# CHAIN O' LAKES WATERSHED

# DIAGNOSTIC STUDY

**October, 2002**

Sponsor

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Funded in Joint Co-operation

**IDNR DIVISION OF SOIL & WATER**
**&**
**NOBLE COUNTY**
**SOIL & WATER CONSERVATION DISTRICT**

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## FOREWARD

AUSPICES

The Chain O' Lakes Watershed Diagnostic Study was authorized by the Noble County Soil and Water Conservation District. Funding for the study was provided by the Noble County Soil and Water Conservation District under a grant from the Indiana Department of Natural Resources (IDNR), Division of Soil Conservation Lake and River Enhancement Program.

ACKNOWLEDGEMENTS

The Noble County Assessors Office permitted the use of the latest Noble County aerial photography.

Williams Aerial & Mapping, Inc. of South Bend, Indiana provided digitized aerial section maps.

Advantage Document Solutions, Corp. of Fort Wayne determined a method of combining and reproducing digitized aerial maps and computer aided drafting overlays.

Commonwealth Biomonitoring, Inc. provided services to assess biological community quality in stream samples.

Gina Weilbaker provided research services for existing water quality, and historical and background information.

Stacey McGinnis of Noble County Soil and Water Conservation District provided valuable administrative assistance and accompanied us on several field checks.

## PURPOSE

Noble County Soil and Water Conservation District (SWCD) identified through its locally led process that the Chain O' Lakes Watershed is one of the most potentially erodible areas in Noble County. It was deemed as a priority area for developing a watershed management plan, implementing best land use management practices and a follow up program to assure long term effectiveness.

The principal objectives of the study were fivefold:

1. Map the Chain O' Lakes Watershed and its principal drainage courses.

2. Map land use and erodible soils in the watershed and identify areas of concern which may pose a threat to the health of the lakes in Chain O' Lakes State Park.

3. Inspect open channel drainage courses within the watershed and map existing channel conditions.

4. Develop maps indicating existing land use and conditions. Noble County SWCD will use the maps to prioritize and address watershed conservation land treatment needs.

5. Identify areas of concern and provide specific recommendations for the implementation of conservation practices.

## EXECUTIVE SUMMARY

### INTRODUCTION

Gensic & Associates Inc. provided professional services to the Noble County Soil and Water Conservation District (SWCD) in conducting a diagnostic study for the implementation of land conservation practices in the Chain O' Lakes Watershed in Noble County, Indiana. The study was funded in kind by the Noble County SWCD with the aid of a grant from the Indiana Department of Natural Resources, Division of Soil Conservation Lake and River Enhancement Program.

The Noble County SWCD identified through its locally led process that the Chain O' Lakes Watershed is one of the most potentially erodible areas in Noble County. It was deemed a priority area for developing a watershed management plan implementing best land use management practices, and developing a follow up program to assure long term effectiveness.

The Chain O' Lakes Watershed was field checked and mapped. Maps were prepared which indicate watershed boundaries, principle drainage courses, erodible soils, land use, stream bank conditions, and land management conditions which may effect runoff water quality.

Problems in the Chain O'Lakes Watershed stemmed primarily from erosion due to agricultural practices on erodible land adjacent to open drainage channels. Other land management problems include livestock in open channels, gully erosion in fields, gravel road side ditches, terraces and inlets in cultivated erodible areas, concentrated livestock, yards, and streambank erosion in meandering open channels.

Land management problem areas are distributed throughtout this large watershed. Common recommendations within this report include vegetative filter strips between erodible cropland and open drainage channels, grassed waterways and rock chutes in eroded gullies, livestock exclusion fencing and streambank protection.

Land management practices which contribute to poor runoff water quality are general throughout the watershed. Establishing priority areas for remedial action would be arbitrary within the scope of this study.

## BACKGROUND AND DESCRIPTION

### CHAIN O' LAKES WATERSHED

The Chain O' Lakes Watershed is located in south central Noble County, Indiana. The watershed consists of the land area drained by Forker Creek upstream from State Road 9. Forker Creek is tributary to the South Branch of the Elkhart River, Elkhart River, Saint Joseph River and Lake Michigan.

The area of the Chain O' Lakes Watershed above Forker Creek at State Road 9 is approximately 12,700 acres (5150 hectares). Chain O' Lakes State Park and its lakes contain 2600 acres (1050 hectares) within the watershed.

### NOBLE COUNTY

Noble County is located in northeastern Indiana. According to the 1996 Census, the population in Noble County is 41,449. This is a 9 percent increase in population from the 1990 Census. Noble County is comprised of 13 townships. The Chain O' Lakes Watershed lies within five of the townships of Noble County. These include Allen, Green, Noble, Jefferson, and Swan. The combined population of the townships is 13,817. (Appendix D - Census Population of Indiana Townships)

Sixty-nine percent of Noble County land is classified as farms, 6 percent of its acreage is unpastured forest, 5 percent is pastured land, and 48 percent of its land is harvested cropland. In Noble County the amount of land in farms decreased one percent from 184,118 acres in 1992 to 181,963 acres in 1997. The average size of a farm in Noble County increased 4 percent from 1992 to 1997 and the number of full time farmers decreased 14 percent from 1992 to 1997. (Appendix D - Census Population of Indiana Townships)

Noble County is in the Steuben morainal lake area of the northern lake and moraine physiographic region. The soils were formed in glacial till, glacial outwash, alluvium, and organic material. Most of the soils of Noble County formed under a native vegetation of deciduous hardwoods. (Appendix E - Soils Survey of Noble County, pg. 107, 108, 111)

The elevation range of Noble County is 1,060 feet above sea level to less than 850 feet above sea level. The largest area of strongly sloping to steep soils is in Green Township. Chain O' Lakes State Park lies totally within Green Township. (Appendix E - Soils Survey of Noble County, pg. 111)

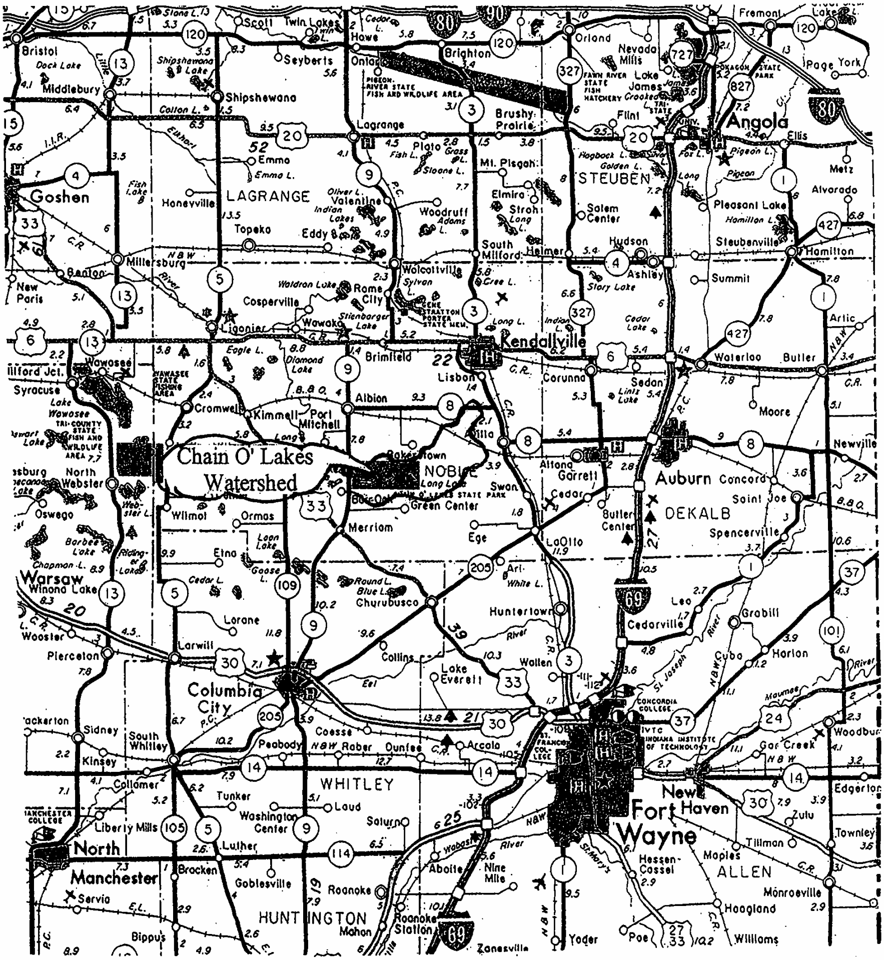



**Figure 1. Chain O' Lakes Watershed Location Map**

Noble County has a continental climate affected by the Great Lakes. Cool Canadian air masses alternating with tropical air masses cause frequent changes in the weather. Rainfall is adequate and the climate is excellent for farming. Hot summers and cold winters are characteristic of Noble County. (Appendix E - Soils Survey of Noble County, pg. 112 & Appendix F – Climatography of the United States No. 60)

Noble County is an agricultural community and some concerns of growing and managing crops are wetness, soil blowing and water erosion, maintaining fertility and the supply of organic matter and maintaining or improving tilth. Wetness can be managed by using tile, open ditches, and diversion terraces. Soil blowing is managed by keeping the soils covered with close-growing crops, leaving crop residue on the fields, growing winter crops, and using windbreaks. Water erosion management includes sod waterways, terraces, and contour strip cropping. A balanced fertilization program improves crops thus better control of erosion. (Appendix E - Soils Survey of Noble County, pg. 47)

The Noble County Soil and Water Conservation District conducted a survey to determine how land in the Chain O' Lakes Watershed was used by sending out 144 questionnaires to landowners and operators in the Chain O' Lakes Watershed. Out of the 144 questionnaires 44 were returned. It was found that production agriculture operations include 45% grain crops, 22% grain and livestock, and 33% other methods. The survey found that the predominant crop rotation by production operators is corn to corn to beans. The four types of conservation practices utilized by operators are grassed waterways, terraces, conservation tillage, and crop rotation. The various recreation activities within the watershed include hunting, hiking, boating, fishing, and swimming. (Appendix G – Results of the Chain O' Lakes Watershed Questionnaire)

## SIGNIFICANT NATURAL AREAS

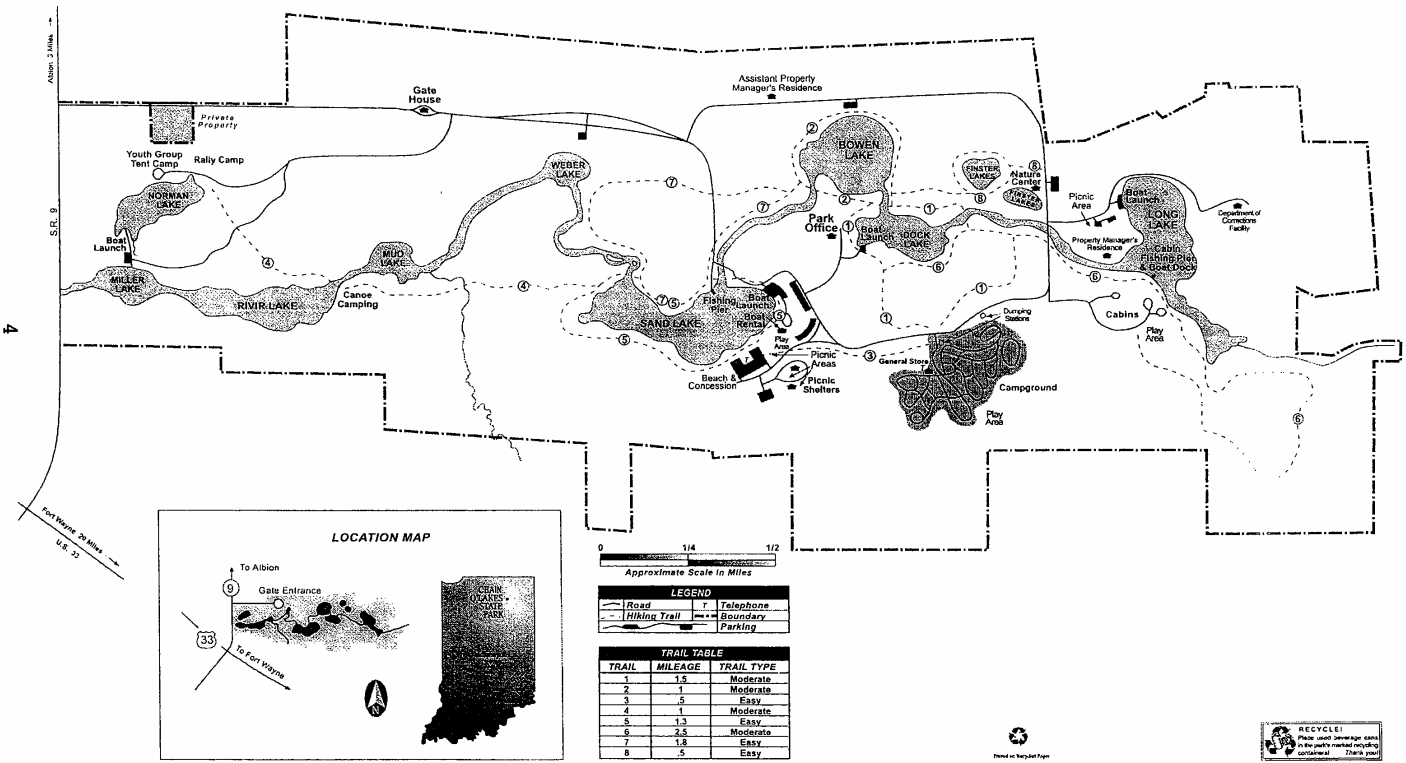
Information regarding endangered, threatened or rare species, high quality natural communities and natural areas provided by the Indiana Department of Natural Resources, Indiana Natural Heritage Data Center is presented in Appendix C.

## CHAIN O' LAKES PARK

The Chain O' Lakes State Park covers 2,718 (2000 hectares) acres and has within its boundary 11 lakes, 8 of which are connected by channels. These lakes were formed approximately 10,000 years ago by glaciers in this area. The lakes in this chain are known as kettle lakes and were huge blocks of ice. As the ice melted, rivers of water carved the connecting channels. (Appendix H – Chain O' Lakes State Park Map and Park Information)

# CHAIN O'LAKES STATE PARK

*2355 E. 75 South • Albion, Indiana 46701 • 260-636-2654*
*2,718 Acres Established 1960*




| TRAIL TABLE | | |
|---|---|---|
| TRAIL | MILEAGE | TRAIL TYPE |
| 1 | 1.5 | Moderate |
| 2 | 1 | Moderate |
| 3 | .5 | Easy |
| 4 | 1 | Moderate |
| 5 | 1.3 | Easy |
| 6 | 2.5 | Moderate |
| 7 | 1.8 | Easy |
| 8 | .5 | Easy |

Figure 2.

The lakes connected by channels are Long Lake, Dock Lake, Bowen Lake, Sand Lake, Weber Lake, Mud Lake, River Lake, and Miller Lake. Finster Lakes and Norman Lake are also located in Chain O' Lakes State Park. Chain O' Lakes State Park contains 212 surface acres of water with seven miles of widely varying shoreline. (IDNR) The surface areas for Bowen, Long, Dock, Miller, Norman, Mud, Rivir, and Sand lakes are 30 acres (12.1 hectares), 40 acres (16.2 hectares), 16 acres (6.5 hectares), 11 acres (4.5 hectares), 14 acres (5.7 hectares), 8 acres (3.2 hectares), 24 acres (9.7 hectares), and 47 acres (19.0 hectares), respectively. (Appendix H – Chain O' Lakes State Park Map and Park Information, Appendix I – Indiana Lake Water Quality Update for 1989 – 1993, Appendix K – Indiana Clean Lakes Program, Lake Water Quality Assessment Report, Appendix M – Indiana Resources – 1980)

The Chain O' Lakes Watershed contains most of the Chain O' Lakes State Park. The park provides a variety of recreational activities to the people of the area and those who travel to the area to enjoy the park. The lakes are used by the public to fish, canoe, boat, swim, and enjoy. Hiking trails at the park vary from .5 mile to 2.5 miles and are rated easy to moderate. A beach, concession stand, and bathhouse are provided. Picnic and play areas are located throughout the park. The park provides camping areas – modern, primitive, canoe camping, youth tent camping, and rally camping. The main campground has a small store. Family cabins may be rented weekly during the summer months. Through the summer months a naturalist is available. Hikes, Junior Naturalist and Hoosier Ecologist programs, and evening activities are offered. (Appendix H – Chain O' Lakes State Park Map and Park Information)

Chain O' Lakes is located in the Southern Michigan/Northern Indiana Till Plain region. This 25,800 square-mile (66,800 square kilometers) region includes a broad, nearly flat to rolling glaciated plain, deeply mantled glacial till and outwash, sandy and gravelly beach ridges and flats, belts of morainal hills, and boggy kettle depressions. Local topography ranges from a few feet to several hundred feet in elevation. Oak and hickory forests are the natural vegetation throughout most of the region. Lakes are common in some areas; however, many depressions are filled with peat deposits or dark mineral oils. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993, pg. 24)

Miami Indians inhabited Noble County before the pioneers settled here. An Indian village was once located on the north shore of Bowen Lake, a lake now within Chain O' Lakes State Park. (Appendix H – Chain O' Lakes State Park Map and Park Information)

## AGRICULTURAL PRACTICES

Noble County is an agricultural community and some concerns of growing and managing crops are wetness, soil blowing and water erosion, maintaining fertility and the supply of organic matter and maintaining or improving tilth. Wetness can be managed by using tile or open ditches and diversion terraces. Soil blowing is managed by keeping the soils covered with close-growing crops, leaving crop reside on the fields, growing winter crops and using windbreaks. Water erosion management includes sod waterways, terraces, and contour strip cropping. A balanced fertilization program improves crops thus better control of erosion. (Appendix E - Soils Survey of Noble County, pg. 47)

There is no detailed information regarding agricultural chemical use for Chain O' Lakes drainage basin. In Indiana, the primary pesticide use is the application of herbicides to corn and soybeans. It is reasonable to assume the generalization of Indiana can be applied to the drainage basin for Chain O' Lakes. Herbicides are applied to the corn and soybean crops during planting in the spring. Due to increase in no-till farming methods, there has been an increase in the use of herbicides applied prior to planting in order to kill all plant growth. Insecticide is another agricultural chemical applied during the summer to approximately 25 percent of the corn crop.

Whether or not the subbasin is in agricultural production or urban development, varying types of pesticides are found in streams. Typically, the pesticide diazinon is applied during the middle of summer in Indiana to fight insects in lawns and garden areas. Based on a study done on Kessinger Ditch, where 94% of watershed is in production agriculture, no traces of diazinon were found. In contrast, diazinon was present in the majority of samples taken in Little Buck Creek, which contains a predominantly urban watershed. (Appendix J - Water Quality in the White River Basin, 1992-96)

There are many important factors affecting pesticide incident in streams. Natural factors, such as type of terrain and soils, are important determinants for pesticide incidence in streams. (Appendix J - Water Quality in the White River Basin, 1992-96)

Based on a study in the White River, most of the herbicide load enters the stream between May and July. From a study performed between 1994 through 1996, 90% of the annual load of the five most common agricultural pesticides entered the stream during this period. This period occurs shortly after atrazine application, which is a common herbicide. Atrazine concentrations are high in the soil, and are susceptible to spilling into the streams during times of runoff. After one to two months, a majority of the atrazine is unavailable for runoff because it has been degraded or bound up in the soil and plant matrix. (Appendix J - Water Quality in the White River Basin, 1992-96)

Another study on the White River Basin has found that agricultural tile drains greatly affect the nitrate concentrations in streams. Aquifers in poorly drained soils, such as tight clay, are protected because the nitrate concentrations cannot penetrate the impermeable layer of clay. On the contrary, the streams in poorly drained areas can have spikes in nitrate concentrations because the discharge from outflow tiles in the poor soils is nitrate rich and discharges into the stream. When the drain tiles become dry during drought times, nitrate concentrations in the stream decrease to baseline conditions. (Appendix J - Water Quality in the White River Basin, 1992-96)

LAKE CLASSIFICATION – Indiana Trophic State Index

The tropic state of a lake refers to its overall level of nutrition or biological productivity. The following trophic state categories are used to describe lake conditions (IDEM, 1996).

> Oligotrophic (Class I) – clear water, very low levels of nutrients support few algae, dissolved oxygen is present in the hypolimnion, can support salmonid fisheries.
>
> Mesotrophic (Class II) – water less clear, moderate levels of nutrients support healthy algal populations, decreasing dissolved oxygen in the hypolimnion, loss of salmonids.
>
> Eutrophic (Class III) – transparency less than two meters, relatively high concentrations of nutrients, no dissolved oxygen in hypolimnion during summer, weeds and algae abundant.
>
> Hypereutrophic (Class IV) – transparency less than 1 meter, no dissolved oxygen in hypolimnion, extremely high nutrient concentrations support thick algal scums, very dense weeds.

The Indiana Trophic State Index (ITSI) was intended to characterize problem lakes and to define the reasons or sources behind complaints from lake users (IDEM, 1996). The TSI condenses water quality data into a single, numerical index. Eutrophy points are assigned for various concentrations of each parameter in the index. More points are given for conditions which are likely to promote greater productivity or which are indicative of greater productivity.

The Indiana TSI scale ranges from 0 to 75 eutrophy points where a total of 0 to 25 points represents oligotrophic conditions, 26 to 50 represents mesotrophic conditions, and 51 to 75 points generally represents eutrophic conditions. The Indiana TSI does not include a category for hypereutrophic lakes. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993)

## CONDITION OF INDIANA LAKES

During 1989 to 1993, most of the 322 lakes had TSI's ranging between 10 – 40 points. When grouped according to trophic class based on the Indiana TSI, 151 lakes were in Class I, 148 lakes in Class II, and only 24 lakes in Class III. An even greater percentage of lake surface area sampled during 1989-1993 consisted of Class I waters. Since the mid 1970's, 64.6% had lower TSI scores, 33.5% had higher TSI scores, and 1.9% had no change in score. Overall, Indiana gained more Class I and II lakes and lost some Class III lakes. The trend shows that the Indiana lakes studied during this period have become less productive since the mid-1970's. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993)

There is a strong relationship between the amount of cropland and the mean TSI for the five ecoregions in Indiana. As the percentage of cropland increases for an ecoregion, the mean TSI for the lakes increases proportionately. Ecoregions where more former cropland is held out of production in CRP programs have lower mean TSI's. As the percentage of conservation tillage in cropland increases, mean ecoregion TSI decreases. There is an inverse relationship between the percentage of highly erodible lands (HEL) in an ecoregion and its mean TSI. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993)

There is a direct relationship between highly erodible land (HEL) and the mean TSI. As the percentage of highly erodible land increases, the trophic state index increases (IDEM, 1996). The use of conservation tillage and other best management practices often disguises the relationship between soil erodibility and water quality index points. However, there has been found a direct relationship between HEL and TSI. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993)

The trophic state of Indiana lakes is determined by a complex interplay of lake morphology, geology, topography, and watershed land uses. Lakes with large watersheds relative to their lake volumes are flushed more frequently with runoff and this is largely a benefit to the lake, especially when a watershed best management practices have been applied. These types of lakes have had a greater decrease in trophic state from the 1970's to the present than lakes with small watershed to lake volumes ratio. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993)

## CONDITION OF THE LAKES OF CHAIN O' LAKES STATE PARK

Bowen, Dock, Long, Miller, Norman, and Rivir lakes have been classified as a Class II, mesotrophic lake. Mud and Sand lakes have been classified as a Class I, oligotrophic lake. Studies have not been conducted on Weber Lake in order to determine the classification. (Appendix I – Indiana Lake Water Quality Update for 1989 – 1993 & Appendix K – Indiana Clean Lakes Program – Lake Water Quality Assessment Report)

LAKES OF CHAIN O' LAKES STATE PARK HISTORICAL FISHERIES DATA AND MEMORANDUM

Historical data on the lakes in the Chain O' Lakes State Park were collected from Indiana Department of Natural Resources (IDNR) reports. The IDNR Tri-Lakes Fisheries Station and the station's fisheries biologist, Mr. Jed Pearson, provided much historical data for the lakes in Chain O' Lakes State Park. Copies of these reports are in Appendix L.

Summary of Watershed Historical Information. Bibliography is given first, followed by summary of report.

Indiana Department of Natural Resources. Bowen Lake Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

The report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that fishing for bluegill, largemouth bass, and redear is at an acceptable level in Bowen Lake. The author recommends that fish management remain the same at this time.

The author found that the greatest threat to Bowen Lake is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been observed that water clarity in Bowen Lake has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Indiana, Department of Natural Resources. Dock Lake Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

The report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that fishing for bluegill and bass is at an acceptable level in Dock Lake. However, crappie numbers have been low. The author recommends that fish management remain the same at this time.

The author found that the greatest threat to Dock Lake is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been noted that water clarity has been on the average poor. The depth of visibility has ranged from one foot to six feet. It has been observed that water clarity in Dock Lake has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Indiana, Department of Natural Resources. Long Lake Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

It has been observed that a large sediment delta has formed at the mouth of in the south basin of the lake. The report found that the fish population has changed little over the past 25 years. The survey conducted by the author found that sport fishing for bluegill and largemouth bass has been satisfactory acceptable level in Long Lake. The author recommends that fish management remain the same at this time.

The author found that the greatest threat to Long Lake is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been observed that water clarity in Long Lake has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Indiana, Department of Natural Resources. Mud and Weber Lakes Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

Except for greater number of fish collected, the report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that bluegill numbers have been low and crappies have increased in Mud and Weber lakes. The survey conducted by the author found that sport fishing for bluegill, redear, and largemouth bass has been satisfactory acceptable level in Mud and Weber lakes. The author recommends that fish management remain the same at this time.

Some natural liabilities in fish habitat in the lakes are shallow depth, low oxygen levels, diverse vegetation, and marsh-type environment. The author found that the greatest threat to Mud and Weber lakes is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been noted that water clarity has been on the average poor. The depth of visibility has ranged from one foot to six feet. It has been observed that water clarity in Mud and Weber lakes has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Indiana, Department of Natural Resources. Norman Lake Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

The report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that sport fishing for bluegill, bass, and bullheads at an acceptable level in Norman Lake. Bass are relatively scarce regardless of increased protection by Fish and Wildlife Services. Norman Lake provides acceptable fishing for bluegills and largemouth bass. Sunfish, bullheads, and some channel catfish provide additional fishing opportunities. The author recommends that fish management remain the same at this time.

Indiana, Department of Natural Resources. River and Miller Lakes Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

The report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that bluegill size has increased and large bass are scarce. The survey conducted by the author found that fishing for bluegill, largemouth bass, and redear is at an acceptable level in River and Miller lakes. The author recommends that fish management remain the same at this time.

The author found that the greatest threat to Rivir and Miller lakes is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been noted that water clarity has been on the average poor. It has been observed that water clarity in Rivir and Miller lakes has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Indiana, Department of Natural Resources. Sand Lake Noble County Fish Management Report 1996. Division of Fish and Wildlife, 1996.

The report found that the fish population has changed little over the past 30 years. The survey conducted by the author found that bluegill size has remained the same and northern pike has been scarce. The survey conducted by the author found that fishing for bluegill, largemouth bass, and redear is at an acceptable level in Sand Lake. The author recommends that fish management remain the same at this time.

The author found that the greatest threat to Sand Lake is the continuous deposit of high loads of sediments and nutrients from the watershed. It has been noted that water clarity has been on the average poor. It has been observed that water clarity in Rivir and Miller has been reduced to inches at various times. The author states that greater effort is needed within the watershed to minimize soil erosion and nutrient loss.

Pearson, Jed. Memorandum to Wayne Stanger, Indiana Department of Natural Resources. 12 November 1996.

The author found that Chain O' Lakes State Park still produces plenty of 7- to 9-inch bluegills and redear sunfish even though there has been heavy fishing pressure. Division of Fish and Wildlife biologists found that Sand and Bowen lakes generated largest size and population of bluegills. Mud and Weber lakes generated the largest redear fish population. Meanwhile, Bowen Lake generated the largest redear fish in terms of size. The author feels that the 14-inch minimum largemouth bass size regulation instituted by the park since 1973 has helped to keep the bluegill population in balance.

The Division of Fish and Wildlife also conducted surveys on water clarity and dissolved oxygen concentrations for Chain O' Lakes State Park. It was found that Sand, Norman, and Bowen lakes had modestly better clarity than the remaining lakes. Long, Norman, and Dock lakes exhibited very high amounts of oxygen at the surface waters, which indicates high algae levels. Mud and Weber lakes are experiencing very low levels of oxygen at the surface waters. On average, fish require 5 parts per million (ppm) for satisfactory health. Except for Miller and Norman lakes, the remaining lakes were below 4 ppm at a depth of 10 feet.

The author does not recommend initiating any new fish management programs at the park lakes. However, the author does recognize the severity of the sediment build-up problem at the inlet of Long Lake.

# WATERSHED SURVEY

# WATERSHED SURVEY

## INTRODUCTION AND METHODS

### STUDY AREAS

The Chain O' Lakes Watershed was divided into civil sections. Aerial photography is available in square mile civil sections and maps were prepared using aerial photography at a readable scale of 1 inch equals 400 feet. Each map contains information regarding the watershed boundary, erodible land, land use, and recommendations.

### MAPS

Maps were prepared as an aid to visualizing the Chain O' Lakes Watershed and its features. Maps should be referred to as the report is read. Each map contains the following information:

- Chain O' Lakes Watershed boundary
- Erodible land
- Road identification
- Current land use (at time of field check)
- Channel locations and stationing
- Problem areas
- Recommendations

The watershed boundary was established by field inspection with aerial photographs, Noble County Surveyors Office watershed maps, and topographic maps in hand. Current land use was verified in the field and existing conditions regarding problem areas were noted on maps during field checks.

Each drainage channel was inspected and conditions were noted on aerial photography. Field notes from maps were transferred to logs in the office. Additional information on drainage channel conditions is provided in the field check logs in Appendix A.

It must be stated that there may be and probably are problem areas in addition to those noted on the maps and in this report. The watershed was field checked, though there are no claims that this report is totally comprehensive regarding problem areas. It is the intent of this report to provide a tool for the Noble County Soil and Water Conservation District to continue the project of managing this watershed.

## LAND USE

For this study land use is divided into the following general categories: cropland, grassland, forest, wetland, pond, farmstead, and residential. Each category may be further described.

Grassland is land predominantly covered by grass and forbs. Grassland may be pasture, fallow fields, or land currently enrolled in the Conservation Reserve Program (CRP). Most of the areas classified as grassland were once cultivated fields or pasture.

Cropland is defined as land where row crops, small grains, or hay are cultivated. Hay is assumed to be part of a cultivated rotation. Tillage methods are not addressed in this report.

Land classified as forest is further described as parkland, plantings, pioneer, mature, or logged. All of the land within Chain O' Lakes State Park is classified as forest - park.

Wetlands are described as open water, meadow, shrub, and forested. The watershed contains numerous, small seasonal upland wetlands which were not noted on the maps. These depressions are important for runoff water quality, but they were difficult to locate for this study.

Land use classified as pond is used to define constructed bodies of water.

Land use is classified as farmstead if it is part of a farm building layout. Cattle, hogs, sheep horses, grain, feedlot, and inactive are used in this report to describe farmstead.

Land use is classified as residential if its primary use is for a permanent residence or seasonal cottage,

## SOILS AND ERODIBLE LAND

Upland soils in the Chain O' Lakes Watershed are primarily of the Miami-Riddles-Brookston, Fox-Oshtemo, Morley-Blount, and Morley-Miami associations. These soil associations are well drained to very poorly drained. Land slopes are nearly level to moderately steep. Slopes in erodible soils range from 2 to 25 percent. The following soils in the Chain O' Lakes Watershed are classified as moderately to severely erodible:

Blount silt loam, 2 to 4 percent slopes, eroded
Boyer loamy sand, 12 to 18 percent slopes, eroded
Casco sandy clay loam, 8 to 15 percent slopes, severely eroded
Fox sandy loam, 6 to 12 percent slopes, eroded
Fox-Casco sandy loams, 12 to 18 percent slopes, eroded

Fox-Casco sandy loams, 18 to 25 percent slopes, eroded
Miami loam, 2 to 6 percent slopes, eroded
Miami loam, 6 to 12 percent slopes, eroded
Miami loam, 12 to 18 percent slopes, eroded
Miami loam, 18 to 25 percent slopes, eroded
Miami clay loam, 6 to 12 percent slopes, severely eroded
Miami clay loam, 12 to 18 percent slopes, severely eroded
Miami loam, gravelly substratum, 2 to 6 percent slopes, eroded
Morley silt loam, 2 to 6 percent slopes, eroded
Morley silt loam, 6 to 12 percent slopes, eroded
Morley silt loam, 12 to 18 percent slopes, eroded
Morley silty clay loam, 6 to 12 percent slopes, severely eroded
Morley silty clay loam, 12 to 18 percent slopes, severely eroded
Morley, Miami, and Rawson loams, 6 to 12 percent slopes, eroded
Rawson sandy loam, 6 to 12 percent slopes, eroded
Rawson, Morley, and Miami loams, 2 to 6 percent slopes, eroded
Riddles sandy loam, 6 to 12 percent slopes, eroded
Riddles sandy loam, 12 to 18 percent slopes, eroded

FIELD CATEGORIES

Individual fields are identified on the aerial photography maps. Select fields will be categorized in the report based on the following criteria.

**Category 1 Field**
A Category 1 Field contains erodible land (EL) and is currently used as cropland. Runoff from a Category 1 field flows directly into an open drainage channel or lake.

**Category 2 Field**
A Category 2 Field is a field used as cropland which contains little or no erodible land (EL). A Category 2 Field discharges runoff directly to an open drainage channel or lake.

**Category 3 Field**
A Category 3 Field contains EL and is currently fallow with grass cover or used as pasture. A Category 3 Field discharges runoff directly to an open drainage channel or lake.

**Category 4 Field** - A Category 4 Field contains EL and is used as cropland. Runoff from a Category 4 Field does not discharge directly into an open drainage channel or lake. Category 4 Fields are frequently plagued by erosion problems and may drain to an open drainage channel through a closed tile or pipe.

## RECOMMENDATIONS

Recommendations are presented in each civil land section report. Locations for recommendations are noted on each map.

Descriptions of land management practices are presented in Appendix B.

## CIVIL SECTION LAND USE REPORTS

The Chain O' Lakes Watershed was mapped by civil sections. Each section contains one square mile (259 hectares). The watershed boundary is noted on maps where the watershed does not contain the entire civil section. This report is written to contain a mini-report for each civil land section and its corresponding map. Each section report contains information regarding the location and general description of the civil land section as well as information on drainage channels, field categories and locations, and special recommendations. It is the intent of this study to read the section report while viewing the corresponding map.

## BIOASSESSMENT REPORT

The Bioassessment Report is presented as a separate section of the Chain O' Lakes Watershed Diagostic Study.

## AGENCIES AND ASSISTANCE PROGRAMS

Technical and/or financial assistance for watershed land and water management are available through the following agencies.

United States Department of Agriculture
Natural Resources Conservation Service
100 East Park Drive
Albion, Indiana 46701
Contact: Sherman Liechty
District Conservationist
260-636-7682 Ext. 3

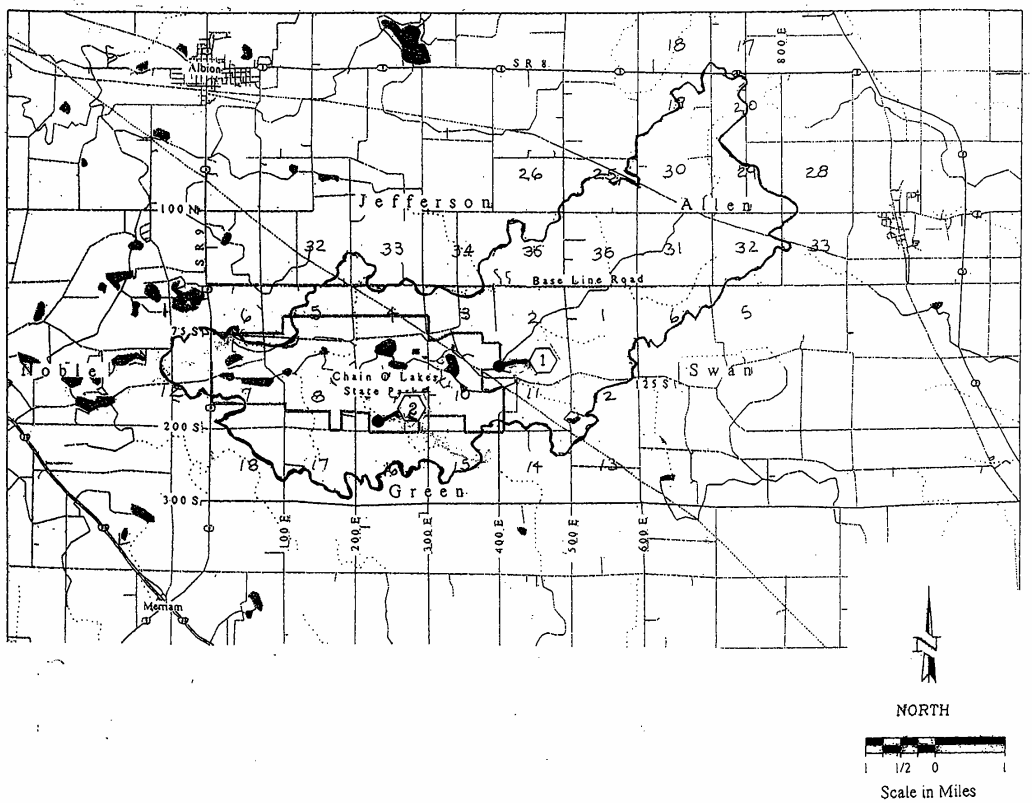
Noble County Soil and Water Conservation District
100 East Park Drive
Albion, Indiana 46701
Contact: Stacey McGinnis
SWCD District Manager
260-636-7682 Ext. 3

Department of Natural Resources
Lake and River Enhancement Program
317-233-3870

Department of Environmental Management
Watershed Management Section
317-233-8803

Regional Watershed Conservationist
Matt Jarvis
765-564-2849

Information regarding current land management practices is presented in Appendix B.




Site 1 Forker Creek at CR 450 E
Site 2 Unnamed tributary (Branch #1) at CR 200 S

**Figure 3. Chain O' Lakes Watershed Water Sample Sites used for the Bioassessment Report**

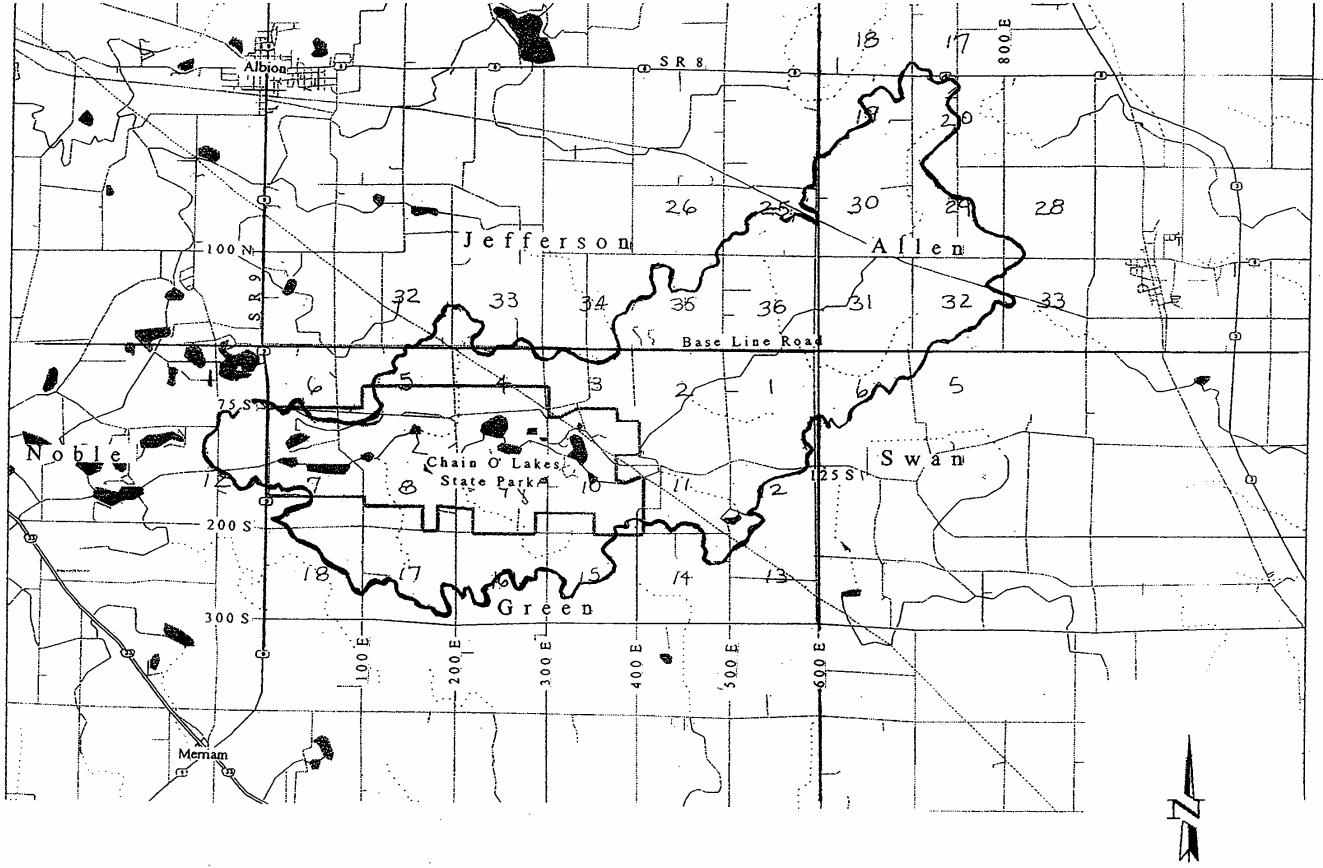



**Figure 4. Chain O' Lakes Watershed Boundary Map Indicating Townships and Civil Sections**

## NOBLE TOWNSHIP SECTIONS 1 & 12

### DESCRIPTION

Noble Township Sections 1 & 12 are located west of Chain O' Lakes State Park and are bounded on the east by State Road 9.

Section 1 & 12 contain 125 acres (52 hectares) of the Chain O' Lakes Watershed. The watershed area in these sections is predominantly cropland.

### DRAINAGE CHANNELS

Sections 1 & 12 contain no open drainage channels. The Baker Tile drains this area and discharges to an open channel in the park just east of State Road 9.

### FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
All fields in Sections 1 & 12 contain areas classified as Category 4.

### SPECIAL RECOMMENDATIONS

There are no special recommendations for Sections 1 & 12. Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 1

DESCRIPTION

Green Township Section 1 is located east of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the west by County Road 500 E. Section 1 contains 640 acres (259 hectares) of the Chain O' Lakes Watershed.

This section contains large areas of mature forest and forest plantings.

DRAINAGE CHANNELS

The Engle Ditch flows southwesterly through the north half of Section 1 with G1 Br#1 flowing from the north and joining the Engle in the northern part of the northwest quarter. The Yarian drains a portion of the northeast quarter. The Hanlon starts in the southwest quarter. Section 1 contains approximately 7200 feet (2195 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 2 Fields:**
The northwest quarter contains cropland north of the Engle Ditch.

**Category 3 Fields:**
The northwest quarter contains pasture south of the Engle Ditch

**Category 4 Fields:**
The northwest, northeast and southeast quarters contain erodible cropland.

SPECIAL RECOMMENDATIONS

Plant a filter strip and construct a livestock exclusion fence along Engle Ditch through the pasture area in the northwest quarter.

Plant vegetation stream bank protection along the Yarian Ditch in the northeast quarter.

Construct and plant grass waterway on erodible land cropland in the northeast quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 2

DESCRIPTION

Green Township Section 2 is located east of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the east by County Road 500 E.

Section 2 contains 670 acres (271 hectares) and lies entirely within the Chain O' Lakes Watershed.

This section contains a large area of mature forest and substantial areas of grassland and cropland.

DRAINAGE CHANNELS

The Engle Ditch flows southwest through the northeast, southeast, and southwest quarters of Section 2. The Hanlon Ditch flows northwest through the southeast quarter and discharges to the Engle. An unregulated open drain flows south through the northeast quarter and also discharges to the Engle Ditch.

Section 2 contains approximately 10,800 feet (3292 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Areas of Category 1 fields are located north and south of the Engle Ditch in the northeast quarter.

**Category 2 Fields:**
Category 2 fields lie adjacent to the Engle and unregulated drain in the northeast quarter.

**Category 3 Fields:**
Areas of Category 3 fields lie adjacent to the Engle and unregulated drain in the northeast quarter and adjacent to the Hanlon in the southeast quarter.

**Category 4 Fields:**
Areas of a Category 4 field lie in the northwest quarter adjacent to a wetland.

SPECIAL RECOMMENDATIONS

Filter strips should be planted adjacent to the Engle and unregulated drains in the northeast quarter.

Livestock exclusion fencing should be constructed north of the Engle through the pasture area in the northeast quarter.

Several areas of pasture erosion in the northeast quarter may be seeded and the Engle would benefit from vegetative stream bank protection if livestock is excluded from the channel.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 3

### DESCRIPTION

Green Township Section 3 is located north of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the west by County Road 300 E. Section 3 contains 610 acres (248 hectares) of the Chain O' Lakes Watershed and 190 acres (77 hectares) of park land. This section is primarily cropland in large areas of erodible soils.

### DRAINAGE CHANNELS

The southeast quarter contains a natural ravine which opens into the park north of Long Lake. The ravine lies primarily in park land.

### FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northern halves of the southwest and southeast quarters and large areas of the north half of Section 2 contain Category 4 fields.

### SPECIAL RECOMMENDATIONS

There are no special recommendations for Section 3.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 4

DESCRIPTION

Green Township Section 4 is located north of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the east by County Road 300 E. Section 4 contains 675 acres (274 hectares) of the Chain O' Lakes Watershed. The south half of the section is park land, 340 acres (138 hectares). The north half of Section 4 contains a mixture of mature forest, cropland, and pasture.

DRAINAGE CHANNELS

The Easterday Ditch flows southerly from County Road 200 E in the northwest quarter with approximately 750 feet (229 meters) flowing through private land before entering the park. The Hoffman tile system drains the south portion of the northeast quarter and discharges to Bowen Lake.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northeast and northwest quarters of section 4 contain areas of category 4 fields.

SPECIAL RECOMMENDATIONS

There is isolated gully erosion, driveway construction erosion and stream bank erosion in the northwest quarter.

The northeast quarter contains a feedlot operation.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 5

DESCRIPTION

Green Township Section 5 is located north of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the east by County Road 200 E. Section 5 contains 595 acres (241 hectares) of the Chain O' Lakes Watershed and 310 acres (126 hectares) of the park. The south half of the section is park land. The private land in the north half of the section contains a mixture of mature forest, grassland and cropland.

DRAINAGE CHANNELS

The Easterday Ditch is located in the northeast quarter and flows easterly to County Road 200 E before it enters park land. This section contains approximately 1800 feet (549 meters) of open channel bordered primarily by forest and grass land.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northeast quarter contains areas of cropland classified as Category 4.

SPECIAL RECOMMENDATIONS

There is an area of gully erosion at the head of the Easterday Ditch in the northeast quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 6

DESCRIPTION

Green Township Section 6 is located north of the park and is bounded on the north by Base Line Road and on the east by State Road 9. Section 6 contains 105 acres (43 hectares) of the Chain O' Lakes Watershed and 95 acres (38 hectares) of Chain O' Lakes Park. The watershed area is primarily within the park.

DRAINAGE CHANNELS

The southwest quarter contains approximately 1000 feet (305 meters) of open channel within the park boundary. The Baker Ditch drains an area of Noble Township Sections 1 & 12 west of State Road 9. This channel has streambank erosion and discharges directly into the wetland adjacent to Norman Lake.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The southwest quarter contains a category 4 field north of the park entrance road.

SPECIAL RECOMMENDATIONS

The drainage tile in the Category 4 field north of the park entrance road should be buffered.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 7

DESCRIPTION

Green Township Section 7 is located south of Chain O' Lakes State Park and is bounded on the west by State Road 9 and on the south by County Road 200 S. Section 7 contains 530 acres (214 hectares) of the Chain O' Lakes Watershed and 350 acres (141 hectares) of the park land. The north half of the section lies within the park boundary. The south half of Section 7 is primarily cropland.

DRAINAGE CHANNELS

There are no open drainage channels on the private land in this section. There are indications of a private tile drainage system which may discharge to Rivir Lake within the park.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
Areas of Category 4 fields lie in the south half of Section 7. The southwest quarter contains a tile drain and the southeast quarter contains terraces and tile risers.

SPECIAL RECOMMENDATIONS

Terraces and tile risers should be properly buffered to prevent cropland runoff from directly entering a closed tile system.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 8

### DESCRIPTION

Green Township Section 8 is located on the south side of Chain O' Lakes State Park and is bounded on the south by County Road 200 S and bounded on the west by County Road 100 E (abandoned within the park boundary). Section 8 contains 645 acres (262 hectares) and lies entirely within the Chain O' Lakes Watershed. This section contains 505 acres (204 hectares) of park. The watershed area in this section is predominantly mature forest. The area outside of the park boundary north of County Road 200 S is primarily cropland.

### DRAINAGE CHANNELS

The No Name Ditch flows north through the southwest corner of the section and discharges into Mud Lake within the park. The channels connecting the lakes within the park were not subject to this study. The area outside of the park boundary contains approximately 1500 feet (457 meters) of open drainage channel.

### FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Erodible cropland lies adjacent to the No Name Ditch in the southwest quarter.

**Category 4 Fields:**
The southwest quarter and southeast quarter contain erodible cropland.

### SPECIAL RECOMMENDATIONS

Plant vegetative filter strip on east and west side of No Name Ditch in the southwest quarter.

The southwest quarter contains a confined livestock operation.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 9

DESCRIPTION

Green Township Section 9 is located south of Chain O' Lakes State Park and is bounded on the south by County Road 200 S and the east by County Road 300 E. Section 9 contains 635 acres (258 hectares) and lies entirely within the Chain O' Lakes Watershed. This section is predominantly park land, containing on 80 acres (24 hectares) of private land. The private land is predominantly cropland.

DRAINAGE CHANNELS

The Sherwood Drain and its branches flow northwesterly through the south half of the section to Sand Lake. Approximately 500 feet (152 meters) of the Sherwood are adjacent to private land in the southeast quarter of the section.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
A Category 1 field touches the east side of the Sherwood in the southeast quarter.

**Category 4 Fields:**
A Category 4 field lies in the southwest quarter of the section.

SPECIAL RECOMMENDATIONS

A filter strip should be planted along the east side of the Sherwood Ditch in the southeast quarter.

There is isolated road erosion and gully erosion in the southwest quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 10

DESCRIPTION

Green Township Section 10 is located south of Chain O' Lakes State Park and is bounded on the south by County Road 200 S and on the east by County Road 400 E. Section 10 contains 605 acres (245 hectares) of the Chain O' Lakes Watershed and 500 acres (203 hectares) of park land. The private land is a mixture of forest and cropland.

DRAINAGE CHANNELS

The Forker Creek flows from east to west through the northeast quarter and discharges into Sucker Lake. The Sherwood flows northwesterly through the southwest quarter. Several ravine/channels flow northerly in the south half of the section and discharge to Sucker Lake. Streambank erosion is a problem within the park on the lower end of the ravine south of Sucker Lake within the park. Section 10 has approximately 3800 feet (1158 meters) of open channel flowing through or adjacent to private land.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
The southwest quarter of Section 10 contains Category 1 fields adjacent to the Sherwood Ditch

**Category 2 Fields:**
A Category 2 field lies north of the Forker in the northeast quarter

**Category 4 Fields:**
The northeast quarter contains small areas of Category 4 fields.

SPECIAL RECOMMENDATIONS

Plant filter strips and provide rock streambank protection along the Sherwood Ditch in the southwest quarter.

Plant a filter strip along the north side of the Forker Creek in the northeast quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 11

DESCRIPTION

Green Township Section 11 is located east of Chain O' Lakes State Park and is bounded on the south by County Road 200 S and is bounded on the east by County Road 500 E. Section 11 contains 590 acres (238 hectares) of the Chain O' Lakes Watershed. This section is a mixture of mature forest, wetlands, pasture, and cropland. Section 11 is a glacial hodge podge containing a beautiful forested esker.

DRAINAGE CHANNELS

The Engle Ditch flows southerly through the northwest quarter and combines with Branch #1 and becomes the Forker. The Thomas flows westerly through the northeast quarter and meets Branch #1 in the northwest quarter. Branch #1 of the Thomas drains Summit Lake and flows northwesterly through the southeast quarter until it meets the Engle in the northwest quarter. The Forker flows southwesterly from the northwest quarter on its way to Sucker Lake in Chain O' Lakes State Park. Section 11 has approximately 16,600 feet (5060 meters) of open channel in the watershed area.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
A Category 1 field lies on the south side of the Thomas in the northeast quarter.

**Category 2 Fields:**
The northwest quarter contains a Category 2 field on the north side of the Forker Creek.

**Category 4 Fields:**
Isolated areas of category 4 fields are located in the northeast and southwest quarters of Section 11.

SPECIAL RECOMMENDATIONS

Filter strip plantings are recommended for the north side of the Forker and south side of the Engle in the northwest quarter.

There are isolated areas of stream bank erosion and gully erosion along all of the open channels in Section 11.

The roads in this section are gravel and suffer from areas of side ditch erosion.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 12

DESCRIPTION

Green Township Section 12 is located east of Chain O' Lakes State Park and is bounded on the west by County Road 500 E and is split by County Road 125 S (Hopewell Road) with no road bordering this section on the north or the south. Section 12 contains 320 acres (130 hectares) of the Chain O' Lakes Watershed. This section contains areas of forest and grassland with relatively little cropland.

DRAINAGE CHANNELS

Branch #1 flows northwesterly from Summit Lake in the southwest quarter. The Thomas flows north and west in the northwest quarter. Section 12 contains approximately 3900 feet (1189 meters) of open drainage channel within the Chain O' Lakes Watershed.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
A Category 1 field lies northeast of Branch # 1 in the southwest quarter.

**Category 3 Fields:**
Erodible land with grass cover lies west of the Thomas Branch in the northwest quarter.

**Category 4 Fields:**
The northeast quarter contains a Category 4 field south of County Road 125 S.

SPECIAL RECOMMENDATIONS

Rock streambank protection is recommended for gully erosion along Branch #1 in the southwest quarter and along the Thomas in the northwest quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 13

DESCRIPTION

Green Township Section 13 is located east of Chain O' Lakes State Park and is bounded on the west by County Road 500 E and bounded on the south by County Road 300 S. Section 13 contains approximately 15 acres (7 hectares) of the Chain O' Lakes Watershed. The area of this section within the watershed is primarily cropland.

DRAINAGE CHANNELS

The area of Section 13 within the Chain O' Lakes Watershed contains no open channels.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The cropland within the watershed in the northwest quarter contains areas of erodible land.

SPECIAL RECOMMENDATIONS

There are no special recommendation for Section 13.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 14

DESCRIPTION

Green Township Section 14 is located east of Chain O' Lakes State Park and is bounded on the east by County Road 500 E and is bounded on the north by County Road 200 S. Section 14 contains approximately 40 acres (16 hectares) of the Chain O' Lakes Watershed. The watershed area within this section is pasture and cropland.

DRAINAGE CHANNELS

There are no open drainage channels within the Chain O' Lakes Watershed in Section 14.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northeast quarter contains erodible cropland.

SPECIAL RECOMMENDATIONS

There are no special recommendations for this section.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 15

DESCRIPTION

Green Township Section 15 is located south of Chain O' Lakes State Park and is bounded on the north by County Road 200 S and bounded on the west by County Road 300 E. Section 15 contains 230 acres (92 hectares) of the Chain O' Lakes Watershed. The watershed area in this section contains primarily mature forest and cropland.

DRAINAGE CHANNELS

The Sherwood Ditch flows southwest through the northwest quarter of this section. Section 15 contains approximately 2400 feet (732 meters) of open drainage channel within the watershed area.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Areas of Category 1 fields are located east and west of the Sherwood Ditch in the northwest quarter.

**Category 2 Fields:**
Areas of Category 2 fields lie east and west of the Sherwood Ditch in the northwest quarter.

**Category 4 Fields:**
Category 4 fields lie in the northeast, southwest, and northwest quarters.

SPECIAL RECOMMENDATIONS

Filter strips should be planted east and west of the Sherwood Ditch in the northwest quarter.

Grass waterways and rock chutes should be constructed east of the Sherwood Ditch in the northwest quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 16

DESCRIPTION

Green Township Section 16 is located south of Chain O' Lakes State Park and is bounded on the east by County Road 200 E and bounded on the north by County Road 200 S. Section 16 contains approximately 355 acres (143 hectares) of the Chain O' Lakes Watershed. This section contains a balance of cropland, grassland, and forest nearly all on erodible land.

DRAINAGE CHANNELS

The Sherwood Ditch flows westerly and then northerly through the northeast quarter. Branch #1 is a ravine/ditch flowing northerly in the northwest quarter. Branch #1A and #1B are wooded ravines which discharge to Branch #1. This section contains approximately 6800 feet (2073 meters) of open drainage channel including ravine channels.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
The northwest quarter contains erodible cropland adjacent to the Branch #1A and #1B ravines.

Erodible cropland lies west of the Sherwood in the northeast quarter.

**Category 2 Fields:**
Areas of Category 2 fields lie along the Sherwood in the northeast quarter.

**Category 3 Fields:**
The grass area for a campground lies south the Sherwood in the northeast quarter.

**Category 4 Fields:**
All quarters of this section within the Chain O' Lakes Watershed contain areas of erodible cropland.

SPECIAL RECOMMENDATIONS

A grass waterway is recommended for gully erosion occurring in the northwest quarter.

A system of grass waterways is recommended for shallow overland flow which creates gullies discharging to the south side of the Sherwood in the northeast quarter.

The Sherwood Ditch should be protected by a filter strip along the west side of the channel in the northeast quarter. A rock chute should be constructed on the south side of the Sherwood at the point of overland flow discharge in the northeast quarter.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 17

DESCRIPTION

Green Township Section 17 is located south of Chain O' Lakes State Park and is bounded on the east by County Road 200 E and bounded on the north by County Road 200 S. Section 17 contains approximately 400 acres (163 hectares) of the Chain O' Lakes Watershed. The area of this section within the watershed is primarily cropland.

DRAINAGE CHANNELS

The No Name Ditch flows north from the northwest quarter. Section 17 contains approximately 1300 feet (396 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Erodible cropland lies west of the open channel in the northwest quarter.

**Category 2 Fields:**
A Category 2 field lies at the head of the open channel in the northwest quarter.

**Category 4 Fields:**
All quarters of Section 17 contain erodible cropland.

SPECIAL RECOMMENDATIONS

The open channel in the northwest quarter should be buffered by a filter strip where it borders cropland. Gully erosion should be addressed west of the ditch.

The southwest quarter contains a confined livestock area.

The area of the watershed in the southeast quarter is a single field. Gully erosion occurs and should be corrected with a system of grass waterways and critical area seeding.

Agricultural land management practices are presented in Appendix B.

## GREEN TOWNSHIP SECTION 18

DESCRIPTION

Green Township Section 18 is located south of Chain O' Lakes State Park and is bounded on the west by State Road 9 and bounded on the north by County Road 200 S. Section 18 contains approximately 165 acres (66 hectares) of the Chain O' Lakes Watershed. Land use within the watershed is predominantly cropland.

DRAINAGE CHANNELS

There are no open drainage channels in this section within the Chain O' Lakes Watershed.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northwest, northeast, and southeast quarters of Section 18 contain areas of Category 4 fields.

SPECIAL RECOMMENDATIONS

A system of grass waterways should be established in the northeast quarter. A predominant gully flows northerly from the high land in the south part of the quarter.

A wetland in the northeast quarter could be restored to help filter upland runoff before it enters a tile drainage system.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 25

DESCRIPTION

Jefferson Township Section 25 is located northeast of Chain O' Lakes State Park and is bounded on the west by County Road 500 E and bounded on the south by County Road 100 N. Section 25 contains approximately 260 acres (105 hectares) of the Chain O' Lakes Watershed. The area of this section within the watershed is primarily cropland.

DRAINAGE CHANNELS

The area of Section 25 within the Chain O' Lakes Watershed contains no open drainage channels.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The south half of Section 25 contains fields with relatively small areas of erodible land.

SPECIAL RECOMMENDATIONS

Construct and plant a grass waterway in an area of gully erosion in the southeast quarter.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 26

### DESCRIPTION

Jefferson Township Section 26 is located north of Chain O' Lakes State Park and is bounded on the east by County Road 500 E and bounded on the south by County Road 100 N. Section 26 contains approximately 15 acres (7 hectares) of the Chain O' Lakes Watershed. The extreme southeast corner of this section contains a farmstead and cropland.

### DRAINAGE CHANNELS

The area of Section 26 within the watershed contains no open drainage channels.

### FIELD CATEGORIES AND LOCATIONS

Not applicable.

### SPECIAL RECOMMENDATIONS

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 32

DESCRIPTION

Jefferson Township Section 32 is located north of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the east County Road 200 E. Section 32 contains approximately 45 acres (19 hectares) of the Chain O' Lakes Watershed. The area within the watershed is primarily cropland.

DRAINAGE CHANNELS

The area of Section 32 within the Chain O' Lakes Watershed contains no open drainage channels.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
All fields within the watershed in the southeast quarter contain erodible land.

SPECIAL RECOMMENDATIONS

There are no special recommendations for Section 32.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 33

DESCRIPTION

Jefferson Township Section 33 is located north of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the west County Road 200 E. Section 33 contains approximately 80 acres (32 hectares) of the Chain O' Lakes Watershed. The area within the watershed contains a mixture of forest, cropland, and grassland.

DRAINAGE CHANNELS

There are no open channels within the watershed in Section 33.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
Areas of erodible land lie within cropland in the southwest and southeast quarters.

SPECIAL RECOMMENDATIONS

There are no special recommendations for this section.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 34

DESCRIPTION

Jefferson Township Section 34 is located north of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the west by County Road 300 E. Section 34 contains approximately 45 acres (17 hectares) of the Chain O' Lakes Watershed. The area of Section 34 within the watershed contains mature forest and little active cropland.

DRAINAGE CHANNELS

The area of Section 34 within the watershed contains no open drainage channels.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The southeast quarter of Section 34 contains a small area of erodible land within an active field.

SPECIAL RECOMMENDATIONS

There are no special recommendations for this section.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 35

### DESCRIPTION

Jefferson Township Section 35 is located northeast of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the east County Road 500 E. Section 35 contains approximately 460 acres (186 hectares) of the Chain O' Lakes Watershed. This section contains mature forest and cropland with relatively small areas of erodible land.

### DRAINAGE CHANNELS

There are no open drainage channels in Section 35.

### FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The southwest, southeast, and northeast quarters of this section contain cropland with areas of erodible land.

### SPECIAL RECOMMENDATIONS

Critical area seeding and a grass waterway are recommended for gully erosion in the southeast quarter.

Agricultural land management practices are presented in Appendix B.

## JEFFERSON TOWNSHIP SECTION 36

DESCRIPTION

Jefferson Township Section 36 is located northeast of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the west County Road 500 E. Section 36 contains approximately 625 acres (254 hectares) of the Chain O' Lakes Watershed. This section contains large areas of mature forest and cropland. A rural residential subdivision is located in the northwest quarter.

DRAINAGE CHANNELS

The Roush Ditch flows southwesterly through the southeast quarter. The Yarian flows northwesterly and joins the Roush to form the Engle Ditch. The Engle flows southwesterly and crosses Base Line Road. Section 36 contains approximately 4800 feet (1463 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 2 Fields:**
The southeast quarter contains a Category 2 field west of the Engle Ditch.

**Category 3 Fields:**
A Category 3 field lies north of the Yarian Ditch in the southeast quarter.

**Category 4 Fields:**
Category 4 fields are located in all quarters of Section 36.

SPECIAL RECOMMENDATIONS

Grass waterways are recommended for areas of gully erosion in the southwest, northwest and northeast quarters.

The southwest quarter contains an area of road construction erosion along a drive serving a new residence. Road erosion also occurs in the northeast quarter.

The northeast and southeast quarters contain concentrated areas of livestock.

Rock streambank protection is recommended for gully erosion along Engle Ditch in the southeast quarter.

The southeast quarter contains a pasture along the Yarian Ditch with pasture erosion, gully erosion, and streambank erosion due to livestock. Livestock exclusion fencing and critical area seeding are recommended for this pasture.

Agricultural land management practices are presented in Appendix B.

## SWAN TOWNSHIP SECTION 5

### DESCRIPTION

Swan Township Section 5 is located east of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the west by County Road 700 E. Section 5 contains approximately 25 acres (11 hectares) of the Chain O' Lakes Watershed. The watershed area within this section is primarily grassland.

### DRAINAGE CHANNELS

The area of Section 5 within the Chain O' Lakes Watershed contains no open drainage channels.

### FIELD CATEGORIES AND LOCATIONS

No fields within the watershed are classified in a category.

### SPECIAL RECOMMENDATIONS

Gully erosion occurs in the northwest quarter.

Agricultural land management practices are presented in Appendix B.

## SWAN TOWNSHIP SECTION 6

DESCRIPTION

Swan Township Section 6 is located east of Chain O' Lakes State Park and is bounded on the north by Base Line Road and bounded on the west by County Road 600 E. Section 6 contains 380 acres (154 hectares) of the Chain O' Lakes Watershed. The watershed area in this section is primarily grassland and forest used as pasture.

DRAINAGE CHANNELS

The Yarian Ditch flows west through the northeast and northwest quarters. Section 6 contains approximately 5300 feet (1615 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 3 Fields:**
The northwest and northeast quarters contain erodible land used as pasture along the north and south sides of the Yarian Ditch.

SPECIAL RECOMMENDATIONS

A grass waterway, filter strip, critical area seeding, and livestock exclusion fence are recommended practices for pasture adjacent to the Yarian Ditch in the northwest quarter.

Rock stream bank protection is recommended for gully erosion on the south side of the Yarian Ditch in the northwest quarter.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 17

DESCRIPTION

Allen Township Section 17 is located northeast of Chain O' Lakes State Park and is bounded on the south by State Road 8 and bounded on the west by County Road 700 E. Section 17 contains approximately 10 acres (3 hectares) of the Chain O' Lakes Watershed. Land use is primarily grassland.

DRAINAGE CHANNELS

There are no open channels within the Chain O' Lakes Watershed in Section 17.

FIELD CATEGORIES AND LOCATIONS

Not applicable

SPECIAL RECOMMENDATIONS

There are no special recommendations for this section.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 18

DESCRIPTION

Allen Township Section 18 is located northeast of Chain O' Lakes State Park and is bounded on the south by State Road 8 and bounded on the east by County Road 700 E. Section 18 contains approximately 5 acres (2 hectares) of the Chain O' Lakes Watershed. Land use within the watershed in this section is cropland.

DRAINAGE CHANNELS

There are no open channels within the watershed in Section 18.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The only field within the watershed in this section is erodible land.

SPECIAL RECOMMENDATIONS

There are no special recommendations for Section 18.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 19

DESCRIPTION

Allen Township Section 19 is located northeast of Chain O' Lakes State Park and is bounded on the north by State Road 8 and bounded on the east by County Road 700 E. Section 19 contains approximately 345 acres (139 hectares) of the Chain O' Lakes Watershed. Land use within the watershed in this section is primarily cropland and forest.

DRAINAGE CHANNELS

The Roush Ditch flows southerly in the southeast quarter of Section 19. This section contains approximately 1600 feet (488 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Areas of erodible cropland lie west of the Roush Ditch in the southeast quarter.

**Category 3 Fields:**
A Category 3 field lies east of the Roush in the southeast quarter.

**Category 4 Fields:**
The northwest, northeast, southwest and southeast quarters contain areas of erodible cropland.

SPECIAL RECOMMENDATIONS

Determine if a filter strip should be established along the Roush Ditch in the southeast quarter.

Check the farmstead east of the Roush due to livestock.

Cropland in the northeast quarter contains areas of gully erosion which may be addressed by grassed waterways and critical area seeding.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 20

### DESCRIPTION

Allen Township Section 20 is located northeast of Chain O' Lakes State Park and is bounded on the north by State Road 8 and bounded on the west by County Road 700 E. Section 20 contains approximately 225 acres (92 hectares) of the Chain O' Lakes Watershed. Land use within the watershed is grassland and mature forest.

### DRAINAGE CHANNELS

The Roush Ditch flows southerly in the southwest quarter. An unregulated open ditch flows westerly and discharges to the Roush. Section 20 contains approximately 2500 feet (762 meters) of open channel.

### FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Erodible cropland lies south of the Roush Ditch in the southwest quarter.

**Category 3 Fields:**
Erodible land currently in grass cover borders the Roush and an unregulated drain in the southwest quarter.

**Category 4 Fields:**
The southwest quarter contains erodible land used as cropland.

### SPECIAL RECOMMENDATIONS

Livestock exclusion fencing should be considered at the head of the Roush Ditch in the southwest quarter.

A filter strip and grass waterways should be established in the cropland south of the Roush Ditch in the southwest quarter.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 28

DESCRIPTION

Allen Township Section 28 is located northeast of Chain O' Lakes State Park and is bounded on the south by County Road 100 N and bounded on the west by County Road 800 E. Section 28 contains approximately 40 acres (17 hectares) of the Chain O' Lakes Watershed. Land use within the watershed is predominantly cropland and pasture.

DRAINAGE CHANNELS

There are no open drainage channels within the Chain O' Lakes Watershed in this section.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The cropland in the southwest quarter is classified as a Category 4 field.

SPECIAL RECOMMENDATIONS

Grassed waterways are recommended to correct gully erosion in the southwest quarter.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 29

DESCRIPTION

Allen Township Section 29 is located northeast of Chain O' Lakes State Park and is bounded on the south by County Road 100 N and bounded on the east by County Road 800 E. Section 29 contains approximately 400 acres (163 hectares) of the Chain O' Lakes Watershed. The area of this section within the watershed contains cropland and mature forest.

DRAINAGE CHANNELS

The side ditch of an abandoned railroad bed flows northwesterly in the northwest quarter.

The Roush Ditch loops into the southwest quarter.

Section 29 contains approximately 4000 feet (1219 meters) of open ditch.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
A small area of erodible cropland lies north of the railroad ditch in the northwest quarter.

**Category 2 Fields:**
Cropland lies north of the railroad ditch in the northwest quarter and west of the Roush Ditch in the southwest quarter.

**Category 4 Fields:**
The southwest quarter and southeast quarter contain cropland with limited erodible land areas.

SPECIAL RECOMMENDATIONS

Gullies along the railroad ditch in the northwest quarter and the Roush Ditch in the southwest quarter should be checked for use of rock streambank protection.

Gullies in the cropland in the southwest quarter and southeast quarter should be checked for correction with grassed waterways or critical area seeding.

A filter strip should be established along the Roush Ditch in the southwest quarter.

Construction erosion was noted in the northeast and southwest quarters.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 30

DESCRIPTION

Allen Township Section 30 is located northeast of Chain O' Lakes State Park and is bounded on the south by County Road 100 N and bounded on the west by County Road 600 E. Section 30 contains approximately 645 acres (261 hectares) of the Chain O' Lakes Watershed. The entire section lies within the watershed and contains cropland and a large area of mature forest.

DRAINAGE CHANNELS

The Roush Ditch flows southerly through the northeast quarter and loops east into Section 29. The Roush also flows southwesterly through the southeast quarter. The length of the open channel in this section is approximately 5800 feet (1768 meters).

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Erodible cropland lies north and south of the Roush Ditch in the southeast quarter and along the Roush in the northeast quarter

**Category 2 Fields:**
Category 2 field cropland lies adjacent to the Roush Ditch in the northeast and southeast quarters.

**Category 4 Fields:**
Cropland in all quarters of Section 30 contain areas of erodible land.

SPECIAL RECOMMENDATIONS

Filter strips should be established along the Roush Ditch in the northeast and southeast quarters.

Pasture erosion should be checked around a pond in the northwest quarter.

Gully erosion in fields in the northwest quarter should be checked for establishing critical area seeding or grassed waterways. Gully erosion along the Roush Ditch in the southeast quarter may be corrected with rock streambank protection.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 31

DESCRIPTION

Allen Township Section 31 is located northeast of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the west by County Road 600 E. Section 31 contains approximately 655 acres (265 hectares) of the Chain O' Lakes Watershed. This section contains large areas of cropland with mature forest. The entire section is within the watershed.

DRAINAGE CHANNELS

The Roush Ditch flows southwesterly through the northeast, northwest, and southwest quarters. The Yarian flows southwesterly through the southeast quarter. Section 31 contains approximately 8000 feet (2438 meters) of open drainage channel.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Erodible cropland lies east of the Roush in the northeast quarter

**Category 2 Fields:**
The Roush is bordered by cropland in the northeast and northwest quarters.

**Category 3 Fields:**
Erodible pasture lies adjacent to the Yarian in the southeast quarter.

**Category 4 Fields:**
All quarters of this section contain cropland with erodible soils.

SPECIAL RECOMMENDATIONS

All quarters contain areas of gully erosion which may be addressed by grassed waterways or critical area seeding.

The northwest, northeast, and southeast quarters contain areas of concentrated livestock. A filter strip should be established along the Roush in the northeast quarter.

A water course outlet buffer is recommended along the Roush in the southwest quarter. Rock streambank protection is recommended for gully erosion along the Roush in the northeast quarter.

The pasture in the southeast quarter should be checked for the possible use of filter strips, grassed waterways, streambank protection, and livestock exclusion fencing.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 32

DESCRIPTION

Allen Township Section 32 is located northeast of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the east by County Road 800 E. Section 32 contains approximately 485 acres (196 hectares) of the Chain O' Lakes Watershed. This section contains a mixture of cropland, grassland, and forest.

DRAINAGE CHANNELS

The Yarian-Wolf Ditch begins in the northwest quarter and flows southwesterly though the southwest quarter. This section contains approximately 2200 feet (671 meters) of open drainage ditch.

FIELD CATEGORIES AND LOCATIONS

**Category 1 Fields:**
Cropland on erodible soil lies adjacent to the Yarian-Wolf in the northwest and southwest quarters.

**Category 4 Fields:**
All quarters of Section 32 contain areas of erodible cropland.

SPECIAL RECOMMENDATIONS

Gully erosion in the southwest, northwest, and northeast should be addressed with critical area seeding, grassed waterways, or filter strips.

A filter strip should be established along the Yarian-Wolf open ditch in the southwest and northwest quarters.

The pasture in the northeast quarter should be checked for land management practices.

Agricultural land management practices are presented in Appendix B.

## ALLEN TOWNSHIP SECTION 33

DESCRIPTION

Allen Township Section 33 is located northeast of Chain O' Lakes State Park and is bounded on the south by Base Line Road and bounded on the west County Road 800 E. Section 33 contains approximately 10 acres (5 hectares) of the Chain O' Lakes Watershed. This section is mostly cropland.

DRAINAGE CHANNELS

There are no open channels in this section.

FIELD CATEGORIES AND LOCATIONS

**Category 4 Fields:**
The northwest quarter of this section contains Category 4 fields.

SPECIAL RECOMMENDATIONS

There is gully erosion in a Category 4 field.

There are areas of gravel road and road side ditch erosion and construction erosion.

Agricultural land management practices are presented in Appendix B.

# BIOASSESSMENT REPORT

## Section 2

# BIOASSESSMENT REPORT

RAPID BIOASSESSMENT OF THE

CHAIN O' LAKES WATERSHED

USING BENTHIC MACROINVERTEBRATES

1999

for the Soil and Water
Conservation District of
Noble County, Indiana

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APPENDICES

Habitat Evaluation Data

Macroinvertebrate Identification Literature

Bioassessment Summary

## EXECUTIVE SUMMARY

A rapid bioassessment technique was used to determine the degree of biological impairment present in the Chain O' Lakes watershed in Noble County, Indiana before implementation of various land treatments in the watershed. The benthic communities of two sites and a nearby reference stream were sampled during May and August 1999 to provide information on "before treatment" conditions during two different seasons (spring and summer).

Water chemistry of two streams flowing into the Chain O' Lakes State Park fell within ranges acceptable to most forms of freshwater aquatic life. Forker Creek had higher levels of sediments, nutrients, and bacteria than the unnamed tributary. These parameters were especially elevated during a storm flow event, when E. coli bacteria concentrations exceeded the Indiana water quality standard for whole body contact.

Both study sites had biological communities which were "slightly impacted" as compared to a regional reference stream. Each site appeared to be adversely affected by degraded aquatic habitat. They were was also affected by degraded water quality during the May sampling period. The proportions of "sediment-tolerant" animals in each stream was much higher than in the regional reference stream. Excessive sediment inputs probably contributed to the biological impairment observed at these sites. However, the biological communities were much improved during the August sampling period, and the number of sediment tolerant animals was lower as well.

Recommendations for improvement of water quality in the watershed include protection of the vegetative border along the stream, protection of groundwater flows to the stream, discouraging channelization and direct access to the stream by livestock, implementation of land treatments to reduce nutrient and sediment inputs, and continued monitoring over time.

## INTRODUCTION

This study was conducted to measure the "biological integrity" of two streams flowing into Chain O' Lakes State Park in Noble County, Indiana. The lakes in this state park have been identified by the Soil and Water Conservation District of Noble County as potentially affected by agricultural runoff. In addition, the streams are headwater tributaries of the Elkhart River, which is listed by the Indiana Department of Environmental Management (IDEM) has as having degraded water quality from nonpoint sources of pollution [1].

This bioassessment is part of a larger diagnostic study sponsored by the Noble County SWCD to determine sources of problems in the watershed and to propose management solutions to solve them. By conducting studies of the biological communities before and after application of land treatments in the watersheds, the effectiveness of land treatments can be determined. Improved water quality will be reflected by an improved aquatic biological community.

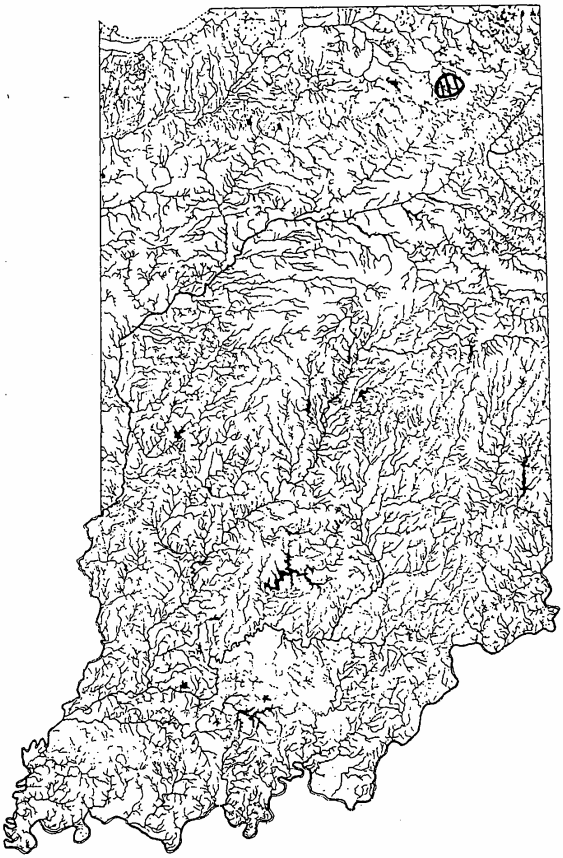
### Local Setting

Chain O' Lakes is located in the "Eastern Corn Belt Plain" ecoregion of the Central U.S. [2]. The area is a glacial till plain (it was one of the last areas in Indiana to be occupied by glacial ice) and lies in what is sometimes called the "Northern Lakes" Natural Region of Indiana [13] This is an area with gently rolling hills and a wide diversity of soils. The area contains many bogs and glacial lakes, as well as other glacial features (knobs, kettles, kames, valley trains, and outwash plains). The original forests were dominated by oak and hickory, but other forest trees were common in the diverse set of habitats. Row crop agriculture and livestock grazing are the most common land uses today.

Chain O' Lakes State Park includes 13 glacial lakes, which are connected in a chain fed by Forker Creek (also known locally as Thumma Ditch). These lakes lie in the upper Elkhart River watershed. At its juncture with the first lake in Chain O' Lakes State Park (Long Lake), Forker Creek is a "second order" stream with a total watershed area of about 30 square kilometers (12 square miles). A smaller, unnamed tributary draining into Sand Lake near the beach area also has a more or less permanent flow supporting a benthic community.

Most of the stream drainages in the upper watershed is artificially channelized but the lower areas retain their natural channel characteristics. Only about 5% of the watershed is wooded, with most of the remainder being used for agricultural purposes. The watershed is shown in Fig. 1.

**Figure 1.**
**Forker Creek Watershed and Chain O' Lakes State Park**



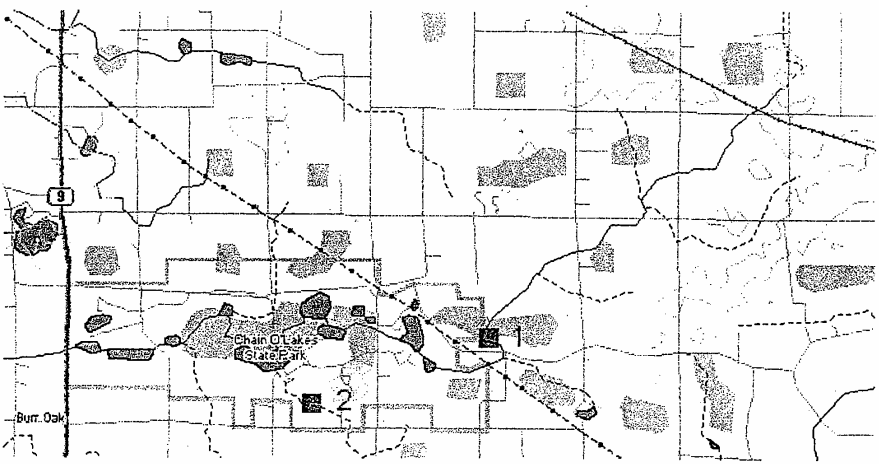
Two "study" sites and a "reference" site were chosen for benthic analysis (Fig. 2). A summary of each site and its watershed area is shown below:

| | |
|---|---|
| Site 1 Forker Creek @ CR 450 E | 30 $km^2$ (12 $mi^2$) |
| Site 2 Unnamed tributary at CR 200 S | 5 $km^2$ (2 $mi^2$) |
| Site 3 Trib. of Pigeon Creek near Mongo (reference) | 25 $km^2$ (10 $mi^2$) |

Site 3 was chosen as the reference site because it lies in the same ecoregion as the two study sites, is similar in size, and is relatively unimpacted by man-made alterations. The stream is in the Pigeon River Fish and Wildlife Area and is one of the highest-quality tributaries of Pigeon River, known to support an excellent aquatic community [5].

All benthic samples and water quality measurements reported here were collected on May 5 and August 4, 1999. The sites are shown in Fig. 2, below. Photographs of the two study sites are shown in Fig. 3.

**Figure 3**
**Study Sites in the Watershed**



## METHODS

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to environmental change [3], benthic (bottom-dwelling) organisms were used to document biological conditions in the watershed. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [4] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used EPA's Protocol III to conduct this study. Protocol III requires a standardized collection technique, a standardized subsampling technique, and identification of at least 100 animals from each site to the genus or species level from both "study sites" and a "reference site." CPOM (Coarse Particulate Organic Matter) samples were also collected and analyzed.

### Reference Site

The aquatic community of a reference site is compared to that of each study site to determine how much impact has occurred. The reference site should be in the same "ecoregion" as the study sites and be approximately the same size. It should be as pristine as possible, representing the best conditions possible for that area. An unnamed tributary of Pigeon Creek in LaGrange County was chosen as the reference site for this study. Its watershed area is about 30 square kilometers, which is not much larger than those of most study sites. In addition, it is located only a few kilometers north of the Chain O' Lakes watershed, and therefore is representative of local conditions. Pigeon Creek is known to have excellent aquatic habitat and one of the highest "biotic index values" for fish communities in northeastern Indiana [5]. Therefore, its habitat and water quality are probably among the best available within this area.

## Sample Collection

Samples in this study were collected by kicknet from riffle habitat where current speed was 20-30 cm/sec. Riffles were used because they were the most important benthic habitat present at all study sites. The kicknet was placed immediately downstream from the riffle while the sampler used a hand to dislodge all attached benthic organisms from rocks upstream from the net. The organisms were swept by the current into the kicknet and subsequently transferred to a white pan. Each sample was examined in the field to assure that at least 100 organisms were collected at each site. In addition, each site was sampled for organisms in CPOM (coarse particulate organic matter, usually consisting of leaf packs from fast-current areas). All samples were preserved in the field with 70% ethanol.

## Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the whole sample in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified. a representative specimen was preserved as a "voucher." All voucher specimens will ultimately be deposited in the Purdue University Department of Entomology collection.

## RESULTS

### Aquatic Habitat Analysis

The following aquatic habitat values were obtained for each site in the study:

| | Score | % of Reference |
|---|---|---|
| Forker Creek (Site 1) | 66 | 83 |
| Unnamed Tributary (Site 2) | 56 | 70 |
| Reference Stream (Site 3) | 80 | 100 |

The maximum value obtainable by this scoring technique is 100, with higher values indicating better habitat. Sites with lower habitat values normally have lower biotic index values as well.

The scores indicate that the lowest habitat value in this study was at Site 2 (unnamed tributary at CR 200 S). Habitat at Site 2 was hampered by the narrowness of its riparian buffer zone and by channel modifications.

## BASE FLOW
## On-Site Water Quality Measurements
## May 6, 1999

| | D.O. mg/l | pH SU | Cond. uS | Temp. (C) |
|---|---|---|---|---|
| Site 1 (Forker Creek) Time = 2:00 p.m. | 11.1 | 8.3 | 400 | 17.0 |
| Site 2 (unnamed trib.) Time = 1:00 p.m. | 9.6 | 8.1 | 450 | 17.0 |

D.O. = Dissolved Oxygen
Cond. = Conductivity
Temp. = Temperature in Degrees Centigrade

### Additional Chemistry and Bacteria Data

| | TSS mg/l | TKN mg/l | NO3 mg/l | P-tot mg/l | PO4 mg/l | E.coli /100 ml |
|---|---|---|---|---|---|---|
| Site 1 (Forker Creek) | 3.5 | 1.36 | 1.50 | <0.1 | 0.03 | 85 |
| Site 2 (unnamed trib.) | 3.0 | 1.67 | 0.66 | <0.1 | <0.02 | 80 |

TSS = Total Suspended Solids
TKN = Total Keldahl Nitrogen
NO3 = Nitrate
P-tot = Total Phosphorus
PO4 = Phosphate
E. coli = Bacteria from warmblooded animal gut

## STORM FLOW
## On-Site Water Quality Measurements
## June 24, 1999

| | D.O. mg/l | pH SU | Cond. uS | Temp. (C) |
|---|---|---|---|---|
| Site 1 (Forker Creek) Time = 7:30 p.m. | 8.5 | 7.6 | 300 | 21.0 |
| Site 2 (unnamed trib.) Time = 7:40 p.m. | 8.7 | 7.7 | 300 | 20.0 |

D.O. = Dissolved Oxygen
Cond. = Conductivity
Temp. = Temperature in Degrees Centigrade

### Additional Chemistry and Bacteria Data

| | TSS mg/l | TKN mg/l | NO3 mg/l | P-tot mg/l | PO4 mg/l | E.coli /100 ml |
|---|---|---|---|---|---|---|
| Site 1 (Forker Creek) | 278 | 4.20 | 0.62 | 0.3 | 0.25 | 4080 * |
| Site 2 (unnamed trib.) | 47 | 1.36 | 2.13 | <0.1 | 0.06 | 150 |

TSS = Total Suspended Solids
TKN = Total Keldahl Nitrogen
NO3 = Nitrate
P-tot = Total Phosphorus
PO4 = Phosphate
E. coli = Bacteria from warmblooded animal gut

* exceeds Indiana water quality standard for whole body contact

**Table 1.**
**Rapid Bioassessment Results - Chain O' Lakes - May 1999**

| | Site # 1 | 2 | 3 |
|---|---|---|---|
| Chironomidae (Midges) | | | |
| Polypedilum fallax | 3 | | 26 |
| P. illinoense | 3 | | 4 |
| Rheotanytarus exiguus | 8 | | 9 |
| Euorthocladius spp. | 21 | 38 | |
| Orthocladius obumbratus | 33 | 38 | 3 |
| Cricotopus bicinctus | | | 9 |
| Dicrotendipes neomodestus | 6 | | |
| Psectrocladius psilopterus | | | 3 |
| Sympotthastia spp. | | | 6 |
| Harnischia sp. | | | 11 |
| Thienemannymia gr. | | | |
| Simuliidae (Blackflies) | 4 | 2 | 2 |
| Tipulidae (Craneflies) | | | |
| Antocha spp. | 1 | | |
| Plecoptera (Stoneflies) | | | |
| Amphinemura venosa | | 5 | 2 |
| Isoperla minuta | | 11 | |
| Perlesta placida | | | 4 |
| Ephemeroptera (Mayflies) | | | |
| Stenonema vicarium | 7 | | 2 |
| Baetis brunneicolor | | | 1 |
| Trichoptera (Caddisflies) | | | |
| Cheumatopsyche spp. | 6 | 3 | |
| Helicopsyche borealis | 4 | | |
| Hydropsyche betteni | | 1 | 1 |
| Lype sp. | 1 | | |
| Brachycentrus numerosus | | | 15 |
| Coleoptera (Beetles) | | | |
| Stenelmis crenata | 1 | | |
| Stenelmis larvae | 1 | | |
| Amphipoda (Sideswimmers) | | | |
| Crangonyx sp. | | 2 | |
| Hyalella azteca | | | 2 |
| Gastropoda (Snails) | | | |
| Ferrissia sp. | 1 | | |
| Total | 100 | 100 | 100 |

Table 2. Data Analysis for 5/99 Samples

| METRICS | Site # 1 | 2 | 3 |
|---|---|---|---|
| # of Genera | 13 | 8 | 15 |
| Biotic Index [16] | 7.2 | 7.4 | 5.1 |
| Scrapers/Filterers | 1.4 | 0.0 | 0.6 |
| EPT/Chironomids | 0.3 | 0.3 | 0.4 |
| % Dominant Taxon | 33 | 38 | 26 |
| EPT Index | 4 | 4 | 6 |
| Community Loss Index | 0.8 | 1.2 | 0.0 |
| % Shredders | 0 | 5 | 3 |

SCORING

| | Site # 1 | 2 | 3 |
|---|---|---|---|
| # of Genera | 6 | 2 | 6 |
| Biotic Index | 2 | 2 | 6 |
| Scrapers/Filterers | 6 | 0 | 6 |
| EPT/Chironomids | 6 | 6 | 6 |
| % Dominant Taxon | 2 | 2 | 4 |
| EPT Index | 2 | 2 | 6 |
| Community Loss Index | 4 | 6 | 6 |
| % Shredders | 2 | 6 | 6 |
| TOTAL | 30 | 26 | 46 |
| % of Reference | 65 | 57 | 100 |
| Impairment Category | S | S | N |

N = NONE S = SLIGHT M = MODERATE

**Table 2.**
**Rapid Bioassessment Results - Chain O' Lakes - August 1999**

| | Site # 1 | 2 | 3 |
|---|---|---|---|
| Chironomidae (Midges) | | | |
| Polypedilum convictum | 1 | 2 | 8 |
| P. illinoense | | | |
| Rheotanytarus exiguus | | 4 | |
| Eukiefferiella potthasti | | | 2 |
| Orthocladius obumbratus | | | |
| Cardiocladius spp. | | 1 | 26 |
| Dicrotendipes neomodestus | | | |
| Psectrocladius psilopterus | | | 2 |
| Heterotrissocladius sp. | | 5 | 4 |
| Glyptotendipes sp. | | | 1 |
| Thienemannymia gr. | 2 | 1 | |
| Simuliidae (Blackflies) | | | 15 |
| Tipulidae (Craneflies) | | | |
| Antocha spp. | 3 | 10 | |
| Tipula sp. | | | 1 |
| Ephemeroptera (Mayflies) | | | |
| Stenonema vicarium | 2 | | |
| Baetis brunneicolor | | | 6 |
| Ameletus sp. | | | 1 |
| Trichoptera (Caddisflies) | | | |
| Cheumatopsyche spp. | 24 | 23 | 11 |
| Hydropsyche betteni | 1 | | |
| H. aerata | | | 2 |
| Ceratopsyche sparna | 2 | 4 | 6 |
| Pycnopsyche spp. | | 2 | |
| Brachycentrus numerosus | | | 1 |
| Coleoptera (Beetles) | | | |
| Stenelmis crenata | 20 | | |
| Stenelmis larvae | 30 | 13 | |
| Macronychus glabratus | | 1 | 1 |
| Odonata (Dragonflies) | | | |
| Basiaeschna spp. | 1 | 1 | 2 |
| Megaloptera (Alderflies) | | | |
| Chauliodes spp. | 10 | | |
| Decapoda (Crayfish) | | | |
| Orconectes inermis | 1 | 2 | |
| Amphipoda (Sideswimmers) | | | |
| Gammarus pseudolimnaeus | | | 10 |
| Crangonyx sp. | | 27 | |

Table 2 (continued)
Rapid Bioassessment Results - Chain O' Lakes - August 1999

| | Site # | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Gastropoda (Snails) | | | |
| Ferrissia sp. | | 1 | |
| Helisoma sp. | | 1 | |
| Pelecypoda (Clams) | | | |
| Sphaerium spp. | 3 | 1 | |
| Hirudinea (Leeches) | | 1 | |
| Oligochaeta (Worms) | | | |
| Tubificidae | | | 1 |
| Total | 100 | 100 | 100 |

## DISCUSSION

Chemical parameters measured at each site indicate that dissolved oxygen, pH, temperature, and conductivity fell within acceptable ranges for most forms of aquatic life. During base flow conditions, nutrient, turbidity, and bacteria levels were low in both Forker Creek and the unnamed tributary. However, during storm flow conditions, Forker Creek had very high turbidity and E.coli concentrations. Phosphorus levels were also much higher during storm flow. The unnamed tributary was relatively unaffected by storm flow.

A total of 41 macroinvertebrate genera were collected at the three sites. The most commonly collected forms were midge larvae, net-spinning caddisflies, and riffle beetles.

The calculated biotic index values for the two study streams flowing into Chain O'Lakes ranged from 57 to 87% of the reference site value. These scores indicate only a "slight" degree of impairment (Fig. 3). In fact, the unnamed tributary's score of 87% of the reference site during August indicated "no impact" during the summer sampling period.

Figure 4 shows the normal relationship of biotic index scores to habitat values (a linear relationship according to [4]). The figure also shows a range of plus or minus 10% to account for a certain amount of measurement variability. When biotic index values fall outside this range, the site typically has degraded water quality. Figure 4 shows that both Forker Creek and the unnamed tributary had biotic index values lower than those predicted by their habitat in May 1999. Therefore, these sites were probably affected by degraded water quality as well as degraded habitat. The biotic values increased at both sites by August 1999 and were they were similar to their habitat values. This indicates that water quality had improved during the summer (a time of relatively low rainfall and sedimentation).

An examination of those metrics showing the greatest difference from the reference stream may provide an important clue about causes of biological impairment. The largest differences during May occurred in the EPT index value. The decline of number and types of EPT organisms is associated with several kinds of environmental degradation. For example, several studies have shown this metric to be associated with instream toxicity [10]. However, changes in other metrics commonly indicating toxicity problems (e.g. a reduction in the number of taxa) were not observed and few "toxic indicator" organisms were observed at any site.

**Figure 3.**
**Degrees of Biological Impairment at Chain O' Lakes**

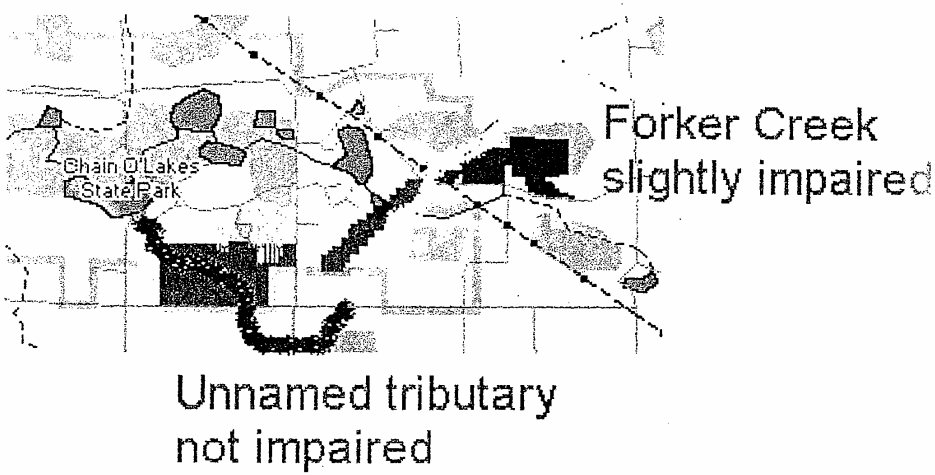


**Figure 4.**
**Habitat vs. Biotic Index Scores**

**Sites falling outside the +10% range are probably affected by degraded water quality**

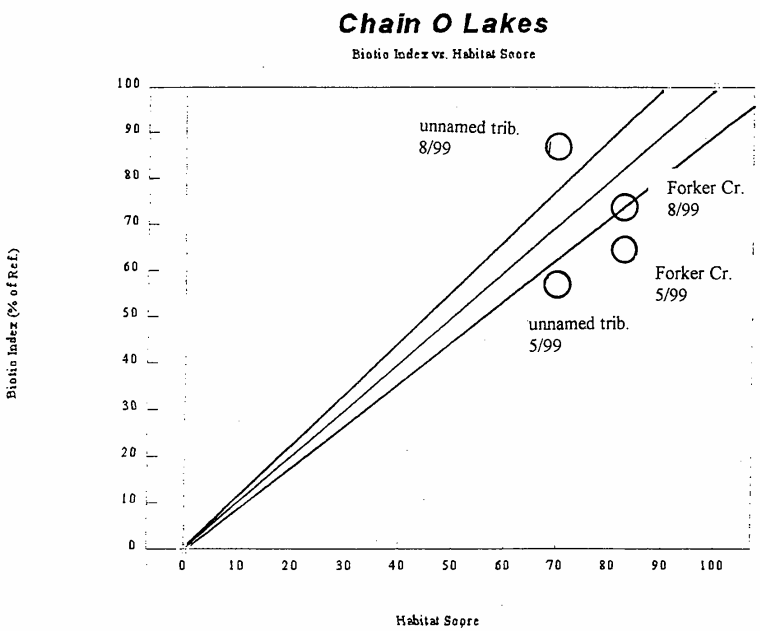


Table 4 shows sediment-tolerance values for many of the commonly collected animals in these streams. The relative abundance of sediment-tolerant forms was much higher in the two study streams than in the reference stream during May 1999. By August, the proportion of sediment-tolerant forms had declined to levels similar to the reference and the biotic index scores improved as well. These results support the possibility that excessive sedimentation may have impaired the biological communities during the early part of the year.

