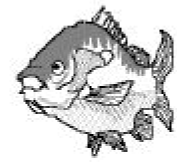


Study conducted by:

COMMONWEALTH BIOMONITORING
8061 Windham Lake Drive
Indianapolis, IN 46214
317-297-7713

INDIAN LAKES IMPROVEMENT PROJECT

A Lake and River Enhancement Project
funded by the Indiana Department of Natural Resources
Division of Soil Conservation
Indianapolis IN

For the Five Lakes Conservation Club
Wolcottville, Indiana

Submitted: January 2001

Table of Contents

	Page Number
Executive Summary	i
I. Introduction	
A. Background of the study	1
B. Steps necessary to formulate a lake management plan	2
II. Identifying critical information	
A. What do we already know about the lakes?	3
B. Summary of available information	6
III. Collection of additional necessary information	
A. Annual water budget	7
B. Threatened and endangered species in the area	9
C. Numbers and kinds of livestock in the watershed	11
D. Stormwater management practices	11
E. Property ownership	13
F. Wetland quality	13
G. Sediment nutrient values	13
H. Wastewater treatment practices	16
I. Land use information in the watershed	16
J. Bacteria update	17
IV. Identification of problems	
A. Nutrient loading based on measured values	18
B. Nutrient loading based on modeling	20
V. Proposed solutions	22
VI. Preliminary cost estimates	24
VII. Easements	29
VIII. Public participation	30
IX. Project constraints	31

X. Signs of success 34

XI. References 35

Table of Contents (Continued)

Page No.

Figures

Fig. 1	The Indian Lakes Chain	1
Fig. 2	Rare biological resources	10
Fig. 3	Town of Wolcottville stormwater system	12
Fig. 4	Plat map of the watershed	14
Fig. 5	Wetlands in the watershed	15
Fig. 6	Land use in the watershed	16
Fig. 7	Sites used for bacteria sampling	18
Fig. 8	Annual phosphorus loading in the watershed	22
Fig. 9	Strategies and proportions of P-removal	24
Fig. 10	LARE land treatments planned for the watershed	26
Fig. 11	Typical sediment-clogged channel	28
Fig. 12	Sensitive wetland areas on Witmer Lake	33
Fig. 13	Photograph of the first cisco caught in the watershed since 1975.	34

Tables

Table 1	Nutrient levels in sediments at channel inlets	13
Table 2	Estimated P- loading from various sources	18
Table 3	Phosphorus removal goals	22
Table 4	Sediment removal - site dimensions	26
Table 5	Potential project constraints	31

Appendices

Eutromod summary
Nutrient sampling results
Public meeting attendance
Information handouts
Channel dredging permit application
Grant applications for dredging project
U.S. Army Corps of Engineers letter - dredging
LARE watershed land treatment summary

Storm filter information

EXECUTIVE SUMMARY

The Five Lakes Conservation Club received a grant from the Indiana Department of Natural Resources Division of Soil Conservation through the Indiana Lake and River Enhancement Program. The purpose of the grant was to assist the club develop an "Engineering Feasibility Plan" for improving water quality in Witmer, Westler, Dallas, Hackenberg, and Messick Lakes in the Indian Lakes chain of LaGrange County, Indiana.

All available information on lake quality was assembled. Then new information was gathered on lake water budgets, rare biological resources, watershed land use, stormwater management, property ownership, wetland quality, sediment nutrient values, wastewater treatment, and bacteria. The new information was used to identify problems in the lakes and work toward economical solutions.

Excessive phosphorus loading was identified as the major impediment to water quality in the Indian Lakes chain. Four major phosphorus control treatments were identified: (1) sediment removal in lake channels receiving off-site drainage and from the Mill Pond on Little Elkhart Creek, (2) additional wastewater treatment at the Adams Lake Regional Sewer District, (3) stormwater runoff treatment in the Town of Wolcottville, and (4) a volunteer program of algae harvesting. The total estimated cost of these measures was $81,000.

