lythrum salicaria, L. virgatum* and any combination thereof) is listed as a noxious weed and a prohibited exotic species in Minnesota. It is illegal to possess, plant, transport, or sell loosestrife in Minnesota.

Chemical Control - A DNR permit is required to spray purple loosestrife in public waters and protected wetlands. There is no fee for this permit. Contact the DNR at the address below to obtain permit information.

Cutting and Hand Pulling - Purple loosestrife can be cut or pulled without a permit. It is important to dispose of the plants away from the water. Allow the plants to dry out, then burn if possible.

Biological control - Leaf-eating beetles (*Galerucella* spp.) are available for control of purple loosestrife. Contact the DNR (address below) for information on how to obtain beetles by field collecting or rearing your own with a beetle rearing kit.

For more info contact:

Minnesota Department of Natural Resources
Purple Loosestrife Program
500 Lafayette Road, Box 25
St. Paul, MN 55155-4025
(651) 296-2835
www.dnr.state.mn.us

University of Minnesota
Minnesota Sea Grant Program
Exotic Species Info Centre
2305 East 5th Street
Duluth, MN 55812-1445
(218) 726-8712
www.seagrant.umn.edu

Pub. 2001 - 15,000

APPENDIX K:

U.S. Army Corps of Engineers and Indiana Department of Environmental Management Permit Applications

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT (33 CFR 325)	OMB APPROVAL NO. 0710-003 Expires October 1996

Public reporting burden for this collection of information is estimated to average 5 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Service Directorate of Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302; and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003), Washington, DC 20503. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT

Authority: 33 U.S.C. 401, Section 10; 1413, Section 404. Principal Purpose: These laws require permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Routine Uses: Information provided on this form will be used in evaluating the application for a permit. Disclosure: Disclosure of requested information is voluntary. If information is not provided, however, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO.	2. FIELD OFFICE CODE	3. DATE RECEIVED	4. DATE APPLICATION COMPLETED

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT=S NAME	8. AUTHORIZED AGENT=S NAME AND TITLE (AN AGENT IS NOT REQUIRED) J.F. New & Associates, Inc. c/o
6. APPLICANT=S ADDRESS	9. AGENT=S ADDRESS 708 Roosevelt Road, Walkerton, IN 46574
7. APPLICANT=S PHONE NOS. W/ AREA CODE a. Business b. Fax	10. AGENT=S PHONE NOS. W/ AREA CODE a. Business 219-586-3400 b. Fax 219-586-3446

11.STATEMENT OF AUTHORIZATION

I hereby authorize J.F. New & Associates, Inc. to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

APPLICANT=S SIGNATURE DATE

NAME, LOCATION AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

13. NAME OF WATERBODY, IF KNOWN (see instructions)

14. PROJECT STREET ADDRESS (If applicable)

15. LOCATION OF PROJECT

COUNTY STATE

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)

17. DIRECTIONS TO THE SITE:

18. NATURE OF ACTIVITY (Description of project, include all features)

19. PROJECT PURPOSE (Describe the reason or purpose of the project, see instructions)

USE BLOCKS 20-22 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. REASON(S) FOR DISCHARGE

21. TYPE(S) OF MATERIAL BEING DISCHARGED AND THE AMOUNT OF EACH TYPE IN CUBIC YARDS

22. SURFACE AREA IN ACRES OF WETLANDS OR OTHER WATERS FILLED (see instructions)

23. IS ANY PORTION OF THE WORK ALREADY COMPLETE? YES ___ NO _ IF YES, DESCRIBE THE COMPLETED WORK.

24. ADDRESSES OF ADJOINING PROPERTY OWNERS, LESSEES, ETC., WHOSE PROPERTY ADJOINS THE WATERBODY (If more than can be entered here, please attach a supplemental list).

25. LIST OF OTHER CERTIFICATIONS OR APPROVALS/DENIALS RECEIVED FROM OTHER FEDERAL, STATE OR LOCAL AGENCIES FOR WORK DESCRIBED IN THIS APPLICATION.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED

* Would include but is not restricted to zoning, building and flood plain permits.

26. Application is hereby made for a permit or permits to authorize the work described in this application. I certify that the information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT DATE SIGNATURE OF AGENT DATE

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

Office of Water Management
Section 401 Water Quality
Certification Program

Application Form and Instructions for Section 401 Water Quality Certification

Note to applicants:

Applicants should also contact the Indiana Department of Natural Resources (DNR) regarding potential permit requirements associated with construction in a floodway or a public freshwater lake. According to 1998 figures, approximately 9% of the projects that required a Section 401 Water Quality Certification also required a permit from the DNR. You can reach the DNR Division of Water at 317-232-4160 or toll free at 1-877-WATER55.

Revised February 14, 2000

Application for Water Quality Certification

Address all applications or questions to:

Indiana Department of Environmental Management
Section 401 Water Quality Certification Program
100 North Senate Avenue P.O. Box 6015 Indianapolis, Indiana 46206-6015
1-800-451-6027 or 317-233-8488

PLEASE PULL OUT APPLICATION FROM PACKET

Failure to provide the information requested in this application may result in a delay of processing or denial of your application.