Table 4. Sediment-Tolerant Species Observed
(Literature references to the species as an indicator are shown in brackets)

| | |
|---|---|
| Cheumatopsyche sp. | [8] [9] [12] |
| Hydropsyche betteni | [8] [7] |
| Macronychus glabratus | [9] |
| Orthocladius obumbratus | [9] [15] |
| Thienemannymia group | [9] [6] |
| Polypedilum spp. | [9] [8] |

| | | May | August |
|---|---|---|---|
| % of Sediment-Tolerant Organisms at the Reference | Site 3 | 13% | 27% |
| % of Sediment-Tolerant Organisms at the Study Sites | | | |
| | Site 1 | 68% | 28% |
| | Site 2 | 80% | 27% |

Even though the watershed of the unnamed tributary was small, the benthic community was unusually diverse and contained animals indicative of "spring-fed" conditions (stoneflies, limnephilid caddisflies, and amphipods). The water temperature remained low and flow was small but constant. This type of freshwater habitat is important to enhance and maintain in lake watersheds.

## RECOMMENDATIONS

1. Continue to monitor these sites using the same biological technique within 3 to 5 years to provide information on water quality after land treatments in the watershed have had a longer chance to take effect.

2. Work toward continued protection of the vegetative buffer zone along the stream corridor. The lower stream presently has a good vegetative buffer and much of the headwaters has improved considerably in riparian quality.

3. Protect the "spring-fed" quality of the unnamed tributary. Preservation of wetlands in the watershed would be the best way to do this.

4. Discourage channelization of these streams. Only the most extreme headwaters have been recently channelized, allowing the lower parts of the stream to retain a natural channel that enhances aquatic habitat.

5. Discourage direct access to the stream by livestock. Large numbers of livestock can trample stream banks, decreasing the ability of streamside vegetation to filter out pollutants and hastening erosion.

6. Evaluate land use to identify significant contributors of nonpoint source pollutants such as livestock waste and eroded soil.

7. Look for signs of continued improvement in water quality. The following changes will indicate improvements:

   a. An increase in the number and kinds of caddisflies, mayflies, and stoneflies. These groups should make up more than half the total macroinvertebrate community and at least 6 or 7 genera should be present in a 100-organism sample.

   b. An increased frequency of intolerant caddisflies and mayflies, especially Ceratopsyche bifida, Chimarra obscura, and Stenonema vicarium.

   c. A decrease in the frequency of tolerant midges and caddisflies.

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# BIOASSESSMENT SUMMARY
## FORKER CREEK (Noble County)

### Purpose

To measure the water quality of Forker Creek by looking at the kinds of animals which live there. What is the stream's present condition and how can it be improved?

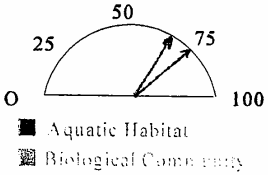
### Watershed Characteristics

The watershed is primarily agricultural but a healthy zone of vegetation has been left along many of the stream banks. The stream and its tributaries flow into and affect 13 lakes in Chain O' Lakes State Park.

### Results

Forker Creek has good aquatic habitat. The biological community was slightly impacted by excessive sediment, especially during spring. E.coli bacteria and nutrient levels are high during storm flow conditions in some tributaries.

Watershed "Speedometer"
A score of 100 is our goal

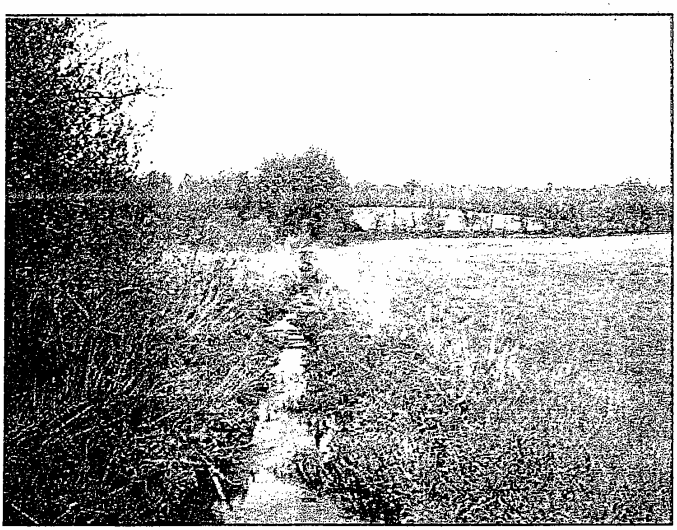



### Recommendations

Work to keep livestock out of streams. Restore stream banks along Forker Creek. Identify erosion hotspots and work with willing landowners to apply Best Management (BMP) practices. Protect wetlands in the watershed.

Date: Spring and Summer 1999
Study conducted by: Commonwealth Biomonitoring
www.biomonitor.com

**Site 1 Forker Creek**



**Site 2**

**Unnamed Tributary**

## Habitat Scoring Results

| | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| SUBSTRATE | 10 | 10 | 12 |
| COVER | 7 | 4 | 10 |
| CHANNEL | 11 | 8 | 13 |
| RIPARIAN | 10 | 11 | 16 |
| POOL/RIFFLE | 9 | 8 | 13 |
| GRADIENT | 10 | 10 | 8 |
| DRAINAGE AREA | 9 | 5 | 8 |
| TOTAL | 66 | 56 | 80 |

COMMONWEALTH BIOMONITORING
Macroinvertebrate Identification Literature

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# APPENDIX A

## CHANNEL FIELD CHECK LOGS

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN - O - LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY JLL / PMG DATE 06-29-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTE
ENGLE DITCH
G1 BRANCH (SIDE DITCH) @ STA. 147+50
06-29-00 80 CLEAR
GREEN TWNSHP - SECT 1

STA 0 — BARN YARD & FIELD DITCH DISCHARGES TO NORTH SIDE OF ENGLE DITCH.

STA. 4 — CHANNEL 2' ± WIDE 2' ± DEEP WITH THICK GRASS BANKS - NOT MAINTAINED ENTERING FROM NORTH - THIS CHANNEL DRAINS BARN YARD & FIELD ACROSS BASELINE ROAD.

STA 8 — 30" DIA CMP ACROSS BASELINE ROAD

STA 9 — FIELD SWALE DRAINING WOODS ON NORTH SIDE OF BASELINE

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB: CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY: JLL / PMG DATE: 6-29-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
EAGLE DITCH
6-29-00 80' CLEAR
GREEN TWNSHP - SECT 1

STA 127 1.5' x 12' ARCHED CMP - OLD LIVESTOCK GATE IN PIPE

STA 127 - 130 SLIGHT BANK EROSION FROM LIVESTOCK.
CHANNEL 10'-12' WIDE, 6' ± DEEP

STA. 130 - 136+50 CHANNEL 10' ± WIDE, 6' ± DEEP FAIRLY
STRAIGHT ALONG EDGE OF PASTURE FORREST

STA. 137 - 147 CHANNEL 6' ± WIDE, 6' ± DEEP
CHANNEL BREAK TO THE NORTH - NORTHEAST
THROUGH PASTURE - GOOD CONDITION

STA. 147 + 50 DITCH DISCHARGING FROM NORTH
CHANNEL 2' ± WIDE, 2' ± DEEP
DRAINING FARM LAND & BARN YARD.

STA. 150 - 163 CHANNEL 6'-8' WIDE 8'-10' DEEP WITH
GRASS BANKS. CHANNEL MEANDERS EAST
BETWEEN BEAN FIELD & WOODS - GOOD
CONDITION.

STA 163 - 170 CHANNEL 6'-8 WIDE, 8'-10' DEEP
GRASS & BRUSH BANKS WITH STEEP
SLOPE. CHANNEL MEANDERS NORTHEAST

STA 170 10' DIA CMP CROSSING BASELINE ROAD

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY PMG DATE 6-29-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70° SUNNY
JEFFERSON TWNSHP SECT 36
& GREEN TWNSHP SECT 1

STA 0 — YARIAN DITCH DISCHARGES TO EAST SIDE OF THUMMA DITCH. WATER CLOUDY DUE TO YARIAN DITCH DREDGING UPSTREAM.

STA 0 TO 5 — CHANNEL 4'-6' WIDE 6'-8' DEEP
GRASS BANKS THROUGH LIGHT WOODS

STA 5 TO 12+50 — CHANNEL 4'-6' WIDE 6'-8' DEEP
SEVERE BANK EROSION DUE TO LIVESTOCK IN CHANNEL AND CHANNEL MEANDER
ADJACENT SLOPE EROSION DUE TO LIVESTOCK

STA 12+50 — 6' Ø CMP CROSS BASELINE RD.
ENTER GREEN TOWNSHIP SECT 1

STA 12+50 TO 22 — CHANNEL 8' WIDE 8'-10' DEEP
EAST BANK GRASS COVER
WEST BANK BRUSH COVER

STA 12+50 TO — CHANNEL DREDGED THIS SUMMER
SPOILS BANKS AND DAMAGED SLOPES NEED SEEDED

STA 22 TO 29 — CHANNEL 4' WIDE 10'-12' DEEP
BANKS GRASS COVERED

STA 29 — 4' Ø CMP CROSS CO. RD. 600 E.
ENTER SWAN TWNSHP SECT 6

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 4-25-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
ENGLE DITCH
4-25-00 65° CLEAR
GREEN TWNSHP SECT 11 & 2

STA 59 CHANNEL DRAINING WOODED WETLANDS DISCHARGES FROM EAST

STA 65 ± ENTER GREEN TOWNSHIP SECTION 2

STA 70-80 STREAM CHANNEL 10'-15' WIDE 5' ± DEEP MODERATE MEANDER & MODERATE EROSION ASSOCIATED WITH MEANDERING. LOGS & LIMBS IN CHANNEL. LOWLAND FOREST VALLEY

STA 80-105 CHANNEL 15'-20' WIDE 5'-6' DEEP FAIRLY STRAIGHT, MINIMAL EROSION THROUGH LOWLAND FOREST. VALLEY

STA 93 BRIDGE ACROSS CHANNEL - BROKEN DOWN

STA 98 TILE DISCHARGE TO CHANNEL & CHANNEL DISCHARGE TO WEST SIDE OF MAIN ENGLE CHANNEL.

PRODUCT 204-1 (Single Sheets) 205-1 (Padded)

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 4-25-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
ENGLE DITCH
4-25-00 65° CLEAR
GREEN TWNSHP SECT 2

STA 101 HANLON DITCH DISCHARGES TO EAST SIDE OF ENGLE DITCH. MUDDY WATER FROM HANLON DUE TO EXCAVATION IN WETLAND ADJACENT TO HANLON.

STA 105 TO 115 CHANNEL 10'± WIDE 6'± DEEP FAIRLY STRAIGHT THROUGH BEAN FIELD. BANKS BRUSH COVERED
→ BUFFER STRIP RECOMMENDED.

STA 111 DITCH DISCHARGING FROM NORTH.

STA 115-127 CHANNEL 8'-10' WIDE 10+' DEEP THROUGH PASTURE BANK EROSION DUE TO LIVESTOCK
→ ADJACENT SLOPE EROSION DUE TO LIVESTOCK

STA 125-127 RIPRAP CHANNEL OK

STA 114-115 SLIGHT MEANDER EROSION

STA 127 ϕ CMP CROSS CO. RD 500E

XDUCT 204-1 (Single Sheets) 205-1 (Padded)

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-25-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
HANLON DITCH
4-25-00 65° CLEAR
GREEN TWNSHP SECT. 2

STA 0 HANLON DITCH DISCHARGES TO EAST SIDE OF ENGLE DITCH

STA 0-10 HANLON DITCH RECENTLY DREDGED 3'-5' WIDE 3'-5' DEEP - SPOILS BANK ON SOUTH SIDE NOT GRADED OR SEED. DITCH THROUGH LOWLAND & REED CANARY GRASS.
WETLAND TO NORTH IS BEING EXCAVATED TODAY. MUDDY WATER FROM EXCAVATION IS BEING PUMPED TO DITCH.
→ EXCAVATION DEPOSITED IN WETLAND.

STA 10 BEAVER DAM

STA 10-13 WETLAND / POND

STA 13-26 CHANNEL 3'-5' WIDE, 8'-12' DEEP
GRASS BANKS IN GOOD CONDITION
ADJACENT FIELDS GRASS

STA 26 ∅ CMP CROSSING CO. RD 500 E

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O' LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY PMG DATE 5-03-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
DITCH TO NORTH FROM
DITCH STA 112
5-03-00 SUNNY 75°
GREEN TWNSHP SECT 2

STA 0-10 ±2' WIDE CHANNEL, 2'-6' DEEP
CHANNEL FAIRLY STRAIGHT
THROUGH BRUSH & GRASS COVERED
BANKS. SOME AREAS OF HEAVY
BRUSH OBSTRUCTION.

STA 9 5' Ø STEEL PIPE CROSSING
UNDER PRIVATE LANE.

STA 10-25 2'-3' WIDE CHANNEL, 4'-8' DEEP
THROUGH FORESTED AREA. SCATTERED
BRUSH & FOREST FLOOR VEGATATION
ON BANKS. SOME STREAM MEANDERING
CAUSING BANK EROSION.

STA 12 FIELD TILE FROM WEST WASHED OUT

STA 16-22 PASTURED FOREST & DITCH BANKS
WITH LIVESTOCK DAMAGE TO BANKS.

STA 25 5' Ø CORRUGATED METAL PIPE
CROSSING UNDER BASELINE
ROAD.

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. 1 OF 3
CALCULATED BY
DATE
CHECKED BY CWS DATE 4-14-00
SCALE

DIAGNOSTIC STUDY
FIELD NOTES
EASTERDAY
4-14-00 - SUNNY 65°
GREEN TOWNSHIP SECT 5 & SECT 4

STA 0 — NATURAL CHANNEL DISCHARGES TO WEST SIDE OF WEBER LAKE, LOW BANKS, WATER 1'-2' DEEP

STA 0-4 — SHALLOW (1'-2') GRASS COVERED BANKS - CHANNEL 14'-18' WIDE WATER 6" DEEP - THROUGH WOODED AREA

STA 4-6 — SHALLOW BANKS, WATER 2" to 6" DEEP, CHANNEL 6'-7' WIDE WITH SOME AREAS NARROWER

STA 6-9 — GRAVEL BOTTOM, GRASS COVERED BANK WITH SOME MEANDERING - CAUSING SOME EROSION - WOODED AREA

STA 9-13 — BANKS 4'-5' HIGH, WATER 3" DEEP, BOTTOM VARIES UP TO 16' WIDE - "STA 13 : NORTH BANK EROSION"

STA 13-16 — SOME MEANDERING - SOME GRASS BANK WITH BANK EROSION - CHANNEL VARIES WIDE to NARROW 3' to 10' WATER DEPTH 12"-16", TREES ON BANKS

STA 17-20 — SCRUB & PIONEER ON BOTH SIDES, BRANCHES IN WATER GRASS BOTTOM 4" to 6" DEEP, Channel meanders w/ BANK 6½ high. BANK - GRASS & SHRUB, "STA 20" - ROAD CMP 48" - EROSION BY CMP BANK / APPROX 8.0'

STA 21-23 — EROSION AROUND CMP UNDER RD, BANKS 3'-4', PLANT COVERED BANKS, BOTTOM 4'-5' WIDE, WATER 3"-4" DEEP CHANNEL THROUGH WOODS

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O' LAKES
SHEET NO. 2 OF 3
CALCULATED BY _____ DATE _____
CHECKED BY LJS DATE 4-14-00
SCALE _____

STA 23-27 CHANNEL 5'-6' WIDE, THOUGH WOODS WITH BANK COVER BEING TREES & PLANTS
STA 26 BRANCHES BUILDING UP IN CHANNEL

STA 27-31 RAVINE COMING IN FROM WEST CHANNEL BOTTOM 4'-5' WIDE, BANKS DIRT LITTLE OR NO COVER 5'-6' HIGH - SOME HIGHER & STEEPER, SOME MEANDERING 48" CMP UNDER ROAD - CHANNEL 12' WIDE - 12' DEEP BY ROAD

STA 31-33 CHANNEL THROUGH WOODS - WATER 3"-5" CHANNEL BOTTOM 6'-7' BANKS APPROX 12' Plant COVER

STA 33-37 BANKS 10'-20' HIGH - THROUGH WOODS - NO COVER ON BANKS BOTTOM 5'-7' WATER 3"-5" SPOILS BANKS

STA 37-39 BANKS 5'-6' 5'-7' BOTTOM THROUGH WOODS

STA 39-40 MEANDERING THROUGH GRASS FIELD, GRASS BANKS & BOTTOM BANKS 2'-3'

STA 40-44 3'-6' GRASS BANKS 6'± grass BOTTOM THROUGH GRASS FIELD WATER 3"-5"

STA 44-48 BANKS 12'± w/ GRASS & SCRUB COVER, BOTTOM 8'

STA 48 48" CMP UNDER ROAD - ROAD SIDE DITCH ON E side of Rd APPROX 7.0' WITH SOME EROSION, WATER 12"-18"

STA 48-51 GRASS BANKS, GRASS BOTTOM CHANNEL 6' WIDE BANK 6' w/ SOME SCRUB - 3"-4" water

STA 51-67 SHALLOW GRASS BANKS 1'-4' - GRASS BOTTOM 10'-14' WIDE THROUGH GRASS FIELD - WATER 6"-8" - LOW GROUND

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FORT WAYNE, INDIANA 46825

JOB CHAIN O' LAKES
SHEET NO. 3 OF 3
CALCULATED BY
DATE
CHECKED BY CWS DATE 4-14-00
SCALE

STA 58 TREE BRANCHES

STA 67-68 WOODED BANKS 6'-8' BOTTOM 6' WIDE
MEANDERING WITH EROSION BY CMP

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JOB CHAIN O'LAKES
SHEET NO. BAKER 1 OF 1
CALCULATED BY
DATE
CHECKED BY MJG DATE 3-3-00
SCALE

DIAGNOSTIC STUDY
FIELD NOTES
3-3-00 CLEAR - 60°
BAKER DITCH
GREEN TWNSHP - SECT 6 & 7

STA 0 OPEN DITCH DISCHARGES TO REED CANARY GRASS & RED TWIG DOGWOOD WETLAND NORTH EAST CORNER OF NORMAN LAKE

STA 3± DITCH ENTERS WETLAND - REED CANARY GRASS - LOW GRADIENT - GRADIENT INCREASE @ 3± BRUSHY DITCH BANKS

STA 4+50± FLOW EMERGES FROM TILE

STA 6 ± FLOW DISAPPEARS TO OLD TILE ?

STA 0 - 8± DITCH BANKS IN FAIR CONDITION

STA 3 - 8± DITCH PASSING THROUGH PARK AREA - TREES & BRANCHES IN CHANNEL - WOODED AREA. LAND USE O.K.

STA 8-10 WOODED AREA. STREAM BANK EROSION 36"ϕ CORRUGATED METAL PIPE UNDER S.R. 9 - RIPRAP AT END OF PIPE

STA 10 S.R. 9 36"ϕ C.M.P.

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JOB CHAIN 'O' LAKES
SHEET NO. BAKER 1 OF 1
CALCULATED BY
DATE
CHECKED BY MJG DATE 3-3-00
SCALE

DIAGNOSTIC STUDY
FIELD NOTES
3-3-00 CLEAR - 60°
BAKER DITCH
GREEN TWNSHP - SECT 27

STA 0 OPEN DITCH DISCHARGES TO REED CANARY GRASS & RED TWIG DOGWOOD WETLAND NORTH EAST CORNER OF NORMAN LAKE

STA 3± DITCH ENTERS WETLAND - REED CANARY GRASS - LOW GRADIENT - GRADIENT INCREASE @ 3± BRUSHY DITCH BANKS

STA 4+50± FLOW EMERGES FROM TILE

STA 6± FLOW DISAPPEARS TO OLD TILE?

STA 0 - 8± DITCH BANKS IN FAIR CONDITION

STA 3 - 8± DITCH PASSING THROUGH PARK AREA - TREES & BRANCHES IN CHANNEL - WOODED AREA. LAND USE OK.

STA 8-10 WOODED AREA. STREAM BANK EROSION 36" ϕ CORRUGATED METAL PIPE UNDER S.R. 9 - RIPRAP AT END OF PIPE

STA 10 S.R. 9 36" ϕ CMP.

PRODUCT 204-1 (Single Sheets) 205-1 (Padded)

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JOB CHAIN LAKES
SHEET NO. MUDD 1 OF 3
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 3-6-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
3-6-00 70° CLEAR
MUD LAKE/NO NAME DITCH
GREEN TWNSHP - SECT 8

STA 0 — OUTLET TO EAST SIDE OF MUDD LAKE CHANNEL 6' WIDE <1' DEEP THROUGH LOW AREA WITH BRUSH

STA 0-4 — 6' WIDE CHANNEL LOW AREA WITH BRUSH NO CHANNEL EROSION PROBLEMS

STA 4-6 — CHANNEL CUT THROUGH 10'± RIDGE SMALL CHANNEL ENTERS FROM EAST THROUGH WETLAND SOME STREAMBANK EROSION IN MAIN CHANNEL

STA 6 — 18" ∅ CMP IN CHANNEL BELOW PARK WALKING PATH.

STA 6-13 — CHANNEL PASSES THROUGH WILLOW, ELM & CANARY GRASS WETLAND. CHANNEL NOT WELL DEFINED IN SOME AREAS.

STA 13-35 — CHANNEL 6'-10' WIDE 2'-4' DEEP MEANDERS, MODERATE GRADIENT, PASSING THROUGH VALLEY 25'-100' WIDE, VALLEY BANKS 10-25' HIGH & AREA IS WOODED, NICE! CHANNEL MEADERS - SOME STREAM BANK EROSION WITH LIMBS & LOGS IN CHANNEL - NO SEVERE EROSION

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JOB: CHAIN O LAKES
SHEET NO. MUDD 2 OF 3
CALCULATED BY: DATE:
CHECKED BY: MJG DATE: 3-6-00
SCALE:

DIAGNOSTIC STUDY
MUD LAKE / NO NAME DITCH

STA 35-50 BEGIN PRIVATE PROPERTY @ STA 35
CHANNEL 6' WIDE 4'-6' DEEP
MODERATE GRADIENT. DITCH CHANNEL
IS STRAIGHT NO APPRECIABLE
STREAMBANK EROSION. DITCH
BANKS BRUSH COVERED. BRUSH
IN DITCH.
6" ϕ TILE ENTERS FROM EAST AT
STA 41+50± - CMP.
10" ϕ CMP ENTERS FROM EAST
AT STA 42+50±
CROPLAND ON BOTH SIDES OF DITCH.
→ BUFFER MAY BE REQUIRED ON
EAST SIDE OF DITCH

STA 50 36" ϕ CMP UNDER C.R 200 S.
DEEP POOL AT OUTLET OF PIPE

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JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 3-3-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
3-3-00 - 70° CLEAR
SHERWOOD-BRANCH 1 & 1A
GREEN TOWNSHP SECT 9

STA 0 ENTER SOUTH SIDE OF SHERWOOD AT STA 31

STA 0 - 10+50 CHANNEL 2'-5' WIDE MEDIUM GRADIENT, STREAM BANKS IN FAIR CONDITION. LOGS & LIMBS IN CHANNEL. DITCH PASSES THROUGH BRUSH AREA.

STA 10+50 BRANCH 1A ENTERS FROM WEST

STA 11+50 BRANCH 1 CROSSES C.R. 200 S.

BRANCH 1A

STA 0 ENTERS BRANCH 1

STA 4+50 BRANCH 1A CROSSES C.R. 200S

STA 0 - 4+50 CHANNEL MEANDERS, STREAM BANK EROSION - SEVERE AT DISCHARGE TO BRANCH 1 - TRASH IN CHANNEL FROM C.R. 200S.

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JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY \ DATE \
CHECKED BY MJG DATE 12-17-99
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
12-17-99 - SNOW 30°
SHERWOOD
GREEN TWNSHP SECT 9

STA 0 OUTLET TO SOUTH SIDE OF SAND LAKE
JUST WEST OF PARK BENCH AREA.

STA 0-15 CHANNEL BANKS 5' TO 20' HIGH
SOME LIGHT STREAMBANK EROSION.

STA 11 ACTIVE GULLY 8' DEEP ENTERS
FROM WEST. EROSION.

STA 0-15 WOODED SOME LIMBS IN CHANNEL

STA 15-30 STRAIGHT DREDGED CHANNEL
THROUGH LOW GROUND - BANKS
3'-8' HIGH - GRASS & SOME
BRUSH ON BANKS - IN GENERAL
CHANNEL IS IN GOOD CONDITION
ADJACENT LAND IS GRASS & BRUSH.

STA 27 GULLY DRAINING WETLAND TO
SOUTH - SOME EROSION.

STA 29 BRANCH 1 ENTERS FROM SOUTH.
- BEGIN BRANCH 1

PRODUCT 204-1 (Single Sheets) 205-1 (Padded)

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JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 12-17-99
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
12-17-99 SNOW 30°
SHERWOOD
GREEN TOWNSHP SECT 9

STA 30-51 FAIRLY STRAIGHT DREDGED CHANNEL BANKS 3'-8' HIGH CHANNEL 5'± WIDE. BANKS GRASS COVERED & STABLE. ADJACENT GROUND IS GRASS & BRUSH

STA 51 SURFACE DRAINAGE FROM CORN FIELD ENTERS FROM EAST - SHOULD HAVE BUFFER

STA 51-55 DITCH 3' DEEP THROUGH LOW GROUND - GRASS COVERED BANKS LOW GRADIENT - NO APPARENT PROBLEMS

STA 55 42" ϕ CMP UNDER C.R. 200 S.

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JOB: CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY: MJG DATE: 4-5-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
NATURAL CHANNEL
4-3-00 - CLOUDY 60°
GREEN TOWNSHIP SECT 10

STA 0 — NATURAL CHANNEL DISCHARGES TO SOUTH END OF LONG LAKE (SUCKERL.) SEVERE MEANDERING, LOGS IN CHANNEL - SEVERE STREAMBANK EROSION - WOODED AREA

STA 0-10 — SEVERE MEANDERING, LOGS IN CHANNEL SEVERE STREAMBANK EROSION - WOODED AREA

STA 10 — TWO RAVINES CONVERGE EACH RAVINE DRAINS WOODED OR PIONEER FOREST UPLANDS. MODERATE MEANDERING AND STREAMBANK EROSION IN CHANNELS AT BOTTOMS OF RAVINES. RAVINE WALLS ARE WOODED AND APPEAR STABLE

THESE ARE NATURAL RAVINES IN PARK PROPERTY.

→ STREAMBANK EROSION IS PROBABLY A SOURCE OF SEDIMENT IN LONG LAKE

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SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-5-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
FORKER DITCH
4-3-00 CLOUDY-60°
GREEN TWNSHP, SECT 10

STA 0 — OUTLET TO SOUTH EAST CORNER OF LONG LAKE (SUCKER LAKE) IN PARK
LOGS AT OUTLET.

STA 0-8 — CHANNEL BOTTOM 20' WIDE WATER 2' DEEP. DITCH BANKS 3'-5' HIGH THROUGH WOODED WETLAND-LOW GROUND - BANK BARE DUE TO WOODS - SOME STREAM BANK EROSION. CHANNEL FAIRLY STRAIGHT.

STA 8-24 — CHANNEL 16' WIDE AT BOTTOM FAIRLY STRAIGHT. DITCH BANKS 8' HIGH GRASS & BRUSH BANKS FAIR CONDITION. WOODS & BRUSH ON SOUTH SIDE (PARK LAND)
CORN FIELD ON NORTH SIDE
→ RECOMMEND BUFFER STRIP.

STA 10 — RIPRAP ON NORTH SIDE, GULLEY FROM WOODS ON SOUTH SIDE
→ RIPRAP.

STA 12 → GULLEY FROM WOODS, SOUTH RIPRAP

STA 24 — EAST LINE OF SECTION 10

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SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-3-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
SHERWOOD
4-3-00 CLOUDY 60°
GREEN TWNSHP SECT 10

STA 106 CROSS RD. 2D. 200 S 42' ϕ CMP

STA 106-110 GRASS & BRUSH DITCH BANKS
& CHANNEL THROUGH FARMSTEAD

STA 108 BRIDGE ACROSS DITCH

STA 110-118 3'-5' DEEP DITCH GRASS
& BRUSH BANKS - CHANNEL
CHORED WITH GRASS &
BRUSH THROUGH LOW GROUND
GENERALLY GOOD CONDITION

STA 118 6" ϕ PVC PIPE FROM NORTH

STA 118-126 8' WIDE CHANNEL 5'-10' DEEP
GRASS & BRUSH BANKS GENERALLY
GOOD CONDITION WHEAT FIELD
NORTH OF DITCH ALFALFA
HAY TO SOUTH.
→ PERMANENT GRASS BUFFER - NORTH

STA 119 GULLEY FROM NORTH
→ NEEDS ROCK CHUTE

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JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 4-3-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
SHERWOOD
4-3-00 - CLOUDY 60°
GREEN TWNSHP SECT 10

STA 124 GULLEY FROM NORTH
→ ROCK CHUTE RECOMMENDED

STA 127 OPEN DITCH BEGINS EAST
OF CO. RD. 300 E TILE OUTLET
FROM WEST.
→ TILE OUTLET NEEDS REPAIRED

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JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MSG DATE 4-13-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
FORKER DITCH
4-13-00 - CLEAR 60°
GREEN TWNSHP SECT 11

STA 24 - 37 — CHANNEL 4'-10' WIDE BANKS 6'-8' DEEP - BANKS GRASS & BRUSH COVERED MODERATE MEANDERING - MEDIUM GRADIENT - WATER 1' DEEP WITH 2' DEEP POOLS - STREAMBANK EROSION PREVALENT ON OUTSIDE BENDS OF MEANDERS.

STA 37 — JUNCTION WITH BRANCH #1 FROM EAST (SUMMIT LAKE & THOMAS DRAINS)

STA 37 - 42 — CHANNEL 10'-15' WIDE BANKS 8' ± DEEP BANKS GRASS & BRUSH COVERED - MODERATE MEANDER WITH STREAMBANK EROSION.

STA 24 - 42 → GRASS FIELD NOW - MAY BECOME PASTURE - SHOULD MAINTAIN BUFFER ON NORTH SIDE OF STREAM.

STA 42 — 8' ± ϕ CMP UNDER GRAVEL ROAD 125 SOUTH

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JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 4-25-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
ENGLE DITCH NORTH OF CR 125S
4-25-00 65° CLEAR
GREEN TWNSHP SECT 11

STA 42 — 8'± DIAMETER CORRUGATED METAL PIPE UNDER C.R. 125 SOUTH (GRAVEL)

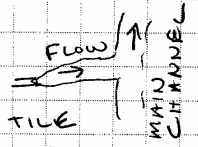
STA 42-70 — CHANNEL 15'± WIDE 6'-8' DEEP MEANDERS, LOG JAMS & LIMBS IN CHANNEL. EROSION ASSOCIATED WITH MEANDERING AND LOG JAMS. CHANNEL BANKS WOODED OR BRUSH COVERED

STA 43 — BANK EROSION AND SLIDE ON EAST SIDE OF CHANNEL

STA 47 — 6" ϕ TILE FROM NORTH SIDE

STA 46-55 → — FIELDS ADJACENT TO CHANNEL BUFFER RECOMMENDED

STA 56 — TILE & CHANNEL DISCHARGING FROM WES




BROKEN TILE
BOILING UP TO FEED CHANNEL

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JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-25-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ENGLE DITCH
4-25-00 65° CLEAR
GREEN TWNSHP SECT 11 & 2

STA 59 CHANNEL DRAINING WOODED WETLANDS DISCHARGES FROM EAST

STA 65 ± ENTER GREEN TOWNSHIP SECTION 2

STA 70-80 STREAM CHANNEL 10'-15' WIDE 5' ± DEEP MODERATE MEANDER & MODERATE EROSION ASSOCIATED WITH MEANDERING. LOGS & LIMBS IN CHANNEL. LOWLAND FOREST VALLEY

STA 80-105 CHANNEL 15'-20' WIDE 5'-6' DEEP FAIRLY STRAIGHT, MINIMAL EROSION THROUGH LOWLAND FOREST. VALLEY

STA 93 BRIDGE ACROSS CHANNEL - BROKEN DOWN

STA 98 TILE DISCHARGE TO CHANNEL & CHANNEL DISCHARGE TO WEST SIDE OF MAIN ENGLE CHANNEL

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JOB CHAIN O LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY MJG DATE 4-13-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
BRANCH #1 FORKER DITCH
4-13-00 - CLEAR 60°
GREEN TWNSHP - SECT 11

STA 0 — DISCHARGE TO FORKER DITCH AT STA 37

STA 1 → CROSS CO. RD. 425 E (GRAVEL) 48" ϕ CMP. SEVERE EROSION ON EAST (UPSTREAM) SIDE OF ROAD - PIPE PARTIALLY BLOCKED BY BRUSH.

STA 0 - 10 — CHANNEL 6' ± WIDE, BANKS 6'-8' DEEP BRUSH BANKS SOME STREAMBANK EROSION.

STA 10 — THOMAS BRANCH DISCHARGES TO NORTH SIDE OF DITCH.

FLD CK 4-24-00

STA 10-16 — CHANNEL ± 4' WIDE 3'-5' DEEP BRUSH COVERED SOME STREAMBANK EROSION

STA 16-20 — CHANNEL 2'-3' WIDE 3' DEEP THROUGH REED CANARY GRASS MEADOW - NO EROSION.

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SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-24-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
BRANCH #1 FORKER DITCH
4-24-00 - PTLY CLOUDY 60°
GREEN TWNSHP - SECT 11

STA 20 4' Φ CMP FIELD CROSSING

STA 20 - 26 CHANNEL 6'± WIDE 6'± DEEP
BRUSH COVERED BANKS BANKS
APPEAR STABLE

STA 26 BEAVER DAM.

STA 26 - 35± FLOODED LOWLAND DUE TO BEAVER
DAM

STA 31 CHANNEL ENTERING PONDED AREA
6' WIDE 10'-15' DEEP CUT THROUGH
ESKER DRAINING WETLAND SOUTH
OF ESKER. - BRIDGE ACROSS CHANNEL
NORTH OF RIDGE SOUTH OF BRANCH #1

STA 35-40 CHANNEL 4' WIDE 4' DEEP BRUSH
COVERED BANKS - STABLE

STA 40-48 CHANNEL 2-3' WIDE 6' DEEP SLIGHT
MEANDER & ASSOCIATED STREAMBANK
EROSION - BRUSH COVERED BANKS.

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JOB: CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY: MJG DATE: 4-24-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
BRANCH #1 FORKER DITCH
4-24-00 PTLY CLOUDY 60°
GREEN TWNSHP SECT 11

STA 44 GULLEY FROM NORTH

STA 48 4' Φ CORRUGATED METAL PIPE (CMP) CROSSING UNDER CO. RD. 500 E

STA 49 GULLEY FROM NORTH - STONES DUMPED IN GULLET.

STA 48 - 57 5' WIDE CHANNEL, 5'-8' DEEP THROUGH GRASS AREA. CHANNEL STRAIGHT WITH BRUSH & GRASS COVERED BANKS

STA 57 3' Φ CMP CROSSING UNDER PRIVATE STONE DRIVE

STA 57 - 59 4' ± WIDE CHANNEL 5' ± DEEP BRUSH & GRASS BANKS

STA 57 SUMMIT LAKE OUTLET

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SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-13-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
THOMAS BRANCH
4-13-00 CLEAR 60°
GREEN TWNSHP SECT 11

STA 0 DISCHARGE TO BRANCH #1 FORKER DITCH AT STA 10

STA 2 48" ϕ CMP PIPE UNDER GRAVEL CO. RD. 125 S

STA 0-2 3' WIDE CHANNEL - SEVERE GRADIENT WITH STREAMBANK EROSION. BRUSH COVERED BANKS & BRUSH IN CHANNEL.

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JOB CHAIN O' LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY PMG DATE 5-03-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
THOMAS DITCH
5-03-00 SUNNY 75°
GREEN TWNSHP SECT 11

STA 0-8 ±4' WIDE CHANNEL, 4-6' DEEP
THROUGH BRUSH & GRASS COVERED CHANNELS
SOME STREAM BANK EROSION DUE TO
STREAM MEANDERING

STA 2 4' Ø CORRUGATED METAL PIPE CROSSING
UNDER C.R. 125 S.

STA 8-14 2-4 WIDE CHANNEL, ±4' DEEP
MEANDERING STREAM WITH SOME
DITCH BANK EROSION.
BRUSH & GRASS COVERED BANKS

STA 9 GULLEY FROM NORTH

STA 13 36" Ø CORRUGATED METAL PIPE
PRIVATE FIELD CROSSING

STA 14-27 2'-4' WIDE CHANNEL, 4'-8' DEEP
THROUGH GRASS & BRUSH BANKS.
MEANDERING STREAM WITH SOME DITCH
BANK EROSION.
HIGH FORESTED BLUFFS ON BOTH SIDES OF
DITCH.

STA 20 GULLEY FROM NORTH

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JOB CHAIN O' LAKES
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY PMG DATE 5-03-00
SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
THOMAS DITCH
5-03-00 SUNNY 75°
GREEN TWNSP SECT 11

STA 26 — OPEN GARBAGE PIT WITH HOUSEHOLD WASTES ±50 NORTH OF DITCH
EXCAVATION IN AREA CAUSING EROSION OF HIGH BLUFFS TO NORTH

STA 27-34 — 2'-4' WIDE CHANNEL, 2'-4' DEEP THROUGH GRASS AREA. CHANNEL STRAIGHT WITH BRUSH & GRASS COVERED BANKS. SOME BRUSH OBSTRUCTION TO FLOW.

STA 29 — SEVERAL MINOR SWALES FROM SOUTH HAVE ERODED DITCH BANK.

STA 34 — 4' ϕ CORRUGATED METAL PIPE CROSSING UNDER C.R. 500 E

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JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY CJS DATE 3-13-01
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
THOMAS
3-13-01
GREEN TWP Sect. 12

STA 34 - 48 ϕ under CR 500E - CHANNEL 4'-6' wide
34-40 GRASS BANKS & BOTTOM - WATER 8"-10" deep
CHANNEL FLOWING THROUGH AREAS OF INTERMITTENT
GRASS & GRASS WITH BRUSH.

STA 40 - 50 CHANNEL LOSES DEFINITION - BECOME SWAMP / WETLAND
WHICH IS GRASS W/ A FEW PATCHES OF BRUSH

STA. 48 ← (APPROX.) - NEW - WELL BUILT LANE GOES THROUGH WETLAND
3'-4' ABOVE WETLAND ELEVATION

STA 50 - 52 CHANNEL IN GRASS / SCRUB AREA - GRASS BOTTOM & BANKS
CHANNEL 2'-4' wide, 8" to 24" deep - 2"-3" water

STA 51 (BRANCH) CHANNEL COMES INTO THOMAS FROM S.E. - IT IS APPROX
1' wide w/ 2"-3" of water - IT is flowing through
a grass/scrub wetland area.

STA 52 - 54 BANKS GET STEEPER from 3' to 10' - Banks grass
w/ a few trees - Grass bottom. SOME CATTAILS IN
BOTTOM, WATER 4"-6" deep.

STA 53 LIMB IN CHANNEL

STA 54+25 MEDIUM SIZE TREE GROWING IN CHANNEL
NO VISIBLE CULVERT UNDER ROAD

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SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
SHERWOOD
4-3-00
GREEN TWN SHP SECT 15

STA 83 CROSS CO. RD. 300 E 60" ϕ CMP.

STA 83-98 3'-5' WIDE CHANNEL BOTTOM
3'-5' DEEP DITCH BANKS
THROUGH LOW GROUND GRASS &
BRUSH DITCH BANKS & LOTS
OF TALL WASTY HORSEWEED.

STA 85 18" ϕ CORRUGATED METAL PIPE (CMP)
FROM NORTH - DRAINING LOW GROUND
THROUGH SPOILS BANK

STA 98-106 3'-5' WIDE CHANNEL - 5'-8' DEEP
GRASS & BRUSH BANKS IN
FAIR CONDITION - CROPLAND - BEANS
EAST & WEST OF DITCH.
→ NEED FILTER STRIP

STA 102-106 SEVERAL GULLEYS ON EAST SIDE
OF DITCH FROM FIELD RUNOFF
→ NEED ROCK CHUTES OR ESTABLISH
A SINGLE RUNOFF POINT

STA 106 CROSS CO. RD. 200 S 42" ϕ CMP

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 3-7-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
3-7-00 CLEAR 60°
SHERWOOD BRANCH 1
GREEN TWNSHP SECT 16

STA 11+50 BRANCH 1 CROSSES C.R. 200S
24" ϕ CMP.

STA 11+50 - 15 SHALLOW CHANNEL MEANDERS THROUGH
GRASS & BRUSH WETLAND AREA.

STA 15 - 25 SHALLOW CHANNEL 1'-2' DEEP - 5' WIDE
MEANDERS THROUGH BOTTOM OF
30±' WIDE WOODED RAVINE
LITTLE STREAMBANK EROSION.
RAVINE BANKS 10-25' HIGH
LIMBS & LOGS IN CHANNEL.
VERY PRETTY - VERY CLEAN.

STA 25 - 32 CHANNEL PASSES THROUG
WOODED WETLAND. CHANNEL
NOT DEFINED IN SOME AREAS.
NO PROBLEMS.

STA 32 - 37 DEFINED CHANNEL BETWEEN
WOODED WETLANDS CHANNEL
ENDS AT 37 OUTLET OF
NICE WOODED WETLAND - BUTTONBUSH
HIGHBUSH CRANBERRY - LOTS OF PEEPERS
TODAY. 8" ϕ & 6" ϕ TILE DRAIN TO
WETLAND FROM WEST CROPLAND
NO APPARENT PROBLEMS.

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JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY MJG DATE 4-3-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ARTHUR BRANCH
4-3-00 CLOUDY 60°
GREEN TWN SHP SECT 16

STA 0 — ARTHUR BRANCH DISCHARGES TO SHERWOOD AT SHERWOOD STA 65

STA 0-4 — GULLY THROUGH BEAN FIELD ABOVE ARTHUR BRANCH TILE.
→ NEED GRASS SWALE

STA 4-17 — SWALE THROUGH WHEAT/GRASS FIELD TO TAIL END OF RAVINE
DIFFICULT TO TELL IF THIS IS GRASS SWALE OR FALLOW. TILE BELOW SWALE WITH A FEW SMALL BLOW OUTS.
→ PERMANENT GRASS SWALE RECOMMENDED.

STA 9 — SWALE ENTERING FROM WEST
→ GRASS SWALE RECOMMENDED

STA 17-21 — WOODED RAVINE - FLOWING WATER
OPEN FLOW ENTERS TILE @ STA 17 ±
→ THIS IS AN ACTIVE OPEN DUMP WITH OIL & PAINT CANS. IN THE CHANNEL.

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SHEET NO. _____ OF _____
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SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
SHEZWOOD
4-3-00 CLOUDY 60°
GREEN TWNSHP SECT 16

STA 55 — CROSS C.R. 200 S 42" ϕ CMP.

STA 55-65 — CHANNEL BOTTOM 5' WIDE - DITCH 5'-10' DEEP CROP - BEAN FIELD WEST OF DITCH - 10' WIDE GRASS & BRUSH BUFFER. TREE PLANTATION & FOREST ON EAST SIDE. DITCH IN GOOD SHAPE

STA 65-66 — SWALE & 3 CMP PIPES 8" ϕ, 12' ϕ & 15" ϕ DISCHARGE TO DITCH FROM SOUTH.
→ - NEED ROCK CHUTE FOR SWALE & REPAIR PIPE/TILE OUTLET.

STA 65 — SWALE & TILES ENTER FROM SOUTH - SEE ARTHUR BRANCH

STA 65-72 — CHANNEL THROUGH WOODS MEDIUM GRADIENT COBBLE BOTTOM GOOD CONDITION

STA 67 — SMALL POND OUTLET CHANNEL ENTERS FROM NORTH - GOOD CONDITION.

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CHECKED BY: MJG DATE: 4-3-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
SHERWOOD
4-3-00 CLOUDY 60°
GREEN TWNSHP SECT 16

STA 72 - 83 — CHANNEL BOTTOM 3'-5' WIDE GRASS & BRUSH BANKS DITCH IN GOOD CONDITION. CAMP AREA GRASS YARD TO SOUTH OF DITCH FOREST & TREE PLANTATION TO NORTH. - SOME STREAMBANK EROSION

STA 73 - 74 — 6" ϕ PVC & RIPRAP ROCK CHUTE ENTER FROM SOUTH THROUGH GRASS YARD GOOD CONDITION

STA 74 - 75 — FOOT BRIDGE ACROSS DITCH

STA 82 — RIPRAP & 8" ϕ P.V.C. SOUTH SIDE OF DITCH - GOOD CONDITION

STA 83 — CO. RD. 300 E 60" ϕ CMP PIPE

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CHECKED BY: MJG DATE: 3-3-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
SHERWOOD BRANCH 1A & 1B
3-3-00 CLEAR 70°
GREEN TWNSHP SECT 16

STA 4+50 BRANCH 1A CROSSES C.R. 200 S

STA 4+50-11 BRANCH 1A LARGE WOODED GULLY WITH 5'-8' WIDE CHANNEL IN BOTTOM - SOME STREAM BANK EROSION IN CHANNEL - MUCH TRASH OLD & NEW IN GULLY AND CHANNEL.

STA 5+50 BRANCH 1B - GULLY ENTERS FROM WEST.

BRANCH 1B

STA 0 BRANCH 1B ENTERS BRANCH 1A AT STA 5+50

STA 0-5 WOODED GULLY CHANNEL IN BOTTOM SOME STREAMBANK EROSION. TRASH IN CHANNEL & GULLY. 24" ϕ CMP FROM NORTH @ STA 4 UNDER C.R. 200S

STA 5 BRANCH 1B CROSSES C.R. 200S - 18" CMP TO NORTH. NORTH OF C.R. 200S IS A GRASS BOTTOM GULLY.

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JOB: CHAIN O LAKES
SHEET NO. MUDD 3 OF 3
CALCULATED BY: MJG DATE: 3-6-00
CHECKED BY: DATE:
SCALE:

DIAGNOSTIC STUDY
FIELD NOTES
MUDD LAKE / NO NAME DITCH
3-6-00 70° CLEAR
GREEN TOWNSHIP SECT 17

STA 50 — CROSS C.R. 200 S - 36" ϕ C.M.P.

STA 50 - 58 — CHANNEL 4'-6' WIDE 4'-6' DEEP
MEANDER THROUGH BRUSH & WOODS
SOME LIMBS & LOGS IN CHANNEL
SOME STREAMBANK EROSION

STA 58 — TILE & GULLET ENTER FROM WEST

STA 58 - 63 — CROP LAND TO SOUTH - COULD USE BUFFER CHANNEL 4'-6' WIDE 4'-6' DEEP, BRUSH COVERED BANKS

STA 63 — OPEN DITCH ENDS - 15" ϕ CMP DISCHARGES TO DITCH FROM SOUTH.

**GENSIC & ASSOCIATES INC.**
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JOB CHAIN - O - LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY JLL DATE 06-29-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ENGLE & ROUSH DITCHES
06-29-00 - 80° CLEAR
JEFFERSON TWP - SECT. 36

STA 171 - 174+50 CHANNEL 10'-12' WIDE 6'-7' DEEP GRASS BANKS ON WEST SIDE OF CHANNEL, 18-20' BRUSH BANK ON EAST SIDE OF CHANNEL WITH SEVERE BANK EROSION FROM STEEP SLOPES.

STA 174+50 MEANDERING CHANNEL ENTERING FROM NORTH - ENGLE DITCH MEANDERS TO THE WEST AT THIS POINT, WATER IN CHANNEL FROM NORTH CLOUDY & SILTY

STA 176 CONCRETE BRIDGE @ FIELD CROSSING

STA 177 - 205 CHANNEL 6'-8' WIDE 6'-8' DEEP GRASS & BRUSH BANK, CHANNEL MEANDERS NORTH & NORTHEAST THRU DENSE WOODED AREA
NOTE: DITCH PATH CANNOT BE DETERMINED ON AERIAL PHOTOGRAPHY FOR THIS SECTION - DENSE WOODS

STA 205 72" DIA. CMP @ C.R. 600 E
LARGE SEDIMENT BASIN @ DOWNSTREAM END OF STRUCTURE

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SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70° SUNNY
JEFFERSON TWNSHP SECT 36
& GREEN TWNSHP SECT 1

STA 0 — YARIAN DITCH DISCHARGES TO EAST SIDE OF THUMMA DITCH. WATER CLOUDY DUE TO YARIAN DITCH DREDGING UPSTREAM.

STA 0 TO 5 — CHANNEL 4'-6' WIDE 6'-8' DEEP
GRASS BANKS THROUGH LIGHT WOODS

STA 5 TO 12+50 — CHANNEL 4'-6' WIDE 6'-8' DEEP
SEVERE BANK EROSION DUE TO LIVESTOCK IN CHANNEL AND CHANNEL MEANDER
ADJACENT SLOPE EROSION DUE TO LIVESTOCK

STA 12+50 — 6' Ø CMP CROSS BASELINE RD.
ENTER GREEN TOWNSHIP SECT 1

STA 12+50 TO 22 — CHANNEL 8' WIDE 8'-10' DEEP
EAST BANK GRASS COVER
WEST BANK BRUSH COVER

STA 12+50 TO — CHANNEL DREDGED THIS SUMMER
SPOILS BANKS AND DAMAGED SLOPES NEED SEEDED

STA 22 TO 29 — CHANNEL 4' WIDE 10'-12' DEEP
BANKS GRASS COVERED

STA 29 — 4' Ø CMP CROSS CO. RD. 600 E.
ENTER SWAN TWNSHP SECT 6

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SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70° SUNNY
SWAN TWNSHP SECT 6
& ALLEN TWNSHP SECT 31

STA 48 SWALE DRAINING ADJACENT BEAN FIELD
DISCHARGING FROM SOUTH

STA 45 TO 59 GRASS BUFFER STRIPS RECOMMENDED

STA 58 24" Ø CMP DISCHARGING FROM SOUTH

STA 59 4' Ø CMP FIELD CROSSING

STA 66 NATURAL SWALE DISCHARGING FROM SOUTHEAST

STA 81 4' Ø CMP CROSS BASELINE RD.
ENTER ALLEN TOWNSHIP SECT. 31

STA 81 TO 96 GRASS COVER ON WEST BANK
GRASS AND BRUSH COVER ON EAST BANK
CHANNEL 2'-4' WIDE, 6'-12' DEEP
CHANNEL STRAIGHT, RESENTLY DREDGED

STA 87 RAVINE DISCHARGING FROM EAST.

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SHEET NO. _____ OF _____
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SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70' SUNNY
SWAN TWNSHP SECT 6

| | |
|---|---|
| STA 29 TO 38 | CHANNEL ±6' WIDE ±10' DEEP<br>GRASS BANKS.<br>BUFFER STRIPS RECOMMENDED |
| STA 30+50 | ERODED SWALE DRAINING ADJACENT<br>BEAN FIELD DISCHARGING FROM SOUTH |
| STA 38 | CHANNEL DISCHARGING FROM SOUTH |
| STA 38 TO 81 | CHANNEL 2'-4' WIDE, 8'-14' DEEP<br>CHANNEL STRAIGHT, RESENTLY DREDGED |
| STA 43+50 | NATURAL RAVINE COLLECTED INTO A<br>24" Ø CMP FIELD CROSSING, 24" Ø CMP<br>DISCHARGING TO YARIAN FROM NORTH.<br>NATURAL RAVINE COLLECTED INTO A<br>24" Ø CMP FIELD CROSSING, 24" Ø CMP<br>DISCHARGING TO YARIAN DITCH FROM<br>SOUTH. |
| STA 44 | 4' Ø CMP FIELD CROSSING |
| STA 47 | 8" Ø CMP TILE & 6" Ø PVC TILE<br>DISCHARGING FROM NORTH. |

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SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT. 19

STA. 335+30 - 338+50 — CHANNEL 2'-4' WIDE, 10'-12' DEEP DENSE VEGETATIVE BANKS MEANDERS NORTH-NORTHEAST. GOOD CONDITION - LOW CHANNEL FLOW

STA. 338+50 — 6" ϕ PLASTIC FIELD TILE DISCHARGES ON WEST SIDE OF DITCH.

STA. 338+50 - 342+50 — CHANNEL 2'-4' WIDE, 8'-12' DEEP VEGETATIVE BANKS MEANDERS NORTHEAST. GOOD CONDITION - LOW CHANNEL FLOW

STA. 342+50 - 344+20 — CHANNEL 2'-4' WIDE, 8'-10' DEEP VEGETATIVE BANKS MEANDERS NORTHWEST GOOD CONDITION - LOW CHANNEL FLOW

STA. 344+20 - 348+00 — CHANNEL 3'-5' WIDE, 6'-8' DEEP VEGETATIVE BANKS MEANDERS NORTHEAST. GOOD CONDITION - LOW CHANNEL FLOW

STA. 348+00 - 350+00 — CHANNEL 3'-8' WIDE, 4'-10' DEEP BANKS MEANDERS NORTH EAST. POOR CONDITION - STAGNET WATER W/ ALGA GROWTH RECOMMEND 2' OVERDIGGING OF DITCH BOTTOM TO REMOVE SEDIMENT FROM RUN-OFF. PLACE LARGE VEGETATIVE BUFFER BETWEEN HORSE CORRAL & EAST SIDE OF DITCH

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SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT. 20

STA. 350+50 — 72" CMP PIPE UNDER CO. RD. 700E
12" CMP PIPE ABOVE 72" CMP PIPE UNDER CO. RD 700E

STA. 350+50 - 355+80 — CHANNEL 4'-6' WIDE, 10'-12' DEEP GRASS BANKS MEANDERS NORTHEAST ALONG BEAN FIELD.
GOOD CONDITION

STA. 355+80 — CHANNEL 2'-4' WIDE, 4'-6' GRASS BANK DISCHARGES INTO MAIN DITCH FROM EAST.

STA 355+80 - 365+00 — CHANNEL 6'-10' WIDE, 10'-12' DEEP GRASS BANKS MEANDERS NORTHEAST THRU LOW LYING WOODED AREA

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DIAGNOSTIC STUDY
FIELD NOTES
RAILROAD SIDE DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT. 29

STA. 0+00 — 24" CMP UNDER CO. RD. 700E - DISCHARGES INTO EAGLE DITCH.

STA. 1+00 - 2+60 — CHANNEL 2'-4' WIDE 4' DEEP VEGATATIVE BANKS MEANDERS SOUTHEAST ALONG RIGHT-OF-WAY OF ABANDONED RAIL ROAD.

STA. 2+75 — 2 - 4" ϕ CMP FIELD TILES W/ RODENT GUARDS ENTERING CHANNEL FROM NORTH

STA. 3+75 — 6" ϕ PVC FIELD TILE ENTERING DITCH FROM NORTH.

STA. 3+75 - 7+00 — CHANNEL 2'-4' WIDE, 4'-6' BRUSH BANKS MEANDERS SOUTHEAST ALONG RIGHT-OF-WAY OF ABANDONED RAILROAD THROUGH WOODS

STA. 7+10 — 6" ϕ PVC FIELD TILE ENTERS DITCH FROM NORTH

STA. 7+10 - 15+00 — CHANNEL 6'-8' WIDE, 10'-12' BRUSH BANKS MEANDERS SOUTHEAST ALONG RIGHT-OF-WAY OF ABANDONED RAILROAD THROUGH WOODS

STA. 15+00 - 23+00 — CHANNEL 4'-6' WIDE, 2'-3 BRUSH BANKS MEANDERS SOUTHEAST ALONG RIGHT-OF-WAY OF ABANDONED RAIL ROAD. CHANNEL IS DRY FROM STAT. 18+00 - 23+00.

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SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT, 29

STA. 291 - 298 — CHANNEL 4'-6' WIDE 10'-12' DEEP GRASS BANKS MEANDERS NORTHEAST GOOD CONDITION

STA 298 - 301+50 — CHANNEL 4'-6' WIDE 10'-12' DEEP GRASS & BRUSH BANKS MEANDERS NORTH ALONG LOW LYING WOODED AREA. GOOD CONDITION

STA 302 — 6" CMP FIELD TILE ENTERING CHANNEL FROM NORTH - 12" ABOVE FLOWLINE OF CHANNEL

STA. 302 - 306+50 — CHANNEL 4'-6' WIDE 8'-10' DEEP GRASS & BRUSH BANK MEANDERS WEST BETWEEN PASTURE / GRASS AND WHEAT FIELD.

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DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT. 30

STA. 315+30 - 319+35 — CHANNEL 4'-6' WIDE, 10'-12' DEEP DENSE GRASS BANKS MEANDERS NORTHWEST. GOOD CONDITION.

STA. 319+35 - 324+00 — CHANNEL 2'-3' WIDE, 10'-12' DEEP DENSE GRASS BANKS MEANDERS NORTH. GOOD CONDITION

STA 324+00 — 60" ϕ CMP UNDER PRIVATE DRIVE

STA. 324+00 - 335+30 — CHANNEL 2'-3' WIDE, 10'-12' DEEP DENSE VEGETATIVE BANKS MEANDERS NORTH INTO SECTION 19 GOOD CONDITION

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DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-30-00 - 80° SUNNY
ALLEN TWNSHP - SECT. 30

| | |
|---|---|
| STA 268 | 6" CMP FIELD TILE ENTERING ON NORTH SIDE OF CHANNEL. FIELD RUNOFF CAUSING BANK EROSION<br>RIP-RAP BANK AND PROVIDE BUFFER STRIP ON NORTH SIDE OF BANK RECOMMENDED |
| STA 269 - 283+50 | CHANNEL 4'-6' WIDE 6'-8' DEEP BANK MEANDERS NORTHEAST. BANKS COVERED WITH HEAVY BRUSH.<br>CHANNEL IN GOOD CONDITION. |
| STA 283+50 - 287+50 | CHANNEL 4'-6' WIDE 8'-10' DEEP GRASS & BRUSH BANKS, SLIGHTLY MEANDERS EAST, CHANNEL IN GOOD CONDITION<br>BUFFER STRIP ON EACH SIDE OF BANK RECOMMENDED. |
| STA 287+50 - 290 | CHANNEL 4'-6" WIDE 8'-10" DEEP GRASS AND BRUSH BANKS. CHANNEL RUNS NORTH PARALLEL TO C.R. 700E. |
| STA 290 | 72" DIA CMP. CROSSING C.R. 700 E SKEWED 25° |
| STA 290+50 | 50' NORTH OF 72" CMP CROSS PIPE MODERATE FIELD & ROAD SIDE DITCH EROSION<br>RIP-RAP SHORE RECOMMENDED |

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DIAGNOSTIC STUDY
FIELD NOTES
ROOSH DITCH
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT. 30

STA. 306+50 — 60" CMP UNDER COUNTY ROAD 700 E

STA. 307+00 — 6" PVC PRIVATE TILE ENTERING DITCH FROM WEST.

STA. 307+00 - 309+00 — CHANNEL 6'-8' WIDE, 10'-12' STEEP
LIGHT BRUSH BANKS PARALLEL TO CO. RD. 700 E - GOOD CONDITION
NOTE: EAST SIDE DITCH BANK PARTIALLY LINED WITH RIP RAP - VERY LOOSE

STA. 309+25 — SMALL SAPLING GROWING IN DITCH BLOCK FLOW.
RECOMMEND REMOVING SAPLING FROM DITCH

STA. 309+25 - 315+30 — CHANNEL 4'-6' WIDE, 12'-14' DEEP GRASS & RIP RAP BANKS (ON EAST SIDE) RUNNING PARALLEL TO CO. RD. 700 E.
NOTE: THIS SECTION OF DITCH HAS SEVERAL PIPES OUTLETING FROM FARM STEAD ADJACENT TO WEST DITCH BANK.
RECOMMEND FURTHER INVESTIGATION OF TILES FUNCTION. PROPERTY OWNER MAYBE DISCHARGING PERIMETER TILE FROM SEPTIC FIELD INTO DITCH - SEWAGE SMELL IS WAS NOTICE WHEN WALKING THIS SECTION.

STA. 315+30 — 24" CMP UNDER CO. RD. 700 E ENTERING DITCH FROM EAST. THIS PIPE OUTLETS DITCH ALONG THE NORTH SIDE OF OLD RAILROAD BED IN SECTION 29 AND FLOWS FROM THE EAST.

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SCALE _____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70° SUNNY
SWAN TWNSHP SECT 6
& ALLEN TWNSHP SECT 31

| | |
|---|---|
| STA 48 | SWALE DRAINING ADJACENT BEAN FIELD DISCHARGING FROM SOUTH |
| STA 45 TO 59 | GRASS BUFFER STRIPS RECOMMENDED |
| STA 58 | 24" Ø CMP DISCHARGING FROM SOUTH |
| STA 59 | 4' Ø CMP FIELD CROSSING |
| STA 66 | NATURAL SWALE DISCHARGING FROM SOUTHEAST |
| STA 81 | 4' Ø CMP CROSS BASELINE RD. ENTER ALLEN TOWNSHIP SECT. 31 |
| STA 81 TO 96 | GRASS COVER ON WEST BANK<br>GRASS AND BRUSH COVER ON EAST BANK<br>CHANNEL 2'-4' WIDE, 6'-12' DEEP<br>CHANNEL STRAIGHT, RESENTLY DREDGED |
| STA 87 | RAVINE DISCHARGING FROM EAST. |

PRODUCT 204-1 (Single Sheets) 205-1 (Padded)

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DIAGNOSTIC STUDY
FIELD NOTES
YARIAN DITCH
6-29-00 70° SUNNY
ALLEN TWNSHP SECT 31

STA 96 TO 106 — CHANNEL 4'-6' WIDE, 4'-6' DEEP
CHANNEL STRAIGHT, RESENTLY DREDGED
GRASS COVER ON BANKS

STA 106 — 5' Ø CMP CROSS CO. RD 700 E
ENTER ALLEN TOWNSHIP SECT 32

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DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-29-00 - 80° CLEAR
ALLEN TWNSHP - SECT. 31

STA 206 - 215 — CHANNEL 2'-4' WIDE 6'-8' DEEP BANKS CHANNEL MEANDERS EASTERLY THROUGH DENSE WOODS - BANK EROSION MINIMAL.

STA 215 — FIELD SWALE FROM NORTH ENTERING ON NORTH DITCH BANK.
→ RIP RAP SWALE

STA 215 - 228 — CHANNEL 2'-4' WIDE 6'-8' DEEP GRASS & BRUSH BANKS. CHANNEL MEANDERS EAST THROUGH DENSE WOODS. MINIMAL BANK EROSION.

STA 229 - 245 — CHANNEL 4'-6' WIDE 6' DEEP GRASS & BRUSH COVERED BANKS. CHANNEL MEANDERS NORTH - NORTHEAST THROUGH PASTURE. MINIMAL BANK EROSION.

STA 246 - 250 — CHANNEL 6'-8' WIDE 6' DEEP DENSE GROUND COVERED BANKS. CHANNEL MEANDERS NORTH BETWEEN CORN & ALFA FIELDS.
BUFFER STRIP RECOMMENDED ON WEST SIDE OF DITCH

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SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
ROUSH DITCH
06-29-00 - 80° CLEAR
ALLEN TWNSHP - SECT. 31

| | |
|---|---|
| STA 251 | 12" VCT ENTERING EAST SIDE OF DITCH. BANK ERODED & TILE BROKEN. RIP RAP BANK & TILE OUTLET RECOMMENDED |
| STA 251 - 260 | CHANNEL 4'-6' WIDE 4'-6' HIGH DENSE GRASS BANK MEANDERS NORTH - NORTHEAST. |
| STA 260 | CONCRETE BRIDGE AT DITCH CROSSING C.R. 100 N |
| STA 261 | RIGHT-OF-WAY / FARM FENCE CROSSING DITCH ON NORTH SIDE OF C.R. 100 N FENCE IS COLLECTING DEBRIS RAISE FENCE OUT OF FLOW LINE OF DITCH RECOMMENDED. |
| STA 261 - 267 (SECT. 30) | CHANNEL 2'-4' WIDE 3'-4' GRASS BANK MEANDERS EAST - NORTHEAST, GOOD CONDITION |
| STA 267 (SECT. 30) | LIMESTONE BRIDGE TRESTLE FOR RAILROAD CROSSING CHANNEL. |

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DIAGNOSTIC STUDY
FIELD NOTES
YARIAN-WOLF DITCH
6-30-00 80° SUNNY
ALLEN TWNSHP - SECT 32

STA. 106+00 - 113+80 — CHANNEL 2'-4' WIDE, 8'-10' DEEP BANKS WITH MODERATE VEGETATION (RECENTLY DIPPED), MEANDERS EAST-NORTHEAST THROUGH PASTURE LAND. RECOMMEND FINAL GRADING & SEEDING OF SPOILS PILE

STA. 113+80 - 115+00 — CHANNEL 2'-4' WIDE, 10'-12' DEEP BANKS WITH MODERATE VEGETATION (RECENTLY DIPPED)

STA. 115+00 — NEW 12" CMP DISCHARGES INTO CHANNEL FROM NORTH, 3' ABOVE DITCH.
RECOMMEND RIP RAP PIPE OUTLET & FINISH OF PIPE OUTLET.
(PIPE PROJECTS 8'± OUT OF SIDE OF DITCH BANK)

STA. 115+00 - 118+80 — CHANNEL 2'-4' WIDE, 12'-14' DEEP BANKS WITH MODERATE VEGETATION, (RECENTLY DIPPED), MEANDERS EAST THROUGH PASTURE LAND.
RECOMMEND FINAL GRADING & SEEDING OF SPOILS PILES

STA. 118+80 - 126+80 — CHANNEL 2'-4' WIDE, 12'-14' DEEP BANKS WITH MODERATE VEGETATION (RECENTLY DIPPED) MEANDERS NORTHEAST THROUGH ALFAFA & CORN FIELDS.
RECOMMED FINAL GRADING & SEEDING OF SPOILS PILES.

PRODUCT 204-1 (Single Sheets) 205-1 (Padded)

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY JLL DATE 06-30-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
YARIAN-WOLF
6-30-00 80° SUNNY
ALLEN TWNSHP - SECT 32

STA. 126+80 - 134+50 — 18" HIGH DENSITY POLYETHYLENE TILE
GOOD CONDITION

STA. 134+50 — 4" TILE RISER AT EDGE OF BEAN FIELD & WETLAND
NOTE: END OF PIPE LOCATION UNKNOWN

STA. 143+50 - 148+50 — GRASS WATERWAY 15'-25' WIDE MEANDERS THROUGH WOODS.
GOOD CONDITION

STA. 148+50 — 48" ϕ CMP UNDER RAILROAD.
RECOMMEND CLEANING SEDIMENT OUT OF NORTH END OF CMP TO PROVIDE ADEQUATE FLOW THROUGH PIPE.

STA. 149+00 — 12" TILE RISER & BLOW HOLE

STA. 149+00 - 153+50 — NATURAL VEGETATIVE SWALE THROUGH MAINTAINED GRASS AREA MEANDERS NORTHEAST
RECOMMEND CONSTRUCTING GRASS WATER WAY & REPAIR TILE UNDER SWALE.
NOTE: SEVERAL BLOW HOLES ARE MARKED BY THE PROPERTY OWNER.

STA. 153+50 - 157+50 — NATURAL SWALE THROUGH LIGHT WOODED AREA. APPROX. 30'-50' WIDE
SWALE IS DRY

**GENSIC & ASSOCIATES INC.**
311 Airport North Office Park
FORT WAYNE, INDIANA 46825

JOB: CHAIN O LAKES
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY: JLL DATE: 06-30-00
SCALE ____

DIAGNOSTIC STUDY
FIELD NOTES
YAPIAN - WOLF
06-30-00 80° SUNNY
ALLEN TWNSHP - SECT 32

STA. 157+50 - 163+50

DRY GULLY WITH 8'-10' BANKS. MEANDERS THROUGH NORTH-NORTHEAST THROUGH PASTURE LAND
RECOMMEND MINOR BANK RECONSTRUCTION & SEEDING

# APPENDIX B

## LAND MANAGEMENT PRACTICES

**IDNR DIVISION OF SOIL CONSERVATION**
**LAKE & RIVER ENHANCEMENT PROGRAM**
**Watershed Land Treatment Projects**
**Cost-Share and Incentive-Payment Practices**

**May 8, 2001**

The State Soil Conservation Board has adopted the following as practices eligible for cost-share or incentive payments in LARE-funded Watershed Land Treatment project areas.

It is important to understand that implementation of any of the practices is predicated on the compilation of a whole farm inventory and development of a complete resource management system (RMS) plan for any farm that is to receive cost-share funds.

## GENERAL CRITERIA FOR APPROVED COST-SHARE PRACTICES

***The combination of cost-share funds from all sources shall not exceed the total cost of actual practice installation. LARE percentage rates shall be adjusted when appropriate. "Incentive" payments are independent of "cost-share" payments.***

***Cost-share for tile installation for all practices will be limited to an 8"diameter tile (or equivalent cost) unless prior approval is obtained. When practice installation requires tile(s) larger than 8", prior approval of the IDNR Agriculture Conservation Specialist must be obtained.***

## SPECIFIC COST-SHARE AND INCENTIVE-PAYMENT PRACTICES

**Blind Tile Inlet:** As an alternative to open tile inlets (risers) on grassed waterways and for field drainage, cost-share funding is available for blind inlets (french drains) which will prevent some of the pollutant problems. The inlets may be replaced with coarse crushed stone which offers some limited filtration to inflowing water, and the stone would then be surrounded by a grassed buffer area. The stone partially impedes water flow, so that during heavy rains much of the runoff would actually flow over the stone rather that into the inlet. An incentive payment of $350 is established for each site. This practice will be maintained for a minimum of 10 years.

**Conservation Tillage:** Original policy allowed for cost-sharing on *no till* and *mulch till*, both of which leave crop residue on the surface to provide protective cover over the soil, preventing sheet and rill erosion. Farmers in some areas of the state have been more receptive to the practices than others, and producers are more apt to no till soybeans than corn. It may be discovered that cost-sharing alone will not be sufficient incentive to initiate no tilling for corn production. As research and experience with the practices continue to expand, it is hoped that their adoption will increase. However, since there is still a reluctance by many farmers to reduce tillage to levels necessary to effectively

control erosion, cost-sharing shall consist of an incentive payment of $12/acre for no till and $8/acre for mulch till, with a maximum of 300 acres/year. **In watershed land treatment project areas, some form of conservation tillage shall be a prerequisite to cost-sharing on other practices, such as structures, which are also intended to control erosion.** Cost-sharing for conservation tillage is not appropriate for land users who already own the appropriate tillage equipment or have already adopted a conservation tillage system, and shall not be made available to any landuser for more than three years (based on a three-year whole farm plan). This practice will be maintained for a minimum of 1 year.

**Cover Crop:** Erosion control can be enhanced with off-season cover crops on fields not having sufficient crop residue. A secondary benefit is that commercial nitrogen fertilizer usage can be reduced since leguminous cover crops add nitrogen to the soil and non-leguminous cover crops can return nitrogen to the soil as they decompose. Acceptance of the practice has varied in watershed project areas. Some producers have had experiences with cover crops that did not meet their expectations. However, new techniques for killing cover crops are making the practice more attractive, especially after production of silage and soybeans. As farmers become more familiar with the economic, environmental, and agronomic benefits of cover crops, it is anticipated that use of the practice will continue even after the cost-share period ends. Cost-sharing shall consist of an incentive payment of $12/acre, with a maximum of 300 acre/year to help pay for seeding and killing the crop. Cost-sharing shall not be made available to any land user for more than three years (based on a three-year whole farm plan). This practice will be maintained for a minimum of 1 season.

**Critical Area Planting:** This practice provides for the planting of vegetation such as trees, shrubs, grass, or legumes on highly or critically eroding areas; it could also be applied to a problem such as a wet seep on a hillside, and could involve a buffer around a wetland. On a limited, case-by-case approval basis, the practice could also be applied on selected portions of field perimeters where other practices are not applicable, but where topography makes the sites susceptible to erosion. Erosion is generally reduced by protecting steep slopes or highly erodible soils. Cost-sharing assists with site preparation, seeding, and maintenance of the planting or stabilization. In most cases, small acreages in a larger field can be vegetated and protected, while the remainder of the field can still be farmed without suffering unacceptable erosion. Cost-sharing shall consist of an incentive payment of $400/acre. This practice will be maintained for a minimum of 10 years.

**Diversion:** In order to re-direct significant surface water flow which would otherwise contribute to erosion, a diversion channel (and downslope supporting ridge) can be constructed across the slope of a field to transport the water to a more stable area. It is determined that the 80%/65% cost-share rates shall be applied toward the engineer's estimate or the actual cost, whichever is less (with the anticipated actual cost to be approximately $3/linear foot). This practice will be maintained for a minimum of 10 years.

**Fencing:** Fences can be beneficial when there is a need to exclude livestock from environmentally sensitive areas, to regulate livestock access to a particular area, or to permit proper grazing distribution in pastures, all of which lead to erosion control and/or water quality protection. The practice does *not* include any form of temporary fencing. Fencing adjacent to water bodies should be installed in conjunction with vegetated filter strips of appropriate recommended widths. The 80%/65% cost-share rates shall be applied toward the engineer's estimate or the actual cost, whichever is less (with the anticipated actual cost to be approximately $1.50/linear foot). This practice will be maintained for a minimum of 20 years.

**Field Windbreak:** A strip/row of trees or shrubs in or adjacent to a field can reduce wind erosion effects, shield crops and enhance their growth, and create wildlife habitat. Although not as directly beneficial to surface water quality as many other practices, a windbreak can constrain wind-blown soil that might be transported into roadside ditches or otherwise enter streams or lakes. Professional assistance regarding species selection and planting regimes can be solicited from IDNR district foresters, and is encouraged. The 80%/65% cost-share rates shall be applied toward the engineer's estimate or the actual cost, whichever is less (with the anticipated actual cost to be approximately $400/acre). This practice will be maintained for a minimum of 15 years.

**Filter Strip:** A vegetated buffer can trap eroded soil and stormwater-borne nutrients and pesticides which might otherwise be transported downslope into surface waters. This practice can be extremely beneficial in affording protection where other measures may not be practicable. Filter strips can also supplement practices which may not, themselves, be fully satisfactory for protecting water bodies from agricultural pollutants. For example, even though conservation tillage can reduce erosion on a crop field, a certain amount of soil can still be eroded from the field -- but could be trapped by a filter strip. The effectiveness of filter strips is influenced by factors such as width, slope, vegetation type, sediment particle size, and runoff rate. Areas taken out of production to create filter strips can be used for access to a field, haying, or to provide a safety buffer to prevent tractor accidents along ditches and streams. This is a highly desirable practice which is strongly encouraged, but is difficult to convince many farmers to adopt since it results in reduced field size. Additional ecological and water quality benefits can be provided if shrubs and/or trees are strategically incorporated into the riparian buffer area. To simplify previous policy, it is determined that $650/acre shall be paid to provide an economic incentive to the landowner. Filter strips are intended to be relatively narrow bands of vegetation, adjacent to water bodies, which will remove pollutants that might otherwise enter the water, and provide ecological benefits. They are not intended for large scale applications covering entire fields. Appropriate widths shall be based on the purpose; added width may be justified to allow for removal of nutrients and/or pesticides. **The maximum width shall be 60 feet.** (In situations where there is no existing buffer zone adjacent to the affected water body, the maximum can be expanded to 66 feet to accommodate herbicide application restrictions.) This practice shall be maintained for a minimum of 10 years.

**Grade Stabilization Structure:** In areas where the concentration and flow velocity of runoff is sufficiently high, an engineered structure such as a rock chute or block chute is

required to control the grade and head-cutting of natural or artificial channels, thereby preventing the advancement or formation of gullies. As with certain other practices, installation of these structures can result in a directed discharge of waterborne pollutants into receiving streams. For this reason, their construction should be accompanied by installation of appropriately designed filter strips which can trap sediment, nutrients, and pesticides upstream from the structure. These filter strips must be sized to allow for conformance with regulations pertaining to application setbacks for specific pesticides used in their vicinity. The 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less, with an anticipated approximate maximum cost to be $6,000/ structure. This practice will be maintained for a minimum of 15 years.

**Grassed Waterway:** Grassy vegetation in an area of concentrated flow can greatly reduce erosion. A grassed waterway is typically a constructed shallow channel that is shaped and vegetated to provide for stable conveyance of runoff. The practice is not appropriate where its construction would destroy significant woody vegetation, and where the present watercourse is not seriously degraded and is capable of conveying existing flows. If the design dictates use of a tile beneath the waterway, consideration must be given to installation of an appropriately sized grass buffer which will remove waterborne pollutants prior to the water's entry through the tile inlet. (Refer to "Tile Riser Grassed Buffer" practice description.) Cost-share for tile installation will be limited to an 8" diameter tile (or equivalent cost) unless prior approval is obtained. The 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less, with an anticipated approximate maximum cost to be $4/linear foot. This practice will be maintained for a minimum of 10 years.

**Integrated Crop Management (ICM):** Includes Nutrient Management and Pest Management (See below).

**Nutrient Management:** Managing the amount, form, placement, and timing of application of plant nutrients is not only a significant economic concern, it is also an important water quality consideration. This practice applies to the management of organic wastes (manure), commercial fertilizers, legume crops, and crop residues. The purpose is to optimize usage of plant nutrients for forage and crop yields, while minimizing their introduction into surface and ground waters, protecting air quality, and maintaining or improving the chemical and biological condition of the soil. Cost-sharing shall be for soil samples that the cooperator has analyzed, and upon which nutrient applications are based. This practice shall be combined with the Pest Management practice and they shall be collectively referred to as *Integrated Crop Management* with an incentive payment of $8/acre, maximum of 300 acres/year. Cost-sharing shall not be made available to any landuser for more than three years (based on a three-year whole farm plan). This practice will be maintained for a minimum of 1 year.

**Pest Management:** Managing agricultural pest infestations (including weeds, insects, and diseases) is critical to producers' financial success. It is essential that adverse effects to plant growth and crop production be reduced, but the use of pesticides can have negative environmental consequences. It is therefore beneficial to water quality goals to minimize chemical usage through application of an integrated approach to pest control.

This generally involves appropriate chemical usage, but also includes enhanced record keeping, scouting, and other forms of non-chemical pest management. This can result in a reduction of chemical introduction into surface and ground waters. This practice shall be combined with the Nutrient Management practice and they shall be collectively referred to as *Integrated Crop Management* with an incentive payment of $8/acre, and a maximum of 300 acres/year. Cost-sharing shall not be made available to any landuser for more than three years (based on a three-year whole farm plan). This practice will be maintained for a minimum of 1 year.

**Livestock Watering Facility:** A trough or tank can be strategically located to provide an acceptable water supply for livestock. This practice is applicable in situations where it is desirable to provide an alternative water source and prevent livestock from entering lakes or streams. This reduces the animals' detrimental impacts on water quality. Installations often require use of crushed stone to provide a suitable base for the tank and, in the case of *spring developments*, require the installation of a water collection system at the spring outflow site, and some PVC piping to direct water to the container. Typically, it is appropriate to apply vegetative cover as a complement to the watering trough installation in order to reduce erosion at the site. Cost-sharing does not apply to any pumps or electrical connections. It is determined that the 80%/65% rates shall be applied toward the estimated or actual cost of the installation, whichever is less, with an anticipated maximum cost of $1,500 per facility. This practice will be maintained for a minimum of 10 years.

**Pasture and Hayland Planting:** It can be beneficial to establish or re-establish long-term stands of adapted species of perennial, biennial, or reseeding forage plants in order to reduce erosion on existing low quality pasture/hayland or to transform heavily eroding land to a more productive use. The land user can not only benefit economically, but reduce erosion which impairs water quality as well. It is determined that the 80%/65% cost-sharing rates shall be applied toward the estimated or actual cost of the installation, whichever is less, and would include seeding, fertilization, and initial maintenance, in accordance with NRCS specifications. The Field Office Technical Guide states that, *for erosion control* (which is the intent of this practice), a grass-legume mixture should be selected, rather than a single variety stand such as alfalfa. Alfalfa not only is more expensive, it is not suitable by itself for erosion control and is not eligible for cost-sharing. The anticipated approximate maximum cost should be no more than $150/acre, but can vary considerably, depending on site conditions. This practice will be maintained for a minimum of 5 years.

**Sediment (Control) Basin:** In some locations it is not practicable to fully control the source of erosion, so some measure is required to constrain the eroded soil. A sediment basin can be constructed which will help preserve reservoirs, ditches, canals, diversions, waterways, streams, and lakes. Such a basin can trap waterborne sediment originating from areas where physical conditions or land ownership preclude treatment of the problem source. Sediment basins are not intended to be recreational ponds, but consideration will be given to hybrid structures that may incorporate constructed wetland characteristics. The practice shall be accompanied by the installation of an appropriate upstream grass buffer zone (based on site-specific design considerations) which will

reduce the introduction of nutrients and/or pesticides. The impoundment structure (dam) shall be vegetated to control its erosion, and promote long term stability. In situations requiring future periodic or occasional maintenance, it is essential that measures be implemented to provide adequate access for maintenance equipment. The 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less (with the anticipated actual cost to be approximately $2/cubic yard). This practice will be maintained for a minimum of 20 years.

**Streambank Protection:** Vegetation and/or structures can be effectively used to stabilize and protect the banks of streams or channels from scour and erosion. This reduces sediment loads that cause downstream damages and pollution, and can also improve the stream for recreation and as habitat for fish and wildlife. Regional IDNR biologists and foresters possess knowledge that may be useful in evaluating project sites and developing appropriate plans, so their inclusion in the planning process is encouraged. This practice applies where streambanks are susceptible to erosion from the action of water or ice, or to damage from livestock. If the affected stream is a "regulated drain" subject to county jurisdiction, it is essential that any project be approved during the planning stage by the county drainage board. Some projects may require regulatory permits from IDNR or the Corps of Engineers, which should be ascertained prior to construction. The 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less. This practice will be maintained for a minimum of 20 years. The anticipated maximum costs would be as follows:

| | |
|---|---|
| Per Site | $5,000 |
| Riprap | $25.00 per linear foot |
| Vegetation | $ 2.50 per linear foot |
| Combination | $ 7.50 per linear foot |

**Terrace (Gradient and Parallel):** An earthen embankment, ridge, or channel constructed across a slope can reduce erosion by intercepting and conducting surface runoff at a nonerosive velocity to a stabilized outlet. These structures can allow otherwise erodible slopes to be cropped. However, it has been determined that their outlets can also serve as direct conduits for pesticides and nutrients transported by the runoff they convey to streams and lakes. It is therefore required that any terrace construction be accompanied by appropriate installation of grassed buffer zones to remove pollutants that would otherwise be directed through tiles into streams or lakes. Cost-share assistance shall be provided for terraces only on a limited basis when erosion is severe and other measures are not practicable. In those cases, tile inlets should be protected by appropriate buffer zones and the outlets should discharge over/through additional appropriately designed grassed buffers or wetlands before discharging into streams or lakes. (Refer to "Tile Riser Grassed Buffer" and "Watercourse Outlet Buffer" practice descriptions.) The 80%/65% rates should be applied toward the engineer's estimate or the actual cost, whichever is less (with an anticipated approximate maximum cost of $2/linear foot). This practice will be maintained for a minimum of 10 years.

**Tile Riser Grassed Buffers:** Certain practices such as grassed waterways, WASCOBs, and terraces (as well as flat, tiled land), which have tile riser inlets can pose a pollution

threat to the streams or lakes into which they discharge runoff. Water that flows into the structures needs to be treated in some way to allow removal of eroded soil, nutrients, and pesticides. Research has shown that grassed buffers can provide such treatment. Therefore, it is determined that appropriate buffers shall be required for all new structures with tile inlets. Installation of buffers is encouraged on existing structures (and tile systems) and cost-share funds are also available for such retrofitting. In order to be consistent with current federal herbicide applications requirements, a 66-foot radius (minimum) grassed buffer area shall be installed around tile inlets. For WASCOBs, seeding is required 66 feet upstream of and to the other side of the riser, but only up to the top of the ridge (on the ridge's upstream side). An incentive payment of $250 is established for each site. This practice will be maintained for a minimum of 10 years under.

**Tree Planting:** Establishing a stand of trees can control erosion, conserve soil, and retain moisture. This can aid in flood reduction, sedimentation control, and wildlife habitat improvement. Water quality benefits can be derived from plantings adjacent to streams which provide shade and act as a food source, and reduce streambank erosion. Mature trees can also serve as barriers to erosion-causing winds. Professional assistance regarding species selection and planting regimes can be solicited from IDNR district foresters, and is encouraged. This highly desirable practice should be encouraged and it is determined that the 80%/65% rates shall be applied toward the estimated or actual cost, whichever is less (with an anticipated maximum of $400/acre). This practice will be maintained for a minimum of 15 years.

**Waste Management System and Waste Utilization:** Livestock waste must be properly managed, from both economic and environmental perspectives. A planned management system is a means of assuring proper storage and/or usage of the manure. A well designed system prevents or minimizes degradation of air, soil, and water resources and protects public health and safety. Systems prevent discharge of pollutants to surface or ground water and allow the waste to be recycled through soil and plants. A waste management system allows for more effective utilization of animal waste and minimizes nutrient and bacteria levels in runoff from barnyards and feedlots. An appropriately sized storage lagoon or waste pit allows producers to spread and incorporate the manure when conditions are ideal, e.g., during peak crop nutrient demand periods, thus reducing commercial fertilizer costs. This also reduces wear on transfer equipment that would otherwise be in continuous operation. A proper system must include an environmentally acceptable strategy for utilizing the waste, which is a prerequisite to cost-sharing on construction of a containment facility. Manure *dry stacking* facilities are appropriate for handling waste and are also eligible for cost-sharing. It is determined that the 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less, for the design and/or construction of waste containment facilities, with a maximum total cost of $20,000 per facility. In addition, the 80%/65% rates shall be applied toward the lesser of the estimated or actual cost of *waste utilization* (with the anticipated maximum being $0.01/gallon, or $0.075/cubic foot). Cost-share funds for waste management are only to be made available to resolve existing livestock waste problems. Funds will not be made available for expansion of a facility to accommodate additional animals, or for new

facilities. This practice will be maintained for a minimum of 15 years for a containment system and 1 year for waste utilization.

**Water and Sediment Control Basin (WASCOB):** Low earthen embankments or ridges can be constructed across slopes or minor watercourses to form sediment traps/water detention basins. They allow otherwise erodible areas to be stabilized so that they can still be cropped. A WASCOB can provide sufficient detention to trap larger soil particles, but may not remove smaller silt and clay particles from water that is discharged through the outlet tile. It has been determined that the outlets can serve as direct conduits for pesticides and nutrients transported by the runoff they convey to streams and lakes. It is therefore required that any WASCOB construction be accompanied by appropriate installation of grassed buffer areas to remove pollutants that would otherwise be directed through tiles into streams or lakes. (Refer to "Tile Riser Grassed Buffer" and "Watercourse Outlet Buffer" practice descriptions.) WASCOBs can be appropriate in settings where the terrain is too steep for grassed waterways, but are not to be considered as a means to allow overly steep slopes to be cropped; such fields would best be converted to other uses. Cost-share assistance should be provided for WASCOBs only on a limited basis when erosion is severe and other measures are not practicable. In those cases, tile inlets shall be protected by appropriate buffers or the outlets should discharge over/through additional appropriately designed filter strips or through constructed or existing wetlands before discharging into streams or lakes. Cost share for tile installation will be limited to an 8" diameter tile (or equivalent cost) unless prior approval is obtained. The 80%/65% rates should be applied toward the engineer's estimate or the actual cost, whichever is less (with an anticipated approximate maximum cost of $1,500/basin). This practice will be maintained for a minimum of 10 years.

> The following guidance shall be applied to construction of WASCOB buffer areas: At a minimum, the area included within a 20 foot radius from the riser, along with the channel and the front slope (riser side) of the ridge, shall be seeded in accordance with NRCS standard, "Filter Strip 393" seeding recommendations. (A larger area may need to be vegetated based on slope and chemical setback criteria). It is not intended that the front slope of the ridge be cropped. It should be constructed at as steep a slope as possible, to minimize the need for fill material, but not so steep as to preclude mowing. The cost of seeding will be covered as part of construction. For existing or new WASCOBs a flat rate incentive payment of $250 will only be available when the buffer area is extended to a 66 foot radius around the riser and to the top of the ridge. (Refer to "Tile Riser Grassed Buffer" practice policy.)

**Watercourse Outlet Buffers:** Concentrated stormwater runoff which is flowing from a field can cause significant erosion where it enters a ditch or stream. The problem can be mitigated with vegetation and/or different types of grade stabilization structures. The runoff can also transport nutrients and/or pesticides washed from soil and plants. In order to reduce the impact of the pollutants, cost-share funds are available for installation of grassed buffers as "stand-alone" features, or to supplement structural measures. Funding is allowed for seeding a 66-foot radius semicircular area upgradient from the point of entry into the ditch/stream. Any existing well-vegetated or wooded areas shall not be

destroyed to accommodate installation of the grassed buffer. An incentive payment of $125 is available for each site, whether to enhance existing conditions or as a part of construction of a new measure such as a grade stabilization structure. This practice will be maintained for a minimum of 10 years.

**Wetland Development or Improvement:** Wetlands have many beneficial attributes including 1) supporting forest, fish, and wildlife resources; 2) retaining and gradually releasing floodwater; 3) recharging ground water; 4) reducing the impacts of eroded soil and nutrients on the ecology of lakes and streams; 5) providing areas for recreation; and 6) sustaining rare and endangered organisms. Approximately 85% of Indiana's original wetlands have been drained or filled, so it has become increasingly more important to protect and/or restore wetlands whenever possible. This practice provides for the creation of an artificial wetland or the restoration of a previously drained wetland by constructing a dike or dam, filling a surface drain, or removing a subsurface drain. It is determined that the 80%/65% rates shall be applied toward the engineer's estimate or the actual cost, whichever is less (with an anticipated approximate maximum cost of $400/acre). This practice will be maintained for a minimum of 15 years.

# IDNR DIVISION OF SOIL CONSERVATION

*LAKE AND RIVER ENHANCEMENT PROGRAM*
*WATERSHED LAND TREATMENT PROJECTS*

## THE FOLLOWING PRACTICES WILL BE ELIGIBLE FOR THE INDICATED INCENTIVE PAYMENTS

| PRACTICE | INCENTIVE PAYMENT |
|---|---|
| Conservation Tillage | |
| No-till | $12 per acre (300 ac/yr, maximum 3 years) |
| Mulch till | $ 8 per acre (300ac/yr, maximum 3 years) |
| Cover Crop | $12 per acre (300 ac/yr, maximum 3 years) |
| Critical Area Planting | $400 per acre |
| Integrated Crop Management | $8 per acre (300 ac/yr, maximum 3 years) |
| Tile Riser Grassed Buffer | $250 each |
| Blind Tile Inlet | $350 each |
| Watercourse Outlet Buffer | $125 each |
| Filter Strip | $650 per acre (maximum of 60 feet wide) |

Appropriate widths will be based on selected purpose(s) from NRCS standard - Filter Strip (393)

## COST-SHARE PRACTICES

The combination of cost-share funds from all sources shall not exceed the total cost of practice installation. LARE percentage rates shall be adjusted when appropriate. "Incentive" payments are independent of "cost-share" payments.

Cost-share for tile installation for all practices will be limited to an 8"diameter tile (or equivalent cost) unless prior approval is obtained. When practice installation requires tile(s) larger than 8", prior approval of the IDNR Agriculture Conservation Specialist must be obtained.

If a practice is applied within one mile of a project-targeted lake, or within one-half mile of a perennial stream in the project watershed, the maximum cost-share is 80% of the practice's cost.

If a practice is applied further than one mile away from a project-targeted lake, or more than one-half mile from a perennial stream in the project watershed, the maximum cost share is 65% of the practice's cost.

*For example: If a landowner installs a grassed waterway for which the contractor charges $4.25 / linear foot, but the engineer's estimate is $4.00/ linear foot, the landowner will be paid either 80% of $4.00/foot ($3.20) or 65% of $4.00/foot ($2.60), depending on the site's proximity to the project-targeted water body.*

**THE FOLLOWING PRACTICES WILL BE COST-SHARED BASED ON THE ACTUAL COST OF INSTALLATION, OR THE FINAL WRITTEN ENGINEERING ESTIMATE, WHICHEVER IS LESS.**

| PRACTICE | ESTIMATED UNIT COST (For planning purposes) |
|---|---|
| Diversion | $3.00 per foot |
| Fencing | $1.50 per foot |
| Field Windbreak | $400 per acre |
| Grade Stabilization Structure | $6,000 (Anticipated maximum per site) |
| Grassed Waterway | $4.00 per foot |
| Livestock Watering Facility | $1,500 per facility |
| Pasture and Hayland Planting | $150 per acre |
| Sediment Basin | $2.00 per cubic yard |
| Streambank Protection | $5,000 (Anticipated maximum per site) |
| Rock riprap | $25 per linear foot |
| Vegetative | $2.50 per linear foot |
| Combination | $7.50 per linear foot |
| Terrace | $2.00 per linear foot |
| Tree Planting | $400 per acre |
| Waste Management System | |
| Containment system | $20,000 maximum per facility |
| Waste utilization | $0.01 per gallon or $0.075 per cubic foot |
| Water and Sediment Control Basin | $1,500 per basin |
| Wetland Development & Improvement | $400 per acre |

*Fact Sheet*

February 1997

# Conservation Reserve Program

USDA United States Department of Agriculture

*Authorization*

The Food Security Act of 1985, as amended, authorizes the CRP, which is implemented through the Commodity Credit Corporation (CCC). The program is also governed by the regulations published in 7CFR part 1410.

*Overview*

The CRP is a voluntary program that offers annual rental payments, incentive payments for certain activities, and cost-share assistance to establish approved cover on eligible cropland.

The program encourages farmers to plant long-term resource-conserving covers to improve soil, water and wildlife resources. CCC makes available assistance in an amount equal to not more than 50 percent of the participant's costs in establishing approved practices. The durations of contracts are between 10 and 15 years.

CRP is administered by the CCC through the Farm Service Agency (FSA). The Natural Resources Conservation Service, Cooperative State Research and Education Extension Service, State forestry agencies, and local soil and water conservation districts provide program support.

*Eligible Land*

To be eligible to be placed in CRP, land must be:

1. Cropland that is planted or considered planted to an agricultural commodity 2 of the 5 most recent crop years (including field margins) which is also physically and legally capable of being planted in a normal manner to an agricultural commodity; or

2. Marginal pasture land that is either:

a. Certain acreage enrolled in the Water Bank Program; or

b. Suitable for use as a riparian buffer to be planted to trees.

*Additional Requirements for Cropland*

In addition to the eligible land requirements, cropland must :

1. Have an Erosion Index (EI) of 8 or higher or be considered highly erodible land according to the conservation compliance provisions (Redefined fields must have an EI of 8 or higher);

2. Be considered a cropped wetland;

3. Be devoted to any of a number of highly beneficial environmental practices, such as filter strips, riparian buffers, grass waterways, shelter belts, wellhead protection areas, and other similar practices;

4. Be subject to scour erosion;

5. Be located in a national or state CRP conservation priority area; or

6. Be cropland associated with or surrounding non-cropped wetlands

continues >

### *Ranking Criteria*

Offers for CRP contracts are ranked according to the Environmental Benefits Index (EBI).

The Natural Resources Conservation Service collects data for each of the EBI factors, based upon the relative environmental benefits for the land offered. Bids are then ranked in comparison to all other bids offered and selections made from that ranking.

EBI factors include:

- Wildlife habitat benefits resulting from covers on contract acreage;
- Water quality benefits from reduced erosion, runoff, and leaching;
- On-farm benefits of reduced erosion;
- Likely long-term benefits beyond the contract period from certain practices such as tree plantings;
- Air quality benefits from reduced wind erosion;
- Benefits of enrollment in conservation priority areas where enrollment would contribute to the improvement of identified adverse water quality, wildlife habitat, or air quality; and
- Cost.

### *Producer Eligibility Requirements*

An applicant must have owned or operated the land for at least 12 months prior to close of the sign-up period unless:

- The new owner acquired the land as a result of death of the previous owner;
- The only ownership change occurred due to foreclosure where the owner exercised a timely right or redemption in accordance with State law; or
- The circumstances of the acquisition present adequate assurance to CCC that the new owner did not acquire the land for the purpose of placing it in CRP.

### *Rental Rates*

The CCC bases rental rates on the relative productivity of soils within each county, and the average of the past three years of local dryland cash rent or the cash rent equivalent.

The maximum CRP rental rate for each offer is calculated in advance of enrollment. Producers may offer land at that rate or may bid a lower rental rate to increase the likelihood that their offer will be accepted.

In addition, CCC offers additional financial incentives of up to 20 percent of the annual payment for certain continuous sign-up practices.

### *Other Payments*

The CCC encourages restoration of wetlands by offering an incentive equal to 25 percent of the costs incurred. This is in addition to the 50-percent cost share provided to establish approved cover.

### *Continuous Sign-Up*

Eligible acreage devoted to certain special conservation practices such as riparian buffers, filter strips, grassed waterways, shelter belts, living snow fences, contour grass strips, salt tolerant vegetation, and shallow water areas for wildlife may be enrolled at any time under the CCC's continuous sign-up, and are not subject to competitive bidding.

All other eligible acreage must be enrolled during a CRP sign-up period. *(See FSA Fact Sheet: Conservation Reserve Program Continuous Sign-Up for High-Priority Practices for further details.)*

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To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington D.C., 20250, or call 1 800-245-6340 (voice) or (202) 720-1127 (TDD).

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# Restoring wetlands with the WRP

## *Wetlands Reserve Program*

**1996** Farm Bill Conservation Provisions

### WRP Now Administered by the USDA Natural Resources Conservation Service

The fourth sign-up for the Wetlands Reserve Program (WRP) brings several significant changes from the first three sign-ups. The Natural Resources Conservation Service, formerly the Soil Conservation Service, now administers the program. The Farm Service Agency will administer payments for the easements and restoration work.

The program is being offered nationwide. The three options in WRP now are permanent easements, 30-year easements, and restoration agreements. See box, page 3, for a description of each option.

Here is a summary of the sign-up process which began October 1, 1996:

1. Interested landowners receive and sign an application. The Natural Resources Conservation Service (NRCS) will determine if the land proposed to be entered into the program is eligible.

2. The landowner, NRCS, and Fish and Wildlife Service (FWS), complete a site ranking worksheet and draw up a preliminary plan for restoring the area to wetlands. The plan includes types of practices, structures for restoration, and estimated costs associated with restoration.

3. Quarterly, the NRCS state office will rank all applications, and make recommendations to the national NRCS office for final selections.

4. The state conservationist will then notify all persons submitting applications as to whether or not they are tentatively accepted. Once landowners are tentatively accepted and are still interested in the program, a certified appraiser will appraise the land intended for WRP. The landowner will be offered the appraised dollar value for the easement up to a maximum easement value of $1000 per acre. The landowner then files the easement and restores the wetland and is reimbursed for a percentage of the restoration cost, depending on the easement type.

## Eligible Land

Those interested in entering land into the WRP must have owned the land for the previous 12 months (except in the case of inheritance) and have clear title to the land. Lands eligible for the WRP must have the potential to contribute to the functions and values of wetland ecosystems. Eligible land falls under one of the following:

### *Agricultural land with restorable wetlands*

Land categorized by NRCS as: 1) wetlands farmed under natural conditions; 2 ) farmed wetlands; 3) prior converted cropland; 4) commenced conversion wetlands; 5) farmed wetland pasture; or 6) land substantially altered by flooding.

### *Land adjacent to wetlands*

Adjacent land that will contribute significantly to wetland values, as long as the adjacent land does not exceed 50% of the easement area. Includes uplands and non-cropped natural wetlands.