As part of the project, a sediment dredging permit application was sent to the Indiana Department of Natural Resources Division of Water. Applications for financial assistance were made to the IDNR LARE program and to the Build Indiana Fund (BIF). Verbal agreements to participate in the proposed treatments were obtained from the Town of Wolcottville and the Adams Lake Regional Sewer District. A local farmer agreed to allow dredged sediments to be applied on agricultural land.

Two public meetings were also held as part of the project. The first meeting explained the planning process and invited local participation. The second meeting explained the findings of the study and some of the possible outcomes. Some landowners participated in a voluntary risk-assessment exercise. In examining their own use of land surrounding the lakes, thirty-three landowners identified erosion from walkways, seawalls, and stormwater runoff as the highest risks to water quality (1.8 points on a scale from 1 to 3).

As a sign of improving conditions in the lakes, the existence of the pollution-intolerant fish <u>Coregonus artedii</u> (cisco) was confirmed from the Indian Lakes chain for the first time since 1975.

INDIAN LAKES IMPROVEMENT PROJECT

I. INTRODUCTION

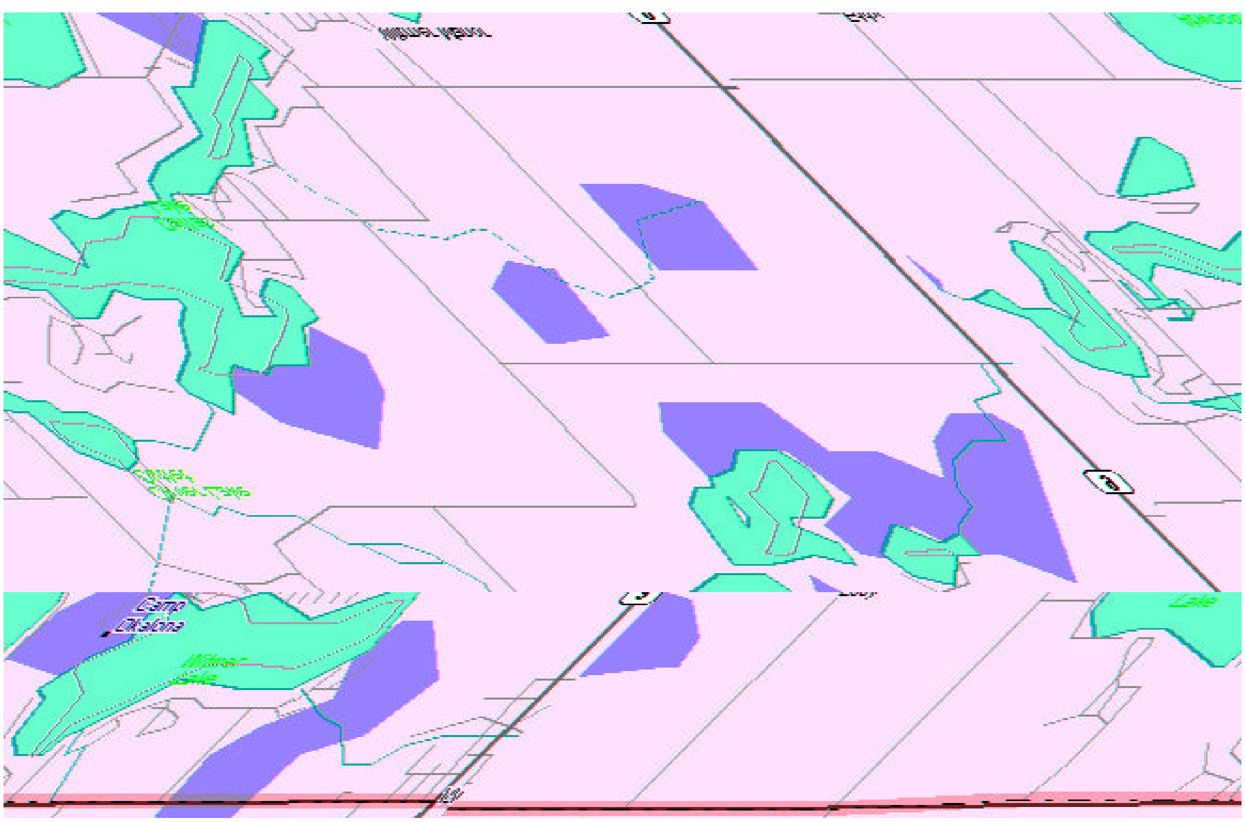
A. BACKGROUND OF THE STUDY

The Indian Lakes chain of lakes in northeastern Indiana is composed of Witmer, Westler, Dallas, Hackenberg, and Messick Lakes. These five lakes in LaGrange County have a combined surface area of 685 acres. The chain has a watershed area of about 51 square miles, fed mostly by Little Elkhart Creek (Figure 1).

