Watershed Diagnostic Study of the Little Calumet—Galien River Watershed

---

Submitted to:
Laurie Rounds
IN DNR-Division of Water Resources
402 West Washington
Room 264
Indianapolis, IN 46204

Prepared by:
Mark O'Leary, MS; Neil Thomas, MS; Doug Eppich, PhD, P.E.;
David Johannesen, MS; Steve Apfelbaum, MS
Applied Ecological Services, Inc.
120 W. Main Street
West Dundee, IL 60118
AES Project Number 99-604

September 2001

TABLE OF CONTENTS **Page**

List of Figures

List of Tables

Executive Summary

Scope and Project Approach

The Little Calumet-Galien River watershed encompasses nearly one-half million acres of land encompassing rural communities, highly industrialized areas, urban centers, high quality natural areas, miles of Lake Michigan shoreline, and a variety of other land uses and cover types. The watershed has been studied extensively at a variety of levels, and therefore there exists an abundance of biological, water quality, demographic, geographical, and other information. This watershed study supplements the existing understanding of conditions as described by others. Proposed recommendations takes into account that different land uses pose different water quality threats and opportunities, and must therefore be managed accordingly.

This study summarizes and integrates the plethora of information available on this study area, and fills in information gaps necessary to meet project goals. Recommendations for BMPs have been customized based on how different land uses create different water quality threats, and potential opportunities for mitigation

The following objectives were identified in the RFP for this study:

1. Describe and map conditions and trends in water resources (streams, rivers, lakes, etc.) within the Little Calumet-Galien Watershed.
2. Identify potential non-point source water quality problems.
3. Identify and prioritize watershed land treatment projects to address existing and potential problems.
4. Project the probability of achieving program success and provide specific directions for future work to optimize success.

The following additional guidelines were used in preparing this study:

This study will take full advantage of and springboard off of prior research in the area conducted by others;

- GIS data will be consistent and compatible with prior GIS data collection efforts to date;
- Proposed BMPs will focus on major land use categories within the watershed such as rural and urban areas, and transitional areas with projections of high population increases;
- Models used to create and prioritize management units will be applicable at a variety of scales, and iterative in that each subsequent run of the model on progressively smaller management units shall provide more detailed and specific information than the last run of the model.

Management units will be ranked according to impending **risk** to water quality, as well as practical, economical, and realistic **opportunities** for the implementation of recommended BMPs.

Using this Document

The organization of and information provided in this document has been prepared such that it can be used as a tool to land managers and decision makers to reduce existing, and prevent or minimize future, nonpoint source pollution.

This document is in two volumes. The first volume includes the text, tables and bibliography. The second volume includes all of the figures and appendices. We have also included as an insert base maps of the study area on acetate that indicate the three major development categories, major streams and waterways, towns and other features that provide a geographical context for other GIS figures. Since all of the figures are of the same scale, the acetate can be laid on top of each figure.

The **Introduction** and **Study Area** provide the historical and contextual framework of the Little Calumet-Galien River Watershed. The **Base GIS** section summarizes geo-referenced information used to provide a contextual framework for this study. Each layer can be used independently, or superimposed on other layers to observe trends within variously scaled geographical areas. This section is important in and of itself in that it can be used by a variety of resource managers and decision makers not only to achieve water quality goals, but to assist in natural resource planning and management, and to develop sound conservation development strategies.

A variety of sources were used to assess **Water Quality** including a field investigation, the Unified Watershed Assessment, IDEM Index of Biotic Integrity Data, IDEM water quality data, and information available on the EPA's BASINS database. Since each measured parameter is geo-referenced on a GIS map, interested readers can compare geo-referenced results with each of the GIS Base Maps.

The **Natural Resources** section summarizes the location of ecologically sensitive areas within the study area. This section will assist natural resource managers in identifying the proximity of measured ecological stressors to high quality ecological areas, as well as potential restoration opportunities.

The **Land Use Categories – Urban, Transitional, and Rural** section identifies areas at the highest risk for development in the near future, and can therefore assist end users in prioritizing efforts to protect and enhance water quality.

The **Management Recommendations for Land Use Categories** section provides a concrete and disciplined approach to implementing BMPs designed to meet a suite of water quality goals. The last subsection provides examples and cost estimates of how a suite of BMPs might be used to accomplish multiple water quality objectives given different development scenarios.

The **Restoration and Protection Opportunities** section identifies existing protected open space areas, as well as unprotected open space areas that would be most amenable to restoration. End users can use this information to prioritize existing open space that can be restored to meet water quality objectives, and to purchase additional open space for restoration.

In many cases, the acquisition and/or restoration of open space areas can be accelerated by spring-boarding off of existing efforts under way. The **Partnership Opportunities** section documents existing efforts, as well as the plethora of agencies and resources that can assist in promoting water quality objectives.

The **Prioritizing Watersheds and Management Units** provides a general framework for focusing in on key parcels for the implementation of BMPs. This section is necessarily general in that different end users of this document will have different objectives, and because we should not discount opportunities that become available because they may not happen to fall within areas identified as a high priority. In prioritizing areas for specific work, this document should be used in its entirety rather than rely on a too general ranking system.

This document is a starting point for future, more specific investigations within the watershed. The **Data Needs and Conclusion** section includes our recommendations for future work that will assist end users in more focused efforts.

Study Area

The Little Calumet-Galien hydrologic unit (HU) is approximately 187,000 hectares (Figure 1). The HU covers the entire Lake Michigan coast line of Indiana, and extends to the northeast into Michigan and west into Illinois. Our study area is limited to that portion of the watershed within the state of Indiana, which includes approximately 139,000 acres.

Introduction

Geological History

The geography of northwest Indiana has been shaped and reshaped throughout the ages by countless geological and climatological events, each of which has, in one way or another, left its mark on the visible landscape or its underlying substrate.

During the Silurian and Devonian eras, this region was part of a vast inland sea. The remains of this sea and the organisms that inhabited it are preserved as dolomitic limestone formed during the Silurian era and as shales formed in the lower Devonian era (Gray, et al. 1987, Wiggers, 1997).

The region's surficial topography was shaped principally by the Wisconsin glaciations of the Pleistocene epoch (75,000 – 12,000 ybp). The most significant glacial features within the vicinity of the Little Calumet are Lake Michigan and the Valparaiso moraine. Materials excavated from Lake Michigan's bed by the Wisconsin Ice Sheet were generally conveyed toward the sheet's terminus. The material that accumulated along the terminus formed a stable ridge ("end moraine") that retained its shape after the ice sheet's final retreat (Erickson, 1990, Wiggers, 1997).

Following the retreat of the Wisconsin ice-sheet, dunes became increasingly important landscape features. Dunes typically form around "seed" structures such as rocks, or pieces of wood. As lake breezes blow sand-grains against these structures, waves of sand begin to take shape. As with ocean waves, these waves of sand, possess a predictable morphology. The portion of the dune that faces the lake develops at a relatively stable 10º slope, while the side facing away from the lake assumes a somewhat less stable 30º slope. At a height of between 50 and 75 feet, the rate at which wind-blown sand accumulates on the lake-facing side approximately matches the rate at which sand is lost to erosion from the side facing away from the lake. Although a few dunes may attain a height of 100 feet or more, such structures are rare (IDNR, 1976).

With the retreat of the glaciers, Lake Michigan, along with the other four great lakes, began to shrink. Over the past 12,000 years Lake Michigan's southern shoreline has retreated between 10 and 15 miles, while its average depth has decreased fully 60 feet from 640 feet MSL (mean sea level) to 580 feet MSL. As the shoreline retreated northward, it left behind series of "fossilized" beaches. Remnant dunes demarcate the southern, inland limits of these paleo-beaches. The oldest and most southerly of these paleo-beaches is the Glenwood beach. This feature was formed between 12,000 and 14,000 ybp (years before present) and has an average elevation of 640 feet MSL. Calumet beach, which is approximately 620 feet MSL and was formed between 9,000 and 12,000 ybp, lies to the north of Glenwood beach. The youngest and most northerly of these paleo-beaches is the Tolleston beach, which has a mean elevation of 605 feet and was formed between 5,000 and 9,000 ybp (Bieber and Smith, 1952, IDNR 1976).

Although the dunes, moraines, swales, rivers and creeks all act to give the landscape an undulating texture, the topography is, on average, remarkably flat. This flatness is both a cause and effect of the riverine systems flowing into Lake Michigan. Prior to channelization, the Little

Calumet functioned like a delta. As water flowed toward Lake Michigan, its velocity would decrease. As the water's velocity decreased, so would its silt-bearing capacities. As silts accumulated over time, the Little Calumet became increasingly shallow and sluggish and contributed to a vast network of freshwater estuaries that surrounded much of Lake Michigan (IDNR, 1976, Stewart, et al., 1997).

Ecological History

For a period of approximately 3,000 years, beginning about 12,000 ybp, the coastal and lake plain region's ecosystem underwent a series of dramatic changes (Adams, 2000). As conditions became warmer and wetter, the ice-sheets of the Wisconsin glacial era retreated, transforming the newly exposed terrain into a cold, tundra-like region, seasonally laced with rapidly flowing streams of melt-water. This tundra in turn gave way to boreal forests dominated by spruce, fir and paper birch. As the climate continued to warm, these forests were transformed into mixed deciduous-coniferous forests dominated by oaks and white pine (Petty and Jackson, 1966).

Indiana's lake plain region is part of the area referred to as the "prairie peninsula" (Transeau, 1935). This region, which extends through Indiana as far east as Pennsylvania and as far south as Kentucky and Tennessee, consists of an archipelago of shifting prairie "islands" within a matrix of forest.

What makes the lake plain region unique is the way in which Lake Michigan and the region's dune-swale topography has stratified these habitats. The interplay of grasslands and forests throughout the eastern United States typically assume chaotic, shifting, fractal configurations resembling ice on a pane of glass. Throughout the region, however, the plant communities are organized into relatively clear strata arranged on a north-south axis. A walk southward through an undisturbed portion of Indiana's coastal and lake plain region would typically reveal the following succession of habitat: 1) beaches, which contain little or no rooted vegetation; 2.) fore-dunes and "blowouts", which are dominated by dune grasses, in particular *Ammophila*, and occasional shrubs such as beach plum. 3.) Beyond the dunes later successional communities dominate, in particular black-oak savannas with periodic blowouts, prairie openings and stands of jack and white pine. 4.) Further south, the landscape is dominated by oak-hickory forests, which are periodically interrupted by swamps, marshes, bogs and other types of wetlands.

Cultural History

The name "Calumet" is a study in this area's rich history. Although its origins are unclear, its name seems to reflect its morphology. It may have come from the Old French word "chalemel", which has to do with reeds, or it might be a corruption of the Potawatomi word "gekelemuk", which means "a low body of deep still water" (LMRPC, 1968; IDNR, 1976).

Like its name, the resources of the Little Calumet's watershed have been claimed by many different cultures. Over the past four centuries, the land within this watershed has been claimed by the Menomonee and the Potawatomi, as well as by France, England and the United States.

Each of these cultures had its own unique perspective on the watershed and its resources. To the Potawatomi and other tribes familiar with this area, the land was seen as a supplier of all life's basic necessities. Bark from elms and birches when tied to saplings created the stable, relatively comfortable "wickiups" in which the Pottawatomi families lived. Acorns, hickory nuts, walnuts, maple sugar, wild rice, cultivated corns and squashes, along with seasonally available fruits, berries and various fish and game species were all critical parts of the Potawatomi diet (Petty and Jackson, 1966, Bogue, 1985, Kindscher, 1988, Mendelsohn, 1996).

The French initially provided an economic complement to the Potowatomi. This population consisted principally of voyageurs and coureurs do bois who were almost entirely male and had little interest in establishing permanent settlements. Their principle role was that of traders who supplied the native populations with durable goods from Europe and New England in exchange for furs and other resources indigenous to the Lake Michigan region (Petty and Jackson, 1966, Bogue, 1985).

Economic and Demographic Trends (1800-present)

19th Century Settlement Patterns

The ethnic composition of Lake Michigan's coastal lake plain region changed abruptly and dramatically during the first half of the 19th century. The chief events precipitating this change were the expulsion of the French from the region following the War of 1812 and the forced expulsion of the native peoples during the "Trail of Tears" in the 1830's.

Although European settlement throughout this area continued at a steady pace throughout the middle decades of the 19th century, it did not come near to matching Chicago's growth rate. In general, northwestern Indiana was viewed as a marshy hinterland that was not particularly suited for urbanization (Cronin, 1990, Mendelsohn, 1996).

Economic development and land "improvement" throughout this region began in earnest during the years immediately following the Civil War. The chief catalysts for this development were a combination of low land prices and strategic location relative to Chicago.

The first truly modern industry to dominate this region was the railroad. Lake Michigan had essentially created a "bottleneck" for railway traffic between Chicago and the cities of the east. As a consequence, the railroads bought up vast tracts of land throughout this region and quickly created the densest network of railroads in the nation.

At first these rail-lines were used primarily for the transport of passengers and agricultural produce, but as the cost of land within Chicago began to rise in tandem with a general distaste for large, polluting industries near residential areas, industrialists quickly saw the advantages of setting up factories in this area. In addition to being home to the nation's largest concentration of railroads, low land prices and generally low population levels created an environment in which industries would "be near associated or allied industries which would unite with them to eliminate objections property owners adjoining might file against them" (Hoyt, 2000, p. 320).

Steel Based Economy (1890-1980)

The primary economic catalyst for Lake Michigan's coastal lake plain region throughout most of the 20th Century has been the steel industry. The largest representatives of this industry include the U.S., the Midwest and the Bethlehem Steel works, which are still among the lakeshore's most commanding industrial sites. In addition to steel, this region is also home to major chemical-manufacturing giants, in particular Monsanto and Uniroyal.

This rapid industrial growth quickly created a plethora of social and environmental problems. First of all, these industries resulted in extremely rapid population growth in an area that was almost completely unprepared for this growth. As population groups of Mexican, Greek, Polish, and African ancestry (and others) migrated into the area, it became evident that unless drastic actions were taken, this region would quickly become an unbelievable marsh filled with literally millions of people constantly ravaged by water-borne diseases such as typhoid.

In order to keep this scenario from playing out, people from the area scrambled to drain the marshland and to install sewers. Soon, the slow, pristine, meandering Calumet was transformed into a polluted, degraded, fast-moving channel emptying untold quantities of effluent and industrial pollutants into Lake Michigan (Bogue, 1985, Mendelsohn, 1996)

Economic Transitions (1980-present)

The past twenty years have brought significant demographic and economic shifts to the tri-county area enveloping Lake Michigan's coastal lake plain region.

NIRPC reports that in general, the period from the early 1980's to the early 1990's was a time of economic decline. During this period, the steel industry, which had been the region's primary economic engine, underwent substantial restructuring. This in turn contributed to the loss of 41,000 jobs, a 5.3% decline in the region's population (751,413 in 1980 to 711,592 in 1990) and substantial declines in annual household income.

The decade of the 1990's brought marked improvements to the region's economy. Throughout this period, the region's economy shifted away from a steel-based production economy toward a more diversified and prosperous service based economy. In 1998, fully 80% of available jobs were service based. This is in sharp contrast to 1980 when service jobs constituted 60% of available jobs while production jobs constituted the remaining 40%. Unemployment rates, which peaked at 15.3% in 1983, had declined to just 3.6% in 1998. The region's population, which had declined markedly throughout the 1980's rose by fully three percent during the years between 1990 and 1998 from approximately 711,600 to 733,500 (NIRPC, 2000).

Throughout most of the 20th century, the Little Calumet-Galien watershed region has been divided between dense, urban-industrial centers within its eastern portion, (including Gary, Hammond and East Chicago), and lower density, less developed regions throughout its western portion. However, this region's population dynamics are expected to shift markedly over the next ten years. Between 1997-2007, the densest areas concentrated in the western portion of the watershed may loose as much as 85% of their population, while the more sparsely populated areas throughout the eastern portion of the watershed may grow by as much as 56%. These trends are reflective of a nationwide tendency toward urban sprawl and suburbanization (SOLAR, 1999).

Ecological Changes

The ecological resources of Lake Michigan's coastal lake plain region have been radically transformed. The principle agents of these changes have been urbanization and industrialization.

Throughout the better part of the 20^{th} century, Lake Michigan's dunes were under constant threat of destruction from excavation and sand mining, while the beaches were threatened with filling. Fully 10 square miles of land have been "reclaimed" from Lake Michigan in this manner.

Concurrent with changes to the dunes, the region's hydrology has also been impacted. Specific impacts include channelization of the Little Calumet River, the Grand Calument River and other tributaries to Lake Michigan, and the construction of drainage canals, in particular the Indiana Harbor Canal. Additional changes include drainage and filling of vast acreages of wetlands while native soil surfaces have been replaced with impermeable, urban surfaces.

Water quality has also been altered through the introduction of improper disposal of industrial wastes and sewage, uncontrolled runoff from agricultural fields and urban surfaces as well as atmospheric deposition of metals and acidic compounds.

Impacts to the region's ecology include the decimation of native plant communities as a consequence of fire suppression, European style agriculture, industrial and residential development and the introduction of non-native, weedy species. Aquatic species have been markedly impacted by pollutants and the introduction of non-native species – most notably the lamprey and, more recently the zebra mussel.

Natural Resource Protection Measures

<u>Preservation of the Dunes Environment</u>
At the same time that social and industrial forces were working against the preservation of the dune's environment, popular sentiment favoring their preservation was growing. Throughout the early part of this century organizations such as the Prairie Club of Chicago and the National Dunes Park spearheaded efforts to preserve some of the best dune specimens. Their efforts culminated in the establishment of Indiana Dunes State Park in the 1920's. The park, which encompassed 2,182 acres at this time (Troy, 1984 and Bogue 1985) was purchased at a cost of one-million dollars. The funds for purchasing the park were raised privately and through matching grants contributed by local industrialists such as Elbert Gary – founder of US Steel and Julius Rosenwalt of Sears, Roebuck and Company (Bogue, 1985).

In 1966, eight miles of shoreline were incorporated into the national park system as "Indiana Dunes National Lakeshore". The following year, part of Indiana Dunes State Park was incorporated into this park. The cost of incorporation, (one-million dollars), was raised through the private fundraising efforts of conservation groups, such as Save The Dunes Council.

The acreages of land receiving federal protection have continued to grow since 1966. By 1987 protected land had reached nearly 14,000 acres. Since then, protected areas have grown to over 15,000 acres and include fully 20 miles of beach front (Read, 1999).

The land acquisition process has been fraught with legal and political obstacles. The park's present configuration reflects this history of compromise. The major portions of the park, which abut Lake Michigan, are laced with roads and the park itself weaves around residential and industrial developments. Midwest Steel, Bethlehem Steel and NIPSCO facilities are located within the central portion of this stretch. Additional parcels separate from the main portions of the park include Calumet Prairie near Gary and the Heron Rookery in Chesterton.

Rehabilitation of the Indiana Harbor Canal

The Indiana Harbor Canal provides an excellent case history for both the destruction, and partial rehabilitation of these connective elements.

Prior to urbanization, the region corresponding with the mouth of the Indiana Harbor Canal, called the Grand Calumet River supported a substantial coastal marsh, which can best be described as a "fresh-water estuary". Historically, this area supported a substantial coastal marsh that served as an important spawning ground for many native, and commercially important fish species and provided nesting and foraging habitat for many species of migratory birds. At the present time this area has been supplanted by an artificial industrial peninsula, and as such, accommodates very little marshland.

In recent years this area's quality has improved markedly as a consequence of relatively minor procedural changes in water treatment by the East Chicago's water treatment plant. The most significant of these changes consisted of switching from the use of chlorine as a bacteriacidal agent to use of ultraviolet radiation. In the absence of chlorine, fresh-water sponges began growing inside the facility. These sponges, which frequently grow to a meter or more in diameter, were so efficient at removing pollutants and sediments from the water flowing into the sanitary canal that East Chicago's sewage treatment system was transformed from a system plagued with problems to a model system that consistently yields water that far exceeds most standards set by the EPA (Early and Gentile, 1996).

The net result of this improvement in water quality has been a marked increase in invertebrate populations, which in turn has resulted in documented increases in the relative abundance and diversity of bird and fish populations. The most remarkable development has been the growing use of the sanitary canal as spawning and hatching grounds for salmon (Early and Gentile,1996).

Nonpoint Source Pollution

Point vs. Non-point Sources

Sources of river pollution vary greatly. Pollutants may enter rivers via specific ("point") sources such as culverts, ditches, or concentrated animal feeding operations, or through diffuse ("non-point") sources caused by soil erosion and runoff from agriculture, construction and drainage activities; atmospheric deposition; road runoff; discharge of hydrocarbons from motorized watercraft; discharge of sewage from combined sewer overflow and faulty septic fields; and thermal pollution from power plants and heat-absorbing urban surfaces.

Significant Non-point Sources

The nature and type of pollutants varies depending on the source. Runoff resulting from construction, agricultural practices and sewer overflow introduce sediments and nutrients into water-ways, while road runoff introduces salts, hydrocarbons and a variety of metals – in particular copper and lead. Industrial sources are among the most diversified pollution sources. Particularly problematic industrial pollutants include phenols (in particular PCB's), ammonia, phosphorous, metals and metallic compounds as well as hydrocarbons – including greases, oils, tars and assorted fuels.

One of the more subtle forms of pollution is thermal pollution. This is particularly problematic in urban areas where pavement, roofing materials and other heat-absorbing surfaces compose a significant portion of the landscape. Power plants can also add significantly to thermal pollution of water ways. This is particularly relevant for the Little Calumet's watershed since there are several such facilities within this area.

An additional, and particularly troubling source of pollutants are contaminated river sediments. Even if all point and non-point pollution sources could be controlled, contamination from sediments would continue to migrate into the water-column. It is estimated that the Grand Calumet River and the Indiana Harbor and Ship Canal contain between four and five million cubic yards of contaminated sediments. Of these sediments, approximately 150,000 cubic yards migrate into the southern end of Lake Michigan annually (NRC, DNR, 2000).

Control and Management

In general, non-point pollution is more difficult to control than point source pollution. Whereas point source pollution, by definition, has a specific, and generally controllable source, non-point pollutants come from diffuse sources and can only be controlled or managed using systemic approaches.