### *Wetlands restored under federal or state programs*

This land is eligible if it currently has an easement for less than 30 years or has fewer than 30 years remaining on the easement.

### *Riparian areas*

Areas along streams, or other waterways that link two or more wetlands which are protected by easements, or other similar agreements, are eligible if: the area averages no more than 300 feet in width on each side of the stream and one mile in length. (Waivers for additional lengths and widths may be granted by NRCS.)

## Minimum and Maximum Size

There is no maximum acreage on WRP. Minimum acreage for permanent and 30-year easements is five acres. Minimum acreage for restoration cost share is one acre.

USDA Natural Resources Conservation Service
Indianapolis, Indiana
November 1996

## During the Sign-up

Those interested in entering land into the WRP should visit the local NRCS office. They should:

- be prepared to provide proof of ownership (title),
- review eligibility requirements with NRCS,
- submit a signed "application" form if the land and landowner are eligible.

## After the Sign-up

After the landowner has signed an application, the following process takes place:

• NRCS flags the easement area and determines land eligibility.

• the landowner, NRCS, and FWS draw up a preliminary plan to restore the wetland. The plan includes cost estimates, describes the restoration practices, and notes future use of the area. If tree planting is done, the tree planting plan must be approved by an Indiana Department of Natural Resources (IDNR) district forester.

• the landowner, NRCS, and FWS complete a ranking worksheet.

• the state conservationist ranks the applications and requests an allocation from NRCS headquarters. Based on the allocation, the highest ranking applicants are tentatively accepted.

• Landowners will be notified whether they are tentatively accepted. During the next eight months, the appraisal and easement acquisition process will take place. Easements should be signed and payments made within eight months of the tentative acceptance notifications.

## Ranking Intents

The local NRCS staff will complete data collection and site review for all applications, and submit the applications to the NRCS state office for evaluation and ranking. State ranking criteria has been established to better meet WRP goals in Indiana. Ranking criteria will consider both environmental benefits and costs, including:

1) percent of hydrology restored
2) location significance, for wetland functions and habitat
3) easement management requirements
4) successful restoration likelihood
5) easement cost per acre
6) restoration cost per acre.

When signing up, landowners can offer their easement areas for a lesser amount than the $1000 per acre maximum payment. Because this will reduce the cost of the intended easement, the rank of the area will improve.

Landowners with the top ranked applications will be made offers for easements. All persons filing an application will be notified about the status of their offer and its state ranking.

## Appraisal and Offer Procedures

NRCS has set a maximum easement value of $1000 per acre in Indiana. Upon tentative acceptance, a certified appraiser will visit the proposed wetland area and place an agricultural value on the land being offered.

If the landowners who received the highest rankings are still interested in the program, NRCS will pay the lowest one of the following :

1) the landowner offer,
2) the appraised agricultural value,
3) the maximum easement value of $1000 per acre.

This offer is made to the landowner in the form of an Option to Purchase Agreement or Contract.

If the landowner accepts, the process continues, and the landowner is obligated to sign the easement when it is ready to be executed. If the landowner declines the offer, NRCS moves on to the next highest ranked offer.

## Easement Development

After the contract is signed, NRCS will conduct title searches, acquire title insurance, and perform a legal survey, if necessary. NRCS will pay for the cost of work related to perfecting the easement.

It is the landowner's responsibility to provide clear title to the land. This may require obtaining subordination agreements of mortgages and other "clouds" on the title. The landowner is responsible for any cost to obtain a clear title.

## Wetlands Reserve Plan of Operation (WRPO)

The WRPO is a detailed document containing the practices required to restore the wetland, referred to as "essential practices". The plan includes a description of practices that will enhance the wetland, and/or supplemental practices.

NRCS will design the wetland restoration and include it as part of the WRPO. The design will include specifications for structures, seedings, and operation and maintenance of the area.

## Uses of the Wetland

The landowner controls access to the area by others. It is still the landowner's private land and others can be allowed to use it or all access can be restricted. However, NRCS personnel are allowed to inspect the site and carry out management activities.

The easement allows use of the area for recreational uses that will not degrade the wetland. Hunting (including fee hunting) and fishing, which comply with state and federal laws, are allowed.

Other uses are prohibited, but landowners may be granted compatible use permits for activities which are compatible with the objectives of the wetland restoration. Permission for compatible uses may be granted by NRCS when requested by the landowner, but approval is not guaranteed. Examples of compatible uses which may be granted are:

- timber harvest, if approved by IDNR district forester,
- wildlife food plots on 5% of the area restored,
- maintenance of private drainage systems.

Examples that are non-compatible uses include:

- planting and harvesting a crop,
- surface mining,
- water supply or waste treatment,
- commercial seed production,
- development of a road.

## Cost Share

For 30-year easements and restoration agreements, USDA will cost share at a rate of 75% of the average cost of establishing essential practices within the easement area. The other 25% of essential practice restoration costs, the costs of supplemental practices, and the cost of essential practices outside the easement area are the responsibility of the landowner. The landowner can seek other funds for those expenses. Places to check include:

- Local rod and gun clubs
- Ducks Unlimited
- Quail Unlimited
- Pheasants Forever
- Other supporting groups
- County Conservation Boards

## Management and Maintenance

The landowner is responsible for controlling noxious weeds per state law on all areas. For restoration cost-share agreements, the landowner is responsible for long-term management and maintenance of the wetland. For easement areas, the NRCS has responsibility for management. The landowner will be encouraged to be involved in management of the wetland as much as possible.

## Landowner Requirements

Landowners accepted into the WRP are required to:

1) grant NRCS a recordable easement on the eligible land,
2) provide clear title to the easement area,
3) ensure that restoration practices are installed and manage them according to the WRPO,
4) provide NRCS or its representative with access to the easement area from a public road,
5) permanently retire cropland acreage bases as determined by the Farm Service Agency.

## Options in the WRP

| Option | Permanent Easement | 30-Year Easement | Restoration Agreement (No Easement) 1/ |
|---|---|---|---|
| Payment for Easement | 100% Agricultural Value (Maximum of $1000 / Acre) | 75% Agricultural Value (Maximum of $750.00 / Acre) | None |
| Payment Options | 1) Lump Sum<br>2) 5-30 Annual Payments<br>3)No Annual Cap | 1) Lump Sum if <$50,000<br>2) 5-30 Annual Payments<br>3) Annual Cap of $50,000 | None |
| Restoration Payments | 100% Reimbursement of Restoration Cost | 75% Reimbursement of Restoration Cost | 75% Reimbursement of Restoration Cost |
| Maintenance Responsibilities | NRCS 2/ | NRCS 2/ | Landowner |

1/ = Does include 10-year operation and maintenance agreement after the establishment period.
2/ = Landowner is required to control noxious weeds, if necessary.

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USDA 1996 Farm Bill Conservation Provisions

June 1997

Fact Sheet

United States Department of Agriculture

# Wetland Functions and Values

*Notice: This information is based on the Interim Final Rule for Highly Erodible Land and Wetland Conservation published in the Federal Register, September 6, 1996. The information contained herein is subject to change in the Final Rule. The rule can be viewed on the World Wide Web at http://www.nrcs.usda.gov.*

## Introduction

Wetlands are some of the most productive and dynamic habitats in the world. The physical, chemical, and biological interactions within wetlands are often referred to as wetland functions. These functions include surface and subsurface water storage, nutrient cycling, particulate removal, maintenance of plant and animal communities, water filtration or purification, and groundwater recharge. Similarly, the characteristics of wetlands that are beneficial to society are called wetland values. Perhaps these can best be thought of as the importance of a wetland function to an individual or group. Some examples of wetland values include reduced damage from flooding, water quality improvement, and fish and wildlife habitat enhancement.

It is important to maintain and restore wetland functions and values because wetlands contribute to the overall health of the environment.

Some basic wetland functions and their associated values are listed below.

## Surface Water storage

This function helps prevent flooding by temporarily storing water, allowing it to soak into the ground or evaporate. This temporary storage can help reduce peak water flows after a storm by slowing the movement of water into tributary streams which allows potential floodwaters to reach mainstream rivers over a longer period of time. Water quality is also improved by removing nutrients, pesticides, and bacteria from surface waters as they are absorbed or broken down by plants, animals, and chemical processes within the wetland.

## Subsurface Water Storage

Wetlands are reservoirs for rainwater and runoff. As this water is released into the ground, it recharges water tables and aquifers, and extends the period of stream flows in many parts of the United States.

## Nutrient cycling

Wetlands enhance the decomposition of organic matter, incorporating nutrients back into the food chain.

## Retention of particles

By filtering out sediments and particles suspended in runoff water, wetlands help prevent lakes, reservoirs, and other resources from being affected by downstream sediment loading. This improves water quality and extends the life of water bodies by reducing sedimentation rates.

## Maintenance of plant and animal communities

Both coastal and inland wetlands provide breeding, nesting, and feeding habitat for millions of waterfowl, birds, fish, and other wildlife. Wetlands in the United States support about 5,000 plant species, 190 species of amphibians, and a third of all native bird species. Coastal wetlands are an integral part of the life cycle for many marine organisms; they are the nursery and

spawning grounds for 60 to 90 percent of U.S. commercial fish catches. Fresh-water wetland vegetation can provide valuable forage for livestock, particularly during drought years in many of the Plains States. Forested wetlands are also an important source of timber from such valuable trees as white cedar, bald cypress, and tupelo.

## Values to Society

There are a number of other values society receives from wetlands. Some of these values are providing sites for hunting, fishing, trapping, photography, outdoor classrooms or environmental education, and the enjoyment of open spaces. The ecological diversity and high productivity of wetlands make them one of the most scenic features on any landscape.

## For More Information

The Natural Resources Conservation Service, Farm Service Agency, Cooperative Extension Service, or your local conservation district can provide more information. Your USDA Service Center is listed in the telephone book under U.S. Department of Agriculture. Information is also available on NRCS's World Wide Web site: http://www.nrcs.usda.gov.

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UNITED STATES DEPARTMENT OF AGRICULTURE

Natural Resources Conservation Service

People in Partnership for a Healthy Land

USDA 1996 Farm Bill

Conservation Provisions

# Fact Sheet Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources. Nationally, it provides technical, financial, and educational assistance primarily in designated priority areas-half of it targeted to livestock-related natural resource concerns and the remainder to other significant conservation priorities.

**Conservation Tools.**

EQIP is one of several conservation programs making up tools in a "conservation toolbox" of Federal, State, and local programs that farmers and ranchers can use to solve their natural resource concerns. EQIP offers financial, educational, and technical help to install or implement structural, vegetative, and management practices called for in 5- to 10-year contracts for most agricultural land uses. USDA also offers the Conservation Reserve Program (CRP), which puts sensitive croplands under permanent vegetative cover for 10 to 15 years. CRP contract holders receive annual rental payments. Other USDA, federal, State, and local programs provide additional tools for producers to care for our private lands-a shared commitment between public and private interests.

**Priority Areas and Locally Led Conservation.**

EQIP works primarily in priority areas where significant natural resource problems exist. In general, priority areas are defined as watersheds, regions, or areas of special environmental sensitivity or having significant soil, water, or related natural resource concerns. These concerns could include soil erosion, water quality and quantity, wildlife habitat, wetlands, and forest and grazing lands. These priority areas are identified through a locally led conservation process. Conservation districts convene a local work group comprised of the district board members and key staff, Natural Resources Conservation Service (NRCS) staff, Farm Service Agency (FSA) county committees and key staffs, Cooperative State Research, Education, and Extension Service and other Federal, State, and local agencies interested in natural rescurce conservation. The conservation districts bring views of local interests to work groups by gathering community input through the locally led conservation process. They thus help ensure that the work groups develop and implement conservation programs that fully reflect local needs and priorities.

The local work group identifies program priorities by completing a natural resource needs assessment and, based on that assessment, develops proposals for priority areas. Priority area proposals are submitted to the NRCS State Conservationist, who selects those areas within the State based on the recommendations from the State Technical Committee.

EQIP can also address additional significant statewide concerns that may occur outside designated priority areas. In the first year of the program, at least 65 percent of the funds will be used in designated priority areas and up to 35 percent can be used for other significant statewide natural resource concerns. Additional emphasis is given to areas where State or local governments offer financial or technical assistance and where agricultural improvements will help meet water quality and other environmental objectives.

**Conservation Plans.**

All EQIP activities must be carried out according to a conservation plan. Conservation plans are site-specific for each farm or ranch and can be developed by producers with help from NRCS or other service providers. Producers' conservation plans should address the primary natural resource concerns. All plans are subject to NRCS technical standards adapted for local conditions and are approved by the conservation district. Producers are not obligated, but are encouraged, to develop comprehensive or total resource management plans.

**Contracts.**

EQIP offers 5- to 10-year contracts that provide incentive payments and cost sharing for conservation practices called for in the site-specific plan. Contract applications will be accepted throughout the year. NRCS conducts an evaluation of the environmental benefits the producer offers. Offers are then ranked according to previously approved criteria developed with the advice of the local work group. The FSA County Committee approves for funding the highest priority applications. Applications are ranked according to environmental benefits achieved weighted against the costs of applying the practices. Higher rankings are given to plans developed to treat priority resource concerns to a sustainable level. EQIP seeks to maximize environmental benefits per dollar spent.

**Practice Payments.**

Cost sharing may pay up to 75 percent of the costs of certain conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices important to improving and maintaining the health of natural resources in the area. Incentive payments may be made to encourage a producer to perform land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management. These payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the program incentive.

**Eligibility.**

Eligibility is limited to persons who are engaged in livestock or agricultural production. Eligible land includes cropland, rangeland, pasture, forestland, and other farm or ranch lands where the program is delivered. The 1996 Farm Bill prohibits owners of large confined livestock operations from being eligible for cost-share assistance for animal waste storage or treatment facilities. However, technical, educational, and financial assistance may be provided for other conservation practices on these "large" operations. In general, USDA has defined a large confined livestock operation as an operation with more than 1,000 animal units. But, because of differences in operations and environmental circumstances across the

country, the national definition of a large confined livestock operation may be amended in each State by the NRCS State Conservationist, after consultation with the State Technical Committee, and approval of the NRCS Chief.

**EQIP Funding.**

Funding for EQIP comes from the Federal Government's Commodity Credit Corporation, which funds several other USDA conservation programs. EQIP's authorized budget of $1.3 billion is prorated at $200 million per year through the year 2002. Conservation practices for natural resource concerns related to livestock production will receive 50 percent of the funding. Total cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the length of the contract.

NRCS has leadership for EQIP. It works with FSA to set the program's policies, priorities, and guidelines.

EQIP continues the Department's commitment to streamlining and improving its conservation programs. Four of USDA's former conservation programs were combined in EQIP: the Agricultural Conservation Program, Water Quality Incentives Program, Great Plains Conservation Program, and the Colorado River Basin Salinity Control Program.

**For more information**

NRCS, FSA, the local Extension Service, or your local conservation district can provide more information. Local USDA Service Centers are listed in the telephone book under U.S. Department of Agriculture. Information is also available here on NRCS's World Wide Web site.

USDA 1996 Farm Bill

# Conservation Provisions

Fact Sheet

June, 1997

USDA - Natural Resources Conservation Service
Indianapolis, Indiana

## EQIP Participation

Understanding the following points will help you evaluate your potential for participating in USDA's Environmental Quality Incentives Program (EQIP) and the steps you must follow to apply successfully.

### You are in control

* You choose who will develop your plan, and you apply the conservation practices called for in your plan.
* There are other program tools besides EQIP. You will develop a conservation plan, not an EQIP plan.
* This is a voluntary program. Participation is a choice.

### Why should you participate

* EQIP is the primary means by which USDA provides funds for conservation work.
* Resource management planning for your farm will give you a better handle on managing your valuable natural resources.
* If you wish, a single plan can be developed that will apply to some or all Federal or State natural resource programs or laws.

### Who can participate

* Farmers and ranchers.
* Under certain conditions, organizations such as districts with taxing authority, sporting clubs, scout troops, tribal councils, and cooperative grazing associations and districts are eligible.
* The land you own or control must be in an identified priority area or have an identified statewide priority natural resource concern.
* Land in the program must be either cropland, pasture, hayland, forestland, or other lands on which crops or livestock are produced.

### Who cannot participate

* State and local governments, including school districts, and State-supported schools.

### Conservation Planning

* You must have or develop a conservation plan for the farm unit of concern.
* Your plan becomes the basis for a 5- to 10-year contract.
* NRCS can provide planning assistance, or conservation plans can be developed at your own cost by non-NRCS sources, then reviewed by NRCS to determine if all practices meet NRCS standards.

### Application Submission

* EQIP applications will be accepted throughout the year. However, the ranking and selecting of offers of producers will occur periodically during designated periods.
* Planning can be done anytime during the year.
* The evaluation of applications is competitive. Applications will be ranked favorably by providing the most environmental benefits at the least cost.
* Federal cost-share for structural and vegetative practices cannot exceed 75 percent of the installation costs.
* Payment rates and percentages are not fixed. Offering to accept a lower percentage of cost-share or incentive payment will likely improve your application's ranking.
* Incentive payments may be made to encourage producers to use land management practices that might not otherwise be performed without the incentive.
* You are strongly encouraged to develop your conservation plan and submit your application as early as possible. Technical assistance with your plan and application may be limited because of the increased requests for assistance close to sign-up periods.

### Payments

* EQIP offers up to $10,000 per person per year, $50,000 per contract.
* Nationally, half of EQIP's funding is targeted to livestock operations.
* Payments are also available for the construction of practices or as incentives to encourage the adoption of innovative conservation practices. Payments cannot be used for technical assistance in developing plans.

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## UPPER SOUTH BRANCH OF ELKHART RIVER

## CONSERVATION PRIORITY AREA

## PRACTICES AND PAYMENT RATES

### **Cost-Share Rates**

| Practice | FOTG# | Payment Limits |
|---|---|---|
| 1) Critical Area Planting | 342 | $400.00/acre |
| 2) Diversion | 362 | $3.00/LF |
| 3) Grade Stabilization Structure | 410 | Not to Exceed $6,000.00 |
| 4) Grassed Waterway | 412 | $4.00/LF |
| 5) Tree Planting (Conversion of Cropland) | 612 | Not to exceed $300.00/acre |
| 6) Water and Sediment Control Basin | 638 | |
| 7) Composting | 317 | |
| 8) Livestock Water Facility | 614 & 516 | |
| 9) Stream Protection | 580 & 584 | Not to Exceed:<br>$2.50/LF Earthen<br>$25.00/LF Rip-Rap<br>$7.50/LF Combo |
| 10) Woodland Improvement | 666 & 660 | Not to Exceed:<br>50% without mgmt. plan*<br>75% with mgmt. plan |

All cost-share will be 75% except for Woodland Improvement. (See note above)*

### **Innovative Practices**

| | |
|---|---|
| 1) Tile Riser Grassed Buffer | $250.00/each |
| 2) Watercourse Outlet Buffer | $125.00/each |

### **Incentive Payments**

| | | |
|---|---|---|
| 1) Conservation Cropping Sequence | 328 | $25.00/ac./yr. –Row Crop & Small Grain, Not to exceed $2,000.00/yr. Max. 3 years.<br><br>$50.00/ac./yr. –New Hay Utilization in rotation. Must be increase in acreage beyond the past five year average. Not to exceed $2,000.00/yr. Max. 3 years. |
| 2) Managing Crop Residue with a Conservation Tillage System | 344 & 329 | $15.00/ac. When no-tilling<br>$8.00/ac. When reduced till<br>Max. 3 years. |
| 3) Field Border | 386 | $.01/sq. ft. |

| | | |
|---|---|---|
| 4) Pasture Management | 510 | $7.00/ac. (as needed)<br>Max. 3 years. |
| 5) Strip Cropping – Field | 586 | $50.00/ac. Max 3 years. |
| 6) Waste Management Plan<br>(Includes Utilization) | 312,425<br>313, 359<br>633 | $0.01 per gal-Phosphorus Limiting<br>$0.006 per gal- when adequate facilities exist<br>$.003 Additional per gal- injecting or incorporating by the end of day or HEL (Max. 3 Yrs.) |
| 7) Cover and Green Manure Crop | 340 | $10.00/ac. |
| 8) Pasture Planting | 512 | $50.00/ac./yr.<br>(New/Increased Ac.)<br>Max. 3 Years. |
| 9) Livestock Exclusion (Fencing from Woodland and Lakes & Streams) | 412 | $1.50/LF |

Revised 1-02-01 slm

UPPER SOUTH BRANCH OF ELKHART RIVER
CONSERVATION PRIORITY AREA

AREA RANKING CRITERIA WORKSHEET

1) Soil Resources

A) Excessive Water Erosion (16 points max.)

Calculate tons of soil saved from sheet and rill erosion for entire tract by calculating the erosion before and after using the RUSLE Procedure. (Use significant critical soil for each field and IN-CPA-16) Erosion Reduced to "T" on cropland eroding.

>4T = 16 points
3 – 4 T = 12 points
2 – 3 T= 8 points
1 – 2 T= 4 points
<T = 0 points _____

B) Adopting Conservation Practices to address Existing Gully and Ephemeral Gully Erosion (6 points). _____

C) Adopting Conservation Practices to Address Existing Streambank Erosion (5 points). _____

TOTAL POINTS FOR ALL SOIL EROSION (27 pts. Max.) _____

2)Water Resources

A) Agrichemical or Other Pollutant Runoff (8 points max.) 1 point for each 40 acres of nutrient/pest management plans to be completed. _____

B) Animal Waste Disposal (10 points max.) 1 point for each 10 animal unit to be covered by a waste utilization plan (Ref. Ag. Waste Mgmt. Field Handbook Chapter 1, pages 1-3) _____

C) Pathogens in Streams (10 point max.) 7 points for excluding livestock from streams and lakes and 1 point extra for moving them distances up to three times the minimum (FOTG) recommended filter strip widths based on landslope. (Example: 1 X minimum filter strip = 2 points, 2 X minimum filter strip width = 4 points and 3 X = 6 points) _____

TOTAL POINTS FOR ALL WATER RESOURCES (28 Points) _____

Woodland Resources

A) 2 points for each 10 acres of woodland with an improvement or tree planting management plan. (10 points max.) _____

**TOTAL POINTS FOR WOODLAND RESOURCES (10 Pts. Max.)** _____

4) Bonus Points

A) "T" Value for Soil to be Reduced Below Tolerable Soil Loss Limit (12 points max.)
Reduced 25% of "T" value for soil = 4 points
Reduced 50% of "T" value for soil = 8 points
Reduced 75% of "T" value for soil = 12 points _____

B) 1 point for each ¼ acre of Filter Strip, Contour Buffer, Field Border to be established and 2 points for each ¼ acre of Riparian Buffer to be established (10 points max.) _____

C) 1 point for every 2 acres of new hardwood tree planting (50% more hardwoods) to be established with tree management plan.(10 pts.max.) _____

D) 1 point for every 5 acres of Woodland that Livestock is to be excluded. (5 points max.) _____

E) 1 point for the establishment of blind inlets, watercourse outlet buffers or tile riser buffers. (10 point max.) _____

**TOTAL OF BONUS POINTS (47 Pts. Max.)** _____

**GRAND TOTAL OF RANKING POINT (112 Pts. Max.)** _____

*Note: Applicants who have already adequately implemented any of the soil, water, woodland resources and/or bonus point evaluation criteria will receive 50% of that possible score.

Revised: 01-02-01 slm

# APPENDIX C

## INDIANA DEPARTMENT OF NATURAL REXOURCES
## INDIANA NATURAL HERITAGE DATA CENTER
## CORRESPONDENCE

**DNR** Indiana Department of Natural Resources

Frank O'Bannon, Governor
Larry D. Macklin, Director
Division of Nature Preserves
402 W. Washington Street, Rm. W267
Indianapolis, IN 46204-2739

November 21, 2001

Ms. Carolyn Schrader
Gensic Associates, Inc.
311 Airport North Office Park
Fort Wayne, IN 46825

Dear Ms. Schrader:

I am responding to your request for information on the endangered, threatened, or rare (ETR) species, high quality natural communities, and natural areas documented from the Chain O' Lakes Watershed Diagnostic Study area, Noble County, Indiana. The Indiana Natural Heritage Data Center has been checked and enclosed you will find information on the ETR species and significant areas documented from the study area.

For more information on the animal species mentioned, please contact Katie Smith, Nongame Supervisor, Division of Fish and Wildlife, 402 W. Washington Room W273, Indianapolis, Indiana 46204, (317)232-4080.

The information I am providing does not preclude the requirement for further consultation with the U.S. Fish and Wildlife Service as required under Section 7 of the Endangered Species Act of 1973. You should contact the Service at their Bloomington, Indiana office.

U.S. Fish and Wildlife Service
620 South Walker St.
Bloomington, Indiana 47403-2121
(812)334-4261

At some point, you may need to contact the Department of Natural Resources' Environmental Review Coordinator so that other divisions within the department have the opportunity to review your proposal. For more information, please contact:

Larry Macklin, Director
Department of Natural Resources
attn: Stephen H. Jose
Environmental Coordinator
Division of Fish and Wildlife
402 W. Washington Street, Room W273
Indianapolis, IN 46204
(317)232-4080

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Printed on Recycled Paper

Please note that the Indiana Natural Heritage Data Center relies on the observations of many individuals for our data. In most cases, the information is not the result of comprehensive field surveys conducted at particular sites. Therefore, our statement that there are no documented significant natural features at a site should not be interpreted to mean that the site does not support special plants or animals.

Due to the dynamic nature and sensitivity of the data, this information should not be used for any project other than that for which it was originally intended. It may be necessary for you to request updated material from us in order to base your planning decisions on the most current information.

Thank you for contacting the Indiana Natural Heritage Data Center. You may reach me at (317)232-4052 if you have any questions or need additional information.

Sincerely,

Ronald P. Hellmich

Ronald P. Hellmich
Indiana Natural Heritage Data Center

enclosure: data sheet

ENDANGERED, THREATENED AND RARE SPECIES,
HIGH QUALITY NATURAL COMMUNITIES, AND SIGNIFICANT NATURAL AREAS DOCUMENTED
FROM THE CHAIN O' LAKES WATERSHED, NOBLE COUNTY, INDIANA

| YPE | SPECIES NAME | COMMON NAME | STATE | FED | LOCATION | DATE | COMMENT |
|---|---|---|---|---|---|---|---|
| GE | | | | | | | |
| HAIN O'LAKES STATE PARK | | | | | | | |
| nphibian | AMBYSTOMA LATERALE | BLUE-SPOTTED SALAMANDER | SSC | ** | T33NR10E 03 WH SWQ SWQ | 1988 | |
| rd | BUTEO PLATYPTERUS | BROAD-WINGED HAWK | SSC | ** | T33NR10E 10 NWQ | 2000 | |
| rd | CERTHIA AMERICANA | BROWN CREEPER | ** | ** | T33NR10E 10 | 1997 | |
| rd | CERTHIA AMERICANA | BROWN CREEPER | ** | ** | T33NR10E 10 EH SEQ NWQ | 2000 | |
| rd | IXOBRYCHUS EXILIS | LEAST BITTERN | SE | ** | T33NR10E 04 SEQ SEQ SEQ | 1994 | |
| rd | NYCTICORAX NYCTICORAX | BLACK-CROWNED NIGHT-HERON | SE | ** | T33NR10E S OF ALBION | 1984 | |
| rd | TYTO ALBA | BARN OWL | SE | ** | T33NR10E 03 SEQ SWQ | 1986 | |
| ammal | TAXIDEA TAXUS | AMERICAN BADGER | SE | ** | T33NR10E 03 SEQ SWQ | 1985 | |
| ptile | EMYDOIDEA BLANDINGII | BLANDING'S TURTLE | SE | ** | T33NR10E 09 & 10 COMMONLINE | 1986 | |
| ERRIAM | | | | | | | |
| HAIN O'LAKES STATE PARK | | | | | | | |
| rd | AMMODRAMUS HENSLOWII | HENSLOW'S SPARROW | SE | ** | T33NR10E 03-10 | 1997 | |
| rd | BUTEO LINEATUS | RED-SHOULDERED HAWK | SSC | ** | T33NR10E 09 NWQ | 1986 | |
| rd | CERTHIA AMERICANA | BROWN CREEPER | ** | ** | T33NR10E 04 & 09 COMMON LINE | 2000 | |

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

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

# APPENDIX D

## CENSUS POPULATION OF INDIANA TOWNSHIPS

# Census Population of Indiana Townships

## NOBLE COUNTY

Township Population || Percent Change

## Population

| | 1960 | 1970 | 1980 | 1990 | 1996 ** |
|---|---|---|---|---|---|
| Noble County | 28,162 | 31,382 | 35,443 | 37,877 | 41,449 |
| Albion township | 1,488 | 1,597 | 1,732 | 1,951 | 2,086 |
| Allen | 3,659 | 4,035 | 4,798 | 5,132 | 5,877 |
| Elkhart | 1,159 | 1,245 | 1,501 | 1,545 | 1,683 |
| Green | 1,002 | 1,064 | 1,301 | 1,482 | 1,587 |
| Jefferson | 999 | 1,127 | 1,189 | 1,230 | 1,340 |
| Noble | 2,064 | 2,291 | 2,490 | 2,724 | 2,968 |
| Orange | 2,934 | 3,500 | 4,016 | 3,703 | 3,923 |
| Perry | 3,586 | 4,070 | 4,436 | 5,110 | 5,452 |
| Sparta | 1,505 | 1,611 | 1,867 | 2,497 | 2,692 |
| Swan | 1,409 | 1,529 | 1,861 | 1,877 | 2,045 |
| Washington | 550 | 718 | 979 | 979 | 1,067 |
| Wayne | 7,007 | 7,810 | 8,274 | 8,636 | 9,627 |
| York | 800 | 785 | 999 | 1,011 | 1,102 |

**Townships may not sum to County total due to revisions that apply only to County

## Percent Change

| | 1960-70 | 1970-80 | 1980-90 | 1960-90 | 1970-90 | 1990-96 |
|---|---|---|---|---|---|---|
| Noble County | 11.43 | 12.94 | 6.87 | 34.50 | 20.70 | 9.43 |
| Albion township | 7.33 | 8.45 | 12.64 | 31.12 | 22.17 | 6.92 |
| Allen | 10.28 | 18.91 | 6.96 | 40.26 | 27.19 | 14.52 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Elkhart** | **7.42** | **20.56** | **2.93** | **33.30** | **24.10** | **8.93** |
| **Green** | **6.19** | **22.27** | **13.91** | **47.90** | **39.29** | **7.09** |
| **Jefferson** | **12.81** | **5.50** | **3.45** | **23.12** | **9.14** | **8.94** |
| **Noble** | **11.00** | **8.69** | **9.40** | **31.98** | **18.90** | **8.96** |
| **Orange** | **19.29** | **14.74** | **-7.79** | **26.21** | **5.80** | **5.94** |
| **Perry** | **13.50** | **8.99** | **15.19** | **42.50** | **25.55** | **6.69** |
| **Sparta** | **7.04** | **15.89** | **33.74** | **65.91** | **55.00** | **7.81** |
| **Swan** | **8.52** | **21.71** | **0.86** | **33.22** | **22.76** | **8.95** |
| **Washington** | **30.55** | **36.35** | **0.00** | **78.00** | **36.35** | **8.99** |
| **Wayne** | **11.46** | **5.94** | **4.38** | **23.25** | **10.58** | **11.48** |
| **York** | **-1.88** | **27.26** | **1.20** | **26.38** | **28.79** | **9.00** |

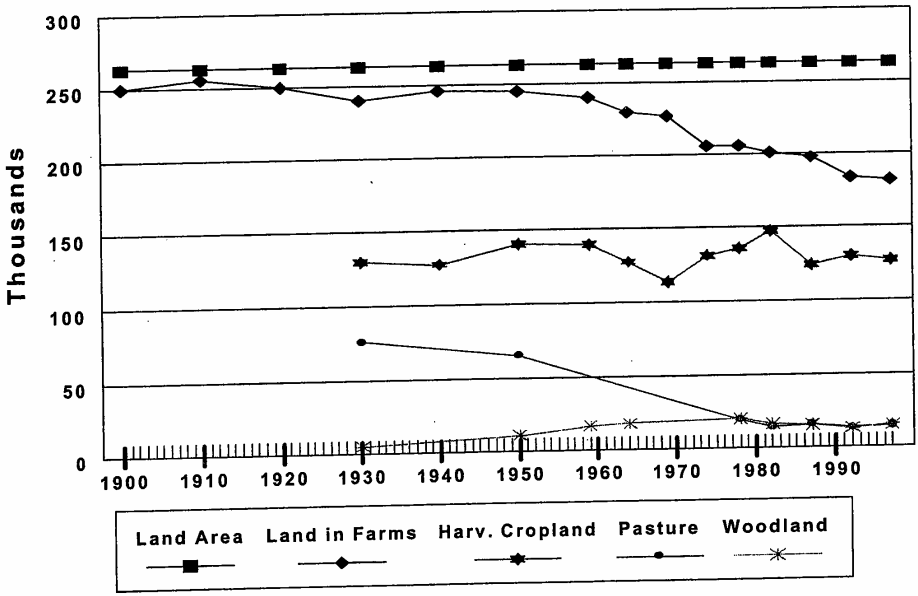
**County Pick List**

**IBRC**

# INDIANA FARM LAND USE HISTORY
## Noble County, Indiana

**Total Land Area 1997 - 263,125 Acres**

| Year | Land in Farms | Harvested Cropland | Land Pastured | Woodland Not Pastured |
|---|---|---|---|---|
| | ------- Acres ------- | | | |
| 1900 | 249,812 | n/a | n/a | n/a |
| 1910 | 255,759 | n/a | n/a | n/a |
| 1920 | 250,169 | n/a | n/a | n/a |
| 1930 | 240,326 | 129,984 | 76,240 | 4,992 |
| 1940 | 246,266 | 127,776 | n/a | n/a |
| 1950 | 245,028 | 140,776 | 65,340 | 10,593 |
| 1959 | 240,511 | 139,661 | n/a | 16,364 |
| 1964 | 230,042 | 127,758 | n/a | 17,599 |
| 1969 | 227,008 | 113,519 | n/a | n/a |
| 1974 | 206,197 | 131,561 | n/a | n/a |
| 1978 | 205,765 | 136,102 | 19,350 | 19,726 |
| 1982 | 201,388 | 147,270 | 14,158 | 15,995 |
| 1987 | 197,875 | 124,520 | 15,299 | 14,931 |
| 1992 | 184,118 | 130,174 | 12,955 | 12,604 |
| 1997 | 181,963 | 126,941 | 14,197 | 14,803 |




Source: U.S. Census of Agriculture
Assembled February 1999

Indiana Agricultural Statistics Service
http://www.nass.usda.gov/in/

# 1997 Census of Agriculture County Profile

United States Department of Agriculture
Indiana Agricultural Statistics Service

AG CENSUS USA

## NOBLE
## INDIANA

---

**Land in farms**

Decreased 1 percent from 184,118 acres in 1992 to 181,963 acres in 1997.

**Average size of farms**

Increased 4 percent from 185 acres in 1992 to 193 acres in 1997.

**Full time farms**

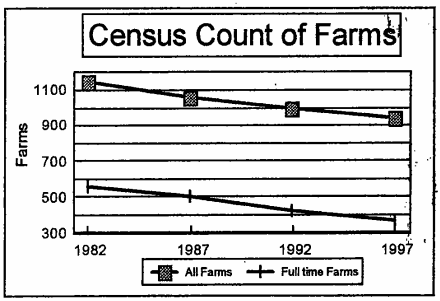
Decreased 14 percent from 423 farms in 1992 to 365 farms in 1997.

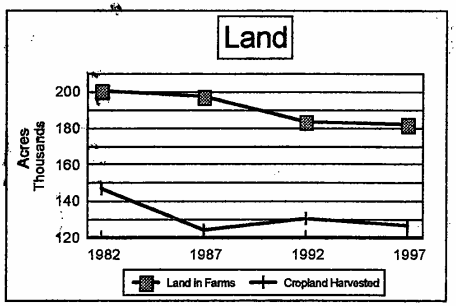
**Market value of agricultural products sold**

Increased 19 percent to $58,841,000 in 1997.
Crop sales accounted for 52 percent of the market value.
Livestock sales accounted for 48 percent of the market value.

**Market value of agricultural products sold, average per farm**

Increased 26 percent from $49,650 in 1992 to $62,464 in 1997.



# APPENDIX E

## SOILS SURVEY OF NOBLE COUNTY

SOIL SURVEY OF

# Noble County, Indiana

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Purdue University Agricultural Experiment Station

**This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.**

**Major fieldwork for this soil survey was completed in the period 1968–73. Soil names and descriptions were approved in 1974. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1974. This survey was made cooperatively by the Soil Conservation Service and the Purdue University Agricultural Experiment Station. It is part of the technical assistance furnished to the Noble County Soil and Water Conservation District. Partial funding of this soil survey was provided by Noble County Soil and Water Conservation District and approved by the County Commissioners and County Council.**

**Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.**

# HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

## Locating Soils

All the soils of Noble County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

## Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetical order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the woodland group and tree and shrub group to which the soil has been assigned.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and those who work with farmers* can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and woodland groups.

*Foresters and others* can refer to the section "Woodland," where the soils of the county are grouped according to their suitability for trees.

*Game managers, sportsmen, and others* can find information about soils and wildlife in the section "Wildlife."

*Community planners and others* can read about soil properties that affect the choice of sites for dwellings, commercial buildings, and for waste disposal facilities in the section "Town and Country Planning."

*Engineers and builders* can find, under "Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

*Scientists and others* can read about how the soils formed and how they are classified in the section "Formation and Classification of Soils."

*Newcomers in Noble County* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental Factors Affecting Soil Use."

**Cover: Diversion terrace helps control erosion on Morley silty clay loam on the knoll and ponding on Houghton muck in the depression.**

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Issued December, 1977

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# SOIL SURVEY OF NOBLE COUNTY, INDIANA

BY PAUL McCARTER, JR., SOIL CONSERVATION SERVICE

FIELDWORK BY PAUL McCARTER, JR. AND JOHN H. HILLIS
ASSISTED BY FRANK KIRSCHNER, REX BROCK, AND DENVER FARMER
SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE,
IN COOPERATION WITH THE PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

NOBLE COUNTY is in the northeastern part of Indiana (fig. 1). The county is nearly rectangular in shape and covers an area of about 410 square miles or 262,400 acres. Albion, the county seat, is in the central part of the county.

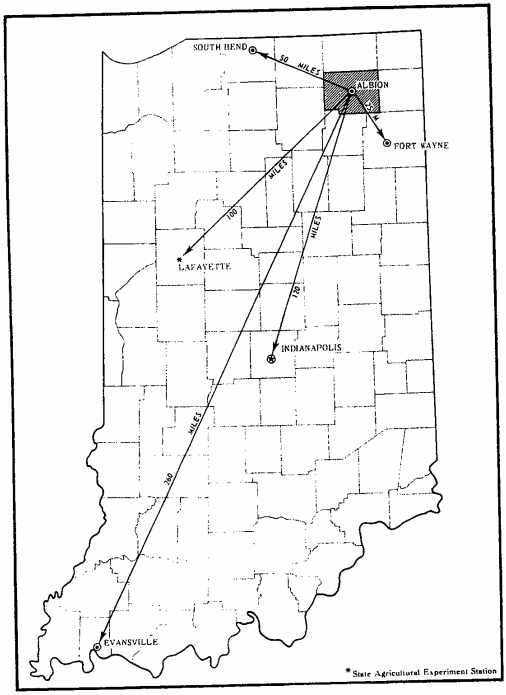


*Figure 1.*—Location of Noble County in Indiana.

The population of Noble County was 31,382 in 1970. Most of the people make their living from farming or work at factories in local towns or in nearby Fort Wayne. In 1969, according to the U.S. Census of Agriculture, about 227,008 acres was farmed. Of this acreage, about 33 percent was used for cultivated crops, 45 percent for other crops, 10 percent for pasture, and 12 percent for woodland. Corn, soybeans, and wheat are the main crops. Cash-grain and general farming are the main enterprises. Many areas, particularly near Kendallville, Ligonier, and Albion and around lakes, have been developed for housing and industry during the past few years. This trend is expected to continue.

The soils of Noble County formed mainly in glacial till, outwash, alluvium, and organic material. Soils that formed in till are well drained to very poorly drained and are mainly medium textured or moderately fine textured. Soils that formed in outwash are mainly medium textured or moderately coarse textured and are very poorly drained to excessively drained. Alluvial soils on flood plains are medium textured and somewhat poorly drained. Organic soils, which are mainly muck and peat, are very poorly drained.

Erosion is the main concern on the sloping soils on uplands and terraces. Drainage is needed in farmed areas of the nearly level, somewhat poorly drained, poorly drained, or very poorly drained soils that formed in outwash, till, or organic material. Irrigation is needed on the somewhat excessively drained or excessively drained soils that formed in outwash.

## *How This Survey Was Made*

Soil scientists made this survey to learn what kinds of soil are in Noble County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and nature of streams; the kinds of native plants or crops; the kinds of rock, if any; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent material that has not been

changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Miami and Fox, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Miami loam, 2 to 6 percent slopes, eroded, is one of several phases within the Miami series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent because it is not practical to show on such a map all the small scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series or of different phases within one series. Two such kinds of mapping units—soil complexes and undifferentiated groups—are shown on the soil map of Noble County.

A soil complex consists of areas of two or more soils so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Fox-Casco sandy loams, 12 to 18 percent slopes, eroded, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Rawson, Morley, and Miami loams, 2 to 6 percent slopes, eroded, is an example of an undifferentiated group in Noble County.

In most areas surveyed, there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Lake borders is a land type in this survey.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing medium for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this failure to slow permeability or a high water table. They see that streets, road pavements, and foundations for houses are cracked on a given kind of soil, and they relate this failure to a high shrink-swell potential. Thus, they use observation and knowledge of soil properties, together with available research data, to predict the limitations or suitability of a soil for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their study and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

## *General Soil Map*

The general soil map at the back of this survey shows, in color, the soil associations in Noble County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful, general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreational facilities, and community

developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or other structure because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The eight soil associations in this survey have been grouped into general kinds of landscapes for broad, interpretative purposes. Each of the broad groups and the soil associations are described on the following pages.

Soil associations and delineations on the general soil map in this soil survey do not fully agree with those on the general soil maps for adjacent counties published at a different date. Differences on the maps are a result of improvements in the classification of soils, particularly in the modifications or refinements in soil series concepts. They can also be the result of the range in slope that is permitted within associations in different surveys. In addition, more precise and detailed maps are needed because the use of the general soil maps has expanded in recent years.

## Moderately Deep or Deep, Well Drained to Very Poorly Drained, Nearly Level to Moderately Steep Mineral Soils That Have a Moderately Coarse Textured to Fine Textured Subsoil; on Uplands or Outwash Plains

The associations in this group are dominated by soils that are well drained to very poorly drained and nearly level to moderately steep. They make up about 85 percent of the county. They are used chiefly for corn, soybeans, and wheat and for grasses and legumes for hay and pasture. Strongly sloping and moderately steep areas are used mainly for pasture or woodland. The limitation for septic tank absorption fields is slight to severe.

### 1. *Warsaw-Parr association*

*Well drained, nearly level soils that have a dominantly moderately fine textured subsoil and are moderately deep and deep over sand and gravel; on outwash plains and uplands*

This association is gently undulating on plains where there are many well drained, shallow potholes and closed, slightly depressional areas. The soils formed under prairie grasses and scattered hardwood trees. The association makes up about 1 percent of the county. It is about 60 percent Warsaw soils, 30 percent Parr soils, and 10 percent soils of minor extent.

Warsaw soils are moderately deep over loose and gravelly sand. They are on outwash plains. The surface layer is about 14 inches of very dark brown loam. The subsoil is about 21 inches thick. In sequence from the top, it is 3 inches of friable, dark brown loam; 12 inches of firm, brown sandy clay loam; 4 inches of firm, brown sandy clay loam; 4 inches of friable, brown loam; and 2 inches of firm, very dark brown gravelly sandy clay loam. The substratum to a depth of about 60 inches is brown, stratified sand and gravelly sand.

Parr soils are deep. They are on flats and in closed, slightly depressional areas in the upland. Depressional areas are narrow and elongated in shape. The surface layer is 12 inches of very dark grayish brown loam. The subsoil is about 30 inches thick. In sequence from the top, it is 5 inches of firm, dark yellowish brown light clay loam; 12 inches of firm, dark yellowish brown clay loam; 7 inches of firm, yellowish brown clay loam; and 6 inches of friable, brown heavy loam. The upper part of the substratum is about 54 inches of pale brown loam and the lower part is about 14 inches of yellowish brown, stratified sand and gravelly sand.

Less extensive in this association are Miami and Fox soils. The well drained Miami soils are flats, knolls, and breaks along depressions and drainageways in the upland. The well drained Fox soils are on flats, on knolls, along depressions, and along drainageways in the upland.

This association is used mostly for crops. Corn, soybeans, and wheat are the main crops. The available water capacity is moderate or high. The surface layer is high in content of organic matter.

Droughtiness is a limitation for crops on Warsaw soils. Parr soils have no limitations for crops. The limitation for septic tank absorption fields is slight on Warsaw soils and moderate on Parr soils. Warsaw soils are a source of sand and gravel.

### 2. *Miami-Riddles-Brookston association*

*Well drained and very poorly drained, nearly level to moderately steep, deep soils that have a moderately fine textured subsoil; on uplands*

This association is nearly level to moderately steep on knolls and along drainageways and nearly level in depressions and in drainageways. It makes up about 28 percent of the county. It is about 40 percent Miami soils, 25 percent Riddles soils, 10 percent Brookston soils, and 25 percent soils of minor extent (fig. 2).

Miami soils are well drained and are gently sloping to moderately steep. They are on knolls, ridges, and breaks along depressions and drainageways in the upland. The surface layer is 8 inches of dark grayish brown loam. The subsurface layer is 3 inches of dark grayish brown loam. The subsoil is about 27 inches thick. In sequence from the top, it is 3 inches of friable, brown light clay loam; 12 inches of firm, dark yellowish brown clay loam; 9 inches of firm, yellowish brown clay loam; and 3 inches of friable, brown light clay loam. The substratum to a depth of about 60 inches is pale brown loam.

Riddles soils are well drained and are nearly level to strongly sloping. They are on knolls and breaks along drainageways and depressions in the upland. The surface layer is 9 inches of dark grayish brown sandy loam. The subsurface layer is 5 inches of brown heavy sandy loam. The subsoil is about 38 inches thick. The upper 33 inches is firm, dark yellowish brown clay loam, and the lower 5 inches is firm, dark yellowish brown sandy clay loam. The substratum to a depth of about 72 inches is yellowish brown loam.

Brookston soils are very poorly drained and are nearly level. They are on flats and in drainageways and shallow depressions in the upland. The surface layer is 13 inches of very dark gray silt loam. The subsoil

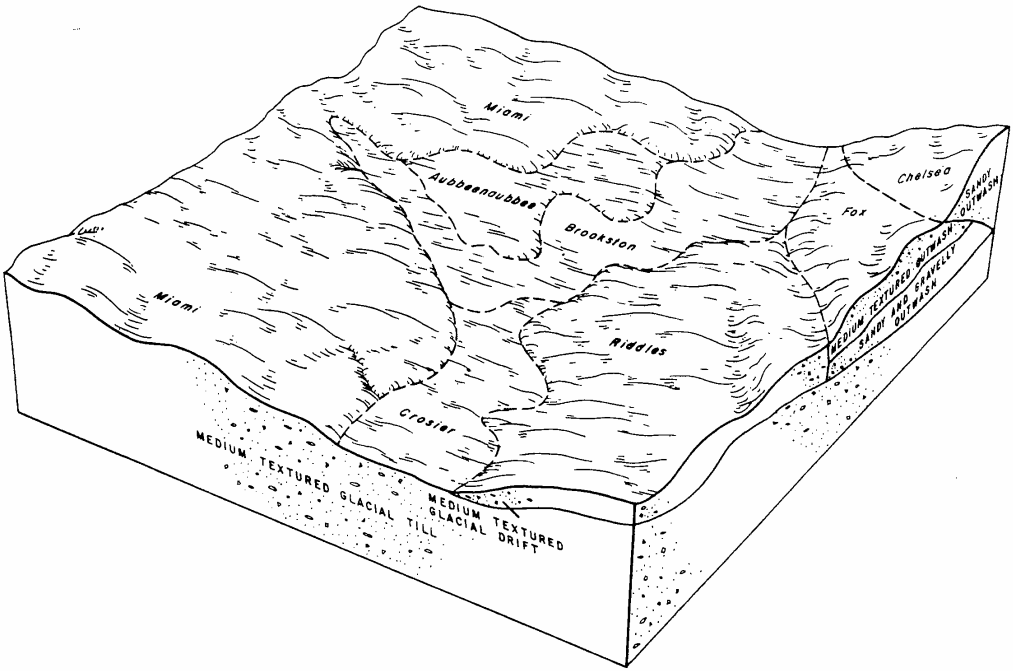


***Figure 2.*—Typical pattern of soils in the Miami-Riddles-Brookston association.**

is about 31 inches thick. In sequence from the top, it is 7 inches of firm, dark gray clay loam mottled with olive; 8 inches of firm, gray clay loam mottled with olive and light olive gray; 10 inches of firm, gray clay loam mottled with yellowish brown and olive; and 6 inches of firm, gray clay loam mottled with yellowish brown and olive. The substratum to a depth of about 60 inches is gray loam mottled with olive.

Less extensive in this association are Aubbeenaubbee, Crosier, Fox, Chelsea, and Metea soils. The somewhat poorly drained Aubbeenaubbee and Crosier soils are on flats and in drainageways in the upland. The well drained Fox soils are on knolls in the upland and along depressions or drainageways and around potholes on outwash plains. The excessively drained Chelsea soils and well drained Metea soils are on knolls in the upland.

This association is used mostly for crops and pasture. Corn, soybeans, wheat, and grasses and legumes for hay and pasture are the main crops. Most of the strongly sloping and moderately steep soils are used for pasture and woodland. The available water capacity is high. The surface layer is low in content of organic matter in Miami and Riddles soils and high in Brookston soils. Maintaining tilth and organic matter are management needs.

Erosion is a hazard on the sloping and steep Miami and Riddles soils. Wetness is a limitation on Brookston soils. The limitation for septic tank absorption fields is moderate or severe on Miami and Riddles, depending on slope, and severe on Brookston soils.

### 3. *Fox-Oshtemo association*

*Well drained, nearly level to moderately steep soils that have a moderately coarse textured to moderately fine textured subsoil and are moderately deep and deep over sand and gravel; on outwash plains and uplands*

This association is nearly level or gently sloping on outwash plains, gently sloping to moderately steep on breaks along drainageways or depressions and around potholes, and gently sloping to moderately steep on knolls (fig. 3). It makes up about 15 percent of the county. It is about 60 percent Fox soils, 15 percent Oshtemo soils, and 25 percent soils of minor extent.

Fox soils are moderately deep over sand and gravelly sand and are nearly level to moderately steep. They are on outwash plains and knolls in the upland. The surface layer is about 9 inches of dark brown sandy loam. The subsoil is moderately fine textured and extends to a depth of about 35 inches. In sequence from the top, it is 5 inches of friable, dark yellowish brown heavy sandy loam; 13 inches of firm, dark brown clay

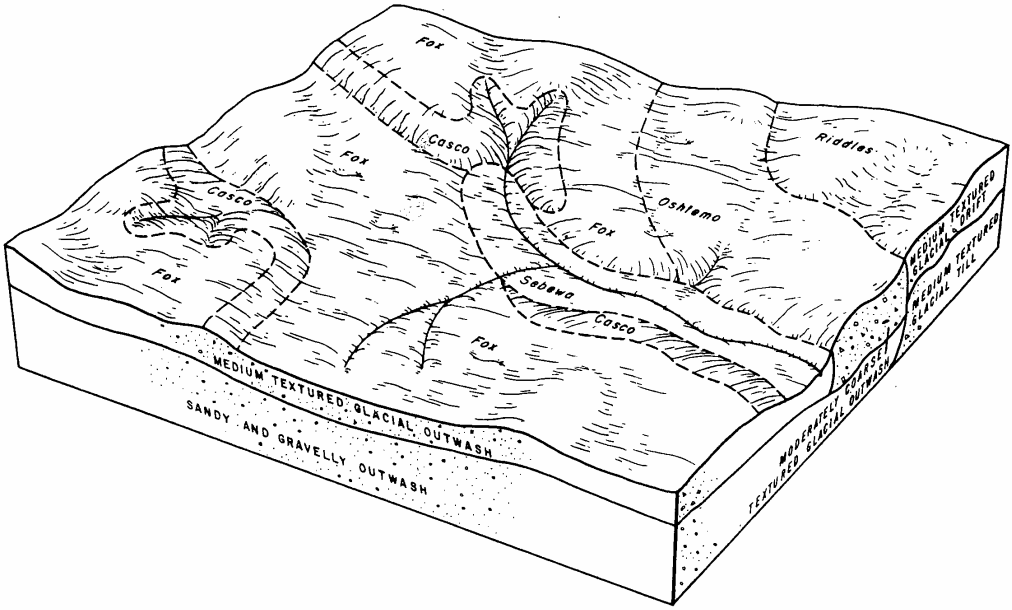


***Figure 3.*—Typical pattern of soils in the Fox-Oshtemo association.**

loam; 6 inches of firm, dark brown sandy clay loam; and 2 inches of friable, dark yellowish brown light sandy clay loam. The substratum to a depth of about 60 inches is brown stratified sand and gravelly sand.

Oshtemo soils are deep and are nearly level to moderately sloping. They are on outwash plains and knolls in the upland. The surface layer is 10 inches of dark brown loamy sand. The subsurface layer is 8 inches of brown loamy sand. The subsoil is moderately coarse textured and is about 35 inches thick. In sequence from the top, it is 5 inches of very friable dark brown sandy loam; 3 inches of friable, dark brown light sandy clay loam; and 27 inches of very friable, yellowish brown loamy sand that has 8 inches of dark brown sandy loam in strata ½ inch to 1½ inches thick. The substratum to a depth of about 60 inches is brown stratified sand and gravelly sand.

Less extensive in this association are Boyer, Casco, Homer, Riddles, and Sebewa soils. The well drained to somewhat excessively drained Casco soils and well drained Boyer soils are on knolls in the upland, in breaks along drainageways or depressions, and around potholes on outwash plains. The well drained Riddles soils are on knolls in the upland. The somewhat poorly drained Homer soils are on flats on outwash plains, and the very poorly drained Sebewa soils are in depressions or drainageways on outwash plains.

This association is used mostly for crops and pasture. Corn, soybeans, wheat, and grasses and legumes for hay and pasture are the main crops. Most of the strongly sloping and moderately steep areas are used for pasture or woodland. The available water capacity is moderate. The surface layer is moderate or low in content of organic matter. Maintaining organic matter is a management need.

Droughtiness is a limitation. Erosion is a hazard in sloping areas. The limitation for septic tank absorption fields is slight. These soils are a source of sand and gravel.

### 4. *Morley-Blount association*

*Well drained to somewhat poorly drained, nearly level to moderately sloping, deep soils that have a fine textured and moderately fine textured subsoil; on uplands*

This association is gently sloping to moderately sloping on knolls and along drainageways. The nearly level areas are on flats and in drainageways in the upland. The association makes up about 35 percent of the county. It is about 48 percent Morley soils, 12 percent Blount soils, and 40 percent soils of minor extent (fig. 4).

Morley soils are moderately well drained or well drained and are gently sloping to moderately sloping. They are on knolls and in areas along drainageways. The surface layer and subsurface layer are 9 inches of dark grayish brown silt loam. The subsoil is about 30

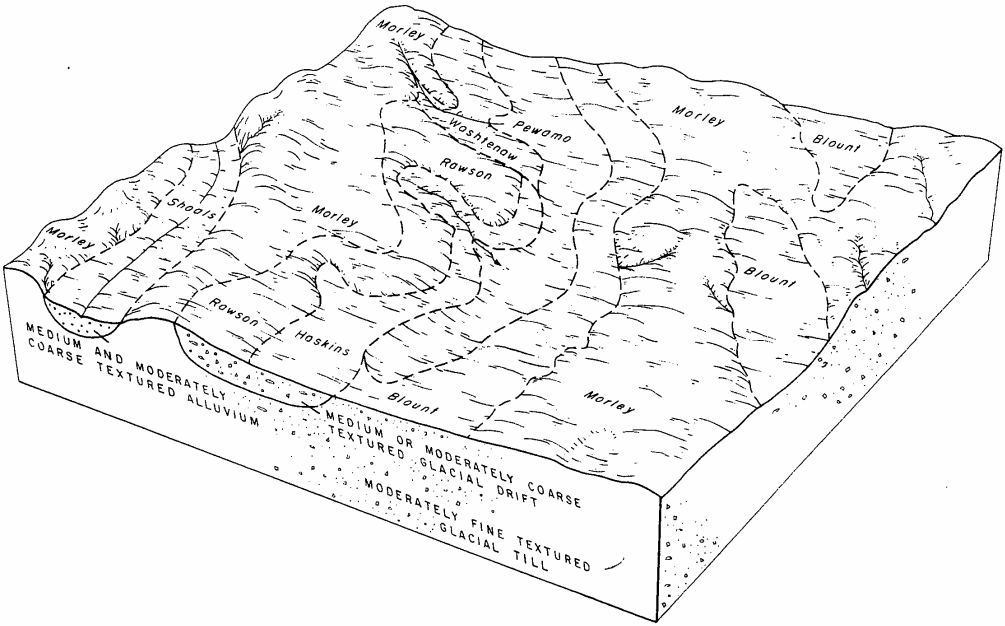


***Figure 4.*—Typical pattern of soils in the Morley-Blount association.**

inches thick. In sequence from the top, it is 3 inches of firm, yellowish brown heavy clay loam; 18 inches of very firm, brown clay mottled with yellowish brown; and 9 inches of firm, brown clay loam mottled with yellowish brown. The substratum to a depth of about 60 inches is brown clay loam mottled with yellowish brown and light brownish gray.

Blount soils are somewhat poorly drained. They are nearly level on flats and in drainageways and are gently sloping on low rises. The surface layer is 7 inches of dark grayish brown silt loam. The subsurface layer is about 2 inches of grayish brown silt loam. The subsoil is about 21 inches thick. In sequence from the top, it is 6 inches of firm, yellowish brown heavy clay loam mottled with grayish brown; 10 inches of very firm, light olive brown silty clay mottled with grayish brown and yellowish brown; and 5 inches of firm, light olive brown clay loam mottled with grayish brown and yellowish brown. The substratum to a depth of about 60 inches is light olive brown clay loam mottled with light olive gray.

Less extensive in this association are Pewamo, Washtenaw, Rawson, Milford, Haskins, and Shoals soils. The very poorly drained Pewamo and Washtenaw soils and poorly drained Milford soils are in depressions and drainageways in the upland. The well drained or moderately well drained Rawson soils are nearly level on flats or gently sloping and moderately sloping on knolls. The somewhat poorly drained Haskins soils are on flats or in drainageways. The somewhat poorly drained Shoals soils are on bottom land along streams.

This association is used mostly for crops. Corn, soybeans, and wheat and grasses and legumes for hay and pasture are the main crops. The available water capacity is high. The surface layer is moderate or low in content of organic matter. Maintaining tilth and organic matter are management needs.

Erosion is a hazard on Morley soils. Wetness is a limitation on Blount soils, and erosion is a hazard in sloping areas. The limitation for septic tank absorption fields is severe.

### 5. *Morley-Miami association*

*Well drained or moderately well drained, moderately sloping to moderately steep, deep soils that have a moderately fine textured or fine textured subsoil; on uplands*

This association is moderately sloping to moderately steep on knolls and breaks along drainageways. It makes up about 6 percent of the county. It is about 55 percent Morley soils, 15 percent Miami soils, and 30 percent soils of minor extent (fig. 5).

Morley soils are moderately well drained or well drained. They are on knolls and along drainageways. The surface layer and subsurface layer are 9 inches of dark grayish brown silt loam. The subsoil is about 30

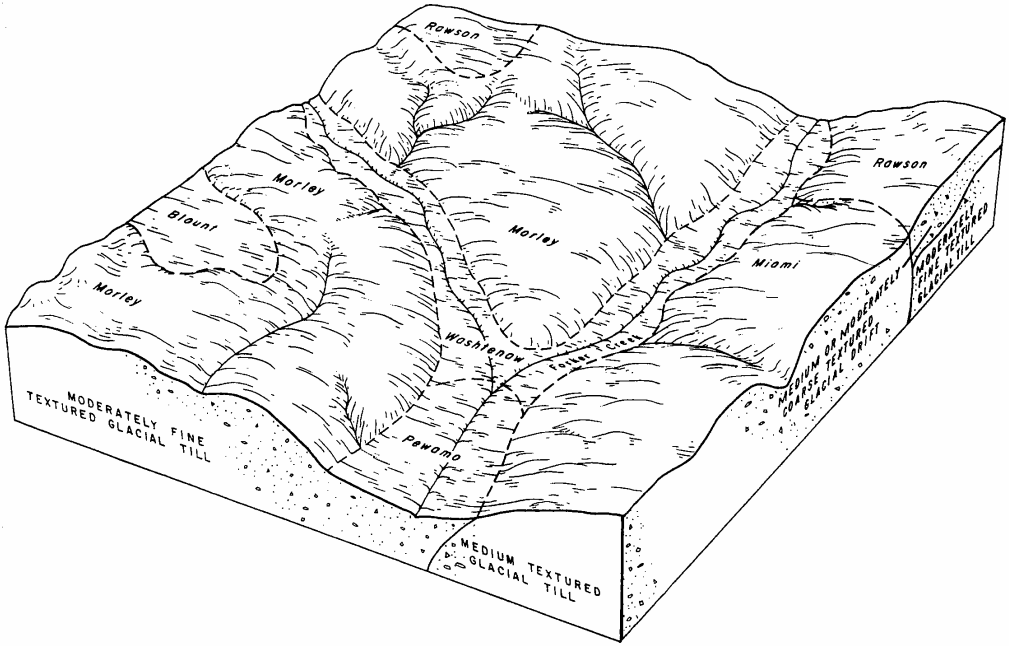


***Figure 5.*—Typical pattern of soils in the Morley-Miami association.**

inches thick. In sequence from the top, it is 3 inches of firm, yellowish brown heavy clay loam; 18 inches of very firm, brown clay mottled with yellowish brown; and 9 inches of firm, brown clay loam mottled with yellowish brown. The substratum to a depth of about 60 inches is brown clay loam mottled with yellowish brown and light brownish gray.

Miami soils are well drained. They are on knolls, breaks, and ridges in the upland. The surface layer is 8 inches of dark grayish brown loam. The subsurface layer is 3 inches of dark grayish brown loam. The subsoil is about 27 inches thick. In sequence from the top, it is 3 inches of friable, brown light clay loam; 12 inches of firm, dark yellowish brown clay loam; 9 inches of firm, yellowish brown clay loam; and 3 inches of friable, brown light clay loam. The substratum to a depth of about 60 inches is pale brown loam.

Less extensive in this association are Washtenaw, Pewamo, Shoals, Rawson, and Blount soils. The very poorly drained Washtenaw and Pewamo soils occupy depressions and drainageways. The somewhat poorly drained Blount soils are on flats, on low rises, and drainageways. The somewhat poorly drained Shoals soils are on bottom land along streams. The well drained and moderately well drained Rawson soils are on knolls and side slopes in the upland.

This association is used mostly for hay, pasture, and woodland. Some moderately sloping areas and a few strongly sloping areas are used for crops. Grasses and legumes for hay and pasture, corn, and wheat are the main crops. The available water capacity is high. The surface layer is moderate or low in content of organic matter. Maintaining tilth and organic matter are management needs.

Erosion is a serious hazard. The limitation for septic tank absorption fields is severe.

## Moderately Deep or Deep, Somewhat Poorly Drained to Very Poorly Drained, Nearly Level Mineral and Organic Soils That Have a Moderately Fine Textured or Fine Textured Subsoil or Organic Material; on Uplands or Outwash Plains

The associations in this group are dominated by soils that are somewhat poorly drained to very poorly drained and are nearly level. They make up about 15 percent of the county. They are used chiefly for corn and soybeans where drainage systems have been installed. Some wheat and grasses and legumes for forage are also grown. Undrained areas are used mainly for pasture, woodland, or wetland wildlife habitat.

### *6. Haskins-Toledo association*

*Somewhat poorly drained and very poorly drained, nearly level, deep soils that have a moderately fine tex-*

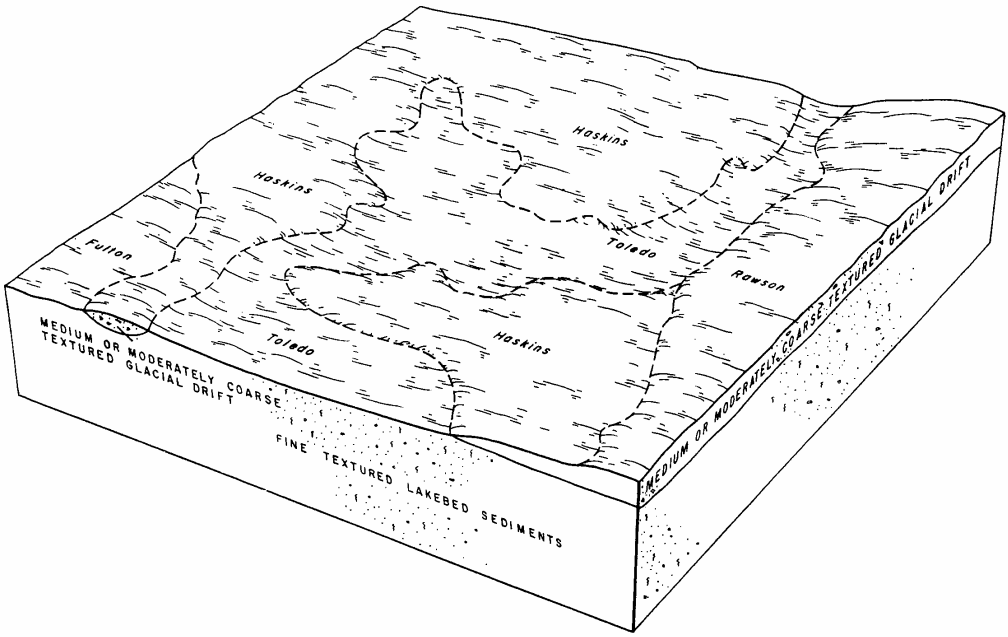


***Figure 6.*—Typical pattern of soils in the Haskins-Toledo association.**

*tured or fine textured subsoil; on outwash plains and uplands*

This association is nearly level on flats and in depressions or drainageways. It makes up about 2 percent of the county. It is about 50 percent Haskins soils, 25 percent Toledo soils, and 25 percent soils of minor extent (fig. 6).

Haskins soils are somewhat poorly drained. They are on flats and in drainageways in the upland and on outwash plains. The surface layer is 8 inches of dark grayish brown loam. The subsurface layer is 3 inches of grayish brown loam mottled with yellowish brown. The subsoil is about 30 inches thick. In sequence from the top, it is 13 inches of firm, grayish brown light clay loam mottled with yellowish brown; 13 inches of very firm, brown light silty clay loam mottled with yellowish brown; and 4 inches of very firm, light brownish gray silty clay mottled with yellowish brown. The substratum to a depth of about 60 inches is grayish brown silty clay mottled with yellowish brown.

Toledo soils are nearly level and very poorly drained. They are in depressional areas in the upland and on outwash plains. The surface layer is 8 inches of very dark gray silty clay loam. The subsoil is about 29 inches thick. In sequence from the top, it is 7 inches of very friable, dark gray silty clay mottled with olive brown; 19 inches of very firm, gray silty clay mottled with olive brown and strong brown; 5 inches of very firm, dark gray silty clay mottled with olive brown and yellowish brown; and 5 inches of very firm, gray silty clay mottled with olive brown and yellowish brown. The substratum to a depth of about 60 inches is gray silty clay mottled with olive brown and yellowish brown.

Less extensive in this association are Fulton, Rawson, and Milford soils. The somewhat poorly drained Fulton soils are on flats in the upland and on outwash plains. The well drained or moderately well drained Rawson soils occupy knolls in the upland and outwash plains. The poorly drained Milford soils are in depressions and drainageways in the uplands and outwash plains.

This association is used mostly for crops. Corn, soybeans, and wheat and grasses and legumes for hay and pasture are the main crops. The available water capacity is high. The surface layer is moderate or high in content of organic matter. Maintaining tilth and organic matter are management needs.

Wetness is a limitation. The limitation for septic tank absorption fields is severe.

### 7. *Houghton-Edwards-Adrian association*

*Very poorly drained, nearly level mucks that are deep or moderately deep over marl or sand and gravel; in depressions on uplands or outwash plains*

This association is in depressional areas where partly decomposed plant remains have accumulated over a

long period. Undrained depressions contain water most of the time. The association makes up about 10 percent of the county. It is about 60 percent Houghton soils, 12 percent Edwards soils, 7 percent Adrian soils, and 21 percent soils of minor extent (fig. 7).

Houghton soils are deep. They formed in deposits of organic material in depressions. The surface layer is 10 inches of very friable, black muck. The next layer is 8 inches of very friable, black muck and a few very dark brown herbaceous fibers. Below this to a depth of about 60 inches is very friable, black muck having a few brown and pale brown herbaceous fibers.

Edwards soils are deep and moderately deep. They formed in deposits of organic material over marl in depressions. The surface layer is 22 inches of very friable, black muck. The next layer is 7 inches of very friable, black muck and many yellowish brown and dark reddish brown herbaceous fibers. The substratum to a depth of about 60 inches is light gray marl and many shell fragments.

Adrian soils are deep or moderately deep. They formed in deposits of organic material over loose sand and gravel in depressions. The surface layer is 12 inches of black muck. The next layer is 22 inches of very friable, black muck and common, dark brown herbaceous fibers. The substratum to a depth of about 60 inches is dark gray sand and gravelly sand.

Less extensive in this association are Palms, Wallkill, Gilford, and Sebewa soils. Also included are lakes, several areas of Marsh, and Marl beds that are in depressional areas in the upland or on outwash plains. The very poorly drained Palms and Wallkill soils are in depressional areas in the upland and on outwash plains. The very poorly drained Gilford and Sebewa soils occupy depressional areas and drainageways in outwash plains.

Drained areas of this association are used mostly for crops. Corn and soybeans are the main crops. Such special crops as mint, sweet corn, potatoes, and onions are well suited if the soils are drained. Most undrained areas are idle and have a plant cover of water-tolerant trees, shrubs, sedges, and grasses. The available water capacity is moderate to very high. The content of organic matter is very high.

Soil blowing is a hazard. Wetness is a severe limitation, and drainage is necessary if crops are grown. The limitation for septic tank absorption fields is severe. Houghton soils are a potential source of peat moss, and Edwards soils are a source of marl.

### 8. *Homer-Sebewa association*

*Somewhat poorly drained and very poorly drained, nearly level soils that have a moderately fine textured subsoil and are moderately deep over sand and gravel; on outwash plains*

This association is on broad outwash plains where the seasonal high water table is at or near the surface or is ponded. It makes up about 3 percent of the county. It is about 40 percent Homer soils, 30 percent Sebewa soils, and 30 percent soils of minor extent (fig. 8).

Homer soils are somewhat poorly drained and are moderately deep to loose sand and gravelly sand. They are on flats between depressions on outwash plains. The surface layer is about 8 inches of dark brown loam. The

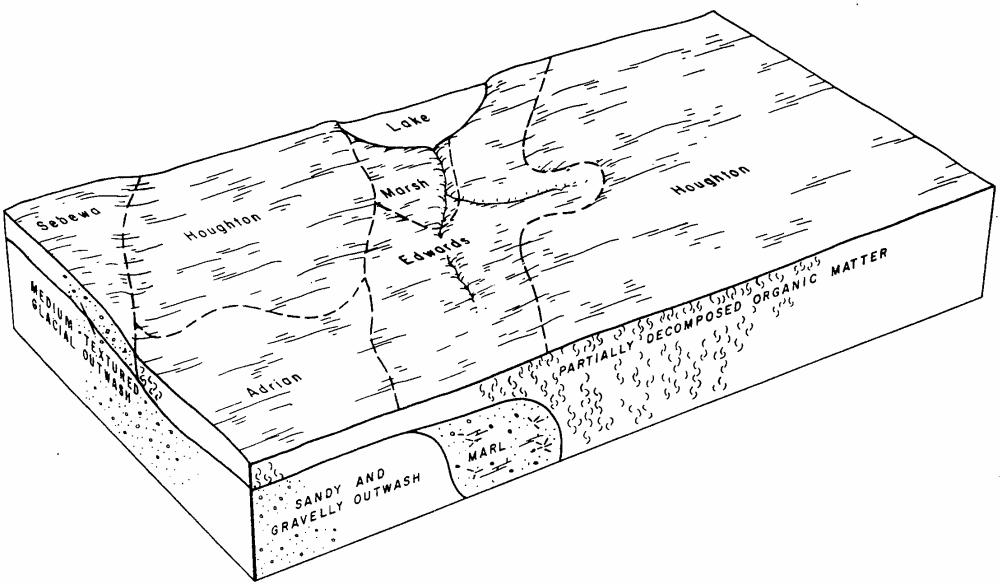


*Figure 7.*—**Typical pattern of soils in the Houghton-Edwards-Adrian association.**

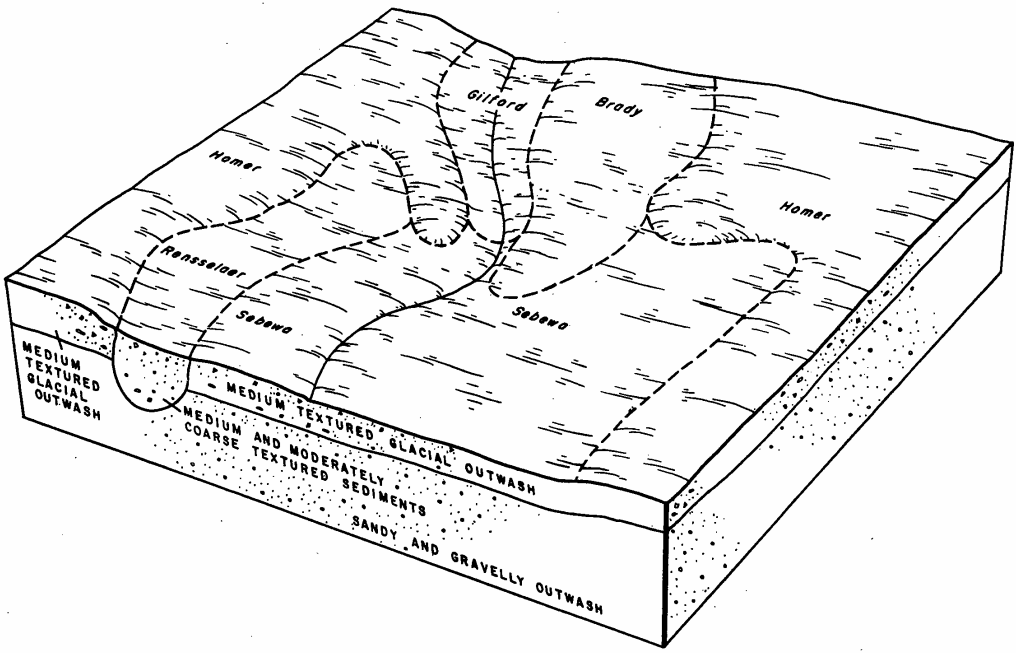


*Figure 8.*—**Typical pattern of soils in the Homer-Sebewa association.**

subsurface layer is about 2 inches of dark grayish brown loam. The subsoil is about 28 inches thick. In sequence from the top, it is 8 inches of firm, yellowish brown heavy loam mottled with grayish brown and dark grayish brown; 7 inches of firm, light brownish gray sandy clay loam mottled with gray and yellowish brown; 9 inches of firm, brown gravelly sandy clay loam mottled with gray and dark brown; and 4 inches of very friable, dark grayish brown gravelly sandy loam and loamy sand. The substratum to a depth of about 60 inches is brown, stratified sand and gravelly sand.

Sebewa soils are very poorly drained and are moderately deep to loose sand and gravelly sand. They are in depressions and drainageways on outwash plains. The surface layer is about 12 inches of very dark gray loam. The subsoil is 26 inches thick. In sequence from the top, it is 12 inches of firm, gray sandy clay loam mottled with light olive brown and brown; 10 inches of firm, grayish brown sandy clay loam mottled with light olive brown; and 4 inches of friable, gray gravelly sandy clay loam mottled with light olive brown. The substratum to a depth of 60 inches is light brownish gray sand and gravelly sand.

Less extensive in this association are Rensselaer, Gilford, and Brady soils. The very poorly drained Rensselaer and Gilford soils are in depressions and drainageways in outwash plains. The somewhat poorly drained Brady soils are on flats between depressions in outwash plains.

This association is used mostly for crops. Corn, soybeans, and wheat are the main crops. The available water capacity is moderate. The surface layer is moderate or high in content of organic matter. Maintaining organic matter is a management need.

Wetness is a limitation. The limitation for septic tank absorption fields is severe. These soils are a source of sand and gravel.

## *Descriptions of the Soils*

This section describes the soil series and mapping units in Noble County. Each soil series is described in detail and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this

profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The symbol following color names in the representative profile descriptions refers to a standard color notation. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Lake borders and Marshes, for example, do not belong to a soil series, but nevertheless, are listed in alphabetical order along with the soil series.

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and woodland group to which the mapping unit has been assigned. The page for the description of each capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing the soils can be found in the Glossary at the end of this survey. More detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*11*).[1]

Descriptions, names, and delineations of soils in this soil survey do not fully agree with soil maps for adjacent counties published at a different date. Differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, and the extent of soils within the survey. Sometimes it is more feasible to combine small acreages of similar soils that respond to use and management in much the same way than it is to manage them separately.

[1] Italic numbers in parentheses refer to Literature Cited, p. 115.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

| Soil | Acres | Percent |
|---|---|---|
| Adrian muck | 1,250 | 0.5 |
| Adrian muck, drained | 830 | .3 |
| Aubbeenaubbee fine sandy loam | 750 | .3 |
| Blount silt loam, 0 to 2 percent slopes | 8,500 | 3.2 |
| Blount silt loam, 2 to 4 percent slopes, eroded | 2,050 | .8 |
| Boyer loamy sand, 2 to 6 percent slopes | 1,150 | .4 |
| Boyer loamy sand, 6 to 12 percent slopes | 1,250 | .5 |
| Boyer loamy sand, 12 to 18 percent slopes, eroded | 1,050 | .4 |
| Brady sandy loam | 970 | .4 |
| Brookston silt loam | 9,400 | 3.6 |
| Casco sandy clay loam, 8 to 15 percent slopes, severely eroded | 1,650 | .6 |
| Chelsea fine sand, 2 to 6 percent slopes | 1,050 | .4 |
| Chelsea fine sand, 6 to 12 percent slopes | 600 | .2 |
| Crosier loam, 0 to 2 percent slopes | 6,500 | 2.5 |
| Edwards muck | 1,400 | .5 |
| Edwards muck, drained | 2,200 | .8 |
| Fox sandy loam, 0 to 2 percent slopes | 9,200 | 3.5 |
| Fox sandy loam, 2 to 6 percent slopes | 11,500 | 4.4 |
| Fox sandy loam, 6 to 12 percent slopes, eroded | 4,900 | 1.9 |
| Fox-Casco sandy loams, 12 to 18 percent slopes, eroded | 970 | .4 |
| Fox-Casco sandy loams, 18 to 25 percent slopes, eroded | 354 | .1 |
| Fulton silt loam | 244 | (1) |
| Gilford sandy loam | 1,350 | .5 |
| Haskins loam, 0 to 2 percent slopes | 4,200 | 1.6 |
| Homer loam | 2,450 | .9 |
| Houghton muck | 6,300 | 2.4 |
| Houghton muck, drained | 9,100 | 3.5 |
| Lake borders | 610 | .2 |
| Marl beds | 660 | .2 |
| Marsh | 2,100 | .8 |
| Martinsville fine sandy loam, 2 to 6 percent slopes | 540 | .2 |
| Metea loamy fine sand, 2 to 6 percent slopes | 1,650 | .6 |
| Miami loam, 2 to 6 percent slopes, eroded | 15,300 | 5.8 |
| Miami loam, 6 to 12 percent slopes, eroded | 3,100 | 1.2 |
| Miami loam, 12 to 18 percent slopes, eroded | 255 | .1 |
| Miami loam, 18 to 25 percent slopes, eroded | 417 | .2 |
| Miami clay loam, 6 to 12 percent slopes, severely eroded | 3,050 | 1.2 |
| Miami clay loam, 12 to 18 percent slopes, severely eroded | 790 | .3 |
| Miami loam, gravelly substratum, 0 to 2 percent slopes | 2,800 | 1.1 |
| Miami loam, gravelly substratum, 2 to 6 percent slopes, eroded | 2,700 | 1.0 |
| Milford silty clay loam | 4,400 | 1.7 |
| Morley silt loam, 2 to 6 percent slopes, eroded | 23,000 | 8.8 |
| Morley silt loam, 6 to 12 percent slopes, eroded | 4,650 | 1.8 |
| Morley silt loam, 12 to 18 percent slopes, eroded | 750 | .3 |
| Morley silty clay loam, 6 to 12 percent slopes, severely eroded | 12,400 | 4.7 |
| Morley silty clay loam, 12 to 18 percent slopes, severely eroded | 2,600 | 1.0 |
| Morley soils, 18 to 25 percent slopes | 1,700 | .6 |
| Morley, Miami, and Rawson loams, 6 to 12 percent slopes, eroded | 1,000 | .4 |
| Oshtemo loamy sand, 2 to 6 percent slopes | 3,500 | 1.3 |
| Oshtemo loamy sand, 6 to 12 percent slopes | 1,700 | .6 |
| Oshtemo sandy loam, 0 to 2 percent slopes | 2,500 | 1.0 |
| Palms muck, drained | 1,300 | .5 |
| Parr loam, 0 to 2 percent slopes | 860 | .3 |
| Pewamo silty clay loam | 12,000 | 4.6 |
| Rawson sandy loam, 2 to 6 percent slopes | 3,500 | 1.3 |
| Rawson sandy loam, 6 to 12 percent slopes, eroded | 1,150 | .4 |
| Rawson loam, 0 to 2 percent slopes | 1,000 | .4 |
| Rawson loam, 2 to 6 percent slopes | 7,600 | 2.9 |
| Rawson, Morley, and Miami loams, 2 to 6 percent slopes, eroded | 4,800 | 1.8 |
| Rensselaer loam | 3,400 | 1.3 |
| Riddles sandy loam, 0 to 2 percent slopes | 1,200 | .5 |
| Riddles sandy loam, 2 to 6 percent slopes | 13,000 | 5.0 |
| Riddles sandy loam, 6 to 12 percent slopes, eroded | 4,900 | 1.9 |
| Riddles sandy loam, 12 to 18 percent slopes, eroded | 820 | .3 |
| Sebewa loam | 7,850 | 3.0 |
| Shoals silt loam | 1,200 | .5 |
| Toledo silty clay loam | 2,000 | .8 |
| Wallkill silt loam | 1,050 | .4 |
| Warsaw loam, 0 to 2 percent slopes | 1,550 | .6 |
| Washtenaw silt loam | 4,100 | 1.6 |
| Whitaker loam | 670 | .3 |
| Water | 4,400 | 1.7 |
| Gravel pits, Made land, Borrow pits | 710 | .2 |
| Total | 262,400 | 100.0 |

[1] Less than 0.1 percent.

hay and pasture. Undrained areas are suitable for pasture or woodland.

Representative profile of Aubbeenaubbee fine sandy loam in a cultivated field, 1,200 feet south and 250 feet east of the center of sec. 3, T. 35 N., R. 9 E.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak very fine and fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A2—8 to 11 inches; grayish brown (10YR 5/2) fine sandy loam; few fine distinct light olive brown (2.5YR 5/4) mottles; weak fine granular structure; very friable; slightly acid; clear wavy boundary.

B1g—11 to 22 inches; grayish brown (2.5Y 5/2) fine sandy loam; common fine distinct brown (10YR 5/3) and yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; very friable; medium acid; clear wavy boundary.

IIB2t—22 to 34 inches; yellowish brown (10YR 5/6) sandy clay loam; many fine distinct grayish brown (10YR 5/2) mottles; moderate medium subangular blocky structure; firm; thick dark grayish brown (10YR 4/2) clay films on faces of peds; few fine pebbles; grayish brown (2.5Y 5/2) fine sandy loam films in vertical cracks and voids; medium acid; gradual wavy boundary.

IIB22tg—34 to 41 inches; yellowish brown (10YR 5/6) sandy clay loam; many medium distinct grayish brown (10YR 5/2) mottles; moderate coarse subangular blocky structure; firm; common iron- and manganese-oxide concretions; few fine pebbles; dark grayish brown (10YR 4/2) clay films on many vertical cracks and on some faces of peds; slightly acid grading to neutral in lower part; clear wavy boundary.

IIC—41 to 60 inches; brown (10YR 5/3) loam; many medium distinct light brownish gray (10YR 6/2) mottles; massive; friable; few fine pebbles; few thin dark grayish brown (10YR 4/2) clay films on vertical cracks and voids; strong effervescence; moderately alkaline.

The solum ranges from 36 to 50 inches in thickness, and the fine sandy loam upper part ranges from 20 to 36 inches in thickness. The Ap horizon is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). The A2 horizon is light brownish gray (10YR 6/2) in some pedons. The IIB2 horizon is clay loam or sandy clay loam. The IIC horizon is loam or light clay loam.

Aubbeenaubbee soils are associated with Crosier and Haskins soils. They are coarser textured in the surface layer and the upper part of the subsoil than Crosier soils and are coarser textured throughout than Haskins soils.

**Au—Aubbeenaubbee fine sandy loam.** This soil occupies irregularly shaped flats and drainageways in the upland. Slopes are 0 to 2 percent. Most areas are 2 to 20 acres in size.

Included with this soil in mapping are low rises where slopes are 2 to 4 percent. Areas ½ acre to 2 acres in size that are too wet for commonly grown crops are identified by spot symbols on the soil map. In a few areas the fine sandy loam upper horizons are 10 to 18 inches thick Also included are a few small mounds of well drained Metea loamy fine sand.

Wetness is a limitation on this Aubbeenaubbee soil, and drainage is needed. Maintaining the supply of organic matter is a management need.

Most areas of this soil are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are moderate or severe for most nonfarm uses. Capability unit IIw–11; woodland group 3o5.

## Blount Series

The Blount series consists of deep, somewhat poorly drained, medium textured soils. These soils are nearly level on flats and gently sloping on low rises and along drainageways in the upland. They formed in moderately fine textured glacial till. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 7 inches of dark grayish brown silt loam. The subsurface layer is 2 inches of grayish brown silt loam. The subsoil is 21 inches thick. In sequence from the top, it is 6 inches of firm, yellowish brown heavy clay loam mottled with grayish brown and light yellowish brown; 10 inches of very firm, light olive brown silty clay mottled with grayish brown and yellowish brown; and 5 inches of firm, light olive brown clay loam mottled with grayish brown and yellowish brown. The substratum to a depth of about 60 inches is light olive brown clay loam mottled with light olive gray.

Permeability is slow, and the available water capacity is high. The content of organic matter is moderate. Runoff is slow or medium. Wetness is a limitation. Erosion is a hazard on sloping soils. The seasonal high water table fluctuates between depths of 1 foot and 3 feet.

Drained areas of these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Undrained areas are suitable for pasture or woodland.

Representative profile of Blount silt loam, 0 to 2 percent slopes, in a cultivated field, 25 feet east and 1,025 feet south of the center of sec. 14, T. 33 N., R. 11 E.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; moderate fine and medium granular structure; friable; neutral; abrupt smooth boundary.

A2—7 to 9 inches; grayish brown (10YR 5/2) silt loam; weak medium platy structure parting to moderate medium granular; friable; neutral; clear smooth boundary.

B21t—9 to 15 inches; yellowish brown (10YR 5/4 and 5/6) heavy clay loam; many medium distinct grayish brown (10YR 5/2) mottles and many fine faint light yellowish brown (10YR 6/4) mottles; moderate fine and medium subangular blocky structure; firm; thin discontinuous grayish brown (10YR 5/2) silt and very fine sand coatings on faces of peds; firm; few fine pebbles; brown (10YR 4/3) and dark grayish brown (10YR 4/2) clay films on most faces of peds; slightly acid; clear smooth boundary.

B22t—15 to 20 inches; light olive brown (2.5Y 5/4) silty clay; common fine distinct grayish brown (2.5Y 5/2) mottles and few fine prominent yellowish brown (10YR 5/6) mottles; moderate medium angular blocky structure; very firm; few fine pebbles; dark grayish brown (10YR 4/2) clay films on most faces of peds; medium acid; clear wavy boundary.

B23t—20 to 25 inches; light olive brown (2.5Y 5/4) silty clay; many fine distinct grayish brown (2.5Y 5/2) mottles and few fine prominent yellowish brown (10YR 5/6) mottles; moderate fine angular blocky structure; very firm; few fine pebbles; continuous dark grayish brown (10YR 4/2) clay films on most faces of peds; slightly acid; clear wavy boundary.

B3t—25 to 30 inches; light olive brown (2.5Y 5/4) clay loam; many fine distinct grayish brown (2.5Y 5/2) mottles and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure; firm; dark grayish brown (10YR 4/2) clay films on vertical ped faces and voids; neutral; gradual wavy boundary.

C—30 to 60 inches; light olive brown (2.5Y 5/4) clay loam; many fine distinct light olive gray (5Y 6/2) mottles;

massive; firm; few fine pebbles; few light olive gray (5Y 6/2) fillings in cracks; strong effervescence; moderately alkaline.

The solum ranges from 22 to 36 inches in thickness. The Ap horizon is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). The A2 horizon is grayish brown (10YR 5/2) or light brownish gray (10YR 6/2). The B22t and B23t horizons are silty clay or heavy silty clay loam. The C horizon is silty clay loam or clay loam.

Blount soils are similar to Haskins and Fulton soils. They contain more clay in the upper part of the subsoil than Haskins soils and less clay in the subsoil and underlying material than Fulton soils.

**BlA—Blount silt loam, 0 to 2 percent slopes.** This soil is on flats between depressions and in shallow drainageways in the upland. Most areas are 3 to 30 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small depressional areas of Pewamo soils. A few low rises have slopes of 2 to 4 percent. Areas ½ acre to 2 acres in size that are too wet for commonly grown crops are identified by spot symbols on the soil map.

Wetness is a limitation on this Blount soil, and drainage is needed. Runoff is slow. The seasonal high water table fluctuates between depths of 1 foot and 3 feet. Maintaining the supply of organic matter is a management need.

Most areas of this soil are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are moderate or severe for most nonfarm uses. Capability unit IIw–2; woodland group 3o5.

**B1B2—Blount silt loam, 2 to 4 percent slopes, eroded.** This soil occupies low rises and slopes along drainageways and depressions in the upland. Areas are mostly undulating. Most are 2 to 5 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is thinner and is grayish brown and the upper part of the subsoil has fewer grayish brown mottles. About 3 to 5 inches of the surface layer has been removed by erosion. The present plow layer is a mixture of the surface layer and the yellowish brown subsoil.

Included with this soil in mapping are small areas of Haskins loam and Morley silt loam. Also included are a few, small, uneroded areas where the surface layer is thicker.

Wetness is a limitation on this Blount soil, and drainage is needed. Runoff is medium. Erosion is a hazard. Maintaining the supply of organic matter and preventing erosion are management needs.

This soil is suited to row crops most of the time. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are moderate or severe for most nonfarm uses. Capability unit IIe–13; woodland group 3o5.

## Boyer Series ✓

The Boyer series consists of well drained, coarse textured soils that are moderately deep over stratified sand and gravelly sand. These soils formed in moderately coarse textured glacial outwash. They are on breaks along drainageways and around potholes on outwash plains and on knolls in the upland. They are gently sloping to strongly sloping. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 8 inches of dark brown loamy sand. The subsoil is about 24 inches thick. In sequence from the top, it is 3 inches of very friable, brown loamy sand; 4 inches of very friable, brown sandy loam; 4 inches of friable, dark brown light sandy clay loam; and 13 inches of very friable, dark brown sandy loam. The substratum to a depth of about 60 inches is pale brown sand and gravelly sand.

Permeability is moderately rapid, and the available water capacity is low. The content of organic matter is low. Runoff is slow or medium. Droughtiness is a limitation. Erosion is a hazard on sloping soils. Soil blowing is also a hazard.

Where slopes are 2 to 12 percent, these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Where slopes are more than 12 percent, they are better suited to hay, pasture, or woodland. Because of droughtiness, crops that mature early in the season are best suited.

Representative profile of Boyer loamy sand, 2 to 6 percent slopes, in a cultivated field, 150 feet east and 250 feet south of the northwest corner of sec. 16, T. 34 N., R. 9 E.

Ap—0 to 8 inches; dark brown (10YR 4/3) loamy sand; weak fine granular structure; very friable; 5 percent fine gravel; slightly acid; abrupt smooth boundary.

B1—8 to 11 inches; brown (7.5YR 5/4) loamy sand; weak fine subangular blocky structure; very friable; 10 percent fine gravel; slightly acid; clear wavy boundary.

B21t—11 to 15 inches; brown (7.5YR 4/4) sandy loam; weak medium subangular blocky structure; very friable; discontinuous reddish brown (5YR 4/4) clay films on most faces of peds; 10 percent fine gravel; medium acid; clear wavy boundary.

B22t—15 to 19 inches; dark brown (7.5YR 4/4) light sandy clay loam; weak medium subangular blocky structure; friable; discontinuous dark reddish brown (5YR 3/4) clay films on most faces of peds; 10 percent fine gravel; medium acid; clear wavy boundary.

B23t—19 to 32 inches; dark brown (7.5YR 4/4) sandy loam; weak coarse subangular blocky structure; very friable; discontinuous reddish brown (5YR 4/4) clay films on faces of some peds and bridges between sand grains; 10 percent fine gravel; slightly acid; abrupt irregular boundary.

IIC—32 to 60 inches; pale brown (10YR 6/3) stratified sand and gravelly sand; single grained; loose; strong effervescence; moderately alkaline.

The solum is 28 to 40 inches thick. The Ap horizon is dark grayish brown (10YR 4/2) or brown (10YR 5/3 or 4/3) loamy sand or sandy loam. The B2t horizon is dominantly sandy loam. In some pedons, it contains a layer of light sandy clay loam or light gravelly clay loam less than 6 inches thick. In some pedons, the lower part of the B2 horizon is gravelly loamy sand or loamy sand. Tongues extend from the lower part of the Bt horizon into the IIC horizon. The IIC horizon is typically stratified gravel and sand, but in some pedons it is dominantly coarse sand.

Boyer soils are associated with Oshtemo, Fox, and Casco soils. They have a thicker solum than Casco soils and a thinner solum than Oshtemo soils. They have a coarser textured subsoil than Fox or Casco soils.

**BoB—Boyer loamy sand, 2 to 6 percent slopes.** This gently sloping soil is on ridgetops and knolls and on breaks along drainageways and around potholes. It occurs on outwash plains and in the upland. Most areas are 5 to 40 acres in size. The profile of this soil is the one described as representative of the series (fig. 9).

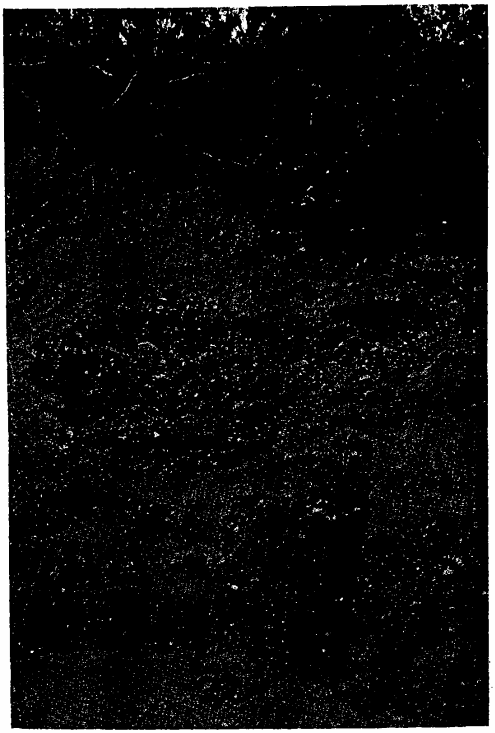

*Figure 9.*—**Profile of Boyer loamy sand, 2 to 6 percent slopes.**

Included with this soil in mapping are small areas where the surface layer is sandy loam or gravelly sandy loam and small areas of Oshtemo loamy sand. Identified by spot symbols on the soil map are potholes less than 2 acres in size that have eroded side slopes and 2 to 3 feet of dark brown sandy loam in the lower part, and small areas where gravel on the surface interferes with tillage.

Droughtiness is a limitation and erosion and soil blowing are hazards on this Boyer soil. The soil absorbs water readily and is easy to work. Runoff is slow. Maintaining the supply of organic matter is a management need.

This soil is suited to row crops most of the time. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Irrigated areas are well suited to these crops. A few areas are used for woodland. Limitations are slight for most nonfarm uses. Capability unit IIIs–2; woodland group 3s17.

**BoC—Boyer loamy sand, 6 to 12 percent slopes.** This soil is on side slopes of ridges and knolls and on breaks along drainageways and around potholes. It occurs on outwash plains and in the upland. Most areas are 3 to 30 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is somewhat lighter in color.

Included with this soil in mapping are some areas where the surface layer is sandy loam or gravelly sandy loam and small areas of Oshtemo loamy sand. Identified by spot symbols on the soil map are potholes less than 2 acres in size that have eroded side slopes and 2 to 3 feet of dark brown sandy loam in the lower part, and areas where pebbles on the surface interfere with tillage. Also included are severely eroded areas where the surface layer is brown sandy loam or gravelly sandy loam.

Droughtiness is a limitation and erosion and soil blowing are hazards on this Boyer soil. The soil absorbs water readily and is easy to work. Runoff is medium. Maintaining the supply of organic matter is a management need. Slope limits irrigation.

This soil is suitable for row crops under good management. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Limitations are moderate for most nonfarm uses. Capability unit IIIe–13; woodland group 3s17.

**BoD2—Boyer loamy sand, 12 to 18 percent slopes, eroded.** This soil occupies ridges or knolls and narrow breaks around potholes and along drainageways of the outwash plains. Most areas are 3 to 25 acres in size, but some broad areas on knolls range from 50 to 200 acres. The profile of this soil is similar to the one described as representative of the series, but the surface layer is brown and is a mixture of topsoil and the upper part of the subsoil. Depth to loose sand and gravelly sand is commonly 24 to 30 inches.

Included with this soil in mapping are small areas where the surface layer is sandy loam or gravelly sandy loam and large areas near Diamond Lake Hill and east of Kimmell where slopes are 18 to 30 percent. In a few areas the depth to loose sand and gravelly sand is less than 24 inches. Also included are small areas of Oshtemo loamy sand. Areas where pebbles on the surface interfere with tillage are identified by spot symbols on the soil map.

Droughtiness is a limitation and erosion and soil blowing are hazards on this Boyer soil. Runoff is medium. Maintaining the supply of organic matter is a management need. Slope limits the use of farm machinery.

This soil is well suited to grasses and legumes for hay and pasture and to woodland. Limitations are severe for most nonfarm uses. Capability unit IVe–13; woodland group 3s17.