Each of the Indian Lakes has been sampled several times over a 25 year period by IDEM, SPEA, and a private consultant (F.X. Browne). These studies indicated the possibility that nutrient levels in the lakes were increasing and that the quality of the lakes was declining. State-endangered cisco, a pollution-sensitive fish once common in the lakes, were thought to be extirpated. Livestock have ready access to streams draining into the lakes. Some of the areas around the lakes were unsewered. Urban runoff from the Town of Wolcottville, immediately upstream from the chain, could also be contributing to water quality problems.

The Five Lakes Conservation Club received funding from the Indiana Lake and River Enhancement program of IDNR in April 1999 to conduct a Feasibility Study designed to help solve some of the lakes problems. This report includes collected additional needed information to finalize an action plan for improving lake quality.

Figure 1. Indian Lakes



B. STEPS NECESSARY TO FORMULATE A PLAN

1. Critical information gaps are identified

2. Specific problems in the watershed which could interfere with lake quality are identified

3. Practical, economical solutions to the problems are identified

4. Specific sites for management are identified and their selections are justified

5. Potential project constraints (excessive costs, land uses, etc.) are identified

6. Sites where easements could be necessary are identified

7. Impacts of the proposed project on condition of the lake are determined

8. A wetland assessment and vegetation survey of areas which may be affected by the proposed project are included

9. A survey of biological and habitat integrity near the proposed project sites are made to determine if the project could impair present lake uses

10. A prediction of the effects of the plan on pollutant loading, lake quality, lake wetlands, aquatic habitat, and flooding is made

11. The process of obtaining permits necessary for construction is begun and documented

12. Conceptual drawings for proposed structures are made

13. Preliminary project cost estimates and timelines are prepared so the Five Lakes Conservation Club can prepare for future phases of the plan

14. Potential sources of funding for future work necessary to carry out the plan are identified

15. The minutes of two meetings with local landowners and people potentially affected by the project are presented

16. An information handout explaining the plan (and made available at the two public meetings) is presented

II. IDENTIFYING CRITICAL INFORMATION

A. WHAT DO WE ALREADY KNOW ABOUT THE LAKES?

USGS, 1980. Drainage atlas of Indiana.

The Indian Lakes Chain is fed mainly by Little Elkhart Creek, which has a total drainage area of 31 square miles. Other lakes in the watershed upstream from the Indian Lakes Chain include Blackman, Adams, Shockopee, Cree, Tamarack, and Nauvoo. Another unnamed tributary with a drainage area of 15 square miles flows into the lower two lakes in the Indian Lakes Chain from the north. Lakes upstream from this tributary include Martin, Olin, and Oliver. Outflow from Atwood Lake also flows into the chain.

Grant, W.F., 1998. Movement of septic system effluent from lake developments into near-shore areas of 18 Indiana lakes. LaGrange County Health Dept. Report.

This report included data on fecal coliform bacteria, phosphorus, and "leachate detector" information for all five of the Indian Lakes chain. The report found that all five of these lakes had surrounding soils with severe limitations for septic systems. The septic leachate detector found septic tank effluent in all five lakes and fecal coliform bacteria counts above 200 MPN/100 ml in all lakes but Messick. The study also found that bacteria levels were highest when the lakes had high water in May and June. The bacteria dropped to safe levels in July and August, as the lake levels also dropped. The study attributed this to the greater influence of septic tanks during high water levels.

Indiana Lake Classification System and Management Plan, 1986. Indiana Department of Environmental Management, Indianapolis IN.

Trophic status of the lakes was determined during the 1970s. The Trophic Indices ranged from 25 (Westler Lake) to 29 (Hackenberg Lake).
The average value was 27, which is considered "Class II" (medium quality).