Specific control measures may include restricting the amount of salts used on roadways, or requiring emissions testing in automobiles. Such controls are typically costly and are clearly outside the scope of this project. Affordable, management-oriented options that are within the scope of this project include reduction of runoff using bank-stabilization techniques, strategic placement of constructed wetlands in locations where they can capture and sequester aquatic contaminants and reconfiguration of channels to reduce flow rates and the water's ability to transport sediments (Lindsey, et al, 1993).

Base GIS Information

The following GIS data summarizes geo-referenced information used to provide a contextual framework for this study. Each layer can be used independently, or superimposed on other layers to observe trends within variously scaled geographical areas. This section is important in and of itself in that it can be used by a variety of resource managers and decision makers not only to achieve water quality goals, but to assist in natural resource planning and management, and to develop sound conservation development strategies.

Most of the information within this document is reported at the watershed (hydrologic units), subwatershed, or management unit scale rather than specific stretch of waterway or parcel. There are several reasons we chose this approach including the following:

1. Most nonpoint source pollution problems within a specific stretch of waterway are symptomatic of problems within uplands and wetlands within the contributing watershed.
2. Most of the restoration strategies used to combat nonpoint source pollution are implemented within wetlands and uplands within the contributing watershed to a specific waterway.
3. It is relatively easy to make the geographical leap to an actual stretch of waterway within a management unit (MU; these are described below), which is the highest resolution watershed unit we deal with.
4. Most of the geographical information available for the study area is at a watershed scale.
5. Most of the modeling used to measure and monitor nonpoint source pollution is at the watershed scale.
6. Using watersheds at a variety of scales allows resource managers to look at individual management units for specific treatments, or to recombine management units into larger watersheds.
7. Parcel-specific information was not generally available for the study area, and is much too detailed for a study of this scope and budget.

Hydrologic Units (HUs) and Major Drainages

The Little Calumet-Galien River Watershed includes several smaller subwatersheds. The United States Geological Survey and the state of Indiana have divided these subwatersheds into hydrologic units (HUs) of various sizes for planning and analysis purposes at the state and regional levels. The size classes include river basins (4 digit accounting units), sub-basins (8 digit cataloging units), and 14 digit hydrologic units, which are the smallest administrative unit available.

HU's can be used to define the major streams and drainages in a watershed. The major streams and rivers included in this study area (Figure 2) include:

- Grand Calumet River (001) flows west into Illinois and discharges into the Little Calumet River north of Burnham, Illinois. High flows in the River are diverted to Lake Michigan by the Lake Michigan Shoreline Industrial Harbor Canal at East Chicago, Indiana. This river has been extensively modified to manage flood flows from its urbanized watershed.

- The Little Calumet River (002) natural drainage pattern flowed west into Illinois and then routed back to the north and east and discharged into Lake Michigan at the Calumet Harbor. The Little Calumet has been extensively modified as follows: a) A flood conveyance route was constructed at Burns Ditch to allow high flows to discharge into Lake Michigan at Burns Harbor; b) with the construction of the Cal-Sag Canal and Thomas O'Brien lock and dam in Illinois, portions of the Little Calumet was modified to flow west into the Des Plaines River in Illinois through the Cal-Sag Canal with flood overflows routed to the natural outlet at the Calumet Harbor (the Cal-Sag Canal discharges into the Chicago Sanitary and Ship Canal and the Chicago Sanitary and Ship Canal discharges into the Des Plaines River). The result is a highly modified river channel with extensive controls on its flowage rates and flow patterns.

- An additional part of the watershed study area is a direct tributary to Lake Michigan (003) and outside of the study limits.

- Trail Creek (004) flows into Lake Michigan at Michigan City. The Trail Creek and Galena River systems are the two main streams within the study area which have been least affected by man-made channel construction.

- The Lubke Arm/White Ditch (005) flows into Lake Michigan north of the Indiana/Michigan border near Michigan City.

- The Galena River (006) flows into Michigan from Indiana at the northeastern corner of the study area.

Hydrologic Unit Size

Individual HUs vary considerably in size. In this study area, HUs range from 140 hectares to 8,000 hectares with an average size of approximately 4,000 hectares.

The 14 digit HU boundary, which is the highest resolution scale available, is generally used to target project activities, resource inventories, and for reporting conservation activities (Figure 3). However, the resolution of the 14 digit HU boundaries, on average, proved too coarse for purposes of this study for the following reasons: 1) Human communities are organized within smaller watershed boundaries; 2) Analysis within the 14 digit HUs does not identify small area patterns well enough to determine project-specific areas; 3) Large watershed units are often too expensive to consider for restoration while smaller areas, which the 14 digit HUs fail to pick up, can provide substantial water quality benefits.

From a landscape analysis perspective, smaller resolution watersheds provide a much more useful level of information for project implementation. Smaller units provide flexibility to address issues in the larger watershed, while still addressing the needs of a smaller watershed unit. Ideally, management units should be small enough that property owners can locate their property within the delineated basin.

Management Units (MUs)

We used models included in ArcView GIS software to divide the larger HUs into higher resolution Management Units (MU's; Figure 4).

ArcView GIS software provides tools for watershed delineation based on a flow accumulation threshold (the size of the upstream watershed draining through a specific point). Several thresholds were modeled to produce drainage basins at a variety of resolutions. A flow accumulation area of 5,000 grid cells (1,148 acres) was selected. The grid cell resolution was approximately 100 feet for a mix of Level 1 and Level 2, 7.5 minute Digital Elevation Models (DEM). (A discussion of issues related to Level 1 versus Level 2 data accuracy can be found in the DEM metadata accompanying this report.)

The MUs generated for this study (191 hectares average) are about 1/10 the size of the 14-digit HUs (4,000 hectares average).

HU boundaries created by USGS do not fit perfectly with the MUs we created for this study. In most cases, MUs can be associated to form a reasonable facsimile of the original HU. However, the ridge top boundaries created in one system will not exactly match those created in the other. There are also a number of small, sliver polygons generated during this process. These polygons are too small for management purposes and are recombined with adjacent MUs.

The results of most of the analysis for this study are summarized and mapped at higher and lower resolutions. For management purposes, these differences can be very important.

Elevation and Slope Models

We used elevation (vertical distance above MSL) and slope (angle of a landform from horizontal, or a flat plane) models based on 7.5 minute DEM data to assist in the delineation of watersheds, drainages, and management units. The results of these models can also be useful to land planners attempting to protect steep areas from inappropriate development.

Elevations range from about 176 meters on the coast to 290 meters on the southern headwaters of the study area (Figure 5). Higher slopes (Figure 6) occur immediately along the coast and along the southeast edge of the study area. Five to ten percent slopes outline some of the major drainages within the study area.

Soils Erodibility Model

Erodibility can be defined as the susceptibility of soil particles to become detached and mobilized by water. The erodibility of soils can have a substantial impact on in-stream turbidity and water quality. We used STATSGO (State Soil Geographic Database) and US EPA BASINS' soils data to determine and map the potential erodibility of soils within the study area (Figure 7).

The Universal Soil Loss Equation was used to rank and map the erodibility of soils within the study area based on a dimensionless soils erodibility factor, which is defined as the susceptibility of soil particle detachment and movement by water. The factor varies from 0.00 for non-erodible soils, to a maximum value of 0.70 for the most erodible soils in the United States. Mean soil erodibility values for the 14 digit hydrologic units were used to depict the soils erodibility potential in the smaller management units (See Figure 7).

Soils in the study area were low to moderately erodible with values ranging from 0.06 to 0.38. The most erodible soils occur in the southwestern part of the study area, and in the upper reaches of the watershed. The least erodible soils occur in the southeastern areas of the study area, and within the lower reaches of the Little Calumet River.

In most areas, the mapped erodibility correlated well with observed water clarity during the August 2000 field visits by AES staff. The Deep River watershed in the southeastern part of study area, for example, was observed to have lowest water clarity in the area (as shown on the erodibility map) with the highest erodibility potentials (0.34 to 0.38; observation site #6). Observed water clarity improved in downstream reaches (observation sites #7 and #8), where the mapped erodibility potential decreased to a moderate (0.25 to 0.34) range. However, Salt Creek was observed to have higher water clarity in the downstream reaches where erodibility potential was 0.25 to 0.34, and lowest water clarity at the upstream observation area (#12) where erodibility was generally 0.25 to 0.34. The highest water clarity occurred in the middle reach where soils erodibility increased to 0.34 to 0.38. Coffee Creek had good clarity throughout the watershed and had mapped erodibility values in the range of 0.25 to 0.34.

The clearest waters observed in the study area occurred within the upper end of the Little Calumet River, in Trail Creek, and in the Galena River at the eastern end of the study area. Erodibility of the watershed tributary to these streams varied from very low (0.06), to fairly low (0.18-0.25). The lowest mapped erosion potentials within the study area occurred in this area.

Hydric Soils

The presence of drained hydric soils is an extremely useful indicator of potential wetland restoration sites. Hydric soils were developed over geologic time and represent the historically wet areas in the study area. Although land uses change, the soils characteristics still hold the tell-tale signs of pre-development, anaerobic conditions. Except in urban areas where soils are not mapped, this measure can provide a reasonable estimate of pre-settlement wetland coverage.

Digital NRCS soils information was available only for La Porte County within the study area. Hydric soils in La Porte County were extracted from the soils GIS coverage and intersected with National Land Cover Data (NLDD) (land use/land cover data). The resulting coverage identified all hydric soils by five land use land cover classes —Developed, Barren, Herbaceous Planted/Cultivated, Forested Uplands and Herbaceous Uplands.

Only 18 percent (1,389 hectares) of the original 7,587 hectares of hydric soils in La Porte County remain as wetland or water. Approximately 82 percent of the historic wetlands have been converted to non-wetland land uses. Restorable land includes all land use classes except

Developed, Water and Wetlands. Using this criteria, 85 percent of the historic wetland area is restorable.

Table 1. Hydric Soils Land Use

Hydric Soils Classified by 1992 Land Use Land Cover Type	Parcel Count	Acres	Percent
Barren	56	50	0%
Developed	4286	4490	24%
Forested Uplands	6571	4212.5	22%
Herbaceous Upland	1349	505	3%
Herbaceous Planted/Cultivated	5478	6172.5	33%
Schrubland	126	57.5	0%
Water	898	1335	7%
Wetlands	3582	2135	11%
TOTAL	**22346**	**18957.5**	**100%**

Figure 8 indicates the extent of hydric soils within La Porte County and highlights hydric areas that are currently in open space.

National Wetland Inventory (NWI) Maps

NWI maps provide a more recent measure of wetland loss. NWI mapping has been complete since 1986. Almost 90% of the lower forty states have been mapped as of January 2000.

NWI does not provide the same quality of mapping resolution as is required of soils mapping. Many of the smaller wetlands were not mapped which results in the NWI underestimating the existing extent of wetlands.

All of the study area has NWI mapping. These digital maps were intersected with NLCD land use/land cover data. The resulting coverage includes NWI sites by 1992 land use land cover classifications. There are approximately 40,000 acres of wetlands mapped in the study area by the NWI program (Figure 9).

Table 2 . NWI Land Cover Type.

Land Use Land Cover Type	Parcel Count	Acres	Percent of Total
Barren	298	130	0%
Developed	7,451	2170	6%
Forested Uplands	27,857	14262.5	36%
Herbacious Upland	4,769	1057.5	3%
Herbacous Planted/Cultivated	14,406	4300	11%
Schrubland	178	27.5	0%
Water	4,704	3690	9%
Wetlands	26,168	13580	35%
TOTALS	85,831	39217.5	100%

FEMA Flood Data

The extent of floodplain areas are useful in identifying non-developable properties that might be available for restoration. We used FEMA's Q3 flood data to identify 100-year and 500-year floodplain areas within La Porte and Lake Counties (the only counties where this data is available).

While floodplain data should be an important theme in developing restoration priorities, we did not use it as a variable in models below due to the limited extent of the data. However, this data is useful for site-specific restoration and is available as part of the GIS metadata.

Figure 10 indicates the extent of the floodplain in La Porte and Lake counties per FEMA Q3 flood data. However, floodway information provided to this study appears to contain probable errors in coding in certain areas. Floodway boundaries generally follow irregular topographic meanderings. In this case, the boundaries are indicated as straight lines across topographic features.

Land Use and Land Cover

Since nonpoint source pollution is generally the result of land characteristics and uses within the contributing watershed, understanding land use and cover is extremely important to understanding, predicting, and mitigating for nonpoint source pollution.

We used National Land Cover Data (NLCD) to generate land use and land cover (LULC) boundaries for the study area (Figure 11). A classified digital image file was downloaded and converted to generate the land use, land cover boundary file. The image file was converted to an Arc grid file, and polygon boundaries were generated from the grid classification. NLCD Land Cover Classification System codes were extracted from an attached file and linked as polygon attributes.

The U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (USEPA) worked together to produce land cover data layer based on 30-meter Landsat thematic mapper (TM) data. The Multi-resolution Land Characterization (MRLC) Consortium, a partnership of federal agencies that produce or use land cover data, purchased and processed the TM data in 1992. Additional information about the dataset can be found in the NLCD_Note to use.htm in the metadata accompanying this report and from the MRLC Regional Team at (605) 594-6114 or mrlc@edcmail.cr.usgs.gov."

Measures of Urbanization

Urbanization is perhaps the most significant factor affecting nonpoint source pollution. Several studies have reported a significant drop in water quality and biological diversity within watersheds where the percent impervious cover exceeds 10%.

As land is developed, the increased number of buildings and roads create a greater amount of impervious surface area that does not allow water to infiltrate into the soil. Impervious surface is a characteristic of an urban or urbanizing area and contributes to water quality degradation. As impervious surface increases, runoff increases, the severity of flooding increases, and water quality decreases. Impervious surface can also be used as an indicator of water quality.[1]

Impervious area varies in percent cover according to development type. The Soil Conservation Service (now the NRCS) offered the following guide: shopping center properties are 95 percent impervious, commercial property are 85 percent impervious, and industrial properties are 75 percent impervious. These land uses are followed by residential properties where residential lots range from 65 to 20 percent impervious, depending upon the size of the lot. [2]

According to Arnold and Gibbons, water quality is affected when the percent impervious area is less than 10 percent. Watersheds that range between 10 and 30 percent impervious are considered "impacted." Watersheds with greater than 30 percent impervious layer are considered seriously degraded.

Higher quality wetlands can be severely degraded by impervious surface runoff. Conversely, bio-filtration and flood control wetlands can be used to mitigate the impacts of impervious surface runoff. Both wetland issues should be considered in a developing watershed.

The following sections discuss various Measures of Urbanization that were considered in developing three development classes (Rural, Urban and Transitional) that will be described in a later section. We also used this information to develop a system to prioritize and rank watersheds and management units for preservation and restoration.

Percent Developed

NLCD (1992) land cover classifications were used to help determine the percent of each HU and MU that were developed by combining and summing the developed land classes (Commercial/Industrial/Transportation, High Intensity Residential, Low Intensity Residential).

---

[1] Chester L. Arnold and James Gibbons, "Impervious Surface Coverage, the Emergence of a Key Environmental Indicator, *American Planning Association Journal* (Spring 1996): 243-245.

[2] Ibid., 247

Highly developed HUs are shown in darker colors. More development generally occurs along Lake Michigan, in the western portions of the study area, and around Gary. Areas around Hobart, Merrillville, and Valparaiso are also highlighted.

Developed lands are summarized by HU (Figure 12) and by MU (Figure 13), and indicate important differences in the resolution between the two summary units. Percent developed cover values within the HUs ranged from less than 1 percent developed to sixty-nine percent developed. The higher resolution of the MUs significantly refines the distribution pattern of developed areas so that percent developed cover values in MUs range from 0 to 100 percent. The difference in resolution can have a significant impact in assessing and in prioritizing management strategies.

Urban Areas (1990 TIGER Data)
The US EPA BASINS database includes an urbanized area map generated from 1990 TIGER line data. The model used to generate the map relies heavily on census place boundaries "which may have high population densities, significant water quality monitoring information and significant discharge." Additional information about the coverage can be found in the EPA BASIN metadata. A map of the urbanized area (Figure 14) and highway system shows highest urban concentrations in the western portion of the study area.

Census Data
1994 TIGER census place data includes incorporated towns and cities, as well as other areas identified by the Census Bureau as a Census Designated Place (CDP). A CDP "is either legally incorporated under the laws of its respective state, or identified by the Census Bureau as a Census Designated Place (CDP)".

CDPs represent important population concentrations that are within as well as outside of incorporated areas. However, these boundaries have not been subjected to the same review as the EPA BASINS urban areas. Additional information on "census place" can be found in the subcodoc.txt file accompanying this study.

A review of the census place coverage extends the urban area east of Merrillville and Crown Point, and also further east along the coastline to the Michigan City area (Figure 15).

Population Estimate (2002)
With sub-urbanization, population concentrations are often found outside of urban centers. Figure 16 illustrates entire census block group boundaries even where they extend beyond the watershed boundary. We have shown the entire block group boundaries because there is no reasonable way to estimate what percent of the population is inside or outside of the study area.

In general, census block group data show raw population concentrations outside of the northwest industrial center. Higher concentrations are found around Portage, west of Merrillville, and in the vicinity of Valparaiso.

Please note that block group areas vary considerably and concentrations shown here may be misleading.

Figure 17 illustrates relative population density (population per hectare) using block group data. This measure is most sensitive in the smaller management units, but may miss similar concentrations in the larger units. Figure 17 illustrates that industrialized areas to the northeast are losing population, while concentrations are increasing in suburbanizing areas.

Population Projections

Population projections are perhaps the best way to predict areas of future growth. Figure 18 indicates projected population losses in more urbanized areas, and increases across agricultural lands in the vicinity of Merrillville, Valparaiso, and north and east of Valparaiso.

It is important to note that census tracts and block group boundaries do not fit well into the watershed modeling schemes used in this study. Block groups and 14-digit HUs or MUs do not follow common boundaries. Population information presented in figures above are important for overall understanding of the greater demographic characteristics of the region, but population information is not comparable with other watershed-based information.

Roads as Indicators of Impervious Surface

The density of roads within a given area is an ideal index to urbanization, the amount of impervious surface, hydrologic segmentation, and ultimately, water quality. In general, urbanization, the amount of impervious surfaces, and hydrologic segmentation increase with road density, while water quality decreases with road density. Studies indicate that 19 percent of the land in urban areas is paved roads.

Road density measurements are particularly useful in that road densities are independent of population measures. For example, population estimates may show declining population within a weakening industrial area, which may suggest that the level of development in that area is decreasing. The density of roads in these areas, however, would still be high. This is important because the amount of impervious surface in these areas losing population would still be high.

The impacts of roads on watersheds are summarized as follows:

1. Roads act as dikes and dams and break the natural drainage patterns into artificially segmented hydrologic units.
2. Roads contain and direct water into and out of artificial systems through culverts, bridges and ditches. This water is often surcharged, or taken from, natural resources such as wetlands.
3. Roads provide access to industrial, commercial, residential and agricultural centers and are therefore a good index of the degree of development (and impervious area) within a study area.
4. Several studies associate increased water quality impairment with increased impervious area. Roads are an index to the amount of impervious area.
5. Roads create vast stretches of impervious surface (19 percent in urban areas) that contribute to non-point source pollution.

It is important that state and local land management organizations and agencies develop a highway benchmark to measure change over time. It is also important for highway mapping organizations to begin adding construction dates to all new GIS highway data. Interested parties could then calibrate runoff models based on the total distance of road within a given drainage basins.

Road density values were calculated using road centerline data from U.S. Department of Commerce TIGER/Line Files (1995). Linear road miles were summed per each MU and divided by the area of each MU to calculate road density per MU.

Figure 19 indicates road density (road distance as a percent of the total study area) within 14D HUs. Figure 20 indicates road density (road distance within each MU as a percent of the total study area) within MUs. Table 3 indicates road densities within three land development categories generated by this study (Rural, Transitional and Urban) which will be described in more detail below.

Table 3: Average road density per development category.

Urban, Rural and Transitional	**Average Density** (meters/ hectare)	**Standard Deviation**	**Minimum Density** (meters/ hectare)	**Maximum Density** (meters/ hectare)
Rural 1	**12.6172**	6.3984	1.0175	27.1161
Rural 2	**16.6634**	7.0328	1.4016	34.3278
Rural 3	**21.6795**	9.4494	4.0543	51.8990
Trans 1	**24.6969**	14.9430	2.6083	79.7287
Trans 2	**26.2594**	11.1590	1.2327	46.0943
Trans 3	**34.4287**	17.9002	10.2202	82.6915
Urban	**65.3993**	32.2071	3.6925	146.7122

Agricultural Lands

Traditionally, agricultural lands have surrounded urban centers to support those centers. Farmland surrounding urban centers has become a prime target for developers. As such, the location of agricultural lands are a good representation of current or future transitional lands.

The location of agricultural lands provided several pieces of information used in this study including the following:

1) Agricultural land in close proximity to areas of projected population growth were used to help define our Transitional land use category described in a subsequent chapter;
2) The presence of agricultural lands within areas targeted for restoration or protection were used to assist in prioritizing key watersheds;
3) Agricultural land uses give insight as to the causes of certain nonpoint source pollutants discussed in the Water Quality chapter;

4) Agricultural lands can be overlayed with floodplain and hydric soils maps to target for acquisition, protection or restoration;
5) In many cases, agricultural lands provide some of the least expensive restoration opportunities within large parcels of property. Agricultural land uses can be compatible with BMP's to improve water quality.

The "agriculture" classes appear to capture agricultural lands reasonably well. Open pasture and cultivated lands are easily differentiated from "forest" and "developed" land use classes.

Percent cover of agricultural land was calculated for each MU (Figure 21) and HU (Figure 22). Darker units have proportionally higher agricultural acreage. Values ranged from 0 where there was no agricultural land, to 1 where the land is 100 percent agricultural. In general, areas of highest agricultural use were found around Crown Point.

<u>SOLAR Development Risk</u>
The Open Lake Institute attempted to measure the risk to development in their 1998 study. While the result of their investigation was not directly used to develop the three land use categories used in this study, it is useful to compare SOLAR results with the results of this study. In general, high risk areas defined by SOLAR are similar to areas defined in this study as "Transitional". We believe the land category results presented in Figure 25 refine the general boundaries expressed by SOLAR.