## Brady Series

The Brady series consists of deep, somewhat poorly drained, moderately coarse textured soils. These soils formed in coarse textured glacial outwash on broad outwash plains. They are nearly level. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 9 inches of very dark grayish brown sandy loam. The

weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21tg—13 to 20 inches; dark gray (5Y 4/1) clay loam; common fine prominent olive (5Y 5/4) mottles; moderate fine subangular blocky structure; firm; few fine pebbles; common discontinuous distinct very dark gray (10YR 3/1) clay films; voids filled with very dark gray (10YR 3/1) silt loam; neutral; clear wavy boundary.

B22tg—20 to 28 inches; gray (5Y 5/1) clay loam; common fine distinct olive (5Y 5/6) and light olive gray (5Y 6/2) mottles; moderate medium subangular blocky structure; firm; few fine pebbles; many discontinuous distinct dark gray (10YR 4/1) clay films on peds and linings of voids; few fillings in voids of very dark gray (10YR 3/1) silt loam; neutral; clear wavy boundary.

B23tg—28 to 38 inches; gray (5Y 5/1) clay loam; many fine distinct yellowish brown (10YR 5/6) mottles and common fine distinct olive (5Y 5/4) mottles; moderate medium and coarse subangular blocky structure; firm; few fine pebbles; many discontinuous distinct dark gray (10YR 4/1) clay films on peds and linings of voids; neutral; gradual wavy boundary.

B3tg—38 to 44 inches; gray (5Y 5/1) clay loam; many fine distinct yellowish brown (10YR 5/6) and olive (5Y 5/3) mottles; weak coarse subangular blocky structure; firm; few fine pebbles; few discontinuous distinct dark gray (10YR 4/1) clay films on peds and pebbles; few light gray (10YR 7/1) lime accumulations; mildly alkaline; gradual wavy boundary.

C—44 to 60 inches; gray (5Y 5/1) loam; common fine distinct olive (5Y 5/3) mottles; massive; friable; 5 percent gravel; few light gray (10YR 7/1) lime accumulations; strong effervescence; moderately alkaline.

The solum ranges from 36 to 48 inches in thickness. The A horizon ranges from 11 to 15 inches in thickness and is black (10YR 2/1), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). The B22tg and B23tg horizons are mainly clay loam or silty clay loam, but some are loam. The C horizon is loam or light clay loam.

Brookston soils are similar to Pewamo and Milford soils. They contain less clay throughout than Pewamo or Milford soils.

**Bx—Brookston silt loam.** This soil occupies broad flats and shallow, narrow, meandering depressions and drainageways of the upland. Slopes are 0 to 2 percent. Most areas are irregular in shape and are 10 to 100 acres in size.

Included with this soil in mapping are small areas of Crosier loam on low rises and adjacent flats. The surface layer is loam in some areas where associated soils have a sandy loam surface layer. Also included are a few small areas of Milford silty clay loam in some deeper depressional areas. Areas ½ acre to 2 acres in size that are too wet for commonly grown crops are identified by spot symbols on the soil map.

Wetness is a serious limitation on this Brookston soil, and drainage is needed. Erosion is a hazard along narrow drainageways during periods of heavy rainfall.

This soil is suited to row crops year after year. Most drained areas are used for corn, soybeans, and wheat and for grasses and legumes for hay or pasture. Undrained areas are used for woodland or pasture. Limitations are severe for most nonfarm uses. Capability unit IIw-1; woodland group 2w11.

## Casco Series

The Casco series consists of well drained to somewhat excessively drained, moderately fine textured soils that are shallow over loose sand and gravelly sand. These moderately sloping to moderately steep soils are on knolls and breaks along drainageways and depressions and around potholes of the outwash plains. They are also on knolls in the upland. They formed in medium textured outwash. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 7 inches of dark yellowish brown sandy clay loam. The subsoil is about 11 inches thick. The upper 8 inches is firm, dark brown clay loam and the lower 3 inches is friable, dark yellowish brown sandy clay loam. The substratum to a depth of about 60 inches is brown sand and gravelly sand.

Permeability is moderate, and the available water capacity is low. The content of organic matter is low. Runoff is rapid or very rapid. Droughtiness is a serious limitation. Erosion is a hazard.

These soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Because of droughtiness, crops that mature early in the season are best suited. Areas where slopes are more than 12 percent are best suited to hay, pasture, or woodland.

Representative profile of Casco sandy clay loam, 6 to 12 percent slopes, severely eroded, in a cultivated field, 850 feet south and 1,700 feet east of northwest corner of sec. 15, T. 35 N., R. 10 E.

Ap—0 to 7 inches; dark yellowish brown (10YR 3/4) sandy clay loam, brown (10YR 5/5) dry; weak very fine subangular blocky structure; friable; 5 percent fine gravel; numerous roots; slightly acid; abrupt smooth boundary.

B21t—7 to 15 inches; dark brown (7.5YR 4/4) clay loam; moderate medium subangular blocky structure; firm; thick continuous dark brown (10YR 3/3) clay films on faces of peds; about 10 percent fine gravel; few roots; neutral; clear wavy boundary.

B22t—15 to 18 inches; dark yellowish brown (10YR 4/4) sandy clay loam; weak fine and very fine subangular blocky structure; friable; thick continuous dark brown (10YR 3/3) clay films on faces of peds; about 5 percent fine gravel; neutral; abrupt irregular boundary.

IIC—18 to 60 inches; brown (10YR 5/3) weakly stratified sand and gravelly sand; single grained; loose; strong effervescence; moderately alkaline.

The solum ranges from 12 to 24 inches in thickness. The Ap horizon is dark yellowish brown (10YR 4/4) or dark brown (7.5YR 4/4). In uneroded pedons it is sandy loam. The B21t and B22t horizons are sandy clay loam, clay loam, or gravelly sandy clay loam. Content of gravel ranges from 5 to 40 percent in the B21t and B22t horizons. The IIC material is mainly coarse sand in some pedons.

Casco soils are associated with Fox and Boyer soils. They have a thinner solum than those soils and a finer textured subsoil than Boyer soils.

**CeC3—Casco sandy clay loam, 8 to 15 percent slopes, severely eroded.** This soil occupies long, narrow breaks along drainageways and around potholes of the outwash plains. It also occupies knolls in the uplands. Slopes are generally short. Most areas are 5 to 20 acres in size.

Included with this soil in mapping are small, less eroded areas where the surface layer is sandy loam and small areas where the subsoil is sandy loam. Also included are small areas that are either less sloping or more sloping and many very small areas of Fox sandy loam. Areas ½ acre to 2 acres in size where pebbles on the surface interfere with tillage and potholes where 2 to 3 feet of dark brown loam are in the

lower part are identified by spot symbols on the soil map.

Droughtiness is a serious limitation and erosion is a hazard on this Casco soil. Runoff is rapid or very rapid. Slope limits irrigation and the use of farm machinery.

This soil is suited to hay and pasture. It is not well suited to row crops. Special management is needed when the soil is used occasionally for corn, soybeans, and small grain. Limitations are severe for most nonfarm uses. Capability unit VIe–3; woodland group 3s17.

## Chelsea Series

The Chelsea series consists of deep, excessively drained, coarse textured soils. These soils formed in coarse textured outwash. They occupy knolls or breaks along drainageways in the upland. They are gently sloping or moderately sloping. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 9 inches of dark brown fine sand. The subsurface layer is 2 inches of grayish brown fine sand. The subsoil is about 44 inches thick. In sequence from the top, it is 18 inches of loose, dark yellowish brown fine sand; 11 inches of loose, yellowish brown fine sand; and 15 inches of loose, light yellowish brown fine sand that has about 4 inches of yellowish brown loamy fine sand in ½- to 1-inch bands. The substratum to a depth of about 65 inches is light yellowish brown fine sand.

Permeability is rapid, and the available water capacity is low. The content of organic matter is low. Runoff is slow or medium. Droughtiness is a severe limitation. Soil blowing is a hazard.

These soils are best suited to orchards, Christmas trees, and vineyards. Some areas are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture.

Representative profile of Chelsea fine sand, 2 to 6 percent slopes, in an orchard, 700 feet east and 1,240 feet north of the center of sec. 8, T. 35 N., R. 11 E.

Ap—0 to 9 inches; dark brown (10YR 3/3) fine sand, pale brown (10YR 6/3) dry; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A2—9 to 11 inches; grayish brown (10YR 5/2) fine sand; weak fine and medium granular structure; very friable; slightly acid; clear smooth boundary.

B21—11 to 29 inches; dark yellowish brown (10YR 4/4) fine sand; single grained; loose; medium acid; gradual wavy boundary.

B22—29 to 40 inches; yellowish brown (10YR 5/4) fine sand; single grained; loose; strongly acid; clear wavy boundary.

A&B—40 to 55 inches; light yellowish brown (10YR 6/4) fine sand; single grained; loose; 4 inches of yellowish brown (10YR 5/4) loamy fine sand in ½- to 1-inch thick bands; very weak medium subangular blocky structure; very friable; few clay bridges between sand grains; strongly acid; gradual wavy boundary.

C—55 to 65 inches; light yellowish brown (10YR 6/4) fine sand; single grained; loose; medium acid.

The Ap horizon is dark brown (10YR 3/3), dark grayish brown (10YR 4/2), or brown (10YR 4/3). The B21, B22, and A&B horizons are strongly acid to medium acid. The B horizon is dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4), or brown (7.5YR 4/4) light sandy loam or loamy sand that has a few ¼- to 1½-inch lamellae. Depth to the upper lamellae ranges from 30 to 48 inches. In the upper 60 inches the lamellae, combined, are less than 6 inches thick.

Chelsea soils are similar to Metea soils and are associated with Oshtemo soils. They are not medium textured or moderately fine textured in the lower part of the B horizon and in the C horizon, as Metea soils characteristically are. They contain more fine sand than Oshtemo soils and lack the medium textured or moderately coarse textured B horizon typical of those soils.

**ChB—Chelsea fine sand, 2 to 6 percent slopes.** This soil is on irregularly shaped ridges or knolls in the upland. Most areas are 3 to 20 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are a few areas that do not have lamellae in the upper 60 inches. In a few places the surface layer is loamy fine sand. Also included are small areas on top of knolls and ridges where slopes are 1 to 2 percent.

Droughtiness is a limitation and soil blowing is a hazard on this Chelsea soil. The soil absorbs water readily. Runoff is slow. Maintaining the supply of organic matter is a management need.

This soil is suited to cultivated crops most of the time. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Some areas are used for orchards or woodland. Limitations are slight for most nonfarm uses. Capability unit IIIs–1; woodland group 3s17.

**ChC—Chelsea fine sand, 6 to 12 percent slopes.** This soil occupies irregularly shaped knolls and long, narrow breaks along drainageways in the upland. Slopes are generally short. Most areas are 2 to 10 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is somewhat thinner.

Included with this soil in mapping are a few small areas that do not have lamellae in the upper 60 inches. In a few areas the surface layer is loamy fine sand. Also included are a few small areas, mainly on small knolls and narrow breaks along depressions and drainageways, where slopes are 12 to 18 percent.

Droughtiness is a severe limitation and soil blowing is a hazard on this Chelsea soil. This soil absorbs water readily. Runoff is medium. Maintaining the supply of organic matter is a management need.

This soil is suited occasionally to cultivated crops if soil blowing is controlled. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Some areas are used for orchards or woodland. Limitations are moderate for most nonfarm uses. Capability unit IIIs–12; woodland group 3s17.

## Crosier Series

The Crosier series consists of deep, somewhat poorly drained, medium textured soils. These soils formed in medium textured glacial till. They are on flats and in drainageways. They are nearly level. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 10 inches of dark grayish brown loam. The subsoil is 25 inches thick. In sequence from the top, it is 4 inches of friable, brown light clay loam mottled with grayish

Lca—29 to 60 inches; light gray (10YR 6/1) marl; massive; friable; many shell fragments; many dark brown (7.5YR 4/4) herbaceous fibers in upper 4 inches; strong effervescence; moderately alkaline.

The organic horizon ranges from 16 to 44 inches in thickness. Where the organic material is less than 24 inches thick, the solum is typically neutral or alkaline throughout. Deeper solums are slightly acid or neutral in the upper part and neutral to moderately alkaline in the lower part. The Oa3 horizon generally contains some marl, and the upper part of the Lca horizon typically contains some herbaceous fibers. In some pedons there are thin layers of mineral material other than marl. The shell content of the marl is variable.

Edwards soils are similar to and associated with Palms, Houghton, and Adrian soils. They are underlain by marl, whereas Palms soils are underlain by loamy mineral material and Adrian soils by sandy mineral material. Edwards soils are not so deep as Houghton soils.

**Ed—Edwards muck.** This soil occupies broad, undrained depressional areas of the uplands and outwash plains. The water table is at or near the surface most of the year. Slopes are 0 to 2 percent. Most areas are 20 to 100 acres in size. The profile of this soil is similar to the one described as representative of the series, but the organic horizon contains more brownish peat and is mixed with the black muck.

Included with this soil in mapping are small areas where the muck is either less than 16 inches or more than 49 inches deep over marl.

Wetness is a serious limitation on this Edwards soil. Drainage outlets are often difficult to obtain in these areas because the water level of adjacent lakes and streams is the same as the level of the water table.

This soil is suitable for wetland wildlife habitat, and it provides some cover for other wildlife. It is not suited to crops. Some areas are used for pasture during dry periods. Limitations are severe for most nonfarm uses. Capability unit Vw-3; woodland group 4w23.

**Em—Edwards muck, drained.** This soil occupies broad, irregularly shaped depressional areas of the uplands and outwash plains. The water table is at least 2 feet below the surface most of the year. Slopes are 0 to 2 percent. Most areas are 20 to 100 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas where the organic soil is either less than 16 inches or more than 44 inches deep over marl. Undrained areas, ½ acre to 2 acres in size, that are too wet for commonly grown crops are identified by spot symbols on the soil map.

Wetness is a serious limitation on this Edwards soil. Drainage has caused subsidence of the muck, and soil blowing is a hazard when the soil is dry. Fire is a hazard because muck readily burns when dry.

This soil is suited to row crops each year. Most areas are used for corn. The soil is well suited to corn and many vegetable crops. Limitations are severe for most nonfarm uses. Capability unit IVw-3; woodland group 4w23.

## Fox Series

The Fox series consists of well drained, moderately coarse textured soils that are moderately deep over sand and gravelly sand. These soils formed in medium textured glacial outwash on outwash plains and knolls in the upland. They are nearly level to moderately steep. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 9 inches of dark brown sandy loam. The subsoil is about 26 inches thick. In sequence from the top, it is 5 inches of friable, dark yellowish brown heavy sandy loam; 13 inches of firm, dark brown clay loam; and 8 inches of mostly firm, dark brown sandy clay loam. The substratum to a depth of about 60 inches is brown, stratified sand and gravelly sand.

Permeability and the available water capacity are moderate. The content of organic matter is moderate. Runoff is slow to very rapid. Droughtiness is a limitation.

These soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The more sloping soils are best suited to hay, pasture, or trees. Because of droughtiness, crops that mature early in the season are best suited.

Representative profile of Fox sandy loam, 0 to 2 percent slopes, in a cultivated field, 150 feet west and 1,420 feet north of the corner of sec. 15, T. 35 N., R. 10 E.

Ap—0 to 9 inches; dark brown (10YR 4/3) sandy loam, pale brown (10YR 6/3) dry; weak fine and medium granular structure; friable; about 7 percent gravel; many roots; slightly acid; abrupt smooth boundary.

B1—9 to 14 inches; dark yellowish brown (10YR 4/4) heavy sandy loam; weak fine and very fine subangular blocky structure; friable; many roots; about 5 percent gravel; slightly acid; abrupt smooth boundary.

B21t—14 to 27 inches; dark brown (7.5YR 4/4) clay loam; moderate fine and medium subangular blocky structure; firm; 15 percent gravel; many continuous distinct dark brown (10YR 3/3) clay films on faces of peds; medium acid; clear wavy boundary.

B22t—27 to 33 inches; dark brown (7.5YR 4/4) sandy clay loam; moderate medium subangular blocky structure; firm; 10 percent gravel; many continuous thin dark brown (10YR 3/3) clay films on faces of peds; medium acid; clear wavy boundary.

B3t—33 to 35 inches; dark yellowish brown (10YR 4/4) light sandy clay loam; weak fine and very fine subangular blocky structure; friable; 10 percent fine gravel; many continuous prominent dark brown (10YR 3/3) clay films on faces of peds; neutral; abrupt irregular boundary.

IIC—35 to 60 inches; brown (10YR 5/3) stratified sand and gravelly sand; single grained; loose; strong effervescence; moderate alkaline.

The thickness of the solum and the depth to calcareous sand and gravelly sand range from 24 to 38 inches. The Ap horizon is dark grayish brown (10YR 4/2) or dark brown (10YR 4/3). Some pedons have an A2 horizon of brown (10YR 5/3) sandy loam 2 to 6 inches thick. The B1 horizon is loam in some pedons. The B21t and B22t horizons range from clay loam to gravelly sandy clay loam and contain more gravel in the lower part. Some pedons have a gravelly sandy clay loam B3t horizon. Tongues of the B3t horizon extend 1 foot to 3 feet into the IIC horizon in some pedons. The IIC horizon varies considerably in content of sand and gravel.

Fox soils are associated with Casco and Oshtemo soils. They have a thicker subsoil than Casco soils and a thinner, finer textured subsoil than Oshtemo soils.

**FoA—Fox sandy loam, 0 to 2 percent slopes.** This nearly level soil is on broad, glacial outwash plains. Areas are irregular in shape and range from 40 to 400 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of a similar soil that is deeper, more acid, and coarser

textured. Circular depressional areas, or potholes, ½ acre to 2 acres in size and having slopes of 2 to 6 percent are identified by spot symbols on the soil map. In some potholes and drainageways, the surface layer is loam and is several feet thick. Also included is a similar moderately well drained soil that has a seasonal high water table at a depth of 3 to 6 feet. This soil is in broad areas along Solomon Creek, near Cosperville and northwest of Ligonier.

Droughtiness on this Fox soil is a limitation, especially for shallow-rooted crops. The soil absorbs water readily. It is easy to work and to keep in good tilth. Runoff is slow. Maintaining the supply of organic matter is a management need.

This soil is suited to row crops year after year. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are slight for most nonfarm uses. Capability unit IIs–2; woodland group 2o15.

**FoB—Fox sandy loam, 2 to 6 percent slopes.** This soil occupies long, narrow breaks along drainageways and around potholes and undulating, irregularly shaped knolls on outwash plains and in the upland. Most areas are 5 to 100 acres in size. The profile of this soil is similar to the one described as representative of the series (fig. 10), but the surface layer is lighter in color.

Included with this soil in mapping are a few areas of Casco soils. Areas of less than 2 acres are identified by spot symbols on the soil map. In some potholes and drainageways, the surface layer is loam and is several feet thick. Some small eroded areas are included. Small gravelly areas where pebbles on the surface interfere with tillage are identified by spot symbols on the soil map.

Erosion is a hazard and droughtiness a limitation on this Fox soil. The soil absorbs water readily. It is easy to work and to keep in good tilth. Runoff is medium. Maintaining the supply of organic matter is a management need.

This soil is suitable for row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are slight for most nonfarm uses. Capability unit IIe–2; woodland group 2o15.

**FoC2—Fox sandy loam, 6 to 12 percent slopes, eroded.** This soil occupies narrow breaks along drainageways and around potholes and irregularly shaped knolls on outwash plains and in the upland. Slopes are generally less than 150 feet long. Most areas are 5 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but about 3 to 5 inches of the surface layer have been removed by erosion. The present surface layer is brown, is a mixture of the surface layer and subsoil, and contains more pebbles than the uneroded soil.

Included with this soil in mapping are many small areas of Casco soils, which are commonly at the crests and at mid slope. Also included are small areas of uneroded Fox soils and small areas of severely eroded soils that have a gravelly surface layer. Steep or very

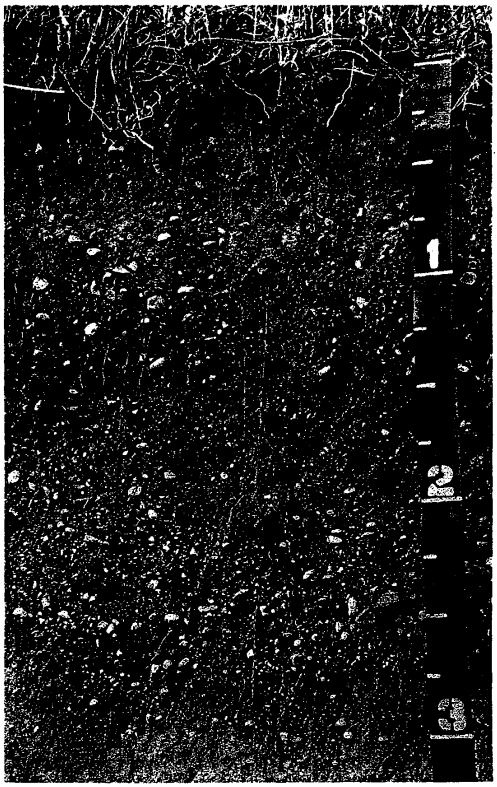


*Figure 10.*—**Profile of Fox sandy loam, 2 to 6 percent slopes.**

steep, narrow breaks or bluffs are identified by spot symbols on the soil map.

Erosion is a hazard and droughtiness a limitation on this Fox soil. The soil absorbs water readily and is easy to work. Runoff is rapid. Maintaining the supply of organic matter is a management need.

Row crops are occasionally suited if erosion is controlled. Most areas of this soil are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Some areas are used for woodland. Limitations are moderate for most nonfarm uses. Capability unit IIIe–13; woodland group 2o15.

**FsD2—Fox-Casco sandy loams, 12 to 18 percent slopes, eroded.** This mapping unit occupies long, narrow breaks along drainageways and around potholes of outwash plains and irregularly shaped knolls in the upland. Slopes are generally less than 100 feet long. Most areas are 5 to 20 acres in size.

This mapping unit is about 50 percent Fox sandy loam, 30 percent Casco sandy loam, and 20 percent soils

of minor extent, including Boyer loamy sand and Oshtemo loamy sand. The Fox and Casco soils have profiles similar to the ones described as representative of their respective series, but the surface layer is thinner and lighter in color. In addition the Casco soil in this unit has a surface layer of sandy loam. Both soils formed in medium textured outwash and are underlain by sand and gravelly sand.

Fox soils are most common at the top of slopes, near the base of slopes, and in areas where slopes are less than 15 percent. Casco soils are commonly at mid slope in the more sloping areas.

Included with this unit in mapping are areas where the surface layer is gravelly sandy loam or gravelly sandy clay loam. Severely eroded areas ½ acre to 2 acres in size and areas, also ½ acre to 2 acres in size, where gravel on the surface interferes with tillage are identified by spot symbols on the soil map.

Erosion is a hazard and droughtiness a limitation. Runoff is very rapid. The content of organic matter is moderate. Slope limits the use of farm machinery.

This mapping unit is suited to hay and pasture or woodland. Many areas are not well suited, but are used for corn, soybeans, and small grain. Limitations are severe for most nonfarm uses. Capability unit IVe–13; woodland group 2o15.

**FsE2—Fox-Casco sandy loams, 18 to 25 percent slopes, eroded.** This mapping unit occupies long, narrow breaks along drainageways and around potholes of outwash plains and irregularly shaped knolls and in the upland. Slopes are generally less than 100 feet long. Most areas are 2 to 15 acres in size.

This mapping unit is about 40 percent Fox sandy loam, 35 percent Casco sandy loam, and 25 percent soils of minor extent, including Boyer loamy sand and Oshtemo loamy sand. The Fox and Casco soils have profiles similar to the ones described as representative of their respective series, but the surface layer is thinner. In addition the Casco soil in this unit has a surface layer of sandy loam. Both soils formed in medium textured outwash and are underlain by sand and gravelly sand.

Fox soils are most common at the top of slopes, near the base of slopes, and in areas where slopes are less than 20 percent. Casco soils are common at mid slope in the more sloping areas.

Included with this unit in mapping are areas where the surface layer is gravelly sandy loam or gravelly sandy clay loam. Severely eroded areas ½ acre to 2 acres in size and areas, also ½ acre to 2 acres in size, where gravel on the surface interferes with tillage are identified by spot symbols on the soil map.

Erosion is a hazard and droughtiness a limitation. Runoff is very rapid. Slope severely limits irrigation and farm equipment.

This mapping unit is suited to pasture or woodland. Most areas are used for pasture or woodland or are idle. Some areas are not suited, but are used for corn, soybeans, or small grain. Limitations are severe for most nonfarm uses. Capability unit VIe–3; woodland group 2r2.

## Fulton Series

The Fulton series consists of deep, somewhat poorly drained, medium textured soils. These soils are nearly level on flats and gently undulating on plains in the upland and on outwash plains. They formed in fine textured sediment that settled out of slow-moving water in lakebeds. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 8 inches of dark grayish brown silt loam. The subsurface layer is 3 inches of mottled, light brownish gray light silty clay loam. The subsoil is about 32 inches thick. In sequence from the top, it is 15 inches of brown silty clay mottled with light brownish gray and yellowish brown; 13 inches of light brownish gray silty clay mottled with yellowish brown and light olive brown; and 4 inches of grayish brown silty clay mottled with light olive brown. The substratum to a depth of about 60 inches is grayish brown silty clay mottled with light olive brown.

Permeability is slow or very slow, and the available water capacity is high. The content of organic matter is moderate. Runoff is slow. The seasonal high water table fluctuates between depths of 1 foot and 3 feet. Wetness is a limitation.

Drained areas of these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture.

Representative profile of Fulton silt loam in a cultivated field, 1,600 feet west and 500 feet south of the northeast corner of sec. 16, T. 34 N., R. 11 E.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak medium granular structure; friable; slightly acid; abrupt smooth boundary.

A2—8 to 11 inches; light brownish gray (10YR 6/2) light silty clay loam; common medium distinct brown (10YR 5/3) mottles and few fine prominent yellowish brown (10YR 5/6) mottles; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—11 to 17 inches; brown (10YR 5/3) silty clay; common fine distinct yellowish brown (10YR 5/6) mottles and common medium distinct light brownish gray (10YR 6/2) mottles; moderate fine angular blocky structure; very firm; patchy grayish brown (10YR 5/2) clay films on faces of peds; medium acid; gradual wavy boundary.

B22t—17 to 26 inches; brown (10YR 5/3) silty clay; common fine distinct yellowish brown (10YR 5/6) mottles and many medium distinct light brownish gray (10YR 6/2) mottles; moderate medium angular blocky structure; very firm; continuous grayish brown (10YR 5/2) clay films on most faces of peds; medium acid; gradual wavy boundary.

B23tg—26 to 39 inches; light brownish gray (2.5Y 6/2) silty clay; common fine distinct yellowish brown (10YR 5/6) mottles and many fine distinct light olive brown (2.5Y 5/4) mottles; moderate coarse prismatic structure parting to moderate fine and medium angular blocky; very fine; dark grayish brown (10YR 4/2) clay films on faces of most peds; neutral; clear wavy boundary.

B3g—39 to 43 inches; grayish brown (2.5Y 5/2) silty clay; moderate medium distinct light olive brown (2.5Y 5/4) mottles; moderate medium prismatic structure parting to moderate angular blocky; very firm; light gray (10YR 7/2) lime nodules; few dark grayish brown (10YR 4/2) clay films on vertical cleavage faces; moderately alkaline; gradual wavy boundary.

C—43 to 60 inches; grayish brown (2.5Y 5/2) silty clay; many medium distinct light olive brown (2.5Y 5/6) mottles; massive; very firm; light gray (10YR 7/2)

a few small areas where the coarse textured overburden is only 12 to 20 inches thick.

Erosion and soil blowing are hazards on this Metea soil. Droughtiness is a limitation, especially for shallow-rooted crops. Runoff is slow.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are slight or moderate for most nonfarm uses. Capability unit IIIe–13; woodland group 2s15.

## Miami Series

The Miami series consists of deep, well drained, moderately fine textured and medium textured soils. These soils formed in medium textured glacial till. They occupy broad flats, knolls, ridges, and breaks along drainageways and depressions in the upland. They are nearly level to moderately steep. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 8 inches of dark grayish brown loam. The subsurface layer is 3 inches of dark grayish brown loam. The subsoil is about 27 inches thick. In sequence from the top, it is 3 inches of friable, brown light clay loam; 12 inches of firm, dark yellowish brown clay loam; 9 inches of firm, yellowish brown clay loam; and 3 inches of friable, brown light clay loam. The substratum to a depth of about 60 inches is pale brown loam.

Permeability is moderate in the subsoil and moderate to moderately slow in the underlying material. The available water capacity is high. The content of organic matter is moderate or low. Erosion is a hazard on sloping soils. Runoff is slow to very rapid. Maintaining the supply of organic matter is a management need.

Where slopes are 0 to 12 percent, these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Where slopes are more than 12 percent, the soils are best suited to hay, pasture, or woodland.

Representative profile of Miami loam, 2 to 6 percent slopes, eroded, in a cultivated field, 1,200 feet west and 150 feet north of the southeast corner of sec. 32, T. 35 N., R. 10 E.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) loam; moderate medium and fine granular structure; friable; few pebbles and small stones; neutral; abrupt smooth boundary.

A2—8 to 11 inches; dark grayish brown (10YR 4/2) loam; weak medium platy structure parting to moderate fine granular; friable; few pebbles; slightly acid; clear smooth boundary.

B1—11 to 14 inches; brown (10YR 5/3) light clay loam; moderate fine subangular blocky structure; friable; few pebbles and small stones; medium acid; clear wavy boundary.

B21t—14 to 26 inches; dark yellowish brown (10YR 4/4) clay loam; moderate medium subangular and angular blocky structure; firm; few pebbles and small stones; dark brown (10YR 3/3) clay films on faces of most peds; medium acid; gradual wavy boundary.

B22t—26 to 35 inches; yellowish brown (10YR 5/4) clay loam; moderate medium and coarse subangular blocky structure; firm; few pebbles and small stones; dark brown (10YR 3/3) clay films on faces of most peds; medium acid; clear wavy boundary.

B3t—35 to 38 inches; brown (10YR 5/3) light clay loam; weak coarse subangular blocky structure; friable; few pebbles and few small stones; vertical dark brown (10YR 3/3) clay films on cleavage faces of most peds; neutral grading to mildly alkaline in lower part; clear irregular boundary.

C—38 to 60 inches; pale brown (10YR 6/3) loam; massive; friable; few pebbles and few small stones; brown (7.5YR 4/4) clay flows on a few vertical cleavage faces; strong effervescence; moderately alkaline.

The solum ranges from 28 to 42 inches in thickness. Coarse fragments, mainly cobbles and pebbles, are less than 10 percent by volume. The Ap horizon is dark grayish brown (10YR 4/2) or dark brown (10YR 4/3) loam unless severely eroded. It is brown (10YR 5/3 and 4/3) or yellowish brown (10YR 5/4) clay loam or light clay loam in severely eroded areas. The A2 horizon is brown (10YR 5/3) or light yellowish brown (10YR 6/4). In some pedons it does not occur, and in others it is mixed with the Ap horizon by cultivation. Some pedons do not have a B1 horizon. The B21t and B22t horizons are dominantly clay loam and lesser layers of heavy loam, silty clay loam, and sandy clay loam. The C horizon is loam or light clay loam.

Miami soils are similar to Morley, Rawson, and Riddles soils. They are coarser textured than Morley soils. They are coarser textured in the lower part of the subsoil and in the substratum than Rawson soils and have a thinner solum than Riddles soils.

**MfB2—Miami loam, 2 to 6 percent slopes, eroded.** This soil occupies irregularly shaped ridgetops or knolls and long, narrow breaks along drainageways and depressions in the upland. Slopes are convex. Most areas are 5 to 80 acres in size. The profile of this soil is the one described as representative of the series (fig. 12).

Included with this soil in mapping are small areas of Crosier loam in narrow drainageways. There are small areas of Riddles soils. Severely eroded areas ½ acre to 2 acres in size are identified by spot symbols on the soil map. In some uneroded areas, especially those in woodland, nearly all the surface layer remains. Areas ¼ acre to 2 acres in size where small stones at or near the surface seriously interfere with tillage are identified by spot symbols on the soil map.

Erosion is a hazard on this Miami soil. Runoff is rapid. Maintaining tilth is a management need.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. A few areas are used for woodland. Limitations are slight or moderate for most nonfarm uses. Capability unit IIe–1; woodland group 1o1.

**MfC2—Miami loam, 6 to 12 percent slopes, eroded.** This soil occupies irregularly shaped knolls and long narrow breaks along drainageways and depressions in the upland. Slopes are generally convex and less than 200 feet long. Most areas are 3 to 600 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the surface layer is somewhat lighter in color. The plow layer is a mixture of the surface layer and the brown upper part of the subsoil.

Included with this soil in mapping are small areas of Riddles sandy loam. In a few small areas of Miami soil the surface layer is sandy loam. Severely eroded areas ½ acre to 2 acres in size are identified by spot symbols on the soil map. The lower part of the substratum is sand and gravelly sand below a depth of 4 to 12 feet in some areas. These areas are 1 acre to 5 acres in size and are on narrow breaks along wel

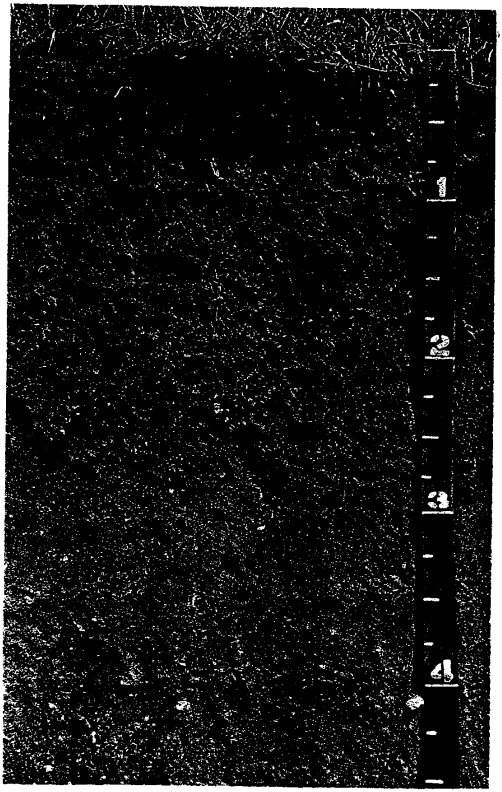


*Figure 12.*—**Profile of Miami loam, 2 to 6 percent slopes, eroded.**

drained depressions north of Ligonier and Sylvan Lake. Also included are some small areas on top of knolls where slopes are 2 to 6 percent.

Erosion is a hazard on this Miami soil. Maintaining tilth is a management need.

This soil is suited to occasional row crops if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay and pasture. A few areas are used for woodland. Limitations are moderate for most nonfarm uses. Capability unit IIIe–1; woodland group 1o1.

**MfD2—Miami loam, 12 to 18 percent slopes, eroded.** This soil occupies irregularly shaped knolls and long, narrow breaks along drainageways and depressions in the upland. Slopes are generally less than 100 feet long. Most areas are 5 to 40 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the surface layer is lighter in color. The plow layer is a mixture of the surface layer and the brown upper part of the subsoil.

Included with this soil in mapping are small areas where slopes are 6 to 12 percent. Severely eroded areas ½ acre to 2 acres in size and a few gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map. In some uneroded areas, especially those in woodland, nearly all the surface layer remains.

Erosion is a serious hazard and slope a limitation on this Miami soil. Runoff is very rapid. Maintaining tilth is a management need.

Some areas of this soil can be used for corn, soybeans, and small grain if erosion is controlled. The soil is better suited to hay, pasture, and woodland. Limitations are severe for most nonfarm uses. Capability unit IVe–1; woodland group 1o1.

**MfE2—Miami loam, 18 to 25 percent slopes, eroded.** This soil occupies irregularly shaped knolls and long, narrow breaks along streams and depressions in the upland. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the surface layer is lighter in color. The plow layer is a mixture of the surface layer and the brown upper part of the subsoil.

Included with this soil in mapping are small areas where slopes are 12 to 18 percent and a few areas where slopes are more than 25 percent. Severely eroded areas ½ acre to 2 acres in size are identified by spot symbols on the soil map. In some uneroded areas, especially those in woodland, nearly all the surface layer remains. Gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map.

Erosion is a serious hazard and slope a limitation on this Miami soil. Runoff is very rapid. Maintaining tilth is a management need.

Most areas are used for pasture or woodland. A few areas are used for crops or are idle. Limitations are severe for most nonfarm uses. Capability unit VIe–1; woodland group 1r2.

**MgC3—Miami clay loam, 6 to 12 percent slopes, severely eroded.** This soil occupies irregularly shaped knolls and long, narrow breaks along drainageways and depressions in the upland. Slopes are commonly less than 200 feet long. Most areas are 2 to 30 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the plow layer is mostly brown clay loam.

Included with this soil in mapping are small moderately eroded areas where the plow layer is a mixture of the original surface layer and the upper part of the subsoil and a few small areas where slopes are 12 to 18 percent. In a few places the moderately alkaline substratum is exposed at the surface. Gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map. Also included are a few uneroded areas that are used for woodland.

Erosion is a serious hazard on this Miami soil. The soil has poor tilth and is difficult to work. It is sticky when wet and hard and cloddy when dry. Productivity is commonly low. Runoff is rapid. Maintaining tilth is a management need.

This soil is well suited to hay, pasture, small grain, or woodland. Most areas are used for corn, soybeans,

or for grasses and legumes for hay or pasture; Limitations are moderate for most nonfarm uses. Capability unit IVe–1; woodland group 1o1.

**MgD3—Miami clay loam, 12 to 18 percent slopes, severely eroded.** This soil occupies irregularly shaped knolls and long, narrow breaks along drainageways and depressions in the upland. Slopes are generally less than 100 feet long. Most areas are 2 to 25 acres in size. The profile of this soil is similar to the one described as representative of the series, but most of the surface layer and, in places, part of the subsoil have been removed by erosion. The plow layer is mainly the upper part of the subsoil.

Included with this soil in mapping are small moderately eroded areas where the plow layer is a mixture of the original surface layer and the upper part of the subsoil, some small areas where slopes are 6 to 12 percent, and some larger areas where slopes are 18 to 30 percent. The moderately alkaline substratum is exposed at the surface in a few places. Gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map. Also included are some areas of woodland where the surface layer is uneroded.

Erosion is a serious hazard and slope a limitation on this Miami soil. The soil has poor tilth and is difficult to work. It is sticky when wet and hard and cloddy when dry. Productivity is commonly low. Runoff is very rapid. Maintaining tilth is a very important management need.

This soil is well suited to hay, pasture, and woodland. Most areas are used for pasture or hay or are idle. A few areas are used occasionally for corn, soybeans, and small grain. Limitations are severe for most nonfarm uses. Capability unit VIe–1: woodland group 1o1.

**MhA—Miami loam, gravelly substratum, 0 to 2 percent slopes.** This soil is on broad flats in the upland. Areas are large and irregular in shape and re between shallow, narrow and elongated, slightly depressed areas and potholes. Most are 50 to 500 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is somewhat darker in color and thicker and the soil is underlain with sand and gravelly sand below a depth of 4 feet.

Included with this soil in mapping are small, elongated depressional areas and potholes of Parr loam. Also included are small, narrow breaks along depressions and around potholes where slopes are 2 to 6 percent. In some areas the solum is 42 to 54 inches thick. Potholes ½ acre to 2 acres in size are identified by spot symbols on the soil map.

Runoff is slow. Maintaining tilth is a management need.

This soil is suited to row crops year after year. Most areas are used for corn, soybeans, and small grain. Limitations are slight or moderate for most nonfarm uses. Capability unit I–1; woodland group 1o1.

**MhB2—Miami loam, gravelly substratum, 2 to 6 percent slopes, eroded.** This soil occupies long, narrow breaks around shallow potholes and along drainageways and depressions and irregularly shaped knolls of the upland. Slopes are generally less than 100 feet long. Most areas are 2 to 10 acres in size. This soil has a profile similar to the one described as representative of the series, but it is underlain by sand and gravelly sand below a depth of 4 feet.

Included with this soil in mapping are small areas of Parr loam in potholes and elongated depressional areas. In some moderately eroded areas the plow layer is a mixture of the surface layer and the brown upper part of the subsoil.

Erosion is a hazard on this Miami soil. Runoff is rapid. Maintaining tilth is a management need.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain. A few areas are used for hay and pasture. Limitations are slight or moderate for most nonfarm uses. Capability unit IIe–1; woodland group 1o1.

## Milford Series

The Milford series consists of deep, nearly level, poorly drained, moderately fine textured soils. They formed in moderately fine textured and fine textured sediment that settled out of still water. They occupy flats and depressions of the uplands and outwash plains. The native vegetation was water-tolerant hardwood trees.

In a representative profile the surface layer is 11 inches of very dark gray silty clay loam and light silty clay. The subsoil is about 38 inches thick. In sequence from the top, it is 5 inches of very firm, dark gray silty clay loam; 10 inches of very firm, dark gray silty clay mottled with yellowish brown and reddish brown; 7 inches of very firm, dark gray silty clay mottled with yellowish brown; 11 inches of very firm, gray silty clay mottled with reddish brown and brown; and 5 inches of very firm, gray light silty clay mottled with yellowish brown. The substratum to a depth of about 63 inches is gray silty clay loam and thin strata of silt loam, sandy loam, and silty clay mottled with yellowish brown.

Permeability is moderately slow, and the available water capacity is high. The content of organic matter is high. Runoff is very slow. Some areas are ponded. Wetness is a serious limitation. The seasonal high water is at or near the surface.

Drained areas of these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Undrained areas are suitable for pasture and woodland.

Representative profile of Milford silty clay loam in a cultivated field, 920 feet south and 225 feet east of the center of sec. 4, T. 34 N., R. 11 E.

Ap—0 to 7 inches; very dark gray (10YR 3/1) silty clay loam, grayish brown (2.5Y 5/2) dry; moderate very fine angular blocky and subangular blocky structure; firm; many roots; neutral; abrupt smooth boundary.

A12—7 to 11 inches; very dark gray (10YR 3/1) light silty clay, grayish brown (2.5Y 5/2) dry; moderate very fine angular blocky and subangular blocky structure; firm; many roots; neutral; clear smooth boundary.

B1g—11 to 16 inches; dark gray (10YR 4/1) silty clay loam; moderate fine and medium angular blocky structure; very firm; few roots; thin very dark gray (10YR 3/1) organic coatings; neutral; clear smooth boundary.

B21g—16 to 26 inches; dark gray (5Y 4/1) silty clay; common fine prominent reddish brown (5YR 4/4) mottles and few fine distinct yellowish brown (10YR 5/4) mottles; moderate medium and coarse angular

blocky structure; very firm; thin very dark gray (10YR 3/1) clay and organic coatings on some faces of peds; few iron- and manganese-oxide concretions; neutral; gradual smooth boundary.

B22g—26 to 33 inches; dark gray (5Y 4/1) silty clay; common fine distinct yellowish brown (10YR 5/4) mottles; moderate medium and coarse prismatic structure parting to moderate medium and coarse angular blocky; very firm; few thin dark gray (5Y 4/1) clay and organic coatings on some vertical faces of peds; neutral; gradual smooth boundary.

B23g—33 to 44 inches; gray (5Y 5/1) silty clay; few fine prominent reddish brown (5YR 4/4) mottles and many fine prominent brown (7.5YR 4/4) mottles; moderate medium and coarse prismatic structure parting to moderate medium and coarse angular blocky; very firm; few iron- and manganese-oxide concretions; neutral; gradual smooth boundary.

B3g—44 to 49 inches; gray (5Y 5/1) light silty clay; common fine distinct yellowish brown (10YR 5/4) mottles; weak medium and coarse prismatic structure parting to moderate coarse angular blocky and subangular blocky; very firm; neutral; gradual smooth boundary.

C—49 to 63 inches; gray (5Y 5/1) silty clay loam with thin strata of silt loam, sandy loam, and silty clay; few fine distinct yellowish brown (10YR 5/4) mottles; massive; friable; strong effervescence; mildly alkaline.

The solum ranges from 40 to 55 inches in thickness. The Ap and A12 horizons are 11 to 15 inches thick and are very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or black (10YR 2/1). The B21g, B22g, and B23g horizons are heavy silty clay loam, silty clay, or light silty clay. The C horizon is dominantly silty clay loam and lesser amounts of silty clay, silt loam, loam, and fine sandy loam.

Milford soils are similar to Toledo and Pewamo soils. They have a coarser textured substratum than Toledo soils. Pewamo soils contain pebbles in the solum, whereas Milford soils do not.

**Mn—Milford silty clay loam.** This soil occupies broad flats and depressions of the uplands and outwash plains. Slopes are 0 to 2 percent. Most areas are irregular in shape and are 5 to 60 acres in size.

Included with this soil in mapping are areas where the surface layer is silt loam. Areas ½ acre to 2 acres in size that are too wet for commonly grown crops are identified by spot symbols on the soil map. The dark surface layer is 8 to 11 inches thick in places. In some areas along Little Cedar Creek, sand and gravelly sand strata are below a depth of 42 inches. Also included are small areas of Blount silt loam on low rises and adjacent flats and a few narrow, elongated areas of Washtenaw silt loam at the base of adjacent eroded slopes.

Wetness is a serious limitation on this Milford soil. Drainage is needed if the soil is cropped. The soil becomes hard and cloddy if worked when wet. Maintaining tilth is a management need.

This soil is suited to row crops year after year. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Some undrained areas are used for woodland. Capability unit IIw–1; woodland group 2w11.

## Morley Series ✓

The Morley series consists of deep, moderately well drained, or well drained, medium textured and moderately fine textured soils. These soils formed in moderately fine textured glacial till. They occupy knolls, ridges, and breaks along drainageways and depressions in the upland. They are gently sloping to moderately steep. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 7 inches of dark grayish brown silt loam. The subsurface layer is 2 inches of dark grayish brown silt loam. The subsoil is about 30 inches thick. In sequence from the top, it is 3 inches of firm, yellowish brown heavy clay loam; 18 inches of very firm, brown clay mottled with yellowish brown; and 9 inches of firm, brown clay loam mottled with yellowish brown. The substratum to a depth of about 60 inches is brown clay loam mottled with yellowish brown and light brownish gray.

Permeability is slow, and the available water capacity is high. The content of organic matter is mostly moderate, but in severely eroded areas it is low. Runoff is rapid or very rapid depending on slope. The plow layer becomes very compact and difficult to work if these soils are cultivated or are trampled by livestock when wet. Maintaining tilth and organic matter are management needs. Erosion is a hazard. Lateral seepage causes wet spots on slopes.

Where slopes are 2 to 12 percent, these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Where slopes are more than 12 percent, the soils are better suited to hay, pasture, or woodland.

Representative profile of Morley silt loam, 2 to 6 percent slopes, eroded, in a cultivated field, 20 feet east and 725 feet south of the center of sec. 14, T. 33 N., R. 11 E.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam; moderate fine and medium granular structure; friable; neutral; abrupt smooth boundary.

A2—7 to 9 inches; dark grayish brown (10YR 4/2) silt loam; weak thick platy structure parting to moderate medium granular; friable; neutral; clear wavy boundary.

B21t—9 to 12 inches; yellowish brown (10YR 5/4) heavy clay loam; moderate fine angular and subangular blocky structure; firm; dark brown (10YR 3/3) clay films on most faces of peds; thin discontinuous brown (10YR 5/3) silt or very fine sand coatings on peds; few small pebbles; medium acid; clear wavy boundary.

B22t—12 to 17 inches; brown (10YR 4/3) clay; few fine distinct yellowish brown (10YR 5/6) mottles; moderate fine and medium angular blocky structure; very firm; thick dark brown (10YR 3/3) clay films on most faces of peds; few small pebbles; medium acid; clear smooth boundary.

B23t—17 to 30 inches; brown (10YR 4/3) clay; common fine distinct yellowish brown (10YR 5/6) mottles; moderate medium angular blocky structure; very firm; thick dark brown (10YR 3/3) clay films on most faces of peds; few small pebbles; slightly acid; clear smooth boundary.

B3t—30 to 39 inches; brown (10YR 5/3) clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to moderate coarse subangular blocky; firm; dark brown (10YR 3/3) clay films on most vertical faces of peds and in linings of vertical cracks; grayish brown (10YR 5/2) lime nodules; few small pebbles; mildly alkaline; gradual wavy boundary.

C—39 to 60 inches; brown (10YR 5/3) clay loam; common fine distinct yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) mottles; massive; firm; common fine pebbles; strong effervescence; moderately alkaline.

The solum ranges from 24 to 42 inches in thickness. The A horizon ranges from 8 to 12 inches in thickness. The Ap horizon is dark grayish brown (10YR 4/2) or brown (10YR 4/3) unless severely eroded. In cultivated areas, the A2 horizon is mixed with the Ap horizon. The B21t, B22t, and

B23t horizons are heavy silty clay loam, heavy clay loam, silty clay, or clay. They are 35 to 50 percent clay in the finest textured part. Some pedons do not have a B3 horizon. In some pedons the B3 horizon is mottled with grayish brown (10YR 5/2) or light brownish gray (10YR 6/2). Some pedons have no light colored mottles throughout the solum. The C horizon is silty clay loam or clay loam.

Morley soils are associated with Miami and Rawson soils. They contain more clay throughout the solum than Miami soils and more clay in the surface layer and upper part of the subsoil than Rawson soils.

**MrB2—Morley silt loam, 2 to 6 percent slopes, eroded.** This soil is on long, narrow breaks along drainageways and depressions and on irregularly shaped knolls and ridgetops in the upland. Most areas are 5 to 80 acres in size. Slopes are mostly complex and undulating. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are long, narrow areas of Blount silt loam in drainageways. In some areas west of Albion and in an area of several square miles in northeastern Washington Township, Morley soils are underlain at a depth of 5 to 10 feet by sand and gravelly sand strata. These areas are gently undulating plains with many well drained potholes. The major potholes are identified by spot symbols on the soil map. Areas of ½ acre to 2 acres where the surface layer is sand or loamy sand and severely eroded areas, also ½ acre to 2 acres in size, are identified by spot symbols on the soil map. In places the surface layer is loam. Also included are small areas of Rawson loam.

Erosion is a hazard on this Morley soil. Runoff is rapid.

This soil is suitable for row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are moderate or severe for most nonfarm uses. Capability unit IIe–6; woodland group 1o1.

**MrC2—Morley silt loam, 6 to 12 percent slopes, eroded.** This soil occupies the long, narrow breaks along drainageways or depressions and around potholes and the irregularly shaped knolls in the uplands. Slopes are convex and are less than 200 feet long. Most areas are 5 to 80 acres. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are somewhat thinner. The plow layer is a mixture of the original surface layer and the yellowish brown upper part of the subsoil.

Some severely eroded areas of ½ acre to 2 acres, identified by spot symbols on the soil map, have a yellowish brown silty clay loam plow layer. Other areas, particularly those in woods, are not eroded. Spot symbols also identify areas of ½ acre to 2 acres where the surface layer is sand or loamy sand. In some places west of Albion and in an area in southeastern Washington Township, Morley soils are underlain at a depth of 4 to 10 feet by sand and gravelly sand. These areas are undulating plains with many well drained potholes, which are identified by spot symbols on the soil map. Gullies 1 foot to 2 feet or more deep are also identified by spot symbols. Also included are small areas particularly on ridgetops where slopes are 2 to 6 percent. In some areas the surface layer is loam and the upper part of the subsoil is clay loam.

Erosion is a serious hazard. Runoff is rapid. Limitations for most nonfarm uses are moderate or severe.

This soil is suited to row crops occasionally if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Capability unit IIIe–6; woodland group 1o1.

**MrD2—Morley silt loam, 12 to 18 percent slopes, eroded.** This soil occupies the long, narrow breaks along drainageways and depressions and the irregularly shaped knolls in the upland. Most areas are 3 to 80 acres. Slopes are generally less than 100 feet long. In the areas southwest, south, and southeast of Albion, however, longer slopes are common. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner. The plow layer is a mixture of the original surface layer and the yellowish brown upper part of the subsoil.

Included in mapping are small areas typically on the tops of knolls where slopes are 2 to 12 percent. Some small severely eroded areas of ½ acre to 2 acres, identified by spot symbols on the soil map, have a yellowish brown silty clay loam plow layer. Other areas, particularly those in woods, are not eroded. West of Albion, some areas are underlain by sand and gravelly sand at a depth of 4 to 10 feet. The surface layer is loam in a few places.

Erosion is a serious hazard, and slope is a limitation. Runoff is very rapid. Limitations are severe for most nonfarm uses.

This soil is well suited to hay or pasture and to woodland. Most areas are used for hay and pasture and woodland. Some are used occasionally for corn, soybeans, and small grain. Capability unit IVe–6; woodland group 1o1.

**MsC3—Morley silty clay loam, 6 to 12 percent slopes, severely eroded.** This soil occupies narrow breaks along drainageways or depressions and irregularly shaped knolls in the uplands. Slopes are generally less than 100 feet long, but in areas south, southwest, and southeast of Albion they are longer. Most areas are 3 to 80 acres in size. The profile of this soil is similar to the one described as representative of the series, but most of the surface layer and, in some places, some of the subsoil have been removed by erosion. Horizons above the substratum are thinner. The plow layer is mainly the yellowish brown silty clay loam subsoil.

Included with this soil in mapping are small, less eroded areas where the surface layer is silt loam. In a few places the calcareous substratum is at the surface. A few gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map. Also included are small areas on the top of knolls where slopes are 2 to 6 percent.

Erosion is a serious hazard on this Morley soil. The soil has poor tilth and is difficult to work. It is sticky when wet and hard and cloddy when dry. Productivity is commonly low. Runoff is rapid.

This soil is suited occasionally to row crops if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. The soil is best suited to hay, pasture, or woodland. Limitations are moderate or severe for

most nonfarm uses. Capability unit IVe–6; woodland group 1o1.

**MsD3—Morley silty clay loam, 12 to 18 percent slopes, severely eroded.** This soil occupies narrow breaks along drainageways and depressions and irregularly shaped knolls in the uplands. Slopes are convex. They are generally less than 100 feet long, but in areas south, southeast, and southwest of Albion they are longer. Most areas are 2 to 60 acres in size. The profile of this soil is similar to the one described as representative of the series, but most of the surface layer and, in places, some of the subsoil have been removed by erosion. Horizons above the substratum are thinner. The plow layer is mainly the yellowish brown silty clay loam subsoil.

Included with this soil in mapping are small areas where the surface layer is silt loam. In a few places the calcareous substratum is at the surface. Gullies 1 foot to 2 feet or more deep are identified by spot symbols on the soil map. Also included are a few, small, uneroded areas that are used for woodland; some areas where slopes are 2 to 12 percent; and small areas, commonly at the tops of knolls, where slopes are 2 to 6 percent.

Erosion is a serious hazard and slope a limitation on this Morley soil. The soil has poor tilth and is difficult to work. It is sticky when wet and hard and cloddy when dry. Productivity is generally low. Runoff is very rapid.

This soil is well suited to meadow, pasture, and woodland. Most areas are used for pasture or hay or are idle, but a few areas are used occasionally for corn, soybeans, and small grain. Limitations are severe for most nonfarm uses. Capability unit VIe–1; woodland group 1o1.

**MtE—Morley soils, 18 to 25 percent slopes.** This mapping unit occupies narrow breaks along depressions and drainageways and irregularly shaped knolls and ridges in the upland. Slopes are mainly convex. Most areas are 5 to 60 acres in size. These soils have profiles similar to the ones described as representative of the series, but the surface layer and subsoil are thinner. In severely eroded areas, the plow layer is mainly the yellowish brown silty clay loam subsoil. In some uneroded areas, especially in woodland, most of the original surface layer remains. In other areas the plow layer is a mixture of the surface layer and the subsoil.

Included with this unit in mapping are a few small areas of Morley soils, commonly on the top of knolls, where slopes are 3 to 12 percent; several areas where slopes are 25 to 35 percent; and a few areas where slopes are as much as 50 percent. In some places the surface layer is loam. In a few, the calcareous clay loam substratum is at the surface. Gullies 1 foot to 2 feet deep are identified by spot symbols on the soil map.

Erosion is a serious hazard and slope a limitation. Runoff is very rapid. Productivity is commonly low. Maintaining tilth and the supply of organic matter are management needs.

This mapping unit is well suited to pasture and woodland. Most areas are used for pasture or woodland or are idle. Limitations are severe for most nonfarm uses. Capability unit VIe–1; woodland group 1r2.

**MuC2—Morley, Miami, and Rawson loams, 6 to 12 percent slopes, eroded.** This mapping unit is on undulating, glacial till planes. It is on irregularly shaped knolls and on narrow breaks along drainageways and depressions in the upland. The unit is between broad areas of soils that formed mainly in medium textured glacial till and those that formed in moderately fine textured glacial till.

Of the total acreage of this mapping unit, about 40 percent is Morley loam, 30 percent is Miami loam, 20 percent is Rawson loam, and 10 percent is soils of minor extent. These soils occur in complex patterns, and any mapped area can contain one or two or all three soils. The Morley, Miami, and Rawson soils have profiles similar to the ones described as representative of their respective series, but the surface layer of Morley soils is mainly loam.

Included with this unit in mapping are small areas of Morley soils where the surface layer is silt loam. Severely eroded areas ½ acre to 2 acres in size where the surface layer is clay loam or silty clay loam are identified by spot symbols on the soil map.

Erosion is a hazard. Runoff is rapid. Maintaining tilth and the supply of organic matter are management needs.

This mapping unit is suited to occasional row crops if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are moderate or severe for most nonfarm uses. Capability unit IIIe–6; woodland group 1o1.

## Oshtemo Series

The Oshtemo series consists of deep, well drained, moderately coarse textured or coarse textured soils. These soils formed in moderately coarse textured glacial outwash. They occupy the broad flats or breaks around potholes and along drainageways or depressions on outwash plains or the knolls in the upland. They are nearly level to moderately sloping. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 10 inches of dark brown loamy sand. The subsurface layer is 8 inches of brown loamy sand. The subsoil is about 35 inches thick. In sequence from the top, it is 5 inches of very friable, dark brown sandy loam; 3 inches of friable, dark brown light sandy clay loam; and 27 inches of very friable, yellowish brown loamy sand that has 8 inches of dark brown sandy loam in ½- to 1½-inch strata. The substratum to a depth of about 60 inches is brown, stratified sand and gravelly sand.

Permeability is moderately rapid, and the available water capacity is moderate. The content of organic matter is moderate or low. Droughtiness is a limitation. Erosion is a hazard on sloping soils. Maintaining the supply of organic matter is a management need.

These soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Because of droughtiness, crops that mature early in the season are better suited than other crops.

Representative profile of Oshtemo loamy sand, 2 to 6 percent slopes, in a cultivated field, 100 feet east

This soil is suited to row crops year after year. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Undrained areas provide habitat for wildlife or are used for woodland or pasture. Limitations are severe for most nonfarm uses. Capability unit IIw–1; woodland group 2w11.

## Rawson Series

The Rawson series consists of deep, well drained and moderately well drained, medium textured and moderately coarse textured soils. These nearly level to moderately sloping soils are on knolls in the upland and on outwash plains. They formed in medium textured or moderately coarse textured glacial drift and in the underlying fine textured or moderately fine textured glacial till or sediment. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 8 inches of dark grayish brown loam. The subsurface layer is 2 inches of grayish brown loam. The subsoil is about 30 inches thick. In sequence from the top, it is 4 inches of friable, brown heavy loam; 8 inches of firm, yellowish brown clay loam; 10 inches of firm, dark yellowish brown clay loam mottled with yellowish brown; and 8 inches of very firm, dark yellowish brown clay mottled with yellowish brown. The substratum to a depth of about 60 inches is brown clay loam mottled with yellowish brown and light brownish gray.

Permeability is moderate in the upper part and slow or very slow in the lower part. The available water capacity is high. The content of organic matter is moderate. Runoff is slow to rapid depending on slope. Erosion is a hazard in sloping areas. Lateral seepage causes wet spots near the base of slopes. Maintaining the supply of organic matter is a management need.

These soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture.

Representative profile of Rawson loam, 2 to 6 percent slopes, in a cultivated field, 100 feet east and 125 feet south of the center of sec. 4, T. 34 N., R. 11 E.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) loam; light brownish gray (10YR 6/2) dry; moderate fine and medium granular structure; friable; slightly acid; abrupt smooth boundary.

A2—8 to 10 inches; grayish brown (10YR 5/2) loam; weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—10 to 14 inches; brown (10YR 5/3) heavy loam; weak fine subangular blocky structure; friable; few fine pebbles; medium acid; clear wavy boundary.

B21t—14 to 22 inches; yellowish brown (10YR 5/4) clay loam; moderate medium subangular blocky structure; firm; few fine pebbles; thin dark yellowish brown (10YR 4/4) clay films on most faces of peds; medium acid; gradual wavy boundary.

B22t—22 to 32 inches; dark yellowish brown (10YR 4/4) clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; moderate medium and coarse subangular blocky structure; firm; few fine pebbles; thin dark brown (10YR 3/3) clay films on most faces of peds; slightly acid; clear wavy boundary.

IIB23t—32 to 40 inches; dark yellowish brown (10YR 4/4) clay; few fine faint yellowish brown (10YR 5/6) mottles; moderate medium and coarse subangular blocky structure; very firm; few fine pebbles; dark brown (7.5YR 4/4) clay films on most vertical faces of peds; slightly acid grading to neutral in the lower part; gradual wavy boundary.

IIC—40 to 60 inches; brown (10YR 5/3) clay loam; few fine distinct yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) mottles; massive; firm; few fine pebbles; strong effervescence; moderately alkaline.

The solum ranges from 30 to 42 inches in thickness. The Ap horizon is dark brown (10YR 4/3), dark grayish brown (10YR 4/2), or brown (10YR 5/3) loam or sandy loam. In some pedons the A2 horizon has been mixed with the Ap horizon by cultivation. Some pedons do not have a B1 horizon. The B21t and B22t horizons are dark brown (10YR 4/3 or 7.5YR 4/4) dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4) heavy loam, sandy clay loam, or clay loam. The IIB23t horizon is dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4), or pale brown (10YR 6/3) silty clay to clay. In some pedons the B22t and IIB23t horizons are mottled with grayish brown (10YR 5/2) or light brownish gray (10YR 6/2). The IIC horizon is clay, clay loam, or silty clay loam. It is moderately fine textured glacial till or fine textured to moderately fine textured sediment.

Rawson soils are associated with Morley and Miami soils. They contain less clay in the surface layer and upper part of the subsoil than Morley soils and more clay in the lower part of the subsoil and in the substratum than Miami soils.

**RaB—Rawson sandy loam, 2 to 6 percent slopes.** This gently undulating soil occupies narrow breaks along drainageways and irregularly shaped knolls of the upland and outwash plains. Most areas are 3 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is sandy loam and the upper part of the subsoil is sandy clay loam.

Included with this soil in mapping are areas where erosion has removed 3 to 5 inches of the surface layer and the plow layer is a mixture of the original surface layer and the brown upper part of the subsoil. In a few small areas the surface layer is loam. In some spots the surface layer is loam and the subsoil is silty clay or clay. Also included are small areas of Haskins loam in narrow drainageways. In some areas a few pebbles and small stones are on the surface and are mixed throughout the profile. Near Bakerstown and north of Big Lake there are several areas 3 to 20 acres in size where the upper part of the subsoil is sandy loam. The gently sloping soils in these areas are on irregularly shaped, low rises. They are somewhat droughty, especially for shallow-rooted crops, and yields are lower during prolonged periods of low rainfall.

Erosion is a hazard on this Rawson soil. Runoff is medium. Lateral seepage causes wet spots near the base of slopes.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are moderate or severe for most nonfarm uses. Capability unit IIe–5; woodland group 1o1.

**RaC2—Rawson sandy loam, 6 to 12 percent slopes, eroded.** This soil occupies narrow breaks along drainageways and irregularly shaped knolls in the upland. Slopes are generally about 50 to 100 feet long. Most areas are 2 to 10 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is sandy loam and the upper part of the subsoil is sandy clay loam. Also, 3 to 6 inches of the surface layer has been removed by erosion, and the plow layer is grayish brown.

Included with this soil in mapping are some small areas where the surface layer is loam and the subsoil is silty clay or clay. Some small areas, especially in woodland, are not eroded. In some areas the surface layer is loam and the upper part of the subsoil is clay loam. In others, a few pebbles and small stones are on the surface and are mixed throughout the profile. Severely eroded areas ½ acre to 2 acres in size are identified by spot symbols on the soil map.

Erosion is a hazard on this Rawson soil. Runoff is rapid. Lateral seepage causes wet spots near the base of slopes.

This soil is suited occasionally to row crops if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Some areas are used for woodland. Limitations are moderate or severe for most nonfarm uses. Capability unit IIIe–5; woodland group 1o1.

**RbA—Rawson loam, 0 to 2 percent slopes.** This gently undulating soil occupies irregularly shaped areas on ridgetops and knolls of the upland and outwash plains. On the plains, slopes are dominantly 1 to 2 percent. Most areas are 2 to 10 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsurface layer are somewhat thicker.

Included with this soil in mapping are some long, narrow areas of Haskins loam in shallow drainageways and small areas of Morley silt loam. Areas ½ acre to 2 acres in size where the surface layer is sand or loamy sand are identified by spot symbols on the soil map. In places a few pebbles and small stones are on the surface and are mixed throughout the profile. In a few areas near Bakerstown and north of Big Lake, the surface layer is sandy loam and the upper part of the subsoil is heavy sandy loam and sandy clay loam.

This Rawson soil has no limitations or hazards that affect use for crops. Runoff is slow.

This soil is suited to row crops each year. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are moderate or severe for most nonfarm uses. Capability unit I–1; woodland group 1o1.

**RbB—Rawson loam, 2 to 6 percent slopes.** This gently undulating soil occupies narrow breaks along drainageways and irregularly shaped knolls in the upland and on outwash plains. Most areas are 3 to 20 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are long, narrow areas of Haskins loam in drainageways and small areas of Morley loam. Erosion has removed about 3 to 5 inches of the surface layer in some places, and the plow layer is a mixture of the original surface layer and the brown upper part of the subsoil. In some areas west of Albion, the soil is underlain at a depth of 5 to 10 feet by sand and gravelly sand. In places a few pebbles and cobblestones are on the surface and are mixed throughout the profile.

Erosion is a hazard on this Rawson soil. Runoff is medium. Lateral seepage causes wet spots near the base of some slopes.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain or for grasses and legumes for hay or pasture. Limitations are moderate or severe for most nonfarm uses. Capability unit IIe–1; woodland group 1o1.

**RdB2—Rawson, Morley, and Miami loams, 2 to 6 percent slopes, eroded.** This undulating or gently sloping mapping unit is on irregularly shaped knolls and ridgetops on glacial till plains of the upland. It occupies areas between soils that formed mainly in medium textured glacial till and those formed in moderately fine textured glacial till.

Of the total acreage of this mapping unit, about 40 percent is Rawson loam, 20 percent is Morley loam, 20 percent is Miami loam, and 20 percent is soils of minor extent. These soils are in a complex pattern, and any mapped area can contain one or two or all three soils. The Miami, Morley, and Rawson soils have profiles similar to the ones described as representative of their respective series, but the surface layer of Morley soils is loam.

Included with this unit in mapping are a few areas of Morley silt loam and small areas of Crosier loam and Haskins loam in drainageways. Severely eroded areas ½ acre to 2 acres in size are identified by spot symbols on the soil map. Some areas, especially in woodland, are not eroded. In many areas pebbles and a few small stones are on the surface and are mixed throughout the profile.

Erosion is a hazard. Runoff is rapid. Maintaining tilth and the supply of organic matter are management needs.

This mapping unit is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and small grain and for grasses and legumes for hay and pasture. Limitations are slight to severe for most nonfarm uses. Capability unit IIe–1; woodland group 1o1.

## Rensselaer Series

The Rensselaer series consists of deep, very poorly drained, medium textured soils. These nearly level soils occupy depressions in the upland or outwash plains. They formed in medium textured and moderately coarse textured sediment in glacial drainageways. The native vegetation was water-tolerant hardwood trees.

In a representative profile the surface layer is 13 inches of very dark grayish brown loam and very dark gray heavy loam. The subsoil is about 29 inches thick. In sequence from the top, it is 5 inches of friable, gray heavy loam mottled with yellowish brown; 7 inches of firm, gray clay loam mottled with strong brown and dark yellowish brown; 13 inches of firm, gray clay loam mottled with strong brown and brown; and 4 inches of very friable, gray heavy sandy loam mottled with brown and yellowish brown. The substratum to a depth of about 60 inches is light brownish gray, stratified fine sand, silt, and sandy loam mottled with olive yellow and yellowish brown.

Permeability is slow, and the available water capacity is high. The content of organic matter is high. Runoff is very slow. Some areas are ponded. Wetness is a serious limitation. The seasonal high water table is at or near the surface.

Drained areas of these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Undrained areas are suitable for pasture or woodland.

Representative profile of Rensselaer loam in a cultivated field, 2,440 feet south and 50 feet west of the northeast corner of sec. 33, T. 35 N., R. 10 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; neutral; abrupt smooth boundary.

A12—8 to 13 inches; very dark gray (10YR 3/1) heavy loam, grayish brown (10YR 5/2) dry; moderate medium granular structure; friable; neutral; clear smooth boundary.

B21tg—13 to 18 inches; gray (5Y 5/1) heavy loam; common fine prominent yellowish brown (10YR 5/4) mottles; weak fine subangular blocky structure; friable; common discontinuous distinct dark gray (5Y 4/1) clay films on faces of peds and in linings of voids; neutral; clear wavy boundary.

B22tg—18 to 25 inches; gray (5Y 5/1) clay loam; common fine prominent strong brown (7.5YR 5/6) mottles and few fine prominent dark yellowish brown (10YR 4/4) mottles; moderate fine and medium subangular blocky structure; firm; many continuous prominent dark gray (5Y 4/1) clay films on most faces of peds and in linings of voids; neutral; gradual wavy boundary.

B23tg—25 to 38 inches; gray (5Y 5/1) clay loam; many fine prominent strong brown (7.5YR 5/6) mottles and few fine prominent brown (7.5YR 4/4) mottles; moderate coarse subangular blocky structure; firm; common discontinuous distinct dark gray (5Y 4/1) clay films on peds and in linings of voids; few black (10YR 2/1) iron- and manganese-oxide concretions; neutral; very wavy boundary.

IIB3g—38 to 42 inches; gray (5Y 5/1) heavy sandy loam; common fine prominent brown (7.5YR 4/4) and yellowish brown (10YR 5/4) mottles; weak coarse subangular blocky structure; very friable; neutral; clear wavy boundary.

IIC—42 to 60 inches; light brownish gray (2.5Y 6/2) stratified fine sand, silt, and sandy loam; many fine prominent olive yellow (2.5Y 6/8) mottles and few fine prominent yellowish brown (10YR 5/6) mottles; massive; very friable; strong effervescence; moderately alkaline.

The solum ranges from 36 to 48 inches in thickness. The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1) and is 10 to 18 inches thick. Some pedons have a B1g horizon. The B22tg and B23tg horizons are gray (5Y 5/1) or dark gray (5Y 4/1). Some pedons do not have a IIB3g horizon. Part of the B2 horizon is silty clay loam, sandy clay loam, or loam in some pedons. The C horizon is stratified silt, fine sand, silt loam, and loam and minor strata of light clay loam and sandy loam.

Rensselaer soils are similar to and commonly associated with Brookston and Sebewa soils. They typically are coarser textured and are more stratified in the substratum than Brookston soils and contain fewer pebbles and a lesser amount of coarse sand in the subsoil and in the substratum than Sebewa soils.

**Re—Rensselaer loam.** This soil occupies broad depressional areas of the upland and outwash plains. Slopes are 0 to 2 percent. Most areas are irregular in shape and are 10 to 60 acres in size.

Included with this soil in mapping are small areas of Whitaker loam on low rises and adjacent flats. In a few long strips at the edge of broad depressional areas, the surface layer is fine sandy loam. In some areas the surface layer is silt loam. In some, the subsoil is as much as 5 percent gravel. In a few, the upper part of the subsoil is silty clay. The surface layer is mucky loam in the lowest part of some depressions. Along Little Cedar Creek this soil is underlain by sand and gravelly sand below a depth of 60 inches. Areas ½ acre to 2 acres in size that are too wet for commonly grown crops and areas 1 acre to 5 acres in size where the surface layer is limy, sandy or loamy material are identified by spot symbols on the soil map.

Wetness is a serious limitation on this Rensselaer soil. Drainage is needed.

This soil is suited to row crops each year. Most areas are used for corn, soybeans, and wheat or for grasses and legumes for hay or pasture. A few areas are used for woodland. Limitations are severe for most nonfarm uses. Capability unit IIw–1; woodland group 2w11.

## Riddles Series

The Riddles series consists of deep, well drained, moderately coarse textured soils. These nearly level to strongly sloping soils occupy flats and knolls or breaks along drainageways and depressions in the upland. They formed in medium textured glacial drift and in the underlying medium textured glacial till. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is about 9 inches of dark grayish brown sandy loam. The subsurface layer is about 5 inches of brown heavy sandy loam. The subsoil is about 8 inches thick. The upper 33 inches is firm, dark yellowish brown clay loam, and the lower 5 inches is friable, dark yellowish brown sandy clay loam. The substratum to a depth of about 72 inches is yellowish brown loam.

Permeability is moderate, and the available water capacity is high. The content of organic matter is moderate. Runoff is slow to very rapid, depending on slope. Erosion is a hazard on sloping soils. Maintaining the supply of organic matter is a management need.

Where slopes are 0 to 12 percent, these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Where slopes are more than 12 percent, they are better suited to hay, pasture, or woodland.

Representative profile of Riddles sandy loam, 2 to 6 percent slopes, in a cultivated field, 1,300 feet east and 225 feet south of the northwest corner of sec. 16, T. 35 N., R. 9 E.

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) sandy loam; moderate fine granular structure; friable; common pebbles and few small stones; slightly acid; abrupt smooth boundary.

A2—9 to 14 inches; brown (10YR 5/3) heavy sandy loam; weak medium platy structure parting to moderate fine granular; friable; many voids filled with dark grayish brown (10YR 4/2) sandy loam; common pebbles and a few small stones; many clean sand grains on faces of peds; many tubular pores; slightly acid; clear wavy boundary.

B21t—14 to 20 inches; dark yellowish brown (10YR 4/4) clay loam; moderate fine subangular blocky structure; firm; common pebbles and few small stones; common discontinuous distinct thin brown (7.5YR 4/4) clay films on faces of peds; common tubular pores; few clean sand grains on faces of peds; medium acid; clear wavy boundary.

B22t—20 to 34 inches; dark yellowish brown (10YR 4/4) clay loam; moderate fine and medium subangular blocky structure; firm; common pebbles and few small stones; many continuous distinct medium brown (7.5YR 4/4) clay films on faces of peds; medium acid; gradual wavy boundary.

B23t—34 to 47 inches; dark yellowish brown (10YR 4/4) clay loam; moderate medium subangular blocky structure; firm; common pebbles and few small stones; many continuous distinct thin brown (7.5YR 4/4) clay films on faces of peds; medium acid; gradual wavy boundary.

B24t—47 to 52 inches; dark yellowish brown (10YR 4/4) sandy clay loam; weak medium and coarse subangular blocky structure; friable; common pebbles and few small stones; many continuous distinct thin brown (7.5YR 4/4) clay films on most vertical and some horizontal faces of peds; slightly acid grading to neutral in lower part; clear wavy boundary.

C—52 to 72 inches; yellowish brown (10YR 5/4) loam; massive; friable; common pebbles and few small stones; strong effervescence; moderately alkaline.

The solum ranges from 42 to 64 inches in thickness. The content of gravel ranges from 2 to 10 percent. The Ap horizon is dark grayish brown (10YR 4/2) or dark brown (10YR 4/3). In some pedons the A2 horizon has been mixed with the Ap horizon by cultivation. Some pedons have a B1 horizon of brown (10YR 5/3) or yellowish brown (10YR 5/4) loam or light clay loam. The B2t horizon is dominantly clay loam and lesser layers of sandy clay loam and loam. Some pedons have a B3 horizon of brown (10YR 5/3), yellowish brown (10YR 5/4), or dark yellowish brown (10YR 4/4) loam or light clay loam. The C horizon is loam or light clay loam. Some pedons have thin strata or pockets of sand or sand and gravelly sand in the B24t, B3, and C horizons.

Riddles soils are associated with Miami and Metea soils. They have a deeper solum than Miami soils and are finer textured in the A horizon and in the upper part of the B horizon than Metea soils.

**RsA—Riddles sandy loam, 0 to 2 percent slopes.** This soil occupies irregularly shaped areas on knolls and ridgetops in the upland. Most areas are slightly undulating, and slopes are mostly 1 to 2 percent. Most areas are 5 to 40 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is 2 to 3 inches thicker.

Included with this soil in mapping are small areas of Crosier loam in narrow drainageways. In some areas the surface and subsurface layers are loam. Gravel and a few small stones are common on the surface and are mixed throughout the profile. In places pockets and strata of sand and gravel are between the subsoil and loam substratum. Also included are a few areas where the depth to the loamy substratum ranges from 24 to 42 inches.

Droughtiness is a limitation for shallow-rooted crops during prolonged periods of low rainfall. Runoff is slow. The content of organic matter is moderate.

This soil is suited to row crops every year. Most areas are used for corn, soybeans, and wheat or for grasses and legumes for hay or pasture. Limitations are slight or moderate for most nonfarm uses. Capability unit I–3; woodland group 1o1.

**RsB—Riddles sandy loam, 2 to 6 percent slopes.** This soil occupies irregularly shaped knolls and narrow breaks along drainageways and depressions in the upland. Slopes are mostly convex and undulating and are less than 250 feet long. Most areas are 5 to 100 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of Crosier loam in narrow drainageways. In a few areas erosion has removed about 3 to 5 inches of the surface layer and the plow layer is a mixture of the surface layer and the brown upper part of the subsoil. In some areas the surface and subsurface layers are loam. Also included are a few areas where the depth to the loamy substratum ranges from 24 to 42 inches. Areas ¼ acre to 2 acres in size where stones at or near the surface seriously interfere with tillage are identified by spot symbols on the soil map. Gravel and a few small stones are common on the surface and are mixed throughout the profile.

Erosion is a hazard on this Riddles soil. Droughtiness is a limitation for shallow-rooted crops during prolonged periods of low rainfall. The content of organic matter is moderate.

This soil is suited to row crops most of the time if erosion is controlled. Most areas are used for corn, soybeans, and wheat or for grasses and legumes for hay or pasture. A few areas are used for woodland. Limitations are slight or moderate for most nonfarm uses. Capability unit IIe–5; woodland group 1o1.

**RsC2—Riddles sandy loam, 6 to 12 percent slopes, eroded.** This soil occupies irregularly shaped knolls and narrow breaks along drainageways and depressions in the upland. Slopes are generally less than 200 feet long. Most areas are 5 to 40 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is thinner and lighter in color and the subsoil is thinner.

Included with this soil in mapping are some uneroded areas, especially in woodland, where nearly all the surface layer remains and small areas on the top of knolls where slopes are 2 to 6 percent. In some areas the surface and subsurface layers are loam. Also included are a few areas where the depth to the loamy substratum ranges from 24 to 42 inches. Areas ¼ acre to 2 acres in size where stones at or near the surface seriously interfere with tillage are identified by spot symbols on the soil map. Gravel and a few cobblestones are common on the surface and are mixed throughout the profile.

Erosion is a hazard on this Riddles soil. Droughtiness is a limitation, especially for shallow-rooted crops, during prolonged periods of low rainfall. Runoff is rapid. The content of organic matter is moderate.

This soil is suited to row crops if erosion is controlled. Most areas are used for corn, soybeans, and wheat or for grasses and legumes for hay or pasture. Some areas are used for woodland. Limitations are moderate for most nonfarm uses. Capability unit IIIe–5; woodland group 1o1.

**RsD2—Riddles sandy loam, 12 to 18 percent slopes, eroded.** This soil occupies irregularly shaped knolls and narrow breaks along drainageways and depressions in the upland. Slopes are generally less than 150 feet long. Most areas are 5 to 40 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the surface layer is lighter in color.

Included with this soil in mapping are small areas where the loamy substratum is at a depth of 30 to 42 inches. Some areas, especially in woodland, are not eroded and nearly all the surface layer remains. In some areas the surface and subsurface layers are loam. Gravel and a few small stones are common on the surface and are mixed throughout the profile.

Erosion is a hazard on this Riddles soil. Droughtiness is a limitation, especially for shallow-rooted crops,

during prolonged periods of low rainfall. Runoff is very rapid. The content of organic matter is moderate.

This soil is well suited to grasses and legumes for hay or pasture and to woodland. Some areas are not well suited, but are used for corn, soybeans, and wheat. Limitations are severe for most nonfarm uses. Capability unit IVe–5; woodland group 1o1.

## Sebewa Series

The Sebewa series consists of very poorly drained, medium textured soils that are moderately deep over sand and gravelly sand. These soils formed in medium textured glacial outwash. They occupy depressional areas and drainageways on glacial outwash plains. They are nearly level. The native vegetation was water-tolerant, mixed hardwood trees.

In a representative profile the surface layer is 12 inches of very dark gray loam. The subsoil is about 26 inches thick. In sequence from the top, it is 12 inches of firm, gray sandy clay loam mottled with light olive brown and brown; 10 inches of firm, grayish brown sandy clay loam mottled with light olive brown; and 4 inches of friable, gray gravelly sandy clay loam mottled with light olive brown. The substratum to a depth of about 60 inches is light brownish gray sand and gravelly sand.

Permeability and the available water capacity are moderate. The content of organic matter is high. Runoff is very slow. Some areas are ponded. Wetness is a serious limitation. The seasonal high water table is at or near the surface.

Drained areas of these soils are suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Undrained areas are suitable for pasture or woodland.

Representative profile of Sebewa loam in a cultivated field, 2,140 feet east and 300 feet north of the southwest corner of sec. 4, T. 35 N., R. 8 E.

Ap—0 to 9 inches; very dark gray (10YR 3/1) loam; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—9 to 12 inches; very dark gray (10YR 3/1) loam; moderate medium granular structure; friable; black 10YR 2/1) organic stains on faces of peds; neutral; clear smooth boundary.

B21tg—12 to 24 inches; gray (5Y 5/1) sandy clay loam; many fine distinct light olive brown (2.5Y 5/4) mottles and common fine prominent brown (7.5YR 5/4) mottles; moderate fine and medium subangular blocky structure; firm; very dark grayish brown (2.5Y 3/2) clay films on most faces of peds; very dark gray (10YR 3/1) iron- and manganese-oxide concretions; 5 percent fine gravel; neutral; clear wavy boundary.

B22tg—24 to 34 inches; grayish brown (2.5Y 5/2) sandy clay loam; few fine faint light olive brown (2.5Y 5/4) mottles; weak fine and medium subangular blocky structure; firm; very dark grayish brown (2.5Y 3/2) clay films on some faces of peds; 10 percent fine gravel; neutral; gradual wavy boundary.

B3g—34 to 38 inches; gray (5Y 5/1) gravelly sandy clay loam; common fine distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few light gray (10YR 7/1) lime nodules; few strong brown (7.5YR 5/6) iron splotches; strong effervescence; mildly alkaline; clear irregular boundary.

IIC—38 to 60 inches; light brownish gray (10YR 6/2) stratified sand and gravelly sand; single grained; loose; strong effervescence; moderately alkaline.

The solum ranges from 24 to 40 inches in thickness. The Ap horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark brown (10YR 2/2) loam or mucky loam and ranges from 10 to 15 inches in thickness. The B21tg and B22tg horizons are clay loam, sandy clay loam, gravelly sandy clay loam, or gravelly clay loam. In some pedons the B3g horizon is heavy loam. The IIC horizon is mostly fine gravel or coarse sand in some pedons.

Sebewa soils are similar to Gilford and Rensselaer soils. They contain more clay in the subsoil than Gilford soils, and they contain less silt or fine sand and are coarser textured in the substratum than Rensselaer soils.

**Se—Sebewa loam.** This soil occupies broad, flat depressional areas and long, narrow drainageways in glacial outwash plains. Slopes are 0 to 2 percent. Areas are irregular in shape and are 10 to 100 acres in size.

Included with this soil in mapping are small areas of Homer loam on low rises and adjacent flats. In places the surface layer and upper part of the subsoil are sandy loam. Deep depressional areas 3 to 5 acres in size where the surface layer is muck or mucky loam are identified by spot symbols on the soil map. In some areas in the northwestern part of the county, the upper part of the substratum has strata of gravelly loam or gravelly sandy loam 4 to 12 inches thick. Some areas near the Elkhart River are frequently flooded or have a high water table most of the time and are underlain with calcareous, loose sand and gravelly sand at a depth of 10 to 24 inches. Many of these frequently flooded areas have accumulations of reddish brown iron-oxide in the subsoil. These areas and undrained areas that are too wet for commonly grown crops are identified by spot symbols on the soil map.

Wetness is a limitation on this very poorly drained Sebewa soil, and drainage is needed. The content of organic matter is high.

This soil is suited to row crops each year if it is drained. It is used for corn, soybeans, and wheat or for grasses and legumes for hay or pasture. Undrained areas are suitable for pasture and woodland. Limitations are severe for most nonfarm uses. Capability unit IIw–4; woodland group 2w11.

## Shoals Series

The Shoals series consists of deep, somewhat poorly drained, medium textured soils. These nearly level soils formed in medium textured and moderately coarse textured alluvium on bottom land. The native vegetation was mixed hardwood trees.

In a representative profile the surface layer is 12 inches of dark grayish brown silt loam. The underlying material to a depth of 60 inches is in sequence downward, 9 inches of mottled brown, grayish brown, and reddish brown silt loam; 12 inches of grayish brown loam mottled with yellowish brown and dark brown; 6 inches of grayish brown light clay loam mottled with dark brown and yellowish brown; 21 inches of grayish brown, stratified silt loam, loam, light clay loam, and sandy loam mottled with dark brown and yellowish brown.

Permeability is moderate, and the available water capacity is high. The content of organic matter is moderate. Runoff is slow. These soils are subject to occasional flooding, and wetness is a limitation. The sea-

Wetness and a fluctuating seasonal high water table 1 foot to 3 feet deep are limitations on this Whitaker soil. Maintaining the supply of organic matter is a management need.

This soil is suited to row crops most of the time if it is drained. Most areas are used for corn, soybeans, and small grain. A few areas are used for hay and pasture or for woodland. Limitations are moderate or severe for most nonfarm uses. Capability unit IIw–2; woodland group 3o5.

## *Use and Management of the Soils*

This part of the survey contains information on the use and management of the soils of Noble County for cultivated crops and forage and shows predicted yields of important crops. It also describes the use of soils for wildlife, trees, engineering structures and practices, town and country planning, and recreation.

Specific management for individual soils is not suggested in this section. Detailed information on use and management can be provided by the local district conservationist of the Soil Conservation Service or by the Noble County Cooperative Extension Service.

### Crops

About 76 percent of Noble County is used for crops and pasture. The main crops are corn, soybeans, and small grain and grasses and legumes for forage. A small acreage is used for tomatoes, potatoes, and other special crops.

The main concerns of management are controlling wetness, soil blowing, and water erosion, maintaining fertility and the supply of organic matter, and maintaining or improving tilth. Of the intensively cultivated acreage, about 33 percent is limited by wetness and 58 percent by the hazard of erosion. Only 2 percent has few limitations for crops.

Conservation and management practices that help to overcome soil hazards and limitations are briefly described in the following paragraphs.

Wetness can be overcome on most soils by tile or open ditches. In some areas the water level of adjacent lakes or streams is so high that the soils cannot be drained unless a pumping system is installed. Diversion terraces carry runoff from higher ground to a safe outlet and keep it off of wet soil. A complete tile system is used to drain broad flats or depressional areas. Random tile is used to drain potholes, narrow depressions, and waterways or to intercept seepage on slopes. Special blinding materials keep out sand when sandy soils are tiled. The drainage of slowly permeable clayey soils is improved by partly backfilling the trench with corn cobbs, straw, or similar material.

Open ditches are generally used for tile outlets. Shallow surface drains in some areas remove excess water and prevent ponding. Some areas of muck and of soils on outwash plains are drained by a system of open ditches. Control of the water table is necessary in these areas because excessive drainage makes soils on outwash plains droughty and increases the rate of oxidation and subsidence of muck.

Soil blowing on coarse textured soils and organic soils can be controlled by keeping the soil covered with close-growing crops, leaving crop residue on the surface, and growing winter crops. Windbreaks also control soil blowing. Soils that have a rough cloddy surface are less susceptible to soil blowing than are other soils.

The hazard of water erosion can be controlled under good management. A dense sod in waterways prevents gullying.

Terraces with proper outlets or contour stripcropping help control erosion. In places large diversion terraces are needed to intercept runoff from sloping areas and carry it to a safe outlet. Contour cultivation helps slow runoff and control erosion.

Erosion can also be controlled by growing close-growing crops, such as grasses and legumes in rotations. The more sloping soils require these crops in the rotation more of the time. Some soils are suitable only for grasses and legumes for hay and pasture or for woodland.

Conservation practices that help to increase content of organic matter, improve tilth, and prevent erosion are leaving crop residue on the surface, growing green manure crops, and applying livestock manure. A balanced fertilization program helps to control erosion by improving crops. When wet, soils should not be worked or trampled by livestock if good tilth is to be maintained.

Crops on all the soils in the county need fertilizer, and lime is needed on many soils. Dark colored, mineral soils in depressional areas and nearly level soils on bottom land generally do not need lime. The kind and amount of fertilizer and lime to be applied should be determined by soil tests.

Droughtiness on coarse textured soils and soils underlain by sand and gravel can be overcome by irrigation. Irrigation is economically feasible for many high-value special crops and for some commonly grown crops during some seasons if adequate water is available. Crops can withstand the stresses of drought if an adequate supply of fertilizer is applied. Crop selection, timeliness of tillage operations, and effective weed control help to overcome this limitation. Crop residue left on the surface helps to control erosion and decrease moisture loss through evaporation.

On the pages that follow, the capability grouping system used by the Soil Conservation Service is explained, the soils in each capability unit are described, and management suited to the soils in each unit is suggested. Predicted yields of the principal crops are listed for all the soils in the county.

#### *Capability grouping*

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to cranberries,

horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for wildlife, forest trees, or engineering.

In the capability system, all kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode, but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to pasture or range, woodland, or wildlife. (None in Noble County.)

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. None in Noble County.)

CAPABILITY SUBCLASSES are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I, there are no subclasses because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c* because the soils in Class V are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, hay, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIe–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Capability unit numbers are generally assigned locally, but are part of a statewide system. All of the units in the system are not represented in Noble County; therefore, the capability unit numbers in this survey are not consecutive.

The soils in Noble County that have been assigned to the same capability unit have about the same limitations, are subject to similar risks of damage, need about the same kind of management, and respond to management in about the same way. Lake borders and Marsh have not been assigned to a capability unit because their properties are too variable.

On the following pages, each capability unit is described and management for each is suggested. To find the capability unit to which a soil has been assigned, refer to the "Guide to Mapping Units" at the back of this survey.

### CAPABILITY UNIT I–1

In this unit are deep, nearly level, moderately well drained or well drained soils on uplands. They have a medium textured surface layer; a moderately fine textured or fine textured subsoil; and a medium textured, moderately fine textured, or fine textured substratum. The content of organic matter is moderate or high. The available water capacity is high, and permeability is moderate, slow, or very slow. Runoff is slow. The seasonal high water table is below 6 feet or at a depth of 3 to 6 feet.

The soils are well suited to all crops commonly grown in the county. Corn, soybeans, and wheat are the main crops, and sweet corn, tomatoes, and other special crops are also suited. Alfalfa, red clover, bromegrass, and orchardgrass are grown for hay and pasture. Row crops can be grown year after year.

The principal management needs are maintenance and improvement of fertility, organic-matter content, and tilth. Crop residue, winter cover crops, and green manure crops help to maintain a desirable level of organic matter and good tilth.

### CAPABILITY UNIT I–9

The one soil in this unit, Riddles sandy loam, 0 to 2 percent slopes, is a deep, well drained, nearly level soil on uplands. It has a moderately coarse textured surface layer, a moderately fine textured subsoil, and a medium textured substratum. The content of organic matter is moderate. The available water capacity is

high, and permeability is moderate. The seasonal high water table is below 6 feet. Runoff is slow.

Corn, soybeans, wheat, and oats and legume-grass mixtures for hay and pasture are the main crops. Alfalfa, red clover, bromegrass, orchardgrass, and tall fescue are suitable for hay and pasture. Row crops can be grown year after year.

The principal management needs are moisture conservation and improvement of organic-matter content and fertility. The soil is very friable, is easy to work, and has good tilth. Crop residue, winter cover crops, and green manure crops help to maintain a desirable level of organic matter and good tilth.

CAPABILITY UNIT IIe-1

In this unit are deep, moderately well drained or well drained, gently sloping soils on uplands. They have a medium textured surface layer, a moderately fine textured or fine textured subsoil, and a medium textured to fine textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate, slow, or very slow. Runoff is medium or rapid. The seasonal high water table is below 6 feet or at a depth of 3 to 6 feet. Water erosion is a hazard.

Corn, soybeans, and wheat or oats are the main crops, and tomatoes, sweet corn, and other special crops are also suited. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are suitable for hay and pasture. Row crops can be grown most of the time if erosion is controlled. Many different cropping combinations are suitable for these soils.

The principal management needs are prevention of erosion and maintenance or improvement of tilth, organic-matter content, and fertility. Drainage is needed in a few small areas on slopes that are wet as a result of seepage. These soils are easy to work, but become hard and cloddy if worked when wet. Crop residue, winter cover crops, minimum tillage, and grass-legume mixtures help to control erosion and to maintain tilth. Grassed waterways, diversions, terraces, and contour cultivation also help to control erosion.

CAPABILITY UNIT IIe-2

The one soil in this unit, Fox sandy loam, 2 to 6 percent slopes, is a moderately deep, gently sloping, well drained soil on outwash plains and in the upland. It has a moderately coarse textured surface layer, a moderately fine textured subsoil, and a coarse textured substratum. The content of organic matter is moderate. The available water capacity and permeability are moderate. Runoff is medium. The seasonal high water table is below 6 feet. Erosion is a hazard and droughtiness is a limitation.

Corn, soybeans, and wheat and alfalfa, red clover, bromegrass, and orchardgrass for hay and pasture are the main crops. Many vegetable crops are suited if irrigated. Row crops can be grown most of the time.

The principal management needs are prevention of erosion, moisture conservation, and improvement of organic-matter content and fertility. This soil is very friable and easy to work. It can be worked soon after rain without damaging tilth. Minimum tillage, crop residue, and winter cover crops help to control erosion and to maintain good tilth. Grassed waterways, terraces, and contour cultivation also help to control erosion.

CAPABILITY UNIT IIe-5

In this unit are deep, moderately well drained and well drained, gently sloping soils on uplands. They have a moderately coarse textured surface layer and a medium textured to fine textured subsoil and substratum. The content of organic matter is moderate. The available water capacity is high, and permeability ranges from very slow to moderate. Runoff is medium. The seasonal high water table is below 6 feet or at a depth of 3 to 6 feet. Erosion is a hazard. Droughtiness is a limitation, especially for shallow-rooted crops, during prolonged periods of low rainfall.

Corn, soybeans, and wheat or oats are the main crops, and tomatoes, sweet corn, and other special crops are also suited. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are suitable for hay and pasture. Row crops can be grown most of the time if erosion is controlled. Many combinations of cropping systems are suited to these soils, including intensively cultivated crops.

The principal management needs are prevention of erosion and maintenance or improvement of organic-matter content and fertility. These soils are easy to work, and tilth is good. Some included soils that have a medium textured surface layer are not droughty. Crop residue, minimum tillage, winter cover crops, and grass-legume mixtures help to control erosion, maintain good tilth, and improve soil fertility. Grassed waterways, diversions, terraces, and contouring also help to control erosion.

CAPABILITY UNIT IIe-6

The one soil in this unit, Morley silt loam, 2 to 6 percent slopes, eroded, is a deep, moderately well drained or well drained, gently sloping soil on uplands. It has a medium textured surface layer, a fine textured subsoil, and a moderately fine textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is slow. Runoff is rapid. The seasonal high water table is 3 to more than 6 feet deep. Water erosion is a hazard.

Corn, soybeans, and wheat or oats are the main crops. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are suitable for hay and pasture. Row crops can be grown most of the time if erosion is controlled.

The principal management needs are prevention of erosion and improvement of tilth, organic-matter content, and fertility. The soil becomes hard and cloddy if worked or pastured when wet. Drainage is needed in a few areas on slopes and in drainageways that are wet as a result of seepage. Crop residue, winter cover crops, green manure crops, and minimum tillage help to control erosion and maintain a desirable level of organic matter and soil tilth. Diversions, terraces, contour farming, and grassed waterways help to control runoff.

CAPABILITY UNIT IIe-11

The one soil in this unit, Martinsville fine sandy loam, 2 to 6 percent slopes, is a deep, well drained,

gently sloping soil on outwash plains and in the upland. It has a moderately coarse textured surface layer, a moderately fine textured subsoil, and a medium textured or moderately coarse textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate. Runoff is medium. The seasonal high water table is below 6 feet. Erosion is the main limitation.

This soil is suited to all crops commonly grown in the county. Corn, soybeans, and wheat and grasses and legumes for hay and pasture are the main crops. Alfalfa, red clover, bromegrass, orchardgrass, nursery stock, and berries are also suited. Many cropping systems, including row crops most of the time, are suitable if erosion is controlled.

The principal management needs are control of erosion and maintenance or improvement of organic-matter content and fertility. Droughtiness is a concern for shallow-rooted crops during prolonged periods of low rainfall. This soil has good tilth and is easy to work. Minimum tillage, crop residue, and green manure crops help to improve or maintain the level of organic matter and tilth. Along with contour farming, terraces, and grassed waterways, they also help to control runoff and erosion.

CAPABILITY UNIT IIe-13

The one soil in this unit, Blount silt loam, 2 to 4 percent slopes, eroded, is a deep, somewhat poorly drained, gently sloping soil on uplands. It has a medium textured surface layer, a fine textured subsoil, and a moderately fine textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is slow. Runoff is medium. The seasonal high water table is at a depth of 1 foot to 3 feet. Erosion is a hazard, and wetness is a limitation.

Corn, soybeans, and wheat or oats are the main crops. Alfalfa, clover, bromegrass, orchardgrass, and tall fescue are suitable for hay or pasture, but the selection of legumes depends on drainage. Many combinations of cropping systems are suited to this soil, including intensively cultivated crops.

The principal management needs are protection from erosion, drainage, and maintenance or improvement of tilth, organic-matter content, and fertility. Compaction and puddling cause poor tilth if this soil is worked or pastured when wet. Crop residue, winter cover crops, green manure crops, and minimum tillage help to control erosion, maintain a desirable level of organic matter, and improve soil tilth. Grassed waterways permit surface water to cross this soil without creating gullies or intensifying siltation. Although contouring helps to control erosion, it commonly increases wetness by retarding surface runoff. Adequate drainage is needed if this soil is to be used for corn, soybeans, small grain, alfalfa, and other commonly grown crops.

CAPABILITY UNIT IIw-1

In this unit are deep, poorly drained and very poorly drained, nearly level soils in depressions on outwash plains and in the upland. They have a medium textured or moderately fine textured surface layer and a moderately fine textured, fine textured, or medium textured subsoil. The content of organic matter is high or moderate. The available water capacity is high, and permeability is slow or moderately slow. Runoff is very slow. Some areas are ponded. The seasonal high water table is at or near the surface. Wetness is the main limitation.