Indiana Natural Resources Commission, 1996. Wetlands within public freshwater lakes. Indiana Register 19:940-953

Includes maps of Witmer, Dallas, Hackenberg, and Messick Lakes, showing wetland profiles (significant wetlands and areas of special concern).

Indiana Department of Natural Resources, 1998. Indiana lakes exotic plant survey. Lake and River Enhancement Program, Indianapolis, IN

Information was collected by IDNR on the presence of exotic plants in Indiana lakes. All five of the Indian Lakes chain lakes supported Eurasian milfoil and curlyleaf pondweed. These were "common" in all lakes except Messick, where they were "abundant." Purple loosestrife was known to be present (but rare) around Witmer, Westler, and Dallas Lakes.

Indiana Department of Environmental Management, 1996. Indiana Lake Water Quality Update for 1989-1993.

Trophic status of the lakes was determined during the 1990s. The IDEM Trophic Indices ranged from 15 (Dallas Lake) to 34 (Hackenberg Lake). The average value was 23. This is an improvement from earlier years.

F.X. Browne, 1992. Diagnostic study of 10 lakes in LaGrange County. Report for the IDNR Lake and River Enhancement Program, Indianapolis IN.

This study included nutrient and modelling data for the Indian Lakes Chain. The study also calculated the IDEM Trophic Index values for each lake. The average value was 41 (much higher than previous studies). The highest value (56) was for Hackenberg Lake. The lake showing the largest increase was Westler (from 18 to 52). Livestock feedlots were found at 13 sites in the watershed. However, modelling indicated that row crop agriculture contributed the largest percentage of nutrients by volume. Very high fecal coliform bacteria levels (greater than 200,000 per 100 ml) were found in several lake inlets. The epilimnion of all lakes was only 5 meters deep. Recommendations for lake management included "nutrient inactivation" and "hypolimnion aeration."

Frey, D.G, 1955. Distributional ecology of the cisco in Indiana. Investigations of Indiana Lakes and Streams 4: 177-228, Indiana Univ. Dept. of Zoology.

During 1952, the author collected water quality data from four of the Indian Lakes chain lakes to determine whether cisco (a fish which requires very high water quality) could maintain viable populations there. Only Dallas and Messick Lakes had viable cisco layers, where water temperature did not exceed 20 degrees C and dissolved oxygen remained greater than 3 mg/l. All four of lakes were known to have supported cisco populations at one time. By 1952, only Dallas Lake still had a remnant population of this fish. Dissolved oxygen was present in the water column of Dallas Lake to a depth of 16 meters during

summer stratification.

Spacie & Loeb, 1990. Long-term trends in trophic state of Indiana lakes following phosphorus reduction. Verh. Internat. Verein. Limnol. 24:464-469.

Among the lakes examined in this study was Dallas Lake. It had a mean retention time of 0.4 years. Phosphorus loading was 1.3 g/sq m/yr. This amount of P-loading was in the "excessive" level, meaning the eutrophication rate would be above normal. The mean chlorophyll-a concentration was 7.4 ug/l, the mean water column phosphorus concentration was 25.7 ug/l, and the mean Secchi disk reading was 2.2 meters.

USGS, 1997. Water resources data: Indiana. Water year 1997. Report # IN-97-1, Water Resources Division, Indianapolis IN

The legal level of the Indian Lakes Chain, as established by the LaGrange County Circuit Court in 1954, is 897.36 feet above sea level. The highest level recorded since 1945 is 901.17 feet (Apr. 7, 1978), while the lowest level has been 896.34 feet. During a typical year, lake level varies by about 2 feet between maximum and minimum.

SPEA, 1998. Secchi Disk Summary Data - 1998. Indiana University, Bloomington, IN

Volunteer monitoring data for Witmer, Dallas, and Westler Lakes. The Secchi Disk values during July and August of 1998 averaged 4 feet in Witmer Lake to 5.4 feet in Dallas Lake. Carlson Trophic Status Index based on Secchi Disk readings ranged from 53 in Dallas Lake to 57 in Witmer Lake. The U.S.EPA classification for these values based on water transparency place each of the lakes in the "poor" category. Carlson TSI values place in lake in the "eutrophic" category.