An image of the SOLAR map publication "Under Pressure" was scanned and fitted to the UTM16 (NAD83) coordinate system (Figure 23). The image was classified into four categories—High Risk, Medium Risk, Low Risk and Permanent Open Lands. These boundaries were converted into polygon boundaries. A GIS "union" of the resulting file was generated from combination with the 14 digit hydrologic units (HU14) and the management units (MU). Percent cover was calculated for each HU14 and MU boundaries and for each risk category. A calculated field combining and weighting the risk factors by HU and MU was generated. The formula used was [2 * (high risk percent cover)+ (medium risk percent cover)], doubling the significance of the high risk values over the medium risk values. These numbers were then normalized to show relative risk values from 0.00 to 1.00.

High Risk, Medium Risk, and Low Risk areas are summarized at Figure 24. Permanent Open Space areas are shown under the Restoration Opportunities Chapter.

Land Use Categories (Urban, Rural, Transitional)

Different land uses affect water quality within a watershed in different ways. Urban land uses, for example, have been highly associated with degraded water quality, while rural land uses have relatively less of an impact on water quality. Lands in transition from rural uses to urban uses may have a negligible affect on water quality during early development, but have a very high potential to degrade water quality if you consider ultimate build out conditions.

It is therefore useful to look at a watershed in terms of known land uses (existing **urban** and **rural** land uses), as well as projected land uses (rural lands **transitioning** into suburban or urban conditions).

Many investigators have quantified urbanization based on percentage of impervious land cover. However, the land cover data available for this study area proved to be too coarse for a useful classification, and it is often a confusing measure for land planners and local governmental organizations to understand. Population data, which is available for the study area, can also be used to quantify urbanization in a way that is easily understood.

We used a population-based spatial model to calculate population per hectare for each MU within the study area. We then categorized each MU into one of three land use categories (Urban, Rural or Transitional) based on population per hectare. This protocol is consistent with a widely recognized paper prepared by Dennis Dreher of the Northeastern Illinois Planning Commission (NIPC) titled "Watershed Urbanization Impacts on Stream Quality Indicators in Northeastern Illinois" (1996). Esseks (1999) reported similar results in the paper "Fiscal Costs and Public Safety Risks of Low-Density Residential Development on Farmland: Findings from Three Diverse Locations on the Urban Fringe of the Chicago Metro Area".

We used the following protocol:

1. Raw population data available for the study area is based on population per census block group rather than on population per hectare, or watershed boundary. We therefore had to convert block group data into density per acre, square mile, and MU. We assumed for this model that population is evenly distributed across a block group.
2. **Urban Land Uses**: The U.S. Census Bureau defines an urban area as an area that consists of a "contiguous territory having a density of at least 1,000 persons per square mile."
3. **Transitional Land Uses**: This category includes lands in transition from rural land uses to suburban or urban land uses with a population of 300-1,000 people per square mile. Dreher (1996) used the same density measurement for transitional lands. Esseks (1999) reported similar results in the paper "Fiscal Costs and Public Safety Risks of Low-Density Residential Development on Farmland: Findings from Three Diverse Locations on the Urban Fringe of the Chicago Metro Area".
4. **Rural Land Uses**: This category includes rural areas with populations from 0-300 people per square mile, which is consistent with the densities Dreher (1996) used.

Figure 25 illustrates the three land use categories described above.

Natural Resources

The Galien-Calumet watershed is ecologically complex. The watershed's close proximity to Lake Michigan to the north and the (now drained) Kankakee swamp to the south allows for the co-existence of startlingly diverse habitats, including beaches, dunes, wetlands, forests and rivers – all within a space of just slightly more than 900 square miles. This juxtaposition of highly disparate habitat types makes this region globally significant. Indiana Dunes National Lakeshore contains over 1,400 vascular plant species, over 90 of which are on Indiana's threatened or endangered list. According to the U.S. Park Service, Indiana Dunes National Lakeshore ranks seventh among national parks for overall native plant diversity (NPS, 2001).

Among the rich habitat types within the study area wetland areas are particularly susceptible to degraded water quality. While wetlands are often referred to as the "kidneys" of a natural system due to their ability to filter, contain, and transform nutrients, excessive levels of nutrients tend to drive biologically diverse wetland plant communities toward weedy species. As a result, emergent marshes tend to become dominated by monocultures of narrow leaved cattail or phragmites; sedge meadows are replaced with reed canary grass; and bottomland forests are replaced with sandbar willow and box elder. Many investigators have also found that animal diversity tends to decline as plant diversity declines.

The following is a summary of important natural communities that occur within the study area, important species and natural areas, as well as the potential affect degraded water quality can have on these communities.

Natural Communities

<u>Beaches</u>

Beaches (or "strand-plains") throughout Lake Michigan can be found in association with both lakes and rivers. By far the most significant of these features are the vast expanses associated with Lake Michigan's shoreline.

Approximately 45 miles of Lake Michigan's shoreline is located within Indiana. Prior to European settlement this undeveloped region consisted mostly of sand and cobble beaches. As this region became increasingly urbanized during the 19th and 20th centuries a substantial portion of the shoreline was filled. To date, approximately 10 square miles of fill ("made land") have been installed along the shoreline (IDNR, 1994).

With the establishment of Dunes National Lakeshore in 1966, approximately 20 miles of beachfront have been protected as permanent open space.

Lake Michigan's beaches are notoriously harsh places for vegetation to become established. On calm, summer days when the waves are low, the loose, sandy or gravely substrate is well drained and, at least in the top few inches, very dry. During storm surges, these same areas may be inundated to a depth of several feet. Highly variable moisture regimes, combined with wave action, greatly limit the type and amount of vegetation present.

Despite the paucity of plant species, these environments provide critical habitat for a wide variety of shorebirds and the invertebrates upon which they feed. Beach-reliant avian species found along Indiana's lakeshore include: Willet, Whimbrel, Marbled Godwit, Ruddy Turnstone, Semipalmated Sandpiper, Least Sandpiper, Baird's Sandpiper, Pectoral Sandpiper, Purple Sandpiper, Dunlin and Buff-breasted Sandpiper.

<u>Dunal and Interdunal Habitats</u>

Indiana's dune and swale region extends southward from Lake Michigan's shoreline for a distance of between 10 and 15 miles.. This region consists of four bands corresponding to Lake Michigan's contemporary and prehistoric strand-plain limits. The most recent (and northerly) of these dunes demarcate the southern limits of Lake Michigan's current strand-plain. The Tolleston beach dunes, which are located immediately south of the shoreline's dunes, demarcated Lake Michigan's southern strand-plain limits between 5,000 and 9,000 ybp. The Calumet beach dunes, which are located south of the Tolleston dunes were formed between 9,000 and 12,000 ybp, while the oldest and most southerly of the dunes, the Glenwood beach dunes, were formed between 12,000 and 14,000 years ybp. (Wiggers, 1997, IDNR 1976).

The dunes that grace Lake Michigan's strand-plain vary from just a few feet in height, to as much as 200 feet in height. Some of the most impressive dunal features include Mt. Baldy, which is protected as part of Dunes National Lakeshore near Michigan City, the Hoosier Slide, (which was excavated near the turn of the century and now hosts NIPSCO's power plant), and Ogden Dunes, which are protected as part of Dunes National Lakeshore's West Beach.

The Tolleston beach dunes, although technically paleo-dunes, lie close to the contemporary dunes and, in some cases, are nearly indistinguishable from their contemporary counterparts. Dunes from the Calumet beach phase are weathered, mound-like features that seldom attain heights greater than 50 feet. The Glenwood beach dunes, being the oldest, are also the most weathered and generally rise only 10 to 30 feet above the surrounding landscape.

Comparisons between the fore-dunes, back-dunes and the paleo dunes provide a surprisingly clear window into ecological succession. The foredunes and, in some cases even portions of the beach, are dominated by low-growing, herbaceous species that are able to tolerate frequent disturbances including, but not limited to, highly variable soil moisture, erosion and fires. With the exception of eastern cottonwood (*Populus deltoides*), trees are not typically found in these areas. Species typically associated with these areas include the following:

Herbaceous species

Sand cress	*Ammophila breviligulata*	Bugseed	*Corispermum hyssopifolium*
Marram grass	*Andropogon scoparius*	Winged pigweed	*Cycloloma atriplicifolium*
Little bluestem grass	*Arabis lyrata*	Canada rye grass	*Elymus canadensis*
Bearberry	*Arctostaphylos uva-ursi*	Seaside spurge	*Euphorbia polygonifolia*
Beach wormwood	*Artemisia caudata*	Hairy puccoon	*Lithospermum croceum*
Common milkweed	*Asclepias syriaca*	Wild bergamot	*Monarda punctata*
Butterfly weed	*Asclepias tuberosa*	Common evening primrose	*Oenothera biennis*
Sea rocket	*Cakile edentula*	Eastern prickly pear	*Opuntia humifusa*
Sand reed	*Calamovilfa longifolia*	Dune goldenrod	*Solidago racemosa gillmanii*
Dune thistle	*Cirsium pitcheri*	Showy goldenrod	*Solidago speciosa*

Trees, Vines and Shrubs

Climbing bittersweet	*Celastrus scandens*	Early wild rose	*Rosa blanda*
Red-osier dogweed	*Cornus stolonifera*	Pasture rose	*Rosa carolina*
Eastern cottonwood	*Populus deltoides*	Dune willow	*Salix syrticola*
Sand cherry	*Prunus pumila*	Starry false solomon's seal	*Smilacina stellata*
Wafer ash	*Ptelea trifoliata*	Summer grape	*Vitis aestivalis*
Fragrant sumac	*Rhus aromatica*	Riverbank grape	*Vitis riparia*
Poison ivy	*Rhus radicans*		

The back dunes are generally more stable than the foredunes and beaches. Plants within these areas, although historically subject to fire, are not subjected the erosive forces associated with the foredunes, or the extraordinarily variable moisture regimes of the beach region. One of the most prominent differences between the foredunes and the back dunes is the relative abundance and diversity of tree species. Whereas trees within the foredunes are primarily restricted to a few scattered cottonwoods, the back-dunes often contain a substantial number of trees and other woody species. Some of the woody species generally associated with the back dunes are listed below.

Vines and Shrubs

Serviceberry	*Amelanchier arborea*	Choke cherry	*Prunus virginiana*
Running strawberry bush	*Euonymus obovatus*	Elder berry	*Sambucus canadensis*
Box huckleberry	*Gaylussacia baccata*	Red berried elder	*Sambucus pubens*
Witch hazel	*Hamamelis virginiana*	Early low blueberry	*Vaccinium angustifolium*
Spicebush	*Lindera benzoin*	Highbush blueberry	*Vaccinium corymbosum*
Virginia creeper	*Parthenocissus quinquefolia*	Maple-leaved arrow-wood	*Viburnum acerifolium*

Trees

Sugar maple	*Acer saccharum*	White pine	*Pinus strobus*
Blue beach	*Carpinus caroliniana*	Jack pine	*Pinus banksiana*
Bitternut hickory	*Carya cordiformis*	Black cherry	*Prunus serotina*
Shagbark hickory	*Carya ovata*	White oak	*Quercus alba*
Flowering dogwood	*Cornus florida*	Red oak	*Quercus rubrum*
Beech	*Fagus grandifolia*	Black oak	*Quercus velutina*
White ash	*Fraxinus americana*	Sassafras	*Sassafras albidum*
Tulip tree	*Liriodendron tulipifera*	American linden	*Tilia americana*
Hop hornbeam	*Ostrya virginiana*		

The interdunal regions contain a wide variety of wetland types. The most distinctive of these in terms of species composition are interdunal ponds, bogs, marshes and swamps.

Interdunal Ponds – The USFWS' classification system for wetlands would generally classify interdunal ponds as complexes of open water and emergent wetland. The edges of these ponds are generally dominated by emergent vegetation, while the centers, or areas which have been cleared out through muskrat activity, consist of open water or aquatic beds.

The water in these features is filtered through sand and, as such, is highly oligotrophic. One species found in these ponds that is particularly well adapted to low nutrient availability is bladderwort (*Utricularia cornuta*). This species compensates for low nutrient availability by capturing aquatic organisms in tiny bladders affixed to floating, root-like filaments. Some of the other species found within these features are included below.

Herbaceous species

Short green milkweed	*Asclepias viridiflora*	Hair beak rush	*Rhynchospora capillacea*
Stiff aster	*Aster ptarmicoides*	Rose gentian	*Sabatia angularis*
Twig rush	*Cladium mariscoides*	Chairmaker's rush	*Scirpus pungens*
Fringed gentian	*Gentiana crinita*	Great bulrush	*Scirpus validus*
Purple gerardia	*Agalinis purpurea*	Nodding ladies tresses	*Spiranthes cernua*
Kalm's St. John's wort	*Hypericum kalmianum*	Common bog arrow grass	*Triglochin maritima*
Lake shore rush	*Juncus balticus-littoralis*	Narrow-leaved cattail	*Typha angustifolia*
Small yellow flax	*Linum medium texanum*	Broad-leaved cattail	*Typha latifolia*
Bog lobelia	*Lobelia kalmii*	Horned bladderwort	*Utricularia cornuta*
Common water horehound	*Lycopus americanus*		

Shrubs and Vines

Red-osier dogwood	*Cornus stolonifera*	Sandbar willow	*Salix interior*
Sand cherry	*Prunus pumila*	Dune willow	*Salix syrticola*
Blue-leaved willow	*Salix glaucophylloides*		

Trees

Eastern cottonwood	*Populus deltoides*

Unfortunately, these ponds, and many of their species are highly sensitive to pollution. Addition of nutrients to these waters tends to enhance the viability of blue-green algae and non-natives such as Eurasian water milfoil (*Myriophyllum spicatum*) at the expense of native species specifically adapted to oligotrophic conditions – such as bladderwort.

Bogs – are both ecologically and geologically peculiar features. The bogs within Lake Michigan's southern rim formed as a consequence of glaciation. As glaciers proceeded through seasonal cycles of advance and retreat, large masses of ice left by glacial retreat were buried when the glaciers readvanced. When this process occurred in clayey soil, "pot-holes" or "kettles" with minimal flow-through or infiltration developed.

Over time, these ponds became filled with continually saturated, decomposing vegetation. This in turn led to reducing (acidic) conditions and low nutrient availability. Specialists within this environment include Sphagnum moss (*Sphagnum* spp.), and several species of carnivorous plants, including the pitcher plants (*Sarracenia* spp.) and sundews (*Drosera* spp.).

Herbaceous Species

Grass pink	*Calopogon pulchellus*	Buckbean	*Menyanthes trifoliata*
Moccasin flower	*Cypripedium acaule*	Royal fern	*Osmunda regalis*
Narrow-leaved sundew	*Drosera intermedia*	Grass of Parnassus	*Parnassia glauca*
Round-leaved sundew	*Drosera rotundifolia*	Snake-mouthed orchid	*Pogonia ophioglossoides*
Marsh shield fern	*Dryopteris thelypteris*	Pitcher plant	*Sarracenia purpurea*
Orange-fringed orchid	*Habenaria ciliaris*		

Shrubs and Vines

Bog rosemary	*Andromeda glaucophylla*	Early low blueberry	*Vaccinium angustifolium*
Leatherleaf	*Chamaedaphne calyculata*	High bush blueberry	*Vaccinium corymbosum*
Box hackberry	*Gaylussacia baccata*	Large cranberry	*Vaccinium macrocarpon*
Poison sumac	*Rhus vernix*	Small cranberry	*Vaccinium oxycoccos*

Trees

Dwarf birch	*Betula pumila*	White pine	*Pinus strobus*
Tamarack	*Larix laricina*		

A prime example of a bog within this area is "Pinhook bog". This feature, which is preserved as part of Dunes National Lakeshore, contains a remarkable 22 threatened and endangered plant species.

Swamps – The Calumet Lacustrine Plain contains over 30 square miles of forested wetlands. For the most part these areas consist of floodplains and bottomlands dominated by relatively low quality species such as eastern cottonwood, willows, box elder and silver maple. Less frequent habitats include forested fens and tamarack-dominated bogs.

Other species which may dominate these areas include: aspen, paper birch, red maple, yellow birch, sycamore and tamarack.

Marshes – "Marshes" is a general term used to describe emergent wetlands that are inundated throughout most of the growing season. In general, marsh vegetation is divided between shallow emergents, deep emergents. Shallow emergents include species such as cattail (*Typha* spp.), bulrush (*Scirpus* spp.) and sedges (*Carex* spp.) grow in water that is typically less than three feet in depth. Deep emergents include species such as lotus (*Nulumbo* spp.) and water lily (*Nuphar* and *Avena* spp), which grow in water that is typically over three feet in depth. Emergent features throughout Lake Michigan's southern rim region include both estuarine features, in particular the "Great Marsh" partially protected as part of Indiana Dunes National Lakeshore, as well as smaller inland features (*Stewart et al., 1997*).

Coastal Marshes
Non-tidal, palustrine wetlands compose the vast majority of the wetlands within the study area. The largest of these features is known as the "Great Marsh". This feature once extended all the way from Gary to Michigan City, and encompassed an area equivalent to nearly 13 square miles. Drainage and filling have markedly reduced the size and quality of this marsh. Prior to European settlement the marsh contained large expanses of bluejoint and sedge dominated communities. At the present time the Great Marsh consists of approximately 1,500 acres of mostly cattail-dominated emergent wetlands.

This area is partially protected as part of Dunes National Lakeshore and, as such, offers considerable opportunity for restoration.

Woodlands – In general, the soils throughout Lake Michigan's southern rim region are droughty and rated as "poor" for the growth of trees. Despite this, microhabitat conditions, such as streams, remnant dunes, or high soil moisture content frequently offered sufficient protection from the annual prairie fires to allow for the development of moderate densities of trees. Although "forests" are not particularly uncommon in this area, they are principally an artifact of fire suppression. Historically, trees would assume sparser, fire-mediated "savanna" configuration (Crankshaw, et al, 1965).

Then, as now, black oak (*Quercus velutina*) and, to a lesser extent white oak (*Q. alba*) were the predominant oak species. Although black oak is substantially less resistant to hot ground fires than Burr Oak (*Quercus macrocarpa*), its ability to resprout damaged or burned limbs makes it particularly adept at surviving crown fires (Crow, 1988). These crown fires, while not killing all the trees, lent them a "stunted" appearance.

Other species likely to occur in association with these woodlands included jack pine (*Pinus banksiana*), only extremely close to Lake Michigan, particularly where fires were intense enough to top kill the competing oaks, as well as shade tolerant understory species such as black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), tulip poplar (*Liriodendron tulipifera*) and black walnut (*Juglans nigra*) (Petty and Jackson, 1966).

Prairies – Prairies within the counties immediately abutting Lake Michigan fall into roughly five discrete communities (Petty and Jackson, 1966). These communities, which are named on the basis of their dominant grasses, are as follows:

1) Big bluestem (*Andropogon gerardii*) – this community typically dominated lower moist slopes and the better aeriated portions of lowlands;
2) Little bluestem (*Andropogon scoparia*) – which is best expressed in well-drained portions of slopes and ridges.;
3) Poverty – bluegrass (*Aristida spp.*, and *Poa pratensis*) – which are best representented in steep, erosion prone areas;
4) Prairie dropseed (*Sporobolis heterolepis*) which dominates the mid to lower portions of slopes; and
5) Slough Grass (*Agropyron spp.*), which is generally associated with wet prairie.

Herbaceous species within these regions are broadly divided into three groups: Matrix species, which are predominantly grasses; Interstitial species, which are predominantly forbs; and Ruderal species, or annuals, which may be either grasses or forbs.

The grasses which predominantly compose the Matrix species of Indiana's prairies show a distinctive suite of physiological characteristics, which complement the stresses of their environment and differentiate them from the majority of grasses associated with contemporary residential and agricultural landscapes. In general these species are perennial, warm-season grasses that utilize a "roots first" growth strategy and C-4 metabolism.

When plants are exposed to fire, the above ground portion invariably suffers more extensive damage than the below ground portion. When fires occur in the spring, cool season annuals, such as crabgrass (Digitaria spp) and foxtail (Setaria spp.) which allocate a significant portion of the resources toward producing above-ground structures early in the growing season are quickly eliminated. On the other hand, when fires are suppressed, cool season grasses are given a distinct competitive edge over warm season grasses.

Interstitial species are typically forbs. As their name implies, these species grow amidst the matrix grasses and generally, but certainly not always, compose a smaller portion of a prairie's biomass. Within contemporary Midwestern prairies interstial forbs rarely attain densities greater than 5% (Petty and Jackson, 1966), but given appropriate disturbance regimes, in particular grazing by ungulates, the percentages may become much higher – possibly even to the point where interstitials and ruderals out-mass the grasses.

"Ruderal" is a general term for plants which grow in disturbed, or "waste" places. Within the prairies of yesteryear, such species were often relegated to microhabitats such as buffalo wallows, or gopher mounds. Today, however, native and non-native ruderals have come to play greatly expanded roles within the residential and agricultural landscapes. Many species of ruderals are shallowly rooted and, as such, are readily eliminated by fire.

In general, each of the three types of disturbance necessary to prevent many of the region's natural areas from returning to a woodland condition (fire, grazing by ungulates and localized disturbances such as herbivory from fossorial vertebrates, or trampling and wallowing by buffalo) effect matrix species, interstitial forb species and annuals differently. Grazing by ungulates, in particular the American bison (*Bison bison*) primarily affects graminoids, thereby increasing the space available for interstitial species. Fire, on the other hand, may increase the dominance and competitive ability of some matrix species at the expense of annuals and interstitials. Small scale animal disturbances, such as gopher mounds or buffalo wallows, may destroy matrix species and expose soil which is then colonized by annuals (Collins and Gibson, 1990).

<u>Woodlands and Prairies</u>
The Indiana counties immediately south of Lake Michigan are all part of a general region known as the "prairie peninsula" (Transeau, 1935). This area, which extends through Indiana to as far east as Pennsylvania and as far south as Kentucky and Tennessee, is essentially an archipelago of

shifting prairie “islands” within a matrix of forest. As one travels from west to east, or north to south within this region, forest cover gradually increases at the expense of prairie.

Preserving and restoring native woodlands and prairies are important not just to enhance biodiversity, but because of the important role these native species play in maintaining and enhancing water quality.