Corn, soybeans, and wheat are the main crops, and tomatoes and sugar beets are suited. Alfalfa, red clover, alsike clover, Ladino clover, bromegrass, and orchardgrass are also suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable if these soils are adequately drained. Areas that lack drainage outlets are suitable for permanent pasture, woodland, and wetland wildlife habitat.

The principal management needs are drainage and maintenance and improvement of tilth, organic-matter content, and fertility. The tilth of these soils greatly influences their productivity. The plow layer becomes puddled and cloddy if worked when wet. Adequate drainage can be provided for most areas by installing a complete tile system. In places random tile lines are beneficial. Surface drains are sometimes needed to remove accumulated surface water from ponded areas. Where feasible, diversion terraces are useful in intercepting runoff from the uplands. Minimum tillage and crop residue help to prevent surface crusting and to improve soil tilth.

CAPABILITY UNIT IIw-2

In this unit are deep, somewhat poorly drained nearly level soils on outwash plains and in the upland. They have a medium textured surface layer, a moderately fine textured or fine textured subsoil, and a medium textured to fine textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability ranges from very slow to moderately slow. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. Erosion is a hazard on low knolls or along drainageways where slopes are 2 to 4 percent. Wetness is the main limitation.

Corn, soybeans, and wheat are the main crops, and tomatoes and sugar beets are suited. Alfalfa, clover, and many grasses are suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops most of the time, are suitable if these soils are drained.

The principal management needs are control of wetness and maintenance or improvement of tilth, organic-matter content, and fertility. Crop residue and winter cover crops help to maintain the level of organic matter, improve tilth, and prevent crusting. Minimum tillage helps to reduce puddling of the surface layer.

CAPABILITY UNIT IIw-4

In this unit are very poorly drained, nearly level soils in depressions in outwash plains. They are moderately deep over stratified, loose sand and gravelly sand or are deep. They have a moderately coarse textured or medium textured surface layer, a moderately coarse textured or moderately fine textured subsoil, and a coarse textured substratum. The content of organic matter is high. Tilth is good. The available water ca-

pacity is moderate. Permeability is mostly moderately rapid, but is moderate in some soils. Runoff is very slow. Some areas are ponded. The seasonal high water table is at or near the surface. The major limitation is wetness.

These soils are suited to most commonly grown crops if drained. Corn and soybeans are the main crops, and onions, cabbage, carrots, sweet corn, and tomatoes are suited. Alfalfa, clover, and many grasses and small grains are also suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable for these soils. Areas that lack drainage outlets are suitable for permanent pasture, woodland, and wetland wildlife habitat.

The principal management needs are drainage and maintenance of organic-matter content and fertility. Tile or open-ditch drainage is effective in lowering the water table and removing excess water. If tile is laid in the gravelly and sandy substratum, special blinding or filters help to keep the sand from clogging the tile. Excessive drainage causes these soils to become droughty.

#### CAPABILITY UNIT IIw-6

The one soil in this unit, Homer loam, is a somewhat poorly drained, nearly level soil on outwash plains. It is moderately deep over stratified, loose sand and gravelly sand. It has a medium textured surface layer, a moderately fine textured subsoil, and a coarse textured substratum. The content of organic matter is moderate. The available water capacity and permeability are moderate. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. Wetness is the main limitation.

This soil is suited to commonly grown crops if it is drained. Corn, soybeans, and wheat are the main crops. Alfalfa, clover, and many grasses are suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable if this soil is adequately drained.

The principal management needs are drainage and maintenance or improvement of organic-matter content and fertility. Special blinding and filtering material is needed to keep sand from clogging tile drains. This soil becomes droughty if the water table is lowered excessively. Minimum tillage and crop residue help to maintain and improve soil tilth and the level of organic matter. The soil becomes cloddy if worked when wet.

#### CAPABILITY UNIT IIw-7

The one soil in this unit, Shoals silt loam, is a nearly level, somewhat poorly drained, alluvial soil on flood plains and bottom land. It has a medium textured surface layer and subsoil and a medium textured or moderately coarse textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. Wetness is the main limitation. This soil is subject to ponding or flooding, especially in winter or spring.

This soil is suited to corn and soybeans. It is less suited to wheat, alfalfa, and clover because these crops are subject to damage from ponding and overflow. Row crops can be grown year after year if the soil is adequately drained.

The principal management needs are drainage, protection from flooding, and maintenance and improvement of fertility and organic-matter content. Drainage is not needed in areas of included soils that are moderately well drained. Diversions are needed in some areas for protection from runoff from adjacent uplands. Some areas are used mainly for permanent pasture because there are no suitable drainage outlets.

#### CAPABILITY UNIT IIw-10

The one soil in this unit, Palms muck, drained, is a deep, very poorly drained, nearly level organic soil in depressional areas in the upland or on outwash plains. It has mixed organic material over moderately coarse textured, medium textured, or moderately fine textured mineral material. The content of organic matter is very high. The available water capacity is very high, and permeability is rapid in the organic material and moderate in the substratum. Runoff is very slow. Some areas are ponded. The seasonal high water table is at or near the surface. This soil has good tilth and is easy to work. Wetness is the main limitation, and soil blowing is a hazard when the soil is dry.

Corn, soybeans, grasses, and many vegetable crops are suited if the soil is drained. Special crops, such as onions, potatoes, carrots, and grass for sod, can be grown. Row crops can be grown year after year.

The principal management needs are maintaining drainage and controlling soil blowing. Tile and open-outlet drainage ditches are commonly used. Drainage permits more rapid oxidation of the muck. Frost damage is a hazard in spring and fall. Fire is a hazard because the organic material burns readily during dry periods.

#### CAPABILITY UNIT IIw-11

The one soil in this unit, Aubbeenaubbee fine sandy loam, is a deep, somewhat poorly drained, nearly level soil in the upland. It is moderately coarse textured in the surface layer and the upper part of the subsoil. The lower part of the subsoil is moderately fine textured, and the substratum is moderately fine textured or medium textured. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. Wetness is the main limitation.

This soil is suited to commonly grown crops if it is drained. Corn, soybeans, and wheat and grasses and legumes for hay and pasture are the main crops. Heaving is a problem for alfalfa during periods of freezing and thawing. Many cropping systems, including row crops year after year, are suitable for this soil.

The principal management needs are drainage and maintenance or improvement of organic-matter content and fertility. This soil has good tilth and is easy to work. If tile drainage is used, special filters are needed to prevent the sand from seeping into and filling the tile lines. Proper location of tile lines to intercept underground seepage is important.

CAPABILITY UNIT IIs-2

In this unit are nearly level, well drained soils on outwash plains. They are moderately deep over stratified, loose sand and gravelly sand. They have a medium textured, coarse textured, or moderately coarse textured surface layer; a moderately fine textured subsoil; and a coarse textured substratum. The content of organic matter is high or medium. The available water capacity and permeability are moderate. Runoff is slow. The seasonal high water table is below 6 feet. Droughtiness is a limitation.

Corn, soybeans, and wheat are the main crops. Alfalfa, red clover, bromegrass, and orchardgrass are suitable for hay and pasture. Many vegetable crops and special crops, such as tomatoes, are suited if irrigated. Many cropping systems, including row crops year after year, are suited.

The principal management needs are moisture conservation and maintenance or improvement of organic-matter content and fertility. These soils are friable and easy to work. Crop residue, cover crops, and minimum tillage help to maintain the level of organic-matter and also control soil blowing.

CAPABILITY UNIT IIIe-1

The one soil in this unit, Miami loam, 6 to 12 percent slopes, eroded, is a deep, well drained, moderately sloping soil on uplands. It has a medium textured surface layer, a moderately fine textured subsoil, and a medium textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate. Runoff is rapid. The seasonal high water table is below 6 feet. Water erosion is a serious hazard.

Corn, soybeans, and wheat or oats are the main crops. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are suitable for hay or pasture. Row crops can be grown occasionally if erosion is controlled.

The principal management needs are prevention of erosion and improvement of tilth, organic-matter content, and fertility. This soil is easy to work, but becomes hard and cloddy if worked or pastured when wet. Contouring, stripcropping, grassed waterways, diversion terraces, winter cover crops, and crop residue help to control runoff and erosion. Otherwise, row crops should be limited in the rotation and close-growing crops or grasses and legumes for forage should be grown most of the time. Green manure crops maintain and increase the level of organic matter and improve soil tilth.

CAPABILITY UNIT IIIe-5

In this unit are deep, moderately well drained and well drained, moderately sloping soils on uplands. They have a moderately coarse textured surface layer, a moderately fine textured and fine textured subsoil, and a medium textured to fine textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability ranges from very slow to moderate. The seasonal high water table is 3 to more than 6 feet deep. Runoff is rapid. Erosion is a hazard. Droughtiness is a limitation, especially for shallow-rooted crops, during prolonged periods of low rainfall.

Corn, soybeans, and wheat or oats and legume-grass mixtures for hay and pasture are the main crops. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are also suited for hay and pasture (fig. 13). Row crops can be grown frequently if erosion is controlled.

The principal management needs are prevention of erosion and improvement of organic-matter content and fertility. These soils are easy to work and tilth is good. Crop residue, winter cover crops, stripcropping, terracing, and grassed waterways help to control runoff and erosion.

CAPABILITY UNIT IIIe-6

In this unit are deep, moderately well drained or well drained, moderately sloping soils on uplands. They have a moderately coarse textured to moderately fine textured surface layer and a moderately fine textured or fine textured subsoil. The content of organic matter is moderate. The available water capacity is high, and permeability ranges from moderate to very slow. Runoff is rapid. The seasonal high water table is 3 to more than 6 feet deep. Erosion is a serious hazard.

Corn, soybeans, and wheat or oats are the main crops. Alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are suitable for hay or pasture. Row crops can be grown frequently if erosion is controlled.

The principal management needs are prevention of erosion and improvement of organic-matter content, tilth, and fertility. These soils become hard and cloddy if worked or pastured when wet. Drainage is needed in a few small areas on slopes that are wet as a result of seepage. Contour farming, stripcropping, crop residue, and winter cover crops help to control runoff and erosion.

CAPABILITY UNIT IIIe-13

In this unit are deep, well drained, gently sloping and moderately sloping soils in the upland and on outwash plains. They are deep or moderately deep over loose sand and gravelly sand. They have a coarse textured or moderately coarse textured surface layer and a moderately coarse textured to moderately fine textured subsoil. Texture of the substratum is variable. The content of organic matter is moderate or low. The available water capacity is dominantly moderate, and permeability is very rapid to moderate. Runoff ranges from slow to rapid. The seasonal high water table is below 6 feet. Droughtiness is a limitation, and erosion is a hazard. Soil blowing is a hazard for some of these soils.

Corn, soybeans, and wheat and alfalfa, red clover, bromegrass, and orchardgrass for hay and pasture are the main crops. Many vegetable crops and special crops are suited if irrigated.

The principal management needs are prevention of erosion and soil blowing, moisture conservation, and improvement of organic-matter content and fertility. These soils are very friable and easy to work. They can be worked soon after rain without damaging soil tilth. Crop residue, barnyard manure, and green manure crops provide a regular supply of organic matter. Contour farming, stripcropping, and grassed waterways help to reduce soil loss.

*Figure 13.*—**Hay and pasture on gently sloping and moderately sloping soils of capability unit IIIe–5.**

CAPABILITY UNIT IIIw–4

The one soil in this unit, Brady sandy loam, is a deep, somewhat poorly drained, nearly level soil on outwash plains. It has a moderately coarse textured surface layer and subsoil and a coarse textured substratum. The content of organic matter is high. The available water capacity is moderate, and permeability is moderately rapid. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. Wetness is the main limitation.

This soil is suitable for commonly grown crops if it is drained. Corn, soybeans, and wheat are the main crops. Alfalfa, clover, and many grasses are also suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable for this soil.

The principal management needs are drainage and improvement of organic-matter content and fertility. Special blinding or filtering material is needed to keep sand out of the tile drains. This soil becomes droughty if the water table is lowered excessively. Crop residue and cover crops supply regular additions of organic matter.

CAPABILITY UNIT IIIw–6

The one soil in this unit, Fulton silt loam, is a deep, somewhat poorly drained, nearly level soil. It has a medium textured surface layer and a fine textured subsoil and substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is slow or very slow. Runoff is slow. The seasonal high water table is at a depth of 1 foot to 3 feet. This soil dries out slowly following rains. Wetness is the main limitation.

This soil is suitable for commonly grown crops if it is drained. Corn, soybeans, and wheat are the main crops. Many legumes and grasses are suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable for this soil.

The principal management needs are drainage and improvement of tilth, organic-matter content, and fertility. Compaction and puddling leads to poor tilth if this soil is worked or pastured when wet. Special blinding around tile is needed to improve the water intake rate. Minimum tillage, crop residue, and favorable moisture content help to maintain good tilth.

CAPABILITY UNIT IIIw–8

The one soil in this unit, Houghton muck, drained, is a deep, very poorly drained, nearly level soil in depressional areas in the upland and on outwash plains. This soil is mixed organic material to a depth of 51 inches or more. The content of organic matter is very

high. The available water capacity is very high, and permeability is rapid. Runoff is very slow. The seasonal high water table is at or near the surface. Some areas are ponded. Wetness is the main limitation. Soil blowing is a hazard when the muck is dry.

This soil is suited to corn, soybeans, grasses, and many vegetable crops if it is drained. Corn and soybeans are the main crops. Special crops, such as blueberries, onions, potatoes, carrots, and grass for sod, can also be grown. Row crops can be grown year after year.

The principal management needs are maintaining drainage and controlling soil blowing. This soil has good tilth and is easy to work. Drainage permits more rapid oxidation and subsidence of the organic material. Frost damage is a hazard in spring and fall. Fire is a hazard because the organic material burns readily during dry periods. Establishing field windbreaks, using cover crops, and artificially wetting the surface layer help to reduce soil blowing.

### CAPABILITY UNIT IIIw-111

The one soil in this unit, Wallkill silt loam, is a deep, very poorly drained soil that is in depressional areas in the upland or on outwash plains. It has medium textured alluvium over buried muck. The content of organic matter is moderate. The available water capacity is very high, and permeability is moderate. Runoff is very slow. The seasonal high water table is at or near the surface. Some areas are ponded. Wetness is the main limitation.

Corn, soybeans, and wheat are the main crops. Red clover, alsike clover, Ladino clover, bromegrass, and orchardgrass are also suited, but the selection of legumes depends on drainage. Many cropping systems, including row crops year after year, are suitable for this soil. Areas that do lack drainage outlets are suitable for permanent pasture, woodland, and wetland wildlife habitat.

The principal management needs are drainage and improvement of organic matter content and fertility. Minimum tillage, crop residue, and green manure crops help to maintain the level of organic matter and good tilth.

### CAPABILITY UNIT IIIs-1

The one soil in this unit, Chelsea fine sand, 2 to 6 percent slopes, is a deep, excessively drained, gently sloping soil. It is coarse textured throughout the profile. The content of organic matter is low. The available water capacity is low, and permeability is rapid. Runoff is slow. The seasonal high water table is below 6 feet. Droughtiness is a serious limitation, and soil blowing is a hazard.

This soil is suited to fruit trees, vineyards, and Christmas trees. Alfalfa and bromegrass or orchardgrass are suitable for hay or pasture. Corn and soybeans can be grown, but yields are commonly low because of droughtiness. Early maturing row crops are less affected by drought. Row crops and special crops can be grown year after year if irrigation is feasible. Wheat is suited to this soil.

The principal management needs are prevention of soil blowing, moisture conservation, and improvement of fertility and organic-matter content. This soil is loose and hard to work when dry. Traction is poor for farm machinery. Frequent fertilizer applications are necessary because of rapid leaching of nutrients. Crop residue and cover crops help to improve and maintain the level of organic matter and to reduce soil blowing. Irrigation also helps to reduce the hazard of soil blowing.

### CAPABILITY UNIT IIIs-2

In this unit are well drained, nearly level or gently sloping soils in the upland or on outwash plains. They are deep or moderately deep over loose sand and gravelly sand. They have a moderately coarse textured or coarse textured surface layer, a moderately coarse textured subsoil, and a coarse textured substratum. The content of organic matter is low or moderate. The available water capacity is low or moderate, and permeability is moderately rapid. Runoff is slow. The seasonal high water table is below 6 feet. Droughtiness is a limitation. Soil blowing is a hazard on soils with a coarse textured surface layer.

Corn, soybeans, and wheat and alfalfa, red clover, bromegrass, and orchardgrass for hay and pasture are the main crops. Early maturing crops are less affected by drought than are other crops. These soils are also well suited to wheat. Many vegetable crops and special crops are suited if irrigated.

The principal management needs are prevention of soil blowing, moisture conservation, and maintenance or improvement of organic-matter content and fertility. These soils are very friable and easy to work. They can be worked soon after rain without damaging soil tilth. Crop residue, cover crops, and minimum tillage help to control soil blowing and to maintain and improve the level of organic matter. Field windbreaks also help to control soil blowing.

### CAPABILITY UNIT IIIs-12

The one soil in this unit, Chelsea fine sand, 6 to 12 percent slopes, is a deep, excessively drained, moderately sloping soil. It is dominantly coarse textured throughout the profile. The content of organic matter is low. The available water capacity is low, and permeability is rapid. Runoff is medium. The seasonal high water table is below 6 feet. Soil blowing is a hazard. Droughtiness is a serious limitation.

This soil is suited to fruit trees, vineyards, and Christmas trees. Alfalfa and bromegrass or orchardgrass are well suited for hay and pasture. Corn and soybeans can be grown, but yields are commonly low because of droughtiness. Wheat is suited to this soil. Row crops or special crops can be grown if irrigation is feasible.

The principal management needs are prevention of soil blowing and improvement of fertility and organic-matter content. This soil is loose and difficult to work when dry. Frequent applications of fertilizer are necessary because of rapid leaching of nutrients. Crop residue, cover crops, and minimum tillage help to control soil blowing and runoff and to maintain the level of organic matter.

### CAPABILITY UNIT IVe-1

In this unit are deep, well drained, moderately slop-

ing or strongly sloping soils on uplands. They are eroded or severely eroded. They have a medium textured or moderately fine textured surface layer, a moderately fine textured subsoil, and a medium textured substratum. The content of organic matter is moderate or low. The available water capacity is high, and permeability is moderate. Runoff is rapid or very rapid. The seasonal high water table is below 6 feet. Water erosion is a severe hazard.

Corn, soybeans, wheat or oats, alfalfa, red clover, bromegrass, tall fescue, and orchardgrass are the main crops. Some areas are woodland. Row crops can be grown occasionally if erosion is controlled. These soils are best suited to hay and pasture.

The principal management needs are prevention of erosion and maintenance or improvement of tilth, organic-matter content, and fertility. The severely eroded soils are difficult to work because they are sticky when wet and hard and cloddy when dry. Conservation cropping systems in which row crops are grown only occasionally help to keep erosion to a minimum.

CAPABILITY UNIT IVe-5

The one soil in this unit, Riddles sandy loam, 12 to 18 percent slopes, eroded, is a deep, well drained, strongly sloping soil on uplands. It has a moderately coarse textured surface layer, a moderately fine textured subsoil, and a medium textured substratum. The content of organic matter is moderate. The available water capacity is high, and permeability is moderate. Runoff is very rapid. The seasonal high water table is below 6 feet. Erosion is a hazard. Droughtiness is a limitation for shallow-rooted crops during prolonged periods of low rainfall. It is not a limitation in included areas where the surface layer is medium textured. Slope is a limitation for the use of farm machinery.

This soil is well suited to permanent pasture or hay. Orchardgrass, tall fescue, bromegrass, red clover, and alfalfa are suitable for hay or pasture. Row crops or wheat or oats can be grown occasionally if erosion is controlled.

The principal management needs are prevention of erosion and improvement of organic-matter content and fertility. This soil has good tilth and is easy to work. Grassed waterways, contour farming, and minimum tillage help to control runoff and erosion. Otherwise, permanent vegetation helps to minimize surface runoff and erosion.

CAPABILITY UNIT IVe-6

In this unit are deep, well drained, moderately sloping or strongly sloping soils on uplands. They have a medium textured or moderately fine textured surface layer, a fine textured subsoil, and a moderately fine textured substratum. The content of organic matter is moderate, except in severely eroded areas, where it is low. The available water capacity is high, and permeability is slow. Runoff is rapid or very rapid. The seasonal high water table is below 6 feet. Erosion is a serious hazard. Slope is a limitation for the use of farm machinery.

These soils are well suited to permanent pasture or hay. Orchardgrass, tall fescue, bromegrass, alfalfa, and red clover are suitable for hay or pasture. If erosion is controlled, row crops and wheat or oats can be grown occasionally.

The principal management needs are prevention of erosion and improvement of organic-matter content, tilth, and fertility. These soils become hard and cloddy if worked or pastured when wet. If severely eroded, they are very sticky and plastic when wet and very hard and cloddy when dry. A conservation cropping system that includes grasses and legumes for forage most of the time is the most effective way to control runoff and erosion. Row crops can be grown occasionally to maintain good stands of grasses and legumes.

CAPABILITY UNIT IVe-16

In this unit are well drained, strongly sloping soils in the upland and on outwash plains. They are moderately deep over stratified, loose sand and gravelly sand. They have a coarse textured or moderately coarse textured surface layer, a moderately coarse textured or moderately fine textured subsoil, and a coarse textured substratum. The content of organic matter is low or moderate. The available water capacity is low or moderate, and permeability is moderate or moderately rapid. Runoff is medium to very rapid. The seasonal high water table is below 6 feet. Droughtiness is a limitation. Erosion and soil blowing are hazards. Slope is a limitation for the use of farm machinery.

These soils are well suited to hay and pasture. Alfalfa, red clover, bromegrass, and orchardgrass are suitable for hay and pasture. These soils are also well suited to woodland.

The principal management needs are prevention of erosion and soil blowing, moisture conservation, and improvement of organic-matter content and fertility. These soils are very friable and easy to work. A conservation cropping system where row crops are grown occasionally is best in controlling erosion and runoff. Cover crops, crop residue, minimum tillage, contour farming, and stripcropping also help to control erosion and runoff.

CAPABILITY UNIT IVw-3

In this unit are moderately deep or deep, very poorly drained, nearly level soils in depressions in the upland and on outwash plains. They have mixed organic material over mineral material at a depth of 21 to 50 inches. The underlying material is marl or coarse textured mineral material. The content of organic matter is very high. The available water capacity is high or very high, and permeability is rapid. Runoff is very slow. The seasonal high water table is at or near the surface. Some areas are ponded. Wetness is the main limitation. Soil blowing is a hazard.

These soils are suited to corn, soybeans, grasses, and many vegetable crops if drained. Corn and soybeans are the main crops. Special crops, such as onions, potatoes, carrots, and grass for sod, are also suited. Row crops can be grown year after year. Areas that are not completely drained are suited to reed canarygrass for pasture.

The principal management needs are maintaining drainage and controlling soil blowing. These soils have good tilth and are easy to work. Drainage permits more rapid oxidation and subsidence of the organic material.

Frost damage is a hazard in spring and fall. Fire is a hazard because the organic material burns readily during dry periods. Cover crops and crop residue help to control soil blowing early in winter and in spring. Shrub windbreaks are beneficial for this purpose throughout the year.

CAPABILITY UNIT Vw-3

In this unit are moderately deep and deep, very poorly drained, nearly level organic soils in undrained depressional areas in the upland and on outwash plains. The depth of the organic material ranges from 16 to 50 inches or more. Some soils are underlain by marl or sand and gravelly sand. The content of organic matter is very high. The available water capacity is high or very high, and permeability is moderate or moderately rapid. Runoff is very slow. Some areas are ponded. The seasonal high water table is at or near the surface most of the year. Wetness is a serious limitation.

Most areas are used for pasture or are in a natural vegetation of sedges, cattails, or water-tolerant trees and shrubs. Because most of these areas do not have outlets, drainage is often not feasible. Reed canarygrass for pasture is well suited. These soils provide habitat for wetland wildlife and some cover for other wildlife.

CAPABILITY UNIT VIe-1

In this unit are deep, well drained strongly sloping or steep soils on uplands. They have a medium textured or moderately fine textured surface layer, a moderately fine textured or fine textured subsoil, and a medium textured or moderately fine textured substratum. The content of organic matter is low or moderate, but in severely eroded areas it is low. The available water capacity is high, and permeability is moderate or slow. The seasonal high water table is below 6 feet. Runoff is very rapid. Erosion is a serious hazard. Slope is a limitation for the use of farm machinery.

These soils are well suited to permanent pasture or woodland. Orchardgrass, tall fescue, bromegrass, alfalfa, and red clover are suitable for hay or pasture. Grasses and legumes are difficult to establish in severely eroded areas, and forage yields are commonly low.

The principal management needs are prevention of erosion and improvement of tilth, organic-matter content, and fertility. The severely eroded soils are sticky and plastic when wet and become hard and cloddy when dry. Permanent grasses and legumes can be maintained by controlling grazing and by timely and adequate applications of lime and fertilizer. Renovating permanent pasture on the contour and establishing and maintaining grassed waterways help to control erosion and runoff.

CAPABILITY UNIT VIe-3

In this unit are moderately sloping to steep, well drained to somewhat excessively drained soils in the upland and on outwash plains. They are moderately deep or shallow over loose sand and gravelly sand. They have a moderately coarse textured or moderately fine textured surface layer, a moderately fine textured subsoil, and a coarse textured substratum. The content of organic matter is moderate or low. The available water capacity is moderate or low, and permeability is moderate. Runoff is very rapid. The seasonal high water table is below 6 feet. Droughtiness is a limitation, and erosion is a hazard. Slope is a limitation for the use of farm machinery.

Alfalfa, red clover, bromegrass, and orchardgrass are suitable for hay and pasture. This soil is also well suited to woodland.

The principal management needs are prevention of erosion, moisture conservation, and improvement of organic-matter and fertility. If not severely eroded, these soils are very friable and easy to work. If severely eroded, they are sticky when wet and hard and cloddy when dry. Contour farming, minimum tillage, and grassed waterways control erosion and reduce runoff. A conservation cropping system that includes row crops most of the time is also an effective way of controlling erosion. Crops can be grown occasionally to maintain good stands of grasses and legumes.

CAPABILITY UNIT VIw-1

This unit consists of a shallow or very shallow, very poorly drained, nearly level depressional Marl beds on uplands and outwash plains. These beds have less than 12 inches of organic or mineral material over alkaline and calcareous marl. The surface layer is mildly alkaline or moderately alkaline and in places contains many calcareous marl fragments (fig. 14). The content of organic matter is high or very high. The available water capacity is variable, and permeability ranges from slow to rapid. Runoff is very slow or ponded. The seasonal high water table is at or near the surface. Wetness is the main limitation.

Marl beds are suited to grasses for pasture and to special crops, such as onions, potatoes, and cabbage. Shallow-rooted crops are best suited. Most areas are used for pasture. Undrained areas are suitable for wetland wildlife habitat, and they provide some cover for other wildlife.

Draining and maintaining the supply of organic material in the surface layer are the principal management needs. These areas have good tilth and are easy to work. Open ditches can be used to drain the areas. Tile generally does not work well in the marl. Productivity depends on the thickness of the organic or mineral surface layer. Plowing up and mixing the marl with the surface layer should be avoided. A cover of permanent grass sod is beneficial.

### *Predicted yields*

Table 2 shows the average yields per acre of the principal crops under high level management for the arable soils of the county.

The following are assumed to be part of high level management:

1. Using crop systems that maintain tilth and organic-matter content.
2. Controlling erosion to the maximum extent feasible to maintain or improve soil quality.
3. Maintaining a high level of fertility by use of fertilizer in accordance with frequent soil tests and recommendations of Purdue University Agricultural Experiment Station.

*Figure 14.*—**Chunks of marl dug from Marl beds having shell fragments.**

4. Liming the soils as indicated by soil tests.
5. Using crop residue to the fullest extent possible to protect and improve the soil.
6. Following minimum tillage where needed to minimize the hazards of compaction and erosion.
7. Using only the crop varieties that are best suited to the climate and the soil.
8. Controlling weeds carefully by tillage and spraying.
9. Draining wet areas so that wetness does not restrict yields.

The yields in table 2 are estimated averages for a period of 5 to 10 years. They are based on farm records; on interviews with farmers, members of the Purdue Agricultural Experiment Station, and area extension agents; and on direct observations of soil scientists and soil conservationists. The prevailing climate, the characteristics of the soils, and the influence of high level management on the soils were considered in making the estimates.

These yield figures are not intended to apply directly to specific tracts of land for any particular year, because the soils differ somewhat from place to place, management differs from farm to farm, and weather conditions vary from year to year. Nevertheless, these estimates appear to be as accurate a guide as can be obtained without detailed and lengthy investigation. They show the relative productivity of soils under high level management.

## Woodland [2]

In table 3, most of the soils of Noble County have been assigned to woodland groups to assist owners in planning their use for wood crops. Each group is made up of soils that are suited to the same kinds of trees, that need approximately the same kind of management, and that have about the same potential productivity.

Each woodland group is identified by a three-part symbol, such as 1o1 or 3s17. The first part of the symbol, always a number, indicates the potential productivity of the soils in the group: 1 means very high; 2, high; 3, moderately high; 4, moderate; and 5, low. These ratings are based on field determination of average site index. Site index is the height in feet that the dominant trees of a given species, on a specified kind of soil, reach in a natural, unmanaged stand in a stated number of years. For the merchantable hardwoods and softwoods in this county, the site index is the height reached in 50 years.

The productivity ratings are based on field determination of average site index of an indicator forest type or species. Site indexes are grouped into site quality classes, and the classes are used to arrive at approximate expected yields per acre in cords and board feet. On the basis of research studies, site index can be converted into approximate expected growth and yield per acre in cords and board feet (*7, 9*).

The second part of the symbol is a lowercase letter. This letter indicates an important soil property that imposes a slight to severe hazard or limitation in managing the soils of the group for wood crops. The letter *c* shows that the main limitation is the kind or amount of clay in the upper part of the soils in the group; *o* shows that the soils have few limitations that restrict their use for trees; *r* shows that the main limitation is steep slopes; *s* shows that the soils are sandy and dry, have little or no difference in texture between the surface layer and subsoil, have low available water capacity, and generally have a low supply of plant nutrients; *w* shows that water in or on the soil, either seasonally or all year, is the main limitation.

The third part of the symbol indicates a woodland group identification number. Identification numbers are generally assigned locally, but are part of a statewide system. All the units of the system are not represented in Noble County; therefore, the numbers in this soil survey are not consecutive.

In table 3, the soils are rated according to management limitations and hazards and the site index is listed for important trees. The most desirable species to favor in natural stands and species suitable for planting are also listed. Parr and Warsaw soils are not assigned to a woodland group because their native vegetation is grass. These soils, however, are suitable for white pine, Norway spruce, red pine, black walnut, and white ash.

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[2] MITCHELL G. HASSLER, woodland conservationist, Soil Conservation Service, helped prepare this section.

TABLE 2.—*Predicted average yields per acre of principal crops*

[Dashes indicate that crop is not grown on specified soil or is not suited to it. Only arable soils are listed]

| Soil | Corn | Soybeans | Wheat | Legume-grass hay | Pasture |
|---|---|---|---|---|---|
| | *Bu* | *Bu* | *Bu* | *Tons* | *A.U.M.*[1] |
| Adrian muck, drained | 110 | 42 | — | — | 8.0 |
| Aubbeenaubbee fine sandy loam | 110 | 38 | 50 | 3.6 | 7.2 |
| Blount silt loam, 0 to 2 percent slopes | 105 | 37 | 47 | 3.4 | 6.8 |
| Blount silt loam, 2 to 4 percent slopes, eroded | 100 | 35 | 45 | 3.3 | 6.6 |
| Boyer loamy sand, 2 to 6 percent slopes | 70 | 26 | 38 | 2.5 | 5.0 |
| Boyer loamy sand, 6 to 12 percent slopes | 60 | 23 | 32 | 2.1 | 4.2 |
| Boyer loamy sand, 12 to 18 percent slopes, eroded | 50 | 18 | 25 | 1.6 | 3.2 |
| Brady sandy loam | 95 | 33 | 43 | 3.1 | 6.2 |
| Brookston silt loam | 145 | 51 | 65 | 4.8 | 9.6 |
| Casco sandy clay loam, 8 to 15 percent slopes, severely eroded | — | — | 20 | 1.3 | 2.6 |
| Chelsea fine sand, 2 to 6 percent slopes | 60 | 21 | 29 | 2.1 | 4.2 |
| Chelsea fine sand, 6 to 12 percent slopes | 50 | 17 | 25 | 1.8 | 3.6 |
| Crosier loam, 0 to 2 percent slopes | 120 | 42 | 52 | 4.0 | 8.0 |
| Edwards muck, drained | 100 | 38 | — | — | 7.2 |
| Fox sandy loam, 0 to 2 percent slopes | 85 | 30 | 42 | 2.8 | 5.6 |
| Fox sandy loam, 2 to 6 percent slopes | 85 | 30 | 42 | 2.8 | 5.6 |
| Fox sandy loam, 6 to 12 percent slopes, eroded | 70 | 24 | 35 | 2.3 | 4.6 |
| Fox-Casco sandy loams, 12 to 18 percent slopes, eroded | 55 | 19 | 28 | 1.8 | 3.6 |
| Fox-Casco sandy loams, 18 to 25 percent slopes, eroded | — | — | 20 | 1.3 | 2.6 |
| Fulton silt loam | 100 | 35 | 45 | 3.3 | 6.6 |
| Gilford sandy loam | 120 | 42 | 54 | 4.0 | 8.0 |
| Haskins loam, 0 to 2 percent slopes | 120 | 43 | 56 | 4.1 | 8.2 |
| Homer loam | 100 | 35 | 50 | 3.3 | 6.6 |
| Houghton muck, drained | 120 | 43 | — | — | 8.6 |
| Martinsville fine sandy loam, 2 to 6 percent slopes | 110 | 38 | 46 | 3.8 | 7.6 |
| Metea loamy fine sand, 2 to 6 percent slopes | 85 | 30 | 42 | 2.8 | 5.6 |
| Miami loam, 2 to 6 percent slopes, eroded | 105 | 37 | 47 | 3.4 | 6.8 |
| Miami loam, 6 to 12 percent slopes, eroded | 95 | 33 | 43 | 3.1 | 6.2 |
| Miami loam, 12 to 18 percent slopes, eroded | 80 | 28 | 36 | 2.6 | 5.2 |
| Miami loam, 18 to 25 percent slopes, eroded | — | — | 29 | 2.1 | 4.2 |
| Miami clay loam, 6 to 12 percent slopes, severely eroded | 80 | 28 | 36 | 2.5 | 5.0 |
| Miami clay loam, 12 to 18 percent slopes, severely eroded | — | — | 32 | 2.0 | 4.0 |
| Miami loam, gravelly substratum, 0 to 2 percent slopes | 115 | 38 | 50 | 3.6 | 7.2 |
| Miami loam, gravelly substratum, 2 to 6 percent slopes, eroded | 105 | 37 | 47 | 3.4 | 6.8 |
| Milford silty clay loam | 135 | 47 | 61 | 4.4 | 8.8 |
| Morley silt loam, 2 to 6 percent slopes, eroded | 90 | 32 | 40 | 3.0 | 6.0 |
| Morley silt loam, 6 to 12 percent slopes, eroded | 80 | 28 | 36 | 2.6 | 5.2 |
| Morley silt loam, 12 to 18 percent slopes, eroded | 65 | 23 | 29 | 2.1 | 4.2 |
| Morley silty clay loam, 6 to 12 percent slopes, severely eroded | 65 | 22 | 28 | 2.0 | 4.0 |
| Morley silty clay loam, 12 to 18 percent slopes, severely eroded | — | — | 25 | 1.8 | 3.6 |
| Morley soils, 18 to 25 percent slopes | — | — | 18 | 1.5 | 3.0 |
| Morley, Miami, and Rawson loams, 6 to 12 percent slopes, eroded | 95 | 34 | 43 | 3.1 | 6.2 |
| Oshtemo loamy sand, 2 to 6 percent slopes | 80 | 28 | 38 | 2.8 | 5.6 |
| Oshtemo loamy sand, 6 to 12 percent slopes | 70 | 24 | 34 | 2.5 | 5.0 |
| Oshtemo sandy loam, 0 to 2 percent slopes | 85 | 30 | 40 | 2.8 | 5.6 |
| Palms muck, drained | 120 | 45 | — | — | 8.8 |
| Parr loam, 0 to 2 percent slopes | 120 | 42 | 54 | 4.0 | 8.0 |
| Pewamo silty clay loam | 130 | 46 | 58 | 4.3 | 8.6 |
| Rawson sandy loam, 2 to 6 percent slopes | 105 | 38 | 44 | 3.6 | 7.2 |
| Rawson sandy loam, 6 to 12 percent slopes, eroded | 95 | 34 | 40 | 3.3 | 6.6 |
| Rawson loam, 0 to 2 percent slopes | 110 | 40 | 46 | 3.8 | 7.6 |
| Rawson loam, 2 to 6 percent slopes | 110 | 40 | 46 | 3.8 | 7.6 |
| Rawson, Morley, and Miami loams, 2 to 6 percent slopes, eroded | 110 | 40 | 46 | 3.8 | 7.6 |
| Rensselaer loam | 140 | 50 | 60 | 4.8 | 9.6 |
| Riddles sandy loam, 0 to 2 percent slopes | 110 | 38 | 46 | 3.8 | 7.6 |
| Riddles sandy loam, 2 to 6 percent slopes | 105 | 36 | 46 | 3.8 | 7.6 |
| Riddles sandy loam, 6 to 12 percent slopes, eroded | 95 | 34 | 40 | 3.3 | 6.6 |
| Riddles sandy loam, 12 to 18 percent slopes, eroded | 80 | 30 | 34 | 2.8 | 5.6 |
| Sebewa loam | 120 | 42 | 60 | 4.0 | 8.0 |
| Shoals silt loam | 130 | 46 | 52 | 4.3 | 8.6 |
| Toledo silty clay loam | 120 | 42 | 54 | 4.0 | 8.0 |
| Wallkill silt loam | 130 | 45 | 52 | 4.6 | 9.2 |
| Warsaw loam, 0 to 2 percent slopes | 90 | 31 | 45 | 3.0 | 6.0 |
| Washtenaw silt loam | 130 | 46 | 52 | 4.3 | 8.6 |
| Whitaker loam | 120 | 42 | 50 | 4.1 | 8.2 |

[1] A.U.M. stands for animal-unit-months, which is a term used to express the carrying capacity of pasture. It is the number of animals carried per acre multiplied by the number of months the pasture can be grazed during a single grazing season without injury to the sod. For example, an acre of pasture that provides 2 months of grazing for five cows has a carrying capacity of 10 animal-unit-months.

*and shrubs*

and Marsh. Properties too variable]

| Plantings for windbreak screens and sound barriers | Plantings for beauty and shade | Planting to attract songbirds and wildlife |
|---|---|---|
| American arborvitae, Lombardy poplar, gray dogwood, red-osier dogwood, silky dogwood, Amur honeysuckle, blue arctic willow, purple willow (medium), purple willow (tall). | American arborvitae, European larch, black sour-gum, red sweetgum, Red River birch, pin oak, red maple, Lombardy poplar, weeping willow, black spruce. | American arborvitae, black sour-gum, pin oak, red maple, black spruce, gray dogwood, red-osier dogwood, silky dogwood, elderberry, Amur honeysuckle, buttonbush, trumpetcreeper. |
| White pine, Norway spruce, white spruce, tulip-poplar, pin oak, basswood, autumn-olive, Amur honeysuckle, highbush cranberry, blackhaw (viburnum), shadbush (serviceberry), arrowwood (viburnum), cornelian cherry (dogwood), althea (rose-of-Sharon), cutleaf sumac. | White pine, white spruce, baldcypress, basswood, cornelian cherry (dogwood), cutleaf sumac. | White pine, Norway spruce, white spruce, tulip-poplar, pin oak, basswood, autumn-olive, Amur honeysuckle, highbush cranberry, spicebush, blackhaw (viburnum), maple leaf (viburnum), shadbush (serviceberry), arrowwood (viburnum), mapleleaf (viburnum), wood), cutleaf sumac, trumpetcreeper, ground euonymus. |
| White pine, red pine, Norway spruce, hemlock (Canadian), blackgum, honeylocust (thornless), autumn-olive, Amur honeysuckle, highbush cranberry, blackhaw, shadbush (serviceberry), spindletree (euonymus), winged burning-bush (euonymus), French lilac (common), mockorange. | White pine, red pine, Norway spruce, hemlock (Canadian), black locust, tulip-poplar, blackgum, honeylocust (thornless), mountainash, Norway maple, ginko (maidenhair), white birch, flowering dogwood, basswood, redbud, cornelian cherry (dogwood), spindletree (euonymus), winged burning-bush (euonymus), flowering crabapple, hawthorne (Washington), pachysandra (spurge). | Hemlock (Canadian), black locust, mountainash, Norway maple, white birch, flowering dogwood, basswood, redbud, autumn-olive, Amur honeysuckle, highbush cranberry, blackhaw, mapleleaf (viburnum), shadbush (serviceberry), cornelian cherry (dogwood), spindletree (euonymus), winged burning-bush (euonymus), flowering crabapple, hawthorne (Washington), mockorange, coralberry. |
| White pine, jack pine, Austrian pine, Virginia pine, forsythia, hazelnut, lilac, scarlet oak, Russian-olive, autumn-olive, blackhaw, shadbush (serviceberry), staghorn sumac, fragrant sumac, flowering quince. | Red pine, Austrian pine, scarlet oak, honey locust (thornless), Russian-olive, staghorn sumac, fragrant sumac, flowering quince. | Scarlet oak, Virginia pine, jack pine, Austrian pine, Russian-olive, autumn-olive, blackhaw shadbush (serviceberry), hazelnut filbert), staghorn sumac, fragrant sumac, flowering dogwood, flowering quince. |
| White pine, jack pine, Austrian pine, forsythia, hazelnut, lilac, tamarisk, privet (Regels). | White pine, jack pine, Austrian pine, black locust, scarlet oak, blackgum. | Black locust, scarlet oak, blackgum, forsythia, hazelnut, privet (Regels), Jersey-tea. |

of a given soil, while important, is only one of the criteria considered. Location, land value, esthetic value, and population density should also be considered. Some soil limitations can be modified or removed. For this reason some soils rated *severe* can be used, especially where good sites are scarce.

This section does not include soil interpretations for cottage foundations and sites. For such interpretations, see the ratings for dwellings in the section "Town and Country Planning."

## *Formation and Classification of Soils*

In this section, the factors that have affected the formation of soils in Noble County are described and the processes of soil formation are explained. The current system of soil classification is explained, and the soils are assigned to the higher categories of this system. Laboratory data pertaining to the physical properties and reaction of selected soils are also provided.

### Factors of Soil Formation

Soil forms through the physical and chemical weathering of deposited or accumulated geologic material. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and has existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have been active.

Climate and plant and animal life, mainly plants, are active in soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The

*for recreational facilities*—Continued

| Playgrounds | Paths and trails | Golf course fairways |
|---|---|---|
| Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. |
| Slight | Slight | Slight. |
| Moderate: slope hinders use | Slight | Slight. |
| Severe: slope severely hinders use | Slight | Moderate: slope hinders use. |
| Severe: slope severely hinders use | Moderate: Slope severely hinders use | |
| Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. |
| Moderate: subject to occasional flooding; somewhat poorly drained. | Moderate: subject to occasional flooding; somewhat poorly drained. | Moderate: subject to occasional flooding; somewhat poorly drained. |
| Severe: very poorly drained; very slow permeability. | Severe: very poorly drained | Severe: very poorly drained; seasonal high water table; very slow permeability. |
| Severe: very poorly drained; mineral material over organic material; subject to ponding. | Severe: very poorly drained; mineral material over organic material; subject to ponding. | Severe: very poorly drained; mineral material over organic material; subject to ponding. |
| Slight | Slight | Slight. |
| Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. | Severe: very poorly drained; seasonal high water table. |
| Moderate: somewhat poorly drained | Moderate: somewhat poorly drained | Moderate: somewhat poorly drained. |

parent material also affects the kind of profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of horizons. Generally, a long time is required for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

### *Parent material*

The soils of Noble County formed in glacial till, glacial outwash, alluvium, and organic material. The county was covered several times by glacial ice sheets similar to the one now covering most of Greenland. These glaciers carried large amounts of glacial till and outwash, which are collectively called glacial drift, for long distances. The glacial drift in Noble County ranges in thickness from about 200 feet in the southwestern part of the county to more than 450 feet in the northeastern part (*14*).

Glacial till is unsorted material deposited by glaciers. A typical particle-size distribution for a soil formed in glacial till is illustrated by the data for the C horizon of Crosier soils in the table of physical and chemical properties under the heading "Laboratory Data." The glacial till in the northern and western part of the county is mostly part of the Packerton Morainic System. Crosier, Brookston, and Riddles soils formed in this medium textured glacial till. In some areas, the till has been covered with deposits of windblown sandy material of variable thickness. Chelsea and Metea soils formed in these sandy areas. The glacial till in the southeastern part of the county is moderately fine textured and is part of the Salamonie Moraine. The moderately fine textured glacial till in Green, Jefferson, Allen, and Wayne Townships is part of the Mississinewa Moraine System. Morley, Blount, Pewamo, and Rawson soils are in this area.

Glacial outwash is assorted soil material deposited by melt water from a glacier. The IIC horizon of Fox sandy loam shows the particle-size distribution of glacial outwash. During warm periods, melt water formed rivers that were several miles wide in places. Streams of melt water were also on, in, or under the glacial ice. This water-sorted material is mostly stratified sand and gravelly sand. It was laid down by moving water in streams.

Outwash plains are common in the northern and western parts of the county along the Elkhart River and Solomon Creek. Fox, Homer, Sebewa, and Oshtemo soils, which formed in loamy outwash over stratified sand and gravelly sand, are common in these areas. Fox and Oshtemo soils formed on knolls and ridges of sandy and gravelly outwash. In a few areas, sandy outwash has been reworked by wind. Chelsea soils formed in these areas. Silt and clay settled out of still water in lakes to form lacustrine deposits. Milford, Fulton, and Toledo soils formed in these deposits. The particle-size data for Milford soils in the physical and chemical properties table show that silt and clay make up most of the soil material.

Alluvial material is along streams that flood. These areas receive fresh deposits of alluvium during floods.

Most areas are along Little Cedar Creek and its tributaries. Shoals soils formed in these areas.

Organic material is partly decomposed remains of reeds, cattails, sedges, and water-tolerant trees and shrubs. They are in deep depressional areas that once were shallow lakes. The largest areas are near lakes and streams. Houghton muck is common in these areas.

### *Climate*

Climate affects the formation of soils through the action of rainfall, temperature changes, and wind. The climate of Noble County is characterized by hot summers and humid, cold winters. The precipitation averages about 34 inches a year. It is fairly well distributed throughout the year, but it is slightly greater in spring. The climate is fairly uniform throughout the county, and differences among the soils cannot be attributed to climate.

Runoff received as rainfall or melting snow moves across the soils and through drainageways. It picks up soil material from higher elevations and deposits it in lower areas. Shoals soils formed in water-moved sediment. Flowing water breaks larger soil particles into smaller ones.

Temperature fluctuations and alternate cycles of freezing and thawing break down particles of soil material. Summer heat speeds up chemical weathering processes and the activity of living organisms, whereas winter slows them down.

Wind transfers soil material from one place to another. Particles of soil material are broken apart by abrasion as they are moved about by wind. Chelsea soils formed in windborne material.

Climate affects the processes of soil formation. Water percolating through the soil moves fine particles of clay from the surface layer to the subsoil. Percolating water also dissolves minerals and moves them through the soil.

Climate indirectly affects soil formation by its influence on plant and animal life. Wet, cool conditions favor the production and accumulation of organic matter. The climate of Noble County in recent times has favored the growth of hardwood trees, which affects the kind of soil that forms.

### *Plant and animal life*

Plants, small animals, and micro-organisms are active in soil formation. Organic material is produced by plants, which absorb nutrients from the lower part of the soil. When the plants die and decay, some nutrients are left on or near the surface. Small burrowing animals, earthworms, bacteria, and fungi mix the organic material into the soil and decompose it into humus.

Most of the soils of Noble County formed under a native vegetation of deciduous hardwoods. In an area north of Ligonier, they formed under prairie grasses. The vegetation in marshes consisted of reeds, sedges, cattails, and water-tolerant trees and shrubs.

Forest vegetation adds organic matter on the surface mainly as leaf litter and dying trees. The dark-colored, natural surface layer is only a few inches thick. In well drained areas, oak, hickory, poplar, walnut, maple, and elm are dominant. Miami and Fox soils formed under deciduous hardwoods.

The forest in poorly drained areas consists mainly of maple, beech, sycamore, and white ash. In these areas, a deep, dark-colored surface layer formed because organic matter was preserved and mixed with mineral material when trees were uprooted by the wind or when soil material washed in from higher areas.

Grass incorporates a large amount of organic matter into a dark surface layer 8 to 12 inches thick. Warsaw soils formed under prairie vegetation.

Marsh areas are common near the Elkhart River and around lakes throughout the county. The vegetation in marshes adds large amounts of organic matter to the soil. This organic matter decomposes slowly because wetness slows the activity of small animals and micro-organisms. Partly decomposed organic material accumulates in these areas as thick deposits of muck and peat. Houghton muck formed under marsh vegetation.

Man has changed the soils by clearing the forests, plowing the prairie grassland, and draining and cultivating the marshes. Sloping areas become more susceptible to erosion when the natural cover is removed and the soil is cultivated. In eroded areas, the organic-matter content is lower and the natural, friable surface layer is replaced by a hard and cloddy layer. Soil blowing has removed much of the surface layer from sandy soils in places. Man also drained the wet depressional soils and improved their aeration. Drainage causes more rapid oxidation of organic matter. The marsh areas are greatly affected by drainage. Subsidence and oxidation of muck have lowered the surface several feet in places.

Washtenaw and Wallkill soils have been forming since man cleared the land. The original surface layer has been covered by recent alluvium. In some places, such as gravel pits, man's activities have greatly changed the soils.

### *Relief*

Relief influences the formation of the soils through its effect on drainage and runoff. The relief in Noble County is predominantly gently sloping or moderately sloping, but some areas are nearly level or steep.

Runoff is generally more rapid on steep slopes and more erosion has occurred. Steep soils are not so distinctly formed as nearly level soils. Soil horizons are thinner and not so strongly leached of carbonates, and plant growth is slower. Because runoff is rapid on steep soils, less water percolates through the soils and the soil-forming processes are slower.

Internal drainage has greatly affected the formation of the soils of the county. Different kinds of soil form from the same kind of parent material. For example, Miami and Crosier soils both formed in medium textured glacial till. Well drained Miami soils formed mainly on sloping knolls. They have a moderately dark surface layer and a brownish subsoil. Somewhat poorly drained Crosier soils formed mainly on nearly level flats and along drainageways. They have a moderately dark surface layer and a grayish, mottled subsoil.

### *Time*

Time is necessary for the formation of soil from

parent material. The length of time required depends on the combined action of the other factors of soil formation.

Alluvial soils are young and show little evidence of soil formation because new material is periodically added. Shoals soils are an example.

Some steep soils are young because erosion removes the material as fast as it forms.

Mature soils have well developed A and B horizons. The leaching of carbonates and the translocation of silicate clay material are processes that require considerable time and are associated with mature soils. Miami, Crosier, and Fox soils are mature.

## Processes of Soil Formation

The differentiation of horizons in the soils of the county involved several processes. Most important are the accumulation of organic matter, the leaching of carbonates and salts more soluble than calcium carbonate, the translocation of silicate clay minerals from one horizon to another, and the reduction and transfer of iron. In all the soils, most of these processes have taken place, but the effect varies from soil to soil.

In the soils of Noble County, organic matter has accumulated in the upper layers and, thus, an A1 horizon has formed. In some of the soils this horizon cannot be identified because it has been mostly or entirely lost through erosion or it has been mixed with the subsoil by cultivation. Much of the organic matter is humus. The organic-matter content is low in severely eroded Morley soils, somewhat high in Pewamo soils, and very high in Houghton soils.

Leaching of carbonates and other salts has taken place in almost all the soils of the county. Well drained soils, such as Miami soils, are generally completely leached, but leaching is slow in the poorly drained or wet soils, such as Brookston soils, because of a seasonal high water table. A comparison between the low pH values of the B horizon in Fox, Homer, and other soils and the high pH values of the C horizon shows how lime has been leached from the soils. Leaching has had little effect on the alluvial soils of the Shoals series because these soils have not been in place long enough. Leaching precedes and permits the translocation of silicate minerals in most falls.

The translocation of silicate clay minerals influenced the formation of horizons in most soils of the county. The clay moved down from the A horizon and accumulated in the B horizon, for example, in Crosier soils. Shoals soils do not show evidence of translocated clay minerals.

In the formation of silicate clays, some iron is generally freed as hydrated oxide, which is more or less strongly red in color depending on the degree of hydration. Morley, Miami, and Fox are examples of soils having iron freed as hydrated oxide.

Most of the soils formed through the process of podzolization, which is most active under forest vegetation and in a somewhat cool, humid climate. In this process, percolating water carries the clay down from the upper layers and deposits it as films along channels or on the faces of peds in the B horizon. Organic acids formed by the decomposition of organic matter in the surface layer dissolve manganese and iron as the solution moves down. The result is an A2 horizon that is lighter in color than the rest of the solum because iron and manganese compounds originally were contained in dark colored minerals. Morley, Miami, Blount, and Crosier soils are affected by podzolization.

Gleying, or the reduction and transfer of iron, has taken place in Pewamo and Blount soils and in other somewhat poorly drained and very poorly drained soils. It has also taken place to some extent in the deep horizons of Morley soils and other well drained and moderately well drained soils. Gray colors in the deep horizons of poorly drained soils, such as Pewamo and Milford soils, indicate the reduction of iron oxides. This reduction is commonly accompanied by some transfer of iron. Yellowish red, yellowish brown, or brown mottles and concretions in the deep horizons of many soils indicate segregation of iron. After it has been reduced, the iron may be removed completely from the horizon, or even from the profile, but in the soils in this county, it is more commonly moved only a short distance within the horizon or into a nearby horizon.

## Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (*13*). Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*10*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system, the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. The same property or subdivisions of this property may be used in several different categories. In table 11, the soils of Noble County are placed in categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad, climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and

group primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, temperature, permeability, depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for the soil properties, such as texture and mineralogy, that are used as family differentiae (see table 11). An example is the coarse-loamy mixed, mesic family of Typic Haplaquolls. Particle-size distribution data, shown in the laboratory data table in this survey, have been used to classify soils in the proper family.

## *Laboratory Data*[5]

The physical and chemical properties of six selected soils in Noble County are shown in table 12. The soils sampled are the Brady, Casco, Crosier, Fox, Homer, and Milford soils. They were sampled between 1969 and 1971. The analysis is of the profiles described in the section "Descriptions of the Soils."

*Methods of sampling and analysis.*—Large samples were taken from carefully selected pits. Samples were thoroughly mixed, air dried, and divided to obtain a sample for testing of approximately 1 pint. Where the soil contained material more than 2 millimeters in diameter, material more than three-quarters of an inch in diameter was sieved out and an estimate, by volume, made and recorded. The material less than three-quarters of an inch in diameter was sieved to obtain two samples: material more than 2 millimeters and material less than 2 millimeters. These samples were weighed in the laboratory to obtain the percent of material 2 millimeters to three-quarters of an inch in diameter. All samples were granulated while moist in the field by rubbing through a ¼-inch screen and were air dried.

The textural class and pH values as computed by laboratory analysis may differ from those in the profile descriptions.

To obtain particle-size distribution, organic matter was destroyed if the organic carbon content was more than 2 percent. Clay content was determined after dispersion by a calgon solution and overnight shaking. Following the clay determination, the suspension was passed through a number 50 sieve and the sand fraction was collected, dried, and weighed. Silt content was determined by adding the percentage of clay and sand and subtracting from 100.

Oxidizable organic carbon was determined by the Walkley-Black method, which involved oxidation of organic carbon by potassium dichromate and sulfuric acid.

The pH was determined by using a glass electrode pH meter on a 1:1 soil-water suspension.

Extractable phosphorus was determined by the Bray P-1 test. The soil was extracted with a 0.025N HCL and 0.03N $NH_4F$ solution, and phosphorus was determined by the molybdophosphoric blue colorimetric method.

Extractable potassium was extracted with neutral 1N ammonium acetate and determined by using an atomic absorption spectrophotometer.

The phosphorus and potassium determinations were made by the routine tests for available nutrients and are reported as pounds per acre. It was assumed that the plow layer for an acre of soil weighs 2,000,000 pounds.

[5] DR. DONALD P. FRANZMIER, associate professor of agronomy, Purdue University, helped prepare this section.

## *Environmental Factors Affecting Soil Use*

The first settlement in Noble County was in 1827, about 3.5 miles southeast of Wolf Lake. The county was organized in 1836. Sparta was the first county seat. The county seat was moved to Augusta, about 2 miles west of Albion, then to Port Mitchell Lake, and finally to Albion in 1856. The population was 2,702 in 1840 and 31,382 in 1970. Kendallville, Ligonier, and Albion are the main industrial and trade centers.

The paragraphs that follow describe the natural features in Noble County that have an effect on soil use. These features are relief, drainage, and climate. Also described are cultural features that have some effect on soil use. These features are transportation facilities and manufacturing and farming.

### Relief and Drainage

Noble County is within the Steuben morainal lake area of the northern lake and moraine physiographic region (*14*).

The relief ranges from nearly level to steep; it is predominantly gently sloping or moderately sloping. The landforms are mainly the result of glaciation. In the northwestern part of the county are mostly nearly level or gently sloping outwash plains. The more sloping areas are around numerous potholes and lakes and along drainageways. The largest area of strongly sloping to steep soils is in Green Township and extends northwest into parts of York, Perry, and Elkhart Townships. The rest of the county is mostly gently sloping or moderately sloping areas that have many small, nearly level flats or depressions.

The elevation of the county ranges from 1,060 feet above sea level in the north-central part to less than 850 feet in the southeastern part. Most of the county is drained by the Elkhart River and its tributaries. The Elkhart River is part of the St. Joseph River Watershed, which drains mostly into Lake Michigan. In the extreme southwestern part, the watershed is drained by tributaries of the Tippecanoe River, which is part of the Mississippi River Watershed. In the southeastern and east-central parts, it is drained by Cedar Creek, a tributary of the Maumee River that flows into Lake Erie.

TABLE 12.—*Physical and chemical*

[Analyses of particle-size and organic carbon content by soil scientists in the Purdue University Agronomy Laboratory; deter-

| Soil | Depth | Sample number | Horizon | Particle-size distribution of less than 2 millimeter material | | | |
|---|---|---|---|---|---|---|---|
| | | | | Sand | | | |
| | | | | Very coarse and coarse 2–0.5 mm | Medium 0.5–0.25 mm | Fine 0.25–0.10 mm | Very fine 0.10–0.05 mm |
| | *In* | | | *Pct* | *Pct* | *Pct* | *Pct* |
| Brady sandy loam | 0–7 | S70IN57–3–1 | Ap | 14 | 21 | 24 | 6 |
| | 7–9 | S70IN57–3–2 | A12 | 14 | 21 | 24 | 5 |
| | 9–17 | S70IN57–3–3 | B1 | 12 | 22 | 24 | 5 |
| | 17–31 | S70IN57–3–4 | B21 | 18 | 25 | 27 | 4 |
| | [1] 17–31 | S70IN57–3–5 | B21t | 17 | 24 | 22 | 3 |
| | 31–53 | S70IN57–3–6 | B22 | 14 | 25 | 42 | 5 |
| | [1] 31–53 | S70IN57–3–7 | B22t | 9 | 22 | 45 | 7 |
| | 53–72 | S70IN57–3–8 | IIC | 10 | 26 | 43 | 9 |
| Casco sandy clay loam | 0–7 | S69IN57–2–1 | Ap | 23 | 17 | 18 | 8 |
| | 7–15 | S69IN57–2–2 | B21t | 51 | 6 | 5 | 2 |
| | 15–18 | S69IN57–2–3 | B22t | 71 | 9 | 2 | 1 |
| | 18–30 | S69IN57–2–4 | IIC | 74 | 6 | 5 | 3 |
| Crosier loam | 0–10 | S71IN57–1–1 | Ap | 5 | 12 | 24 | 13 |
| | 10–14 | S71IN57–1–2 | B1 | 3 | 8 | 17 | 11 |
| | 14–22 | S71IN57–1–3 | B21t | 5 | 10 | 18 | 9 |
| | 22–35 | S71IN57–1–4 | B22t | 4 | 10 | 20 | 1 |
| | 35–60 | S71IN57–1–5 | C | 13 | 15 | 20 | 11 |
| Fox sandy loam | 0–9 | S69IN57–1–1 | Ap | 25 | 21 | 19 | 5 |
| | 9–14 | S69IN57–1–2 | B1 | 24 | 21 | 20 | 5 |
| | 14–27 | S69IN57–1–3 | B21t | 24 | 21 | 16 | 3 |
| | 27–33 | S69IN57–1–4 | B22t | 37 | 22 | 13 | 3 |
| | 33–35 | S69IN57–1–5 | B3t | 61 | 17 | 4 | 1 |
| | 35–42 | S69IN57–1–6 | IIC | 57 | 23 | 13 | 1 |
| Homer loam | 0–8 | S70IN57–1–1 | Ap | 19 | 18 | 14 | 5 |
| | 8–10 | S70IN57–1–2 | A2 | 18 | 19 | 16 | 5 |
| | 10–18 | S70IN57–1–3 | B1t | 13 | 14 | 13 | 5 |
| | 18–25 | S70IN57–1–4 | B21t | 14 | 14 | 11 | 4 |
| | 25–34 | S70IN57–1–5 | B22t | 34 | 14 | 10 | 3 |
| | 34–38 | S70IN57–1–6 | IIB3 | 46 | 29 | 10 | 2 |
| | 38–60 | S70IN57–1–7 | IIC | 51 | 18 | 11 | 5 |
| Milford silty clay loam | 0–7 | S69IN57–3–1 | Ap | 4 | 2 | 3 | 4 |
| | 7–11 | S69IN57–3–2 | A12 | 3 | 2 | 3 | 4 |
| | 11–16 | S69IN57–3–3 | B1g | 2 | 2 | 3 | 4 |
| | 16–26 | S69IN57–3–4 | B21g | 1 | 1 | 2 | 3 |
| | 26–33 | S69IN57–3–5 | B22g | 1 | 1 | 3 | 6 |
| | 33–44 | S69IN57–3–6 | B23g | 1 | 1 | 3 | 6 |
| | 44–49 | S69IN57–3–7 | B3 | 1 | 1 | 1 | 2 |
| | 49–63 | S69IN57–3–8 | C | 11 | 15 | 15 | 5 |

[1] Horizon contains 4 inches of bands of sandy clay loam.

## Climate [6]

Noble County has a continental climate somewhat modified by the Great Lakes. The climate results from the influence of cool Canadian air masses alternating with tropical air masses from the south to bring changes within days and variable seasons. The climate is excellent for farming.

Rainfall is generally adequate during the growing season. In mid-summer, however, evaporation exceeds rainfall for brief periods. As a result, lawns, pastures, and crops are adversely affected.

Weather changes come from the passing of weather fronts and associated centers of low and high air pressure. In general, a high brings lower temperatures, lower humidity, and sunny days. An approaching low brings increasing temperatures, increasing southerly winds, higher humidity, and rain. This activity is greatest in the spring and least late in summer and early in fall.

Temperatures in a 30-year period ranged from –23°

[6] By LAWRENCE A. SCHAAL, State climatologist, Department of Agronomy, Purdue University.

*properties of selected soils*

minations of pH, extractable P, and extractable K by Purdue Plant and Soil Analysis Laboratory. The symbol < means less than.]

| Particle-size distribution of less than 2 millimeter material—continued | | Fraction greater than 2 millimeters | Textural class | Organic carbon | pH of 1:1 soil:water solution | Extractable | |
|---|---|---|---|---|---|---|---|
| Silt 0.05–0.002 mm | Clay <0.002 mm | | | | | P | K |
| *Pct* | *Pct* | *Pct* | | *Pct* | | *Lb per acre* | *Lb per acre* |
| 27 | 8 | 6 | Sandy loam | 1.45 | 7.0 | 156 | 165 |
| 32 | 4 | 9 | Sandy loam | 1.57 | 6.8 | 141 | 105 |
| 28 | 9 | 7 | Sandy loam | | 6.7 | 208 | 90 |
| 19 | 7 | 5 | Sandy loam | | 6.7 | 40 | 60 |
| 21 | 13 | 0 | Sandy loam | | 6.6 | 22 | 90 |
| 7 | 7 | 5 | Loamy sand | | 6.6 | 33 | 60 |
| 7 | 10 | 0 | Loamy sand, sandy loam | | 6.5 | 33 | 75 |
| 8 | 4 | 3 | Sand, loamy sand | | 6.5 | 21 | 30 |
| 16 | 18 | 3 | Sandy loam, sandy clay loam | 0.99 | 7.0 | 20 | 150 |
| 10 | 26 | 4 | Sandy clay loam | 0.58 | 6.6 | 5 | 180 |
| 5 | 12 | 12 | Sandy loam | | 6.7 | 6 | 105 |
| 9 | 3 | 8 | Sand and gravelly sand | | 7.8 | 4 | 30 |
| 37 | 9 | 5 | Sandy loam, loam | | 7.3 | 9 | 60 |
| 38 | 19 | 2 | Loam | | 6.8 | 2 | 75 |
| 33 | 25 | 4 | Loam | | 6.8 | 2 | 105 |
| 32 | 23 | 5 | Loam | | 6.8 | 2 | 105 |
| 31 | 10 | 11 | Sandy loam | | 8.1 | 1 | 75 |
| 24 | 6 | 14 | Sandy loam | 0.61 | 5.8 | 15 | 90 |
| 20 | 10 | 27 | Gravelly sandy loam | < 0.1 | 5.8 | 12 | 90 |
| 12 | 24 | 30 | Gravelly sandy clay loam | | 5.8 | 21 | 135 |
| 5 | 20 | 22 | Gravelly sandy clay loam, gravelly sandy loam | | 5.7 | 28 | 120 |
| 8 | 9 | 7 | Sandy loam | | 5.9 | 26 | 90 |
| 4 | 2 | 5 | Sand and gravelly sand | | 7.8 | 10 | 30 |
| 34 | 10 | 10 | Sandy loam | 1.16 | 6.9 | 51 | 225 |
| 31 | 11 | 10 | Sandy loam | 1.51 | 7.0 | 60 | 300 |
| 41 | 14 | 12 | Loam | | 5.3 | 3 | 90 |
| 34 | 23 | 18 | Gravelly loam | | 5.4 | 2 | 165 |
| 14 | 25 | 25 | Gravelly sandy clay loam | | 5.4 | 5 | 180 |
| 5 | 8 | 20 | Gravelly loamy sand | | 7.7 | 11 | 75 |
| 12 | 3 | 30 | Sand and gravelly sand | | 8.1 | 3 | 30 |
| 53 | 34 | <1 | Silty clay loam | 3.13 | 7.0 | 58 | 285 |
| 52 | 36 | <1 | Silty clay loam | 2.35 | 7.0 | 60 | 240 |
| 53 | 36 | <1 | Silty clay loam | 2.67 | 7.1 | 44 | 225 |
| 49 | 44 | <1 | Silty clay | 0.90 | 7.4 | 24 | 240 |
| 49 | 40 | <1 | Silty clay loam, silty clay | 0.44 | 7.1 | 30 | 270 |
| 44 | 45 | <1 | Silty clay | 0.64 | 7.3 | 48 | 255 |
| 55 | 40 | <1 | Silty clay loam, silty clay | | 7.0 | 44 | 300 |
| 31 | 23 | 3 | Loam | | 7.2 | 25 | 195 |

F. to 111°. Temperatures of 90° or higher occurred on an average of 19 days a year, and those continually below 32° occurred on an average of 47 days a year. The data in tables 13 and 14 come from a cooperative weather station of the National Weather Service located 5 miles east of Albion, which is a rural location considered climatologically representative of the county (*8*).

Average annual precipitation is evenly distributed throughout the year. Spring and early summer rain, however, generally exceeds precipitation in winter. Spring rain is considered reliable, insuring near maximum soil moisture as summer approaches and an excellent growing season. Sometimes wetness in spring delays planting. The least amount of precipitation generally occurs in February.

Following is the probability of unusually heavy rain, as indicated by a weather study of the area (*8*):

| Frequency in 100 years | Inches in 1 hour | Inches in 6 hours | Inches in 12 hours |
|---|---|---|---|
| 4 | 2.1 | 3.2 | 3.7 |
| 10 | 1.7 | 2.8 | 3.2 |
| 20 | 1.5 | 2.4 | 2.8 |

TABLE 13.—*Temperature and precipitation*

[Data from U.S. Weather Station 5 miles east of Albion; elevation 983 feet, for period 1941–1972]

| Month | Temperature | | | | Precipitation | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average daily maximum | Average daily minimum | Average monthly highest maximum | Average monthly lowest minimum | Average monthly total | One year in 10 will have— Less than— | One year in 10 will have— More than— | Days with snow cover of 1 inch or more | Average depth of snow on days with snow cover of 1 inch or more |
| | *° F* | *° F* | *° F* | *° F* | *Inches* | *Inches* | *Inches* | *Number* | *Inches* |
| January | 32 | 16 | 52 | –6 | 2.0 | 0.5 | 4.0 | 16 | 2.8 |
| February | 35 | 18 | 54 | –2 | 1.6 | .4 | 2.8 | 14 | 2.9 |
| March | 45 | 26 | 68 | 7 | 2.2 | .9 | 3.8 | 5 | 1.7 |
| April | 60 | 38 | 80 | 22 | 3.4 | 1.2 | 5.2 | 1 | .5 |
| May | 70 | 47 | 85 | 31 | 3.5 | 2.1 | 4.7 | 0 | 0 |
| June | 80 | 57 | 91 | 42 | 4.0 | 1.7 | 6.4 | 0 | 0 |
| July | 86 | 58 | 92 | 49 | 3.9 | 1.6 | 6.4 | 0 | 0 |
| August | 82 | 59 | 91 | 45 | 3.0 | 1.4 | 5.3 | 0 | 0 |
| September | 76 | 52 | 87 | 35 | 2.8 | .9 | 5.7 | 0 | 0 |
| October | 65 | 42 | 81 | 25 | 2.7 | .7 | 5.1 | 0 | 0 |
| November | 48 | 31 | 68 | 14 | 2.7 | 1.1 | 4.1 | 2 | 1.0 |
| December | 35 | 20 | 57 | 0 | 2.2 | .4 | 4.4 | 13 | 2.7 |
| Year | 59 | 39 | [1] 95 | [2] –9 | 34.0 | 25.2 | 42.2 | 51 | 2.6 |

[1] Average annual highest temperature.
[2] Average annual lowest temperature.

TABLE 14.—*Probabilities of last freezing temperature in spring and first in fall*

[Data recorded at U.S. Weather Station]

| Probability | Dates for given probability and temperatures | | | | |
|---|---|---|---|---|---|
| | 16° F or lower | 20° F or lower | 24° F or lower | 28° F or lower | 32° F or lower |
| Spring: | | | | | |
| 1 year in 10 later than | March 30 | April 10 | April 24 | May 3 | May 21 |
| 2 years in 10 later than | March 25 | April 5 | April 18 | April 29 | May 16 |
| 5 years in 10 later than | March 14 | March 24 | April 6 | April 20 | May 7 |
| Fall: | | | | | |
| 1 year in 10 earlier than | November 11 | November 1 | October 24 | October 11 | September 25 |
| 2 years in 10 earlier than | November 17 | November 6 | October 28 | October 16 | September 30 |
| 5 years in 10 earlier than | November 29 | November 18 | November 7 | October 27 | October 11 |

Snowfall averages 27 inches a year. December, January, and February average 6 inches each. In 1948, December snowfall totaled 20 inches. In a recent 30-year period, the greatest daily snowfall was 8 inches on March 27, 1934. Snow generally protects winter grain from the cold air.

Cloudiness in Noble County can be indicated by that observed in nearby Allen County, where 181 days out of 365 are cloudy and 77 are clear (*3*). The sun is observed for 58 percent of daylight hours. This percent ranges from 37 in December to 72 in July and August.

Relative humidity at noon averages about 55 percent in summer and 65 percent in winter. On most nights, relative humidity increases to 95 to 100 percent. This increase is frequently accompanied by dew or frost.

Winds are most frequently from the southwest. During a few winter months, however, the dominant direction is northwest. The velocity of these winds averages 8 miles per hour in August and 12 miles per hour in March and April. Damaging winds originate from thunderstorms or tornadoes. In a 53-year period, only five tornadoes were reported. Thunderstorms occur about 46 days a year.

## Transportation Facilities and Manufacturing

Noble County is crossed by two east-west railroads

# APPENDIX F

## CLIMATOGRPHY OF THE UNITED STATES - NO. 60

# Climate of Indiana

## Topographic Features

The three principal land regions in Indiana are: the Great Lakes Plain in the north, the Central Till Plains and, in the south, the Interior Low Plateau that is characterized by hills, ridges, knolls, caves and waterfalls. Elevations range from a little more than 300 feet above sea level at the mouth of the Wabash in the southwest corner of the state to a little over 1,200 feet in Randolph and Stueben counties. South central Indiana is unglaciated and therefore has the most rugged terrain. The Kankakee Valley in the northwest slopes gently toward the west and drains what was formally marshlands, but where muckland farming is now practiced extensively. Many small lakes abound in northeastern Indiana among numerous glacial moraines and hills. Prairie soils extend into west central and northwest Indiana.

Indiana, because of its location in the middle latitude in the interior of the continent, has an invigorating climate with warm summers and cool winters. Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana. Climatological variations within the state are caused by differences of latitude, elevation, terrain, soil, and lakes.

The soils of Indiana account for some variations in rainfall needs for farming. The sandy soil of the north has a low water holding capacity; on the other hand, drainage is rapid during rainy periods and flooding is rarely a problem. Some of the clays in eastcentral Indiana are compact, with poor drainage and frequent ponding, but distress of crops from lack of rain occurs infrequently. Much of the land in southcentral Indiana has a poor retention capacity for water because of the underlying limestone. Such areas need frequent rains to sustain proper growth and development of crops.

Most of the state is drained by the Wabash River system. The total drainage area of the Wabash is 33,000 square miles, of which 24,000 square miles is in Indiana. Other river basins are the Maumee in the extreme northeast, the St. Joseph (Lake Michigan) and Kankakee (Illinois River) in the northcentral and northwest, while some of the extreme south and southeast area drains into the Ohio River.

The effect of Lake Michigan on the climate of northern Indiana is well defined in the climatological data. This effect is most pronounced just inland from the Lake Michigan shore and diminishes rapidly with distance. Cold air passing over the warmer lake water induces precipitation in the lee of Lake Michigan in the fall and winter. As a result of this phenomena, winter precipitation, especially snowfall, is greatest in the counties of Lake, Porter, and LaPorte. Lake-related snowfall and cloudiness often extend to central Indiana in the winter. Severe local snowstorms often occur just inland from Lake Michigan. In the spring, daily maximum temperatures decrease northward in northern Indiana because of the cooling effect of the Lake. Average daily minimum temperatures in the fall are higher in northwestern Indiana than farther south.

## Temperature

Variations of temperature and precipitation occur in short distances where terrain is hilly. On calm,

clear nights the valley bottoms have lower temperatures than the slopes and tops of the surrounding hills. Temperatures can range from around minus 35 degrees to plus 115 degrees, although prolonged severe hot or cold spells are uncommon.

The dates of the last freezing temperature in the spring and the first in the fall vary greatly from year to year. Two-thirds of the time they occur within a 20- to 24-day period centered at the mean date. The average date of the last freezing temperature in the spring ranges from the first week of April in the Ohio River Valley of the southwest to the second week of May in the extreme northeast. The usual trend of a later date toward the north is reversed in extreme northwestern Indiana, where the average date is about April 30 near Lake Michigan. In the fall the avearage date of the first temperature of 32 degrees or colder is from October 7 in the extreme northeast to October 26 along the Ohio River in the southwest. Spring freezes are later and fall freezes are earlier in valleys and hollows along a given latitude. The gradual slope of the terrain upward from southwestern Indiana to northeastern Indiana results in lower minimum temperatures and shorter growing seasons in the east compared to the west at the same latitude. In the Kankakee Valley, peat or muck lands experience late spring and early fall frosts because of the soil characteristics.

## Precipitation

Average annual rainfall ranges from 36 inches in northern Indiana to 44 inches in southern Indiana. July rainfall averages about the same in all areas. The greater precipitation in the south compared with the north comes in the winter months. Southern Indiana has the greatest rainfall in March and the least in October. The wettest month in northern and central Indiana is June and the driest is February. The mean annual number of days when precipitation exceeds 0.10 inch is about 75 days. However, the average increases to 85 in LaPorte county near Lake Michigan and also in southcentral Indiana. A low count of 70 prevails along the Wabash River from westcentral Indiana to the northeast.

Annual precipitation is adequate, but an uneven distribution in the summer occasionally limits crops. Mild droughts occasionally occur in the summer when evaporation is highest and dependance on rainfall is greatest for crops. Approximately one-third of the annual rainfall flows to the Mississippi or Great Lakes, mainly during cool weather. The soil usually becomes saturated with water several times during the winter and spring. Ground water storage is generally abundant in the north and central areas where glacial deposits cover ancient lake beds or streams. An underlying bed of limestone with shallow soils limits ground water storage in much of southcentral Indiana.

Floods occur in some part of the state nearly every year and have occurred in every month of the year. The months of greatest flood frequency are from December through April. The primary cause of floods is prolonged periods of heavy rains, although rain falling on snow and frozen ground is a contributing factor.

Average annual snowfall ranges from 10 inches in southern Indiana to 60 inches in the north and is highest in LaPorte county near Lake Michigan. Snowfall varies greatly from year to year depending on both temperature and the frequency of winter storms. At a given latitude in central and southern Indiana snowfall amounts increase toward the east because of the higher elevation.

## Other Climatic Features

Cloudiness is least in the fall and greatest in the winter. The northern part of the state is cloudier than the south, particularly in the winter when the Great Lakes have their greatest effect upon the weather.

Average relative humidity differs very little at night over Indiana. Often it is 100 percent. During the day relative humidity is usually lower in the south than in the north. This is true for all seasons.

However, the simultaneous occurrence of high temperatures and high relative humidity is most frequent in the south.

Evaporation from a water surface in a four-foot diameter tank ranges from six inches at Valparaiso to eight inches at Evansville in July. Evaporation is three or four inches in the north in April and October, a little higher in the south.

Severe storms which damage property and cause loss of life are most frequent in the spring. Indiana has an annual average of 11 days with tornadoes. Property damage is greatest from high winds during thunderstorms, while hail occasionally causes loss of crops over small areas during the summer.

Prevailing winds are generally from the southwest during most of the year. During the winter months they prevail from a northerly direction and are more persistent. The land and sea breeze effect is prominent in the summer and the cooling sea breeze tends to reduce daytime maximum temperatures along the shore and for up to a mile inland.

## Weather and the Economy

Indiana has a range of latitude from 38 degrees to nearly 42 degrees north, which provides a climate suitable for a variety of crops. Corn, fall wheat, spring oats, and soybeans are the most important crops in the state. Tomatoes, strawberries, and melons are grown commercially in the southwest where the growing season is long. Tobacco is grown in the extreme southeast. Fruit is grown in the lower Wabash River Basin, but the risk of frost, late spring freezes and severe winter kill must be considered real problems. Beef production is a major operation in the rolling hills of southern Indiana. Agricultural interests have taken advantage of the fairly reliable rainfall and temperatures favorable for crop and vegetative growth, while the huge steel mills and oil refineries make the Lake Michigan waterfront one of the world's great industrial centers.

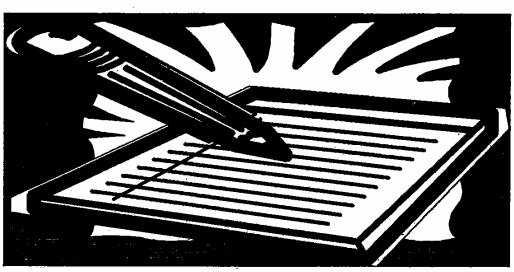
**The above article from CLIMATOGRAPHY OF THE UNITED STATES NO. 60 published November 1976 by the National Climatic Data Center**

# APPENDIX G

## RESULTS
## OF
## THE CHAIN O' LAKES WATERSHED QUESTIONNAIRE

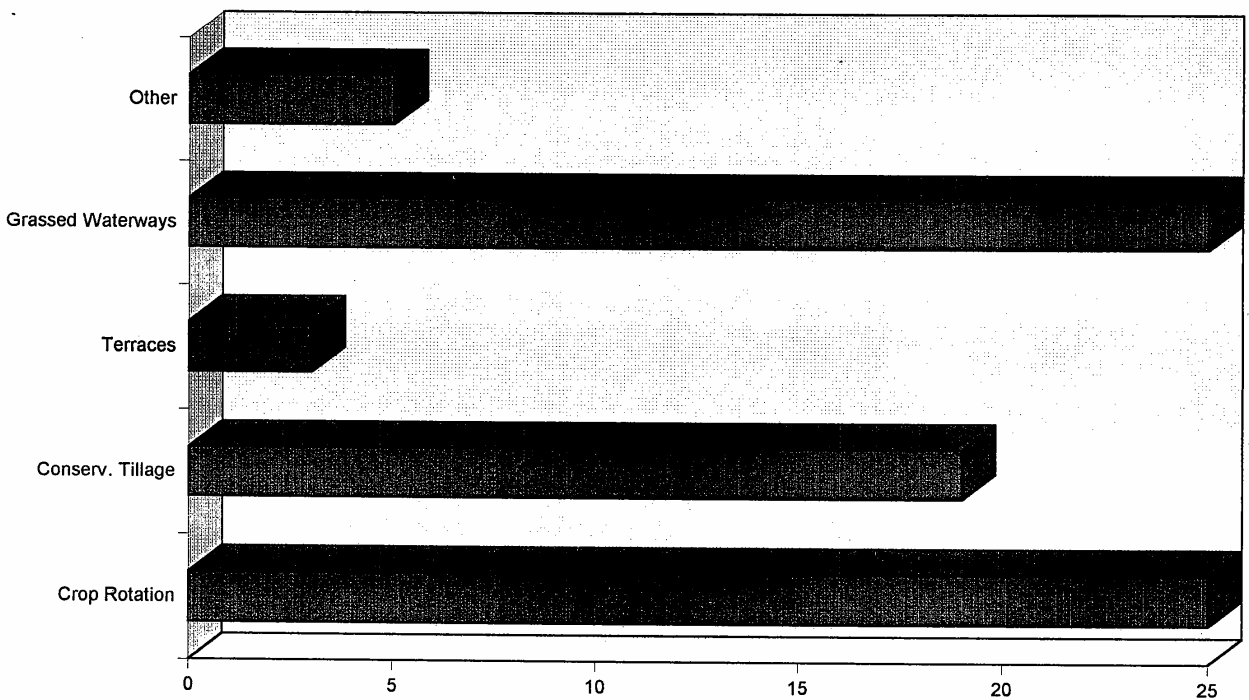
# 1996

# Results Of The Chain O'Lakes Watershed Questionnaire



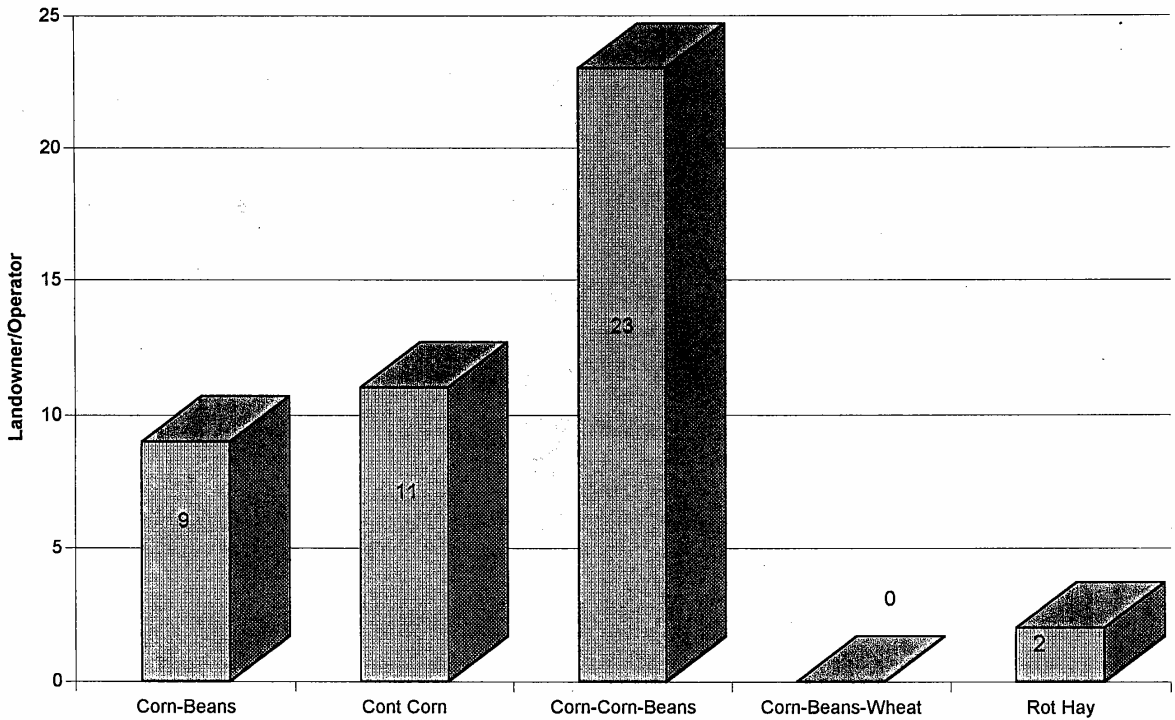
- 144 Questionnaires Mailed
- 44 Questionnaires Returned
- Overall Response 31%

## Conservation Practices Being Utilized To Control Soil Erosion



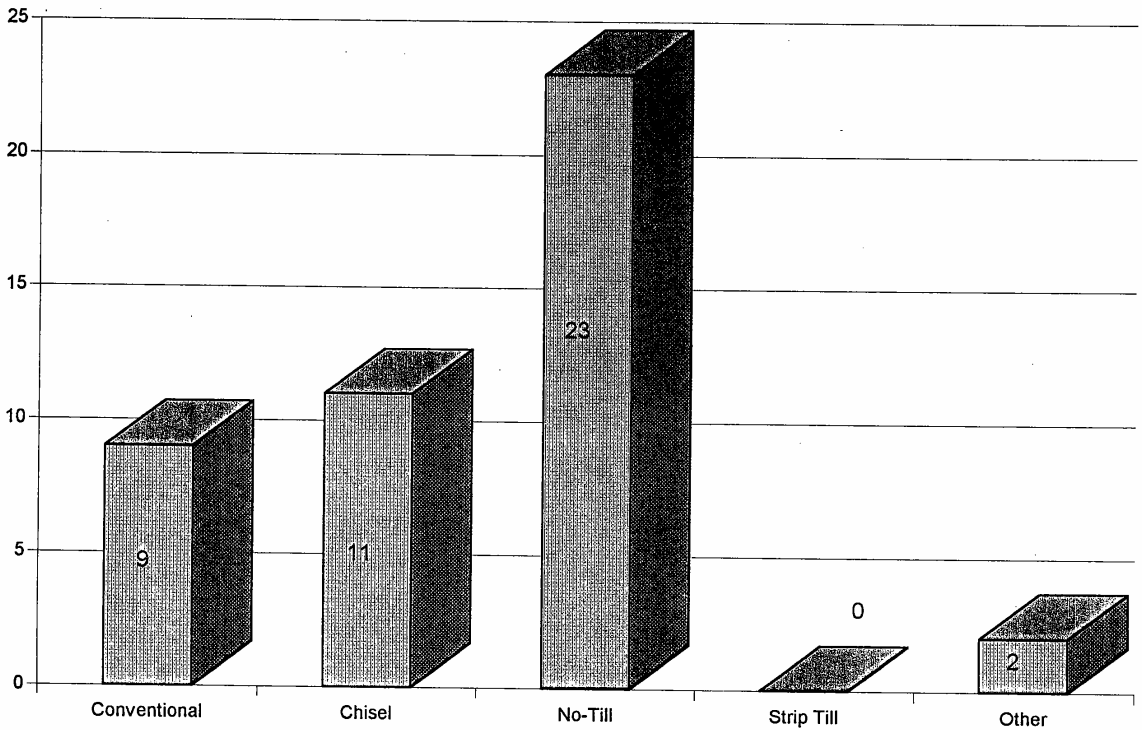

Based on Response of 44 [illegible]

## Predominate Crop Rotation Systems Used By Landowner/Operator

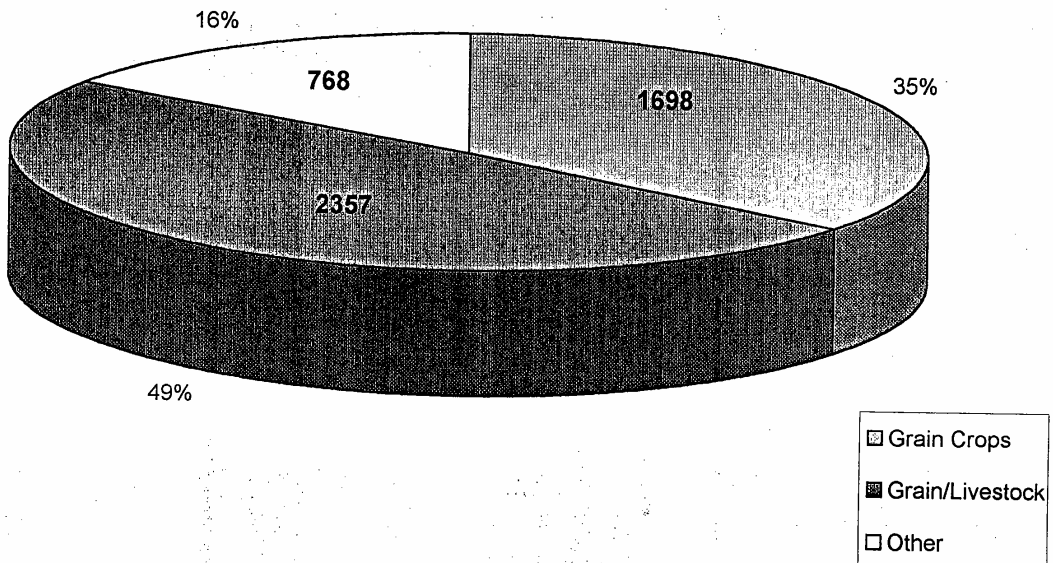



Based on Responses of 44 Landowner/Operators

## Predominate Crop Tillage Systems Used By Landowner/Operators

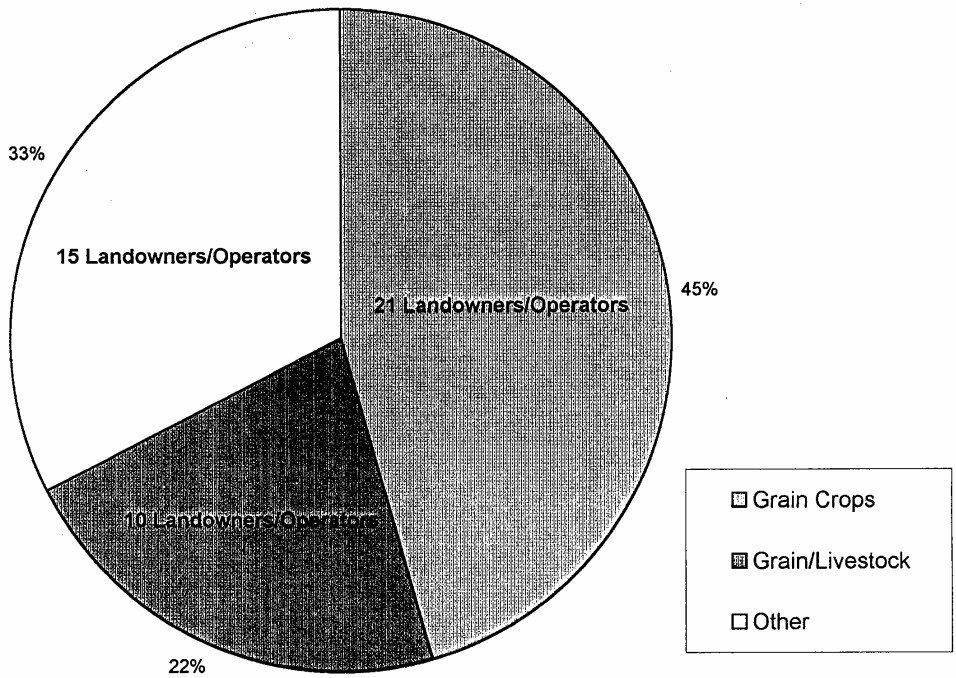


## Number of Acres Farmed In Each Operation



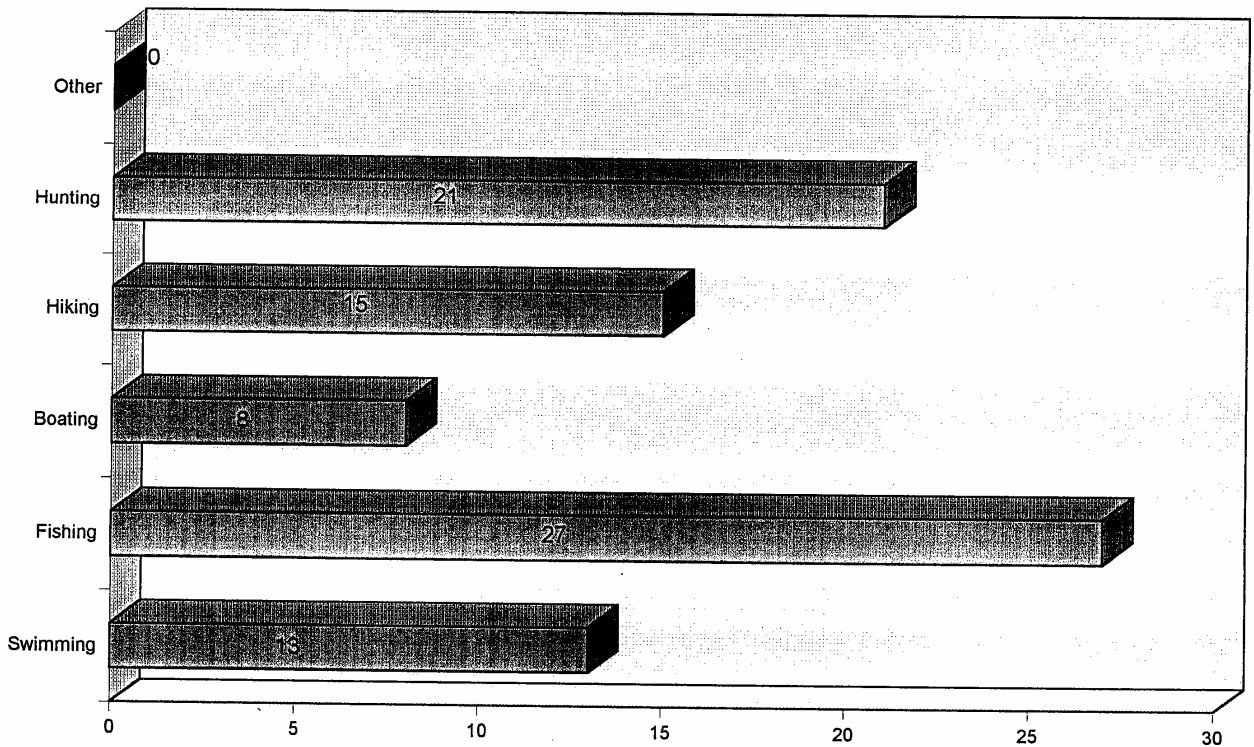

Based on Responses of 44 Landowner/Operators

## Farming Operation Used by Landowners/Operators




Based on Responses of 44 Landowner/Operators

## Recreational Activity Utilized Within The Watershed



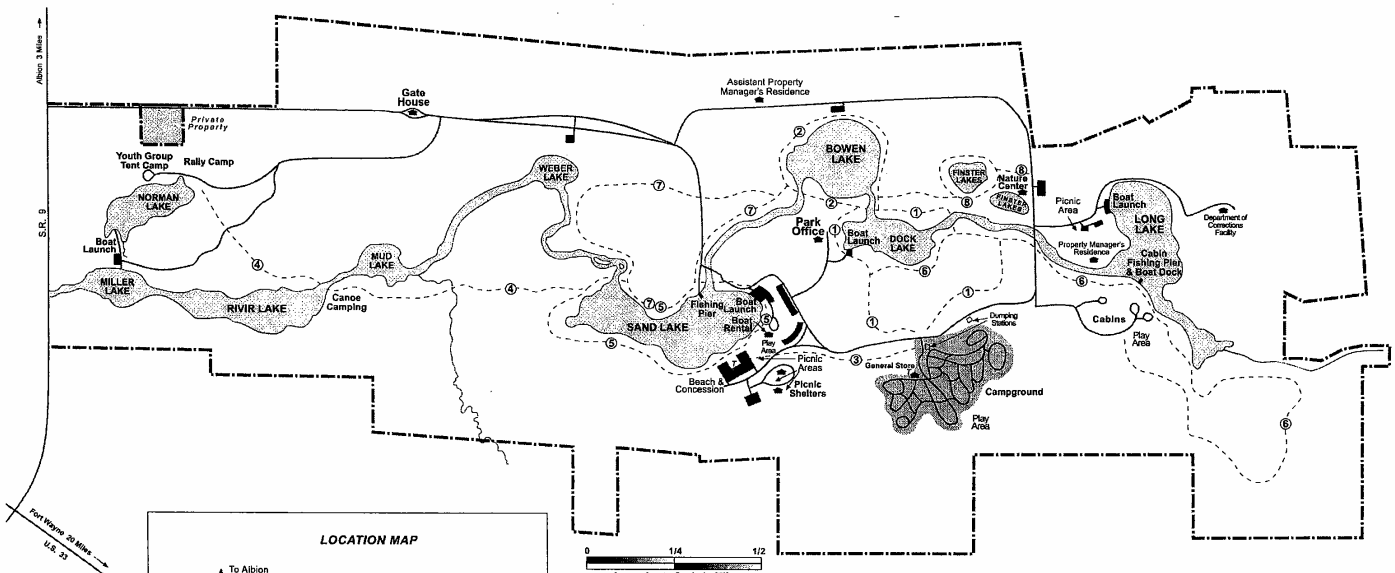

Based on Responses of 44 Landowner/Operators

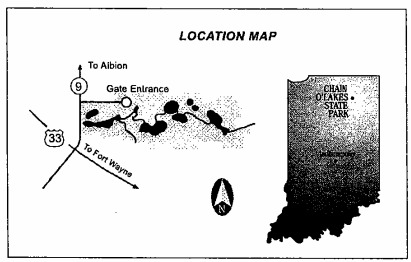
# APPENDIX H

## CHAIN O' LAKES STATE PARK MAP
## AND
## PARK INFORMATION

# CHAIN O'LAKES STATE PARK

**2355 E. 75 South • Albion, Indiana 46701 • 260-636-2654**
**2,718 Acres Established 1960**




0 1/4 1/2
*Approximate Scale in Miles*

| LEGEND | | | |
|---|---|---|---|
| | *Road* | T | *Telephone* |
| | *Hiking Trail* | | *Boundary* |
| | | | *Parking* |

| TRAIL TABLE | | |
|---|---|---|
| *TRAIL* | *MILEAGE* | *TRAIL TYPE* |
| 1 | 1.5 | Moderate |
| 2 | 1 | Moderate |
| 3 | .5 | Easy |
| 4 | 1 | Moderate |
| 5 | 1.3 | Easy |
| 6 | 2.5 | Moderate |
| 7 | 1.8 | Easy |
| 8 | .5 | Easy |

Printed on Recycled Paper

RECYCLE! Place used beverage cans in the park's marked recycling containers! Thank you!