For office use only
Project Manager:
Date Received:
IDEM I.D. Number:
County:

1. APPLICANT INFORMATION	2. AGENT INFORMATION
Name of Applicant	Name of Agent
Mailing address (Street/ PO Box/ Rural Route, City, State, Zip)	Mailing address (Street/ PO Box/ Rural Route, City, State, Zip)
Daytime Telephone Number	Daytime Telephone Number
Fax Number	Fax Number
E-mail address (optional)	E-mail address (optional)
Contact person: (required)	Contact person:

3.PROJECT LOCATION

County		Nearest city or town	
U.S.G.S. Quadrangle map name (Topographic map)		Project street address (if applicable)	
Quarter	Section	Township	Range
Type of aquatic resource(s) to be impacted (lake, river, stream, ditch, wetland, etc. include name if applicable)		Project name or title (if applicable)	
		UTM North	UTM East
Other location descriptions or driving directions			

4. PROJECT PURPOSE and DESCRIPTION

Use additional sheet(s) if required	
Has any construction been started? YES NO	Anticipated start date
If yes, how much work is completed?	
Project purpose and description	

5. Project Information: Applicants must answer all the following questions.

What is the linear feet of impacts to the waterbody below the ordinary high water mark (OHWM) and/or bank clearing?

What is the acreage or square footage of wetlands or other water resources that are proposed to receive a discharge of material (ie. fill), mechanically cleared, or to be excavated?

What is the area of wetlands or other water resources on the site, in acreage or square feet?

Describe the type, composition and quantity (in cubic yards) of fill material to be placed in the wetland or below the OHWM of the water to receive the material (wetland or other water to be filled).

Describe the type, composition and quantity (in cubic yards) of material proposed to be removed from the wetland or below the OHWM of the water resource.

6. Drawing/Plan Requirements (applicants must provide the following)

a. Top/aerial/overhead view of the project site

b. Cross sectional view

c. North arrow, scale, property boundaries

d. Include wetland delineation boundary (if applicable). Label the impact wetlands as I-1, I-2, etc. and mitigation areas as M-1,etc.

e. Location of all surface waters, including wetlands, proposed works, erosion control measures, existing structures, disposal area for excavated material, fill locations, including quantities, and wetland mitigation (if applicable)

f. Approximate water depths and bottom configurations (if applicable)

g. Provide plans on 8 2 by 11 inch paper, unless directed otherwise

7. Documentation Requirements (applicants must provide the following)

a. A Corps of Engineers approved wetland delineation for projects with wetland impacts

b. Photographs of the project site. Indicate where they were taken on the overhead view of the project plans

8. Additional information that MAY be required (IDEM will notify you if needed)

a. Erosion control and/or storm water management plans

b. Sediment analysis

c. Wetland mitigation plan including: type, size, location, methods of construction, planting and monitoring plans

d. Species surveys for fish, mussels, plants and threatened or endangered species

e. Any other information IDEM deems necessary to determine the impact to water quality

9. Permitting Requirements

a. Have you applied for an Army Corps of Engineers Section 404 permit? _____ Yes _____ No If yes, please supply the Corps of Engineers ID Number, the Corps of Engineers District, the project manager, and a copy of any correspondence with the Corps. **If no, contact** the Army Corps of Engineers regarding the possible need for a permit application. (See instructions 11.)

b. Have you applied for, received, or been denied any other federal, state, or local permits, variances, licenses, or certifications for this project? Please give the permit name, agency from which it was obtained, permit number, and date of issuance or denial.

10. Adjoining Property Owners and Addresses

List the names and addresses of landowners adjacent to the property on which your project is located and the names and addresses of other persons (or entities) potentially affected by your project. Use additional sheet(s) if required.

Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip

11. Signature - Statement of Affirmation

I hereby request a Water Quality Certification to authorize the activities described in this application. I certify that I am familiar with the information contained in this application and to the best of my knowledge and belief, such information is true and accurate. I certify that I have the authority to undertake and will undertake the activities as described in this application. I am aware that there are penalties for submitting false information. I understand that any changes in project design subsequent to IDEM's granting of WQC are not covered by the WQC, and I may be subject to civil and criminal penalties for proceeding without proper authorization. I agree to allow representatives of the IDEM to enter and inspect the project site. I understand that the granting of other permits by local, state, or federal agencies does not release me from the requirement of obtaining the WQC requested herein before commencing the project.

Applicant's Signature: ____ Date: ____________________

APPENDIX L:

Action Register

Action Register

Date: ____

Goal (choose from goals listed below): ____

Task completed: ____

Type of task (circle appropriate task type):

Meeting Who attended by: ____

Education Number attended: _____ Number distributed: _____
Distributed to: ____

Investigation Sources of information: ____

Field Work

Other

Provide a description of the task in the space below. Please include what portion of the goal(s) or objective(s) this task completes, a listing of other actions required based on this task, and any suggested future actions.

Additional notes:

Task completed by:____________________________________

Goals:
Increase stakeholder participation/form watershed group.
Improve water clarity within Flat and Gilbert Lakes.
Reduce productivity levels within Flat and Gilbert Lakes.
Increase dissolved oxygen levels in Gilbert Lake.
Reduce the coverage of purple loosestrife around Flat Lake.