The deep roots of native woody and herbaceous prairie plants provide paths for water to infiltrate into the ground. This not only reduces runoff volume, but captures many of the nutrients that would runoff into streams and rivers. Prairie plants also have a dense network of roots that help hold soil in place and prevent erosion.

Wetlands: Definition, Classification and Distribution

Wetlands are defined by the Fish and Wildlife Service as:

> “…lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water [meaning that]…1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3.) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.” (Cowardin, 1979)

Northwestern Indiana is fortunate to have an abundance of wetlands. These features play many critical roles in the regions ecology and economy. Some of these roles include:

1.) Providing habitat for many species of fish and wildlife
2.) Providing critical habitat for a wide range of plant species, including a high percentage of Indiana’s threatened and endangered species
3.) Regulating the movement of ground and surface water by providing storage for floodwater and groundwater infiltration areas.
4.) Improving of water quality through sequestation and / or conversion of potentially harmful organic and inorganic compounds.
5.) Providing recreational opportunities, including hunting, fishing and wildlife observation
6.) Providing research opportunities for students and scientists

According to the U.S. Fish and Wildlife Service’s National Wetland Inventory (1986) approximately 11%, or 65-68 square miles of Lake Michigan’s southern rim consists of wetlands (IDNR, 1994). Specific sub-types include:

1) Emergent wetlands, including estuaries, coastal marshes, and inland wetlands;
2) Shrub-scrub wetlands, including shrub swamps and bogs;
3) Forested wetlands, including wooded swamps and bottomland hardwood forests;

4) Aquatic beds; and
5) Mudflats and other wetlands with unconsolidated bottom material.

The total area encompassed by each wetland type is summarized in Table 4.

Table 4. Total area of Wetlands within the Calumet Lacustrine Plain by type.

Wetland Classification		**Num-ber**	**% of Total**	**(sq. mi. & Ha.)**	**% of Total**
System	**Class**				
Palustrine	Forested	1,543	21.3	31.1 (8,060)	45.8
	Scrub-shrub	430	5.9	4.9 (1,270)	7.2
	Emergent	2,758	38.1	20.5 (5,310)	30.1
	Aquatic bed	303	4.2	1.0 (260)	1.4
	Unconsolidated bottom / shore	2,058	28.4	5.2 (1,350)	7.7
Riverine	Unconsolidated bottom / shore	35	0.5	1.2 (310)	1.7
Lacustrine	Emergent	1	<.1	<.1 (<26)	0.1
	Aquatic bed	1	>.1	0.1 (<26)	0.1
	Unconsolidated bottom / shore	113	1.6	4.0 (1040)	5.9
TOTAL		**7,242**	**100**	**68 (17,650)**	**100**

*IDNR 1994

Fish Communities

The Little Calumet-Galien River Watershed once supported a fish fauna as rich as its terrestrial communities. While investigators have had difficulty reconstructing presettlement fish communities within the study area, biologists are fairly certain that much of the diversity has been lost. Simon and Stewart (1999) report that the number of native species within the southern Lake Michigan basin has declined 22% since European settlement. The remainder of this section relies heavily on and Simon and Stewart's 1999 paper documenting the reasons for declines in native fish species, and includes recommendations for the restoration of native fish communities.

It has long been known that the health of streams and its associated fauna depends on the health of the contributing watershed. Fish habitat within the Little Calumet-Galien River watershed has been impaired by a variety of factors including channelization, water quality degradation, toxins and agrichemicals, sedimentation, wetland drainage and filling, deforestation, and the introduction of exotic species (e.g. lamprey, alewife, carp). Spawning and nursery areas have been altered or destroyed. Degraded habitat has favored tolerant species (species that increase in abundance under degraded conditions) over intolerant species (species sensitive to changes in water and habitat quality).

As with restoration of terrestrial ecosystems, successful restoration of aquatic habitats requires an understanding of "baseline" conditions. Ideally, historical records and remnant sites in pristine condition are used to establish baseline conditions. However, historical data for Lake Michigan and its associated watershed are scarce prior to 1950, and there are no remaining pristine sites within the study area. Nonetheless, Simon and Stewart (1999) were able to make several important observations:

- The number of native species within the studied area has declined by 22% since presettlement times. This declining trend is also found in the adjacent Maumee River watershed where natives have decreased by 44%, and in the Illinois River watershed where natives have decreased by 67%.
- Greater fish diversity was found in privately held lands than in publicly held lands. This suggests that publicly held lands are not serving as refugia for the remainder of the unprotected watershed.
- Public waterways are often stocked with game fish for sportsman. Simon and Stewart (1998) suggest that stocking may contribute to reductions in native fish diversity.
- The Galien River watershed was the only watershed studied where tributaries did not contain exotic species. This makes the Galien River watershed an important watershed to keep free of exotics.
- The highest quality riverine habitats measured by Simon and Stewart (1999) included Reynolds Creek, which is in the headwaters of the East Branch of the Little Calumet River, and the Little Calumet River upstream of Mineral Springs Road. Simon and Stewart (1999) recommend that these areas be used as restoration models, and sources for recolonization.
- Extensive habitat restoration will be necessary to reduce the loss of native species. This includes not only the restoration of in-stream habitat, but also the restoration of habitat and wise land use in upland and wetland areas within the contributing watershed.

Natural Heritage Data

Despite decades of degradation across the Little Calumet-Galien River watershed, small remnants of the rich biodiversity of the region persist within the study area. Important areas identified by the Indiana DNR's Natural Heritage Database are included in Figures 26 and 27.

Figure 26 is a map of important Natural Heritage Communities, protected Conservation Areas, and Natural Areas within the study area. Figure 27 is a map of locations (often referred to as element occurrences) where threatened, endangered, or rare plants or animals have been documented. The presence of Natural Heritage Communities, Conservation Areas, or element occurrences was used to rank management units for protection and restoration.

The status of a particular species is particularly relevant for this area due to the juxtaposition of urban-industrial pressures with highly complex ecological conditions. In addition to simply being resources worthy of preservation, threatened, endangered, rare, or environmentally sensitive species can serve as indicators of ecological health.

Water Quality

A number of sources were queried to summarize existing water quality data and nonpoint source pollution information within the study area. Investigators spent three days in the field measuring the cross sectional area of selected tributaries, and characterizing the streams. The results of the Unified Watershed Assessment (UWA) were summarized and described. The Indiana Department of Environmental Management (IDEM) was queried for the Index of Biotic Integrity (IBI) and water quality data. IDEM results were summarized, and sample points were mapped. Information contained within the U.S. EPA's BASINS database was compiled and summarized. We also summarized expected water quality trends given projected land use changes.

Field Observations

AES staff conducted field investigations August 22-24, 2000 to measure the cross sectional area of selected tributaries, characterize the streams, and make general observations regarding potential sources of nonpoint source pollution. Eighteen data points were collected. We also observed much of the watershed from the air to take pictures, and to gain a larger, contextual understanding of potential nonpoint source pollution factors. Data sheets and representative photographs are included as Appendices B and C. Sample locations are included as Figure 28.

Site Selection Criteria
We selected sample sites based on the following criteria:

1. Sample sites included the major streams within the study area including Galena River, Little Calumet River, Trails Creek, Salt Creek, Turkey Creek, Deep River, Coffee Creek, and Sand Creek.
2. Sample sites included a representation of upstream, downstream and middle reaches to provide some indication of potential changes along the major streams.
3. Sample sites were representative of the stream reach.
4. Additional sites were chosen on the Little Calumet that were outside of the study area to observe river conditions at the western limit of the Little Calumet River, as well as Hart Ditch, which is a major western watershed tributary.

General Observations
We made the following general observations regarding potential sources of nonpoint source pollution during the field visits:

- It appeared that along most of the tributaries and streams there was a relatively wide, generally wooded, buffer area. This is probably because land surrounding much of the tributaries are poorly drained, or wetland.

- Most of the agricultural fields we observed in mid-August (row crops or pasture) appeared to be well vegetated, and did not appear to be contributing substantial amounts of sediment into adjacent waterways. However, we did observe a number of agricultural fields that had completely bare ground during our site visit.
- Perhaps the most significant thing we noted from the air was that several construction sites contained vast areas of bare ground that in many cases did not appear to be protected with silt fence. It appears that sedimentation from open construction sites could be one of the single most important factors in contributing to non-point source pollution regarding sedimentation.
- Most of the bridges we observed crossing the waterways had erosion problems, from new construction, roadside ditches, and storm drains within the bridges themselves. Many of the storm drains discharged immediately beneath the bridge onto bare, unprotected soil under the bridges. This appears to be a significant source of sedimentation into the waterways over which the bridges crossed.
- During the site visit it appeared that many of the agricultural fields had fencerows in place. This is a positive observation in that fencerows protect the fields to a certain extent from wind-generated erosion.
- We did not observe many areas in pasture with livestock grazing on it. However, the few areas that we did observe had very poor erosion control and livestock were allowed free access to the creek. This is a significant source of sedimentation in localized areas.
- In general, it appeared that most of the residential and commercial areas within the watershed used traditional land planning designs in which detention is not used and that there was no apparent effort to reduce impervious area. This is partially exhibited in wide streets and extensive turf grass areas.
- Some but not all of the new residential developments used detention ponds.
- We observed from the air what appears to be a very long and extensive pipeline project that did not appear to employ adequate soil erosion control measures.

Water Clarity

The clarity of water within streams is a general indicator of turbidity and total suspended solids. We visually estimated water clarity in three categories: > 12” (clear), 6”-12” (moderately turbid), and < 6” (turbid). The following summarizes water clarity observations, and associates these observations with additional qualitative data collected during the site visits (eg. bed composition, vegetative cover, condition of the bank, and other parameters included on the attached data sheets in Appendix C).

Stream water clarity was generally observed as clear or only moderately turbid in the upper stream reaches during the visits on August 22-24, 2000. Clarity decreased as the streams moved to their confluence with the Little Calumet River. Trail Creek, located at the upper end of the Little Calumet River watershed was observed to have clear water at both observation locations (#15 and #16). The monitoring location on Trail Creek reported average total suspended solids of 16.5 mg/l between 1995-97, and a decreasing trend from a value of 30.4 mg/l reported in 1970-74. This stream also had sandy banks and beds that contributed to the water clarity.

The upper reach of the Little Calumet River (#13) was observed to have clear water with over 12" of visibility and also had a sandy bed and banks.

Water clarity in Salt Creek was observed at three locations (#3, #5, and #12). The water clarity was lowest at the upstream location (#12) south of the urbanizing area of Valparaiso. Salt Creek became less turbid north of Valparaiso. The stream waters remained relatively clear to the Little Calumet River confluence. Considerable Salt Creek bank side area included wooded buffer. The water in Salt Creek remained clear even as the bed composition changed from sandy gravel in the middle reaches to silts and clays in the downstream reaches.

Turkey Creek—Deep River streams were located in the western part of the watershed in a more urbanizing area. The bed composition of these streams was sandy silt and gravelly sand. Observed turbidity (#6, #7, and #8) was medium (6"-12" of visibility) despite bed materials that should produce clear waters. Considerable bank erosion was noticed on these streams in addition to poor livestock management practices at several locations which likely contributed to observed turbidity.

Water clarity at Coffee Creek and Sand Creek (observation sites #14, #17, and #18) was generally clear with over 12" of visibility. These streams are located outside of the developed area and have gravelly sand beds and banks that contributed to water clarity. Bank erosion along these streams was minimal, and much of the observed riparian corridor consisted of wooded areas.

Water clarity in the Little Calumet River was observed at four locations (#2, #4, #9, and #10). Clarity decreased as the river flowed west. Clear water was observed at observation site #2, the upstream reach of the river. Clarity of approximately 6" of visibility was observed at #4 in the middle of Porter County. Observation site #4 was in the vicinity of the water monitoring station #170154. Clarity less than 6" of visibility was observed in the Lake County reaches of the River.

The observation site on the Galena River (#1), in the eastern part of the watershed study area, provided the highest observed water clarity. The watershed tributary to this creek was generally developed adjacent to the road network, but undeveloped away from the roads. The streambed was gravelly sand, and the bed a mixture of gravelly sand and silts/clays.

Observation site locations are shown in Figure 28, and the observed water clarity at the observation locations is shown in Table 5.

Table 5. Observed Water Clarity

Stream	Location	Observed Depth of Visibility
Galena River	Upper Reach (#1)	>12"
Little Calumet River	Upper Reach (#2)	>12"
Salt Creek	Lower Reach (#3)	>12"
Little Calumet River	Middle Reach (#4)	≈6"
Salt Creek	Middle Reach (#5)	>12"
Deep River	Upper Reach (#6)	<6"
Deep River	Middle Reach (#7)	6" to 12"
Turkey Creek	Middle Reach (#8)	6" to 12"
Little Calumet River	Middle Reach (#9)	<6"
Little Calumet River	Middle Reach (#10)	<6"
Hart Ditch	Lower Reach (#11)	6" to 12"
Salt Creek	Upper Reach (#12)	≈6"
Trail Creek	Middle Reach (#13)	>12"
Coffee Creek	Upper Reach (#14)	>12"
West Branch Trail Creek	Middle Reach (#15)	>12"
East Branch Trail Creek	Middle Reach (#16)	>12"
Coffee Creek	Middle Reach (#17)	>12"
Sand Creek	Middle Reach (#18)	>12"

Other Field Indicators of Water Quality

Observable water quality indicators were identified at each observation site. These indicators included presence of filamentous algae, indicators of nutrient loading, and presence of septic odors.

At Turkey Creek (#8), we observed that the bed was contaminated with an oily substance that was released when the bed was disturbed. No septic odors or evidence of chronic septic system failures was observed at any of the sites. Filamentous algae were not observed nor were other indicators of heavy nutrient loading.

Unified Watershed Assessment (UWA)

The Unified Watershed Assessment (UWA) is the result of a U.S. EPA mandate to assess water resources in each state to prioritize watersheds for nonpoint source pollution remediation. During 1998, Indiana ranked the **present condition** of water in lakes, rivers and streams using 8-digit HUCs. Measured parameters were scored on a scale of one (good water quality) to five (degraded water quality). In 1999, **resource concerns and stressors** were identified using the scale of 11-digit HUCs. The 1999 investigations indicated that all 11-digit HUCs within Indiana do not meet designated uses or other natural resource goals.

The following is a summary of the scores for measured parameters within the study area:

- The entire study area is identified as a priority watershed.
- All sub-basins except for 050 are eligible for 2001 Incremental Funding.
- The study area contains one of the highest concentrations in the state of critical biological resources of most concern.
- Information on lake trophic status was only available for sub-basins 020, 030, and 050, which all received a score of 3 (moderate impairment).
- All sub-basins except 020 received a score of 5 (heavily impaired or degraded) for residential septic system density. 020 received a score of 4.
- Sub-basin 020 received a score of 4 (impaired) for urbanization pressure. Sub-basins 080, 050, 040, and 030 received a score of 3 (moderate impairment). Sub-basins 090, 070, and 100 received a score of 3 (moderate impairment) for cropland pressure. The remaining sub-basins received a score of 2.
- Sub-basins 020 and 030 received a score of 1 for livestock pressure; 040, 050, and 080 received a 2; and 070, 090, and 100 received a 3.

The results of the UWA are useful in that it is a broad-brushed assessment of existing conditions for purposes of prioritizing federal funding for nonpoint source pollution remediation. Results are assessed at a coarse scale which makes it difficult to use this data to identify specific sub-basins or project areas for remediation. But the UWA is useful to determine whether project sites are likely to fall in an area eligible for funding. Indiana land managers would be better off using information contained at the Management Unit scale to prioritize projects and specific sites for funding.

Index of Biotic Integrity

The Index of Biotic Integrity (IBI) evaluation system scores a stream location based on 12 biological metrics that incorporate zoogeographic, ecosystem, community, population, and individual perspectives to analyze fish community data. The Indiana Department of Environment collected data included in this report during 1990-1996.

General interpretation of IBI scores is:

Table 6. Interpretation of IBI Scores.

IBI Score	Integrity Class	Characteristics
58-60	Excellent	Pristine Conditions
48-52	Good	Decreased Species Richness Sensitive Species Present
40-44	Fair	Absence of Intolerant and Sensitive Species
28-34	Poor	Top carnivores and many expected species absent or rare
12-22	Very Poor	Few species and individuals present; diseased fish frequent

IBI scores were determined at fifty analysis locations (Figure 29) within streams in the study area. IBI scores varied from a high of 57 to a low of 12 and were distributed according to the following table:

Table 7. Variability of IBI Scores.

IBI Score	Number of Sites	Stream Ranking
52+	1	Excellent
44-52	1	Good
34-44	6	Fair
22-34	21	Poor
below 22	21	Very Poor

The following general stream locations were ranked as follows:

Excellent:

Cedar Creek in Lake County. However, a separate location on Cedar Creek at the same coordinates was tabulated with an IBI score of 17.

Good:

Upper Reynold's Creek in LaPorte County.

Fair:

Coffee Creek (two locations)
Reynolds Creek
Sager Creek
The Little Calumet River at Cline Avenue in Gary

Poor or Very Poor

One location on the Galena River in LaPorte County near Springville
Six locations on the Deep River and its upper tributaries in Lake County
Two locations on Turkey Creek prior to its confluence with the Deep River in Lake County
Two locations on lower Salt Creek and one location near the upper end of Salt Creek in Porter County
One site on lower Reynold's Creek
Three locations on its lower ditch tributaries in Porter County
One location on lower Trail Creek in LaPorte County

In general, water quality in the streams as assessed using the IBI is generally better in the middle reaches than in the lower reaches. It also indicates that the upper reaches are especially susceptible to the effects of existing activities within the study area.

Table 8. Range of IBI scores for each of Stream:

Stream	IBI Range	County
Cedar Creek	17-57	Lake
Coffee Creek	36	Porter
Damon Run	29	Porter
Deep River	13-31	Lake
Deer Creek	21	Lake
Dunes Creek	30-34	Porter
E. Branch Grand Calumet	20-32	Lake
Indiana Harbor Canal	16	Lake
Little Calumet River	23-44	Lake/LaPorte

Reynold's Creek	17-45	LaPorte
Sager Creek	23-38	Porter
Salt Creek	14-32	Porter
Turkey Creek	12-18	Lake
West Branch Grand Calumet River	21	Lake
Willow Creek	30	Porter

Twelve field observation sites were located by IDEM near IBI study sites. Recorded IBI values were generally correlated to observations in the field as described below:

- At Site 3 (Salt Creek) we observed severely eroded banks, logjams (indicative of flashy stream flow), and moderate shade suppression. The recorded IBI (12-15) was low.
- At Site 6 (Deep River) we observed significant shade suppression, toe erosion in the channel and eroded roadside ditches. The recorded IBI (16-21) was low.
- At Site 7 (Deep River) we observed significant bank erosion, mass wasting and tree falls. The bed and bank were sandy silt. The recorded IBI (16-21) was low.
- At Site 8 (Turkey Creek) we observed that the site was contaminated with an oily substance. We also observed mass wasting of the side slopes, and tree falls. Observed turbidity was medium during the time of the field observation. Recorded IBI scores were low, and very low (12-21).
- At Site 12 (Salt Creek) stream conditions varied from relatively good to relatively degraded in more urbanized settings. Recorded IBI scores varied widely as well.
- At Sites 5, 10, 14, 15, 16, 17, 18 we observed relatively good field conditions which correlated with higher IBI scores.

IDEM Water Quality Data

IDEM provided additional water quality information based on field measurements and laboratory analysis of water samples collected within the study area from 1991 to 2000. This data was compiled in a GIS format and evaluated. The field data listed general water quality parameters including pH, turbidity and dissolved oxygen. The laboratory data listed a battery of contaminants, several of which are listed as EPA priority toxic pollutants.

The three **field data parameters measured** included dissolved oxygen, pH, and turbidity.

Dissolved Oxygen

Dissolved oxygen is an indicator of the health of a stream. Generally, dissolved oxygen concentrations of greater than 5.0 mg/l are required to sustain high quality gamefish populations. Several locations (mostly on the Grand Calumet River (Figure 30) had measured concentrations lower than 5.0 mg/l, including one location in the lower reach of the Little Calumet River where the measured concentration was less than 3.0 mg/l. Dissolved oxygen concentrations in a stream vary considerably depending on:

1) The time during which the sample was collected,
2) Precipitation history immediately preceding the sample collection,
3) Water temperature, and
4) Barometric pressure.

However, very low oxygen concentrations measured at the Little Calumet River location is indicative of problematic water quality conditions.

pH

PH is a measure of acidity. A pH of 7.0 is neutral. Values below 7.0 indicate acidic conditions, and values above 7.0 indicate basic conditions. Acceptable values for pH in a stream vary from 6.5 to 9.0. No extremely basic conditions were found in the sample data (greater than 9.0). Acidic conditions were all located in the Salt Creek stream (Figure 31).

Turbidity

Turbidity is a unit of measurement quantifying the degree to which light traveling through a water column is scattered by the suspended organic (including algae) and inorganic particles, and as such is a measure of the water clarity. Clear water has a 0 NTU[3]. Values under 50 NTU are considered acceptable for aquatic life. Values over 200 NTU are considered very problematic and evidence of severely degraded water.

The upper reaches of Salt Creek had the highest measured turbidity levels in the study area (Figure 32). Nine of the sample sites located in the Upper Salt Creek area had turbidity measurements over 50 NTU. This supports our field observation in the upper reach of Salt Creek where observed clarity was about 6 inches.

The two highest measurements were 560 and 1681 NTU. The Little Calumet River had eight sites with elevated turbidity (many for which elevated turbidity was measured at several different times). The highest turbidity reading in the Little Calumet River was 736 NTU. This supports field observations in the middle reaches of the Little Calumet where observed clarity was < 6 inches.

Trail Creek had four locations where turbidity measured between 50 and 60 NTUs, which is just above the accepted maximum of 50 NTUs. This is somewhat consistent with field observations

[3] NTU – Nephelometric Turbidity Unit is a measure of the intensity of light scattered by a sample under defined conditions based on a comparison with the intensity of light scattered by a standard format in reference solution under the same conditions.

where observed clarity at Trail Creek was > 12 inches. We would expect relatively clear water based on the sandy bed and bank observed at our two study locations.

Laboratory Measure Parameters

Contaminants identified by the EPA as priority pollutants and additional contaminants of water quality concern were measured from stream samples collected in the study watershed by the IDEM. These measurement results and the locations of the samples were analyzed as part of this water quality evaluation.