## DESCRIPTION OF TRAILS

1. MODERATE — 1.5 miles. Begins just north of the campground and follows a ridge through the woods before dropping down in a valley, crosses two channels as it circles around the north side of Dock Lake, and returns to the campground.
2. MODERATE — 1 mile. Begins at the parking lot on the north shore of Bowen Lake, follows the lake shore through the woods past a burial mound and returns to the parking lot.
3. EASY — .5 mile. Links the campground with the beach.
4. MODERATE — 1 mile. Takes you past four lakes, wooded areas, swamps and open fields.
5. EASY — 1.3 miles. Follows the shore around Sand Lake through willows and open areas.
6. MODERATE — 2.5 miles. Provides access to Long Lake by way of Trail 1 through open field, locust and pine trees. It then follows the southwest shore of Long Lake through creek bottoms and woods.
7. EASY — 1.8 miles. Begins at the Sand Lake fishing pier, follows along the channel to Bowen Lake, then turns west to connect with Weber Lake and return along the channel to Sand Lake. It winds through lowlands, along two different channels, and through an upland forest.
8. EASY — .5 mile. A self-guiding nature trail. It begins at the interpretive center, circles Finster Lake crossing a glacial kame, and returns to the interpretive center.

## STAY ON MARKED TRAILS!

Please let wild animals remain wild. Feeding deer is prohibited. Feeding of wild animals can result in harm to both animals and people. Animals who depend on handouts become a nuisance to park visitors and a danger to themselves. Please lock up all food and coolers inside cars or campers. Roll car windows up tightly.

## THIS IS YOUR PARK

All visitors are expected to observe the following rules which are designed to fulfill the purpose for which state parks were established, namely, to preserve a primitive landscape in its natural condition for the use and enjoyment of the people.

## RULES AND REGULATIONS

- Do not injure or damage any structure, rock, tree, flower, bird or wild animal within the Park. Do NOT gather limbs, brush or trees (either dead or alive) for firewood! It MUST be allowed to remain to rebuild the natural humus.
- Any firearm, BB gun, air gun, $CO_2$ gun, bow and arrow, or spear gun in possession in a state park must be unloaded or un-nocked and stored in a case or locked within a vehicle except when participating in an activity authorized by written permit.
- Dogs and cats must be kept on a leash no longer than six feet and attended at all times. Pets are not allowed in the family cabins or their immediate vicinity.
- There shall be no vending or advertising without permission of the Department of Natural Resources.
- Camping is permitted only in the campground. Youth groups must be under adult supervision.
- Fires shall be built only in places provided.
- Please comply with the Carry In/Carry Out trash policy in all day use areas. Overnight guests must put waste in receptacles provided for that purpose.
- Motorists will observe speed limits as posted, and park in designated areas.
- Swimming is limited to the beach at Sand Lake and only when lifeguards are on duty.
- Drinking water should be taken only from pumps, hydrants or fountains provided for that purpose. This water is tested regularly for purity.
- Report lost or found articles to the park office.
- All motorized vehicles must remain on paved roadway. Snowmobiles are prohibited.
- Use of metal detectors prohibited.
- The park is closed from 11 p.m. until 7 a.m., except to fishermen and campers at their site, and cabin guests with a receipt or key.

*For a compete list of rules and regulations inquire at park office.*

## ACTIVITIES AND FACILITIES

***BOATS & CANOES*** — Boats, canoes and paddleboats are rented by the hour or day. Life jackets are also available. Only electric trolling motors are allowed.

***CAMPING*** — Campground equipped with flush toilets, hot water and showers. Occupancy is limited to two weeks. All sites will accommodate trailers. Electricity is available as are dump stations. Some sites may be reserved. A rally campground and youth tent area are also available.

***FAMILY CABINS*** — Family housekeeping cabins may be rented from April through October. Cabins are rented by the week from Saturday to Saturday during June, July and August. They may be rented by the night during April, May, September and October. Non-smoking cabins are available. Six of the cabins are also available in the winter. Cabins are not rented to persons under the age of 21.

***FISHING*** — Bass, bluegill and other small gamefish are common. A state fishing license, which may be purchased at the park office, is required.

***GROCERIES*** — A small store is located in the campground.

***HIKING*** — More than 10 miles of hiking trails are available. They are rated as easy or moderate.

***INTERPRETIVE NATURALIST SERVICE*** — A naturalist is available through the summer months. Hikes, Junior Naturalist and Hoosier Ecologist programs, plus evening activities are offered. Ask for a schedule at the gatehouse, park office or nature center.

***PICNIC AREAS*** — Tables, toilet facilities, playground equipment and playfields.

***REFRESHMENT STAND*** — Soft drinks, ice cream and snacks are available at the beach refreshment stand. Operating hours are same as beach.

***SWIMMING*** — There is no charge for swimming, which is permitted only when a lifeguard is on duty. The bathhouse and beach are open the Saturday before Memorial Day and no later than Labor Day.

***TELEPHONE*** — Public phones are located near the campground control station and the beach.

***ADDITIONAL INFORMATION*** about activities and facilities is available at the park office.

Please carry out all trash you produce in order to keep your park clean and beautiful for others to enjoy!

## FOR MORE INFORMATION

*Write:* Chain O'Lakes State Park
2355 E. 75S
Albion, Indiana 46701
*Call:* (260) 636-2654

DNR
Indiana Department of Natural Resources

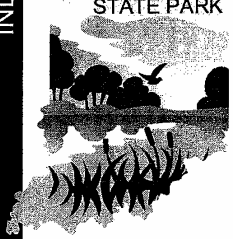
## SPECIAL NOTE

Receipts from admission and service charges are used to help defray the operation and maintenance costs of the park. List of fees available in the park office.

The programs, services, facilities and activities of the Indiana Department of Natural Resources are available to everyone. DNR prohibits discrimination on the basis of race, color, national origin, age, sex, or disability. If you believe that you have been discriminated against in any program, activity, or facility as described above, or if you desire further information please write to: Department of Natural Resources, Executive Office, 402 W. Washington St., Rm. W256, Indianapolis, IN 46204, (317) 232-4020.

INDIANA

# CHAIN O'LAKES STATE PARK



One of the most interesting features at Chain O'Lakes State Park is its shape. It is about a mile wide and four miles long. Within its boundaries are 2,718 acres including 212 surface acres of water and more than seven miles of widely varying shoreline.

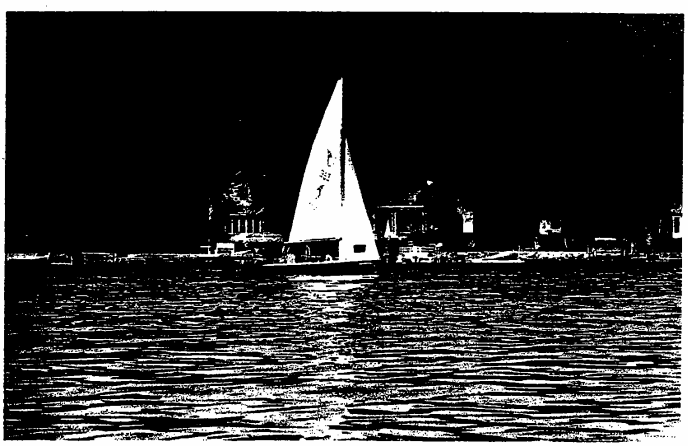
The lakes in this chain are known as kettle lakes and were formed by the last glaciers in this area approximately 10,000 years ago. The lakes were actually huge blocks of ice. Rivers of water resulting from melting ice carved the channels which connect eight of the 11 lakes in the park.

Prior to its settlement by pioneers, the area was inhabited by Miami Indians. An Indian village of about 30 bark wigwams was located on the north shore of Bowen Lake. William Bowen was one of the first settlers in this area in the 1830's. In 1840, he constructed a home on the north shore of Bowen Lake.

# APPENDIX I

## INDIANA LAKE WATER QUALITY UPDATE
## FOR
## 1989 - 1993

# Indiana Lake Water Quality Update for 1989–1993



Indiana Department of Environmental Management
Clean Lakes Program
Indianapolis, Indiana

November 1996

# Preface

Beginning in 1970, the State of Indiana recognized the need to generate physical, chemical, and biological data from all of its public lakes and reservoirs. It was further recognized that these data should be organized into a system that would permit the comparison of one lake to another. Such a system should also permit the prioritization of lakes and reservoirs according to their need for protection and/or renovation.

In 1971 the Indiana lake studies program gained momentum and became more organized as study methods were standardized. However, the classification system was still in an evolutionary state and was not developed to its present form until 1972.

By 1975 a majority of the State's public lakes and reservoirs had been sampled by biologists with the Indiana State Board of Health (ISBH). Each lake was then classified according to its trophic nature using the ISBH Lake Eutrophication Index developed by Mr. Harold BonHomme of the ISBH. A logical comparison of the lakes could be done as the data fell into four broad eutrophication classes. It was apparent, however, that the data were quite voluminous and in a form suited more for administrative use. It was also apparent that there was a need for an independent group of experts to evaluate and compare the BonHomme method against classification systems being used by other states. This group was also to assist with organizing the data into a workable Lake Management Plan for the State. The data could then be updated and the Plan revised as needed by the State.

A contract was initially entered into with Ball State University (BSU) to accomplish the first of these tasks. Doctors Byron Torke and Herb Senft deemed BonHomme's method to be most appropriate for lakes in Indiana. They then divided the lakes into several management groups using cluster analysis. Their findings and recommendations were published in 1976 as the *Indiana Lake Classification System and Management Plan.*

The *Indiana Lake Classification System and Management Plan* was updated and reprinted by BSU in 1986. Results included resample data for 13 lakes, as well as first-time data for six additional lakes. Older data, which had been omitted from the original editions, was also included. Concurrent with this, most of the water quality functions (and staff) of the ISBH were transferred in 1986 to the newly formed Indiana Department of Environmental Management (IDEM).

Shortly thereafter, the IDEM contracted Indiana University (IU) to manage the State's new Clean Lakes Program. Funded by the U.S. Environmental Protection Agency through Section 314 of the Clean Water Act, a comprehensive resampling of Indiana's lakes began in 1988. Approximately 300 lakes have since been sampled or resampled under the direction of Mr. William Jones of IU's School of Public and Environmental Affairs (SPEA). New trophic scores were determined using the Indiana Trophic State Index, the former ISBH Index mentioned above. The results presented here represent

collection efforts from 1988 through 1993. In addition to updating and revising the trophic scores on Indiana lakes, the present report is the first to interpret trends which have occurred in the trophic state of Indiana lakes over the past 25 years.

Unlike the earlier reports, this volume does not include a discussion of lake management. The subject of lake management has been thoroughly addressed in a number of fine works. For information on lake management, readers are recommended to consult:

Cooke, G.D., E.B. Welch, S.A. Peterson and P.R. Newroth. 1993. *Restoration and Management of Lakes and Reservoirs. Second Edition.* Lewis Publishers, Ann Arbor, MI.

Olem, H. and G. Flock, eds. 1990. *Lake and Reservoir Restoration Guidance Manual. 2nd edition.* EPA 440/4–90–006. Prepared by the North American Lake Management Society for U.S. Environmental Protection Agency, Washington, D.C.

## Acknowledgments

This report was written by William W. Jones of Indiana University's School of Public and Environmental Affairs (SPEA). It represents five years of traversing the state of Indiana, reading maps, searching for lake access, extracting stuck trailers, seemingly endless washing of laboratory glassware, and most importantly, having the opportunity to visit and sample the beautiful and varied lakes of Indiana. This work required the dedicated efforts of many people. Therefore, it is with gratitude that we recognize the superb efforts of the following SPEA graduate students who conducted the lake sampling and laboratory analyses of the water samples: Ed Eichner, Christine Mathias, Kelly Boatman, Jim Dierolf, Eric Welling, Richard Harris, Jeff Jontz, Andy Perun, Mark Pfister, Jeff Swertfeger, Louise Clemency, Jeff Helmuth, Anne Huber, Lara Strong, Laura Bieberich, Lisa Blazure, Craig Czarnecki, Mike Jenson, Eric Jordain, Heather Ratliff, Kathy Baird, James Joerke, Tim Kroeker, Ken McBride and Rob Price.

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# LAKE WATER QUALITY ASSESSMENT IN INDIANA

Indiana has over 500 public lakes and reservoirs, ranging from 5-acre ponds to 10,700-acre Monroe Reservoir, the largest inland lake in the state. These lakes are a valuable resource for all Hoosiers. Protecting and managing the water quality of our public lakes is an important role of the Indiana Department of Environmental Management (IDEM).

**How Does IDEM Monitor Indiana Lakes?**

Comprehensive lake monitoring is an important component of the ***Indiana Clean Lakes Program***. Through this program, the water quality of approximately 80 public lakes is monitored each year. The goals of this monitoring program are to: (a) identify water quality trends in individual lakes, (b) identify lakes needing special management, and (c) track water quality improvements due to industrial discharge and runoff reduction programs.

Public lakes in Indiana are defined as those having navigable inlets or outlets, or those occurring on public lands. However, a number of these public lakes have no boat access so they cannot be monitored in this program. In the 1970s, the lake survey crew dragged a small boat across fields to gain access to some lakes. For the present study, lakes were sampled only where a boat trailer or canoe could be launched from a public right-of-way. In addition, several more-or-less private lakes with public access are included in this report in cases where the public has reasonable access to the lake. For this first round of lake sampling, we did not sample lakes included in the original Indiana Department of Natural Resources Lake Enhancement Program because these lakes were already being assessed.

The sampling program generally proceeds from Steuben County in northeast Indiana southward until the entire state is covered. It takes approximately five years to sample all the state's lakes once and then the process is repeated. Sampling is conducted during July and August of each year. Lake conditions are generally more uniform in July and August so results from one year are more comparable to results from another year. In addition, the July-August period often represents worst-case water quality conditions in Indiana lakes because this is when algae are actively growing and lakes are most strongly stratified.

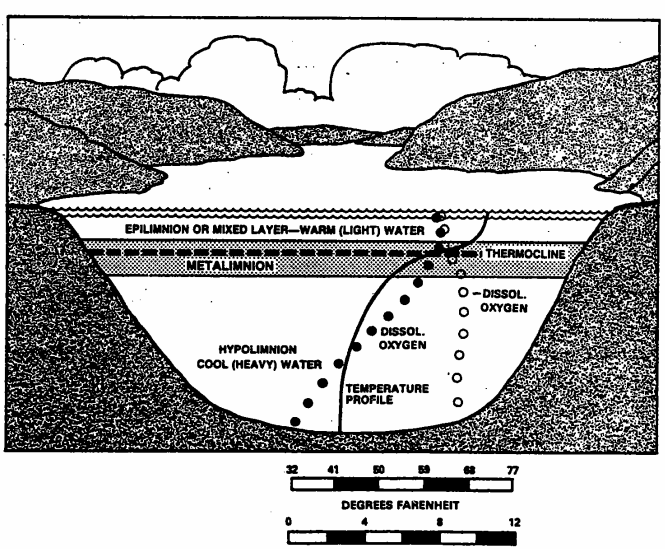
Most Indiana lakes having maximum depths of 16 to 23 feet or greater undergo thermal stratification during the summer. As the sun and air temperatures warm the surface water of a lake the warmed water becomes less dense. This "lighter" water floats on top of the cold, more dense water at the lake's bottom. Summer wind and waves may not be strong enough to overcome the density differences between the surface and bottom waters and ***thermal stratification*** occurs. In a stratified

lake, the surface waters (***epilimnion***) circulate and mix all summer while the bottom waters (***hypolimnion***) may stagnate because they are isolated from the surface (Figure 1). Thus, water characteristics in the epilimnion and hypolimnion of a given lake may be significantly different during stratification.

To account for potential differences between the epilimnions and hypolimnions of stratified lakes, water samples are collected from three feet below the surface and from three feet above the bottom. In addition, dissolved oxygen and temperature are measured at one-meter intervals from the surface to the bottom of each lake. Samples are collected from one site on each lake, usually over the deepest water.

This sampling protocol was chosen to gather data from as many lakes as possible, as frequently as possible, given the limited financial resources of the program. One sample per lake is not necessarily the ideal frequency of sampling to account for seasonal or spatial variability in lakes. However, if we collected three samples per year from each lake, or sampled three locations in each lake, available time and funds would permit us to monitor only 27 lakes each year instead of our target of 80 lakes. At this lower rate, it would take 15 years to sample all the Indiana public lakes instead of the current 5 years. Therefore, with the current protocol, the July/August sampling period helps standardize seasonal variability in the data and the five-year sampling frequency allows more frequent monitoring of each lake to detect longer term changes in lake conditions.

**Figure 1.** A cross-sectional view of a thermally stratified lake in mid-summer. The water temperature profile (curved solid line) illustrates how rapidly the water temperature decreases in the metalimnion compared to the nearly uniform temperatures in the epilimnion and hypolimnion. Solid circles represent the dissolved oxygen profile in a productive (eutrophic) lake where organic matter decomposition depletes DO in the hypolimnion. Adapted from: Olem and Flock (1990).



**What Water Quality Parameters are Included in These Assessments?**

The comprehensive evaluation of lakes requires collecting data on a number of different, and sometimes hard-to-understand, water quality parameters. Some of the more important parameters include:

**Phosphorus**. An essential plant nutrient which most often controls aquatic plant growth. Phosphorus is found in fertilizers, human and animal wastes, and yard waste.

***Soluble reactive phosphorus (SRP)*** —dissolved phosphorus readily usable by algae. SRP is often in very low concentrations in lakes with dense algae populations because it is all used up by the algae themselves. This form of phosphorus may be chemically released from storage in lake sediments when dissolved oxygen is lacking in the hypolimnion.

***Total phosphorus (TP)*** —includes dissolved and particulate phosphorus. In most lakes, TP concentrations greater than 0.04 mg/L may cause algal blooms.

**Nitrogen**. An essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air.

***Nitrate ($NO_3$)***—a chemically oxidized form of dissolved nitrogen which is used by algae. Nitrate is found in lakes when dissolved oxygen is present, usually the well-mixed surface waters.

***Ammonia ($NH_4$)***—a chemically reduced form of dissolved nitrogen. Ammonia is the preferred form of nitrogen for algal use. It is also produced by bacteria as they decompose dead plant and animal matter. Ammonia occurs most abundantly where dissolved oxygen is lacking, often in anoxic hypolimnions of eutrophic lakes.

***Organic Nitrogen (Org N)*** - includes nitrogen found in plant and animal matter. Organic nitrogen may be in dissolved or particulate form. In our analytical procedures, organic nitrogen plus ammonia equals total Kjeldahl nitrogen.

**Dissolved Oxygen (D.O.)**. Dissolved gas essential for respiration of fish and other aquatic organisms. Fish need at least 3–5 parts per million (ppm) of D.O. Lakes receive most of their dissolved oxygen by diffusion of oxygen from the atmosphere into the surface waters. The concentration of dissolved oxygen in the freely-mixing epilimnetic water maintains an equilibrium with the concentration of oxygen in the atmosphere. Oxygen diffuses into the water or escapes from the water to maintain this equilibrium. Additional dissolved oxygen is released into lake water by aquatic plants as a by-product of photosynthesis. Occasionally, the rate of photosynthesis may exceed the rate of oxygen loss to the atmosphere, resulting in supersaturation of oxygen (greater than 100% saturation). Oxygen is consumed in the water by respiration of fish and other aquatic organisms, by bacterial decomposition of organic matter (dead algae, leaves, etc.), and by chemical reactions (for example, nitrification oxidizes ammonia ($NH_4$) to nitrate ($NO_3$) which removes 3 atoms of oxygen from the water). A lake's hypolimnion often has low D.O. concentrations because oxygen consumption by bacteria and chemical reactions may consume it, and there is no source of replacement oxygen during stratification.

Dissolved oxygen concentrations also affect chemical reactions in water. For example, low D.O. near the bottom sediments may allow dissolved phosphorus (SRP) to be released from the sediments into the water. If less than 50% of a lake's water column has oxygen (see % Water Column Oxic data), greater hypolimnetic concentrations of SRP and ammonia can result.

**Secchi Disk Transparency**. The depth to which the black & white Secchi disk can be seen. The Secchi disk transparency depth is reduced by suspended algae, soil, and sediment particles in the water.

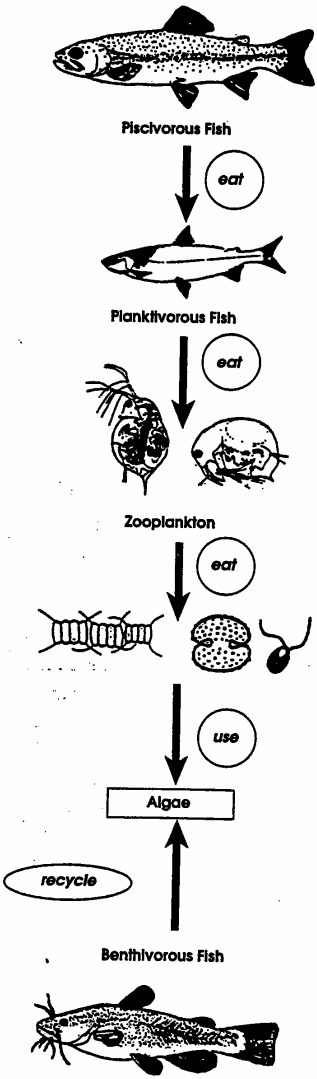
**Light Transmission**. Similar to the Secchi disk transparency, this measurement uses a light meter (photocell) to determine the *rate* at which light transmission is diminished in the upper portion of the water column. Another important light transmission measurement is the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. This depth is considered the lower limit where algae have enough light to photosynthesize.

**Plankton**. Important members of the aquatic food web (Figure 2). Include the algae (microscopic plants) and the zooplankton (small shrimp-like animals that eat algae). Determined by filtering water through a net having a very fine mesh (63 micron = 63/1000 millimeter). The plankton net is towed up through the water column from the one percent light level to the surface. Of the many different algal species present in the water, we are particularly interested in the blue-green algae. Blue-green algae are those which most often form nuisance blooms and their dominance in lakes may indicate poor water conditions.

**Chlorophyll *a***. The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll *a* is by far the most dominant chlorophyll pigment and occurs in great abundance. Thus, chlorophyll *a* is often used as a direct estimate of algal biomass. Chlorophyll determination includes collecting algae from a known volume of water onto a filter. The chlorophyll in the algae is then dissolved and read on a spectrophotometer.

**NOTE ON CONCENTRATION UNITS:** Concentrations of materials in water are expressed as mass per unit volume of water. Usually these are in milligrams per liter (mg/L) which can also be considered as Parts per Million (PPM). For particularly low concentrations, micrograms per liter (µg/L or Parts per Billion (PPB)) are often used as the units. There are 1000 micrograms per milligram, thus a concentration of 134 µg/L is also equivalent to 0.134 mg/L. See Appendix A for commonly used equivalents and conversions.

**Figure 2.** A simple representation of the aquatic food chain.



# LAKE CLASSIFICATION

## Background

Adequate lake and water data are a prerequisite for any form of decision making in water resources management. However, the vast quantity of physical, chemical and biological information that can be compiled on a given lake is not always straightforward and can be confusing to evaluate. For example, the condition of a lake is determined by a complex set of interacting factors including: lake volume, depth and shape; nutrients; oxygen; light; temperature; water circulation patterns; and even fish species.

To facilitate the understanding of lakes, ***limnologists*** (scientists who study fresh water lakes) have long used a variety of lake classification techniques. The reason to classify lakes stems from the need to simplify and organize the analysis of the large amounts of information collected from lakes. Lake classification indices primarily facilitate three tasks: (1) decision making, (2) prioritizing, and (3) creating public awareness. Nevertheless, the classification of a certain lake does not necessarily imply that we know everything about that lake.

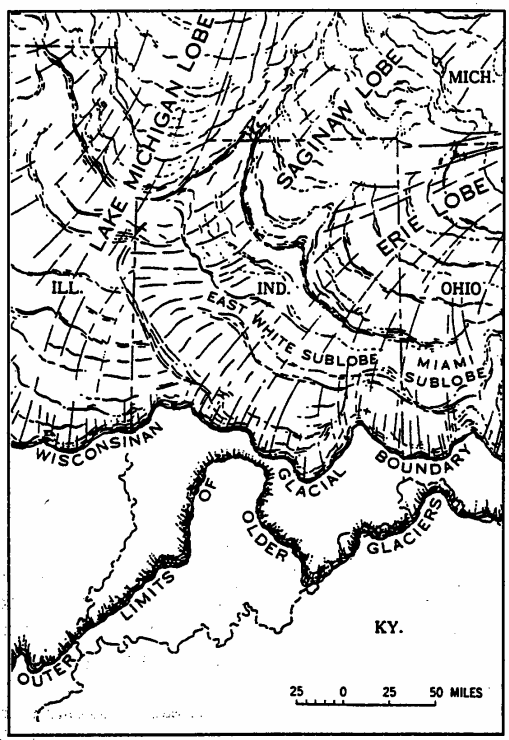
A simple index of lake quality should be lake specific and easy to measure, relevant to all lake uses, and objective and independent of other variables (Porcella, Peterson and Larsen 1980). The process of classifying lakes includes three phases: (1) description, (2) comparison, and (3) synthesis. The descriptive phase involves the gathering of data and information. When acquiring data, one must remember that the resulting classification can only be as good as the data which form it. Both precision and accuracy in measurement as well as the amount, representativeness, and variability of the data will affect the usefulness and predictive value of the classification. The comparative phase involves the determination of similarities and differences among the sets of measured parameters. Last, the synthesis phase involves the actual formulation of categories (Porcella, Peterson and Larsen 1980).

## Lake Classification Based on Lake Origin

A variety of attempts at lake classification have been made over the years. In his first volume of *A Treatise of Limnology,* Hutchinson (1957) classified lakes on the basis of the forces which created them. Hutchinson identified 76 lake origin types in this classification.

Several of Hutchinson's lake classifications are of major importance to Indiana lakes. The majority of natural lakes in Indiana were formed by glacial activity during the Wisconsin stage of continental glaciation which ended about 10,000 years ago (Figure 3). Most of these lakes are confined to two

**Figure 3.** Recent glaciation in Indiana. The Wisconsinan Glacial Boundary started receding about 14,000 years ago.



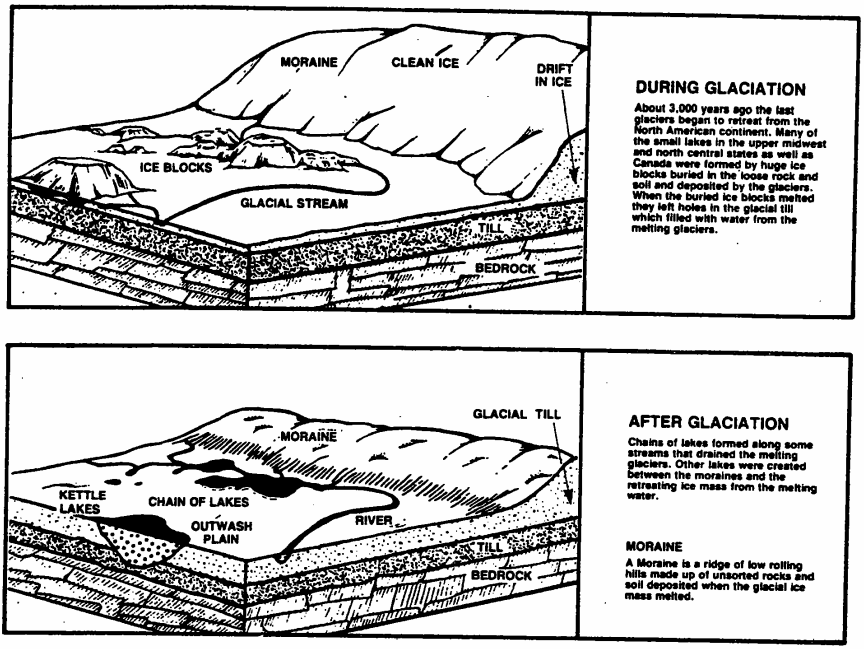

regions of glacial moraines in the northern part of the state, the Valparaiso Morainal Area to the west and the Steuben Morainal Area to the east. Lakes formed by glacial activity were either scoured out by the glacier (for example, the Great Lakes) or formed by melting ice blocks left on the landscape as the glacier retreated north (Figure 4). Most of Indiana's glacial lakes are ***"ice block"*** or ***kettle lakes***. Lake Tippecanoe, the deepest lake in Indiana (123 feet), and Lake Wawasee, the largest natural lake in Indiana (3,410 acres) are both glacial lakes. Other important lake formation forces in Indiana include:

***Solution lakes***—occupy basins formed by the solution of limestone in karst regions and exist as caves, sinkholes and swallow holes in the Mitchell Plain in southern Indiana. Solution lakes are typically circular in shape.

***Oxbow lakes***—lakes in former river channels which have been dammed by sediment deposition or erosional action of rivers.

***Artificial lakes***—includes farm ponds, mill ponds, strip pits, borrow pits, and reservoirs created by excavation or by damming a stream or river. Lake Monroe, the largest (10,700 acres) inland

**Figure 4.** Lake formation processes during glaciation. Source: Olem and Flock (1990).



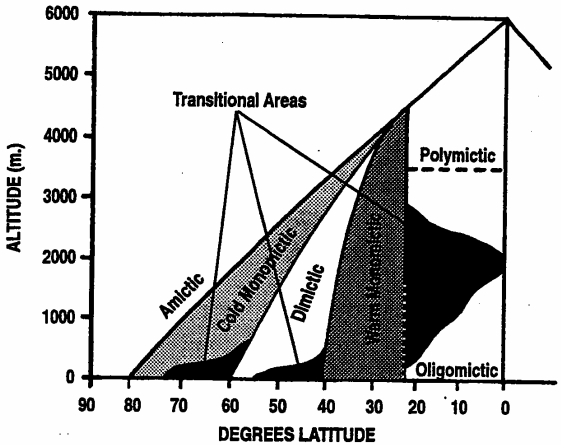

body of water in Indiana, is a reservoir. Reservoirs are usually elongate with many narrow branches because the lake occupies the valleys of a river or stream and its tributaries. Strip pits are prevalent in the coal mining region of southwestern Indiana but other types of lakes formed by mining operations such as quarries and borrow pits may be found throughout the state.

## Lake Classification Based on Thermal Stratification

As the effects of climate, morphometry (lake physical measures), latitude, elevation, and chemistry on stratification became more evident, limnologists began proposing a variety of classification schemes based on these parameters. The most widely accepted classification based on thermal stratification is one developed by Hutchinson and Loffler (1956). Although the area and depth of a lake can have significant effects on whether and how a lake mixes, Hutchinson and Loffler believed that most lake circulation patterns can be determined by the elevation and latitude of the lake (Figure 5).

Some lakes in high latitudes (Greenland, for example) have ice cover year-round and never mix. These lakes are called ***amictic***. Certain sub-arctic lakes never reach a temperature greater than 4°C, the temperature of greatest water density. These lakes are stratified during the winter, but mix all summer long at or just below 4°C. Because they circulate during one period per year they are called ***cold monomictic***. In contrast, the water in some sub-tropical lakes never drops to 4°C and these

Figure 5. A thermal classification of lakes (modified from Hutchinson and Loeffler (1956).




***warm monomictic*** lakes circulate all winter at or near the 4°C temperature and stratify during the summer. In tropical areas where the temperatures remain well above 4°C throughout the year, lakes can remain stratified all year and may circulate only infrequently. These lakes are referred to as ***oligomictic***. Finally, there are some tropical lakes at high elevation where temperatures remain uniformly near 4°C. These lakes undergo frequent or continuous circulation with only light winds and are called ***polymictic***.

**Lake Classification Based on Trophic Parameters**

Lake classification based on a lake's ***trophic*** condition (or trophic state) can be a valuable tool for assessing lake data. The trophic state of a lake refers to its overall level of nutrition or biological productivity. While the trophic state concept has been used for many years, the definitions of trophic state categories is still not generally agreed upon. Weber (1907) coined the terms "oligotrophic" and "eutrophic" in describing relationships among northern German peat bogs. In 1917, Naumann used "oligotrophic" and "eutrophic" to characterize associations of phytoplankton (Hutchinson 1967). Today, the following trophic state categories are used to describe lake conditions:

***Oligotrophic***—clear water, very low levels of nutrients (total phosphorus < 6 μg/L) support few algae, dissolved oxygen is present in the hypolimnion, can support salmonid (trout and salmon) fisheries.

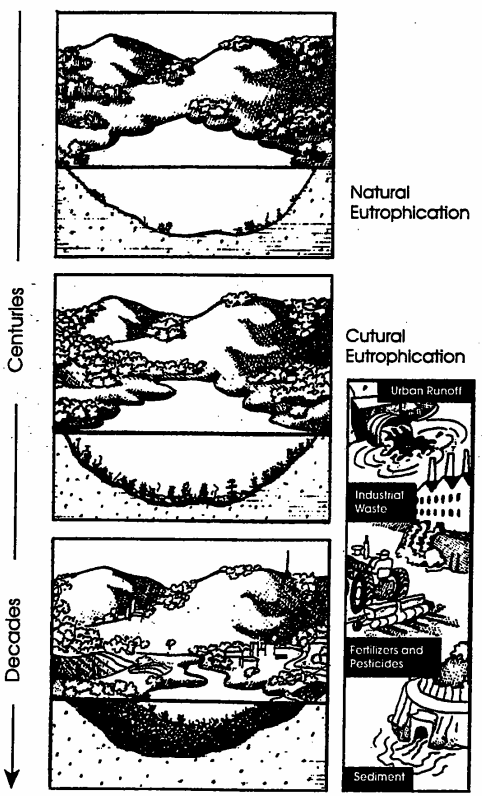
***Mesotrophic***—water less clear, moderate levels of nutrients (total phosphorus 10–30 μg/L) support healthy algal populations, decreasing dissolved oxygen in the hypolimnion, loss of salmonids.

***Eutrophic***—transparency less than two meters, relatively high concentrations of nutrients (total phosphorus > 35 μg/L), no dissolved oxygen in hypolimnion during summer, weeds and algae abundant.

***Hypereutrophic***—transparency less than 1 meter, no dissolved oxygen in hypolimnion, extremely high nutrient concentrations (total phosphorus > 80 μg/L) support thick algal scums, very dense weeds.

The progression of lake condition from oligotrophy to eutrophy is called ***eutrophication.*** Eutrophication, by definition, is a lake's biological response to increased nutrients, organic material and/or silt (Cooke et al., 1993). As nutrients such as phosphorus and nitrogen wash into lakes via runoff water or attached to eroded soil, they stimulate the increased growth of aquatic plants. The additional plant material and eroded soil eventually settle and accumulate on the lake bottom, causing the lake to become more shallow. While this is a natural aging process, it usually progresses very slowly—there are a number of European and African lakes which have remained oligotrophic for many thousands of years. However, the slow, natural eutrophication process can be accelerated greatly in lakes where human activities have increased watershed soil erosion and nutrient losses. Instead of thousands of years, *cultural eutrophication* may only take decades to degrade a lake (Figure 6).

**Figure 6.** The lake eutrophication process. Human land-disturbing activities accelerate greatly the rate of eutrophication. Adapted from Freshwater Foundation (1985).




All trophic state lake classifications are based on the division of the trophic continuum into trophic categories as above. Unfortunately, there is no clear delineation between where oligotrophy ends and mesotrophy or eutrophy begins. It is widely agreed that nutrients, particularly phosphorus, are responsible for changes in productivity in lakes. Results of studies conducted by Richard Vollenweider in the 1970s are often used as guidelines for evaluating concentrations of water quality parameters. His results are given in Table 1 on the following page. Vollenweider relates the concentrations of phosphorus, nitrogen and chlorophyll to expected lake trophic state.

Nutrients alone do not determine trophic state. For example, a lake could have phosphorus concentrations in the eutrophic range in Table 1 but if there was only limited algae or rooted plant growth, the lake could not be classified eutrophic. Other factors, such as light or temperature, can limit the growth of algae or rooted plants. Therefore, trophic classifications based on nutrients alone can only be used as a guideline to the expected trophic condition.

A further point of confusion with the existing terminology is that "eutrophic" is

**Table 1.** Values of Some Water Quality Parameters and Their Relationship to Lake Production (after Vollenweider (1979) as reported in Wetzel (1983)).

| *PARAMETER* | *Oligotrophic* | *Mesotrophic* | *Eutrophic* | *Hypereutrophic* |
|---|---|---|---|---|
| Total Phosphorus (µg/L or PPB) | Mean: 8.0<br>Range: 3.0–17.7 | 26.7<br>10.9–95.6 | 84.4<br>16–386 | >750<br>750–1200 |
| Total Nitrogen (µg/L or PPB) | Mean: 661<br>Range: 307–1630 | 753<br>361–1387 | 1875<br>393–6100 | –*<br>–* |
| Chlorophyll *a* (µg/L or PPB) | Mean: 1.7<br>Range: 0.3–4.5 | 4.7<br>3–11 | 14.3<br>3–78 | –*<br>100–150 |

*no values specified for this trophic class

often confused with poor water quality. Excellent or poor water quality is a subjective classification which depends on the use of the water and the attitudes of the lake users. For example, the aesthetically pleasing, clear blue water of oligotrophic lakes cannot support high fish production. A canoeist may consider this as "good" water quality for canoeing while an angler might consider this as "poor" water quality for fishing.

**Trophic State Indices**

Because the numbers and units used to report water quality data vary so much, and because the data parameters themselves are somewhat difficult to interpret in total, a trophic state index (TSI) is often useful to help evaluate water quality data. A TSI condenses water quality data into a single, numerical index. Different index points are assigned for various water quality concentrations. These index or eutrophy points can then be used to compare the trophic state of one lake at different times, or to compare the trophic states of different lakes.

Because TSIs condense actual data into a single number, information is lost. For example, a TSI change from 25 to 40 points suggests that a lake has gotten more productive, however, the TSI value of 40 alone does not give any information about the concentrations of phosphorus or oxygen, or about the transparency. Therefore, it is important to refer to the actual data in conjunction with the TSI value when evaluating lake conditions.

**The Indiana Trophic State Index**

In order to deal with the large variety of lakes found in Indiana, a substantial amount of information is needed on each lake and each lake's respective problems. The Indiana Trophic State Index (ITSI) was intended to characterize problem lakes and to define the reasons or sources behind complaints from lake users. The ITSI was not originally intended to be a tool for lake management. In the early 1970s, the ITSI was used primarily for same day recognition of lake problems, advanced eutrophy, and changes in lake regime. The ITSI was not used as a means of ranking Indiana public lakes until the mid-1970s.

The Indiana TSI is a multi-parameter index. Data must be collected for a number of physical, chemical and biological lake parameters. For phosphorus and nitrogen data, water samples are collected from a lake's epilimnion and hypolimnion and the mean of these values is used to determine the eutrophy points. Data for other index parameters are collected as indicated in Table 2.

Eutrophy points are assigned for various concentrations of each parameter in the index. More points are given for conditions which are likely to promote greater productivity or which are indicative of greater productivity. Most index parameters generate 1 to 4 eutrophy points. The scale is, however, weighted (up to 35 points maximum) towards the abundance of plankton and presence of blue-green algae dominance. Such heavy emphasis is given to algae in the index due to citizen perception of what constitutes poor lake water quality. Points for each index parameter are then totaled for the final lake TSI.

The ITSI scale ranges from 0 to 75 eutrophy points where a total score of 0 to 25 points represents generally oligotrophic conditions (Class I), 26 to 50 points generally represents mesotrophic conditions (Class II), and 51 to 75 points generally represents eutrophic conditions (Class III). The Indiana TSI does not include a category for hypereutrophic lakes. Earlier reports included a Class IV to represent remnant/oxbow lakes. This class was dropped in this report because it is not based on trophic condition.

In 1990, in response to complaints about the difficulty and time needed to collect and analyze all the plankton data required to generate an Indiana TSI score, the plankton metric of the index was changed. The original metric required two different plankton tows—one from a depth of 5 feet to the surface and a second tow for a distance of 5 feet which included the beginning of the metalimnion. This second tow required a specialized closing net which many consultants and several state agencies did not have. The change was accomplished by comparing plankton counts using the two-tow method to counts using a single tow from the one percent light level to the surface. Six lakes were sampled and compared in this way. A mathematical relationship was generated from these data so that the eutrophy points generated using both methods were approximately equivalent. The resulting plankton metric is the one shown in Table 2.

**The Carlson Trophic State Index**

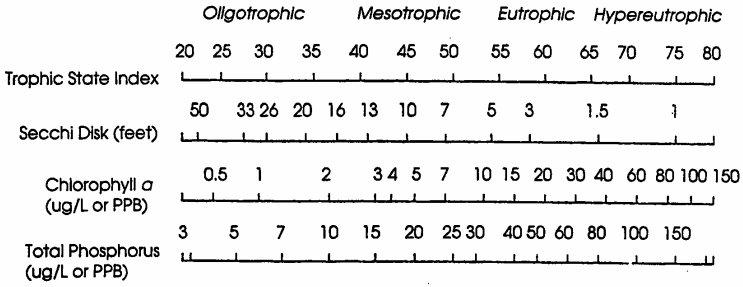
The most widely used and accepted TSI in the United States is one developed by Bob Carlson called the Carlson TSI (Carlson 1977). Carlson analyzed summertime total phosphorus, chlorophyll *a*, and Secchi disk transparency data for numerous north temperate zone lakes and found statistically significant relationships among the three parameters. He developed mathematical equations for these relationships and these form the basis for the Carlson TSI (Figure 7). Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll *a* or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass.

As a further aid in interpreting TSI results, Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive); eutrophic (very productive) and hypereutrophic (extremely productive). Using Carlson's index, a lake with a summertime Secchi disk depth of 7 feet would have a TSI of 50 points (located on the in line with the 7 feet). This lake would be in the mesotrophic category. Because the index was constructed using relationships among transparency, chlorophyll, and total phosphorus, a lake having a Secchi disk depth of 7 feet would be expected to have 7 µg/L (PPB) chlorophyll and 25 µg/L (PPB) total phosphorus (see Figure 7).

**Table 2.** The Indiana Trophic State Index

| *Parameter and Range* | *Eutrophy Points* |
|---|---|
| I. Total Phosphorus (mg/L) | |
| A.At least 0.03 | 1 |
| B.0.04 to 0.05 | 2 |
| C.0.06 to 0.19 | 3 |
| D.0.2 to 0.99 | 4 |
| E. 1.0 or more | 5 |
| II. Soluble Phosphorus (mg/L) | |
| A.At least 0.03 | 1 |
| B.0.04 to 0.05 | 2 |
| C.0.06 to 0.19 | 3 |
| D.0.2 to 0.99 | 4 |
| E. 1.0 or more | 5 |
| III. Organic Nitrogen (mg/L) | |
| A.At least 0.5 | 1 |
| B.0.6 to 0.8 | 2 |
| C.0.9 to 1.9 | 3 |
| D.2.0 or more | 4 |
| IV. Nitrate (mg/L) | |
| A.At least 0.3 | 1 |
| B.0.4 to 0.8 | 2 |
| C.0.9 to 1.9 | 3 |
| D.2.0 or more | 4 |
| V. Ammonia (mg/L) | |
| A.At least 0.3 | 1 |
| B.0.4 to 0.5 | 2 |
| C.0.6 to 0.9 | 3 |
| D.1.0 or more | 4 |
| VI. Dissolved Oxygen: Percent Saturation at 5 feet from surface | |
| A.114% or less | 0 |
| B.115% 50 119% | 1 |
| C.120% to 129% | 2 |
| D.130% to 149% | 3 |
| E.150% or more | 4 |
| VII. Dissolved Oxygen: Percent of measured water column with at least 0.1 ppm dissolved oxygen | |
| A.28% or less | 4 |
| B.29% to 49% | 3 |
| C.50% to 65% | 2 |
| D.66% to 75% | 1 |
| E.76% 100% | 0 |
| VIII. Light Penetration (Secchi Disk) | |
| A.Five feet or under | 6 |
| B.Greater than five feet | 0 |
| IX. Light Transmission (Photocell)—Percent of light transmission at a depth of 3 feet | |
| A. 0 to 30% | 4 |
| B.31% to 50% | 3 |
| C.51% to 70% | 2 |
| D.71% and up | 0 |
| X. Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface: | |
| A.less than 3,000 organisms/L | 0 |
| B.3,000 to 6,000 organisms/L | 1 |
| C.6,001 to 16,000 organisms/L | 2 |
| D.16,001 to 26,000 organisms/L | 3 |
| E.26,001 to 36,000 organisms/L | 4 |
| F.36,001 to 60,000 organisms/L | 5 |
| G.60,001 to 95,000 organisms/L | 10 |
| H.95,001 to 150,000 organisms/L | 15 |
| I.150,001 to 5000,000 organisms/L | 20 |
| J.greater than 500,000 organisms/L | 25 |
| K.Blue-Green Dominance: additional points | 10 |

**Figure 7. Carlson's Trophic State Index.**




Not all lakes have the same relationship between transparency, chlorophyll, and total phosphorus as Carlson's lakes do. Other factors such as high suspended sediments or heavy predation of algae by zooplankton may keep chlorophyll concentrations lower than might be otherwise expected from the total phosphorus concentrations. For example, the high suspended sediments in many Indiana lakes tends to make transparency worse than otherwise predicted by Carlson's index. While results such as this may suggest that Carlson's TSI does not work well in Indiana, a limnologist can evaluate the relative positions of transparency, chlorophyll *a*, and total phosphorus for a particular lake on Figure 6 above and gain valuable insights into how that lake functions.

# RESULTS

Physical, chemical and biological data collected for all 322 lakes sampled during the 1989-93 period are included in Appendix B. Lakes are listed alphabetically by county. Lake areas and depths are taken from the *Indiana Lakes Guide* (DNR 1993) and *The Indiana Water Resource* (Clark 1980). Maximum lake depths were modified, when necessary, by our own measurements while on the lakes. The mean value of the epilimnetic and hypolimnetic samples for nitrate, ammonia, organic nitrogen, soluble reactive phosphorus and total phosphorus are included in the appendix.

In addition, the Indiana Trophic State Index (TSI) for each lake is given for the current data and for the mid-1970s data if the lake was sampled at that time. The Indiana TSI is used because this index has been the basis for evaluating lake condition in Indiana since the 1970s. In cases where a particular lake was sampled both in the mid-1970s and during 1989–93, the change in TSI is also shown. An increase in TSI between the two periods indicates an increase in conditions which can promote eutrophication. A decrease in TSI suggests a decrease in trophic state at a particular lake.

Interpreting Indiana TSI changes and how they relate to changing trophic state is somewhat difficult. For example, a slight shift in algal species composition can add or subtract 10 points from a lake's TSI depending on whether blue-green algae dominate the plankton. Similarly, a slight shift in transparency can result in a 6 point change. In addition, Indiana TSI parameters vary naturally over time, particularly during the summer months. Analysis of these factors suggests that these natural changes can account for a TSI change of up to 10 points on a given lake. Therefore, we suggest that a TSI change of at least +/- 10 points is needed to indicate an actual change in lake trophic state.

A frequency distribution of TSIs for the lakes sampled during 1989–93 is shown in Figure 8. Most of the 322 lakes had TSIs ranging between 10–40 points. When grouped according to trophic class based on the Indiana Trophic State Index, 151 lakes (46.6% of all lakes sampled) were in Class I (oligotrophic), 148 lakes (46.0%) in Class II (mesotrophic), and only 24 lakes (7.4%) in Class III (eutrophic) (Table 3). An even greater percentage of lake surface area sampled during 1989-93 consisted of Class I waters. Class I lakes accounted for 61,695 acres of water (62.2% of total lake area sampled). There were 33,070 acres of water with a Class II designation (33.3%) and only 4,487 total acres (4.5%) in Class III.

**Changes Since the Mid-1970s Survey**

A more important gage of the trend in Indiana lake conditions is the change in TSI between the mid-1970s and the 1989–93 data set. Of the 277 lakes sampled in both periods, 179 (64.6%) had lower TSI scores in 1989–93, 93 had increases in TSI scores, and 5 had no change in their 1970s TSI score (Figure 9; Table 4). If we disregard the lakes which gained or lost 10 or fewer points (129 lakes),

**Figure 8.** Distribution of Indiana TSI scores for lakes sampled during 1989–93.

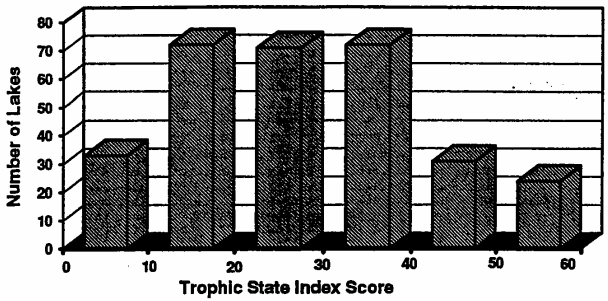



**Table 3.** Distribution of Lakes by Trophic Class (1989–93).

| Trophic Class | Number of Lakes (% of total) | Size in Acres (% of total) |
|---|---|---|
| I | 150 (46.6%) | 61,695 (62.2%) |
| II | 148 (46.0%) | 33,070 (33.3%) |
| III | 24 (7.4%) | 4,487 (4.5%) |

**Figure 9.** Indiana TSI score changes for lakes sampled in the 1970s and 1989–93.

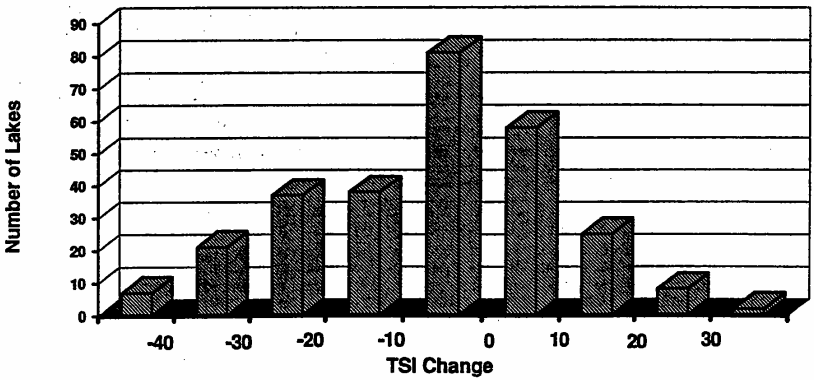


**Table 4.** Changes in Eutrophy Points between the 1970s and 1990s.

| *Lake Trophic Rank* | *Rank in '70s* | *Eutrophy Pts Increased*[a] | *Eutrophy Pts Decreased*[a] | *Eutrophy Pts Unchanged*[a] |
|---|---|---|---|---|
| Class I | 92 | 51 (55.4%) | 38 (41.3%) | 3 (3.3%) |
| Class II | 127 | 40 (31.5%) | 85 (66.9%) | 2 (1.6%) |
| Class III | 58 | 2 (3.4%) | 56 (96.6%) | 0 (0%) |
| TOTAL | 277 | 93 (33.6%) | 179 (64.6%) | 5 (1.8%) |

[a] Number of lakes (% of lakes in category)

then 96 (37%) lost points and 36 (14%) gained points. Thus, the overall trend shows that the Indiana lakes studied during this period have become less productive since the mid-1970s.

In a number of cases, the change in TSI score from the 1970s to 1989–93 was enough to shift the lake into a higher or lower trophic class. For example, in 134 of the lakes sampled during both periods conditions improved enough to move the lake into a lower (better) trophic class, while conditions in 72 lakes worsened enough to move them into a higher (worse) trophic class (Table 5). A comparison of the number of lakes in each trophic class for the two sampling periods is shown in Figure 10. Again, this shows that overall Indiana gained more Class I and II lakes and lost some Class III lakes.

**Comparison With Carlson's Index**

The Carlson TSI is the most widely used trophic state index in the United States. However, the Indiana TSI predates Carlson's index. Because of this Indiana state lake managers have continued to use the Indiana TSI as a comparative tool for the earlier studies in the 1970s.

Because of its wide use, it is important to also evaluate Indiana's lakes using Carlson's TSI as well. As it turns out, Carlson's criteria for using total phosphorus to predict the trophic status of lakes (Figure 7) is very similar to that proposed by Vollenweider (Table 1). Both scales rely on phosphorus because of the importance of that nutrient in promoting growth in algae and rooted aquatic plants. These scales are compared in Table 6.

**Figure 10.** Comparison of Indiana TSI class for lakes sampled in the mid-1970s and 1989–93.

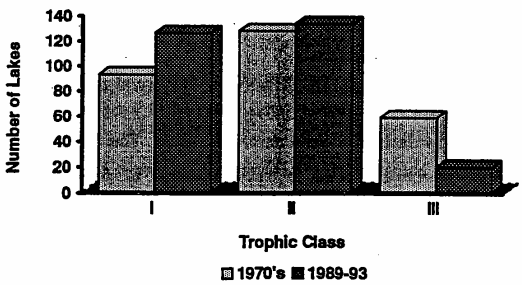


**Table 5.** Change in Trophic Class Between the 1970s and 1990s. (Number of lakes in each category are indicated.)

| *Trophic Class* | *Moved to Worse Class* | *Moved to Better Class* | *No Class Change* | *Total Number Lakes* |
|---|---|---|---|---|
| I | 24 | NA | 68 | 92 |
| II | 12 | 41 | 74 | 127 |
| III | 36 | 93 | 148 | 58 |

**Table 6.** Relationship Between Total Phosphorus and Trophic State.

| *Trophic Classification* | *Carlson Total Phos. Criteria* | *Vollenweider's Mean Total Phos. Criteria* |
|---|---|---|
| Oligotrophic | < 0.015 mg/L | 0.008 mg/L |
| Mesotrophic | 0.015–0.035 mg/L | 0.027 mg/L |
| Eutrophic | 0.035 -0.065 mg/L | 0.084 mg/L |

**Table 7.** Comparison of Carlson's Total Phosphorus TSI and the Indiana TSI for 1990s Data.

| *Trophic Classification* | *# Lakes Determined by the Indiana TSI* | *# Lakes Determined by Carlson's TSI* |
|---|---|---|
| Oligotrophic | 150 | 4 |
| Mesotrophic | 148 | 136 |
| Eutrophic | 24 | 182 |

If we apply Carlson's TSI for total phosphorus to the 1989–93 Indiana lake data we get quite a different trophic class distribution than we did using the Indiana TSI (Table 7). Using Carlson's TSI, over 56% of Indiana's lakes are classified as eutrophic while less than 2% are classified as oligotrophic. Why do we get such different results between the two indices?

Remember that eutrophication is defined as the biological response to increased amounts of nutrients (especially phosphorus), organic matter, and/or silt. Carlson's total phosphorus TSI predicts the *potential* amount of algal production based on the amount of available phosphorus. If something else besides phosphorus limits the growth of algae (for example, low light due to high suspended silt in the water or high predation by zooplankton grazers) than the *actual* trophic state will be lower than that predicted by phosphorus alone.

For example, Figure 11 plots the relationship between chlorophyll and total phosphorus for 69 Indiana lakes sampled in 1993 for which we have chlorophyll data. Carlson's equation predicting chlorophyll *a* from total phosphorus data is shown as a solid line. The majority of Indiana lakes fall below the line representing Carlson's equation. This means that for a given amount of phosphorus, Indiana lakes have less chlorophyll (less algae produced) than predicted by Carlson's relationship. For example, a phosphorus concentration of 0.10 mg/L should yield approximately 60 ug/L of chlorophyll according to Carlson's line, but Indiana lakes produce much less chlorophyll than this. Something else must be limiting algal production in Indiana lakes.

Likewise, Figure 12 plots the relationship between chlorophyll and Secchi disk transparency, with Carlson's chlorophyll-Secchi disk relationship represented by a solid line. For example, a chlorophyll

**Figure 11.** Chlorophyll-phosphorus relationship in Indiana lakes compared to Carlson's relationship.

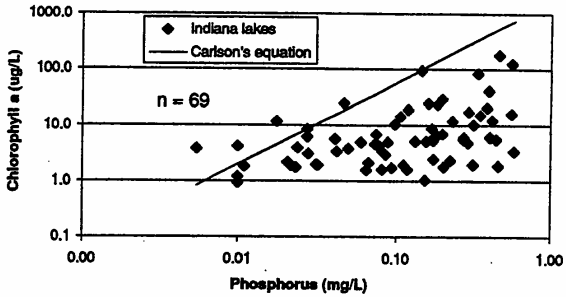
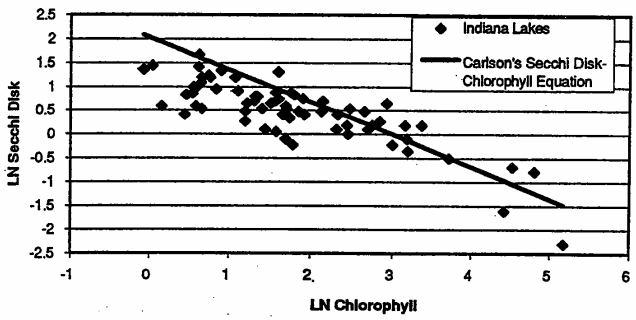



**Figure 12.** Chlorophyll-Secchi disk transparency relationship in Indiana lakes compared to Carlson's relationship.




a concentration of 10 ug/L should result in a Secchi disk of about two meters according to Carlson. Again, most of the Indiana lakes fall below Carlson's line. This means that something else besides algae must be reducing transparency in Indiana's lakes.

In both of these cases, the culprit is likely the higher suspended silt content of Indiana lakes. High suspended silt in the water can reduce the penetration of sunlight which, in turn, reduces algal growth. Likewise, high suspended silt also reduces Secchi disk transparency. Carlson's TSI does not account for suspended silt because the lakes he used to develop his index from had low suspended silt contents. Thus, many Indiana lakes could be mis-classified using Carlson's index.

An appropriate use of Carlson's TSI in Indiana is to identify lakes where nonalgal turbidity or other limiting factors are significant enough to cause deviation from this index. Carlson himself proposed this in a recent paper (Carlson 1991). This simple evaluation could aid lake managers in identifying watershed management strategies. For example, in cases where a poor fit with Carlson's model is linked to non-algal turbidity, watershed and in-lake sources of suspended sediments can be investigated.

Overall, while high suspended silt in Indiana lakes may be responsible for reduced algal growth, the suspended silt itself is an important factor in causing eutrophication according to the definition of Cooke et al. (1993) and it is an aesthetic problem in lakes as well. Because Indiana's TSI depends so heavily on algae densities, high suspended silt content may actually result in lower trophic state

scores. This further emphasizes the need to use trophic state indices as only a guide in assessing the specific condition of lakes. The final assessment must consider all the data available to the limnologist and lake manager.

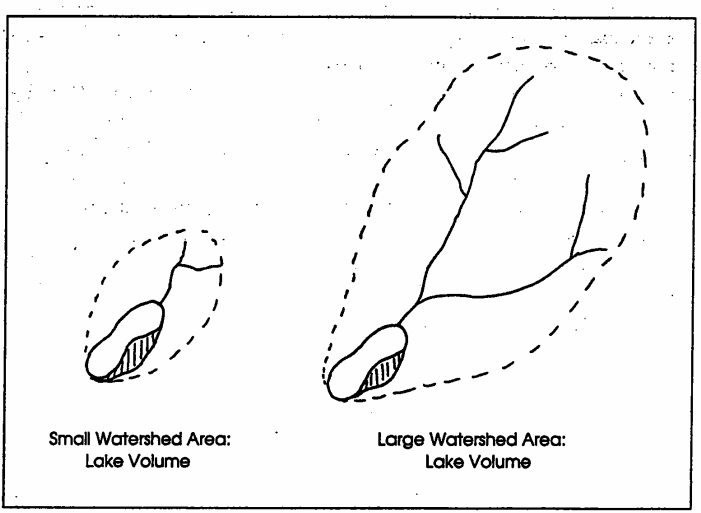
**Lake Trophic State and Morphology**

The morphology (form and structure) of lake basins has important effects on nearly all of the physical, chemical and biological parameters of lakes (Wetzel 1983). For example, lake depth affects whether a lake stratifies. Lake size affects wind fetch and thus the amount and depth of turbulent mixing. Lakes with a large volume (large mean depth) have more dilutional capacity and should be able to resist trophic changes due to nutrient additions better than small volume lakes receiving the same quantity of nutrients.

To investigate whether lake morphology has an effect on the trophic state of Indiana lakes, we tested several morphological parameters for which we had data against the Indiana TSI (the dependent variable) using simple linear regression. No statistically significant correlation existed between TSI and lake area, mean lake depth, lake volume, or watershed area.

We further investigated the influence of watershed area to TSI by considering the ratio of the watershed area of a particular lake to its volume. Lakes with large watersheds relative to their volume will flush more frequently and will be more influenced by the watershed (Figure 13). With a larger watershed, more runoff will flow into the lake and this will flush the lake more frequently. Likewise, greater runoff can cause more soil erosion and more nutrient loading to a lake. This, of course, depends on watershed land use activities and management practices. On the other hand, lakes with large watersheds relative to lake size or volume should be less influenced by shoreline activities such as septic systems and lawn fertilizers, when compared to the watershed influence.

**Figure 13.** Comparison of two watershed sizes for lakes having the same volume. The larger watershed will result in a much greater flushing rate for the lake.



We had watershed size and lake volume information for 155 of the 261 lakes sampled during both time periods. The following model was developed to test three hypotheses using SAS, a widely-used statistical analytical software package:

$$Y_i = ß_0 + ß_1 I_y + ß_2 X_i + ß_3 I_y X_i + e_i \quad \text{where:}$$

$Y_i$ = Indiana TSI values
$ß_0$ = intercept
$ß_{1,2,3}$ = slope
$I_y$ = 1 for 1989 to 1993 data,
0 for 1970s data
$X_i$ = log (watershed area to lake volume ratio)

The following hypotheses were tested:

Hypothesis #1: the ratio of watershed area to lake volume (WSA/Vol) is related to TSI.

The null hypothesis ($H_0$) for this test was that all slopes (ß values) are equal to zero. If the slope relating TSI with WSA/Vol is zero, that means that TSI does not change with an increase in WSA/Vol. The alternative hypothesis is that all ß values do not equal zero. Results of this test were:

$F = 19.76$
$P = 0.0001$
$R^2 = 0.162$

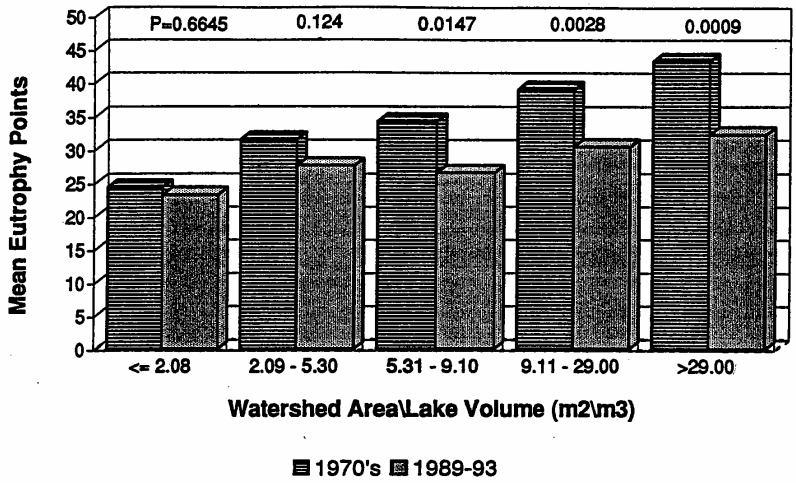
The very low probability statistic (P) means that the slopes are not equal to zero so there is a relationship between TSI and the WSA/Vo. The P value of 0.0001 means that there is only a 1 in 10,000 probability that the relationship observed is due entirely to chance. Although this proves that there is a relationship between TSI score and WSA/Vol, the model above only accounts for 16% of the variation in the data ($R^2$). This is not surprising because there are many other factors which affect the trophic state of lakes. Nonetheless, this is a relatively good $R^2$ value.

Hypothesis #2: there is a significant difference in TSI scores between the mid-1970s and the 1989–93 data sets.

To test this, we divided the lakes into five equal sized groups (quintiles) based on the WSA/Vol ratio. Each resulting group had 31 lakes. A WSA/Vol value of 5 means that there are 5 square meters of watershed for every cubic meter of water in the lake. Graphically, the data suggest that there are differences between the 1970s and 1989–93 data sets and that this difference increases as the WSA/Vol ratio increases (Figure 14). In all cases, the lakes sampled in the 1970s had higher TSIs than those sampled during 1989–93.

To test whether these differences were significant, we conducted a Student's T-test of the difference between the TSI means for each group. The results are shown as the probability values above the columns in Figure 14. The probability values are the probabilities that the differences between the 1970s and 1989–93 TSI values for the groups tested are due to chance alone. Therefore, a high probability value indicates little difference between the mean TSI scores and a low probability value

**Figure 14.** Mean lake TSI score for both sampling periods with lakes grouped according to their watershed area/ lake volume ratios. Lower P values indicate a more statistically significant difference in mean TSI.



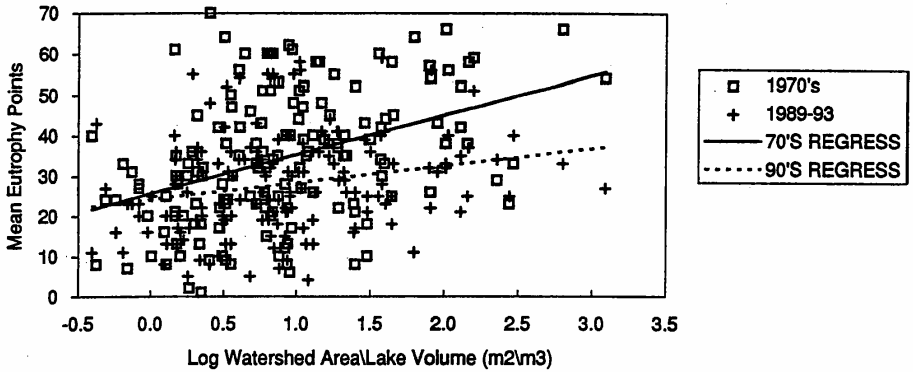

suggests that there is a difference. For the <2.08 quintile, the high probability (66%) means that there is little real difference in TSI scores between the two data sets. For the other quintiles, the probabilities get smaller, meaning that the differences are more likely to be real.

Hypothesis #3: lakes with larger WSA/Vol ratios have shown greater improvement in TSI than those with smaller ratios.

This hypothesis is supported by the results above but we further tested it by comparing the linear regression slopes of the TSI values for each lake by sampling period. The results shown in Figure 15 illustrate that the slope of the 1970s TSI scores is greater than that for the 1989–93 TSI scores. This difference in slope is statistically significant at the 98% level. From this we can conclude that lakes with large watershed area/lake volume ratios showed greater improvement in TSI scores between the 1970s and the 1989-93 periods than did the lakes with smaller WSA/Vol ratios.

Why did the lakes with large WSA/Vol ratios improve more? Recall that these lakes are influenced more strongly by their watersheds. The water in these lakes is replaced (flushed) by inflowing water more frequently. The reduction in trophic state in these lakes suggests that the quality of runoff from their watersheds has improved. Statewide efforts to implement watershed Best Management Practices (BMPs) would result in improved runoff water quality in all watersheds but resulting in-lake improvements will be more evident in those lakes with large WSA/Vol ratios because these lakes are flushed more frequently with the improved watershed water. Therefore, we may be seeing the results of successful watershed treatment programs in our Indiana lakes.

**Figure 15.** Relationship between TSI and WSA/Vol for 1970s and 1989–93 lake data. Lakes with larger WSA/Vol ratios had greater reduction in TSI than those with smaller WSA/Vol ratios.




**Regional Trends**

It is often said that a lake is a reflection of its watershed. This generally refers to the fact that the water quality of a lake can be influenced strongly by human land use activities within the lake's watershed. Natural features of watersheds, such as soils, topography, and vegetation patterns, may also influence the characteristics of lakes by affecting the rate of water runoff and the composition of materials carried in that runoff. Because of this, there has been considerable interest in analyzing regional landscape patterns and their effect on water quality.

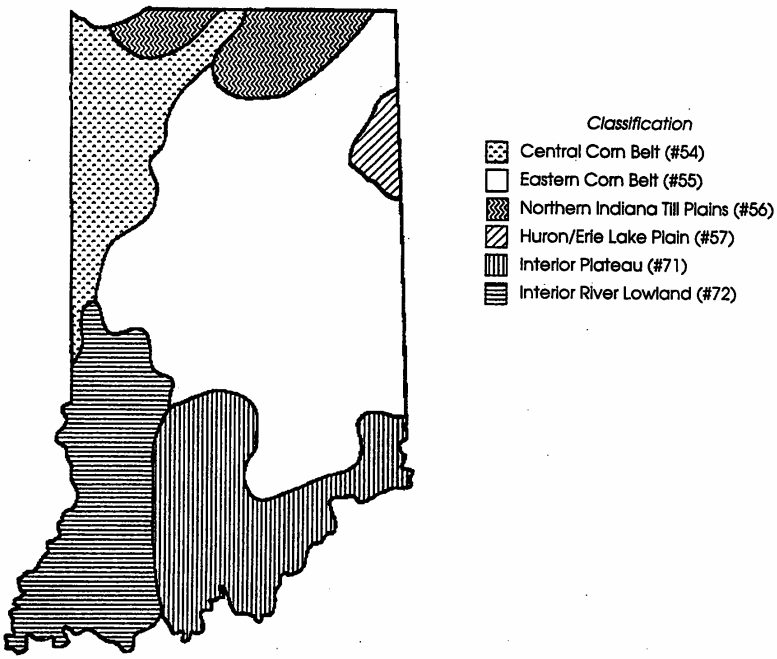
The most widely used system for delineating regional landscape patterns is the ecoregion. Ecoregions are generally considered to be regions of relative homogeneity in ecological systems or in relationships between organisms and their environments (Omernik and Gallant 1988). Omernik and Gallant delineated ecoregions of the Upper Midwest according to patterns of spatial homogeneity with regard to soils, land use, land-surface form, and potential natural vegetation. Their resulting map identifies six ecoregions within Indiana (Figure 16).

**Ecoregion Descriptions** (from Omernik and Gallant 1988)

Central Corn Belt Plains (map unit #54). The Central Corn Belt Plains ecoregion consists of a dissected glacial till plain mantled with loess. It covers 46,000 square-miles of Illinois and Indiana. It has mostly low relief and soils originally developed in tall-grass prairie and oak/hickory forest. Today, almost all of this ecoregion is cultivated for feed crops (corn, soybeans, feed grains and some forage) for livestock. Only 5% of the land remains in woodland. Nonpoint source pollution in the Central Corn Belt Plains is derived from crop and livestock production.

Eastern Corn Belt Plains (map unit #55). The Eastern Corn Belt Plains ecoregion is a gently rolling glacial till plain broken by moraines and outwash plains. Local relief is generally less than 50 feet.

**Figure 16.** Ecoregions of Indiana.




The ecoregion covers 31,800 square miles of Indiana, Ohio and Michigan. It supports a diverse hardwood forest and approximately 75% is currently is in cropland, primarily corn and soybeans. This ecoregion has few natural lakes or reservoirs.

Southern Michigan/Northern Indiana Till Plain (map unit #56). This 25,800 square-mile ecoregion includes a broad, nearly flat to rolling glaciated plain, deeply mantled by glacial till and outwash, sandy and gravelly beach ridges and flats, belts of morainal hills, and boggy kettle depressions. Local topography ranges from a few feet to several hundred feet in elevation. Oak/hickory forests are the natural vegetation throughout most of this ecoregion. Land is managed for cropland, livestock, forest and woodland, and urban use. Approximately 25% of the region is urbanized. Lakes are common in some areas; however many depressions are filled with peat deposits or dark mineral soils.

Huron/Erie Lake Plain (map unit #57). This ecoregion consists of a broad, nearly level lake plain crossed by beach ridges and low moraines. Most of the area was originally covered by forested wetlands. Local relief is generally only a few feet. The ecoregion covers 11,000 square miles of Indiana, Ohio, and Michigan. Cash crop farming is the primary land use in the Huron/Erie Lake Plain and soils are often poorly drained. Approximately one-tenth of the region is urbanized. There are few lakes or reservoirs in this ecoregion.

Interior Plateau (map unit #71). The Interior Plateau includes a till plain of low topographic relief formed from Illinoian glacial drift materials, rolling to moderately dissected basin terrain, and rolling to deeply dissected plateaus. Layers of limestone, sandstone, siltstone, and shale underlie much of this region. Limestone outcrops are common, as are limestone sinks. This 56,000 square mile ecoregion extends from Indiana and Ohio south to northern Alabama. Local relief varies from 100–200 feet on the till plains, to 400 feet in the more hilly terrain, to more than 800 feet on some of the steeper hills. Many of the soils of the Interior Plateau developed from underlying sedimentary rock. Acreage in this ecoregion is managed for cropland, livestock, pasture, woodland and forest. There are numerous quarries and some coal surface mines. Natural lakes are few.

Interior River Lowland (map unit #72). The Interior River Lowland is comprised of a dissected glacial till plain, rolling narrow ridgetops, and hilly to steep ridge slopes and valley sides. It covers 29,000 square miles in Indiana, Kentucky, Illinois, and Missouri. Local relief varies from a few feet on the till plains, to 100 feet on rolling ridges, to nearly 600 feet on more prominent ridges. Land uses are varied: cropland, livestock, pasture, timber, and coal surface mines. About one-third of the region is forested, primarily in oak and hickory. Lakes, reservoirs, and numerous ponds are scattered throughout the ecoregion. The greatest land use impacts on stream water quality in the region result from crop and livestock production and surface mining.

**Ecoregion Trends**

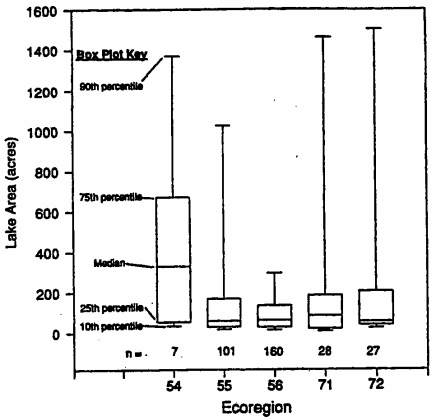
Ecoregions have been used to identify spatial trends in water quality by several authors. Omernik et al. (1991) developed a map showing the distribution of summer total phosphorus in lakes in ecoregions of Minnesota, Wisconsin, and Michigan. Heiskary, Wilson, and Larsen (1988); Wilson and Walker (1989); and Heiskary (1989) have identified relationships between lake trophic state and ecoregions in Minnesota and have used these relationships to develop lake management strategies.

*Morphometry.* Only five of the six ecoregions in Indiana contain lakes sampled during this study. The Huron/Erie Lake Plain ecoregion (map unit #57) is the one in which we have no lakes. Ecoregion 56 contains the largest number of study lakes in Indiana (160) and Ecoregion 54 contains the fewest (7) (Figure 17). Despite having the fewest lakes, the Central Cornbelt Plains (#54) has the greatest median lake size (327 acres) and the greatest range in lake size. One large reservoir (J.C. Murphy) skews the results. Ecoregions 55, 56, and 72 all have about the same median lake areas (55–62 acres) while median lake size in ecoregion 71 is slightly larger (83 acres). Although it has the greatest number of lakes, Ecoregion 56 has the narrowest range of lake area between the 10th and 90th percentiles. The greater overall ranges in lake area for ecoregions 54, 71, and 72 likely result from the larger reservoirs in those regions.

The deepest Indiana lakes in this study are in ecoregions 55 and 56 with median depths of 39 and 34 feet, respectively. These ecoregions contain mostly natural lakes (Figure 18). The remaining ecoregions contain many reservoirs which tend to have shallower median depths in Indiana (median depths ranging from 25–26 feet).

*Secchi Disk Transparency.* Median Secchi disk transparency varies greatly among the ecoregions of Indiana (Figure 19). Lakes in the Central Corn Belt Plains (#54) had the lowest median transparency (2.9 feet). This region has only a few shallow lakes. Wind resuspension of sediments is more of a problem in shallow lakes and this adversely affects transparency.

**Figure 17.** Box plots showing the distribution of median lake area among Indiana ecoregions. Only those lakes sampled in 1989–93 are included.




The next lowest transparencies are in the Interior River Lowland (#72) where the median transparency was 3.9 feet. This region is characterized by relatively shallow reservoirs. Although this area is largely forested, the steeper topography can cause increased runoff following rain storms. In addition, the larger watersheds of reservoirs often result in lower transparencies due to more runoff.

The highest median Secchi disk transparency (9.0 feet) occurs in the Interior Plateau ecoregion (#71). This region too has mostly shallow reservoirs but most lie within Hoosier National Forest and a variety of state forests and parks. The somewhat protected watersheds and the greater percentage of forested land in these lakes' watersheds can reduce soil erosion which contributes to low transparencies and can reduce nutrient losses which contribute to algal growth.

*Total Phosphorus.* The highest median phosphorus concentration (0.132 mg/L) occurs in the lakes within the Eastern Cornbelt Plains (#55) (Figure 20). This ecoregion as a whole is 75% agricultural. Lakes in the Interior Plateau ecoregion (#71) have the lowest median total phosphorus concentration (0.045 mg/L). As mentioned above, many of the reservoirs in this region are within public lands. The range in total phosphorus concentrations for lakes in this region was also very low. This suggests that total phosphorus concentrations are consistently low in lakes in this ecoregion. The remaining

**Figure 18.** Box plots showing the distribution of median lake depth among Indiana ecoregions. Only those lakes sampled in 1989–93 are included.

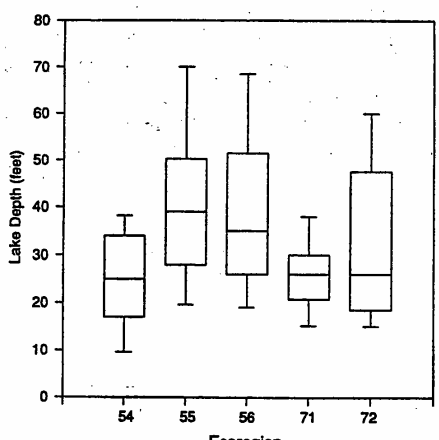
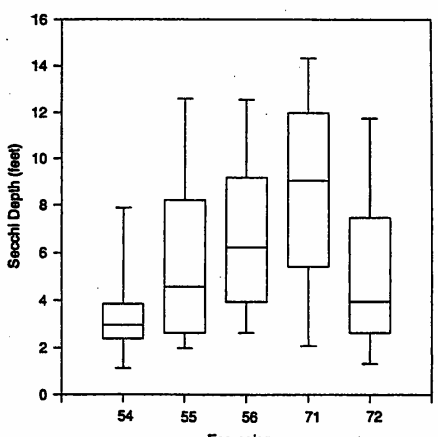



**Figure 19.** Box plots showing the distribution of Secchi disk transparency by Indiana ecoregion for lakes sampled in 1989–93.



regions' median total phosphorus concentrations vary between 0.84 and 0.89 mg/L. Note that all these median total phosphorus concentrations are above the mesotrophic category identified in Table 1 previously.

*Trophic State Index.* The median trophic state indices of lakes by ecoregion closely parallel the trends for total phosphorus and Secchi disk transparency (Figure 21). The lowest median Indiana TSI was 15 for the Interior Plateau ecoregion (#71). Seventy-five percent of the lakes in this ecoregion had TSIs in the oligotrophic range (<25). This suggests that lakes are consistently less productive in this ecoregion.

Lakes in the Eastern Corn Belt Plains ecoregion (#55) had the highest median TSI, 31 points. Seventy-five percent of the lakes in this region are classified in the mesotrophic category according to the Indiana trophic state classification system. The remaining ecoregions had median TSI scores ranging from 24 to 28.

Three ecoregions (#54, #56 and #71) had more Class I lakes (oligotrophic) than any other single class (Figure 22). The Southern Michigan/Northern Indiana Till Plains ecoregion (#56) has the most Class I lakes (79). Because of the large number of lakes in this region, it shares the distinction of having the highest number of Class III lakes with the Eastern Corn Belt Plains ecoregion (10).

Class II lakes (mesotrophic) are the most frequent lakes encountered in the Eastern Corn Belt Plains (#55) and Interior River Lowland (#72) ecoregions. Fourteen percent of the lakes in the Interior River Lowland ecoregion are designated Class III (eutrophic). Neither the Central Corn Belt Plains (#54) nor the Interior Plateau (#71) ecoregions have any Class III lakes.

The median change in TSI scores decreased in all ecoregions for the 261 lakes sampled both during the mid-1970s and during 1989–93 (Figure 23). The Central Corn Belt Plains ecoregion (#54) had the greatest median TSI decrease of about 12 points. More than 75% of the lakes in this ecoregion had a decrease in TSI during this period. The Eastern Corn Belt Plains ecoregion (#55) had the next greatest median decrease (7 points).

**Figure 20.** Box plots showing the distribution of total phosphorus by Indiana ecoregion for lakes sampled in 1989–93.

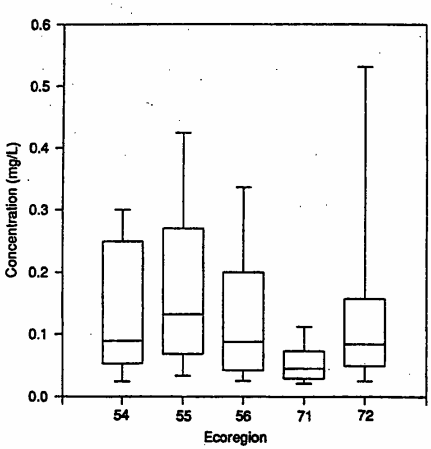



**Figure 21.** Box plots showing the distribution of median TSI scores by Indiana ecoregion for lakes sampled in 1989–93.

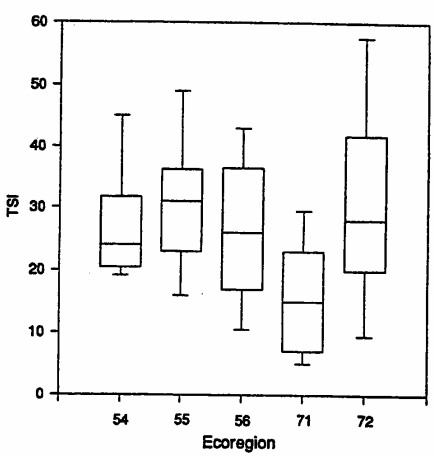
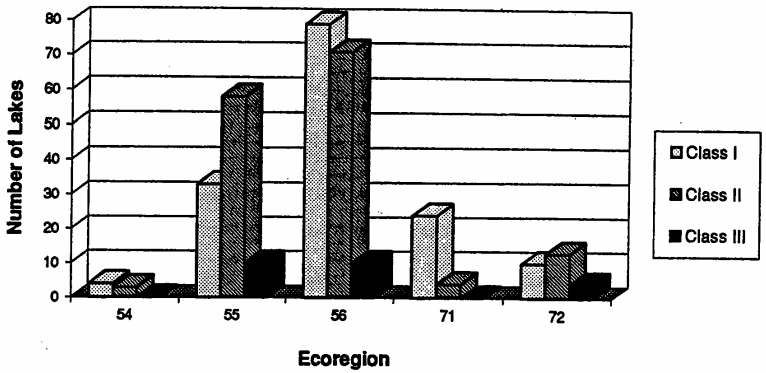


**Figure 22.** Box plots showing change in TSI score by ecoregion for 1989–93 lake data.

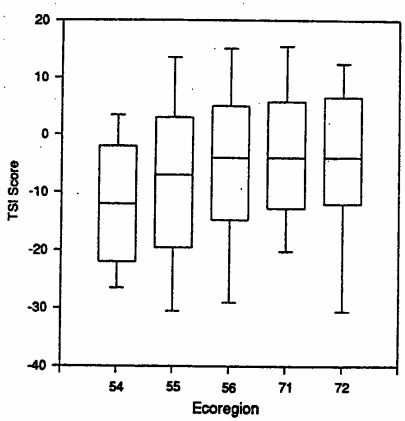



*Agricultural Land Use.* A closer look at agricultural data shows several important differences in agricultural land use practices and conditions in Indiana's ecoregions (Table 8). Agricultural data used in this table are county-level from 1992. Only those counties with lakes were included in the ecoregion summaries.

Several relationships are apparent from Table 8. Those ecoregions with a high percentage of cropland have higher TSIs. Ecoregions with a high percentage of cropland in the Conservation Reserve Program (CRP) also tend to have lower TSIs. These relationships are easier to see graphically.

There is a strong relationship between the amount of land in cropland and the mean TSI for the five ecoregions (Figure 24). As the percentage of cropland increases for an ecoregion, the mean TSI of lakes in that ecoregion increases proportionately. The regression line accounts for nearly 98% of the variation between these two parameters. We should note that the statistical strength of this relationship is diminished because there are only five data points, however; one cannot overlook the close fit of the data.

**Figure 23.** Box plots showing change in TSI score by ecoregion for 1989–93 lake data.




There is nearly as strong a relationship between the percentage of lands in CRP and TSI (Figure 25). Ecoregions where more former cropland is held out of production have lower mean TSIs. Agricultural BMPs also appear to affect TSIs at the ecoregion level (Figure 26). As the percentage of conservation tillage applied to cropland increases, mean ecoregion TSI decreases. The regression fit is a respectable 71%.

There is an inverse relationship between the percentage of highly erodible lands (HEL) in an ecoregion and its mean TSI, but a straight-line regression only accounts for 10% of the variation between the two parameters (Figure 27). One outlier (ecoregion #71) has a low mean TSI but a relatively high percentage (13%) of HEL. Examination of Table 8 shows that ecoregion #71 also has the smallest amount of cropland (15%) and the highest percentage

**Table 8. Agricultural Data for Indiana Ecoregions.**

| *Ecoregion* | *% Highly Erodible Lands* | *% Cropland* | *% Conservation Tillage* | *% CRP* | *Mean TSI* |
|---|---|---|---|---|---|
| 54 | 7 | 57 | 40 | 1.9 | 34 |
| 55 | 10 | 57 | 33 | 4.1 | 31 |
| 56 | 13 | 51 | 42 | 6.9 | 29.1 |
| 71 | 13 | 15 | 51 | 14.4 | 15 |
| 72 | 18 | 50 | 39 | 1.8 | 29.6 |

Source: CTIC (1992)

of conservation tillage (51%) of the five Indiana ecoregions. It is possible that these two variables affect TSI more than the HEL. In fact, the HEL determination is for the potential for erosion. If the land is not disturbed or if BMPs are used, the actual erosion threat is not realized. This could be happening in ecoregion #71.

The results of the regional analysis of lake productivity is summarized in Table 9.

**Figure 24.** Relationship between mean ecoregion TSI and % cropland for 1989–93 data.

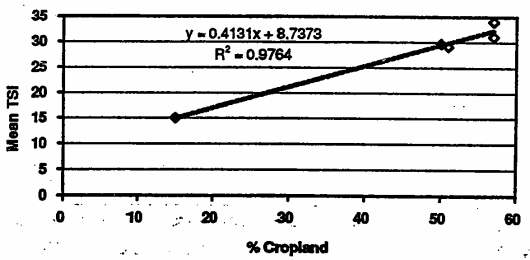



**Figure 25.** Relationship between mean ecoregion TSI score and % land in Conservation Reserve Program for 1989–93 data.

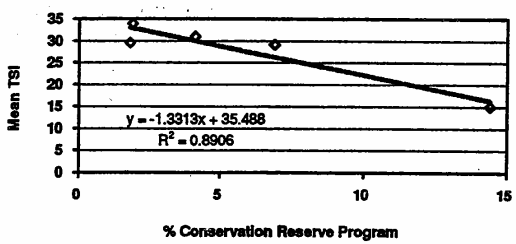


**Figure 26.** Relationship between mean ecoregion TSI score and % land in conservation tillage for 1989-93 data.

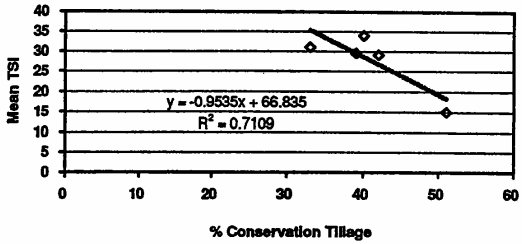



**Figure 27.** Relationship between mean ecoregion TSI score and % highly erodible lands for 1989-93 data.

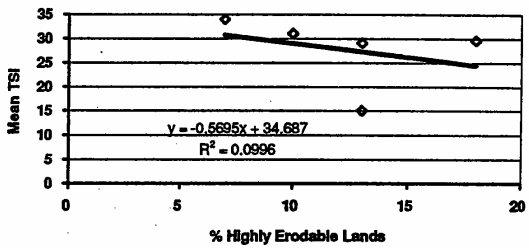



**Table 9.** Summary of Regional Trends in Indiana Lake Productivity.

| *Ecoregion* | *Regional Trends* |
|---|---|
| Central Corn Belt Plains (#54) | Flat topography; loess soils; 57% cropland; 1.9% CRP; Mean TSI=34.0 |
| Eastern Corn Belt Plains (#55) | Mostly flat topography; loess soils; 57% cropland; 4.1% CRP; Mean TSI=31.0 |
| S. Michigan/N. Indiana Till Plains (#56) | Flat to rolling topography; outwash soils; 51% cropland; 6.9% CRP; Mean TSI=29.1 |
| Interior Plateau (#71) | Flat to dissected plateaus; sedimentary soils; mixed land use; 15% cropland; 14.4% CRP; forested lake watersheds; Mean TSI=15.0 |
| Interior River Lowland (#72) | Rolling to steep topography; glacial till & loess soils; 50% cropland; 51% cons. tillage; 1.8% CRP; 18% HEL; Mean TSI=29.6 |

## SUMMARY

The trophic state of Indiana lakes is determined by a complex interplay of lake morphology, geology, topography, and watershed land uses. Lakes with large watersheds relative to their lake volumes are flushed more frequently with runoff and this is largely a benefit to the lake, especially when watershed best management practices have been applied. Our data show that these lakes have had a greater decrease in trophic state from the 1970s to the present than lakes with small watershed:lake volume ratios.

There are some regional trends evident in Indiana lake quality, however; we do not see the clear-cut distinctions documented in Minnesota ecoregions. Regional differences appear to be most affected by the percentages of cropland, conservation tillage and conservation reserve program (CRP) land within an ecoregion. Topography and soils may have additional but less identifiable influences on lake trophic state.

One difficulty in analyzing Indiana lake data is that the data are not at the same scale. Chemistry and biology data are available at the lake level. Morphology data are generally available at the lake level but they are incomplete because lake volumes are not measured for all Indiana lakes. The watershed is an ideal unit for geology, topography, and land use data but this information is only available at the county level. Ecoregion data are available for still larger areas. A goal for future work should be to develop a data base of lake-related information at the smallest possible scale, preferably the watershed.

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# APPENDIX A:
# Useful Metric Equivalents and Conversions

| ...ric Prefix[a] | Value (Grams) | Scientific Notation |
|---|---|---|
| ...nogram (ng) | 0.000000001 | $10^{-9}$ grams |
| microgram (µg) | 0.000001 | $10^{-6}$ grams |
| milligram (mg) | 0.001 | $10^{-3}$ grams |
| centigram (cg) | 0.01 | $10^{-2}$ grams |
| decigram (dg) | 0.1 | $10^{-1}$ grams |
| gram (g) | 1.0 | $10^{1}$ grams |
| kilogram (kg) | 1000.0 | $10^{3}$ grams |

[a]also applies to metric volumes, for example milliliters, liters, etc.

*Conversions/Equivalents*

| | | |
|---|---|---|
| 1 kg | = | 2.205 lb |
| 1 ton | = | 2000 lb |
| 1 meter | = | 3.28 ft |
| 1 mile | = | 5280 ft |
| 1 gal | = | 3.785 liters |
| 1 $ft^3$ | = | 28.3 liters |
| 1 $m^3$ | = | 1000 liters |
| 1 $m^3$ | = | 35.3 $ft^3$ |
| 1 acre | = | 43,560 $ft^2$ |
| 1 hectare | = | 10,000 $m^2$ |
| 1 hectare | = | 2.47 acres |

# APPENDIX B:
# Raw Water Quality Data for Lakes Sampled Between 1989 and 1993

| LAKE | AREA (ac) | MAX. DEPTH (ft) | YEAR SAMPLED | TROPHIC POINTS (1970's) | (1985) | (1989-93) | CHANGE | Tot P mean (mg/L) | SRP mean (mg/L) | Org. N mean (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Myers | 96 | 59 | 1989 | 21 | | 34 | 13 | 0.147 | 0.125 | 0.938 |
| Pretty | 97 | 40 | 1989 | 28 | | 20 | -8 | 0.060 | 0.008 | 1.009 |
| Thomas | 16 | 58 | 1991 | 51 | | 29 | -22 | 0.265 | 0.220 | 1.610 |
| MARTIN CO. | | | | | | | | | | |
| West Boggs | 600 | 30 | 1989 | 45 | | 41 | -4 | 0.176 | 0.153 | 1.435 |
| MIAMI CO. | | | | | | | | | | |
| Mississinewa | 3180 | 45 | 1991 | 18 | 24 | 25 | 7 | 0.051 | 0.000 | 1.011 |
| MONROE CO. | | | | | | | | | | |
| Beanblossom | 17 | 17 | 1992 | | | 5 | NA | 0.046 | 0.009 | 0.526 |
| Bryants Creek | 9 | 23 | 1992 | 15 | | 7 | -8 | 0.054 | 0.009 | 0.644 |
| Cherry | 4 | 30 | 1993 | 15 | | 10 | -5 | 0.041 | 0.006 | 0.230 |
| Griffy | 130 | 30 | 1990 | 40 | | 19 | -21 | 0.028 | 0.003 | 1.363 |
| Lemon | 1650 | 28 | 1990 | 40 | | 26 | -14 | 0.056 | 0.028 | 1.381 |
| Monroe, Lower | 10750 | 38 | 1990 | 25 | 3 | 5 | -20 | 0.026 | 0.005 | 0.566 |
| Monroe, Upper | 10750 | 38 | 1990 | 27 | 15 | 14 | -13 | 0.033 | 0.006 | 0.675 |
| MONTGOMERY CO. | | | | | | | | | | |
| Waveland | 360 | 27 | 1991 | 20 | | 36 | 16 | 0.329 | 0.223 | 1.460 |
| NEWTON CO. | | | | | | | | | | |
| J.C. Murphy | 1515 | 8 | 1990 | 47 | | 20 | -27 | 0.061 | 0.031 | 1.668 |
| NOBLE CO. | | | | | | | | | | |
| Bartley | 34 | 38 | 1990 | 35 | | 56 | 21 | 0.049 | 0.048 | 1.938 |
| Baugher | 32 | 36 | 1991 | 54 | | 56 | 2 | 0.362 | 0.302 | 1.364 |
| Bear | 136 | 59 | 1993 | 46 | | 37 | -9 | 0.201 | 0.173 | 1.518 |
| Beck | 10 | 24 | 1993 | | | 25 | NA | 0.160 | 0.006 | 5.031 |
| Big | 228 | 70 | 1990 | 38 | | 52 | 14 | 0.059 | 0.172 | 1.732 |
| Bixler | 120 | 43 | 1993 | 38 | | 23 | -15 | 0.449 | 0.424 | 1.718 |
| Bowen | 30 | 36 | 1991 | 41 | | 34 | -7 | 0.458 | 0.420 | 1.029 |
| Crane | 28 | 26 | 1991 | 45 | | 47 | 2 | 0.523 | 0.459 | 1.198 |
| Cree | 58 | 26 | 1993 | 39 | | 17 | -22 | 0.157 | 0.027 | 3.608 |
| Deer | 36 | 24 | 1993 | | | 41 | NA | 0.302 | 0.331 | 0.665 |
| Diamond | 105 | 81 | 1993 | 21 | | 33 | 12 | 0.042 | 0.023 | 1.326 |
| Dock | 16 | 40 | 1991 | 38 | | 35 | -3 | 0.333 | 0.243 | 1.775 |
| Duely | 21 | 19 | 1993 | 42 | | 35 | -7 | 0.098 | 0.002 | 1.064 |
| Eagle | 81 | 49 | 1993 | | | 39 | NA | 0.205 | 0.172 | 0.766 |
| Engle | 48 | 29 | 1993 | 26 | | 13 | -13 | 0.032 | 0.006 | 1.174 |
| Gilbert | 28 | 36 | 1993 | 28 | | 17 | -11 | 0.022 | 0.006 | 0.420 |
| Gordy | 31 | 35 | 1993 | 43 | | 39 | -4 | 1.272 | 0.042 | 1.977 |
| Hall | 10 | 35 | 1993 | 16 | | 10 | -6 | 0.049 | 0.000 | 1.488 |
| Harper | 11 | 25 | 1993 | 60 | | 25 | -35 | 0.085 | 0.022 | 0.520 |
| Henderson | 22 | 35 | 1993 | 73 | | 44 | -29 | 0.146 | 0.004 | 1.613 |
| High | 123 | 25 | 1993 | 53 | | 39 | -14 | 0.046 | 0.012 | 1.145 |
| Hindman | 13 | 20 | 1993 | 52 | | 21 | -31 | 0.073 | 0.004 | 1.008 |
| Horseshoe | 18 | 28 | 1993 | 40 | | 27 | -13 | 0.024 | 0.001 | 1.032 |
| Jones | 115 | 25 | 1993 | | | 56 | NA | 0.334 | 0.219 | 3.106 |
| Knapp | 88 | 59 | 1993 | 43 | | 34 | -9 | 0.317 | 0.363 | 0.230 |
| Latta | 42 | 38 | 1993 | 36 | | 26 | -10 | 0.464 | 0.258 | 0.456 |
| Little Long | 71 | 32 | 1993 | 32 | | 34 | 2 | 0.174 | 0.170 | 0.995 |
| Long | 40 | 32 | 1990 | 33 | | 41 | 8 | 0.039 | 0.025 | 2.208 |
| Lower Long | 66 | 55 | 1989 | | | 20 | NA | 0.147 | 0.180 | 0.737 |
| Mirror | 7 | 45 | 1993 | | | 17 | NA | 0.397 | 0.171 | 6.087 |
| Moss | 9 | 19 | 1993 | 51 | | 30 | -21 | 0.081 | 0.001 | 1.251 |
| Norman | 14 | 46 | 1990 | 39 | | 26 | -13 | 0.281 | 0.281 | 1.516 |
| Port Mitchell | 15 | 31 | 1990 | 30 | | 55 | 25 | 0.094 | 0.121 | 1.611 |
| Rider | 5 | 15 | 1993 | 55 | | 16 | -39 | 0.088 | 0.005 | 2.233 |
| River | 24 | 32 | 1991 | 38 | | 32 | -6 | 0.476 | 0.418 | 1.189 |
| Round | 99 | 66 | 1993 | 24 | | 31 | 7 | 0.184 | 0.168 | 1.826 |
| Sacarider | 33 | 60 | 1993 | 35 | | 54 | 19 | 0.275 | 0.258 | 0.429 |
| Sand | 47 | 51 | 1989 | 23 | | 16 | -7 | 0.198 | 0.149 | 0.494 |

| NO3 mean (mg/L) | NH4 mean (mg/L) | D.O. Sat. @5 ft | %Water Column Oxic | Secchi Disk (ft) | % light @3 ft | Blue-Green Algae | Green Algae | Diatoms | Other Algae | Zoo-plankton | Total Plankton |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.212 | 0.688 | 103 | 56 | 9.8 | 45 | 14938 | 114 | 152 | 930 | 209 | 16343 |
| 0.908 | 0.031 | 111 | 82 | 13.8 | 61 | 207 | 0 | 90 | 0 | 13 | 310 |
| 0.051 | 2.446 | 102 | 12 | 4.9 | 25 | 69 | 0 | 0 | 750 | 111 | 930 |
| | | | | | | | | | | | |
| 5.557 | 1.807 | 90 | 25 | 2.1 | 19 | 1844 | 0 | 0 | 0 | 12 | 1856 |
| | | | | | | | | | | | |
| 2.617 | 0.112 | 138 | 83 | 5.3 | 48 | 636 | 200 | 35 | 70 | 69 | 1010 |
| | | | | | | | | | | | |
| 0.066 | 0.017 | 68 | 100 | 6.2 | 55 | 409 | 409 | 163 | 654 | 74 | 1709 |
| 0.072 | 0.027 | 93 | 89 | 11.8 | 58 | 226 | 395 | 113 | 4738 | 119 | 5591 |
| 0.022 | 0.618 | 67 | 100 | 5.6 | 31 | 271 | 1279 | 246 | 2435 | 1731 | 5962 |
| 0.118 | 0.280 | 129 | 75 | 13.5 | 62 | 4178 | 0 | 0 | 144 | 325 | 4647 |
| 0.105 | 0.380 | 90 | 67 | 3.3 | 32 | 1166 | 284 | 43 | 469 | 354 | 2316 |
| 0.078 | 0.079 | 101 | 100 | 5.6 | 60 | 454 | 4242 | 1703 | 93 | 64 | 6556 |
| 0.072 | 0.028 | 103 | 100 | 3.3 | 55 | 175 | 16447 | 1949 | 176 | 298 | 19045 |
| | | | | | | | | | | | |
| 0.641 | 3.219 | 55 | 23 | 2.0 | 10 | 2270 | 2443 | 172 | 31849 | 221 | 36955 |
| | | | | | | | | | | | |
| 0.274 | 0.032 | 111 | 100 | 8.9 | 40 | 1557 | 195 | 583 | 43 | 201 | 2579 |
| | | | | | | | | | | | |
| 1.226 | 1.200 | 69 | 56 | 3.9 | 28 | 371269 | 789 | 2104 | 1578 | 791 | 376531 |
| 0.521 | 0.917 | 128 | 43 | 3.6 | 11 | 73337 | 38415 | 1397 | 6286 | 1202 | 120637 |
| 0.027 | 0.858 | 106 | 30 | 4.9 | 31 | 8269 | 370 | 278 | 2499 | 753 | 12169 |
| 0.022 | 0.018 | 99 | 80 | 8.2 | 42 | 31181 | 0 | 630 | 21039 | 841 | 53691 |
| 1.495 | 0.492 | 115 | 90 | 6.2 | 37 | 1181714 | 4857 | 3885 | 1943 | 348 | 1192747 |
| 0.023 | 1.359 | 107 | 50 | 5.9 | 37 | 3368 | 823 | 1234 | 19335 | 1032 | 25792 |
| 0.505 | 1.306 | 114 | 60 | 5.6 | 10 | 2559 | 93 | 884 | 1349 | 81 | 4966 |
| 0.750 | 1.703 | 188 | 30 | 2.0 | 3 | 13572 | 127 | 319 | 4843 | 458 | 19319 |
| 0.158 | 0.340 | 101 | 63 | 12.1 | 45 | 10435 | 387 | 4551 | 1181 | 18893 | 35447 |
| 0.125 | 1.007 | 128 | 47 | 2.0 | 28 | 8358 | 393 | 196 | 1094 | 640 | 10681 |
| 0.267 | 0.379 | 105 | 25 | 5.2 | 37 | 62825 | 171 | 683 | 1707 | 202 | 65588 |
| 0.436 | 0.832 | 140 | 63 | 3.9 | 13 | 1095 | 12585 | 2257 | 14227 | 1285 | 31449 |
| 0.372 | 0.556 | 91 | 52 | 4.9 | 24 | 24782 | 60 | 1206 | 3859 | 216 | 30123 |
| 0.094 | 1.096 | 117 | 26 | 3.3 | 48 | 4562 | 211 | 272 | 1148 | 851 | 7044 |
| 0.026 | 0.640 | 100 | 57 | 9.8 | 33 | 1154 | 79 | 1063 | 645 | 96 | 3037 |
| 0.022 | 0.854 | 95 | 73 | 17.4 | 70 | 2015 | 76 | 171 | 1083 | 480 | 3825 |
| 0.033 | 1.453 | 86 | 57 | 10.5 | 44 | 70776 | 0 | 214 | 1428 | 375 | 72793 |
| 0.022 | 0.018 | 97 | 100 | 6.6 | 42 | 2351 | 187 | 51 | 2861 | 568 | 6018 |
| 0.255 | 2.282 | 107 | 69 | 10.8 | 56 | 22058 | 175 | 233 | 5507 | 651 | 28624 |
| 2.917 | 0.251 | 164 | 100 | 1.6 | 8 | 9119 | 1E+05 | 25629 | 31100 | 3713 | 187817 |
| 0.022 | 0.172 | 93 | 24 | 2.3 | 8 | 64112 | 2530 | 185 | 10860 | 2088 | 79775 |
| 0.865 | 0.587 | 135 | 52 | 6.2 | 52 | 10862 | 137 | 1708 | 15508 | 1047 | 29262 |
| 0.830 | 0.720 | 92 | 66 | 7.2 | 44 | 34666 | 436 | 1746 | 2681 | 927 | 40456 |
| 0.022 | 0.710 | 101 | 67 | 3.3 | 28 | 110731 | 9421 | 15019 | 21709 | 937 | 157817 |
| 1.276 | 1.308 | 96 | 22 | 5.6 | 45 | 4441 | 116 | 696 | 1127 | 128 | 6508 |
| 0.022 | 1.439 | 97 | 64 | 13.5 | 80 | 8207 | 167 | 2638 | 2408 | 279 | 13699 |
| 0.022 | 1.722 | 109 | 26 | 4.9 | 73 | 2117 | 69 | 312 | 555 | 206 | 3259 |
| 2.228 | 0.430 | 88 | 56 | 8.2 | 39 | 116801 | 2786 | 214 | 24431 | 299 | 144531 |
| 8.999 | 0.778 | 104 | 67 | 8.9 | 58 | 3261 | 263 | 236 | 2709 | 330 | 6799 |
| 0.022 | 0.403 | 86 | 77 | 10.8 | 62 | 1260 | 5651 | 36 | 0 | 499 | 7446 |
| 0.888 | 0.604 | 96 | 55 | 6.2 | 52 | 39196 | 168 | 1067 | 17352 | 567 | 58350 |
| 0.386 | 1.158 | 78 | 57 | 6.2 | 37 | 21790 | 927 | 696 | 22485 | 1569 | 47467 |
| 1.137 | 1.432 | 78 | 82 | 3.9 | 31 | 215226 | 4181 | 2420 | 1760 | 1338 | 224925 |
| 0.772 | 0.108 | 85 | 67 | 7.9 | 46 | 7877 | 43 | 779 | 9695 | 733 | 19127 |
| 0.442 | 1.155 | 76 | 33 | 4.6 | 10 | 1807 | 981 | 3665 | 568 | 322 | 7343 |
| 0.022 | 1.067 | 106 | 25 | 5.2 | 67 | 4283 | 777 | 252 | 1134 | 272 | 6718 |
| 0.169 | 0.830 | 104 | 30 | 3.0 | 30 | 158017 | 4480 | 480 | 400 | 1386 | 164763 |
| 0.425 | 0.975 | 104 | 87 | 8.2 | 45 | 2409 | 186 | 5093 | 5010 | 716 | 13414 |

# APPENDIX C:
# Glossary

| | |
|---|---|
| **anaerobic** | being able to survive in the absence of oxygen |
| **anoxic** | having no oxygen |
| **benthic** | referring to bottom zones of lakes or bottom-dwelling forms |
| **benthivore** | organism that feeds on the lake bottom |
| **chlorophyll** | the green pigment in plants |
| **density** | weight in grams per unit volume (1 ml) of a substance |
| **detritus** | dead organic matter and its associated microbial elements, particulate (POM) or dissolved (DOM) organic matter |
| **dimixis** | two circulation or mixing periods, vernal and autumnal, per year; dimictic lakes circulate after the ice melts before summer stratification and after temperature stratification is destroyed and before the ice forms |
| **epilimnion** | the upper, well-mixed, well-illuminated, nearly isothermal region of a stratified lake |
| **eutrophy** | the condition of water being rich in plant nutrients and in organic production |
| **fetch** | the distance over which wind can blow uninterrupted by land |
| **hypolimnion** | the poorly illuminated lower region of a directly stratified lake; denser, colder water protected from wind action; lies below the metalimnion; overlies the profundal zone |
| **internal loading** | nutrients or pollutants entering a body of water from its sediments |
| **inverse stratification** | condition where warm water lies beneath colder water in a vertical temperature profile; winter stratification beneath ice cover |
| **limnology** | the study of inland waters |
| **littoral** | referring to the marginal region of a body of water; the shallow, near-shore region; often defined by the band from zero depth to the outer edge of the rooted plants |
| **macrophytes** | large plants |
| **metalimnion** | the central water layer between the epilimnion and hypolimnion in a stratified lake |
| **nanoplankton** | composed of plankters sized from 2 to 20 μm |

| | |
|---|---|
| **net plankton** | the portion of the plankton community retained by a net with interstices of 50 to 63μm |
| **oligotrophy** | the condition of water being poor in plant nutrients, and the results |
| **oxidation** | a chemical process that can occur: (1) in the uptake of oxygen (combustion); (2) in the removal of hydrogen ($H_2S$-S); (3) in the increase of the valence. *Reduction* in the reverse process. |
| **pH** | the negative logarithm of the hydrogen ion concentration expressed in gram equivalents (for example, lake pH of 7 means that the hydrogen ion concentration in the water is $10^{-7}$) |
| **photosynthesis** | the process by which plants convert water and carbon dioxide ($CO_2$) into organic matter (carbohydrates) with the aid of light energy |
| **phytoplankton** | that portion of the plankton community composed of microscopic plants; also known as the algae |
| **piscivore** | organism that eats fish |
| **planktivore** | organism that eats plankton, especially zooplankton |
| **plankton** | the community of microscopic aquatic plants (phytoplankton) and animals (zooplankton) |
| **polymixis** | many circulation or mixing periods per year or nearly continuous circulation |
| **primary production** | the production of organic matter from inorganic materials by plants with the help of light energy |
| **profundal** | the deep region of a lake or reservoir below the light-controlled limit of plant production |
| **Secchi disk** | a white disc about 20 cm in diameter, lowered into water to measure transparency on the basis of visibility |
| **thermocline** | the imaginary plane within the metalimnion at the depth where the rate of temperature change is the greatest in a vertical temperature profile |
| **turnover** | the circulation period when the density stratification of a lake or reservoir is destroyed by the equalization of temperature, resulting in the mixing of the entire water mass; also known as overturn |
| **zooplankton** | the fraction of the plankton community composed of animals; the individual is the zooplankter |

# APPENDIX J

## WATER QUALITY
## IN THE
## WHITE RIVER BASIN, INDIANA

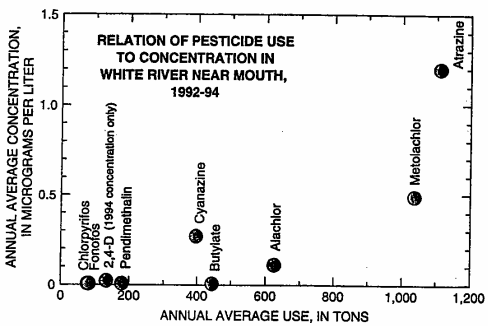
## FACTORS INFLUENCING PESTICIDE OCCURRENCE IN STREAMS

Pesticide occurrence in streams in the White River Basin is influenced by land use and agricultural practices such as pesticide application, drainage of cropland, and cropping methods. Natural factors, such as the type of terrain and soil characteristics, also are important determinants of pesticide occurrence in streams. In addition, the distribution of individual pesticides in streams throughout the watershed depends on the physical and chemical properties of the pesticides that are in use—properties such as sorption (the ability of a pesticide to stick to soil particles), degradation (the ease with which a pesticide breaks down in the environment), and volatilization (the tendency of a pesticide to become gaseous and rise into the atmosphere).

Photo by Jeffrey Martin, U.S. Geological Survey

*Agriculture is the primary source of pesticides found in streams in the White River Basin.*

### PESTICIDE PROPERTIES AFFECT CONCENTRATIONS IN STREAMS

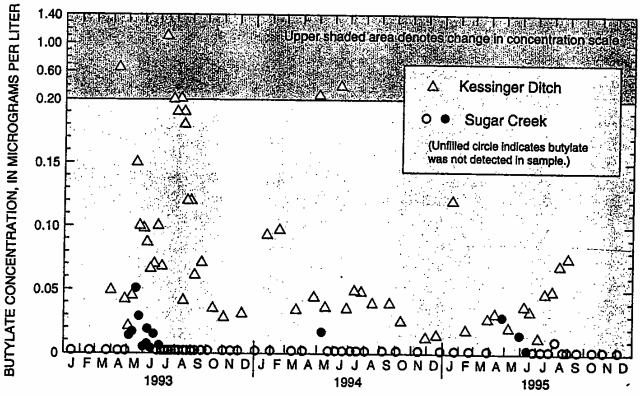



*Pesticide use only partially determines pesticide concentrations in streams.*

Pesticide concentrations in streams in the White River Basin generally increase with increasing use. Yet as shown in the figure to the left, the correlation between use and concentration is not strong for every compound. The properties of individual pesticides affect their behavior in the environment and, consequently, their ultimate concentrations in streams. Some pesticides stay close to areas where they are used, whereas others are mobile in water and are easily transported into streams. Pesticides that degrade quickly may not be found at concentrations that are anticipated solely on the basis of use; however, degradation products of the pesticides may be present in appreciable concentrations. The human health and ecological implications of many, though not all, pesticides found in streams can be evaluated with guidelines available from scientific and regulatory agencies. The health effects of degradation products generally are not known.

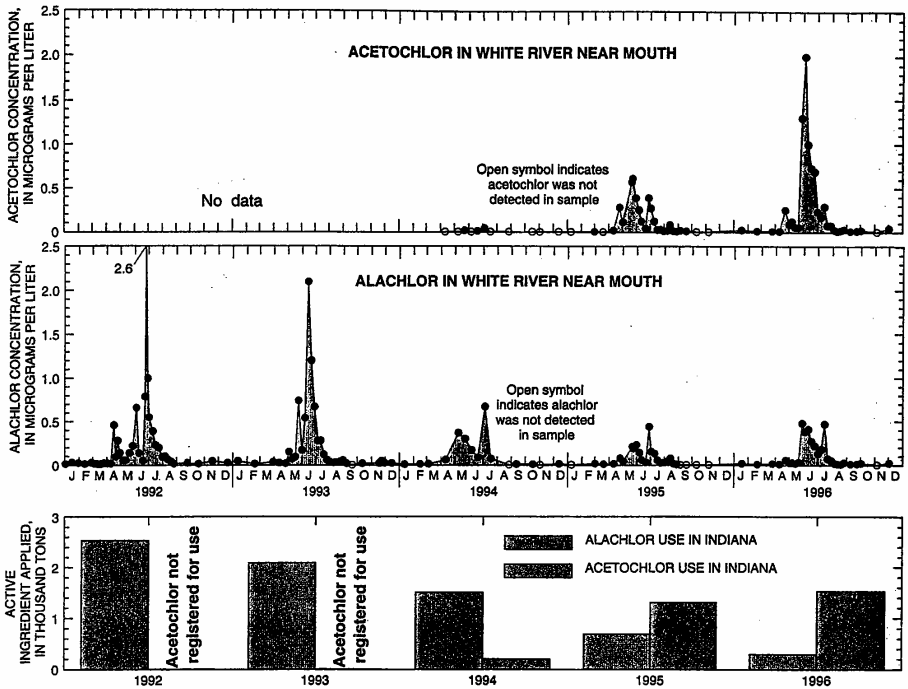
### STREAM QUALITY REFLECTS REGIONAL HERBICIDE USE

Differences in butylate concentrations from streams of similar size in two different parts of the White River Basin illustrate the effect of regional patterns of pesticide use on pesticide concentrations in streams (Crawford, 1996). Butylate, a corn herbicide, was commonly applied in 1993. During 1993, about eight times as many acres were treated with butylate and four times more butylate was applied in southern Indiana than in central Indiana. This difference in use was reflected in stream quality—concentrations in Kessinger Ditch (in southern Indiana) were substantially higher than in Sugar Creek (in central Indiana).




*High butylate application rates near Kessinger Ditch result in high concentrations in the ditch.*

## TRENDS IN HERBICIDE USE WITH TIME ARE REFLECTED IN STREAM QUALITY




*Alachlor concentrations in streams in the White River Basin steadily declined from 1992 through 1996, which corresponded with a decline in alachlor use in the basin. Application of acetochlor, a corn herbicide registered for use in 1994, has partially replaced the use of alachlor in the basin. Acetochlor was detected at only trace concentrations during the 1994 growing season. By 1996, acetochlor was commonly detected in the White River with a peak concentration of about 2 micrograms per liter (Crawford, 1997).*

Photo by Charles Crawford, U.S. Geological Survey

*Herbicides applied to corn and soybeans dominate pesticide use in the White River Basin.*

## BETTER DRAINED SOILS TRANSMIT MORE PESTICIDES TO STREAMS

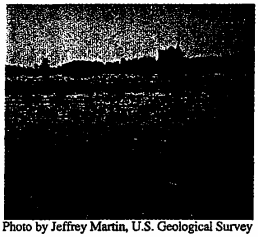
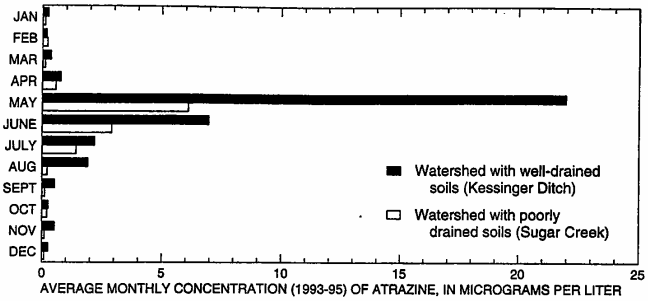


Photo by Jeffrey Martin, U.S. Geological Survey

*Clay soils in the Sugar Creek watershed cause ponding of water and inhibit drainage.*

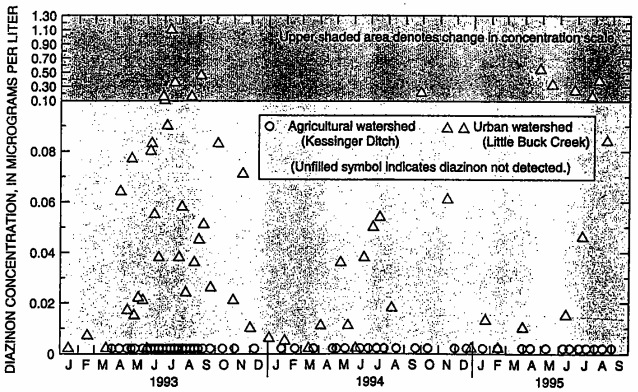



*Well-drained soils in the Kessinger Ditch watershed carry more pesticides to streams than the clay soils in the Sugar Creek watershed.*

Differences in atrazine concentrations in streams from two similar-sized watersheds with different soil-drainage characteristics are illustrated above. Atrazine was chosen for this illustration because of its widespread use in the White River Basin. In 1993, atrazine was applied to 90 percent of the corn crop in central and southern Indiana, and the rate of application was similar in these two areas. Because of this widespread use and similar cropping and pesticide-application practices throughout the basin, differences in concentrations of atrazine are attributed to natural factors, such as soil drainage. The Sugar Creek watershed, in central Indiana, has poorly drained clay soils; only 29 percent of the soils in the watershed are moderately well drained to well drained without artificial drainage. In contrast, 68 percent of the soils in the Kessinger Ditch watershed, in southern Indiana, are moderately well drained to well drained without artificial drainage because of coarse-textured soils and hilly terrains. Average monthly concentrations of atrazine in Kessinger Ditch, where dissolved atrazine is carried through the better drained soils into the ditch, were typically twice those in Sugar Creek.

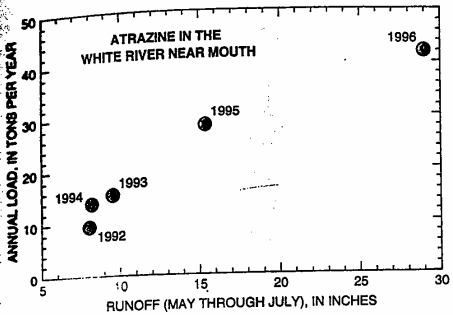
## LAND USE AFFECTS TYPES OF PESTICIDES FOUND IN STREAMS

The types of land use—agricultural or urban—in a watershed help determine the types of pesticides expected in streams draining the watershed. Trends in the concentration of the insecticide diazinon illustrate the effect of land use on pesticide occurrence in streams. Diazinon is commonly applied during midsummer in Indiana to combat insect infestations in lawns and gardens. It is less commonly used for agricultural purposes in the basin. Diazinon was present in almost all samples collected from Little Buck Creek, which drains a predominantly urban watershed (57 percent urban). In contrast, diazinon was not found in Kessinger Ditch, where 94 percent of the watershed is agricultural and less than 2 percent is urban.




*Common urban pesticides, such as diazinon, occur at higher concentrations in streams in urban watersheds than in streams in agricultural watersheds.*

## SPRING RUNOFF TRANSPORTS MOST HERBICIDES INTO STREAMS

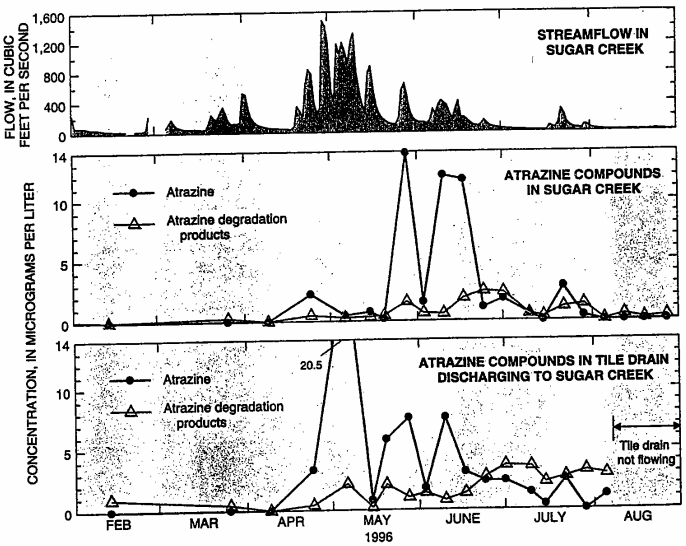



*The annual amount of atrazine carried in the White River reflects the amount of runoff received from May through July.*

Most of the annual herbicide load (the amount of herbicides carried by a river in one year) enters the White River between May and July. For example, from 1994 through 1996, 69 to 90 percent of the annual load of the five most commonly applied agricultural pesticides entered the river during this period. The amount of runoff from May through July is a key factor in determining the amount of herbicides, such as atrazine, in streams of the White River Basin (see illustration). During this period, which is shortly after atrazine application, atrazine concentrations in and on the soil are high, and the herbicide is susceptible to moving into streams when runoff occurs. Within 1 to 2 months, most of the applied atrazine is unavailable for transport because it is degraded or bound up in soil and plant material. Even heavy runoff at this time contributes only small amounts of atrazine to the river.

## TILE DRAINS ARE SIGNIFICANT PATHWAYS FOR PESTICIDES

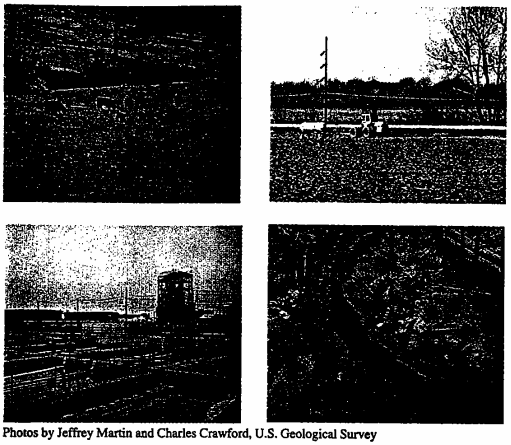
Agricultural tile drains provide an important pathway for the transport of pesticides to streams in the White River Basin (Fenelon and Moore, in press). Most poorly drained agricultural soils, which are common in the upper midwestern United States, contain tile-drain systems. Tile drains "short circuit" the groundwater system by intercepting water percolating through the soil and shallow ground water and rapidly transporting it to streams. Because tile drains typically flow during wet periods from late winter to early summer, they are able to transport recently applied pesticides to streams. In the example to the right, atrazine concentrations become elevated in the tile drain and the creek after atrazine is applied in early spring. Within about 2 months, as atrazine is naturally degraded, the concentration of atrazine degradation products is greater than the concentration of atrazine. In mid-August, the tile drain stops flowing and concentrations of all atrazine compounds in the creek are low.




*In spring, tile-drain water with elevated concentrations of atrazine empties into Sugar Creek and raises atrazine concentrations in the creek.*

## NITRATE IN STREAMS AND GROUND WATER

The primary source of nitrate in the White River Basin is nitrogen fertilizer (Martin and others, 1996). Most of the nitrogen fertilizer in the basin (about 90 percent) is applied to corn. Much of the remaining nitrogen fertilizer is applied to wheat. Nitrate is a public concern primarily because of its adverse effects on human health. The USEPA MCL for nitrate in drinking water is 10 mg/L. In some aquifers in the White River Basin, nitrate concentrations exceed this level (see p. 14). In streams, median nitrate concentrations generally ranged from 2 to 6 mg/L—much higher than those at most other streams monitored in the United States (see p. 20). Even so, concentrations of nitrate in streams in the White River Basin rarely exceeded 10 mg/L. The primary concern with nitrogen in streams in the basin is not drinking-water quality but its role in stimulating excessive growth of algae in lakes in Indiana and in the Gulf of Mexico. Runoff from Corn Belt States, which includes Indiana, is a possible cause of a "dead" zone in the Gulf of Mexico—one of the largest oxygen-deficient zones in the world (U.S. Environmental Protection Agency, 1997).

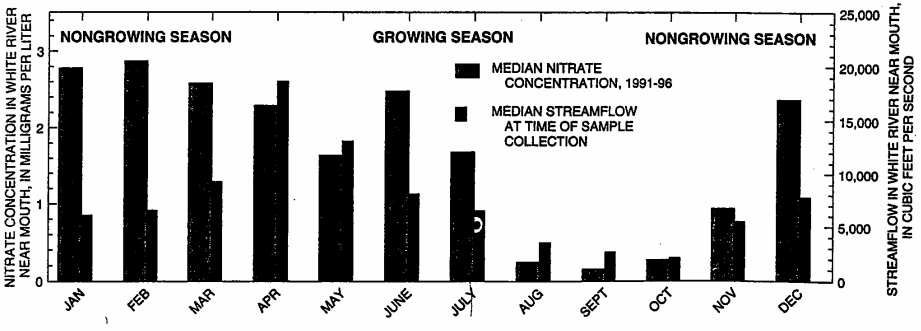


Photos by Jeffrey Martin and Charles Crawford, U.S. Geological Survey

*Sources of nitrate, such as farm-animal manure, commercial fertilizers, and effluent from sewage-treatment plants, can stimulate excessive aquatic vegetation in lakes or streams (lower right).*

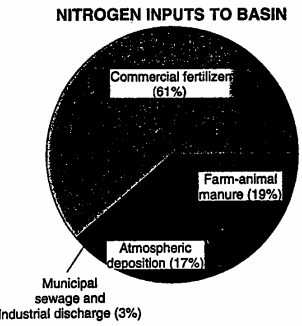
### NITRATE CONCENTRATIONS IN STREAMS SHOW A SEASONAL PATTERN

Nitrate concentrations in streams in the White River Basin have a seasonal pattern that is controlled by the transport and availability of nitrate (Martin and others, 1996). Nitrate is primarily available for transport during the nongrowing season, when it may build up in the soil because plants are not taking up large amounts of nutrients. Because nitrate is very mobile in water, it is easily flushed from saturated soils and transported to rain-swollen streams during wet periods. Nitrate concentrations in streams and streamflow are typically lowest in late summer and early fall when plants (both on land and in the streams) are using nitrate and soils are dry. As plants die or go dormant and soils regain moisture in fall, nitrate concentrations in streams begin to increase. Concentrations remain high into late spring and then start to decline as streamflow declines and plants begin to remove nitrate and water from the soils. Included in this seasonal pattern is a large rise in nitrate concentrations in June and July, soon after application of nitrogen-based fertilizer to corn crops in mid-May to mid-June.



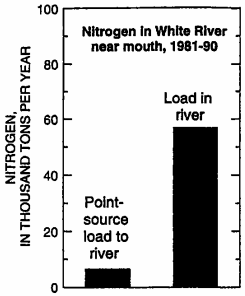

*Nitrate concentrations in the White River typically are highest during wet periods (high streamflow) and decrease during the growing season.*

## MOST NITROGEN IN WHITE RIVER IS FROM NONPOINT SOURCES




Most of the nitrogen input into the White River Basin comes from nonpoint sources, primarily from application of commercial fertilizer (Martin and others, 1996). Only about 3 percent of the nitrogen enters the basin from point sources (municipal sewage and industrial discharge).

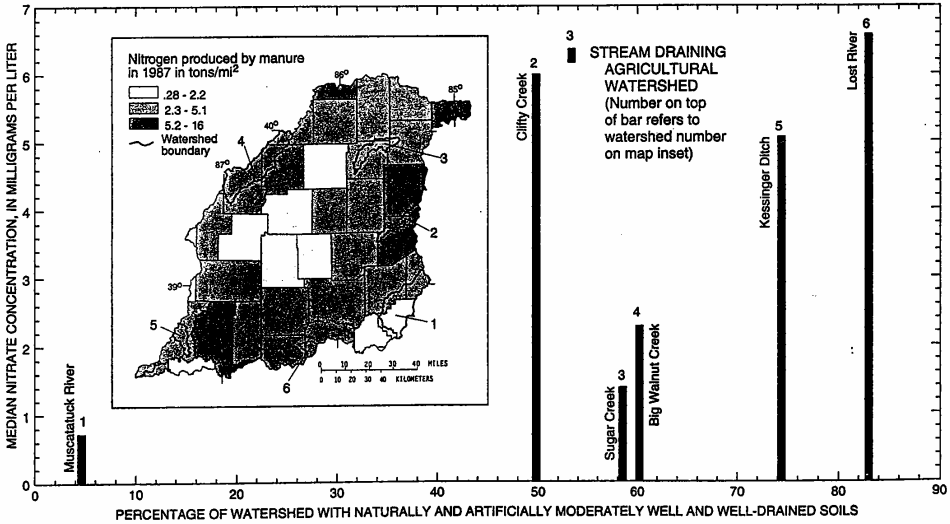
Much of the nitrogen throughout the basin is consumed by plant uptake and other natural processes. About 11 percent of the nitrogen in the water at the mouth of the White River comes from point-source discharges; the remainder enters the river from nonpoint sources (Martin and others, 1996).




## NITRATE CONCENTRATIONS IN STREAMS RELATED TO SOIL DRAINAGE

Soil drainage is a major factor controlling the concentrations of nitrate in streams in the White River Basin. Natural drainage is a function of the coarseness of soils (a sand drains better than a clay) and the slope (hills drain better than flat areas). Drainage is artificially enhanced by ditches and tile drains.

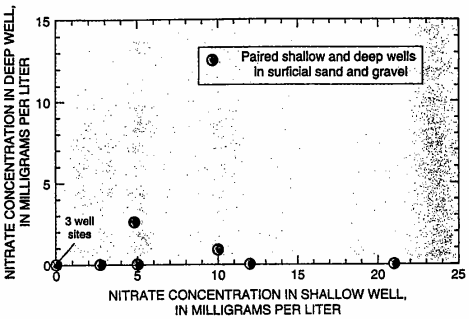
Nitrate concentrations in streams increase as the proportion of well-drained soils (both naturally and artificially well drained) increase. This pattern holds for five of six agricultural streams studied. The one exception is Clifty Creek (watershed number 2), where nitrate concentrations are much higher than would be expected on the basis of percentage of well-drained soils. In this watershed, animal waste is believed to be contributing to high nitrate concentrations in the stream. The amount of nitrogen produced by manure from farm animals in the counties drained by Clifty Creek is higher than in each of the other watersheds.




*Nitrate concentrations in streams increase as the proportion of well-drained soils increases. Manure from farm animals also can increase nitrate concentrations.*

## NITRATE CONCENTRATIONS IN GROUND WATER DECREASE WITH DEPTH

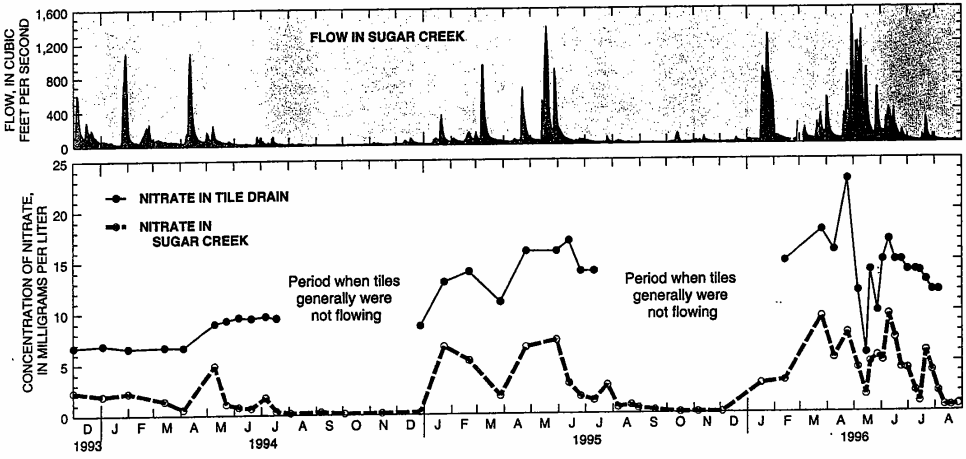
In the White River Basin, paired shallow and deep wells in surficial sand and gravel outwash (shown in diagram on previous page) showed that the highest concentrations of nitrate were in samples from the wells just below the water table. At depths of 25 to 50 feet below the water table, little or no nitrate was detected (Moore and Fenelon, 1996). Shallow ground water has high concentrations of nitrate, in part because most nitrate sources originate at land surface. Nitrate concentrations tend to decrease with depth as water containing nitrate moves downward into the ground-water system and is diluted. The decrease in nitrate concentrations with depth also is influenced by the availability of dissolved oxygen. As dissolved oxygen concentrations decrease with depth, nitrate is converted to nitrogen gas by anaerobic bacteria (bacteria that don't need oxygen to live) which use nitrate for energy production.




*High concentrations of nitrate were found in shallow wells. In deep wells (25 to 50 feet below the water table), little or no nitrate was detected.*

## TILE DRAINS HAVE MAJOR INFLUENCE ON NITRATE CONCENTRATIONS IN STREAMS

Agricultural tile drains have a major influence on nitrate concentrations in many streams in the White River Basin. Aquifers in most of the poorly drained soils of the basin are protected by overlying clay and have low nitrate concentrations. However, the streams flowing in these areas can have elevated nitrate concentrations because of outflow from tile drains that artificially drain nitrate-rich shallow ground water and water percolating through soils (Fenelon and Moore, in press). In Sugar Creek, which flows through an agricultural watershed with poorly drained soils, nitrate concentrations are elevated when tiles are flowing. During periods when tiles go dry (mid-summer to late fall), nitrate concentrations in the creek drop to background levels. These low concentrations are typical of concentrations found in the aquifers, the source of water to the creek during these periods.




*Nitrate concentrations in Sugar Creek are elevated when tile drains are flowing but drop to background levels when tiles go dry.*

# APPENDIX K

## INDIANA CLEAN LAKES PROGRAM
## LAKES WATER QUALITY ASSESSMENT REPORT

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

1 ha = 2.47 ac

**Lake Name:** Rivir (Chain O') **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 9.4 **Surface Area (ha)** 9.7 = 24 ac

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 2 | 0 |
| Light Trans. @ 3' (%) | - | - | 40 | 3 |
| 1% Light Level (ft.) | - | - | 11 | - |
| D.O. Saturation @ 5' (%) | - | - | 136 | 3 |
| % Water Col. Oxic | - | - | 48 | 3 |
| pH | 8.6 | 7.5 | 8.05 | - |
| Alkalinity (mg/L) | 158 | 228 | 193 | - |
| Conductivity (umhos) | 380 | 332 | 356 | - |
| NO3 (mg/L) | 0.06 | 0.022 | 0.041 | 0 |
| NH4 (mg/L) | 0.025 | 1.513 | 0.769 | 3 |
| Org. N. (mg/L) | 0.23 | 0.23 | 0.230 | 0 |
| Sol. Phos (mg/L) | 0.005 | 0.651 | 0.328 | 4 |
| Total Phos (mg/L) | 0.031 | 0.725 | 0.378 | 4 |
| Chlorophyll a (ug/L) | 10.15 | - | 10.15 | - |
| Plankton (#/L) | - | - | 131296 | 15 |
| % Blue-Green Algae | - | - | 20.6 | 0 |

TN

**TOTAL EUTROPHY POINTS** 35

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Sand (Chain o' Lakes) **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 15 **Surface Area (ha)** 19 = 47

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 4.4 | 0 |
| Light Trans. @ 3' (%) | - | - | 62 | 2 |
| 1% Light Level (ft.) | - | - | 21 | - |
| D.O. Saturation @ 5' (%) | - | - | 99 | 0 |
| % Water Col. Oxic | - | - | 43 | 3 |
| pH | 8.4 | 7.5 | 7.95 | - |
| Alkalinity (mg/L) | 157 | 235 | 196 | - |
| Conductivity (umhos) | 387 | 355 | 371 | - |
| NO3 (mg/L) | 0.022 | 0.022 | 0.022 | 0 |
| NH4 (mg/L) | 0.018 | 1.256 | 0.637 | 3 |
| Org. N. (mg/L) | 0.23 | 0.23 | 0.230 | 0 |
| Sol. Phos (mg/L) | 0.003 | 0.422 | 0.213 | 4 |
| Total Phos (mg/L) | 0.032 | 0.474 | 0.253 | 4 |
| Chlorophyll a (ug/L) | 3.08 | - | 3.08 | - |
| Plankton (#/L) | - | - | 17434 | 3 |
| % Blue-Green Algae | - | - | 41.9 | 0 |

TN

**TOTAL EUTROPHY POINTS** 19

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Miller (Chain O') **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 2.2 **Surface Area (ha)** 4.5 = 11.0ac

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 2.2 | 0 |
| Light Trans. @ 3' (%) | - | - | 46 | 3 |
| 1% Light Level (ft.) | - | - | 12 | - |
| D.O. Saturation @ 5' (%) | - | - | 81 | 0 |
| % Water Col. Oxic | - | - | 59 | 2 |
| pH | 8.3 | 7.4 | 7.85 | - |
| Alkalinity (mg/L) | 156 | 216 | 186 | - |
| Conductivity (umhos) | 380 | 328 | 354 | - |
| NO3 (mg/L) | 0.022 | 0.022 | 0.022 | 0 |
| NH4 (mg/L) | 0.018 | 1.532 | 0.775 | 3 |
| Org. N. (mg/L) | 0.23 | 0.23 | 0.230 | 0 |
| Sol. Phos (mg/L) | 0.001 | 0.294 | 0.148 | 3 |
| Total Phos (mg/L) | 0.05 | 0.536 | 0.293 | 4 |
| Chlorophyll a (ug/L) | 8.65 | - | 8.65 | - |
| Plankton (#/L) | - | - | 266715 | 20 |
| % Blue-Green Algae | - | - | 8.1 | 0 |

TN

**TOTAL EUTROPHY POINTS** 35

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Norman **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 11.5 **Surface Area (ha)** 5.7 = 14

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 2.1 | 0 |
| Light Trans. @ 3' (%) | - | - | 45 | 3 |
| 1% Light Level (ft.) | - | - | 13 | - |
| D.O. Saturation @ 5' (%) | - | - | 99 | 0 |
| % Water Col. Oxic | - | - | 39 | 3 |
| pH | 8.1 | 7.4 | 7.75 | - |
| Alkalinity (mg/L) | 149 | 189 | 169 | - |
| Conductivity (umhos) | 370 | 275 | 323 | - |
| TN NO3 (mg/L) | 0.022 | 0.022 | 0.022 | 0 |
| TN NH4 (mg/L) | 0.018 | 1.638 | 0.828 | 3 |
| TN Org. N. (mg/L) | 0.23 | 0.23 | 0.230 | 0 |
| Sol. Phos (mg/L) | 0.003 | 0.558 | 0.281 | 4 |
| Total Phos (mg/L) | 0.037 | 0.643 | 0.340 | 4 |
| Chlorophyll a (ug/L) | 9.3 | - | 9.3 | - |
| Plankton (#/L) | - | - | 94232 | 10 |
| % Blue-Green Algae | - | - | 50.1 | 10 |

**TOTAL EUTROPHY POINTS** 37

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Mud (Chain o Lakes) **County:** Noble

**Date Sampled:** 8/22/94 **Max Depth (m):** 7.9 **Surface Area (ha)** 3.2 = 8 ac

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 2 | 0 |
| Light Trans. @ 3' (%) | - | - | 32 | 3 |
| 1% Light Level (ft.) | - | - | 9.5 | - |
| D.O. Saturation @ 5' (%) | - | - | 37 | 0 |
| % Water Col. Oxic | - | - | 100 | 0 |
| pH | 7.5 | 6.9 | 7.2 | - |
| Alkalinity (mg/L) | 177 | 304 | 240 | - |
| Conductivity (umhos) | 350 | 375 | 363 | - |
| NO3 (mg/L) | 0.022 | 0.022 | 0.022 | 0 |
| NH4 (mg/L) | 0.018 | 7.14 | 3.579 | 4 |
| Org. N. (mg/L) | 0.705 | 1.01 | 0.858 | 2 |
| Sol. Phos (mg/L) | 0 | 1.161 | 0.581 | 4 |
| Total Phos (mg/L) | 0.057 | 0.001 | 0.029 | 0 |
| Chlorophyll a (ug/L) | 17.94 | - | 17.94 | - |
| Plankton (#/L) | - | - | 67130 | 10 |
| % Blue-Green Algae | - | - | 30.5 | 0 |

TN

**TOTAL EUTROPHY POINTS** 23

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Dock **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 6.4 **Surface Area (ha)** 6.5 = 16

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 1.1 | 6 |
| Light Trans. @ 3' (%) | - | - | 26 | 4 |
| 1% Light Level (ft.) | - | - | 9 | - |
| D.O. Saturation @ 5' (%) | - | - | 126 | 2 |
| % Water Col. Oxic | - | - | 70 | 1 |
| pH | 8.8 | 7.4 | 8.1 | - |
| Alkalinity (mg/L) | 178 | 187 | 183 | - |
| Conductivity (umhos) | 420 | 300 | 360 | - |
| NO3 (mg/L) | 0.09 | 0.022 | 0.056 | 0 |
| NH4 (mg/L) | 0.018 | 0.375 | 0.197 | 0 |
| Org. N. (mg/L) | 0.483 | 0.23 | 0.357 | 0 |
| Sol. Phos (mg/L) | 0.003 | 0.107 | 0.055 | 2 |
| Total Phos (mg/L) | 0.067 | 0.193 | 0.130 | 3 |
| Chlorophyll a (ug/L) | 34.63 | - | 34.63 | - |
| Plankton (#/L) | - | - | 119183 | 15 |
| % Blue-Green Algae | - | - | 88.7 | 10 |

TN

TOTAL EUTROPHY POINTS 43

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Bowen **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 17.3 **Surface Area (ha)** 12.1 = 30

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 3.1 | 0 |
| Light Trans. @ 3' (%) | - | - | 60 | 2 |
| 1% Light Level (ft.) | - | - | 17 | - |
| D.O. Saturation @ 5' (%) | - | - | 101 | 0 |
| % Water Col. Oxic | - | - | 38 | 3 |
| pH | 8.6 | 7.4 | 8 | - |
| Alkalinity (mg/L) | 163 | 282 | 222 | - |
| Conductivity (umhos) | 390 | 400 | 395 | - |
| NO3 (mg/L) | 0.04 | 0.022 | 0.031 | 0 |
| NH4 (mg/L) | 0.049 | 3.545 | 1.797 | 4 |
| Org. N. (mg/L) | 0.23 | 2.115 | 1.173 | 3 |
| Sol. Phos (mg/L) | 0 | 1.074 | 0.537 | 4 |
| Total Phos (mg/L) | 0.03 | 0.772 | 0.401 | 4 |
| Chlorophyll a (ug/L) | 3.57 | - | 3.57 | - |
| Plankton (#/L) | - | - | 39347 | 5 |
| % Blue-Green Algae | - | - | 74.9 | 10 |

TN

TOTAL EUTROPHY POINTS 35

# INDIANA CLEAN LAKES PROGRAM

## -LAKE WATER QUALITY ASSESSMENT REPORT-

**Lake Name:** Long (Chain O' Lakes) **County:** Noble

**Date Sampled:** 7/12/94 **Max Depth (m):** 9.8 **Surface Area (ha)** 16.2 = 40

| Parameter | Epilimnion | Hypolimnion | Mean | Eutrophy Points |
|---|---|---|---|---|
| Secchi disk (m) | - | - | 2.4 | 0 |
| Light Trans. @ 3' (%) | - | - | 48 | 3 |
| 1% Light Level (ft.) | - | - | 14 | - |
| D.O. Saturation @ 5' (%) | - | - | 127 | 2 |
| % Water Col. Oxic | - | - | 56 | 2 |
| pH | 8.6 | 7.4 | 8 | - |
| Alkalinity (mg/L) | 185 | 330 | 257 | - |
| Conductivity (umhos) | 453 | 496 | 474 | - |
| NO3 (mg/L) | 0.97 | 0.022 | 0.496 | 2 |
| NH4 (mg/L) | 0.021 | 3.307 | 1.664 | 4 |
| Org. N. (mg/L) | 0.23 | 0.23 | 0.230 | 0 |
| Sol. Phos (mg/L) | 0.003 | 0.302 | 0.153 | 3 |
| Total Phos (mg/L) | 0.025 | 0.599 | 0.312 | 4 |
| Chlorophyll a (ug/L) | 9.88 | - | 9.88 | - |
| Plankton (#/L) | - | - | 23372 | 3 |
| % Blue-Green Algae | - | - | 67.9 | 10 |

TN

**TOTAL EUTROPHY POINTS** 33

# APPENDIX L

## IDNR FISH MANAGEMENT REPORTS AND MEMORANDUM

# Bowen Lake
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Bowen lake is a 30-acre natural lake located within Chain o' Lakes State Park south of Albion. Maximum depth is 65 feet and average depth is 36 feet. The inlet flows from Dock Lake and the outlet flows to Sand Lake. Much of the watershed is wooded although general farming occurs upstream of the park. All of the shoreline is wooded. Public access is available at boat ramps at Dock and Sand lakes. Shoreline fishing is limited.

Water clarity has generally been fair, ranging from 2-9 feet and averaging 5¾ feet (Table 1). Oxygen levels during summer are usually low at depths greater than 10 feet. Records show that high amounts may occur at times at 10 feet and low levels are present to depths of 40 feet or more. The water is moderately fertile (trophic index = 34). Coontail is the most common submerged plant species and it encircles much of the lake. Arrow arum and arrowhead are also abundant around the edge.

The management history of Bowen Lake began with state acquisition. An initial fish population survey was conducted in 1966. Trout were then stocked up through 1971. Another survey was made in 1971 and a water quality ckeck was made in 1972. A 14-inch size limit on largemouth bass was imposed in 1973 and subsequent surveys were conducted in 1975 and 1981.

On July 15-17, 1996, another survey was conducted to obtain current information on the status of the fish community. Sampling effort consisted of 30 minutes of electrofishing, four gill net lifts and four trap net lifts. The results, along with comparisons to previous surveys, are presented in this report.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Bowen Lake from 1966-96.*

| Depth (ft) | 7/66 | 7/71 | 8/72 | 6/75 | 6/81 | 7/96 |
|---|---|---|---|---|---|---|
| 0 | 8.0 | 8.0 | 9.0 | 11.0 | 8.0 | 9.0 |
| 5 | 14.4 | 9.0 | 9.5 | 8.0 | 8.0 | 9.0 |
| 10 | 12.0 | 10.0 | 12.5 | 8.0 | 8.0 | 1.2 |
| 15 | 6.4 | 3.0 | 9.0 | 5.0 | 5.0 | 0.6 |
| 20 | 4.0 | 2.0 | 0.8 | 4.8 | 2.0 | 0.6 |
| 25 | 6.4 | 1.0 | 1.8 | 7.0 | 1.0 | 0.6 |
| 30 | 5.6 | 0.5 | 1.4 | 9.0 | 0.5 | 0.6 |
| 35 | 4.0 | 0.0 | 0.2 | 6.0 | 0.0 | 0.6 |
| 40 | 2.0 | 0.0 | 0.2 | 5.0 | 0.0 | 0.6 |
| Secchi (ft) | 6.0 | 9.0 | 9.0 | 2.0 | 3.5 | 5.0 |

## *SURVEY RESULTS*

During the survey, 1,112 fish weighing 364 pounds were collected. Sixteen species were present. Bluegills dominated the catch by number (69%) andweight (30%). Largemouth bass ranked second by number (11%) and weight (24%). Altogher, sport fish accounted for 96% of the survey catch and 72% of the weight.

The 765 bluegills sampled during the survey were 2-9½ inches long. Although 54% were 4-5 inches long, as many as 23% were 7-inch or larger and 12% were 8-inch or larger. The electrofishing catch rate was average (108/15-min) compared to other lakes in the area. Most (64%) were caught in trap nets. Bluegills weights were better than average. Their growth rate was also above average as age-4 bluegills nearly 7 inches long and age-6 bluegills were nearly 9 inches long.

The 126 largemouth bass collected during the survey measured 4½-21 inches long. However, only eight bass were 14-inch or larger. The majority (62%) were 10-13½ inches long. The electrofishing catch rate (52/15-min) was double the normal catch rate. Bass weights were generally average for all sizes, although some small bass weighed more than usual. Growth was average as age-4 bass were nearly 12 inches long.

Redear ranked third numerically (10%) and were 4½-11 inches long. Their average weight was nearly ⅓ pound. Other sport fish included 35 black crappies up to 11½ inches long, 11 yellow bullheads, 11 warmouth, three yellow perch and two brown bullheads. Nonsport fish included 17 spotted gar up to 34½ inches long, nine white suckers, seven golden shiners, five bowfin, four lake chubsuckers and one carp, spotted sucker and brook silverside.

## *MANAGEMENT IMPLICATIONS*

Few changes have been noted in Bowen Lake's fish community over the past 30 years. Bluegills and bass have consistently been the major sport fish. Redear were releatively important in the 1966 and 1996 catches. Except in 1971 and 1996, crappie catches have been consistently low. Nonsport fish have not been particularly abundant, although more gar were caught in the latest survey.

Bluegills numbers remain high despite relatively high fishing pressure at the park lakes. More bluegills were collected in 1996 than all previous surveys combined. Bluegill size apparently increased slightly after 1971 (Table 3). Mean length increased from 4 inches in 1966 and 3½ inches in 1971 to 5 inches 1981 and 1996. As

Table 2. *Number of fish collected during fish population surveys at Bowen Lake from 1966-96.*

| Species | 1966 | 1971 | 1975 | 1981 | 1996 |
|---|---|---|---|---|---|
| | | | Number | | |
| Bluegills | 152 | 193 | 216 | 171 | 765 |
| Bullheads | 9 | 7 | 1 | 8 | 13 |
| Crappies | 0 | 35 | 3 | 8 | 35 |
| Lm bass | 64 | 50 | 41 | 33 | 126 |
| Redear | 157 | 9 | 12 | 26 | 114 |
| Trout | 0 | 0 | 1 | 0 | 0 |
| Other sunfish | 47 | 85 | 10 | 23 | 11 |
| Bowfin | 2 | 6 | 2 | 4 | 5 |
| Carp | 0 | 0 | 0 | 1 | 1 |
| Chubsuckers | 4 | 37 | 4 | 7 | 4 |
| Gar | 10 | 9 | 3 | 4 | 17 |
| Shiners | 0 | 1 | 1 | 1 | 7 |
| Suckers | 7 | 9 | 5 | 10 | 10 |
| Others | 4 | 8 | 8 | 2 | 4 |

Table 3. *Size of bluegills collected at Bowen Lake from 1966-96.*

| Inches | 1966 | 1971 | 1975 | 1981 | 1996 |
|---|---|---|---|---|---|
| | | | Number | | |
| 1-1½ | 0 | 0 | 1 | 1 | 0 |
| 2-2½ | 7 | 53 | 10 | 2 | 32 |
| 3-3½ | 63 | 44 | 17 | 31 | 55 |
| 4-4½ | 39 | 58 | 32 | 38 | 321 |
| 5-5½ | 10 | 26 | 18 | 35 | 134 |
| 6-6½ | 13 | 4 | 40 | 28 | 49 |
| 7-7½ | 16 | 4 | 60 | 27 | 82 |
| 8-8½ | 4 | 3 | 37 | 8 | 78 |
| 9-9½ | 0 | 1 | 1 | 1 | 14 |
| Total | 152 | 193 | 216 | 171 | 765 |
| Mean | 4.2 | 3.5 | 5.8 | 5.0 | 5.0 |

many as 174 7-inch or larger bluegills were caught in 1996 of which 92 were 8-inch or larger. In 1966, only 20 7-inch or larger bluegills were caught and only four were 8-inch. Whether these differences in bluegill catches simply reflect differences in vulnerability of bluegills to various trap nets used during surveys, variations in year class strength, or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass less than 14 inches long do appear to be more abundant in Bowen Lake than most area lakes.

Based on results of the recent survey, Bowen Lake provide satisfactory fishing for bluegills, largemouth bass and redear. Large bass are scarce however. Crappies occasionally provide additional fishing opportunities. Therefore, no changes in fish management are suggested at this time.

The most serious problem with Bowen Lake, as well as other lakes in the park, is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lake's aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nutrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Submitted by:
Jed Pearson, fisheries biologist
November 20, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 5, 1997

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Bowen Lake | Noble | 7/15-17/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | 2/5/97 |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 4 |
| **Township** | **Nearest town** | |
| 33n | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Through Sand or Dock lakes | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 30 | 65 | 36 | 1,077 | 894.13 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch | Southeast corner | Dock Lake |
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Thumma Ditch | Southwest corner, flows to Sand Lake |

Water level control

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

Bottom type

| | |
|---|---|
| Boulder | |
| Gravel | X |
| Sand | X |
| Muck | X |
| Clay | |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

Fish population surveys,IDNR,1966,1971,1975,1981

Water chemistry,IDNR,1972

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours<br>0.5 | Total hours<br>0.5 |
| TRAPS | Number of traps<br>2 | Days<br>2 | Total lifts<br>4 |
| GILL NETS | Number of nets<br>2 | Days<br>2 | Total lifts<br>4 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color<br>green tea | Turbidity<br>5 Feet 0 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 74.5 | 60 | 41.0 |
| 2 | 74.5 | 62 | |
| 4 | 74.5 | 64 | |
| 6 | 74.0 | 66 | |
| 8 | 70.0 | 68 | |
| 10 | 63.5 | 70 | |
| 12 | 60.5 | 72 | |
| 14 | 47.0 | 74 | |
| 16 | 53.5 | 76 | |
| 18 | 50.5 | 78 | |
| 20 | 48.0 | 80 | |
| 22 | 46.0 | 82 | |
| 24 | 45.0 | 84 | |
| 26 | 43.5 | 86 | |
| 28 | 42.5 | 88 | |
| 30 | 42.0 | 90 | |
| 32 | 42.0 | 92 | |
| 34 | 41.5 | 94 | |
| 36 | 41.5 | 96 | |
| 38 | 41.0 | 98 | |
| 40 | 41.0 | 100 | |
| 42 | 41.0 | Comments | |
| 44 | 41.0 | | |
| 46 | 41.0 | | |
| 48 | 41.0 | | |
| 50 | 41.0 | | |
| 52 | 41.0 | | |
| 54 | 41.0 | | |
| 56 | 41.0 | | |
| 58 | 41.0 | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 9.0 | 137 | |
| 5 | 9.0 | | |
| 10 | 1.2 | | |
| 15 | 0.6 | | |
| 20 | 0.6 | | |
| 25 | 0.6 | | |
| 30 | 0.6 | | |
| 35 | 0.6 | | |
| 40 | 0.6 | | |
| 45 | 0.6 | | |
| 50 | 0.2 | | |
| 55 | 0.2 | | |
| 60 | 0.0 | 257 | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | common |
| Arrowhead | Sagittaria sp. | | common |
| Pickerelweed | Pontederia sp. | | rare |
| Spatterdock | Nuphar sp. | | rare |
| Water lily | Nymphaea sp. | | rare |
| SUBMERGENTS | | | |
| American pondweed | Potamogeton nodasus | 5 | rare |
| Coontail | Ceratophyllum demersum | 5 | common |
| OTHERS | | | |
| Filamentous algae | | | |

Comments

**Relative Abundance and Size of Fish Collected at Bowen Lake**

| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
|---|---|---|---|---|---|
| Bluegill | 765 | 68.8 | 2.0 - 9.4 | 110.13 | 30.3 |
| Largemouth bass | 126 | 11.3 | 4.5 - 20.8 | 86.85 | 23.9 |
| Redear | 114 | 10.3 | 4.4 - 10.8 | 34.01 | 9.3 |
| Black crappie | 35 | 3.1 | 4.3 - 11.7 | 14.68 | 4.0 |
| Spotted gar | 17 | 1.5 | 16.1 - 34.5 | 40.64 | 11.2 |
| Yellow bullhead | 11 | 1.0 | 9.2 - 13.5 | 9.18 | 2.5 |
| Warmouth | 11 | 1.0 | 5.3 - 8.1 | 3.30 | 0.9 |
| White sucker | 9 | 0.8 | 12.5 - 22.5 | 19.76 | 5.4 |
| Golden shiner | 7 | 0.6 | 5.8 - 8.8 | 1.15 | 0.3 |
| Bowfin | 5 | 0.4 | 17.2 - 26.7 | 19.76 | 5.4 |
| Lake chubsucker | 4 | 0.4 | 7.5 - 11.0 | 1.89 | 0.5 |
| Yellow perch | 3 | 0.3 | 7.2 - 9.7 | 0.92 | 0.3 |
| Brown bullhead | 2 | 0.2 | 14.2 - 14.3 | 3.47 | 1.0 |
| Carp | 1 | 0.1 | 31.0 | 16.75 | 4.6 |
| Spotted sucker | 1 | 0.1 | 14.6 | 1.36 | 0.4 |
| Brook silverside | 1 | 0.1 | 1.7 | 0.01 | 0.0 |
| | 1112 | | | 363.86 | |

*Common names of fishes recognized by the American Fisheries Society

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | 3 | 0.4 | 0.01 | 1 | 15.5 | | | | |
| 2.5 | 29 | 3.8 | 0.01 | 1 | 16.0 | | | | |
| 3.0 | 20 | 2.6 | 0.02 | 1 | 16.5 | | | | |
| 3.5 | 35 | 4.6 | 0.03 | 2 | 17.0 | | | | |
| 4.0 | 155 | 20.3 | 0.04 | 2 | 17.5 | | | | |
| 4.5 | 166 | 21.7 | 0.07 | 2 | 18.0 | | | | |
| 5.0 | 95 | 12.4 | 0.09 | 2 | 18.5 | | | | |
| 5.5 | 39 | 5.1 | 0.13 | 2,3 | 19.0 | | | | |
| 6.0 | 31 | 4.1 | 0.18 | 2,3 | 19.5 | | | | |
| 6.5 | 18 | 2.4 | 0.23 | 2,3,4 | 20.0 | | | | |
| 7.0 | 33 | 4.3 | 0.28 | 3,4 | 20.5 | | | | |
| 7.5 | 49 | 6.4 | 0.35 | 3,4 | 21.0 | | | | |
| 8.0 | 61 | 8.0 | 0.40 | 4,5 | 21.5 | | | | |
| 8.5 | 17 | 2.2 | 0.47 | 5 | 22.0 | | | | |
| 9.0 | 12 | 1.6 | 0.59 | 6 | 22.5 | | | | |
| 9.5 | 2 | 0.3 | 0.67 | 6,7 | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 765 | | 110.13 | |
| Electrofishing catch: | | 216 | Gill net catch: | | 59 | Trap net catch: | | 490 | |

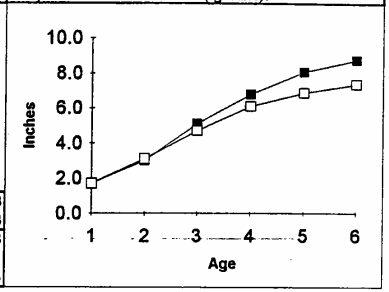
| Number, Percentage, Weight and Age of Largemouth Bass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | 1 | 0.8 | 1.36 | 5 |
| 1.5 | | | | | 15.0 | 2 | 1.6 | 1.68 | 4,5 |
| 2.0 | | | | | 15.5 | | | | |
| 2.5 | | | | | 16.0 | | | | |
| 3.0 | | | | | 16.5 | | | | |
| 3.5 | | | | | 17.0 | | | | |
| 4.0 | | | | | 17.5 | | | | |
| 4.5 | 2 | 1.6 | 0.06 | 1 | 18.0 | 1 | 0.8 | 3.00 | |
| 5.0 | 2 | 1.6 | 0.06 | 1 | 18.5 | | | | |
| 5.5 | 6 | 4.8 | 0.09 | 1 | 19.0 | | | | |
| 6.0 | 2 | 1.6 | 0.12 | 1 | 19.5 | | | | |
| 6.5 | 1 | 0.8 | 0.14 | 1 | 20.0 | 1 | 0.8 | 4.54 | |
| 7.0 | 2 | 1.6 | 0.17 | 2 | 20.5 | | | | |
| 7.5 | 10 | 7.9 | 0.23 | 2 | 21.0 | 1 | 0.8 | 5.40 | |
| 8.0 | 3 | 2.4 | 0.28 | 2 | 21.5 | | | | |
| 8.5 | 6 | 4.8 | 0.30 | 2 | 22.0 | | | | |
| 9.0 | 3 | 2.4 | 0.34 | 2,3 | 22.5 | | | | |
| 9.5 | 3 | 2.4 | 0.41 | 2,3 | 23.0 | | | | |
| 10.0 | 4 | 3.2 | 0.51 | 3 | 23.5 | | | | |
| 10.5 | 21 | 16.7 | 0.57 | 3 | 24.0 | | | | |
| 11.0 | 14 | 11.1 | 0.62 | 3 | 24.5 | | | | |
| 11.5 | 9 | 7.1 | 0.71 | 3,4 | 25.0 | | | | |
| 12.0 | 6 | 4.8 | 0.81 | 3,4 | | | | | |
| 12.5 | 16 | 12.7 | 0.94 | 4,5 | | | | | |
| 13.0 | 5 | 4.0 | 1.09 | 4,5 | | | | | |
| 13.5 | 3 | 2.4 | 1.15 | 4 | | | | | |
| 14.0 | 2 | 1.6 | 1.31 | 4 | Total | 126 | | 86.85 | |
| Electrofishing catch: | | 104 | Gill net catch: | | 19 | Trap net catch: | | 3 | |

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 11 | 1.7 | | | | | |
| | stdev | 0.22 | | | | | |
| 1994 | 30 | 1.7 | 3.2 | | | | |
| | stdev | 0.29 | 0.60 | | | | |
| 1993 | 13 | 1.7 | 3.1 | 5.4 | | | |
| | stdev | 0.29 | 0.42 | 0.68 | | | |
| 1992 | 9 | 1.6 | 3.0 | 4.9 | 6.9 | | |
| | stdev | 0.51 | 0.62 | 1.13 | 0.80 | | |
| 1991 | 8 | 1.6 | 2.8 | 4.7 | 6.6 | 8.0 | |
| | stdev | 0.25 | 0.37 | 0.51 | 0.62 | 0.40 | |
| 1990 | 5 | 1.7 | 3.0 | 5.2 | 6.9 | 8.2 | 8.8 |
| | stdev | 0.11 | 0.25 | 0.57 | 0.03 | 0.34 | 0.13 |
| Mean* | | 1.7 | 3.0 | 5.1 | 6.8 | 8.1 | 8.8 |
| SD | | 0.04 | 0.15 | 0.31 | 0.18 | 0.09 | |
| Count | | 76 | 65 | 35 | 22 | 13 | 5 |

*Bluegill growth at Bowen Lake (dark line) compared to other area lakes (light line).*



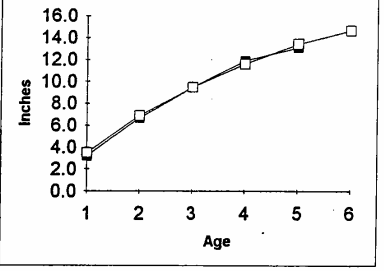

** Age groups with less than three samples not included in year class averages*

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 12 | 3.4 | | | | | |
| | stdev | 0.48 | | | | | |
| 1994 | 19 | 3.1 | 6.6 | | | | |
| | stdev | 0.63 | 0.75 | | | | |
| 1993 | 21 | 3.2 | 6.9 | 9.7 | | | |
| | stdev | 0.66 | 0.93 | 1.01 | | | |
| 1992 | 15 | 3.3 | 6.7 | 9.8 | 12.2 | | |
| | stdev | 0.44 | 0.92 | 0.83 | 0.73 | | |
| 1991 | 5 | 2.9 | 6.5 | 8.9 | 11.6 | 13.1 | |
| | stdev | 0.34 | 1.22 | 2.28 | 1.40 | 1.06 | |
| 1990 | | | | | | | |
| | stdev | | | | | | |
| Mean* | | 3.2 | 6.7 | 9.5 | 11.9 | 13.1 | |
| SD | | 0.18 | 0.17 | 0.47 | 0.44 | | |
| Count | | 72 | 60 | 41 | 20 | 5 | |

*Largemouth bass growth at Bowen Lake (dark line) compared to other area lakes (light line).*

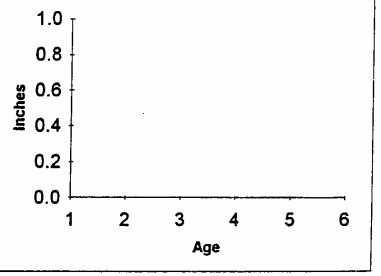



** Age groups with less than three samples not included in year class averages*

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
| SD | | | | | | | |
| Count | | | | | | | |




** Age groups with less than three samples not included in year class averages*

# Dock Lake
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Dock lake is a 16-acre natural lake located within Chain o' Lakes State Park south of Albion. Maximum depth is 22 feet and average depth is 16 feet. Its watershed is approximately 8,000 acres in size and its hydraulic retention time is estimated to be only 12 days. The inlet flows from Long Lake and the outlet flows to Bowen Lake. Much of the watershed is wooded although general farming occurs upstream of Long Lake. All of the shoreline is wooded. Public access is available at a gravel ramp on the south shore. Shoreline fishing is limited.

Water clarity has generally been poor, ranging from less than 1 foot to 6 feet (Table 1). Oxygen levels during summer are low at depths greater than 10 feet. The water is moderately fertile (trophic index = 35). Coontail is the most abundant submerged plant species and encircles much of the lake. Spatterdock and arrow arum are also abundant around the edge.

The management history of Dock Lake began with state acquisition. An initial fish population survey was conducted in 1966. Weed control was conducted in the late 1960s. Another survey was made in 1971 and a 14-inch size limit on largemouth bass was imposed in 1973. Subsequent surveys were conducted in 1975 and 1981.

On July 29-30, 1996, another survey was conducted to obtain current information on the status of the fish community. Sampling effort consisted of 21 minutes of electrofishing, two gill net lifts and two trap net lifts. The results, along with comparisons to previous surveys, are presented in this report.

## *SURVEY RESULTS*

During the survey, 271 fish weighing 163½ pounds were collected. Fourteen species were present. Bluegills dominated the catch by number (35%) and ranked fifth in weight (8%) behind largemouth bass (24%), redear (21%), carp (17%) and spotted gar (15%). Sportfish accounted for 92% on the catch and 62% of the weight.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Dock Lake from 1966-96.*

| Depth (ft) | 7/66 | 7/71 | 6/75 | 6/81 | 7/96 |
|---|---|---|---|---|---|
| 0 | 10.4 | 8.0 | 7.0 | 7.0 | 12.0 |
| 5 | 12.0 | 8.0 | 5.0 | 6.0 | 11.0 |
| 10 | 6.4 | 5.0 | 4.0 | 5.0 | 0.6 |
| 15 | 0.0 | 0.2 | 0.8 | 2.0 | 0.6 |
| 20 | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 |
| Secchi (ft) | 6.0 | 4.5 | 2.0 | 0.7 | 4.5 |

The 96 bluegills sampled during the survey were 2½-9 inches long. As many as 22% were 7-inch or larger. However, only 22 bluegills were captured by electrofishing. Most (70%) were caught in trap nets. Bluegills weights were slightly better than average. Growth of older bluegills was also above average. Age-4 bluegills averaged nearly 7 inches long and age-6 bluegills averaged nearly 8 inches long.

The 44 largemouth bass collected during the survey measured 5-18 inches long. However, only seven bass were 14-inch or larger. The majority (61%) were 10-13½ inches long. The electrofishing catch rate (109/hr) was average. Bass weights among smaller fish were average but larger fish weighed more than normal. Growth was average as age-4 bass were 11¼ inches long and age-6 bass were 13⅛ inches.

Redear ranked second numerically (33%) and were 4½-9½ inches long. Their average weight was over ⅛ pound. Other sport fish included seven black crappies up to 11½ inches long, six yellow bullheads, four warmouth and two brown bullheads.

Nonsport fish included 13 spotted gar up to 31½ inches long, three brook silversides, two golden shiners, two carp ranging from 27-31 inches long, a bowfin, lake chubsucker and spotted sucker.

## *MANAGEMENT IMPLICATIONS*

Few changes have been noted in Dock Lake's fish community over the past 30 years. Bluegills and bass have consistently been the major sport fish. Redear were relatively important in the 1966 and 1996 catches.

Table 2. *Number of fish collected during fish population surveys at Dock Lake from 1966-96.*

| | Number | | | | |
|---|---|---|---|---|---|
| Species | 1966 | 1971 | 1975 | 1981 | 1996 |
| Bluegills | 216 | 64 | 45 | 47 | 96 |
| Bullheads | 8 | 4 | 2 | 22 | 8 |
| Crappies | 0 | 7 | 6 | 9 | 7 |
| Lm bass | 73 | 37 | 17 | 26 | 44 |
| Redear | 135 | 0 | 2 | 7 | 89 |
| Trout | 1 | 1 | 0 | 0 | 0 |
| Other sunfish | 20 | 12 | 2 | 15 | 4 |
| Bowfin | 0 | 1 | 2 | 1 | 1 |
| Carp | 0 | 0 | 7 | 1 | 2 |
| Chubsuckers | 9 | 0 | 4 | 1 | 1 |
| Gar | 1 | 9 | 3 | 2 | 13 |
| Shiners | 9 | 3 | 2 | 2 | 2 |
| Suckers | 8 | 1 | 4 | 9 | 1 |
| Others | 3 | 2 | 1 | 8 | 3 |

Crappie catches have been consistently low. Nonsport fish have never been particularly abundant, although more gar were caught in the latest survey. Trout were formerly stocked in nearby Bowen Lake and apparently some swam into Dock Lake.

Bluegill size apparently increased slightly after 1971 (Table 3). Mean length increased from 4⅜ inches in 1966 to 5¾ inches in 1975 and was 5¼ in 1981 and 1996. As many as 21 7-inch or larger bluegills were caught in 1996 of which eight were 8-inch or larger. In 1966, 23 7-inch or larger bluegills were caught but only one was 8-inch. Whether these differences simply reflect differences in vulnerability of bluegills to various trap nets used during surveys, variations in year class strength, or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass do not appear to be any more abundant in Dock Lake despite greater protection under the limit.

Based on results of the recent survey, Dock Lake provides satisfactory fishing for bluegills, largemouth bass and redear. Bullheads provide some additional fishing opportunities. No changes in fish management are suggested at this time.

Work is underway to replace the existing gravel boat ramp with a concrete ramp and to improve the access area. Shallow depth of the water at the existing ramp makes boat launching difficult especially during high water.

The most serious problem with Dock Lake is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lake's aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nutrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Table 3. *Size of bluegills collected at Dock Lake from 1966-96.*

| | Number | | | | |
|---|---|---|---|---|---|
| Inches | 1966 | 1971 | 1975 | 1981 | 1996 |
| 1-1½ | 0 | 0 | 0 | 0 | 0 |
| 2-2½ | 10 | 1 | 4 | 1 | 1 |
| 3-3½ | 42 | 8 | 5 | 5 | 4 |
| 4-4½ | 60 | 12 | 2 | 11 | 35 |
| 5-5½ | 36 | 22 | 3 | 4 | 19 |
| 6-6½ | 45 | 10 | 13 | 4 | 16 |
| 7-7½ | 22 | 6 | 9 | 7 | 13 |
| 8-8½ | 1 | 5 | 9 | 5 | 7 |
| 9-9½ | 0 | 0 | 0 | 0 | 1 |
| Total | 216 | 64 | 45 | 37 | 96 |
| Mean | 4.6 | 5.1 | 5.8 | 5.2 | 5.2 |

Submitted by:
Jed Pearson, fisheries biologist
November 20, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 10, 1997

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Dock Lake | Noble | 7/29-30/96 |
| Biologist's name | | Date of approval (Month, day, year) |
| Jed pearson | | 2/10/97 |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 9 |
| Township | Nearest town | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Ramp on south shore | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 16 | 22 | 16 | 266 | 894.13 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch | East end | Long Lake |
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Thumma Ditch | North shore to Bowen Lake |

Water level control

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

Fish population surveys,IDNR,1966,1971,1975,1981

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours<br>0.35 | Total hours<br>0.35 |
| TRAPS | Number of traps<br>2 | Days<br>1 | Total lifts<br>2 |
| GILL NETS | Number of nets<br>2 | Days<br>1 | Total lifts<br>2 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color<br>green | Turbidity<br>4 Feet 6 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 77.0 | 60 | |
| 2 | 77.0 | 62 | |
| 4 | 77.0 | 64 | |
| 6 | 76.0 | 66 | |
| 8 | 76.0 | 68 | |
| 10 | 73.0 | 70 | |
| 12 | 69.0 | 72 | |
| 14 | 66.0 | 74 | |
| 16 | 62.0 | 76 | |
| 18 | 59.0 | 78 | |
| 20 | 57.0 | 80 | |
| 22 | 56.0 | 82 | |
| 24 | | 84 | |
| 26 | | 86 | |
| 28 | | 88 | |
| 30 | | 90 | |
| 32 | | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | Comments | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 12.0 | 137 | |
| 5 | 11.0 | | |
| 10 | 0.6 | | |
| 15 | 0.6 | | |
| 20 | 0.0 | 222 | |
| 25 | | | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | abundant |
| Arrowhead | Sagitarria sp. | | common |
| Spatterdock | Nuphar sp. | | abundant |
| Water lily | Nymphaea sp. | | common |
| SUBMERGENTS | | | |
| Coontail | Ceratophyllum demersum | 5 | abundant |
| OTHERS | | | |
| Filamentous algae | | | |

Comments

| Relative Abundance and Size of Fish Collected at Dock Lake | | | | | |
|---|---|---|---|---|---|
| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
| Bluegill | 96 | 35.4 | 2.7 - 9.0 | 13.49 | 8.3 |
| Redear | 89 | 32.8 | 4.7 - 9.7 | 33.96 | 20.8 |
| Largemouth bass | 44 | 16.2 | 5.0 - 17.9 | 39.42 | 24.1 |
| Spotted gar | 13 | 4.8 | 7.0 - 31.7 | 25.82 | 15.8 |
| Black crappie | 7 | 2.6 | 4.9 - 11.5 | 2.41 | 1.5 |
| Yellow bullhead | 6 | 2.2 | 9.4 - 13.4 | 5.28 | 3.2 |
| Warmouth | 4 | 1.5 | 7.8 - 8.7 | 2.09 | 1.3 |
| Brook silverside | 3 | 1.1 | 1.6 - 1.7 | 0.02 | 0.0 |
| Brown bullhead | 2 | 0.7 | 14.3 - 16.9 | 4.53 | 2.8 |
| Golden shiner | 2 | 0.7 | 4.5 - 9.1 | 0.37 | 0.2 |
| Carp | 2 | 0.7 | 27.0 - 30.9 | 28.00 | 17.1 |
| Bowfin | 1 | 0.4 | 25.9 | 6.25 | 3.8 |
| Lake chubsucker | 1 | 0.4 | 9.5 | 0.47 | 0.3 |
| Spotted sucker | 1 | 0.4 | 14.0 | 1.36 | 0.8 |
| | 271 | | | 163.47 | |
| *Common names of fishes recognized by the American Fisheries Society | | | | | |

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | | | | | 15.5 | | | | |
| 2.5 | 1 | 1.0 | 0.01 | 1 | 16.0 | | | | |
| 3.0 | | | | | 16.5 | | | | |
| 3.5 | 4 | 4.2 | 0.03 | 1,2 | 17.0 | | | | |
| 4.0 | 17 | 17.7 | 0.05 | 2 | 17.5 | | | | |
| 4.5 | 18 | 18.8 | 0.05 | 2 | 18.0 | | | | |
| 5.0 | 13 | 13.5 | 0.07 | 2 | 18.5 | | | | |
| 5.5 | 6 | 6.3 | 0.11 | 2 | 19.0 | | | | |
| 6.0 | 11 | 11.5 | 0.16 | 2 | 19.5 | | | | |
| 6.5 | 5 | 5.2 | 0.22 | 2,3 | 20.0 | | | | |
| 7.0 | 6 | 6.3 | 0.28 | 3,4 | 20.5 | | | | |
| 7.5 | 7 | 7.3 | 0.32 | 4,5 | 21.0 | | | | |
| 8.0 | 3 | 3.1 | 0.36 | 4,5 | 21.5 | | | | |
| 8.5 | 4 | 4.2 | 0.41 | 5,6 | 22.0 | | | | |
| 9.0 | 1 | 1.0 | 0.54 | | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 96 | | 13.49 | |
| Electrofishing catch: | | 22 | Gill net catch: | | 7 | Trap net catch: | | 67 | |

# Long Lake
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

*BACKGROUND*

Long Lake is a 40-acre natural lake located in Chain o' Lakes State Park south of Albion. Maximum depth is 32 feet and average depth is 20 feet. It drains 7,860 acres and has an estimated hydraulic retention time of 30 days. The major inlet flows from Summit Lake and other upland areas outside the park and the outlet drains to Dock Lake. A large sediment delta has accumulated at the mouth of the inlet in the lake's south basin (Sucker Lake). Nearly all of the immediate watershed is wooded but general farming occurs upstream. Public access is available at a gravel boat ramp on the west side of the lake. Shore anglers have access to a fishing dock near the park rental cabins and along the shore near the ramp.

Water clarity has generally been poor at Long Lake, ranging from 2-6 feet and averaging 4 feet (Table 1). The lake gets very turbid after heavy rains. At times, adequate amounts of oxygen are present only in the top 5 feet of water. Below 10 feet oxygen levels are less than 3 ppm. The water is moderately fertile (trophix index = 43). Coontail is the most abundant submerged plant, although aquatic plants are not as prevalent in Long Lake as they are in other park lakes. Arrow arum is abundant around much of the shoreline.

The fish management history of Long Lake began with creel surveys in 1959-60. Anglers fished an average of 212 hours per acre each year and caught 15,000 fish, mostly bluegills (84%). An initial fish population survey was conducted in 1971 and a 14-inch minimum size limit was imposed on largemouth bass in 1973. From 1976 through 1980, intensive sampling was conducted to estimate sunfish densities and angler harvest. Population estimates of age-2 and older bluegills varied from 15,000 to 27,000 and anglers removed an average of 5,100 annually. Yearly fishing pressure averaged 214 hours per acre. Estimates of age-2 and older largemouth bass varied from 414 to 1,486. Anglers removed as many as 63% of the adult bluegills and 17% of the adult bass each year. Approximately 20,000 surplus age-1 bluegills were stocked in 1981 and they comprised half of the year class one year later. Two more mark-recapture studies of bass were made in 1987 and 1993. Densities of 8-inch and larger bass were 18 and 17 per acre. Electrofishing catch rates averaged 135 per hour and were 23% above average for similar lakes with a 14-inch bass size limit.

On July 31 to August 2, 1996, another survey was conducted to obtain current information on the status of the fish community. Effort consisted of 45 minutes of electrofishing, four gill net lifts and four trap net lifts.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Long Lake from 1971-96.*

| Depth (ft) | 7/71 | 6/75 | 6/93 | 7/96 |
|---|---|---|---|---|
| 0 | 8.0 | 7.0 | 7.0 | 11.0 |
| 5 | 8.0 | 7.0 | 7.0 | 11.0 |
| 10 | 2.0 | 4.0 | 5.0 | 1.2 |
| 15 | 0.5 | 1.0 | 3.0 | 0.4 |
| 20 | 0.0 | 0.8 | 1.0 | 0.2 |
| 25 | 0.0 | 0.8 | 0.5 | 0.2 |
| 30 | 0.0 | 0.6 | 0.0 | 0.0 |
| Secchi (ft) | 5.5 | 2.0 | 6.0 | 3.0 |

*SURVEY RESULTS*

During the survey, 871 fish weighing 317 pounds were collected. Seventeen species were present. Bluegills dominated the catch by number (53%), followed by redear (42%) and largemouth bass (11%). Bass ranked first in weight (29%), followed by spotted gar (24%) and bluegills (12%). Altogether, sport fish accounted for 90% of the catch and 63% of the weight.

The 464 bluegills sampled during the survey were 2-9 inches long. Most of the bluegills (64%) were 3½-4½ inches long. Only 11% were 7-inch or larger and less than 2% were 8-inch or larger. The electrofishing catch rate was low (73/15-min) compared to other lakes in the area but the trap catch rate was high (55/lift). Bluegill weights were average and their growth rate was also average. Age-4 bluegills were 6½ inches long and age-6 bluegills were 7½ inches.

The 93 largemouth bass collected during the survey were 4½-17½ inches long. Twenty-one were 14-inch or larger. Over half of the bass were 11-13½ inches. Several age-0 bass were also observed. The electrofishing catch rate (28/15-min) was average compared to other lakes. Bass weights and growth were also average. Age-4 bass were 12 inches long and age-6 bass averaged 15½ inches long.

The 122 redear were 4½-10¼ inches long. As many as 42 were 8-inch or larger. Other sport fish included 73 black crappies up to 8¾ inches, 17 yellow bullheads, five warmouth, three brown bullheads, two pumpkinseeds and a 5-inch yellow perch.

Nonsport fish included 36 spotted gar ranging from 13½-31¼ inches long, 20 golden shiners, 10 white suckers up to 21⅛ inches, eight lake chubsuckers, five brook silversides and one bowfin, carp and johnny darter.

Table 2. *Number of fish collected during fish population surveys at Long Lake from 1971-96.*

| | Number | | | |
|---|---|---|---|---|
| Species | 1971 | 1975 | 1993 | 1996 |
| Bluegills | 140 | 137 | 338 | 464 |
| Bullheads | 1 | 6 | 37 | 20 |
| Crappies | 66 | 16 | 27 | 73 |
| Lm bass | 100 | 69 | 206 | 93 |
| Redear | 24 | 26 | 50 | 122 |
| Trout | 1 | 0 | 0 | 0 |
| Yellow perch | 1 | 0 | 11 | 1 |
| Other sunfish | 50 | 21 | 14 | 7 |
| Bowfin | 11 | 3 | 5 | 1 |
| Carp | 1 | 1 | 0 | 1 |
| Chubsuckers | 65 | 8 | 12 | 8 |
| Gar | 5 | 2 | 9 | 36 |
| Shiners | 1 | 1 | 4 | 29 |
| Suckers | 25 | 45 | 23 | 10 |
| Others | 6 | 16 | 5 | 6 |

## *MANAGEMENT IMPLICATIONS*

Based on results of numerous surveys conducted since 1971, few changes have been noted in the fish community at Long Lake over the past 25 years (Table 2). Variations in catches probably reflect differences in sampling gear and effort or minor fluctuations in specific populations.

Bluegills and largemouth bass have consistently been the major sport fish. Redear and crappies have also been important. Bullheads have been present but never accounted for much of the catch. Yellow perch have always been scarce. Nonsport fish, especially carp, have not been particularly abundant, but more gar and golden shiners were caught in the most recent survey.

Except for 1975, the survey results indicate bluegill size has also changed little despite the heavy fishing pressure that Long Lake experiences (Table 3). Fish as large as 9 inches have been sampled during each survey. Mean length in 1971 was similar to mean length in 1993 and 1996. Nearly the same number of 7-inch and larger bluegills were caught in 1975, 1993 and 1996.

In summary, Long Lake still provides satisfactory fishing for bluegills, largemouth bass and redear. Crappies and bullheads provide some additional fishing opportunities. Therefore, no changes in fish management are suggested at this time.

The most serious problem facing Long Lake, as well as other lakes within the park, is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lake's aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nurtrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Table 3. *Size of bluegills collected at Long Lake from 1966-96.*

| | Number | | | |
|---|---|---|---|---|
| Inches | 1971 | 1975 | 1993 | 1996 |
| 1-1½ | 0 | 0 | 5 | 0 |
| 2-2½ | 13 | 6 | 19 | 27 |
| 3-3½ | 41 | 8 | 86 | 72 |
| 4-4½ | 30 | 13 | 109 | 241 |
| 5-5½ | 39 | 39 | 49 | 42 |
| 6-6½ | 10 | 29 | 24 | 36 |
| 7-7½ | 3 | 27 | 26 | 38 |
| 8-8½ | 3 | 11 | 18 | 7 |
| 9-9½ | 1 | 4 | 2 | 1 |
| Total | 140 | 137 | 338 | 464 |
| Mean | 4.1 | 5.6 | 4.4 | 4.3 |

Submitted by:
Jed Pearson, fisheries biologist
November 21, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 11, 1997

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Long Lake | Noble | 7/31-8/2/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | 2/11/97 |

## LOCATION

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 3,10 |
| **Township** | **Nearest town** | |
| 33N | Albion | |

## ACCESSIBILITY

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Ramp on west shore | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 40 | 32 | 19.8 | 632 | 895.8 | 1-2' |

## INLETS

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch (Forker Creek) | Southeast corner | Runoff |
| | | |
| | | |

## OUTLET

| Name | Location |
|---|---|
| Thumma Ditch | West side, flows to Dock Lake |

Water level control

None

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park and general farming

Development of shoreline

Park manager's residence

Previous surveys and investigations

Creel surveys, IDNR,1959-60. Fish surveys,IDNR,1971,1975,1993 (unpublished). Sunfish exploitation, IDNR,1976-1980. Bluegill stocking study,IDNR,1982. Largemouth bass sampling,IDNR,1987,1993.

## SAMPLING EFFORT

| | Day hours | Night hours | Total hours |
|---|---|---|---|
| ELECTROFISHING | | 0.75 | 0.75 |
| TRAPS | Number of traps 2 | Days 2 | Total lifts 4 |
| GILL NETS | Number of nets 2 | Days 2 | Total lifts 4 |

## PHYSICAL AND CHEMICAL CHARACTERISTICS

| Color | Turbidity |
|---|---|
| green | 3 Feet 0 Inches (Secchi disk) |

## TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 75.5 | 60 | |
| 2 | 75.5 | 62 | |
| 4 | 76.0 | 64 | |
| 6 | 76.0 | 66 | |
| 8 | 74.0 | 68 | |
| 10 | 68.0 | 70 | |
| 12 | 63.0 | 72 | |
| 14 | 57.5 | 74 | |
| 16 | 56.0 | 76 | |
| 18 | 55.0 | 78 | |
| 20 | 53.0 | 80 | |
| 22 | 52.0 | 82 | |
| 24 | 51.5 | 84 | |
| 26 | 50.5 | 86 | |
| 28 | 50.0 | 88 | |
| 30 | 50.0 | 90 | |
| 32 | 49.5 | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

Comments

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 11.0 | 171 | |
| 5 | 11.0 | | |
| 10 | 1.2 | | |
| 15 | 0.4 | | |
| 20 | 0.2 | | |
| 25 | 0.2 | | |
| 30 | 0.0 | | |
| 35 | | 257 | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |

Comments

*ppm = parts per million

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | Abundant |
| Cattail | Typha sp. | | Rare |
| Pickerelweed | Pontederia sp. | | Common |
| Spatterdock | Nuphar sp. | | Common |
| Water lily | Nymphaea sp. | | Common |
| SUBMERGENTS | | | |
| Coontail | Ceratophyllum demersum | 6 | Abundant |
| Leafy pondweed | Potamogeton foliosus | 6 | Rare |
| OTHERS | | | |
| Filamentous algae | | | Common |
| Lizard's Tail | Saururus cernuus | shoreline | Common |

Comments

**Relative Abundance and Size of Fish Collected at Long Lake**

| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
|---|---|---|---|---|---|
| Bluegill | 464 | 53.3 | 2.0 - 8.9 | 37.98 | 12.0 |
| Redear | 122 | 14.0 | 4.3 - 10.2 | 34.62 | 10.9 |
| Largemouth bass | 93 | 10.7 | 4.7 - 17.7 | 91.25 | 28.7 |
| Black crappie | 73 | 8.4 | 4.1 - 8.7 | 14.70 | 4.6 |
| Spotted gar | 36 | 4.1 | 13.5 - 31.2 | 75.18 | 23.7 |
| Golden shiner | 29 | 3.3 | 1.6 - 8.8 | 5.66 | 1.8 |
| Yellow bullhead | 17 | 2.0 | 8.9 - 13.3 | 14.91 | 4.7 |
| White sucker | 10 | 1.1 | 9.3 - 21.3 | 19.26 | 6.1 |
| Lake chubsucker | 8 | 0.9 | 7.0 - 11.8 | 4.47 | 1.4 |
| Warmouth | 5 | 0.6 | 2.8 - 6.4 | 0.74 | 0.2 |
| Brook silverside | 5 | 0.6 | 2.1 - 2.3 | 0.01 | 0.0 |
| Brown bullhead | 3 | 0.3 | 10.8 - 16.0 | 4.85 | 1.5 |
| Pumpkinseed | 2 | 0.2 | 5.2 - 6.6 | 0.32 | 0.1 |
| Yellow perch | 1 | 0.1 | 5.0 | 0.05 | 0.0 |
| Bowfin | 1 | 0.1 | 19.6 | 2.88 | 0.9 |
| Carp | 1 | 0.1 | 27.8 | 10.56 | 3.3 |
| Johnny darter | 1 | 0.1 | 1.6 | 0.00 | 0.0 |
| | 871 | | | 317.44 | |

*Common names of fishes recognized by the American Fisheries Society

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | 6 | 1.3 | 0.01 | 1 | 15.5 | | | | |
| 2.5 | 21 | 4.5 | 0.02 | 1 | 16.0 | | | | |
| 3.0 | 15 | 3.2 | 0.02 | 1,2 | 16.5 | | | | |
| 3.5 | 57 | 12.3 | 0.03 | 2 | 17.0 | | | | |
| 4.0 | 144 | 31.0 | 0.04 | 2 | 17.5 | | | | |
| 4.5 | 97 | 20.9 | 0.06 | 2 | 18.0 | | | | |
| 5.0 | 31 | 6.7 | 0.08 | 2,3 | 18.5 | | | | |
| 5.5 | 11 | 2.4 | 0.12 | 2,3 | 19.0 | | | | |
| 6.0 | 22 | 4.7 | 0.17 | 3 | 19.5 | | | | |
| 6.5 | 14 | 3.0 | 0.21 | 3 | 20.0 | | | | |
| 7.0 | 24 | 5.2 | 0.25 | 3,4 | 20.5 | | | | |
| 7.5 | 14 | 3.0 | 0.31 | 4,5 | 21.0 | | | | |
| 8.0 | 7 | 1.5 | 0.37 | 5 | 21.5 | | | | |
| 8.5 | | | | | 22.0 | | | | |
| 9.0 | 1 | 0.2 | 0.50 | 7 | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 464 | | 37.98 | |
| Electrofishing catch: | | 220 | Gill net catch: | | 25 | Trap net catch: | | 219 | |

## Number, Percentage, Weight and Age of Largemouth Bass

| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | | | | | 14.5 | 4 | 4.3 | 1.58 | |
| 1.5 | | | | | 15.0 | 1 | 1.1 | 1.72 | |
| 2.0 | | | | | 15.5 | 1 | 1.1 | 2.04 | |
| 2.5 | | | | | 16.0 | 3 | 3.2 | 2.16 | |
| 3.0 | | | | | 16.5 | 1 | 1.1 | 2.39 | |
| 3.5 | | | | | 17.0 | 1 | 1.1 | 2.43 | |
| 4.0 | | | | | 17.5 | 2 | 2.2 | 2.81 | |
| 4.5 | 1 | 1.1 | 0.04 | | 18.0 | | | | |
| 5.0 | | | | | 18.5 | | | | |
| 5.5 | | | | | 19.0 | | | | |
| 6.0 | 3 | 3.2 | 0.10 | | 19.5 | | | | |
| 6.5 | 1 | 1.1 | 0.14 | | 20.0 | | | | |
| 7.0 | | | | | 20.5 | | | | |
| 7.5 | 4 | 4.3 | 0.21 | | 21.0 | | | | |
| 8.0 | 1 | 1.1 | 0.27 | | 21.5 | | | | |
| 8.5 | 2 | 2.2 | 0.27 | | 22.0 | | | | |
| 9.0 | 2 | 2.2 | 0.34 | | 22.5 | | | | |
| 9.5 | 1 | 1.1 | 0.40 | | 23.0 | | | | |
| 10.0 | 1 | 1.1 | 0.50 | | 23.5 | | | | |
| 10.5 | 4 | 4.3 | 0.57 | | 24.0 | | | | |
| 11.0 | 9 | 9.7 | 0.63 | | 24.5 | | | | |
| 11.5 | 12 | 12.9 | 0.70 | | 25.0 | | | | |
| 12.0 | 3 | 3.2 | 0.82 | | | | | | |
| 12.5 | 6 | 6.5 | 0.94 | | | | | | |
| 13.0 | 11 | 11.8 | 1.05 | | | | | | |
| 13.5 | 11 | 11.8 | 1.22 | | | | | | |
| 14.0 | 8 | 8.6 | 1.39 | | Total | 93 | | 91.25 | |

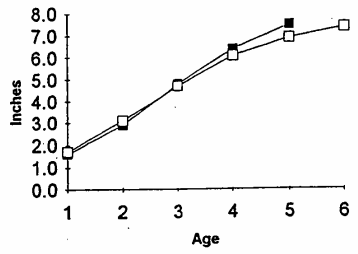
| | | | | | |
|---|---|---|---|---|---|
| Electrofishing catch: | 85 | Gill net catch: | 7 | Trap net catch: | 1 |

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 14 | 1.6 | | | | | |
| | stdev | 0.23 | | | | | |
| 1994 | 25 | 1.7 | 2.9 | | | | |
| | stdev | 0.23 | 0.48 | | | | |
| 1993 | 16 | 1.6 | 3.1 | 5.0 | | | |
| | stdev | 0.26 | 0.38 | 0.67 | | | |
| 1992 | 4 | 1.5 | 2.8 | 4.4 | 6.2 | | |
| | stdev | 0.52 | 0.82 | 1.01 | 0.56 | | |
| 1991 | 9 | 1.8 | 3.0 | 4.9 | 6.6 | 7.5 | |
| | stdev | 0.31 | 0.44 | 0.47 | 0.34 | 0.27 | |
| 1990 | | | | | | | |
| | stdev | | | | | | |
| Mean* | | 1.6 | 2.9 | 4.8 | 6.4 | 7.5 | |
| SD | | 0.13 | 0.13 | 0.28 | 0.28 | | |
| Count | | 68 | 54 | 29 | 13 | 9 | |

*Bluegill growth at Long Lake (dark line) compared to other area lakes (light line).*



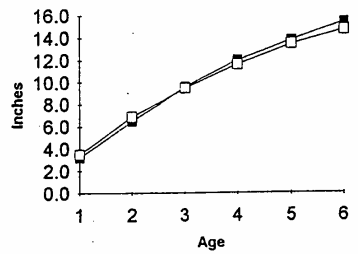

** Age groups with less than three samples not included in year class averages*

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 5 | 3.4 | | | | | |
| | stdev | 0.71 | | | | | |
| 1994 | 9 | 3.0 | 6.6 | | | | |
| | stdev | 0.45 | 0.58 | | | | |
| 1993 | 11 | 2.9 | 6.3 | 9.6 | | | |
| | stdev | 0.47 | 0.68 | 0.65 | | | |
| 1992 | 12 | 3.2 | 6.0 | 8.9 | 11.2 | | |
| | stdev | 0.44 | 0.93 | 0.96 | 0.74 | | |
| 1991 | 18 | 3.1 | 6.5 | 9.4 | 11.8 | 13.0 | |
| | stdev | 0.62 | 0.92 | 0.75 | 0.61 | 0.66 | |
| 1990 | 6 | 3.8 | 7.2 | 10.4 | 12.9 | 14.5 | 15.4 |
| | stdev | 0.79 | 0.57 | 0.92 | 0.96 | 0.88 | 0.75 |
| Mean* | | 3.2 | 6.5 | 9.6 | 12.0 | 13.8 | 15.4 |
| SD | | 0.32 | 0.45 | 0.64 | 0.85 | 1.02 | |
| Count | | 61 | 56 | 47 | 36 | 24 | 6 |

*Largemouth bass growth at Long Lake (dark line) compared to other area lakes (light line).*

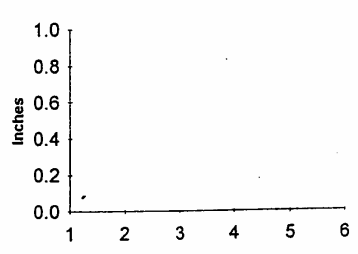



** Age groups with less than three samples not included in year class averages*

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
| SD | | | | | | | |
| Count | | | | | | | |




** Age groups with less than three samples not included in year class averages*

# Mud and Weber lakes
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Mud and Weber lakes are two small interconnected basins located within Chain o' Lakes State Park south of Albion. Mud Lake is listed at 8 acres and Weber Lake is listed at 15 acres. Openwater and wetlands extend so much between the lakes as a result of the dam on Miller Lake that the two basins are virtually one lake. Maximum depth is 30 feet in Weber Lake and 27 feet in Mud Lake. The inlet flows from Sand Lake into Weber Lake and the outlet flows to Rivir Lake from Mud Lake. Much of the watershed is wooded although general farming occurs upstream of the park. All of the shoreline is wooded. Public access is available at boat ramps at Miller and Sand lakes. Shoreline fishing is not available.