The EPA has identified two concentration levels for contaminants: the **Criteria Continuous Concentration (CCC)** is the concentration of a contaminant for which exposure can be tolerated over a sustained time period without adverse effect. The **Criteria Maxiumum Concentration (CMC)** is the highest contaminant concentration for which an organism can be exposed over a very short time period without adverse effect. The following figures show the locations of samples where contaminant measurements were above the **CCC**.

Lead

Lead is a heavy metal contaminant that was measured in the watershed study area. The EPA has set CCC and CMC levels for lead as a priority toxic pollutant because lead can cause nephrotoxicity, neurotoxicity, and hypertension in humans. The CCC for lead is 2.5 µg/l and the CMC is 6.5 µg/l. Several locations where lead was sampled in the watershed (Figure 33) were public water supply intake locations receiving water from Lake Michigan. However, the outlet of Trail Creek also had significant concentrations of priority contaminant metals with three sample locations reporting lead concentrations above the CCC. The highest concentrations for each of the three sites were 6 µg/l, 10 µg/l and 18 µg/l. Salt Creek had one sample location where lead was measured above the CCC (7.8 µg/l). The northwestern area of the watershed including the Grand Calumet River and the Indiana Harbor Ship Canal had several samples showing lead above the CCC. The highest reported concentration of lead in the Grand Calumet River was 31 µg/l, and in the Indiana Harbor Ship Canal, 26 µg/l. The lead concentration measured in the Burns Ditch sample was 19 µg/l.

Copper

Copper is a metal that can affect internal organs of humans and is a priority toxic pollutant as defined by the EPA. The CCC for copper is 9 µg/l and the CMC is 13 µg/l. Two locations in Salt Creek contained copper levels between CCC and CMC concentrations (Figure 34). Extremely high concentrations of copper were measured at six locations near water plants that use water from Lake Michigan. High concentrations of copper in Lake Michigan were also reflected in copper concentrations recorded at the downstream end of Trail Creek (29 µg/l) that were well above the CMC. High copper levels were also measured at the Burns Ditch outlet and in the Indiana Harbor Canal.

Zinc

Zinc is a priority contaminant commonly found in water for which the EPA has established a CCC and CMC of 120 µg/l as a general water standard criteria. Zinc is toxic only in considerably higher concentrations than many other metals, but zinc is often found in much higher concentrations in streams. Zinc was measured above the CCC at only four locations in the watershed (Figure 35). Again, as with copper, the outlet of Trail Creek had several samples for which zinc was measured above the CMC, including the highest measured concentration of 1400 µg/l. Burns Ditch had zinc in several of the samples, but only one above the CCC (240 µg/l). The Grand Calumet River had one sample at the CCC (120 µg/l). The Indiana Harbor samples were consistently above the CMC, and the highest measured concentration was 36,000 µg/l. Zinc was not measured above the CCC in Salt Creek.

Nitrogen

Nitrogen is a nutrient that at elevated levels can cause eutrophication problems in streams. Nitrogen causes health problems in infants in the form of nitrate. In the form of un-ionized ammonia, nitrogen is toxic to aquatic organisms at higher pH levels. Water sample results showed no locations with elevated levels of nitrate. Elevated ammonia levels were found at several locations (Figure 36), but as shown by Figure 31, the pH levels in these streams were below the 9.0 level at which ammonia becomes toxic. Ionized ammonia (NH_4) is non-toxic and occurs at low pH conditions; non –ionized ammonia (NH_3) is toxic and occurs at high pH conditions. Elevated, but low concentrations of ammonia were measured in the Indiana Harbor Ship Canal, and at the Trail Creek outlet. Higher concentrations were measured near the US Steel Plant on the Grand Calumet River.

Phosphorus

Phosphorous is often the limiting nutrient in streams and is therefore considered one of the controlling factors in the water quality of a stream. Phosphorous concentrations above 0.3 mg/l are problematic. Elevated phosphorous levels were measured at several of the sample locations (Figure 37), most of which were in the lower reaches of the streams. The Little Calumet River (including Burns Ditch) had two locations with a high concentrations including a high measurement of 3.14 mg/l in Burns Ditch. Trail Creek had a high concentration of 0.38 mg/l at the creek outlet. Salt Creek had a concentration of 0.63 near its confluence with the Little Calumet River.

The highest measured phosphorous concentration was in the upper reach area of Salt Creek where an extremely high measured concentration of 38.4 mg/l was reported. Again, several of the ditches and streams in the northwest part of the study area reported high measured concentrations phosphorous.

Total Suspended Solids

Total suspended solids are the measurement, together with turbidity, of sediment loading in a riverine system. Some amount of suspended solids is normal and part of the natural erosion and stream ecosystem process. However, elevated suspended solid concentrations are indicators of severe erosion within the watershed, lack of sediment control in upland areas, elevated water flows in the riverine system, and often indicate the need for maintenance practices in or along the streams themselves.

Total suspended solids concentrations over 30 mg/l were chosen as indicative of abnormally high conditions. The mg/l concentration is within the range of TSS standards for states with a TSS concentration standard for surface water. Figure 38 shows the locations for which total suspended solids (TSS) were measured at over the 30 mg/l concentration level. As with most of the other contaminants, the northwestern portion of the watershed showed elevated suspended solids at several locations. The lower areas of the watershed (Little Calumet River, Burns Ditch, lower reaches of Salt Creek, and lower reaches of Trail Creek) had elevated suspended solids. The worst situation was near the confluence of Salt Creek with the Little Calumet River where four locations showed TSS above 100 mg/l. Again, the upper reach of Salt Creek showed elevated contaminants.

Fecal Coliforms

Coliforms are bacteria that can ferment lactose and produce carbon dioxide within 48 hours at 35^{o}C. *Escherichia coli* (E. coli) is a coliform found in the human intestine which is excreted in human and other mammalian waste. The presence of E. coli in a water body is a good indicator of fecal contamination and the potential of the water body for disease.

The EPA recommends that recreational bathing waters should not exceed 126 fecal coliforms /100 ml based on a geometric mean of five samples taken over a 30-day period. The presence of E. coli in a water body results from poor sanitary sewage treatment, combined sewer overflows, failing septic systems, and livestock operations near the stream system. Several locations with elevated counts of E. coli were found when analyzing the watershed samples (Figure 39). These locations included the northwestern area of the study site, six locations on the Little Calumet River east of the Burns Ditch, nine locations scattered throughout Salt Creek, locations on the main stem of Trail Creek, and on both the east and west branches of Trail Creek. The large number of sites with elevated levels of E. coli suggest there as a watershed problem with fecal waste materials.

U.S. EPA BASINS Data

The U.S. EPA BASINS database includes four water quality monitoring stations within the study area that provide water quality data for an extended time period. The locations are shown in Table 9. Water quality data is tabulated from three time periods reflecting the commencement of Clean Water Act regulation (1970-74), a middle time period between the Clean Water Act and the present time (1985-89), and current conditions (1995-97). Incomplete data is available for many of the contaminants of concern in the BASINS database.

Table 9 indicates significant decreases in phosphorous and BOD[4], and increases in dissolved oxygen levels between 1970 and 1997. However, the table also shows that nitrate levels consistently increased between 1970 and 1997 at all monitoring sites.

[4] BOD is Biochemical Oxygen Demand and quantifies the oxygen required for biochemical degradation of organic material (carbonaceous demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron. It may also include oxygen required to oxide in reduced forms of nitrogen (unless their oxidation is prevented by an inhibitor).

A major source of both BOD and phosphorous in the streams is sanitary sewage discharge (a point source discharge). The decrease in these constituents and the increase in dissolved oxygen concentrations indicate that the improvement of sewage plant treatment in the study area has had a major beneficial effect in water quality. This is consistent with the general point source contaminant reduction that generally occurred after the implementation of Clean Water Act regulations.

Nitrate in streams is caused by excessive or improper applications of fertilizer. Since nitrate is highly soluble, it can be conveyed to streams either in surface stormwater runoff, or through agricultural drain tiles. Increasing concentrations of nitrate were measured at the tabulated monitoring locations (Table 9), from 1970 to present. This non-point source contaminant is a cause for concern.

Table 9. Average Watershed Water Quality Values.

Sample Location	Years	Mean Water Temperature (°C)	Total P	TKN	NO_3	BOD (5-day)	Chloride	Arsenic	Zinc	Dissolved Oxygen	Total Suspended Solids
Salt Creek Mile 17.4 ID. 171403 Reach Segment #20	70-74 85-89 95-97	12.10 12.45 11.32	0.41 0.20 0.16	- 0.81 -	1.19 3.04 3.41	7.42 1.41 0.75	36.42 41.00 -	ND	ND	7.11 9.05 10.15	32.03 34.25 28.36
Trail Creek Mile 1.0 ID. 174330 Reach Segment #002	70-74 85-89 95-97	11.98 13.01 12.35	2.66 0.34 0.11	- 2.34 -	0.79 1.63 2.63	3.53 2.75 1.15	26.69 38.20 -	-	-	8.44 7.24 9.82	30.39 27.05 16.54
Lake George Canal Mile 3.2 ID. 170143 Reach Segment #010	70-74 85-89 95-97	17.95 15.98 17.27	0.51 0.17 0.06	- 1.93 1.09	0.38 1.25 1.66	5.72 2.58 1.98	59.95 48.00 55.20	-	-	-	-

Little Calumet River Mile 38.56 ID. 170154 Reach Segment #021	70-74 85-89 95-97	11.61 11.95 12.82	0.40 0.21 0.09	- 0.64 -	0.77 0.93 1.50	2.61 1.79 0.33	27.90 26.92 -	-	-	8.80 8.90 9.59	55.85 33.00 74.81

Notes:
ND - not detected
All tabulated values are mg/l except temperature

Water Quality Trends and Summary

Causes

It is difficult to determine precise causes and sources of non-point source pollution. By definition, these pollutants come from a variety of areas and sources within the contributing watershed. That is why it is important to address non-point source pollution issues in terms of the smallest practical watershed unit, which in this study, is the management unit. Water quality managers can then focus on those management units with the highest levels of contaminants, and see what can be done within the contributing watershed to reduce those pollutants.

Table 10. Summarizes many of the causes for excessive pollutants addressed in this report:

pollutant	***cause***
low dissolved oxygen	*soil erosion, human and animal wastes, elevated water temperatures, urban stormwater runoff BOD*
acidic pH	*materials stockpiles,*
high turbidity	*1)soil erosion, 2) elevated and highly varied stream flows, 3) improper construction site management of sediment, 4)agricultural practices, 5) increasing land development without proper stormwater management practices*
lead	*point source discharges, waste water treatment plant (WWTP) discharges, atmospheric deposition, urban stormwater runoff*
copper	*point source discharges, WWTP discharges, atmospheric deposition, urban stormwater runoff, backwater flow from Lake Michigan*
zinc	*point source discharges, WWTP discharges, atmospheric deposition, urban stormwater runoff*
nitrogen	*1) excessive applications of fertilizer, 2) failing septic systems, 3) sewage treatment plant discharges, animal husbandry*
phosphorous	*1) excessive applications of fertilizer close to stream, 2) failing septic systems close to stream , 3) WWTP discharges, animal husbandry close to stream*
total suspended solids	*1)soil erosion, 2) elevated and highly varied stream flows, 3) improper construction site management of sediment, 4)agricultural practices, 5) increasing land development without proper stormwater management practices*
fecal coliforms	*1)failing septic systems, 2)improper animal husbandry practices*

Point or Non-source Point Pollution?

Table 10 above indicates that several of the measured pollutants can be caused by point or non-point sources. We compared locations where excessive levels of measured pollutants were encountered with the location of EPA-permitted dischargers to get a better idea as to whether high levels of pollutants were caused by point or non-point sources. We found that in many cases an EPA-permitted discharger was located immediately upstream of the location having high levels of pollutants. While this information does not prove that permitted dischargers are the cause of high measured levels of pollutants in the stream, it does provide justification for studying these areas more closely.

Table 11 below summarizes areas where high levels of pollutants were measured downstream from a facility permitted by the EPA as a discharger.

pollutant	excessive concentration locations	permitted upstream vicinity dischargers
low dissolved oxygen	*Burns Ditch* *Grand Calumet* *Grand Calumet* *Indiana Harbor Canal*	*municipal WWTP* *Steel Industrial, municipal WWTP* *none* *none*
acidic pH	*Salt Creek*	*3 small WWTP*
lead	*Trail Creek* *Salt Creek* *Burns Harbor* *Grand Calumet* *Indiana Harbor Canal*	*municipal WWTP* *municipal WWTP* *none* *Steel Industrial* *none*
copper	*Trail Creek* *Grand Calumet* *Salt Creek*	*municipal WWTP* *municipal WWTP* *none*
zinc	*Trail Creek* *Indiana Harbor Canal* *Burns Ditch*	*WWTP* *none* *none*
*nitrogen (Ammonia_*	*Grand Calumet*	*none*
phosphorous	*Salt Creek* *Grand Calumet* *Trail Creek* *Burns Ditch*	*municipal WWTP* *municipal WWTP* *municipal WWTP* *municipal WWTP*
total suspended solids	*Lower Salt Creek* *Trail Creek* *Upper Salt Creek* *Grand Calumet* *Grand Calumet* *Burns Ditch* *Burns Harbor*	*small WWTP* *municipal WWTP* *none* *municipal WWTP* *Chemical Industrial* *municipal WWTP* *none*
fecal coliforms		*located downstream of 4 small WWTP*

We also generated a GIS graphic (Figure 40) by merging all EPA point sources into a single file. No attempt way made to sort through the various facilities to determine which site was more at risk than another site. The basic assumption is that the more sites there are within a watershed the more likely there are to be problems with point source water quality issues.

The following point sources were considered in generating the point source model in Figure 40.

- Industrial Facilities Discharge (IFD) sites
- Permit Compliance System (PCS) sites and loadings
- Toxic Release Inventory (TRI) sites
- CERCLIS-Superfund National Priority List (NPL) sites
- Resource Conservation and Recovery Information System (RCRIS) sites

- Mineral Industry Locations

Measured "Hot Spots"
We used measured IBI scores and IDEM's water quality data to generate a graphic illustrating measured "hot spots" within the study area. Please note that this summary only includes sampled areas and makes no judgment as to the quality of streams where no samples were taken.

The drawing was generated as follows: Each IDEM water quality parameter described above was ranked on a scale of one to three within each management unit with one representing little to no contamination, two representing moderate contamination, and three representing high levels of contamination. IBI scores within each management unit were also ranked on a scale of one to three with one representing higher diversity, two representing moderately impaired diversity, and three representing highly impaired diversity. The score of each of the 10 variables (nine IDEM water quality parameters and one IBI score) were summed and divided by 10 to generate a score for each management unit. The results are illustrated in Figure 41.

Water Quality Risks Model
The Measured "Hot Spots" model in and of itself has limited utility primarily because of the relatively small sample size where water quality and IBI measurements were taken. We developed a Water Quality Risks model using a variety of resources to get a better handle on management units at highest risk for water quality contamination. This model incorporates variables that directly measure water quality such as IDEM Water Quality scores and IBI scores, as well as variables that are highly associated with water quality impairment, and therefore can be used to indirectly predict water quality risks such as development class and road density.

We developed the Water Quality Risks Model as follows:

Each management unit within the study area was ranked on a scale of one to three with three representing management units at highest risk for water quality impairment, and one representing management units at lowest risk for water quality impairment. A suite of variables was considered in each of the three risk categories. The management unit was scored as high, moderate or low risk (high=3, medium=2, low=1) depending on the highest category in which one of the variables fit. The following lists variables considered in each of the three categories used to rank each of the management units.

High Water Quality Risks (High=3)
- Transitional Developments
- Listed IDEM Contaminant Present
- Highest Road Densities
- Highest Soil Erodibility (>= 0.25) (Function of slope and runoff)
- Highest Percent Developed
- Highest Number of Permitted Point Dischargers

Moderate Water Quality Risks (Moderate=2)
- Rural Developments

Moderate Road Densities
Moderate Erodibility (0.06-0.18)
Moderate Number of Permitted Point Dischargers

Low Water Quality Risks (Low=1)

Urban Developments (Low risk because water quality impairment less likely to get any worse since it's already urban)
Lowest Road Densities
Lowest Percent Developed
Lowest Number of Permitted Point Dischargers

Management Units are ranked similarly to using a trichotomous key. A user starts at the top and determines whether any of the variables under High Water Quality Risks fit the management unit. If so, the management unit is ranked as High Risk. If not, a user sees if any of the variables under Moderate Water Quality Risks fit the management unit. If so, the management unit is ranked as Moderate Water Risk. If not, the management unit is ranked as Low Water Quality Risks by default.

Figure 42 illustrates the results of the Water Quality Risks model.

Management Recommendations for Land Use Categories

Different land uses require different types of techniques to combat non-point source pollution. While similar techniques may be used under different land use situations, other techniques are land-use specific. It is thus useful to consider the suite of management techniques associated with each land use category.

This section provides an overview of non-point source pollution water quality goals, as well as management techniques for the three land use categories, Urban, Rural and Transitional areas. We have also summarized the efficacy of BMPs when used for each of the three development categories.

A general cost estimate for implementing easily quantifiable techniques is provided at the end of this section.

Goals

Contaminant Reduction

Contaminant reduction goals are designed to accomplish the following:

- Reduce the use of materials contributing to nonpoint source pollution;
- Reduce the quantity of materials contributing to nonpoint source pollution;
- Adjust the timing and use of materials contributing to nonpoint source pollution so that they are applied (as in the case of fertilizers) when plant uptake is maximized, and runoff is minimized;
- Use alternative non-contaminating materials;
- Use techniques for capture and removal of materials before they become contaminants in the environment.

Base Flow Maintenance

Nonpoint source pollution is conveyed by surface runoff. Base flows can be maintained by reducing surface runoff, and by infiltrating water into shallow and deep ground water systems.

Reduction of Peak Flows

Peak flows convey a disproportionately high amount of nonpoint source pollution contaminants. The goals of reduction of peak flows can be achieved by reducing the rate and volume of stormwater runoff, by desynchronizing runoff from tributary areas, and by a series of techniques that focus on reducing peak flows.

Reducing Water Level Fluctuations

High water level fluctuations destabilize ecological systems, and contribute to shoreline erosion. Non-point source pollution management efforts should include measures to reduce water level fluctuations to provide for biologically predictable seasonal high water levels, and gradual release. This is contrasted with wildly changing water levels typical of urban areas and row cropped agricultural lands.

Watershed Planning and Regulations

Future development and redevelopment should be planned at the watershed and management unit scale in such a way that achieves nonpoint source pollution goals. Planning can either be voluntary, or supported by local, state and federal ordinance. In either case, education and financial incentives will improve the likelihood of success.

Techniques

Many of the same water management techniques can be useful in accomplishing these five goals. Rather than focusing on just one goal and/or technique, managers should strive to "nest" the multiple techniques so that multiple benefits are accomplished. Linking techniques spatially (and temporally) throughout a watershed, on each farm, in each development, or by retrofitting in each urban area, is the best way to accomplish these overall goals within the watershed.

It is important to establish the baseline performance of the watershed to determine prior to implementing a given technique. Future performance criteria can then be developed to project and document the efficacy of each effort.

Appendix A provides a list of some of the many sources available that describes each of these techniques in detail.

Contaminant Reduction

1. Source Management
    a. Education
    b. Alternative materials (e.g., organic fertilizers).
    c. Construction site and bare soil management.
    d. Natural landscaping instead of lawn.
    e. Constructed native buffers in designed landscape areas.

2. Financial Incentive Programs
    a. Provide material efficiency tax credits.
    b. Provide water volume/rate reduction and storage incentives and payments.
    c. Demonstrate regional tax rate reduction with better contaminant reduction programs.

3. Capture, Assimilation and Removal of contaminants
    a. Upland buffers.
    b. Swale systems.
    c. Sediment traps.
    d. Biomass removal.
    e. Sediment removal.
    f. Polyacrimilable resin- use.

4. Development Re-design
    a. Stormwater Treatment Train integration
    b. Detention pond retrofitting

<u>Base Flow Maintenance</u>

1. Engineered infiltration systems and reduced surface runoff systems
    a. French drains.
    b. Rain garden.
    c. Infiltration trenches.
    d. Swales.

2. Agricultural Treatments
    a. Grass waterways.
    b. Exfiltration tile systems.
    c. Native landscaping/wildlife plantings.
    d. Buffers along streams, ditches, wetlands, and depressional areas
    e. Dechannelization of streams.
    f. Restoration of historic wetlands and ditches through dechannelizing waterways, disabling agricultural drain tiles, and not farming nonproductive depressional areas.
    g. Excluding livestock from waterways and wetlands

3. Natural Treatments
    a. Prairie woodland and wetland restorations.
    b. Landscape scale water treatment/management restoration.
    c. Rain gardens.
    d. Floodplain and drainage way restoration.

4. Development Re-design
    a. Stormwater Treatment Train integration.
    b. Detention pond retrofitting
    c. Conservation Development Planning

Reduction of Peak Flows

1. Engineered Solutions
   a. Detention and retention ponds.
   b. Dry dams.
   c. Gated reservoir storage.
   d. Reduce impervious lands.
   e. Cistern installations to capture roof/driveway runoff.

2. Natural Solutions
   a. Wetland restoration.
   b. Native landscaping ecological restoration.
   c. Cover crop all bare soil areas.
   d. Increase interception of precipitation by planting appropriate vegetation.
   e. Agricultural BMP's (no till, permanent cover crops, crop residue management, grassy waterways).
   f. Dechannelize streams/channels/ditches.

3. Development Re-design
   a. Stormwater Treatment Train integration.
   b. Detention pond retrofitting

Reducing Water Level Fluxes

1. Use Overall Systems Approach
   a. Stormwater Treatment Train in urban, agricultural and transitional areas.
   b. BMPs in agricultural.
   c. BMPs in transition.
   d. BMPs in urban.
   e. Restore hydraulic geometry of streams using all possible techniques necessary.

2. Landscape Park Water Management Areas
   a. Design/install water management parks (e.g., Prairie Green).
   b. Create localized areas for rototill water level dynamics separate from ecologically important areas.