Water clarity has generally been poor, ranging from 1½-4½ feet and averaging 3 feet (Table 1). Oxygen levels during summer are usually low. Amounts as low as 3 ppm have been recorded at the surface. Levels this low are stressful to fish and can cause fish kills. No information is available on the fertility of the water but it appears to be high, a characteristic of highly organic wetlands. Coontail is the most abundant submerged plant species and encircles much of the basin. Spatterdock is abundant and lilies are common around the edge and within the area between the basins. Duckweed and filamentous algae cover much of the surface. Duckweed is so profuce that at times it is carried downstream in large quantities to Rivir and Miller lakes. Several flooded trees and fallen logs cover much of the bottom.

The management history of Mud and Weber lakes began with state acquisition. An initial fish survey was conducted at Mud Lake in 1966. Weber Lake was first surveyed in 1967. Weed control was conducted in the late 1960s and a 14-inch size limit on largemouth bass was imposed in 1973. Subsequent surveys at both lakes were conducted in 1975 and 1981.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Mud and Weber lakes from 1975-96.*

| | Mud Lake | | | Weber Lake | | |
|---|---|---|---|---|---|---|
| Depth (ft) | 6/75 | 6/81 | 7/96 | 6/75 | 6/81 | 7/96 |
| 0 | 7.0 | 5.0 | 3.0 | 10.0 | 5.0 | 4.0 |
| 5 | 5.5 | 4.0 | 2.0 | 9.0 | 5.0 | 3.0 |
| 10 | 3.5 | 3.5 | 0.6 | 5.0 | 4.0 | 2.0 |
| 15 | 2.0 | 1.0 | 0.6 | 2.0 | 3.5 | 0.8 |
| 20 | 1.0 | 1.0 | 0.0 | 1.6 | 0.4 | 0.4 |
| 25 | 0.2 | 0.6 | 0.0 | 0.6 | 0.4 | 0.0 |
| Secchi (ft) | 2.5 | 1.5 | 4.5 | 3.0 | 1.5 | 4.5 |

On July 15-17, 1996, another survey was conducted to obtain current information on the status of the fish community in both basins. Total sampling effort consisted of 45 minutes of electrofishing, four gill net lifts and four trap net lifts. Catches in both basins were combined and the results, along with comparisons to previous surveys, are presented in this report.

## *SURVEY RESULTS*

During the survey, 769 fish weighing 340 pounds were collected. Fifteen species were present. Bluegills dominated the catch by number (40%) but ranked fourth in weight (12%) behind spotted gar (26%), redear (22%) and largemouth bass (14%). Redear ranked second by number (27%) and largemouth bass ranked third (11%). Altogether, sport fish accounted for 89% of the survey catch and 61% of the weight.

The 311 bluegills sampled during the survey were 1½-8 inches long. As many as 17% were 7-inch or larger but only 2% were 8-inch. The electrofishing catch rate was low (45/15-min) compared to other lakes in the area. About equal numbers were caught by electrofishing (134) and trap nets (138). Bluegill weights and growth were average. Age-4 bluegills were 5¾ inches long and age-6 bluegills were 7½ inches long.

The 87 largemouth bass collected during the survey measured 3⅛-18 inches long. However, only 13 were 14-inch or larger. Most of them were either age-1 fish (25%) measuring 3⅛-5½ inches or age-2 fish (18%) measuring 6½-8 inches. The electrofishing catch rate (25/15-min) was normal compared to other lakes. Bass weights and growth were also average.

The 209 redear were 2⅛-9¾ inches long. As many as 81 were 8-inch or larger. Their average weight was ⅛ pound. Other sport fish included 36 black crappies up to 12 inches long, 18 warmouth, 15 brown bullheads, eight yellow bullheads and one yellow perch. Nonsport fish included 36 lake chubsuckers, 27 spotted gar ranging from 20-35⅛ inches long, nine bowfin, seven grass pickerel, three brook silversides and a pirate perch.

## *MANAGEMENT IMPLICATIONS*

Except for much greater numbers of fish collected in 1996, few changes have been noted in the fish community at Mud and Weber lakes over the past 30 years. Bluegills and bass have consistently been the major sport fish. Redear have also been relatively important. More crappies were caught during the last two surveys than previously but remain insignificant in the community.

Table 2. *Number of fish collected during fish population surveys at Mud and Weber lakes from 1966-96.*

| | Number | | | | |
|---|---|---|---|---|---|
| Species | 1966 | 1967 | 1975 | 1981 | 1996 |
| Bluegills | 31 | 36 | 47 | 60 | 311 |
| Bullheads | 1 | 0 | 2 | 9 | 23 |
| Crappies | 4 | 1 | 7 | 17 | 36 |
| Lm bass | 7 | 23 | 15 | 12 | 87 |
| Redear | 19 | 9 | 27 | 2 | 209 |
| Other sunfish | 0 | 4 | 8 | 15 | 18 |
| Bowfin | 1 | 3 | 5 | 3 | 9 |
| Carp | 1 | 3 | 1 | 1 | 0 |
| Chubsuckers | 7 | 20 | 6 | 5 | 36 |
| Gar | 2 | 1 | 8 | 15 | 27 |
| Shiners | 4 | 0 | 41 | 37 | 1 |
| Suckers | 1 | 3 | 0 | 0 | 0 |
| Others | 1 | 1 | 2 | 3 | 12 |

Table 3. *Size of bluegills collected at Mud and Weber lakes from 1966-96.*

| | Number | | | | |
|---|---|---|---|---|---|
| Inches | 1966 | 1967 | 1975 | 1981 | 1996 |
| 1-1½ | 0 | 1 | 0 | 0 | 1 |
| 2-2½ | 4 | 12 | 2 | 3 | 23 |
| 3-3½ | 3 | 7 | 7 | 4 | 34 |
| 4-4½ | 14 | 8 | 17 | 5 | 49 |
| 5-5½ | 5 | 4 | 4 | 15 | 91 |
| 6-6½ | 4 | 3 | 6 | 14 | 59 |
| 7-7½ | 1 | 1 | 8 | 15 | 47 |
| 8-8½ | 0 | 0 | 2 | 3 | 7 |
| 9-9½ | 0 | 0 | 1 | 1 | 0 |
| Total | 31 | 36 | 47 | 60 | 311 |
| Mean | 4.2 | 3.4 | 4.9 | 5.6 | 4.9 |

Nonsport fish have not been particularly abundant, although more golden shiners were collected in 1975 and 1981 and more gar and chubsuckers were caught in the latest survey.

Bluegill numbers have been consistently low in Mud and Weber lakes, although many more were collected in 1996 than all previous surveys combined. Mean bluegill size apparently increased slightly since the 1960s and more 7-inch or larger bluegills were collected in the latest survey, despite the heavy fishing pressure that the park lakes normally experience (Table 3). Whether these differences in bluegill catches simply reflect differences in vulnerability of bluegills to the various types of gear used during surveys, variations in year class strength, or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass do not appear to be more abundant in Mud and Weber lakes than most lakes.

Based on results of the recent survey, Mud and Weber lakes continue to provide satisfactory fishing for bluegills, largemouth bass and redear. Large bass are scarce however. Crappies can occasionally provide additional fishing opportunities. Therefore, no changes in fish management are suggested at this time.

Besides the natural limitations in fish habitat due to the shallow depth of the basins, low oxygen levels, dense aquatic plants and their marsh-like condition, the most serious problem with Mud and Weber lakes, as well as other lakes within the park, is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lakes' aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nutrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Submitted by:
Jed Pearson, fisheries biologist
November 20, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 6, 1997

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Mud Lake | Noble | 6/24-26/96 |
| Biologist's name | | Date of approval (Month, day, year) |
| Jed Pearson | | 2/6/97 |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 7,8 |
| Township | Nearest town | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| At Miller and Sand lakes | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 8 | 27 | 8.5 | 68 | 891.52 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch | Eastern corner | Weber Lake |
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Thumma Ditch | Western corner, flows to Rivir Lake |

Water level control

Dam downstream of Miller Lake

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

Fish population surveys,IDNR,1966,1975,1981

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours<br>0.75 | Total hours<br>0.75 |
| TRAPS | Number of traps<br>2 | Days<br>2 | Total lifts<br>4 |
| GILL NETS | Number of nets<br>2 | Days<br>2 | Total lifts<br>4 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color<br>tea | Turbidity<br>4 Feet 6 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 74.0 | 60 | |
| 2 | 74.0 | 62 | |
| 4 | 73.5 | 64 | |
| 6 | 72.0 | 66 | |
| 8 | 66.0 | 68 | |
| 10 | 59.5 | 70 | |
| 12 | 55.0 | 72 | |
| 14 | 51.0 | 74 | |
| 16 | 49.0 | 76 | |
| 18 | 47.0 | 78 | |
| 20 | | 80 | |
| 22 | | 82 | |
| 24 | | 84 | |
| 26 | | 86 | |
| 28 | | 88 | |
| 30 | | 90 | |
| 32 | | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | Comments | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 3.0 | 137 | |
| 5 | 2.0 | | |
| 10 | 0.6 | | |
| 15 | 0.6 | | |
| 20 | 0.0 | 205 | |
| 25 | | | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | Common |
| Cattail | Typha sp. | | Rare |
| Spatterdock | Nuphar sp. | | Abundant |
| Water lily | Nymphaea sp. | | Common |
| SUBMERGENTS | | | |
| Bladderwort | Utricularia sp. | 4 | Rare |
| Coontail | Ceratophyllum demersum | 4 | Abundant |
| Curly-leaf pondweed | Potatmogeton crispus | 4 | Common |
| OTHERS | | | |
| Duckweed | | | Abundant |
| Filamentous algae | | | Abundant |
| Water meal | | | Common |

Comments

# Sand Lake
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Sand Lake is a 47-acre natural lake located in Chain o' Lakes State Park south of Albion. Maximum depth is 51 feet and average depth is 27 feet. It drains 9,536 acres and has an estimated hydraulic retention time of 48 days. The major inlet flows from Bowen Lake and the outlet drains to Weber Lake. A smaller inlet enters the southeast corner of the lake. Nearly all of the immediate watershed is wooded but general farming occurs upstream of the park. Public access is available at a concrete boat ramp on the north shore. The park beach and boat rental area are located on the east end of the lake. Shore anglers have access to a fishing dock on the north shore.

Water clarity has generally been good at Sand Lake, ranging from 2½-12 feet and averaging 7¾ feet (Table 1). Clarity averaged 2¾ feet in June, 7½ feet in July and 10½ in August. Surface oxygen levels range from 6- 13 ppm and average 9½ ppm. Levels at 10 feet vary from 1-13 ppm and average 6¼ ppm. Below 10 feet oxygen levels are usually less than 5 ppm. Despite these low levels, stocked trout are able to survive through much of the summer. The water is moderately fertile (trophix index = 32). Coontail is the most abundant submerged plant species and encircles much of the basin. Arrow arum is abundant around the shoreline.

The fish management history of Sand Lake began with creel surveys in 1959-60 and annual trout stockings in 1963. Anglers fished an average of 107 hours per acre and caught 8,600 fish each year, mostly bluegills (90%). Currently 500 rainbow trout are stocked each spring. Tagging in 1986-87 and 1992 indicated anglers catch 12-33% of the stocked trout. In 1973 a 14-inch minimum size limit was imposed on largemouth bass.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Sand Lake from 1971-96.*

| Depth (ft) | 7/71 | 8/72 | 6/75 | 8/75 | 6/81 | 8/86 | 8/89 | 7/96 |
|---|---|---|---|---|---|---|---|---|
| 0 | 10.0 | 9.0 | 11.0 | 8.2 | 13.0 | 8.0 | 10.0 | 6.0 |
| 5 | 8.0 | 8.0 | 7.0 | 8.0 | 8.0 | 8.0 | 9.5 | 6.0 |
| 10 | 8.0 | 13.0 | 4.0 | 8.0 | 3.0 | 1.0 | 10.5 | 2.5 |
| 15 | 3.0 | 9.0 | 3.0 | 9.6 | 3.0 | 0.4 | 8.5 | 0.4 |
| 20 | 1.0 | 0.6 | 5.0 | 0.8 | 1.0 | 0.0 | 2.0 | 0.4 |
| 25 | 1.0 | 0.4 | 5.0 | 0.4 | 0.5 | 0.0 | 2.0 | 0.4 |
| 30 | 1.0 | 0.4 | 5.0 | 0.4 | 0.5 | 0.0 | 1.5 | 2.5 |
| 35 | 0.4 | | 7.0 | 0.4 | 0.5 | 0.0 | 1.5 | 3.0 |
| 40 | 0.8 | 0.2 | 5.6 | 0.4 | 0.0 | 0.0 | 0.5 | 0.4 |
| 45 | 0.0 | | 4.6 | 0.4 | 0.0 | 0.0 | 0.2 | 0.4 |
| 50 | 0.0 | 0.0 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Secchi (ft) | 9.0 | 10.0 | 3.0 | 11.0 | 2.5 | 9.0 | 12.0 | 6.0 |

Fish population surveys and various water quality checks have been conducted at Sand Lake on numerous occasions. The initial survey was conducted in July 1966. Followup surveys were done in 1971, 1975, 1981 and 1993. In a mark-recapture study in 1993, it was estimated that Sand Lake contained 761 largemouth bass 8-inches or larger. The electrofishing catch rate was low (69/hr), 37% below average for similar lakes with a 14-inch bass size limit. On July 22-24, 1996, another survey was conducted to obtain current information on the status of the fish community. Effort consisted of 44 minutes of electrofishing, four gill net lifts and four trap net lifts.

## *SURVEY RESULTS*

During the survey, 1,074 fish weighing 373 pounds were collected. Seventeen species were present. Bluegills dominated the catch by number (61%), followed by redear (12%) and largemouth bass (11%). Bass ranked first in weight (26%), followed by bluegills (23%) and spotted gar (15%). Altogether, sport fish accounted for 93% of the catch and 68% of the weight.

The 654 bluegills sampled during the survey were 2-9 inches long. Most of the bluegills (41%) were 4-5 inches long. As many as 20% were 7-inch or larger and 6% were 8-inch or larger. The electrofishing catch rate was low (71/15-min) compared to other lakes in the area but the trap catch rate was high (97/lift). Bluegill weights were average for small fish, above average for fish 5-7½ inches long, and average for larger fish. Their growth rate was also average up to age-4 (6.4 in) and above average at age-6 (8.4 in).

The 119 largemouth bass collected during the survey were 4½-21 inches long. Fifteen were 14-inch or larger. Half of the bass were 10-13½ inches. Several age-0 bass were observed but not collected. The electrofishing catch rate (36/15-min) was average compared to other lakes. Bass weights and growth were also average. Age-4 bass averaged nearly 12 inches long and age-6 bass were 14½ inches long.

The 130 redear were 2½-9½ inches long. Most of them were 5-6 inches long but 16 were 8-inch or larger. Other sport fish included 41 black crappies up to 10¼ inches long, 18 yellow bullheads, 16 warmouth, six yellow perch, six brown bullheads, two pumpkinseeds and two 13-inch rainbow trout.

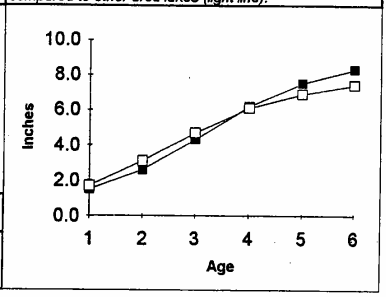
Nonsport fish included 27 spotted gar up to 32 inches long, 19 lake chubsuckers, 13 white suckers, six brook silversides, five golden shiners, 5 grass pickerel and five bowfin.

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 13 | 1.5 | | | | | |
| | stdev | 0.25 | | | | | |
| 1994 | 23 | 1.5 | 2.7 | | | | |
| | stdev | 0.26 | 0.56 | | | | |
| 1993 | 15 | 1.3 | 2.5 | 4.3 | | | |
| | stdev | 0.14 | 0.30 | 0.37 | | | |
| 1992 | 11 | 1.3 | 2.2 | 3.6 | 5.6 | | |
| | stdev | 0.17 | 0.26 | 0.46 | 0.39 | | |
| 1991 | 15 | 1.6 | 2.8 | 4.5 | 6.3 | 7.2 | |
| | stdev | 0.16 | 0.60 | 0.80 | 0.72 | 0.41 | |
| 1990 | 4 | 1.6 | 2.9 | 4.7 | 6.7 | 7.7 | 8.3 |
| | stdev | 0.41 | 0.44 | 0.36 | 0.63 | 0.42 | 0.22 |
| Mean* | | 1.5 | 2.6 | 4.3 | 6.2 | 7.5 | 8.3 |
| SD | | 0.12 | 0.26 | 0.45 | 0.57 | 0.32 | |
| Count | | 81 | 68 | 45 | 30 | 19 | 4 |

*Bluegill growth at Rivir/Miller Lakes(dark line) compared to other area lakes (light line).*



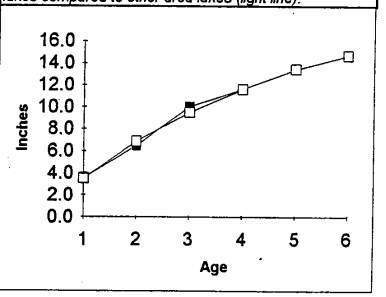

** Age groups with less than three samples not included in year class averages*

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 10 | 4.0 | | | | | |
| | stdev | 0.55 | | | | | |
| 1994 | 7 | 3.1 | 5.7 | | | | |
| | stdev | 0.21 | 2.18 | | | | |
| 1993 | 1 | 3.9 | 6.9 | 10.0 | | | |
| | stdev | 0.00 | 0.00 | 0.00 | | | |
| 1992 | 7 | 3.8 | 7.2 | 10.0 | 11.6 | | |
| | stdev | 0.44 | 1.15 | 0.94 | 0.73 | | |
| 1991 | 2 | 3.8 | 6.2 | 9.1 | 10.6 | 12.0 | |
| | stdev | 0.17 | 0.02 | 0.76 | 0.37 | 0.40 | |
| 1990 | | | | | | | |
| | stdev | | | | | | |
| Mean* | | 3.6 | 6.5 | 10.0 | 11.6 | | |
| SD | | 0.49 | 1.06 | | | | |
| Count | | 24 | 14 | 7 | 7 | | |

*Largemouth bass growth at Rivir/Miller (dark line) lakes compared to other area lakes (light line).*

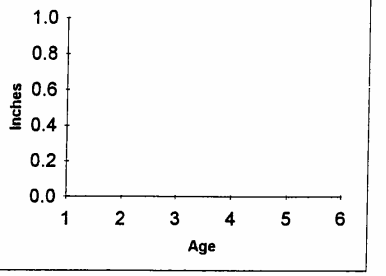



** Age groups with less than three samples not included in year class averages*

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
| SD | | | | | | | |
| Count | | | | | | | |




** Age groups with less than three samples not included in year class averages*

| Number, Percentage, Weight and Age of Largemouth Bass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | | | | | 15.5 | | | | |
| 2.5 | | | | | 16.0 | | | | |
| 3.0 | | | | | 16.5 | 1 | 3.3 | 2.34 | 5 |
| 3.5 | | | | | 17.0 | 1 | 3.3 | 2.37 | 6 |
| 4.0 | 1 | 3.3 | 0.04 | 1 | 17.5 | | | | |
| 4.5 | 3 | 10.0 | 0.03 | 1 | 18.0 | | | | |
| 5.0 | 3 | 10.0 | 0.05 | 1 | 18.5 | | | | |
| 5.5 | 3 | 10.0 | 0.07 | 1 | 19.0 | | | | |
| 6.0 | 1 | 3.3 | 0.08 | 1 | 19.5 | | | | |
| 6.5 | | | | | 20.0 | | | | |
| 7.0 | 2 | 6.7 | 0.15 | 2 | 20.5 | | | | |
| 7.5 | 5 | 16.7 | 0.17 | 2 | 21.0 | | | | |
| 8.0 | | | | | 21.5 | | | | |
| 8.5 | | | | | 22.0 | | | | |
| 9.0 | | | | | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | 1 | 3.3 | 0.47 | 3 | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | 3 | 10.0 | 0.78 | 4,5 | | | | | |
| 12.5 | 5 | 16.7 | 0.91 | 4,5 | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | 1 | 3.3 | 1.08 | 4 | | | | | |
| 14.0 | | | | | Total | 30 | | 14.87 | |

| Electrofishing catch: | 21 | Gill net catch: | 1 | Trap net catch: | 8 |
|---|---|---|---|---|---|

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | 3 | 0.5 | 0.01 | 1 | 15.0 | | | | |
| 2.0 | 10 | 1.6 | 0.01 | 1 | 15.5 | | | | |
| 2.5 | 18 | 2.8 | 0.01 | 1 | 16.0 | | | | |
| 3.0 | 13 | 2.1 | 0.02 | 1,2 | 16.5 | | | | |
| 3.5 | 53 | 8.4 | 0.03 | 2 | 17.0 | | | | |
| 4.0 | 47 | 7.4 | 0.04 | 2 | 17.5 | | | | |
| 4.5 | 46 | 7.3 | 0.06 | 2,3 | 18.0 | | | | |
| 5.0 | 37 | 5.8 | 0.08 | 2,3 | 18.5 | | | | |
| 5.5 | 40 | 6.3 | 0.12 | 3 | 19.0 | | | | |
| 6.0 | 52 | 8.2 | 0.17 | 3,4 | 19.5 | | | | |
| 6.5 | 58 | 9.2 | 0.20 | 4 | 20.0 | | | | |
| 7.0 | 101 | 16.0 | 0.26 | 4,5 | 20.5 | | | | |
| 7.5 | 102 | 16.1 | 0.30 | 5 | 21.0 | | | | |
| 8.0 | 36 | 5.7 | 0.38 | 5 | 21.5 | | | | |
| 8.5 | 15 | 2.4 | 0.44 | 6,7 | 22.0 | | | | |
| 9.0 | 2 | 0.3 | 0.48 | 7 | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 633 | | 113.10 | |
| Electrofishing catch: | | 77 | Gill net catch: | | 86 | Trap net catch: | | 470 | |

| Relative Abundance and Size of Fish Collected at Rivir and Miller Lakes | | | | | |
|---|---|---|---|---|---|
| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
| Bluegill | 633 | 65.7 | 1.6 - 8.9 | 113.10 | 32.2 |
| Redear | 141 | 14.6 | 2.2 - 9.6 | 30.11 | 8.6 |
| Lake chubsucker | 33 | 3.4 | 7.5 - 11.3 | 13.71 | 3.9 |
| Largemouth bass | 30 | 3.1 | 4.1 - 17.2 | 14.87 | 4.2 |
| Spotted gar | 30 | 3.1 | 2.7 - 34.7 | 98.76 | 28.1 |
| Black crappie | 27 | 2.8 | 3.1 - 9.6 | 4.71 | 1.3 |
| Yellow bullhead | 22 | 2.3 | 9.7 - 13.4 | 20.29 | 5.8 |
| Warmouth | 17 | 1.8 | 2.1 - 8.1 | 2.83 | 0.8 |
| Brown bullhead | 14 | 1.5 | 6.8 - 15.8 | 18.08 | 5.1 |
| Golden shiner | 5 | 0.5 | 8.2 - 9.0 | 1.49 | 0.4 |
| Brook silverside | 4 | 0.4 | 2.8 - 3.9 | 0.02 | 0.0 |
| Bowfin | 3 | 0.3 | 26.1 - 27.8 | 23.50 | 6.7 |
| Spotted sucker | 2 | 0.2 | 14.2 - 15.0 | 2.93 | 0.8 |
| White sucker | 1 | 0.1 | 11.4 | 0.62 | 0.2 |
| Channel catfish | 1 | 0.1 | 23.4 | 6.50 | 1.8 |
| | 963 | | | 351.52 | |

*Common names of fishes recognized by the American Fisheries Society

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours | Total hours<br>see Rivir Lake report - 1996 |
| TRAPS | Number of traps<br>1 | Days<br>2 | Total lifts<br>2 |
| GILL NETS | Number of nets<br>1 | Days<br>2 | Total lifts<br>2 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS AT MILLER LAKE | |
|---|---|
| Color<br>blue-green | Turbidity<br>4 Feet 0 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 73.0 | 60 | |
| 2 | 73.0 | 62 | |
| 4 | 74.0 | 64 | |
| 6 | 74.0 | 66 | |
| 8 | 74.0 | 68 | |
| 10 | 74.0 | 70 | |
| 12 | 73.0 | 72 | |
| 14 | 72.0 | 74 | |
| 16 | 68.0 | 76 | |
| 18 | 65.0 | 78 | |
| 20 | 61.0 | 80 | |
| 22 | 56.0 | 82 | |
| 24 | 54.0 | 84 | |
| 26 | 52.0 | 86 | |
| 28 | 51.0 | 88 | |
| 30 | | 90 | |
| 32 | | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | Comments | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 7.0 | 137 | |
| 5 | 7.0 | | |
| 10 | 4.0 | | |
| 15 | 0.6 | | |
| 20 | 0.4 | | |
| 25 | 0.0 | 222 | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: Re-survey: X | (Fish collections combined with Rivir Lake) |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Miller Lake | Noble | 7/8-10/96 |
| Biologist's name | | Date of approval (Month, day, year) |
| Jed Pearson | | |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 7 |
| Township | Nearest town | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Located on north shore | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 11 | 27 | 14 | 157 | 891.36 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch (Forker Ck) | East end | Rivir Lake |
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Forker Creek | West end, flows to Muncie Lake |

Water level control

Concrete dam on Forker Creek

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | X |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

Fish population surveys, IDNR,1966,1968,1971,1975,1981.

Northern pike sampling, IDNR,1984

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Cattail | Typha sp. | 2 | rare |
| Spatterdock | Nuphar sp. | 6 | common |
| Water lily | Nymphaea sp. | 6 | rare |
| SUBMERGENTS | | | |
| Coontail | Ceratophyllum demersum | 6 | abundant |
| OTHERS | | | |
| Duckweed | Lemna sp. | surface | abundant |
| Filamentous algae | | | abundant |

Comments

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours<br>0.56 | Total hours<br>0.56 |
| TRAPS | Number of traps<br>2 | Days<br>2 | Total lifts<br>4 |
| GILL NETS | Number of nets<br>3 | Days<br>1 | Total lifts<br>3 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color<br>blue-green | Turbidity<br>3 Feet 8 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 77.5 | 60 | |
| 2 | 77.0 | 62 | |
| 4 | 77.0 | 64 | |
| 6 | 77.0 | 66 | |
| 8 | 76.0 | 68 | |
| 10 | 74.5 | 70 | |
| 12 | 72.0 | 72 | |
| 14 | 67.0 | 74 | |
| 16 | 63.0 | 76 | |
| 18 | 57.5 | 78 | |
| 20 | 54.0 | 80 | |
| 22 | 51.0 | 82 | |
| 24 | 49.5 | 84 | |
| 26 | 48.0 | 86 | |
| 28 | 47.5 | 88 | |
| 30 | 46.0 | 90 | |
| 32 | 45.5 | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

Comments

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 8.0 | 154 | |
| 5 | 8.0 | | |
| 10 | 1.0 | | |
| 15 | 4.0 | | |
| 20 | 2.0 | | |
| 25 | 0.0 | | |
| 30 | 0.0 | 239 | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |

Comments

*ppm = parts per million

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Rivir Lake | Noble | 7/8-10/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | 2/4/97 |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 7 |
| **Township** | **Nearest town** | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Through Miller Lake | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 24 | 33 | 16 | 380 | 891.44 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch | Northeast corner | From Mud Lake |
| Unnamed | Southeast corner | Runoff |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Thumma Ditch | West to Miller Lake |

Water level control

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | X |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park and general farming

Development of shoreline

Natural shoreline. A canoe campground is located in the northeast corner.

Previous surveys and investigations

Fish population surveys,IDNR,1966,1968,1971,1975,1981

Table 2. *Number of fish collected during fish population surveys at Rivir and Miller lakes from 1966-96.*

| | Number | | | | | |
|---|---|---|---|---|---|---|
| Species | 1966 | 1968 | 1971 | 1975 | 1981 | 1996 |
| Bluegills | 540 | 362 | 338 | 139 | 258 | 633 |
| Bullheads | 28 | 24 | 31 | 2 | 34 | 36 |
| Crappies | 2 | 13 | 6 | 17 | 10 | 27 |
| Lm bass | 56 | 25 | 135 | 19 | 21 | 30 |
| Northern pike | 0 | 0 | 1 | 0 | 9 | 0 |
| Redear | 186 | 69 | 49 | 15 | 28 | 141 |
| Trout | 0 | 0 | 0 | 3 | 1 | 0 |
| Other sunfish | 55 | 37 | 51 | 5 | 58 | 17 |
| Bowfin | 2 | 11 | 6 | 1 | 1 | 3 |
| Carp | 1 | 0 | 2 | 0 | 0 | 0 |
| Chubsuckers | 18 | 17 | 12 | 9 | 25 | 33 |
| Gar | 10 | 16 | 21 | 6 | 17 | 30 |
| Shiners | 3 | 0 | 6 | 23 | 20 | 5 |
| Suckers | 32 | 16 | 0 | 1 | 4 | 3 |
| Others | 9 | 5 | 2 | 2 | 3 | 5 |

## *MANAGEMENT IMPLICATIONS*

Based on results of several surveys conducted since 1966, few changes have been noted in the fish community at Rivir and Miller lakes over the past 30 years (Table 2). Bluegills, largemouth bass and redear have been the major sport fish. Crappies and bullheads have also been present. Nine northern pike were collected in 1981 after the stocking program began but none were caught in 1996. A few trout that were annually stocked in Sand Lake were also caught in 1975 and 1981. Nonsport fish, especially carp, have not been particularly abundant, but more suckers were collected in earlier surveys and more shiners were caught in 1975 and 1981.

Electrofishing bluegills has generally been difficult at Rivir and Miller lakes. Turbid conditions in June 1975 and 1981 and the dense bed of coontail around the shore limited sampling effectiveness. However, survey results indicate that bluegill size has increased and that more larger bluegills may now be present despite the heavy fishing pressure that the park lakes normally experience (Table 3). Few 8-inch or larger bluegills were collected from 1966-71. The catch of 8-inch bluegills increased in 1975-81 and was greatest in 1966. Many more 7-inch bluegills were also caught in 1966. Mean bluegill size has also been about 1 inch larger from 1975-96 than 1966-71. Whether these differences in bluegill atche simply reflect differences in vulnerability of bluegills to the various types of gear used during surveys, variations in year class strength, or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass do not appear to be any more abundant in Rivir and Miller lakes than most lakes. Furthermore, the dense beds of coontail apparently do not prevent bass and other predators from controlling bluegill recruitment. Bluegill growth is good and large fish are present.

Based on results of the latest survey, Rivir and Miller lakes continue to provide satisfactory fishing for bluegills, largemouth bass and redear. Large bass are scarce however. Crappies and bullheads can provide additional fishing opportunities. Therefore, no changes in fish management are suggested at this time.

The most serious problem with Rivir and Miller lakes, as well as other lakes within the park, is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lakes' aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nutrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Submitted by:
Jed Pearson, fisheries biologist
November 20, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 4, 1997

Table 3. *Size of bluegills collected at Rivir and Miller lakes from 1966-96.*

| | Number | | | | | |
|---|---|---|---|---|---|---|
| Inches | 1966 | 1968 | 1971 | 1975 | 1981 | 1996 |
| 1-1½ | 0 | 0 | 0 | 1 | 0 | 3 |
| 2-2½ | 18 | 10 | 11 | 4 | 6 | 28 |
| 3-3½ | 169 | 66 | 22 | 20 | 10 | 66 |
| 4-4½ | 79 | 59 | 67 | 21 | 20 | 93 |
| 5-5½ | 133 | 55 | 83 | 11 | 45 | 77 |
| 6-6½ | 90 | 99 | 75 | 33 | 52 | 110 |
| 7-7½ | 51 | 68 | 64 | 23 | 96 | 203 |
| 8-8½ | 0 | 5 | 16 | 16 | 24 | 51 |
| 9-9½ | 0 | 0 | 0 | 10 | 5 | 2 |
| Total | 540 | 362 | 338 | 139 | 258 | 633 |
| Mean | 4.5 | 5.1 | 5.3 | 5.7 | 6.1 | 5.6 |

# Rivir and Miller lakes
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Rivir and Miller lakes are two small interconnected basins located within Chain o' Lakes State Park south of Albion. Rivir Lake contains 24 acres and Miller contains 11 acres. The basins are connected by a short channel and as a result of a dam on Miller Lake are virtually one lake. Maximum depth is 33 feet in Rivir Lake and 27 feet in Miller Lake. The inlet flows from Mud Lake into Rivir Lake and the outlet flows outside the park to Muncie Lake. Nearly all of the immediate watershed is wooded but general farming occurs upstream of the park. All of the shoreline is wooded. Public access is available at a boat ramp on the north shore of Miller Lake. Shoreline fishing is not available, although anglers sometimes fish near the dam along State Road 9.

Water clarity has generally been fair, ranging from 1 foot in Rivir Lake in 1981 to 9 feet in Miller Lake in 1968 (Table 1). Average clarity is 3¾ feet in Rivir Lake and 4¾ feet in Miller Lake. Ample amounts of oxygen are present to depths of 10 feet during summer and drop to low levels at 15 feet. Rivir Lake is moderately fertile (trophix index = 32). Coontail is the most abundant submerged plant species and encircles much of the basin. Dense mats of algae often develop on top of the coontail. Spatterdock is common around the edge. Duckweed is regularly washed down from Mud and Weber lakes and covers much of the surface area of both lakes.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Rivir and Miller lakes from 1966-96.*

| | | | Rivir Lake | | | |
|---|---|---|---|---|---|---|
| Depth (ft) | 7/66 | 7/68 | 7/71 | 6/75 | 6/81 | 7/96 |
| 0 | 10.4 | 7.4 | 8.0 | 10.0 | 6.0 | 8.0 |
| 5 | 8.0 | 7.2 | 8.0 | 7.5 | 6.0 | 8.0 |
| 10 | 10.4 | 1.0 | 2.8 | 5.0 | 5.0 | 1.0 |
| 15 | 1.6 | 0.4 | 0.4 | 4.0 | 5.0 | 4.0 |
| 20 | 0.8 | 0.0 | 0.0 | 1.0 | 4.0 | 2.0 |
| 25 | 0.0 | 0.0 | 0.0 | 0.6 | 1.0 | 0.0 |
| 30 | | 0.0 | 0.0 | 0.2 | 0.5 | 0.0 |
| Secchi (ft) | 5.3 | 5.0 | 5.0 | 2.5 | 1.0 | 3.8 |
| | | | Miller Lake | | | |
| Depth (ft) | 7/66 | 7/68 | 7/71 | 6/75 | 6/81 | 7/96 |
| 0 | 12.0 | 8.2 | 7.0 | 9.0 | 6.0 | 7.0 |
| 5 | 13.6 | 1.6 | 7.0 | 8.0 | 5.0 | 7.0 |
| 10 | 10.4 | 1.0 | 4.0 | 7.0 | 5.0 | 4.0 |
| 15 | 4.0 | 1.0 | 1.4 | 5.0 | 5.0 | 0.6 |
| 20 | 0.8 | 0.0 | 0.0 | 1.0 | 5.0 | 0.4 |
| 25 | 0.0 | | 0.0 | 0.8 | 3.5 | 0.0 |
| Secchi (ft) | 6.8 | 9.0 | 5.5 | 2.5 | 1.5 | 4.0 |

The management history of Rivir and Miller lakes began with state acquisition. An initial fish survey was conducted at both lakes in 1966. Weed control was conducted in the late 1960s and a 14-inch size limit on largemouth bass was imposed in 1973. Subsequent surveys at both lakes were conducted in 1975 and 1981. Miller Lake was stocked with 154 northern pike in 1979 and 175 pike in 1980 to increase pike abundance in the park lakes. Three were later caught in gill nets in 1984 in Miller Lake and two were caught in Rivir Lake. No progeny of stocked pike were found.

On July 15-17, 1996, another survey was conducted to obtain current information on the status of the fish community in both basins. Total sampling effort consisted of 34 minutes of electrofishing, four gill net lifts and four trap net lifts. Catches in both basins were combined and presented in this report.

## *SURVEY RESULTS*

During the survey, 963 fish weighing 351½ pounds were collected. Fifteen species were present. Bluegills dominated the catch by number (66%) and weight (32%). Redear ranked second in number (15%) and third in weight (9%). Largemouth bass made up only 3% of the catch by number and 4% by weight. Spotted gar were second in weight (28%). Altogether, sport fish accounted for 92% of the catch and 60% of the weight.

The 633 bluegills sampled during the survey were 1½-9 inches long. As many as 40% were 7-inch or larger. The electrofishing catch rate was very low (34/15-min) compared to other lakes in the area but the trap catch rate was high (78/lift). Bluegill weights were average. Their growt rate was also average up to age-4 (6 2 in) and above average at age-6 (8.3 in).

The 30 largemouth bass collected during the survey were 4-17¼ inches long. Only two were 14-inch or larger. Many were age-1 fish (37%) or age-2 fish (23%). Several age-0 bass were observed but not collected. The electrofishing catch rate (9/15-min) was also very low compared to other lakes. Bass weights and growth were also average.

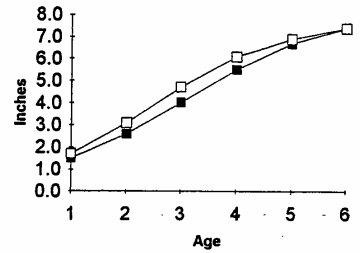
The 141 redear were 2¼-9½ inches long. Most of them were 4-6 inches long but 23 were 8-inch or larger. Other sport fish included 27 black crappies up to 9½ inches long, 22 yellow bullheads, 17 warmouth, 14 brown bullheads, and a 23½-inch channel catfish. Non-sport fish included 33 lake chubsuckers, 30 spotted gar up to 37½ inches long, golden shiners, brook silversides, bowfin, two spotted suckers and a white sucker.

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 2 | 1.4 | | | | | |
| | stdev | 0.01 | | | | | |
| 1994 | 12 | 1.4 | 2.6 | | | | |
| | stdev | 0.16 | 0.49 | | | | |
| 1993 | 5 | 1.4 | 2.3 | 3.8 | | | |
| | stdev | 0.23 | 0.38 | 0.68 | | | |
| 1992 | 9 | 1.6 | 2.7 | 3.7 | 5.2 | | |
| | stdev | 0.22 | 0.26 | 0.28 | 0.47 | | |
| 1991 | 18 | 1.5 | 2.7 | 4.1 | 5.4 | 6.6 | |
| | stdev | 0.29 | 0.63 | 0.84 | 0.82 | 0.63 | |
| 1990 | 7 | 1.4 | 2.6 | 4.3 | 5.9 | 6.8 | 7.4 |
| | stdev | 0.10 | 0.20 | 0.33 | 0.61 | 0.63 | 0.61 |
| Mean* | | 1.5 | 2.6 | 4.0 | 5.5 | 6.7 | 7.4 |
| SD | | 0.09 | 0.15 | 0.26 | 0.35 | 0.20 | |
| Count | | 51 | 51 | 39 | 34 | 25 | 7 |

*Bluegill growth at Norman Lake (dark line) compared to other area lakes (light line).*



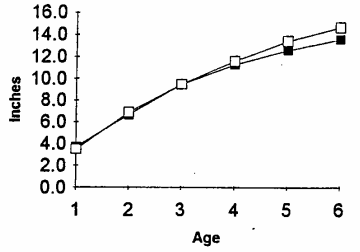

** Age groups with less than three samples not included in year class averages*

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 4 | 3.7 | | | | | |
| | stdev | 0.22 | | | | | |
| 1994 | 4 | 3.3 | 6.2 | | | | |
| | stdev | 0.62 | 0.41 | | | | |
| 1993 | 7 | 3.1 | 6.4 | 8.5 | | | |
| | stdev | 0.22 | 0.24 | 0.44 | | | |
| 1992 | 7 | 4.0 | 7.4 | 9.7 | 10.9 | | |
| | stdev | 1.33 | 1.12 | 1.01 | 0.92 | | |
| 1991 | 4 | 4.0 | 7.4 | 10.1 | 11.3 | 12.4 | |
| | stdev | 0.81 | 1.95 | 1.71 | 1.96 | 1.40 | |
| 1990 | 4 | 4.1 | 6.2 | 9.7 | 11.7 | 12.9 | 13.6 |
| | stdev | 0.68 | 0.50 | 0.79 | 0.60 | 0.60 | 0.33 |
| Mean* | | 3.7 | 6.7 | 9.5 | 11.3 | 12.6 | 13.6 |
| SD | | 0.39 | 0.63 | 0.68 | 0.42 | 0.36 | |
| Count | | 30 | 26 | 22 | 15 | 8 | 4 |

*Largemouth bass growth at Norman Lake (dark line) compared to other area lakes (light line).*

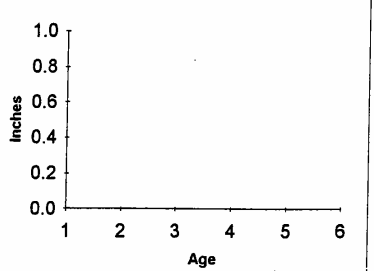



** Age groups with less than three samples not included in year class averages*

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
| SD | | | | | | | |
| Count | | | | | | | |




** Age groups with less than three samples not included in year class averages*

| Number, Percentage, Weight and Age of Largemouth Bass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | | | | | 15.5 | | | | |
| 2.5 | | | | | 16.0 | | | | |
| 3.0 | | | | | 16.5 | 1 | 3.0 | 1.90 | 7 |
| 3.5 | 1 | 3.0 | 0.03 | 1 | 17.0 | | | | |
| 4.0 | 1 | 3.0 | 0.02 | 1 | 17.5 | | | | |
| 4.5 | 2 | 6.1 | 0.04 | 1 | 18.0 | | | | |
| 5.0 | | | | | 18.5 | | | | |
| 5.5 | | | | | 19.0 | | | | |
| 6.0 | | | | | 19.5 | 1 | 3.0 | 3.15 | 8 |
| 6.5 | 1 | 3.0 | 0.08 | 2 | 20.0 | | | | |
| 7.0 | 1 | 3.0 | 0.16 | 2 | 20.5 | | | | |
| 7.5 | 1 | 3.0 | 0.17 | 2 | 21.0 | | | | |
| 8.0 | 3 | 9.1 | 0.20 | 2,3 | 21.5 | | | | |
| 8.5 | 1 | 3.0 | 0.26 | 3 | 22.0 | | | | |
| 9.0 | 4 | 12.1 | 0.29 | 3 | 22.5 | | | | |
| 9.5 | 1 | 3.0 | 0.35 | 4 | 23.0 | | | | |
| 10.0 | 1 | 3.0 | 0.40 | 4 | 23.5 | | | | |
| 10.5 | 1 | 3.0 | 0.47 | 5 | 24.0 | | | | |
| 11.0 | 2 | 6.1 | 0.60 | 4 | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | 3 | 9.1 | 0.72 | 4 | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | 2 | 6.1 | 0.92 | 5 | | | | | |
| 13.5 | 2 | 6.1 | 1.22 | 5,6 | | | | | |
| 14.0 | 4 | 12.1 | 1.30 | 6 | Total | 33 | | 21.67 | |
| Electrofishing catch: | 29 | | Gill net catch: | | 2 | Trap net catch: | | 2 | |

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | 1 | 0.5 | 0.01 | 1 | 15.0 | | | | |
| 2.0 | | | | | 15.5 | | | | |
| 2.5 | 14 | 6.9 | 0.01 | 1,2 | 16.0 | | | | |
| 3.0 | 7 | 3.5 | 0.02 | 2 | 16.5 | | | | |
| 3.5 | 4 | 2.0 | 0.03 | 2,3 | 17.0 | | | | |
| 4.0 | 3 | 1.5 | 0.04 | 2,3 | 17.5 | | | | |
| 4.5 | 3 | 1.5 | 0.05 | 3 | 18.0 | | | | |
| 5.0 | 2 | 1.0 | 0.08 | 4 | 18.5 | | | | |
| 5.5 | 9 | 4.5 | 0.09 | 3,4,5 | 19.0 | | | | |
| 6.0 | 18 | 8.9 | 0.13 | 4,5 | 19.5 | | | | |
| 6.5 | 40 | 19.8 | 0.18 | 4,5,6 | 20.0 | | | | |
| 7.0 | 52 | 25.7 | 0.24 | 5,6 | 20.5 | | | | |
| 7.5 | 38 | 18.8 | 0.28 | 5,6 | 21.0 | | | | |
| 8.0 | 11 | 5.4 | 0.33 | 5,6 | 21.5 | | | | |
| 8.5 | | | | | 22.0 | | | | |
| 9.0 | | | | | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 202 | | 37.94 | |
| Electrofishing catch: | | 29 | Gill net catch: | | 3 | Trap net catch: | | 170 | |

**Relative Abundance and Size of Fish Collected at Norman lake**

| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
|---|---|---|---|---|---|
| Bluegill | 202 | 72.1 | 1.7 - 8.2 | 37.94 | 25.6 |
| Largemouth bass | 33 | 11.8 | 3.7 - 19.4 | 21.67 | 14.6 |
| Channel catfish | 14 | 5.0 | 16.3 - 24.2 | 51.05 | 34.4 |
| Brown bullhead | 9 | 3.2 | 2.3 - 13.2 | 4.17 | 2.8 |
| Yellow bullhead | 8 | 2.9 | 8.8 - 11.5 | 5.03 | 3.4 |
| Warmouth | 6 | 2.1 | 2.7 - 6.7 | 0.56 | 0.4 |
| Redear | 5 | 1.8 | 6.7 - 8.0 | 1.44 | 1.0 |
| Carp | 2 | 0.7 | 28.3 - 30.9 | 25.00 | 16.9 |
| Spotted gar | 1 | 0.4 | 21.8 | 1.37 | 0.9 |
| | 280 | | | 148.23 | |

*Common names of fishes recognized by the American Fisheries Society

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | Common |
| Cattail | Typha sp. | | Common |
| Spatterdock | Nuphar sp. | | Abundant |
| SUBMERGENTS | | | |
| Coontail | Ceratophyllum demersum | 5 | Abundant |
| OTHERS | | | |
| Duckweed | Lemna sp. | | Common |
| Filamentous algae | | | Common |
| Water meal | Wolffia sp. | | Common |

Comments

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours | Total hours |
| | | 0.36 | 0.36 |
| TRAPS | Number of traps | Days | Total lifts |
| | 2 | 2 | 4 |
| GILL NETS | Number of nets | Days | Total lifts |
| | 2 | 2 | 4 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | | |
|---|---|---|
| Color | Turbidity | |
| tea | 5 Feet | 0 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 76.0 | 60 | |
| 2 | 76.0 | 62 | |
| 4 | 75.0 | 64 | |
| 6 | 71.5 | 66 | |
| 8 | 66.0 | 68 | |
| 10 | 62.0 | 70 | |
| 12 | 60.0 | 72 | |
| 14 | 57.0 | 74 | |
| 16 | 54.0 | 76 | |
| 18 | 52.0 | 78 | |
| 20 | 50.0 | 80 | |
| 22 | 49.0 | 82 | |
| 24 | 47.0 | 84 | |
| 26 | 46.0 | 86 | |
| 28 | 45.0 | 88 | |
| 30 | 44.5 | 90 | |
| 32 | 43.5 | 92 | |
| 34 | 43.0 | 94 | |
| 36 | 43.0 | 96 | |
| 38 | 42.5 | 98 | |
| 40 | 42.5 | 100 | |
| 42 | 42.0 | Comments | |
| 44 | 42.0 | | |
| 46 | 42.0 | | |
| 48 | 42.0 | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 11.0 | 154 | |
| 5 | 11.0 | | |
| 10 | 4.0 | | |
| 15 | 0.6 | | |
| 20 | 0.6 | | |
| 25 | 0.6 | | |
| 30 | 0.6 | | |
| 35 | 0.4 | | |
| 40 | 0.0 | | |
| 45 | 0.0 | 171 | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Norman Lake | Noble | 6/17-19/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | 2/5/97 |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 7 |
| **Township** | **Nearest town** | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| On south shore | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 14 | 46 | 20 | 280 | 893.01 | None |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| 18-inch tile | South shore to Miller Lake |

Water level control

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | |
| Sand | X |
| Muck | X |
| Clay | |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

Fish population surveys,IDNR,1966,1971,1975

Sunfish exploitation study,IDNR,1976-80; Dissolved oxygen and catfish check,INDR,1982,1983

Crappies were relatively important in the 1971 catch but not in 1966 or 1996. Redear were also more abundant in the 1966 and 1971 catches. Nonsport fish have never been particularly abundant. Channel catfish currently remain important in terms of weight within the fish community but will likely disappear as they die out.

Bluegill size has apparently increased somewhat over sizes noted in 1966 and 1971 (Table 3). Whether this simply reflects greater vulnerability of large bluegills to trap nets used in 1996, variations in year class strength or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass remain relatively scarce in Norman Lake despite greater protection under the limit.

Based on results of the recent survey, Norman Lake provides satisfactory fishing for bluegills and largemouth bass. Other sunfish, bullheads and some channel catfish provide additional fishing opportunities. No changes in management are suggested at this time.

Submitted by:
Jed Pearson, fisheries biologist
November 19, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 5, 1997

Table 3. *Size of bluegills collected at Norman Lake from 1966-96.*

| | Number | | |
|---|---|---|---|
| Inches | 1966 | 1971 | 1996 |
| 1-1½ | 0 | 0 | 1 |
| 2-2½ | 2 | 0 | 14 |
| 3-3½ | 20 | 6 | 11 |
| 4-4½ | 65 | 20 | 6 |
| 5-5½ | 45 | 30 | 11 |
| 6-6½ | 44 | 22 | 58 |
| 7-7½ | 16 | 14 | 90 |
| 8-8½ | 3 | 5 | 11 |
| 9-9½ | 0 | 1 | 0 |
| Total | 195 | 98 | 202 |

# Norman Lake
# NOBLE COUNTY
# FISH MANAGEMENT REPORT
# 1996

Department of Natural Resources

Division of Fish and Wildlife

## *BACKGROUND*

Norman lake is a 14-acre natural lake located within Chain o' Lakes State Park south of Albion. Maximum depth is 46 feet and average depth is 20 feet. It has a very small watershed and drains into Miller Lake through an underground tile. All of the shoreline is wooded. Public access is available at a gravel ramp on the south shore. Shoreline fishing is limited.

Water clarity is fair, ranging from 5-11 feet (Table 1). Oxygen levels during summer are low in depths greater than 10 feet. The water is moderately fertile (trophic index = 27). Coontail is the most abundand submerged plant species and encircles much of the lake. Spatterdock is also abundant around the edge.

The management history of Norman Lake began with state acquisition. An initial fish population survey was conducted in 1966. Some weed control was conducted in the late 1960s. Another survey was conducted in 1971 and a 14-inch size limit on largemouth bass was imposed in 1973. From 1976 through 1979, intensive sampling was conducted to estimate sunfish densities and angler harvest. Population estimates of age-2 and older bluegills varied from 9,600 to 28,000 and anglers removed an average of 4,900 annually. Estimates of age-2 and older largemouth bass varied from 180 to 920. Anglers removed about 33% of the adults bluegills and 20% of the adult bass each year. Channel catfish were stocked every other year from 1980 through 1988 but were discontinued in lieu of stocking other more popular species at other lakes in the area.

On June 17-19, 1996, another survey was conducted to obtain current information on the status of the fish community. Sampling effort consisted of 22 minutes of electrofishing, four gill net lifts and four trap net lifts. The results, along with comparisons to previous surveys, are presened in this report.

Table 1. *Oxygen levels (ppm) and water clarity (secchi depth) at Norman Lake from 1966-96.*

| Depth (ft) | 7/66 | 5/71 | 6/96 |
|---|---|---|---|
| 0 | 5.6 | 13.0 | 11.0 |
| 5 | 6.4 | 11.9 | 11.0 |
| 10 | 4.8 | 9.4 | 4.0 |
| 15 | 0.8 | 7.8 | 0.6 |
| 20 | 0.4 | 5.6 | 0.6 |
| 25 | 0.4 | 6.4 | 0.6 |
| 30 | 0.4 | 6.2 | 0.6 |
| Secchi (ft) | 6.9 | 11.0 | 5.0 |

## *SURVEY RESULTS*

During the survey, 280 fish weighing 148 pounds were collected. Nine species were represented. Bluegills dominated the catch by number (72%) and ranked second in weight (26%) after channel catfish (34%). Largemouth bass ranked second numerically (12%). Sport fish accounted for 99% of the catch and 82% of the weight.

The 202 bluegills sampled during the survey were 1½-8 inches long. As many as 79% were 6-inch or larger and 50% were 7-inch or larger. However, only 29 bluegills were captured by electrofishing. Most (84%) were caught in trap nets. Bluegills weights and growth rates were average. Age-4 bluegills averaged 5½ inches long and age-6 bluegills averaged 7½ inches.

The 33 largemouth bass collected during the survey measured 3½-19½ inches long. However, only six bass were 14-inch or larger. The electrofishing catch rate (79/hr) was below average. Bass weights and growth were also average as age-4 bass were 11⅛ inches long and age-6 bass were 13½ inches.

Fourteen channel catfish, ranging from 16⅛-24¼ inches long, were collected. Average weight was 3½ pounds. In addition, nine brown bullheads and eight yellow bullheads were collected. Other sport fish included six warmouth and five redear. Nonsport fish included two carp up to 31 inches long and one spotted gar.

## *MANAGEMENT IMPLICATIONS*

Very few changes have been noted in Norman Lake's fish community over the past 30 years. Bluegills, bass and bullheads have consistently been the major sport fish.

Table 2. *Number of fish collected during fish population surveys at Norman Lake from 1966-96.*

| | Number | | |
|---|---|---|---|
| Species | 1966 | 1971 | 1996 |
| Bluegills | 195 | 98 | 202 |
| Bullheads | 17 | 14 | 17 |
| Channel catfish | 0 | 0 | 14 |
| Crappies | 0 | 24 | 0 |
| Largemouth bass | 39 | 14 | 33 |
| Redear | 89 | 55 | 5 |
| Other sunfish | 22 | 2 | 6 |
| Bowfin | 7 | 4 | 0 |
| Carp | 0 | 1 | 2 |
| Chubsuckers | 48 | 45 | 0 |
| Gar | 1 | 1 | 1 |
| Shiners | 3 | 3 | 0 |

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | Rare |
| Cattail | Typha sp. | | Rare |
| Spatterdock | Nuphars sp. | | Common |
| SUBMERGENTS | | | |
| Curly-leaf pondweed | Potamogeton crispus | 4 | Rare |
| Coontail | Ceratophyllum demersum | 4 | Abundant |
| OTHERS | | | |
| Duckweed | Lemna sp. | | Abundant |
| Filamentous algae | | | Abundant |

Comments

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours | Total hours<br>See Mud Lake report - 1996 |
| TRAPS | Number of traps | Days | Total lifts<br>See Mud Lake report - 1996 |
| GILL NETS | Number of nets | Days | Total lifts<br>See Mud Lake report - 1996 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color<br>tea | Turbidity<br>4 Feet 6 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 75.5 | 60 | |
| 2 | 75.5 | 62 | |
| 4 | 74.5 | 64 | |
| 6 | 72.5 | 66 | |
| 8 | 71.0 | 68 | |
| 10 | 70.0 | 70 | |
| 12 | 68.0 | 72 | |
| 14 | 65.0 | 74 | |
| 16 | 61.5 | 76 | |
| 18 | 58.0 | 78 | |
| 20 | 54.0 | 80 | |
| 22 | 52.0 | 82 | |
| 24 | 50.0 | 84 | |
| 26 | 48.0 | 86 | |
| 28 | | 88 | |
| 30 | | 90 | |
| 32 | | 92 | |
| 34 | | 94 | |
| 36 | | 96 | |
| 38 | | 98 | |
| 40 | | 100 | |
| 42 | | Comments | |
| 44 | | | |
| 46 | | | |
| 48 | | | |
| 50 | | | |
| 52 | | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 4.0 | 137 | |
| 5 | 3.0 | | |
| 10 | 2.0 | | |
| 15 | 0.8 | | |
| 20 | 0.4 | | |
| 25 | 0.0 | 239 | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Weber Lake | Noble | 6/24-26/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | |

**LOCATION**

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 5 |
| **Township** | **Nearest town** | |
| 33N | Albion | |

**ACCESSIBILITY**

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| At Miller and Sand lakes | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 15 | 30 | 18 | 270 | 893.56 | 1-2' |

**INLETS**

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch | South shore | Sand Lake |
| | | |
| | | |

**OUTLET**

| Name | Location |
|---|---|
| Thumma Ditch | West side, flows to Mud Lake |

Water level control

Dam downstream of Miller Lake

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

Bottom type

| | |
|---|---|
| Boulder | |
| Gravel | |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

Natural shoreline

Previous surveys and investigations

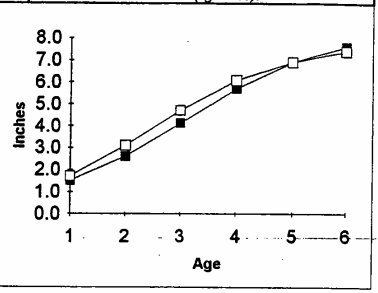
Fish population surveys,IDNR,1967,1975,1981

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 14 | 1.7 | | | | | |
| | stdev | 0.27 | | | | | |
| 1994 | 16 | 1.6 | 2.9 | | | | |
| | stdev | 0.18 | 0.29 | | | | |
| 1993 | 17 | 1.4 | 2.6 | 4.4 | | | |
| | stdev | 0.22 | 0.35 | 0.55 | | | |
| 1992 | 8 | 1.3 | 2.5 | 4.0 | 5.7 | | |
| | stdev | 0.14 | 0.29 | 0.61 | 0.41 | | |
| 1991 | 14 | 1.5 | 2.6 | 4.1 | 5.9 | 7.0 | |
| | stdev | 0.18 | 0.48 | 0.90 | 0.93 | 0.57 | |
| 1990 | 3 | 1.4 | 2.3 | 4.0 | 5.6 | 6.8 | 7.6 |
| | stdev | 0.29 | 0.28 | 0.70 | 0.94 | 0.68 | 0.54 |
| Mean* | | 1.5 | 2.6 | 4.1 | 5.7 | 6.9 | 7.6 |
| SD | | 0.12 | 0.24 | 0.22 | 0.12 | 0.16 | |
| Count | | 72 | 58 | 42 | 25 | 17 | 3 |

*Bluegill growth at Mud and Weber lakes (dark line) compared to other area lakes (light line).*



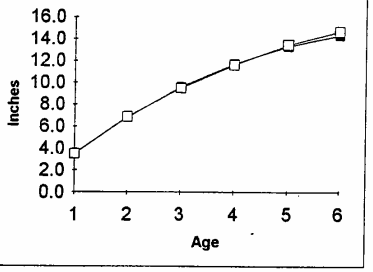

* Age groups with less than three samples not included in year class averages

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 16 | 3.8 | | | | | |
| | stdev | 0.57 | | | | | |
| 1994 | 13 | 3.2 | 6.7 | | | | |
| | stdev | 0.41 | 0.51 | | | | |
| 1993 | 10 | 3.4 | 6.3 | 9.1 | | | |
| | stdev | 0.59 | 0.68 | 0.52 | | | |
| 1992 | 12 | 3.2 | 6.2 | 9.1 | 11.0 | | |
| | stdev | 0.51 | 0.80 | 0.97 | 0.91 | | |
| 1991 | 11 | 3.6 | 7.2 | 10.3 | 12.3 | 13.4 | |
| | stdev | 0.54 | 0.95 | 0.73 | 0.74 | 0.93 | |
| 1990 | 4 | 4.0 | 7.4 | 10.0 | 11.9 | 13.2 | 14.3 |
| | stdev | 1.60 | 1.62 | 1.62 | 1.30 | 1.50 | 1.11 |
| Mean* | | 3.5 | 6.8 | 9.6 | 11.7 | 13.3 | 14.3 |
| SD | | 0.33 | 0.53 | 0.62 | 0.63 | 0.12 | |
| Count | | 66 | 50 | 37 | 27 | 15 | 4 |

*Largemouth bass growth at Mud and Weber lakes (dark line) compared to other area lakes (light line).*

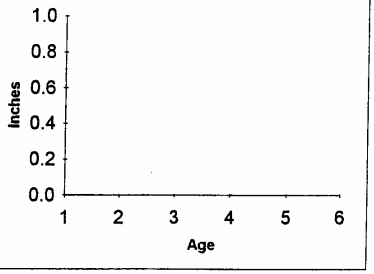



* Age groups with less than three samples not included in year class averages

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
| SD | | | | | | | |
| Count | | | | | | | |




* Age groups with less than three samples not included in year class averages

| Number, Percentage, Weight and Age of Largemouth Bass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | 5 | 5.7 | 1.47 | 5,6 |
| 1.5 | | | | | 15.0 | 2 | 2.3 | 1.93 | 5 |
| 2.0 | | | | | 15.5 | 2 | 2.3 | 1.73 | 6 |
| 2.5 | | | | | 16.0 | 1 | 1.1 | 2.36 | |
| 3.0 | | | | | 16.5 | | | | |
| 3.5 | 1 | 1.1 | 0.03 | 1 | 17.0 | | | | |
| 4.0 | 5 | 5.7 | 0.03 | 1 | 17.5 | | | | |
| 4.5 | 10 | 11.5 | 0.04 | 1 | 18.0 | 1 | 1.1 | 2.80 | 7 |
| 5.0 | 8 | 9.2 | 0.06 | 1 | 18.5 | | | | |
| 5.5 | 1 | 1.1 | 0.07 | 1 | 19.0 | | | | |
| 6.0 | | | | | 19.5 | | | | |
| 6.5 | 2 | 2.3 | 0.14 | 2 | 20.0 | | | | |
| 7.0 | 7 | 8.0 | 0.15 | 2 | 20.5 | | | | |
| 7.5 | 3 | 3.4 | 0.19 | 2 | 21.0 | | | | |
| 8.0 | 4 | 4.6 | 0.23 | 2 | 21.5 | | | | |
| 8.5 | | | | | 22.0 | | | | |
| 9.0 | 2 | 2.3 | 0.33 | 3 | 22.5 | | | | |
| 9.5 | 8 | 9.2 | 0.39 | 3 | 23.0 | | | | |
| 10.0 | 4 | 4.6 | 0.42 | 3,4 | 23.5 | | | | |
| 10.5 | 1 | 1.1 | 0.47 | 3 | 24.0 | | | | |
| 11.0 | 2 | 2.3 | 0.68 | 4 | 24.5 | | | | |
| 11.5 | 2 | 2.3 | 0.69 | 4 | 25.0 | | | | |
| 12.0 | 5 | 5.7 | 0.77 | 4,5 | | | | | |
| 12.5 | 2 | 2.3 | 1.00 | 4 | | | | | |
| 13.0 | 3 | 3.4 | 1.06 | 4 | | | | | |
| 13.5 | 4 | 4.6 | 1.09 | 5,6 | | | | | |
| 14.0 | 2 | 2.3 | 1.35 | 5 | Total | 87 | | 48.54 | |
| Electrofishing catch: | 76 | | Gill net catch: | 6 | Trap net catch: | 5 | | | |

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | 1 | 0.3 | 0.01 | 1 | 15.0 | | | | |
| 2.0 | 8 | 2.6 | 0.01 | 1 | 15.5 | | | | |
| 2.5 | 15 | 4.8 | 0.01 | 1 | 16.0 | | | | |
| 3.0 | 9 | 2.9 | 0.02 | 1,2 | 16.5 | | | | |
| 3.5 | 25 | 8.0 | 0.03 | 2 | 17.0 | | | | |
| 4.0 | 30 | 9.6 | 0.04 | 2 | 17.5 | | | | |
| 4.5 | 19 | 6.1 | 0.06 | 2,3 | 18.0 | | | | |
| 5.0 | 38 | 12.2 | 0.10 | 3 | 18.5 | | | | |
| 5.5 | 53 | 17.0 | 0.13 | 3 | 19.0 | | | | |
| 6.0 | 27 | 8.7 | 0.15 | 3,4 | 19.5 | | | | |
| 6.5 | 32 | 10.3 | 0.20 | 3,4,5 | 20.0 | | | | |
| 7.0 | 30 | 9.6 | 0.25 | 4,5 | 20.5 | | | | |
| 7.5 | 17 | 5.5 | 0.30 | 5,6 | 21.0 | | | | |
| 8.0 | 7 | 2.3 | 0.38 | 5,6 | 21.5 | | | | |
| 8.5 | | | | | 22.0 | | | | |
| 9.0 | | | | | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 311 | | 39.91 | |
| Electrofishing catch: | | 134 | Gill net catch: | | 39 | Trap net catch: | | 138 | |

| Relative Abundance and Size of Fish Collected at Mud and Weber Lakes | | | | | |
|---|---|---|---|---|---|
| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
| Bluegill | 311 | 40.4 | 1.7 -8.2 | 39.91 | 11.7 |
| Redear | 209 | 27.2 | 2.3 - 9.8 | 74.36 | 21.8 |
| Largemouth bass | 87 | 11.3 | 3.3 - 17.9 | 48.54 | 14.3 |
| Black crappie | 36 | 4.7 | 3.3 - 12.0 | 10.63 | 3.1 |
| Lake chubsucker | 36 | 4.7 | 3.1 - 11.0 | 8.70 | 2.6 |
| Spotted gar | 27 | 3.5 | 19.8 - 35.3 | 87.35 | 25.7 |
| Warmouth | 18 | 2.3 | 2.2 - 7.3 | 2.13 | 0.6 |
| Brown bullhead | 15 | 2.0 | 5.6 - 16.5 | 21.71 | 6.4 |
| Bowfin | 9 | 1.2 | 16.1 - 25.1 | 31.40 | 9.2 |
| Yellow bullhead | 8 | 1.0 | 11.0 - 14.1 | 9.56 | 2.8 |
| Grass pickerel | 7 | 0.9 | 3.0 - 13.2 | 1.91 | 0.6 |
| Brook silverside | 3 | 0.4 | 3.2 - 4.0 | 0.01 | 0.0 |
| Golden shiner | 1 | 0.1 | 4.0 | 4.00 | 1.2 |
| Yellow perch | 1 | 0.1 | 8.5 | 0.25 | 0.1 |
| Pirate perch | 1 | 0.1 | 2.9 | 0.02 | 0.0 |
| | 769 | | | 340.48 | |
| *Common names of fishes recognized by the American Fisheries Society | | | | | |

Table 2. *Number of fish collected during fish population surveys at Sand Lake from 1966-96.*

| | Number | | | | | |
|---|---|---|---|---|---|---|
| Species | 1966 | 1971 | 1975 | 1981 | 1993 | 1996 |
| Bluegills | 76 | 126 | 144 | 187 | 401 | 654 |
| Bullheads | 1 | 3 | 2 | 3 | 20 | 24 |
| Crappies | 1 | 12 | 1 | 3 | 16 | 41 |
| Lm bass | 28 | 70 | 18 | 29 | 141 | 119 |
| Northern pike | 0 | 0 | 0 | 1 | 0 | 0 |
| Redear | 12 | 3 | 7 | 22 | 152 | 130 |
| Trout | 0 | 4 | 15 | 15 | 28 | 2 |
| Yellow perch | 1 | 0 | 1 | 8 | 35 | 6 |
| Other sunfish | 11 | 18 | 13 | 3 | 28 | 18 |
| Bowfin | 1 | 7 | 2 | 1 | 3 | 5 |
| Carp | 0 | 0 | 2 | 0 | 0 | 0 |
| Chubsuckers | 13 | 23 | 3 | 6 | 20 | 19 |
| Gar | 4 | 5 | 4 | 8 | 23 | 27 |
| Shiners | 3 | 5 | 2 | 0 | 1 | 5 |
| Suckers | 2 | 8 | 7 | 13 | 7 | 13 |
| Others | 4 | 10 | 1 | 2 | 37 | 11 |

## *MANAGEMENT IMPLICATIONS*

Based on results of numerous surveys conducted since 1966, few changes have been noted in the fish community at Sand Lake over the past 30 years (Table 2). The variations in actual catches probably reflect differences in sampling gear and effort or minor fluctuations in specific populations (note: only electrofishing was used in 1966).

Bluegills and largemouth bass have consistently been the major sport fish. Redear have also been important, primarily since 1981. Crappies and bullheads have also been present but never accounted for much of the catch. Northern pike have always been scarce. Nonsport fish, especially carp, have not been particularly abundant, but more gar were caught in the two most recent surveys.

The survey results also indicate that bluegill size has changed little despite the heavy fishing pressure that Sand Lake experiences (Table 3). Eight-inch fish have been sampled during each survey. However, some 9-inch bluegills have been collected since 1975. Nevertheless, mean length in 1971 (4.9 in) was identical to mean length in 1996. Whether these minor differences in bluegill catches also reflect differences in vulnerability of bluegills to the various types of gear used during surveys, variations in year class strength, or an actual increase related to the 14-inch largemouth bass size limit is unknown. However, bass do not appear to be any more abundant in Sand Lake than most lakes.

Based on results of the latest survey, Sand Lake still provides satisfactory fishing for bluegills, largemouth bass and redear. Large bass remain scarce though. Crappies, bullheads and stocked trout provide additional fishing opportunities. Therefore, no changes in fish management are suggested at this time.

The most serious problem facing Sand Lake, as well as other lakes within the park, is the continued input of high loads of sediments and nutrients from the watershed. At times, water clarity is reduced to inches. This limits the quality of fish habitat and the lake's aesthetic appeal. Greater effort is needed within the watershed to minimize soil erosion and nutrient loss. Ideally, the upper reaches of the watershed should be acquired under state ownership and added to the park.

Submitted by:
Jed Pearson, fisheries biologist
November 21, 1996

Approved by: Gary Hudson
Gary Hudson, fisheries supervisor
February 5, 1997

Table 3. *Size of bluegills collected at Sand Lake from 1966-96.*

| | Number | | | | | |
|---|---|---|---|---|---|---|
| Inches | 1966 | 1971 | 1975 | 1981 | 1993 | 1996 |
| 1-1½ | 1 | 0 | 2 | 1 | 22 | 0 |
| 2-2½ | 43 | 12 | 30 | 9 | 32 | 34 |
| 3-3½ | 21 | 14 | 43 | 22 | 67 | 101 |
| 4-4½ | 8 | 24 | 23 | 53 | 63 | 190 |
| 5-5½ | 0 | 33 | 19 | 30 | 95 | 122 |
| 6-6½ | 1 | 17 | 13 | 34 | 65 | 73 |
| 7-7½ | 0 | 14 | 11 | 28 | 39 | 95 |
| 8-8½ | 2 | 12 | 2 | 9 | 17 | 36 |
| 9-9½ | 0 | 0 | 1 | 1 | 1 | 3 |
| Total | 76 | 126 | 144 | 187 | 401 | 654 |
| Mean | 2.7 | 4.9 | 3.9 | 5.0 | 4.5 | 4.8 |

# FISH SURVEY REPORT

*Indiana Division of Fish and Wildlife*

| Type of survey | |
|---|---|
| Initial: | Re-survey: X |

| Lake name | County | Date of survey (Month, day, year) |
|---|---|---|
| Sand Lake | Noble | 7/22-24/96 |
| **Biologist's name** | | **Date of approval (Month, day, year)** |
| Jed Pearson | | 2/5/97 |

## LOCATION

| Quadrangle name | Range | Section |
|---|---|---|
| Merriam | 10E | 8,9 |
| **Township** | **Nearest town** | |
| 33N | Albion | |

## ACCESSIBILITY

| State owned public access site | Privately owned public access site | Other access site |
|---|---|---|
| Ramp and boat rentals | | |

| Surface acres | Maximum depth (ft) | Average depth (ft) | Acre feet | Water level (msl) | Extreme fluctuations (ft) |
|---|---|---|---|---|---|
| 47 | 51 | 27 | 1,270 | 893.56 | 1-2' |

## INLETS

| Name | Location | Origin |
|---|---|---|
| Thumma Ditch (Forker Creek) | Northeast corner | Bowen Lake |
| Heltzel Ditch | Southeast corner | Runoff |
| | | |

## OUTLET

| Name | Location |
|---|---|
| Thumma Ditch (Forker Creek) | Northwest corner to Weber Lake |

Water level control

Dam downstream of Miller Lake

| POOL | ELEVATION (Feet MSL) | ACRES |
|---|---|---|
| TOP OF DAM | | |
| TOP OF FLOOD CONTROL POOL | | |
| TOP OF CONSERVATION POOL | | |
| TOP OF MINIMUM POOL | | |
| STREAMBED | | |

| Bottom type | |
|---|---|
| Boulder | |
| Gravel | X |
| Sand | X |
| Muck | X |
| Clay | X |
| Marl | |

Watershed use

Chain o' Lakes State Park

Development of shoreline

A beach, beachhouse, boat rental and fishing docks are located at the eastern end of the lake.

Previous surveys and investigations

Creel survey,IDNR,1962. Fish population surveys,IDNR,1966,1971,1975,1981,1993(unpublished)

Trout surveys,IDNR,1986,1987,1992. Bass sampling,IDNR,1993. Various water quality checks.

| SAMPLING EFFORT | | | |
|---|---|---|---|
| ELECTROFISHING | Day hours | Night hours | Total hours |
| | | 0.73 | 0.73 |
| TRAPS | Number of traps | Days | Total lifts |
| | 2 | 2 | 4 |
| GILL NETS | Number of nets | Days | Total lifts |
| | 2 | 2 | 4 |

| PHYSICAL AND CHEMICAL CHARACTERISTICS | |
|---|---|
| Color | Turbidity |
| blue-green | 6 Feet 0 Inches (Secchi disk) |

TEMPERATURE, DISSOLVED OXYGEN (ppm), TOTAL ALKALINITY (ppm), pH

| Depth (ft) | Degrees F | Depth (ft) | Degrees F |
|---|---|---|---|
| Surface | 76.0 | 60 | |
| 2 | 76.0 | 62 | |
| 4 | 76.0 | 64 | |
| 6 | 76.0 | 66 | |
| 8 | 76.0 | 68 | |
| 10 | 76.0 | 70 | |
| 12 | 72.0 | 72 | |
| 14 | 67.0 | 74 | |
| 16 | 64.0 | 76 | |
| 18 | 62.0 | 78 | |
| 20 | 59.5 | 80 | |
| 22 | 57.5 | 82 | |
| 24 | 55.0 | 84 | |
| 26 | 54.0 | 86 | |
| 28 | 53.0 | 88 | |
| 30 | 52.0 | 90 | |
| 32 | 51.0 | 92 | |
| 34 | 51.0 | 94 | |
| 36 | 50.0 | 96 | |
| 38 | 49.5 | 98 | |
| 40 | 49.0 | 100 | |
| 42 | 49.0 | Comments | |
| 44 | 49.0 | | |
| 46 | 49.0 | | |
| 48 | 48.5 | | |
| 50 | 48.5 | | |
| 52 | 48.5 | | |
| 54 | | | |
| 56 | | | |
| 58 | | | |

| Depth (ft) | Oxygen* | Alkalinity* | pH |
|---|---|---|---|
| Surface | 6.0 | 137 | |
| 5 | 6.0 | | |
| 10 | 2.5 | | |
| 15 | 0.4 | | |
| 20 | 0.4 | | |
| 25 | 0.4 | | |
| 30 | 2.5 | | |
| 35 | 3.0 | | |
| 40 | 0.4 | | |
| 45 | 0.4 | | |
| 50 | 0.0 | 222 | |
| 55 | | | |
| 60 | | | |
| 65 | | | |
| 70 | | | |
| 75 | | | |
| 80 | | | |
| 85 | | | |
| 90 | | | |
| 95 | | | |
| 100 | | | |
| Comments | | | |

*ppm = parts per million

| COMMON SPECIES OF AQUATIC PLANTS | | | |
|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME | DEPTH (ft) | ABUNDANCE |
| EMERGENTS | | | |
| Arrow arum | Peltandra virginica | | Abundant |
| Arrowhead | Sagitarria sp. | | Common |
| Spatterdock | Nuphar sp. | | Common |
| Water lily | Nymphaea sp. | | Common |
| SUBMERGENTS | | | |
| Curly-leaf pondweed | Potamogeton crispus | 11 | Rare |
| Coontail | Ceratophyllum demersum | 11 | Abundant |
| Large-leaf pondweed | Potamogeton amplifolius | 11 | Rare |
| Leafy pondweed | Potamogeton foliosus | 11 | Rare |
| Milfoil | Myriophyllum sp. | 11 | Rare |
| OTHERS | | | |
| Filamentous algae | | | Common |
| Lizard's Tail | Saururus cernuus | shoreline | Rare |

Comments

| Relative Abundance and Size of Fish Collected at Sand Lake | | | | | |
|---|---|---|---|---|---|
| Common Name* | Number | Percent | Length range (in) | Weight (lb) | Percent |
| Bluegill | 654 | 60.9 | 2.0 - 8.9 | 86.73 | 23.2 |
| Redear | 130 | 12.1 | 2.7 - 9.5 | 28.05 | 7.5 |
| Largemouth bass | 119 | 11.1 | 4.6 - 21.2 | 95.09 | 25.5 |
| Black crappie | 41 | 3.8 | 4.5 - 10.2 | 11.00 | 2.9 |
| Spotted gar | 27 | 2.5 | 12.3 - 31.8 | 53.93 | 14.5 |
| Lake chubsucker | 19 | 1.8 | 5.5 - 10.7 | 6.10 | 1.6 |
| Yellow bullhead | 18 | 1.7 | 7.4 - 13.3 | 14.90 | 4.0 |
| Warmouth | 16 | 1.5 | 4.3 - 8.5 | 3.44 | 0.9 |
| White sucker | 13 | 1.2 | 7.1 - 22.6 | 28.62 | 7.7 |
| Yellow perch | 6 | 0.6 | 6.0 - 11.4 | 2.10 | 0.6 |
| Brown bullhead | 6 | 0.6 | 14.2 - 13.4 | 11.61 | 3.1 |
| Brook silverside | 6 | 0.6 | 1.7 - 3.8 | 0.03 | 0.0 |
| Golden shiner | 5 | 0.5 | 2.1 - 8.9 | 0.85 | 0.2 |
| Grass pickerel | 5 | 0.5 | 9.2 - 13.4 | 1.79 | 0.5 |
| Bowfin | 5 | 0.5 | 12.9 - 27.0 | 26.98 | 7.2 |
| Pumpkinseed | 2 | 0.2 | 3.2 - 5.9 | 0.20 | 0.1 |
| Rainbow trout | 2 | 0.2 | 13.0 - 13.1 | 1.77 | 0.5 |
| | 1074 | | | 373.19 | |
| *Common names of fishes recognized by the American Fisheries Society | | | | | |

| Number, Percentage, Weight and Age of Bluegill | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | | | | |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | 1 | 0.2 | 0.01 | 1 | 15.5 | | | | |
| 2.5 | 33 | 5.0 | 0.01 | 1 | 16.0 | | | | |
| 3.0 | 74 | 11.3 | 0.02 | 1 | 16.5 | | | | |
| 3.5 | 27 | 4.1 | 0.03 | 1,2 | 17.0 | | | | |
| 4.0 | 81 | 12.4 | 0.05 | 2 | 17.5 | | | | |
| 4.5 | 109 | 16.7 | 0.07 | 2 | 18.0 | | | | |
| 5.0 | 77 | 11.8 | 0.09 | 2 | 18.5 | | | | |
| 5.5 | 45 | 6.9 | 0.13 | 2 | 19.0 | | | | |
| 6.0 | 37 | 5.7 | 0.16 | 2,3 | 19.5 | | | | |
| 6.5 | 36 | 5.5 | 0.23 | 3 | 20.0 | | | | |
| 7.0 | 47 | 7.2 | 0.28 | 3,4 | 20.5 | | | | |
| 7.5 | 48 | 7.3 | 0.34 | 4,5 | 21.0 | | | | |
| 8.0 | 24 | 3.7 | 0.38 | 4,5 | 21.5 | | | | |
| 8.5 | 12 | 1.8 | 0.44 | 5,6 | 22.0 | | | | |
| 9.0 | 3 | 0.5 | 0.52 | 6,7 | 22.5 | | | | |
| 9.5 | | | | | 23.0 | | | | |
| 10.0 | | | | | 23.5 | | | | |
| 10.5 | | | | | 24.0 | | | | |
| 11.0 | | | | | 24.5 | | | | |
| 11.5 | | | | | 25.0 | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | | | | | | | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | Total | 654 | | 86.73 | |
| Electrofishing catch: | | 209 | Gill net catch: | | 59 | Trap net catch: | | 386 | |

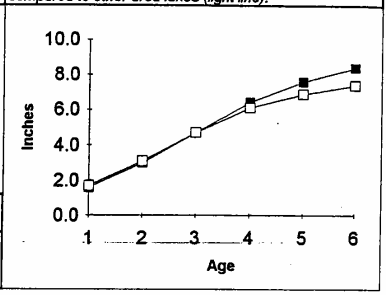
| Number, Percentage, Weight and Age of largemouth Bass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish | Total Length (in) | Number Collected | Percent | Average Weight (lb) | Age of Fish |
| 1.0 | | | | | 14.5 | 3 | 2.5 | 1.50 | 5,6 |
| 1.5 | | | | | 15.0 | | | | |
| 2.0 | | | | | 15.5 | 3 | 2.5 | 1.82 | 6 |
| 2.5 | | | | | 16.0 | | | | |
| 3.0 | | | | | 16.5 | | | | |
| 3.5 | | | | | 17.0 | 1 | 0.8 | 2.73 | |
| 4.0 | | | | | 17.5 | | | | |
| 4.5 | 1 | 0.8 | 0.06 | 1 | 18.0 | | | | |
| 5.0 | | | | | 18.5 | | | | |
| 5.5 | 9 | 7.6 | 0.08 | 1 | 19.0 | | | | |
| 6.0 | 5 | 4.2 | 0.12 | 1 | 19.5 | | | | |
| 6.5 | 1 | 0.8 | 0.14 | 1 | 20.0 | | | | |
| 7.0 | 1 | 0.8 | 0.17 | 2 | 20.5 | | | | |
| 7.5 | 5 | 4.2 | 0.22 | 2 | 21.0 | 3 | 2.5 | 5.54 | |
| 8.0 | 7 | 5.9 | 0.25 | 2 | 21.5 | | | | |
| 8.5 | 2 | 1.7 | 0.32 | 2,3 | 22.0 | | | | |
| 9.0 | 5 | 4.2 | 0.30 | 2,3 | 22.5 | | | | |
| 9.5 | 5 | 4.2 | 0.42 | 2,3 | 23.0 | | | | |
| 10.0 | 6 | 5.0 | 0.50 | 3,4 | 23.5 | | | | |
| 10.5 | 10 | 8.4 | 0.56 | 3 | 24.0 | | | | |
| 11.0 | 5 | 4.2 | 0.64 | 3,4 | 24.5 | | | | |
| 11.5 | 9 | 7.6 | 0.73 | 3,4 | 25.0 | | | | |
| 12.0 | 5 | 4.2 | 0.81 | 3,4,5 | | | | | |
| 12.5 | 14 | 11.8 | 0.92 | 4,5 | | | | | |
| 13.0 | 10 | 8.4 | 1.03 | 3,4,5 | | | | | |
| 13.5 | 4 | 3.4 | 1.25 | 4,5,6 | | | | | |
| 14.0 | 5 | 4.2 | 1.28 | 5,6 | Total | 119 | | 95.09 | |
| Electrofishing catch: | | 106 | Gill net catch: | | 9 | Trap net catch: | | 4 | |

Bluegill
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 17 | 1.8 | | | | | |
| | stdev | 0.24 | | | | | |
| 1994 | 28 | 1.5 | 3.2 | | | | |
| | stdev | 0.24 | 0.54 | | | | |
| 1993 | 9 | 1.6 | 2.8 | 4.8 | | | |
| | stdev | 0.25 | 0.31 | 0.40 | | | |
| 1992 | 8 | 1.4 | 3.1 | 4.5 | 6.7 | | |
| | stdev | 0.16 | 0.39 | 0.69 | 0.41 | | |
| 1991 | 6 | 1.6 | 2.9 | 4.6 | 6.2 | 7.5 | |
| | stdev | 0.32 | 0.61 | 0.83 | 0.93 | 0.60 | |
| 1990 | 5 | 1.7 | 2.9 | 4.7 | 6.4 | 7.7 | 8.4 |
| | stdev | 0.37 | 0.63 | 0.74 | 0.37 | 0.25 | 0.23 |
| Mean* | | 1.6 | 3.0 | 4.7 | 6.4 | 7.6 | 8.4 |
| SD | | 0.13 | 0.16 | 0.15 | 0.28 | 0.17 | |
| Count | | 73 | 56 | 28 | 19 | 11 | 5 |

*Bluegill growth at Sand Lake (dark line) compared to other area lakes (light line).*



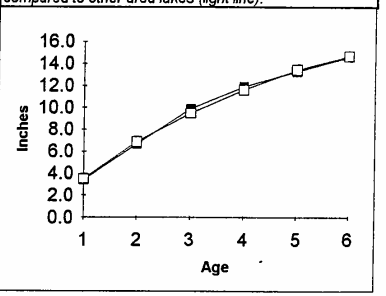

** Age groups with less than three samples not included in year class averages*

Largemouth bass
Intercept: 0.8

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1995 | 10 | 3.6 | | | | | |
| | stdev | 0.55 | | | | | |
| 1994 | 15 | 3.1 | 6.6 | | | | |
| | stdev | 0.36 | 0.72 | | | | |
| 1993 | 20 | 3.4 | 6.6 | 9.5 | | | |
| | stdev | 0.58 | 0.91 | 1.06 | | | |
| 1992 | 17 | 3.2 | 6.4 | 9.2 | 11.4 | | |
| | stdev | 0.45 | 1.65 | 1.65 | 0.90 | | |
| 1991 | 11 | 3.5 | 6.5 | 10.3 | 11.8 | 12.9 | |
| | stdev | 0.51 | 1.34 | 1.24 | 1.22 | 1.01 | |
| 1990 | 5 | 3.7 | 7.3 | 10.3 | 12.4 | 13.8 | 14.6 |
| | stdev | 1.38 | 1.13 | 1.57 | 1.11 | 0.73 | 0.77 |
| Mean* | | 3.4 | 6.7 | 9.9 | 11.9 | 13.3 | 14.6 |
| SD | | 0.25 | 0.34 | 0.55 | 0.48 | 0.58 | |
| Count | | 78 | 68 | 53 | 33 | 16 | 5 |

*Largemouth bass growth at Sand Lake (dark line) compared to other area lakes (light line).*




** Age groups with less than three samples not included in year class averages*

Intercept:

BACK-CALCULATED LENGTH (inches) AT EACH AGE

| Year Class | Count | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| 1994 | | | | | | | |
| 1993 | | | | | | | |
| 1992 | | | | | | | |
| 1991 | | | | | | | |
| 1990 | | | | | | | |
| 1989 | | | | | | | |
| Mean* | | | | | | | |
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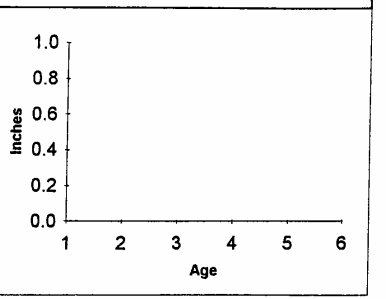
| Count | | | | | | | |




** Age groups with less than three samples not included in year class averages*

Wayne - call me if you want the original photos —

# MEMORANDUM

**State of Indiana * Department of Natural Resources**

TO: Wayne Stanger
FROM: Jed Pearson
DATE: 11/12/96
SUBJECT: Chain O' Lakes Park fishery survey

Fx 636-2556

The following text is from a news release I issued last August 30 to the local media regarding the initial results of our fishery survey at the park.

**Bluegills abundant in park lakes**

Despite years of heavy pressure from anglers, Chain O' Lakes State Park near Albion continues to produce plenty of 7- to 9-inch bluegills and redear sunfish, according to results of a recent survey conducted by the Division of Fish and Wildlife.

Biologists captured a total of 3,125 bluegills ranging in size from two to 9½ inches long and 810 redear up to 11 inches long in nine of the park lakes sampled during July.

Sand and Bowen lakes produced the most bluegills and the largest, while Mud and Weber lakes produced the most redear. Bowen Lake also contained the largest redear.

"The park lakes have been popular fishing spots for many years," says Jed Pearson, DFW biologist who has sampled the lakes periodically since 1971. "I was impressed this year as much as I was 25 years ago."

Pearson says he is amazed the lakes continue to support so many big bluegills, especially considering the number of fish caught by anglers each summer and during the winter. He credits the amount of food available for bluegills in each lake.

"There are an awful lot of bugs and other food items out there for bluegills to eat," says Pearson. "At times, the insect hatches at night were so thick we could barely open our eyes or breathe without choking on them."

Pearson thinks that a 14-inch minimum size limit on largemouth bass in effect at the park since 1973 may have also helped keep bluegill numbers in balance. Bass and other predators feed on small bluegills. Those that escape are able to

find plenty of food to maintain good growth.

"The lakes are basically in pretty good shape," says Pearson. "We don't see the need to make any changes in the way they are managed but we would like to see efforts continue to cut down on runoff of sediment and nutrients to them, especially at Long Lake."

#####

(end of news release text)

Since August, we have looked at the scale samples we took from various fish to determine their age and growth rate. Although all growth data has been compiled, we have not yet made any comparisons with previous growth data. I don't think we will find any major changes. Fish in the park lakes have always grown fairly well.

During our surveys, we also looked at water clarity and dissolved oxygen concentrations. Sand Lake had slightly better clarity than the other lakes, as did Norman and Bowen. Surface oxygen amounts were very high in Long, Norman and Dock lakes and indicates that plantonic algae levels are probably also high. Oxygen levels were very low at the surface of Mud and Weber lakes. Generally, oxygen levels in all lakes were low below 10 feet. Fish normally require 5 ppm (parts per million) for good health. They tend to avoid areas where levels drop below 4-5 ppm. Fish kills can occur where oxygen levels drop below 3 ppm.

| | | | Oxygen amounts (ppm) at 5-foot intervals | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lake | color | clarity | surface | 5' | 10' | 15' | 20' | 25' |
| Bowen | tea | 5'0" | 9.0 | 9.0 | 1.2 | 0.6 | 0.6 | 0.6 |
| Dock | green | 4'6" | 12.0 | 11.0 | 0.6 | 0.6 | 0.0 | |
| Long | green | 3'0" | 11.0 | 11.0 | 1.2 | 0.4 | 0.2 | 0.2 |
| Miller | blue-green | 4'0" | 7.0 | 7.0 | 4.0 | 0.6 | 0.4 | 0.0 |
| Mud | tea | 4'6" | 3.0 | 2.0 | 0.6 | 0.6 | 0.0 | |
| Norman | tea | 5'0" | 11.0 | 11.0 | 4.0 | 0.6 | 0.6 | 0.6 |
| Rivir | blue-green | 3'8" | 8.0 | 8.0 | 1.0 | 0.4 | 0.2 | 0.0 |
| Sand | blue-green | 6'0" | 6.0 | 6.0 | 2.5 | 0.4 | 0.4 | 0.4 |
| Weber | tea | 4'6" | 4.0 | 3.0 | 2.0 | 0.8 | 0.4 | 0.0 |

Based on initial results of the surveys, the Division of Fish and Wildlife will not initiate any new fish management programs at the park lakes. However, our Division recognizes the serious problem with the buildup of sediment at the mouth of the inlet to Long Lake (Sucker Lake), as well as other lake inlets, and strongly supports any effort to reduce the amount of sediment and nutrient inputs to the lakes.

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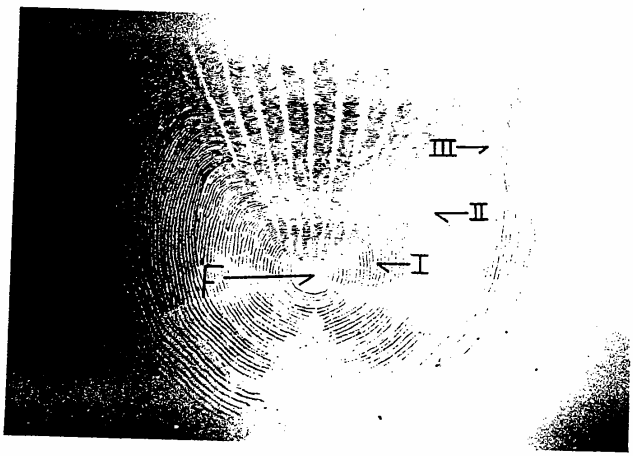


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# APPENDIX M

## INDIANA WATER RESOURCE - 1980

Soil maps 557

**Table 61 (continued)**

| Lake Number | Lake Name | Drainage Area (square miles) | Surface Area (acres) | Gross Storage (million gallons) |
|---|---|---|---|---|
| 60 | Lake George | 14.80 | 488.0 | na |
| 61 | Lake James | 47.80 | 1,034.0 | 10,943 |
| 62 | Lake Pleasant | 3.18 | 424.0 | 1,137 |
| 63 | Lime Lake | na | 30.0 | 107 |
| 64 | Lime Lake | 17.50 | 57.0 | 139 |
| 65 | Little Turkey Lake | na | 58.0 | 254 |
| 66 | Little Otter Lake | 15.70 | 34.0 | 241 |
| 67 | Long Lake | 2.80 | 154.0 | 241 |
| 68 | Long Lake | 67.90 | 92.0 | 501 |
| 69 | Loon Lake | 2.13 | 138.0 | 205 |
| 70 | Mirror Lake | na | 9.0 | 39 |
| 71 | Otter Lake | 6.91 | 118.0 | 638 |
| 72 | Pigeon Lake | 35.30 | 61.0 | 303 |
| 73 | Pleasant Lake | 1.12 | 53.0 | 387 |
| 74 | Round Lake | 7.25 | 30.0 | 110 |
| 75 | Silver Lake | 3.79 | 238.0 | 827 |
| 76 | Snow Lake | 40.20 | 310.0 | 2,606 |
| 77 | Walters Lake | na | 53.0 | 179 |
| 78 | Bartley Lake | na | 34.0 | 140 |
| 79 | Baugher Lake | 31.00 | 32.0 | 127 |
| 80 | Bear Lake | 6.98 | 136.0 | 987 |
| 81 | Big Lake | 8.89 | 228.0 | 1,834 |
| 82 | Bixler Lake | 5.28 | 120.0 | 681 |
| 83 | Bowen Lake | na | 30.0 | 351 |
| 84 | Bristol Lake | na | 27.0 | 241 |
| 85 | Crane Lake | na | 28.0 | 117 |
| 86 | Cree Lake | 4.85 | 58.0 | 296 |
| 87 | Crooked Lake | 1.51 | 206.0 | 2,945 |
| 88 | Deer Lake | na | 36.0 | 136 |
| 89 | Diamond Lake | 4.80 | 105.0 | 840 |
| 90 | Dock Lake | na | 16.0 | 74 |
| 91 | Duely Lake | 11.20 | 21.0 | 58 |
| 92 | Eagle Lake | 3.22 | 81.0 | 342 |
| 93 | Engle Lake | 4.19 | 48.0 | 218 |
| 94 | Gilbert Lake | 0.37 | 28.0 | 159 |
| 95 | Gordy Lake | 9.40 | 31.0 | 221 |
| 96 | Harper Lake | 2.76 | 11.0 | 52 |
| 97 | High Lake | 4.43 | 123.0 | 404 |
| 98 | Hindman Lake | 8.66 | 13.0 | 45 |
| 99 | Horseshoe Lake | 1.62 | 18.0 | 81 |
| 100 | Jones Lake | 70.30 | 114.0 | 312 |
| 101 | Knapp Lake | 6.02 | 88.0 | 990 |
| 102 | Latta Lake | 2.52 | 42.0 | 293 |
| 103 | Little Long Lake | 4.55 | 71.0 | 570 |
| 104 | Long Lake | 12.00 | 40.0 | 205 |
| 105 | Lower Long Lake | 4.35 | 66.0 | 508 |
| 106 | Marl Lake | na | 30.0 | 166 |
| 107 | Marvin Morgan Lake | na | na | 42 |
| 108 | Miller Lake | na | 11.0 | 52 |
| 109 | Millers Lake | na | 28.0 | 133 |
| 110 | Muncie Lake | 42.80 | 47.0 | 188 |
| 111 | Niezer Lake | 0.14 | 26.0 | 48 |
| 112 | Norman Lake | na | 14.0 | 91 |
| 113 | Northport Feeder Lake | na | 658.2 | 2,851 |
| 114 | Pleasant Lake | 0.29 | 20.0 | 175 |
| 115 | Port Mitchell Lake | na | 15.0 | 58 |
| 116 | Richard Grieger Lake | na | na | 55 |
| 117 | River Lake | 18.60 | 24.0 | 125 |
| 118 | Round Lake | 3.47 | 99.0 | 697 |
| 119 | Sacarider Lake | 1.43 | 33.0 | 241 |



**Table 61 (continued)**

| Lake Number | Lake Name | Drainage Area (square miles) | Surface Area (acres) | Gross Storage (million gallons) |
|---|---|---|---|---|
| 120 | Sand Lake | 14.90 | 47.0 | 413 |
| 121 | Schockopee Lake | na | 21.0 | 91 |
| 122 | Silver Lake | 0.28 | 34.0 | 71 |
| 123 | Skinner Lake | 14.00 | 125.0 | 570 |
| 124 | Smalley Lake | 27.10 | 69.0 | 495 |
| 125 | Sparta Lake | 0.69 | 31.0 | 55 |
| 126 | Steinbarger Lake | 24.30 | 73.0 | 518 |
| 127 | Sweet Lake | na | 16.0 | 68 |
| 128 | Sylvan Lake | 33.80 | 575.0 | na |
| 129 | Tamarack Lake | 15.90 | 50.0 | 286 |
| 130 | Tamarack Lake | 19.40 | 84.0 | 436 |
| 131 | Upper long Lake | 2.08 | 86.0 | 619 |
| 132 | Village Lake | 12.00 | 12.0 | 52 |
| 133 | Waldron Lake | 134.00 | 216.0 | 1,016 |
| 134 | Wible Lake | na | 49.0 | 211 |
| 135 | Williams Lake | na | 46.0 | 348 |
| 136 | Black Lake | na | 24.0 | 130 |
| 137 | Blue Lake | 3.58 | 239.0 | 1,632 |
| 138 | Brown Lake | na | 23.0 | 188 |
| 139 | Cedar Lake | 0.79 | 131.0 | na |
| 140 | Goose Lake | 1.51 | 84.0 | na |
| 141 | Larwill Lake | na | 9.0 | 55 |
| 142 | Little Wilson Lake | 0.52 | 8.0 | 42 |
| 143 | Loon Lake | 11.10 | 222.0 | 1,867 |
| 144 | New Lake | 0.29 | 50.0 | 286 |
| 145 | Old Lake | 2.81 | 32.0 | 202 |
| 146 | Round Lake | 3.36 | 125.0 | na |
| 147 | Shriner Lake | 0.94 | 111.0 | na |
| 148 | Troy Cedar Lake | 5.33 | 93.0 | 827 |
| 149 | Wilson Lake | 0.46 | 29.0 | 127 |
| 150 | Huntington Lake | 721.00 | 905.0 | 4,066 |

na: not available