3. Development Re-design
   a. Stormwater Treatment Train integration.
   b. Detention pond retrofitting

Watershed Planning and Regulation

1. Watershed Planning
   a. Watershed Scale

b. Management Unit Scale
c. Local, county, municipal, state, and federal efforts
d. Education

2. Regulations
   a. Stormwater management ordinances
   b. Floodplain ordinances
   c. Local, state and federal wetland, stream, riparian corridor, floodplain, and upland buffer area regulations.
3. Incentives
   a. Provide material efficiency tax credits.
   b. Provide water volume/rate reduction and storage incentives and payments.
   c. Demonstrate regional tax rate reduction with better contaminant reduction programs

Table 12 associates proposed management techniques designed to achieve water quality goals with land use categories. The first heading (Goals) includes the primary goals associated with potential nonpoint source pollution management programs described at the beginning of this section. Alpha-numeric codes under the headings Agricultural, Urban and Transitional, represent techniques that could be used to accomplish the goals.

Table 12. Primary Water Quality Goals and Techniques per Land Category

Goals	**Locations**		
	Agriculture	Urban	Transition
Contaminant reduction	1a, 1b, 2a, 2c, 3a-f, 4a	1a-e, 2a-c, 3a-e, 4a-b	1a-e, 2a-c, 3a-f, 4a-b
Base flow maintenance	1a-d, 2a-g, 3a-d, 4a, 4c	1a-d, 2a, 2c, 2d-e, 3a-d, 4a-c	1a-d, 2a-f, 3a-d, 4a-c
Reduction of peak flow	1a-c, 1e, 2a-f, 3a	1a-e, 2a-d, 2f, 3a-b	1a-e, 2a-f, 3a-b
Reduction of water level fluctuations	1a-b, 1e, 2a-b, 3a-b	1a, 1d, 1e, 2a-b, 3a-b	1a-c, 1d, 2a-b, 3a-b
Watershed Planning and Regulation	1a-d, 2a-c, 3a-c	1a-d, 2a-c, 3a-c	1a-d, 2a-c, 3a-c

Table 13 compares Best Management Practices (BMPs) designed to achieve water quality goals with their estimated efficacy when implemented within the three development categories. The BMPs are rated as H, M or L to denote High, Medium, or Low effectiveness when applied to a particular land use. A blank indicates that the effectiveness of that treatment for the designated land category is not known.

Table 13. BMP Effectiveness per Land Category.

URBAN AREAS	**Contaminent Reduction**						**Runoff Reduction**		**Baseflow**
Developed Sources	**TSS**	**BOD**	**Oil/Grease**	**Nitrogen**	**Phosphorous**	**Metals**	**Rate**	**Volume**	**Maintenance**
Reduced Usage				H	H	M			
Alternative Material Usage				H	H	M			
Natural Landscaping Usage	M			H	H	L	H	H	L
Paved Area Sweeping	M	L	L	L	M	M			
Rain Garden Installation		L		L	L		L	L	L
Construction Site Sources									
Polyacrilimide Use	L				L	L			
Maintenance of Erosion Control	L					L			
Expedited Vegetation Planting	L					L	L	L	
Capture, Assimilation and Removal of Contaminants									
Upland Prairie	H	H	H	M	H	H	M	M	M
Swale Systems	M	L	M	L	M	M	M	L	
Sedimentation Basins	M	L	M	L	M	M	H	L	
Wetland Treatment	M	M	H	H	M	M	H	M	
Stormwater Treatment Train	H	H	H	H	H	H	H	M	M
Infiltration Systems	H	H	H	H	H	H	H	H	M
Development Re-design									
Treatment Train Integration	H	H	H	H	H	H	H	H	M
Detention Basin Retrofit	M	L	M	L	M	M	H	L	
Retention Basin Retrofit	H	H	H	H	H	H	H	H	M
TRANSITIONAL AREAS									
Developed Sources									
Reduced Usage				H	H	M			
Alternative Material Usage				H	H	M			
Natural Landscaping Usage	M			H	H	L	H	H	M
Paved Area Sweeping	M	L	L	L	M	M			
Construction Site Sources									
Polyacrilimide Use	M				L	L			
Maintenance of Erosion Control	M					L			
Expedited Vegetation Planting	M					L	L	L	
Capture, Assimilation and Removal of Contaminants									
Upland Prairie	H	H	H	M	H	H	M	M	M
Swale Systems	M	L	M	L	M	M	M	L	
Sedimentation Basins	M	L	M	L	M	M	H	L	
Wetland Treatment	M	M	H	H	M	M	H	M	
Stormwater Treatment Train	H	H	H	H	H	H	H	M	M
Infiltration Systems	H	H	H	H	H	H	H	H	H

Agricultural Use *Developed Sources*	**Contaminent Reduction**							**Runoff Reduction**	**Baseflow**
	TSS	**BOD**	**Oil/Grease**	**Nitrogen**	**Phosphorous**	**Metals**	**Rate**	**Volume**	**Maintenance**
Reduced Fertilizer Usage				H	H				
Optimally Timed Fertilizer Use				H	M				
Livestock Exculsion	H	H		H	H				
No-Till Cropping Practices	H						H	H	M
Capture, Assimilation and Removal of Contaminants									
Stream Buffers	H	H		M	H		L	L	L
Grassed Waterways	H	L		L	M		M	L	L
Wetland Conversions	H	H		H	M		H	M	L
Prairie Conversions	H	H		H	H		H	H	M
Historic Stream Restoration	M								

Cost Estimates for Implementation

Cost estimates for the implementation of water quality BMPs vary dramatically by specific technique (or suite of techniques) employed, scale, property values, and other factors. The following is a description and cost estimate for the implementation of three theoretical BMP projects. Each project is representative of each of the three land use categories (urban, rural and transitional). Please note that while these projects are relatively complex and expensive, in many cases, the implementation of very simple and relatively inexpensive BMPs can result in substantial water quality benefits. The three representative projects were chosen to provide the reader with an example of how various techniques can work together, as well as to demonstrate the thought process that goes into designing projects that are sensitive to water quality objectives.

100-acre Agricultural Field

This example is of a 100-acre corn field with a 20’ wide stream running through the property for 300’. A one-acre farmed wetland currently under crop production is on site and is to be rehydrated by removing the drain tiles, taken out of agricultural production, and seeded with wetland plants. The existing stream will be cleaned out by removing debris jams, and a 50’ wide riparian buffer will be brushed and seeded. The example includes losing crop land associated with restoring the farmed wetland, and creating the riparian buffer.

Table 14. 100-acre Agricultural Field BMPs.

Task	Unit	amount	$/Unit	Cost
Stream Restoration (300 l.f.)	acre	0.137	$3,000.00	$ 411.00
Brush Riparian Buffer (600 l.f.)	acre	0.68	$3,000.00	$2,040.00
Seed Riparian Buffer	acre	0.68	$ 750.00	$ 510.00
Disable Tile in FW	l.s.	1	$1,000.00	$1,000.00
Seed Farmed Wetland	acre	1	$ 750.00	$ 750.00
				$4,711.00
Loss in Crop Production	acre	1.68	$ 300.00	$ 504.00
Total including Crop Loss				$5,215.00

Detention Basin Retrofit*

Traditionally stormwater detention basins were designed to accommodate relatively severe storm events and, as such, are often inadequate to fully remedy the impacts of urban runoff on aquatic life, stream-bank stability, aesthetics and long-term flood risks.

One of the more practicable solutions to this problem is to retrofit existing detention basins. The appropriateness of retrofitting techniques is, in part, a function of existing basin structure.

Dry bottom basins vegetated in native plants tend to be ineffective at removing runoff pollutants, consequently an appropriate retrofitting scheme for this sort of system is to transform it into a wet-bottom basin. This may be done either by replacing the entire structure, or by placing weirs or plates in front of existing outlets. In some cases a pool may be excavated at the basin's outlet. Such a structure, in conjunction with a clog-resistant orifice, is effective for removing gross pollutants from the out-flow. In addition, construction of a settling basin near the detention basin's inlet will effectively dissipate the energy of incoming flows and allow larger sediments and particulates to settle out at an easily maintainable location.

The effectiveness of wet bottom basins and retrofitted dry-bottom basins can be further enhanced through the introduction o microtopographic relief, including small berms, or planting shelves with emergent and wetland vegetation. These efforts, in particular the introduction of nutrient-absorbing emergent vegetation, will greatly enhance water quality through advanced sediment control and nutrient uptake.

The cost for detention basin retrofitting is estimated at $210 per acre of drainage area served

* Summary based on the following resource:

Northeastern Illinois Planning Commission, for Illinois Environmental Protection Agency – Division of Water Pollution Control, 1995. Flossmoor Stormwater Detention Basin Retrofit: A Demonstration of Detention Modifications to Improve Non-point

Source Pollution Control. Illinois Environmental Protection Agency. Springfield, Illinois

Conservation Developments

Conservation developments integrate open space, natural resource areas, and attempt to minimize impervious landscapes such as roads, parking lots, and other features to allow for greater infiltration of runoff.

In some conservation developments, over 80% of the land has even been restored to native prairie wetlands and woodland vegetation which results in increased marketability and premium lot and home sales.

Conservation developments saves money. By clustering homes and consolidating infrastructure (municipal sewer, water, and other utilities), reducing pavement widths (eg. From 34 ft to 18-28 ft), using trail systems instead of sidewalks, planting native landscaping, and using alternative stormwater management strategies, both front end investment costs and long-term maintenance costs can be significantly reduced. Nearly $2 million in savings was realized in a project AES was involved in by using swales instead of curbs, gutters, and storm sewers, and reducing road widths to 18-24 feet.

Use of native wildflower and prairie landscaping in open spaces in a development can also save money. In one development, with over 200 acres of open space, this savings was several million dollars compared to if the land was planted with lawns and ornamental landscapes.

Developers appreciate savings from front-end money borrowed for a construction loan. This is the most expensive and riskiest money since it is spent during predevelopment, and is not reimbursed until cash flow is generated through sales.

Conservation developments are more readily marketed and can be sold at higher market premiums than conventional developments. Premiums of 30-50% have not been unusual in some conservation developments, and resale values are usually substantially higher than convention development re-sales.

Conservation developments make sense for watersheds. Less impervious land equates to less runoff from the land. More native vegetation equates to less runoff, and the water that does runoff is usually cleaner. Reduced rates of discharge reduce downstream erosion problems on the land, in the rivers, and into the lakes and wetlands of a watershed.

Conservation developments make good ecological, economic and cultural sense. High quality of life opportunities for human communities foster a better economy and better life for the people, flora and fauna in a watershed.

Table 15. Cost of Native vs. Non-native Species for Landscaping.

Procedures & Material Site Preparation	Soded Turf Grasses	Seeded Turf Grasses	Prairie or Wetland Seeding
Spraying	$140.00	$140.00	$140.00
Irrigation	$1,680.00	$1,680.00	
Top Soil	$4,480.00	$4,480.00	
Tilling	$392.00	$392.00	$392.00
Sod & Seeding	$5,964.00		
Seed & Seeding		$1,064	$1,232.00
Wild Flower Planting			$1,680.00
First Year Mowing		$672.00	$196.00
Total Installation Per Acre	**$13,440.00**	**$8,428.00**	**$1,960.00 to 3,640.00**
Subsequent Annual Upkeep Per Acre	**$1,120.00**	**$1,120.00**	**$168.00**

1. Spraying must be done on site with live, undesirable vegetation such as quack grass or thistle.
2. Irrigation costs assume on underground automatic system.
3. Top soil is figured at approximately 3" depth hauled in from off-site
4. Wild flower planting is optional on low profile site. The figure is based on 1,000 seedings installed per acre planted.
5. Annual maintenance for turf grass includes 12 mowing per year plus fertilizer and watering. Annual maintenance for prairie / wetland grasses include annual burns, occasional spot spraying or mowing.

Restoration and Protection Opportunities

Restoration and protection opportunities are similar enough to be addressed in the same section, but merit independent reviews. Restoration, for purposes of this study, refers to restoring or enhancing the ecological integrity and sustainability of degraded natural communities, or re-creating lost natural communities. The most successful restoration efforts occur when managers permanently restore lost or degraded ecological systems (e.g. hydrology, prescribed fire). Protection refers to preserving the habitat and ecological systems required to sustain a particular species or natural community, in perpetuity.

Since property to restore or protect exceeds the resources available to complete restoration and protection activities, land managers must decide where to begin. We recommend a modified triage approach in which the greatest amount of effort is expended in achieving the greatest amount of good. High priority restoration parcels, for example, would include parcels with the highest potential for success with the least amount of intervention. This might include spending a couple of thousand dollars to disable drain tiles and rehydrating a 100 acre farmed wetland. High priority protection parcels, for example, would include protecting parcels with the greatest abundance of rich resources. Indiana's state and national parks along Lake Michigan are good examples of protecting the most resource-rich areas.

Protection

Management units (MUs) were prioritized for protection based on the three general assumptions: 1) MUs rich in rarer species (as evinced by IDNR element occurrence data and IDEM IBI data) were ranked higher than MUs poor in rarer species; 2) MUs with an abundance of existing protected open space were ranked higher than MUs with little protected open space; 3) MUs at high risk for erosion were ranked higher than MUs with a lower risk for erosion.

We developed the Protection Priorities model as follows:

Each management unit within the study area was ranked on a scale of one to three with three representing management units at highest priority for protection, and one representing management units at lowest priority for protection. A suite of variables was considered in each of the three categories. The management unit was scored as high, moderate or low priority (high=3, medium=2, low=1) depending on the highest category in which one of the variables fit. The following lists variables considered in each of the three categories used to rank each of the management units.

High Protection Priorities (High=3)
- IBI > 44
- IDNR element occurrence > 20 occurrences
- *Protected open space > 33% of the unit by area
- Erodibility >= 0.36

Medium Protection Priorities (Medium=2)

IBI = 33-44
*Protected open space = 10-33% of the unit by area
Erodibility = 0.24-0.36
IDNR element occurrence = 1-22 occurrences

Low Protection Priorities (Low=1)
IBI < 33
*Protected open space < 10% of the unit by area
Erodibility < 0.24
IDNR element occurrence = 0 occurrences

*Protected open space includes all NWI sites, and privately or publicly protected lands.

Management Units are ranked similar to using a trichotomous key. A user starts at the top and determines whether any of the variables under High Protection Priorities fit the management unit. If so, the management unit is ranked as High Priority. If not, a user sees if any of the variables under Medium Protection Priorities fit the management unit. If so, the management unit is ranked as Medium Protection Priority. If not, the management unit is ranked as Low Protection Priority by default.

Figure 43 illustrates the results of the protection priorities model. While this model is a reasonable first cut at prioritizing management units for protection, the model is limited by the variables considered, and by the geographical extent of some of the variables. IBI scores, for example, are only available within some of the management units. Land managers can easily modify this model to incorporate additional variables as they become available.

Restoration

Management Units (MUs) for restoration were prioritized for restoration based on the following assumptions: 1) Highly recuperative parcels that could be restored at relatively low costs were ranked higher than parcels that would be expensive to restore: 2) Parcels containing important natural resources such as wetlands, or rare species or natural communities, were ranked higher than parcels without these resources; 3) Sites with less development were ranked higher than developed sites due to the variety of constraints and expenses associated with restoring developed land.

We developed the Restoration Priorities model as follows:

Each management unit within the study area was ranked on a scale of one to three with three representing management units at highest priority for restoration, and one representing management units at lowest priority for restoration. A suite of variables was considered in each of the three categories. The management unit was scored as high, moderate or low priority (high=3, medium=2, low=1) depending on the highest category in which one of the variables fit.

The following lists variables considered in each of the three categories used to rank each of the management units. Variables in **bold** were actually considered as part of this model. Variables in normal weight were not considered as part of this model because they were not available for the study; however, they should be included as the information becomes available.

High Restoration Priorities (High=3)

- High recuperative potential
- Relatively low cost
- Easily stabilized
- Other special features
- High percentage hydric soil
- High percentage floodplain/floodway
- **IBI > 44**
- **IDNR element occurrence > 22 occurrence**
- **Percent developed < 30%**
- **Agricultural area > 50%**
- **Active EPA 319 sites > 3**

Medium Restoration Priorities (Medium=2)

- Moderately recuperative
- Moderate restoration costs
- Medium percentage hydric soil
- Medium percentage floodplain/floodway
- **IBI = 33-44**
- ***Protected open space = 10-33% of the unit by area**
- **Erodibility = 0.24-0.36**
- **IDNR element occurrence = 1-22 occurrences**
- **Agricultural area = 0 - 50%**

Low Restoration Priorities (Low=1)

- Low recuperative potential
- High restoration costs
- Low percentage hydric soil
- Low percentage floodplain/floodway
- **IBI < 33**
- ***Protected open space < 10% of the unit by area**
- **Percent developed >30%**
- **Agricultural area = 0%**
- **IDNR element occurrence = 0 occurrences**

*Protected open space includes all NWI sites, and privately or publicly protected lands.

Management Units are ranked similarly to using a tricotomous key. A user starts at the top and determines whether <u>any</u> of the variables under High Restoration Priorities fit the management unit. If so, the management unit is ranked as High Priority. If not, a user sees if <u>any</u> of the variables under Medium Restoration Priorities fit the management unit. If so, the management unit is ranked as Medium Restoration Priority. If not, the management unit is ranked as Low Protection Priority by default.

Figure 44 illustrates the results of the restoration priorities model. While this model is a reasonable first cut at prioritizing management units for protection, the model is limited by the variables considered, and by the geographical extent of some of the variables. IBI scores, for example, are only available within some of the management units. The presence of hydric soils and floodplain/floodway boundaries are extremely useful in restoration planning. However, these variables were not used in this model because data was not available over the entire watershed. Counties where hydric soil and floodplain/floodway data is available is included under the Base GIS Information earlier in the report. Interested land managers can easily modify this model to incorporate additional variables as they become available.

Land Availability

The need to restore or protect land is mute without the land to work with. While data was not available to develop a model for land availability, we recommend that the following variables be considered and ranked.

High Priority

- Willing buyer/seller
- Low Cost
- High protection priorities
- High restoration priorities
- High water quality risks
- High grant potential
- Cooperating owner
- Regulatory support
- Community support

Medium Priority

- Medium protection priorities
- Medium restoration priorities
- Medium water quality risks
- Grant potential
- Neutral or ambivalent community

Low Priority

- No willing sellers
- High clean up costs
- Potential litigation
- Low protection priorities
- Low restoration potential
- Low water quality risks
- Low grant potential

No regulatory support
Community not supportive

Partnership Opportunities

Partnership opportunities consist of situations where one or more federal, state, regional or local organizations work together to address specific environmental or ecological needs. Partnerships reduce duplication of efforts, and help focus attention on projects of interest to a variety or organizations.

The presence or absence of partnership projects within a watershed provides useful information. One can infer from the presence of projects that: 1) a person or organization has identified a problem and is attempting to study or mitigate the problem; 2) a project represents an interest group in a particular geographic area; or 3) an organization was in a position to obtain funding for a project in a specific location.

The occurrence of a project does not mean that all of the important environmental problems in an area have been addressed or even that the most urgent issues have been addressed. However, existing projects do suggest that there is community support for a particular environmental issue. And funding sources tend to fund community-supported projects over those without support

One can infer several things from the absence of projects in certain areas as well. First, the lack of projects in an area may indicate that an area is in good shape and does not require any special attention. Second, a lack of projects may suggest that the organizational efforts in the area have not evolved to the point of addressing the problems. Third, a lack of projects may suggest there is no active environmental or ecological advocacy group capable of addressing the problems.

Partnership opportunities are developed best from an inventory of the funding programs available for a specific use in a specific area. In most areas there are established interest groups already involved in the protection or restoration of some local resource. Often this includes an inventory of current or historic projects within a study area.

Advocacy groups do a good job of identifying and monitoring many of the outstanding problems in a region or problems that have a special appeal to local citizens. The presence of these groups helps identify specific problems and special interests in the local communities. This may include watchdog organizations that monitor the activities on industrial polluters or it may be an organization that is dedicated to protecting a special resource.

Regional and local funding agencies and organizations provide similar insights into issues and interest. Outside of the government funded programs there are numerous private foundations. A list of these organizations is available through the Secretary of State. There may be thirty or forty thousand of these organizations in any particular state. Often these lists are available in digital formats and have mailing addresses and often the organization's primary function.

At the local level, property owners provide another partnership opportunity. Access to digital property boundaries (cadastral data) and land records data will help identify landowners of properties in high-need watersheds and where restoration opportunities exist. By combining the needs models with the restoration opportunity models and ownership provide a most useful tool in watershed protection and restoration. Identification of landowners of key parcels in a watershed is extremely helpful is restoration/protection design. Also identifying cooperative and uncooperative landowners by parcel boundary is very helpful.

Other partnership opportunities are found in the school systems, from the university systems through the public school systems. The universities provide research assistance and often project funding. Often students provide the labor to complete the projects. High schools may adopt streams or wetland habitat to study and to serve as field laboratories. To a lesser extent the lower schools also adopt and use the filed resources as laboratories and learning centers.

Industry and industrial properties often provide restoration and preservation partnership opportunities. Many industries will have an interest in the well-being of their employees and will support local efforts to enhance the quality of their community. Many industries are familiar with federal and state environmental permits and are willing to make a "good neighbor" effort to clean up problems and issues in close proximity to their facilities.

Mapped Opportunities

Where possible we attempt to map the various concerns to show both functional and geographic overlaps. Certain federal and state programs will cover any geographic unit, while regional and local organizations focus on specific resources within a geographic region.

We have selected several potential candidates for partnership opportunities within the watershed

Figure 45 indicates that the IDEM has provided funding assistance through the 319 grant process to communities striving to complete projects that help attain clean water goals. Since 319 grants are a 60/40 split between the EPA and the community, this map also shows communities that have the will to financially back water quality projects.

Figure 46 shows the absence of public watershed projects (LARE, 319, EQUIP and Watershed Projects) within the project area. Even though the study area is perhaps the most biologically diverse part of Indiana, and perhaps the most degraded, most of the watershed efforts have occurred in other parts of the state.

Figure 47 indicates that there are several colleges and university within or near the study area that could potential partnership opportunities.

Figure 48 shows the abundance of industrial sites within the area categorized according to the type of pollution each is responsible for.

Figure 49 shows the location of coastal recreational sites larger than 10 acres.

On-Line Opportunities for Partnership and Funding Development

The WEB is perhaps the first place to begin looking for potential partnership opportunities and funding sources. A fairly extensive list of on-line opportunities within the watershed is provided below.

Federal Programs
URL http://www.arts.gov/federal.html

USDA Conservation Programs

URL http://www.nrcs.usda.gov/NRCSProg.html

PROGRAMS LISTED IN URL ABOVE:

Conservation Technical Assistance
Environmental Quality Incentives Program
Soil Survey Programs
Wetlands Reserve Program
Snow Survey and Water Supply Forecasting
Wildlife Habitat Incentives Program
Conservation Plant Materials Center
Forestry Incentives Program
Watershed Surveys and Planning
Farmland Protection Program
Emergency Watershed Protection
Watershed Protection and Flood Prevention Operations
Conservation Farm Option
Rural Abandoned Mine Program
Resource Conservation and Development
Grazing Lands Conservation Program
Stewardship Incentive Program (Forest Service)
Conservation Reserve Program (Farm Service Agency)
Flood Risk Reduction Program (Farm Service Agency)

Other Related NRCS Programs

Program Listing

URL http://www.nhq.nrcs.usda.gov/PROGRAMS/cprogram.htm
Program Listing with Telephone Numbers
URL http://www.nhq.nrcs.usda.gov/PROGRAMS/cpcntcs.html - eqip

Programs Listed in URL Above:
American Heritage Rivers Initiative
Areawide Conservation Planning
Conservation Farm Option
Conservation Planning
Conservation of Private Grazing Lands
Conservation Reserve Program
Conservation Technical Assistance
Coral Reefs Initiative
Emergency Watershed Protection Program
Environmental Quality Incentives Program (EQUIP)
Farmland Protection Program
Forestry Incentive Program
Grazing Lands Conservation Initiative
Locally Led Conservation
Outreach & Socially Disadvantaged Farmer
Plant Materials Program
Resource Conservation and Development Program
Rural Abandoned Mine Program
Soil Survey Program & Resource Assessment
Urban Resources Partnership
Watershed Protection & Flood Prevention Program
Wetland Reserve Program
Wildlife Habitat Incentives Program

NRCS Field Offices

State Map
URL http://offices.usda.gov/scripts/ndISAPI.dll/oip_public/USA_map

NRCS Indiana Index to Field Offices
URL
http://offices.usda.gov/scripts/ndISAPI.dll/oip_public/pgCountyMap?SPIDERSESSION=%3f%3f%3f%3f%3f%3f%5f%3f%3f%3f%40%5b%3f%3f%3f%3fBOs%5cH%3f%3f%3f%3f%3f%3f%3f%3f%3fMIJVzhJOkVvq%5f%3f%3f%3fG%60MAFgHOc%40yWS%3fHKssQ%40VgCC%40KrPc%3fMISoRCvgHZSxyAS%3fQFU

U.S. Environmental Protection Agency Region V
URL http://www.epa.gov/region5/

Northwest Indiana Initiative (NWI)
URL http://www.epa.gov/region5/orc/gi/nwi.htm

Northwest Indiana Environmental Initiative Action Plan
URL http://www.epa.gov/reg5ogis/nwi/actplan.htm

EPA Funding Sources
URL http://www.cleanstart.com/federal.htm
URL http://www.epa.gov/brownfields/
URL http://www.epa.gov/epahome/grants.htm
URL http://www.epa.gov/grtlakes/seahome/resources/funding_sources2000.htm
URL http://www.epa.gov/ogd/cfda.htm
URL http://www.epa.gov/swerosps/bf/pilot.htm

EPA Great Lakes Funding Sources
URL http://www.epa.gov/glnpo/fund/glf.html

Region V GLIN GIS Data for Great Lakes Area
URL http://www.great-lakes.net/gis/data/geographic.html - in

Planning for Lake Michigan
URL http://www.epa.gov/glnpo/lakemich/michplanning.html

U.S. Fish and Wildlife Service

US Fish and Wildlife Service
URL http://www.fws.gov/

USFWS Region 3
URL http://www.fws.gov/r3pao/
URL http://www.fws.gov/r3pao/maps/indiana.htm
URL http://www.fws.gov/r3pao/n_ind/

Partnership Opportunities
URL http://www.fws.gov/r3pao/partners/indiana.html

National Wetland Inventory
URL http://www.nwi.fws.gov/

NWI Regional Coordinators
URL http://wetlands.fws.gov/NWI_RegCoord.htm

CMT Indiana Projects
URL **http://ecos.fws.gov/cmt_mapplet/**

U.S. Army Corps of Engineers Division and District Offices by State
URL http://www.usace.army.mil/where.html - State

Chicago District
URL http://www.usace.army.mil/ncc/

Detroit District
http://www.lre.usace.army.mil/what.html

GIS Boundaries & Files
http://corpsgeo1.usace.army.mil/

Detroit Projects
URL http://www.lre.usace.army.mil/functions/pp/projects.html

Chicago Projects
URL http://www.usace.army.mil/lrc/projects.htm

Chicago Regulatory Permits
URL http://www.usace.army.mil/lrc/co-r/index.htm

USACE Literature
URL http://www.usace.army.mil/inet/functions/cw/cecwo/reg/techbio.htm

Indiana DNR
Indiana DNR Main Page
URL http://www.state.in.us/dnr/

Major topics in the Lake Michigan Coastal Area
URL http://www.state.in.us/nrc_dnr/lakemichigan/wpfiles/

Lake Michigan Coastal Coordination Program
URL http://www.state.in.us/dnr/lakemich/index.htm

LakeRim GIS Project
URL http://129.79.145.25/indmaps/ims/lakerimmo/lakerim_front.html

Advocacy Organizations

The ACCESS INDIANA Teaching & Learning Center Environmental Agencies, Organizations & Institutions
URL http://tlc.ai.org/envirorg.htm

Community Organizations -- Indiana
URL http://www.cqs.com/in.htm

Council for Environmental Stewardship, Indiana Bloomington
URL http://www.indiana.edu/~stewards/

Cyber Indiana, Environmental Organizations
URL http://www.cyberindiana.com/outdoors/orgs.html

EcoIndiana County Listings
URL http://netdirect.net/~ecoindy/counties/

Hoosier Chapter Sierra Club Links
URL http://www.inetdirect.net/sierra/links.html

Izaak Walton League of America, DeKalb County, Indiana
URL http://home.infospace.com/ikes1

Organizations in Indiana
URL http://www.idealist.org/indi.htm - environment

Indiana Environmental Organizations and WEB Sites
URL http://www.arealinks.net/environmental.html

Northwest Indiana Geographic Information System (GIS) Forum Resources & Services (Northwestern University)
URL http://www.lib.iun.indiana.edu/GIS_services.htm

Northwest Indiana On-Line GIS User Community
URL http://members.aol.com/niguc/file.html - data

Saves the Dunes Council
URL http://www.savedunes.org/

Indiana Colleges and Universities, Indiana Commission for higher Education
URL http://www.che.state.in.us/interactive list.htm

Ducks Unlimited Regions
URL http://www.ducks.org/yourstate/

Ducks Unlimited Indiana
URL
http://www.ducommunity.org/servlet/sites_ProcServ/DBPAGE=cge&GID=01002011500938793227690098

The Nature Conservancy of Indiana
URL http://www.tnc.org/infield/State/Indiana/tncinmap.htm

Pheasants Forever
URL http://www.pheasantsforever.org/

Prioritizing Watersheds and Management Units

It is difficult to come up with a clean ranking system prioritizing watersheds and management units for focused water quality efforts. The Unified Watershed Assessment identifies the entire Little Calumet-Galien River Watershed as at least somewhat impaired, and IDEM water quality data indicates that different contaminants are problems at different locations within the watershed. Furthermore, opportunities to restore green space outside of so called high risk areas should not be ignored simply because they occur outside of high risk areas. At some point in the future, these open space areas will likely be targeted for development, and the implementation of BMPs today will protect waters at risk in the future.

The subsection Water Quality Trends and Summary in the Water Quality section identifies areas where multiple contaminants were measured at similar locations. These areas should be considered the highest risk for future water quality contamination since any more development will exacerbate existing problems. However, the actual implementation of BMPs in these areas may be constrained due to existing land uses (industrial land uses, for example) that are not likely to change.

We developed an overall ranking system for the entire watershed by scoring each MU based on four categories: Protection Priorities, Restoration Priorities, Water Quality Risks, and Land Availability. Table 16 illustrates the ranking process for a single management unit. Please note that while a variety of variables are listed under each category, we only used those variables available for this study.

Each category as well as the scoring system is summarized below.

<u>Protection Priorities:</u> This category ranks each MU based on the presence of known, high quality resources, as well as a MU's tendency toward erosion. MU's with high quality resources were ranked higher than MU's with low quality resources. MU's with a tendency toward erosion was ranked higher than MU's with a low tendency toward erosion.

<u>Restoration Priorities</u>: MU's with the highest potential for restoration were ranked the highest in this category. Restoration potential considered economic cost, the recuperative potential of the MU, and the presence of high quality resources. MU's that would be expensive to restore with low likelihood for success were ranked the lowest.

<u>Water Quality Risks</u>: This category considers those MU's at the highest risk for water quality related problems. High risk variables considered included the known presence of contaminants, the known presence of important natural resources, and transitional development areas where open space is projected to be converted to developed space in the near future.

<u>Land Availability</u>: This category ranks highest those MU's that are most readily available for protection or purchase, and would reap the greatest watershed benefits with the least expenditure. None of the land availability variables were available for this study.

Each of the four categories are scored on a scale of 1-3 (where 1 = high priority, 2 = medium priority, and 3 = low priority). A single category can have a high score of 3, or a low score of 1. The sum of the score of each category is then used to create a score for each MU. A single MU can have a high score of 16, and a low score of 4 (For example. A score of 3 would be given to a MU if the MU's IBI score was >44, or if the T and E value was > 20, or if open space was > 0.30, or if erodibility was >= 0.36. If the IBI was > 44 and the T and E value was < 20, the score would still be 3).

Table 16 below shows variables that were considered in prioritizing management units, and how each variable was weighted.

Prioritizing Management Units

Variables	Protection Priorities	Restoration Priorities	Water Quality Risks	Land Availability Variables
IBI	> 44	> 44	>22	Willing Buyer/Seller
T&E	>20	>20	NA	Low Cost
Point Discharge	NA	NA	>=1	
EPA 319	NA	Active EPA 319 sites	NA	
Open Space*	>=0.30	>=0.30	NA	High Protection Priorities
Development	NA	<0.30	>=0.30	High Restoration Potential
Cultivated	NA	>0.50	NA	High Water Quality Risks
Road Density	NA	NA	>=53 meters/hectare	High Grant Potential
Urban-Transition-Rural	NA	NA	Transitional Development	Cooperating Owner
Erodability	>=0.36	NA	>=0.25	Regulatory Support
Listed Contaminants	NA	NA	Yes, if any contaminants are listed per MU	Supportive Community
Recuperative Potential	NA	High	NA	
Stabilization Potential	NA	Easily	NA	
Wetlands Present	NA	Present* Included in Open Land	NA	
Floodplain/ Floodway Present	NA	Present	NA	
Other Special Features	NA	Undefined	NA	
Cost	NA	Relatively Low Cost	NA	
Hydric Soils Present	NA	High	NA	
Score	**High = 3**	**High = 3**	**High = 3**	**High = 3**
IBI	34-44	34-44	Rural Development	Med. Protection Priorities
T&E	<20	<20	NA	Med. Restoration Potential
Point Discharge	NA	NA	No Discharge Points	Med. Water Quality Risks
EPA 319	NA	Inactive Sites	NA	Grant Potential
Open Space*	<0.30	<0.30		Ambivalent Community
Development	NA	<0.30	<0.30	
Cultivated	NA	<0.50	NA	

Variables	Protection Priorities	Restoration Priorities	Water Quality Risks	Land Availability Variables
Road Density	NA	NA	<53meters/hectare	-24
Urban Transitional Rural	NA	NA	Rural Development	
Erodability	Erodability >= 0.25		Erodability 0.06-0.18	
Listed Contaminants		**Listed Contaminant (these areas may be easily improved with BMP's)**		
Recuperative Potential				
Easily Stabilized				
Wetlands				
Floodplain/ Floodway				
Other Special Features				
Cost		Moderate Restoration Cost		
Hydric Soils				
Score	**Med = 2**	**Med = 2**	**Med = 2**	**Med = 2**
IBI	<33	<33	<33	Condemnation necessary
T&E	0	0	NA	High Clean up Costs
Point Discharge	NA	NA	0	Potential litigation
EPA 319		No 319 Projects		Low Protection Priorities
Open Space*	<0.10	<0.10	NA	Low Restoration Potential
Development	NA	<=0.30	<=0.30	Low Water Quality Risks
Cultivated	NA	0	NA	Low Grant Potential
Road Density	NA	NA	<24	No regulatory Support
Urban-Transition-Rural	NA	NA	Urban Development	Hostile Community
Erodability	<0.24	<0.24	<0.24	Low = 1
Listed Contaminants	NA	NA	>0	
Recuperative Potential		Low Recuperative Potent.		
Easily Stabilized				
Wetlands				

Variables	Protection Priorities	Restoration Priorities	Water Quality Risks	Land Availability Variables
Floodplain/ Floodway				
Other Special Features				
Restoration Cost		High Restoration Costs		
Hydric Soils				
Score	**Low=1**	**Low=1**	**Low=1**	**Low=1**

Figure 50 indicates MUs that should receive the highest attention based on the ranking system used above. We believe that this is a good first cut for ranking MUs with available information, but we also recognize that the resolution is still rather course in many of the MUs. The GIS data and models used within this study can be easily modified to incorporate additional data as it becomes available. The section Data Needs and Conclusion describes our recommended approach for obtaining higher resolution, parcel specific information.

Data Needs and Conclusion

This report identifies important MUs to focus attention on within the Little Calumet-Galien River using a variety of measures. The Protection Opportunities chapter uses three models to prioritize management units based on Protection, Restoration, and Land Availability variables. Determining the availability of land was beyond the scope of this study. However, this study should be used to concentrate efforts on determining the availability of land at select section locations.

Water Quality “hot spots” were determined in the Water Quality section where MUs were ranked according to known and projected risks to water quality. The Water Quality Risks model incorporated measured data with existing and projected land use data. It also incorporated known point sources to get a better understanding of whether the measured pollution was caused by point or non-point sources.

We attempted to account for the results of all four models (Protection Priorities, Restoration Priorities, Water Quality Risks, and Land Availability) by creating and running an overall model described in the section on Prioritizing Management Units.

The strength and weakness of all of these models rely primarily on the strength of the measured variables. While we have included a comprehensive list of the variables we believe should go into the models, not all of the variables were equal. However, the programs are set up so that missing variables, or more details on existing variables, can be incorporated into the model.

The following information contains our recommendations for obtaining data that would provide higher resolution results.

BASINs NPSM Analysis and SWAT

The BASIN's software and data provided an important source of information for this report. The functions ASSESS and TARGET were used to review major sources of chemical and nutrient runoff. Unfortunately, the Non-point Source Model (NPSM) that "estimates land-use-specific non-point source loadings for selected pollutants at the watershed level (cataloging unit or user-defined subwatershed scale)" would not work with the data provided within the BASINs software. The RF1 (EPA Reach File 1) representation of stream systems was coded improperly and could not be easily corrected (Figure 51). The more detailed RF3 reach files are not coded to support any BASIN models, nor are the newly developed NDH reach files.

The RF1 file uses flood control channels that were created to shunt floodwaters into Lake Michigan during high water periods. Reach data fields for normal flow (which flow away from Lake Michigan and into the Mississippi system) were not coded. Recoding and adding stream reaches to RF1 Basins data was not practical given database limitations. Also, none of the tributaries from other important drainages in La Porte County (a major agricultural area) were included in the file.

BASIN's support and training staff recommended that correcting to RF1 would not be as cost-effective since BASIN's version 3 will address all of these specific problems. BASIN's version 3.0 will be released within the next few months. This version will include a new model called "SWAT" which is a river basin (watershed) model developed to quantify the impact of land management practices in large, complex watersheds. The model was developed with TMDL assessment and management in mind. This model is much more flexible than the current BASIN version 2 models. The Version 3 model uses landscape data such as watershed boundaries, elevation models and land use themes to automatically prepare many of the input data. Stream reach connectivity is automatically defined and coded. Local data is much easier to incorporate into the new version. Additional information regarding BASIN version 3 can be found at the EPA website: http://www.epa.gov/ost/ftp/basins/system/BASINS3/areadb3.htm.

Other GIS data considerations

Several GIS data types would be helpful for further analysis—SSURGO soils for Lake and Porter counties and cadastral (property boundaries) for all counties. Detailed soils, as can be seen with the La Port County SSURGO coverage will provide historic information defining a large portion of historic wetlands. The same hydric information can be intersected with land use information providing a ranking of restoration opportunities. The same is true with floodplain/floodway data.

Parcel size and location are two critical pieces of information that can be found in cadastral files. A quick review of parcel data can reveal the distribution of larger, more easily restored properties for both water quality and flood control purposes. The distribution of the parcels across the landscape helps identify currently protected lands, potential linkages and high-potential restoration opportunities.
Building dates and parcel size, which are often included in cadastral data, can be used to show historic development patterns and identify both areas and specific properties that are likely to be developed in the near future. Tax-based land use (based on highest potential property value) can be used up update land use and land cover generated from aerial photography and satellite imagery, providing great insight to subdivision trends. This is particularly helpful in determining land use areas in transition.

Figure 52 illustrates how parcel boundary information can be used to identify owners of target properties.

Ownership information can consume a significant amount of time when on-site visits are required. Time spent in land records offices can be arduous as each separate community/county has its own land records system.

Cost share programs are not uncommon for the development of digital soils data. In North Carolina the state agencies, NRCS, USGS, county governments and others will jointly fund a soils mapping and digitizing effort. The state also provides guidance to local government for land records mapping.

The variety and value of these data sets greatly exceeds the efforts required for data development. Such information is used as much in the private sector as in the public, generally providing for a better decision-making process.

BIBLIOGRAPHY

Adams, J. 2000. North America during the last 15,000 Years. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Bacone, J. A. and R. K. Campbell, 1980. Presettlement Vegetation of Lake County, Indiana in Proceedings of the Seventh North American Prairie Conference – August 4-6, 1980, pp. 27 – 37.

Bacone, J. A., C. L. Hedge, J. Fix and T. W. Post. Unpublished. The Status of the Top 25 Priority Wetlands in Indiana's Coastal Zone: A Comparison 1979-1996. Indiana Department of Natural Resources

Bacone, J. A., C. L. Hedge, J. Fix and T. W. Post, 1998. The Status of Natural Areas In Indiana's Coastal Zone: A comparison: 1979-1996. Indiana Department of Natural Resources – Division of Nature Preserves. State of Indiana, Indianapolis, Indiana

Bieber, C. L. and Smith, N. M., 1952. Industrial Sands of the Indiana Dunes. Indiana Department of Conservation, Geological Survey Bulletin No. 7.

Bogue, Margaret Beattie, 1985. Around the Shores of Lake Michigan. University of Wisconsin Press.

Brower, J., J. Zar and C. von Ende, 1990. Field and Laboratory Methods for General Ecology, third edition. Wm. C. Brown Publishers. Dubuque, Iowa.

Cowardin, L. M., V. Carter, F. C. Golet and E. T. Laroe, 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service, Department of the Interior. Washington, D.C.

Crankshaw, W. B., S. A. Qadir and A. A. Lindsey, 1965. Edaphic Controls of Tree Species in Presettlement Indiana, Ecology, Vol. 46, No. 5.

Collins, S. L. and D. J. Gibson, 1990. Effects of Fire on Community Structure in Tall-grass and Mixed-Grass Prairie – *in* Fire in North American Tallgrass Prairies, ed. Scott L. Collins and Linda Wallace. University of Oklahoma Press, Norma Publishing Division. Pp. 81-98.

Cronin, William, 1992. Nature's Metropolis: Chicago and the Great West. Norton Press

Crow, T. R., 1988. Reproductive Mode and Mechanisms for Self Replacement of Northern Red Oak (Quercus rubra) – A Review. Forest Science, Vol. 34, No. 1, pp. 19-40

Daniel, G. 1977. Dune Country: A Guide for Hikers and Naturalists. The Swallow Press, Inc. Chicago, Illinois

Early, T. and J. Gentile, 1996. Wastewater: An Environmental Resource (Video). East Chicago Aquatic Resources Institute.

Environmental Planning and Engineering, Inc. 1976. A Regional Park Conceptual Development Plan for the Little Calumet River in Northwestern Indiana. Prepared for the Indiana Department of Natural Resources. Environmental Planning and Engineering, Inc., Indianapolis, Indiana

Erickson, J. 1990. Ice Ages: Past and Future. TAB Books. Blue Ridge Summit, Pa.

Glen-Lewin, D. C., L. A. Johnson, T. W. Jurik, A. Akey, M. Leoschke and T. Rosburg, 1990. Fire in Central North American Grasslans: Vegetative Reproduction, Seed Germination and Seedling Establishment – in Fire in North American Tallgrass Prairies, ed. Scott L. Collins and Linda Wallace. University of Oklahoma Press, Norma Publishing Division. Pp. 28-45.

Gray, H. H., C. H. Ault, and S. J. Keller. 1987. Bedrock Geology Map of Indiana. Bloomingon: Indiana Geological Survey.

Hall, G. N., R.W. Cramer. 1968. Little Calumet River Study: A Regional Planning and Flood Control Project. Lake Michigan Region Planning Council, Chicago, Illinois

Hoyt, H. 2000. One Hundred Years of Land Values in Chicago: The Relationship of the Growth of Chicago to the Rise of its Land Values, 1930-1933. Beard Books, Inc.

Indiana Department of Natural Resources – Coastal Zone Management Program. 1976. Natural Resources Inventory. Technical Report No. 101. Indiana State Planning Services Agency. Indianapolis, Indiana

Indiana Department of Natural Resources. 1975. An Analysis of the Recreation Potential of the Little Calumet River. State of Indiana, Indianapolis, Indiana

Indiana Department of Natural Resources – Division of Water. 1994. Water Resource Availability in the Lake Michigan Region, Indiana. State of Indiana, Indianapolis, Indiana.

Lindsey, G., A. Esparza and M. Hashem. 1993. Controlling Urban Nonpoint Source Pollution in the Grand Calumet River, Indiana Harbor Ship Canal, and Nearshore Lake Michigan Area of Concern: A Preliminary Assessment. (IUSPEA Publication No. 93-E02) Prepared for the Northwestern Indiana Regional Planning Commission and Indiana Department of Environmental Management. Indiana University School of Public and Environmental Affairs, Indianapolis, Indiana

Little Calumet River Advisory Committee. 1970. Report to the Governor. Lake-Porter County Regional Transportation and Planning Commission

Little Calumet River Basin Commission. 1976. Flood Insurance Programs. Little Calumet River Basin Commission, Highland, Indiana

Mendelsohn, Betsy, 1996. "Rustbelt Hell or Redevelopment Heaven? Lake Calumet: Land of Contrasts". The Green Pages of the University of Chicago Free Press, September, 1996.

National Park Service, 2001. "Indiana Dunes National Lakeshore". Nation Park Service web-page: http://www.nps.gov/indu/

Northwestern Indiana Regional Planning Commission, 2000. Northwest Indiana Demographic and Economic Trends: Facts and Figures about Population and Employment in Northwest Indiana.

Petty, R. O. and M. T. Jackson. 1966. Plant Communities in 1816 – 1966: Natural Features of Indiana. Indiana Academy of Science. Indianapolis, Indiana

Purdue-Calumet Development Foundation in collaboration with the Little Calumet Planning Coordinating Committee. 1964. Value of Potential Development in the Little Calumet Flood Plain – A Summary Report.

Risser, P. G. 1990. Landscape Processes and the Vegetation of the North American Grassland – in Fire in North American Tallgrass Prairies, ed. Scott L. Collins and Linda Wallace. University of Oklahoma Press, Norma Publishing Division. Pp. 133-146.

Seastedt, T. R. and R. A. Ramundo, 1990. The influence of fire on Belowground Processes of Tallgrass Prairie – In Fire in North American Ttallgrass Prairies, ed. ScottL. Collins and Linda Wallace. University of Oklahoma Press, Norma Publishing Division. Pp. 99-118.

Stewart, P. M., J. T. Butcher, and M. E. Becker, 1997. Ecological Assessment of the Three Creeks Draining the Great Marsh at Indiana Dunes National Lakeshore. Report to the National Park Service, Water Resources Division and the Indiana Dunes National Lakeshore. Lake Michigan Ecological Research Station. Great Lakes Science Center – Biological Resources Division. U.S. Geological Survey, Porter, Indiana

Swink, F.A. and G. Wilhelm, 1994. Plants of the Chicago region. Indiana Academy of Sciences.

The Nature Conservancy and Ball State University. 1999. Biodiversity Conservation Opportunities in the Toleston Strandplain of Northern Lake County, Indiana: A Strategic Plan for Conservation Success. The Nature Conservancy.

Transeau, E. N., 1935. The Prairie Peninsula. Ecology: 16:423-437.

Troy, Sylvia, 1984. The Indiana Dunes Story – How nature and people made a park. Shirley Heinze Fund

U.S. Army Corps of Engineers, Chicago District, North Central Division. March 13 and 14, 1990. Summary of Coordination Meeting.

Wiggers, R., 1997. Geology Underfoot in Illinois. Mountain Press Publishing, Missoula, Montana

Appendix A

References for Water Quality BMPs

American Fisheries Society, 1983. Stream Obstruction Removal Guidelines. American Fisheries Society, Bethesda, Maryland

American Society of Civil Engineers, 1992. Design and Construction of Urban Stormwater Management Systems. American Society of Civil Engineers, New York, New York.

Anacosta Restoration Team. Metropolitan Washington Council Watershed Sourcebook. Department of Environmental Programs, Metropolitan Washington Council of Government Colleted Papers, Metropolitan Information Center, Metropolitan Washington Council of Governments.

Apfelbaum, S. I., J. D. Eppich, T. H. Price, and M. Sands. 1995. *The Prairie Crossing Project: Attaining Water Quality and Stormwater Management Goals in a Conservation Development*: in Using Ecological Restoration to Meet Clean Water Act Goals: A National Symposium, March 14 – 16, 1995. pp. 33-38. Northeaster Illinois Planning Commission: Natural Resources Department, Chicago, Illinois

Applied Ecological Services and Thompson Dyke and Associates for Northeastern Illinois Planning Commission, 1997. Natural Landscaping for Public Officials. Northeastern Illinois Planning Commission, Chicago, Illinois

Christopher B. Burke Engineering, 1996. Indiana Drainage Handbook: An Administrative and Technical Guide for Activities within Indiana Streams and Ditches. Christopher B. Burke Engineering, Rosemont, Illinois

Christopher B. Burke Engineering, Ltd. for Maumee River Basin Commission. 1996. MRBC Obstruction Removal Program. Maumee River Basin Commission, Fort Wayne, Indiana 46802

Illinois State Water Survey. 1998. Field Manual of Urban Stream Restoration. Illinois State Water Survey, Champaign, Illinois

Iowa Department of Natural Resources, 1987. How to Control Streambank Erosion. IDNR, SCS, USDA. Des Moines, Iowa.

Isenhart, T. M., R. C. Schultz, J. P. Colletti and C. A. Rodrigues, 1995. *Design, Function and Management of Integrated Riparian Management Systems*, in Using Ecological Restoration to Meet Clean Water Act Goals: A National Symposium, March 14 – 16, 1995. pp. 93-102. Northeastern Illinois Planning Commission: Natural Resources Department, Chicago, Illinois

Land and Water, Inc., 1995. Land and Water Magazine, July/ August 1995. Land and Water, Inc., Fort Dodge, Iowa.

Lindsey, G., A. Esparza and M. Hashem for Northwestern Indiana Regional Planning Commission and the Indiana Department of Environmental Management, 1993.

Controlling Urban Nonpoint Source Pollution in the Grand Calumet River, Indiana Harbor Ship Canal, and Near-shore Lake Michigan Area of Concern: A Preliminary Assessment. Northwestern Indiana Regional Planning Commission and the Indiana Department of Environmental Management, Indianapolis, Indiana

North Carolina Department of Environmental Health and Natural Resources. Erosion and Sediment Control Planning / Design Manual and Field Manual. North Carolina Department of Environmental Health and Natural Resources.

Northeastern Illinois Planning Commission, 1995. Demonstration of Improved Stormwater System Design: Southgate Commerce Center, Matteson, Illinois. Northeastern Illinois Planning Commission, Chicago, Illinois

Northeastern Illinois Planning Commission, 1995. Flossmoor Stormwater Detention Basin Retrofit: A demonstration of Detention Basin Modifications to Improve Nonpoint Source Pollution Control. Northeastern Illinois Planning Commission, Chicago, Illinois

Northeastern Illinois Planning Commission, 1994. Homewood Prairie Lakes Stormwater Wetland Biofilter for the Control of Sediment Pollution: A Demonstration of Stormwater Best Management Practices for Urban Development. Northeastern Illinois Planning Commission, Chicago, Illinois

Northeastern Illinois Planning Commission, 1990. Model Stormwater Drainage and Detention Ordinance: A Guide for Local Officials. Northeastern Illinois Planning Commission, Chicago, Illinois

Northeastern Illinois Planning Commission, 1997. Reducing the Impacts of Urgan Runoff: The Advantages of Alternative Site Design Approaches. Northeastern Illinois Planning Commission, Chicago, Illinois

Northeastern Illinois Planning Commission. Urban Stormwater Best Management Practices for Northeastern Illinois. 1993. Northeastern Illinois Planning Commission, Chicago, Illinois

Rust Environment and Infrastructure in cooperation with Applied Ecological Services for DuPage County Department of Environmental Concerns Stormwater Management Division Inc. 1995. Streambank Stabilization Program. DuPage County DEC: Dept. of Environmental Concerns. Wheaton, Illinois.

South Carolina Department of Health and Environmental Control, 1995. South Carolina's Developer's Handbook for Freshwater Wetlands. South Carolina Department of Health and Environmental Control, U.S. Army Corps of Engineers, Charleston, South Carolina.

The Hoosier Heartland Resource Conservation and Development Council, Inc. Urban Development Planning Guide, Third Edition. Indianapolis, Indiana.

The Northeastern Illinois Soil Erosion and Sedimentation Control Steering Committee, 1981. Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois. The Northeastern Illinois Soil Erosion and Sedimentation Control Steering Committee, Lisle, Illinois

Tip of the Mitt Watershed Council, 1995. Understanding, Living with and Controlling Shoreline Erosion: A Guidebook for Shoreline Property Owners. Tip of the Mitt Watershed Council, Conway, Michigan.

U.S. Army Corps of Engineers, 1983. Streambank Protection Guidelines for Landowners and Local Governments. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi

U.S. Department of Agriculture, Forest Service, Southern Region, 1992. Stream Habitat Improvement Handbook. Technical Publication R8-TP16. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, Georgia.

U.S. Department of Agriculture, Natural Resources Conservation Service. Miscellaneous data. USDA, NRCS, Indianapolis, Indiana.

U. S. Department of Agriculture, Natural Resources Conservation Service, 1995. Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement. USDA, NRCS. Champaign, Illinois

U.S. Department of Agriculture, Natural Resources Conservation Service, 1997. Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois. USDA, NRCS, Chicago, Illinois. Chicago Metro Urban and Community Assistance Office

U.S. Department of Agriculture, Natural Resources Conservation Service. NRCS National Engineering Handbook. U.S. Department of Agriculture USDA, NRCS, Indianapolis, Indiana.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1993. NRCS Engineering Field Handbook. USDA, NRCS, Indianapolis, Indiana

U.S. Department of Agriculture, Natural Resources Conservation Service. NRCS Technical Guide, Section 4: Standard Specifications. USDA, NRCS, Indianapolis, Indiana.

Urban Conservation Program, IDNR. Indiana Handbook for Erosion Control on Developing Areas: Guidelines for Protecting Water Quality through the Control of Soil Erosion and Sedimentation on Construction Sites. Indiana Department of Natural Resources, Division of Soil Conservation. Indianapolis, Indiana.

Walech, Stuart G., 1989. Urban Surface Water Management. John Wiley & Sons, Inc. New York, New York.

Appendix B

Photos of Field Observation Sites


August 22, 2000 – Photo No. 1: Site No. 6 – Stream Name: Deep River. County: Lake


August 22, 2000 – Photo No. 2: Site No. 6 – Stream Name: Deep River. County: Lake

August 22, 2000 – Photo No. 3: Site No. 6 – Stream Name: Deep River. County: Lake

August 22, 2000 – Photo No. 4: Site No. 7 – Stream Name: Deep River. County: Lake

August 22, 2000 – Photo No. 5: Site No. 7 – Stream Name: Deep River. County: Lake

August 22, 2000 – Photo No. 6: Site No. 8 – Stream Name: Turkey Creek. County: Lake

August 22, 2000 – Photo No. 7: Site No. 8 – Stream Name: Turkey Creek. County: Lake

August 22, 2000 – Photo No. 8: Site No. 8 – Stream Name: Turkey Creek. County: Lake

August 22, 2000 – Photo No. 9: Site No. 9 – Stream Name: Little Calumet River. County: Lake

August 22, 2000 – Photo No. 10: Site No. 9 – Stream Name: Little Calumet River: County: Lake


August 22, 2000 – Photo No. 11: Site No. 4 – Stream Name: Little Calumet River. County: Lake


Photo No. 12: Site No. 4 – Stream Name: Little Calumet River: County: Lake

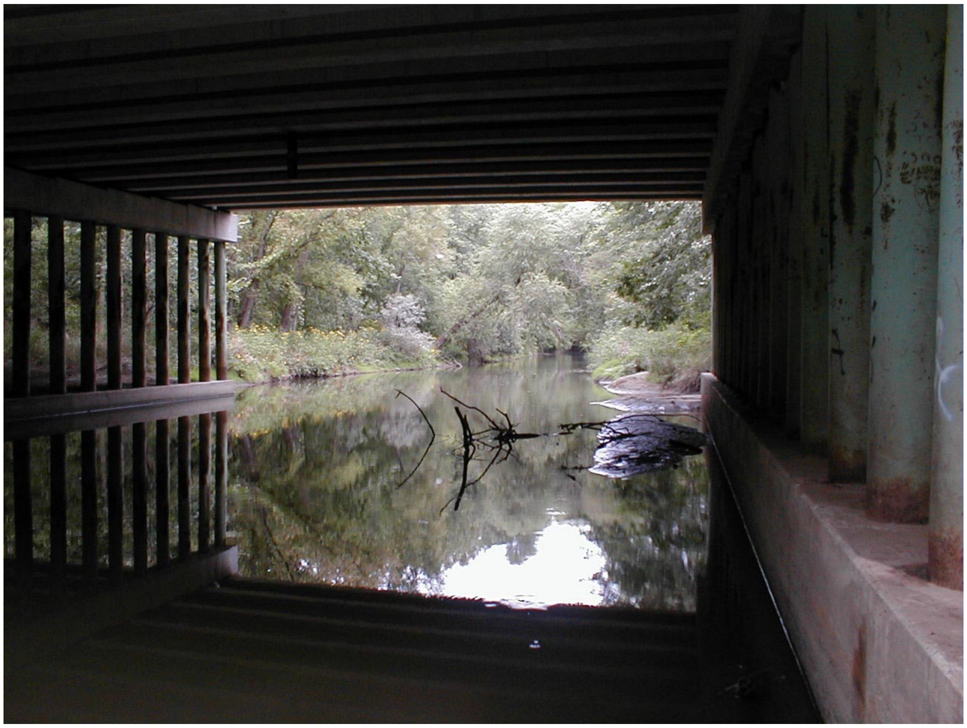
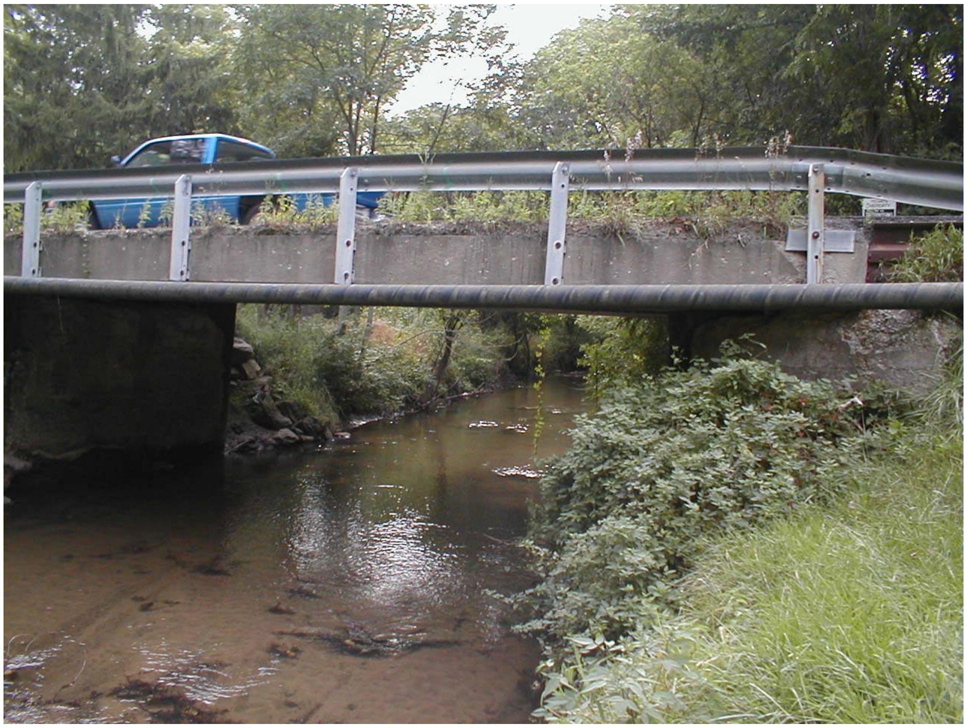

August 22, 2000 – Photo No. 13: Site No. 4 – Stream Name: Little Calumet River: County: Lake


Photo No. 14: Site No. 3 – Stream Name: Salt Creek: County: Porter


August 22, 2000 – Photo No. 15: Site No. 3 – Stream Name: Salt Creek: County: Porter


August 22, 2000 – Photo No. 16: Site No. 5 – Stream Name: Salt Creek: County: Porter



August 22, 2000 – Photo No. 17: Site No. 5 – Stream Name: Salt Creek: County: Porter

August 22, 2000 – Photo No. 18: Site No. 12 – Stream Name: Salt Creek: County: Porter

Photo No. 19: Site No. 12 – Stream Name: Little Salt Creek. County: Porter

August 22, 2000 – Photo No. 20: Site No. 2 – Stream Name: Little Calumet River: County: Porter

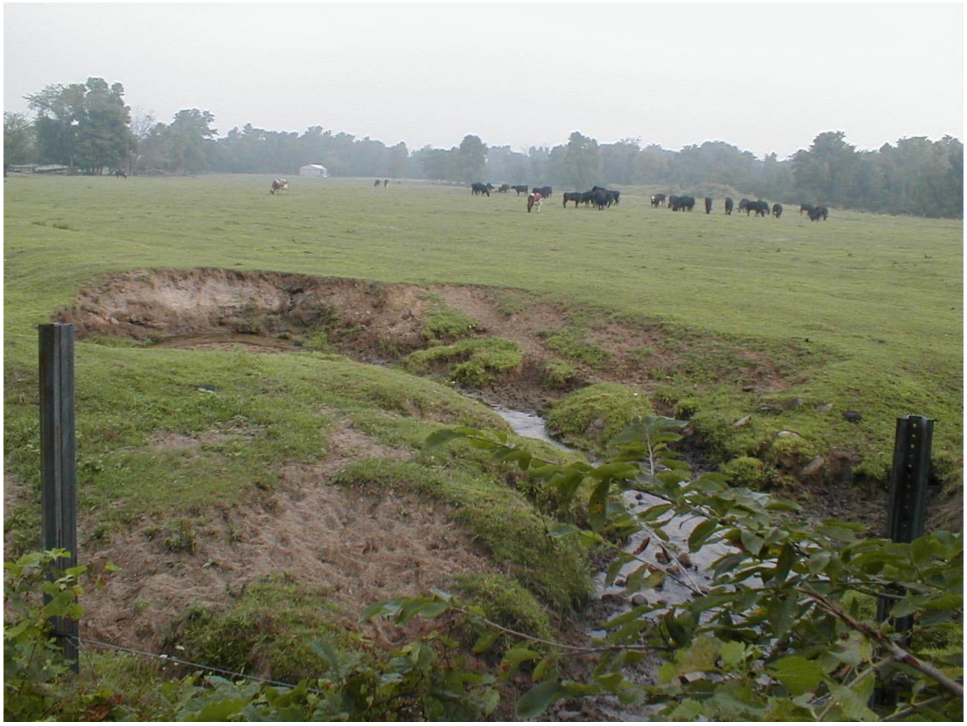

August 22, 2000 – Photo No. 21: Site No. 2 – Stream Name: Little Calumet River. County: Porter


August 22, 2000 – Photo No. 22: Site No. 1 – Stream Name: Galean River: County: LaPorte

August 22, 2000 – Photo No. 23: Site No. 1 – Stream Name: Galean River: County: LaPorte


August 23, 2000 – Photo No. 1. Stream Name: Trail Creek. County: LaPorte


August 23, 2000 – Photo No. 2. Stream Name: Trail Creek. County: LaPorte


August 23, 2000 – Photo No. 3. Stream Name: West Branch – Trail Creek. County: LaPorte


August 23, 2000 – Photo No. 4. Stream Name: West Branch – Trail Creek. County: LaPorte


August 23, 2000 – Photo No. 5. Stream Name: West Branch – Trail Creek. County: LaPorte


August 23, 2000 – Photo No. 6. Stream Name: East Branch – Trail Creek. County: LaPorte

August 23, 2000 – Photo No. 7. Stream Name: Coffee Creek. County: Porter

August 23, 2000 – Photo No. 8. Stream Name: Coffee Creek. County: Porter


August 23, 2000 – Photo No. 9. Stream Name: Coffee Creek. County: Porter

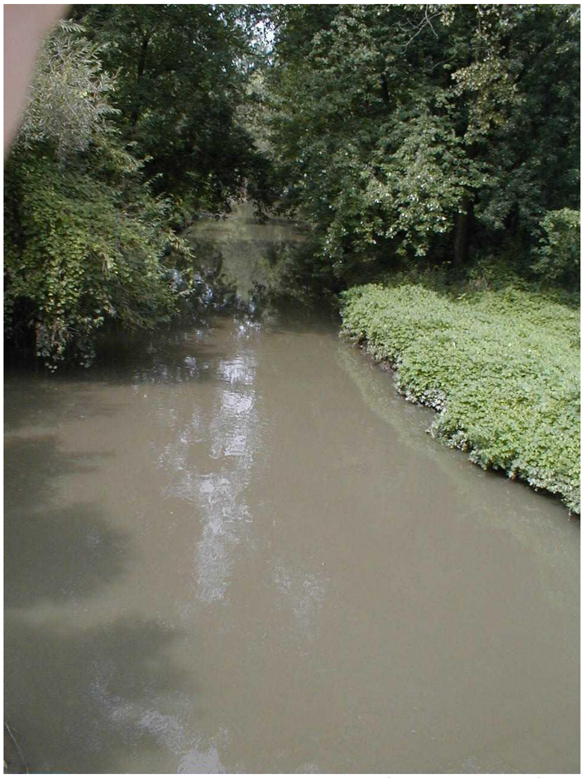

August 23, 2000 – Photo No. 10. Stream Name: Coffee Creek. County: Porter

August 23, 2000 – Photo No. 11. Stream Name: Sand Creek. County: Porter

August 23, 2000 – Photo No. 12. Stream Name: Sand Creek. County: Porter


August 23, 2000 – Photo No. 13. Stream Name: Hart Ditch. County: Lake


Photo No. 14. Stream Name: Hart Ditch. County: Lake



August 23, 2000 – Photo No. 15: Site No. 10 – Stream Name: Little Calumet River: County: Lake

August 23, 2000 – Photo No. 16: Site No. 10 – Stream Name: Galean River: County: Lake

Appendix C

Field Observation Data Sheets