IDNR, 1998. Fish Management Reports. Witmer, Westler, Dallas, Hackenberg, Hackenburg Lakes.

IDNR fisheries biologists collected fish from all five of the Indian Lakes during the summer of 1998. They also conducted a creel survey of fishermen. The most frequently caught fish in the creel survey were bluegill (46%) and black crappie (30%) with an estimated total weight of over 3000 pounds. Local lake residents accounted for only 16% of the fishermen interviewed. In the fisheries surveys conducted by biologists, bluegill accounted for about three-quarters of

all fish caught in each lake, but up to 26 additional species were present (no cisco were caught). The only fish commonly stocked in the lakes are channel catfish, which appeared to be doing well in each lake. No diseased fish were caught. No serious shoreline erosion or nuisance aquatic plant growths were noted.

B. SUMMARY OF AVAILABLE INFORMATION

Water quality of the Indian Lakes Chain has declined significantly during the past 50 years. The IDNR fisheries data suggested that since 1975 the lakes no longer support the pollution intolerant fish Coregonus artedii (cisco). The epilimnion (the upper layer of water where oxygen is present during the summer) in Dallas Lake has been reduced from 16 meters to 5 meters during this time. The other four lakes have had similar reductions in the amount of aerated water.

Nutrient and sediment inputs are still too high. If they remain where they are, the lakes will continue to age more rapidly than the natural rate. Most of the lakes are presently classified as "Class II" which means that they have an intermediate level of concern. Such lakes frequently support extensive growths of macrophytes or algae but seldom to the extent that their uses are impaired.

Most of the nutrient and sediment inputs to the chain are from Little Elkhart Creek feeding Witmer Lake, simply because this stream's watershed area is so large. However several smaller, unnamed tributaries draining into the lakes also have excessively high nutrient inputs. The inlets to Messick Lake at CR 550 S and to Hackenberg Lake at CR 75 W were identified as problem areas by F.X. Browne. Of the five lakes, water quality is consistently lowest in Hackenberg. The F.X. Browne trophic estimates probably over-stated the water quality problems, since no index values before or afterward were as high as those presented in their study.

Fecal coliform levels have been high in the lakes at times, especially during high water. Some studies suggest that septic tanks from lakeshore property owners are contributing to the high bacteria levels. Sewers are currently being built to serve some lake homes and alleviate this problem. The Town of Wolcottville's wastewater treatment plant no longer discharges its effluent to the lakes, thereby eliminating a previously important source of nutrient loading.

The lakes have a healthy fish community, dominated by bluegill. Nuisance species such as carp are present but in very small numbers and do not appear to have increased significantly over time.

III. COLLECTION OF ADDITIONAL NECESSARY INFORMATION

WHAT ADDITIONAL INFORMATION DO WE NEED TO MAKE GOOD DECISIONS ABOUT LAKE MANAGEMENT IN THIS WATERSHED?

A. Annual water budget
B. Endangered, threatened and rare species in the area
C. Numbers and kinds of livestock in the watershed
D. Stormwater management practices in the watershed
E. Property ownership
F. Wetland quality
G Sediment nutrient values at inlet sites
H. Wastewater treatment practices upstream from Wolcottville
I. Land use information in the watershed
J. Bacteria update

A. ANNUAL WATER BUDGET

This information was prepared using available data on watershed size, average evaporation rate, and local precipitation. The size of each sub watershed was obtained from the U.S. Geological Survey [1]. In the North Branch of the Elkhart River, each square mile of watershed area is associated with an average of 7.5 gallons of runoff per second [2].

INPUTS	area (square miles)	annual input (billion gallons)
Little Elkhart Creek	31	7.3
Oliver Lake tributary	15	3.6
Atwood Lake tributary	1	0.2
Other tributaries	1	0.2
Local runoff	0.5	0.1
Groundwater		0.1
Direct Precipitation		0.7
OUTPUTS		
Messick Lake outflow		11.1
Evaporation		1.1
Seepage		0.1

This information was prepared using data from the Indiana Lake Classification and Management Plan

	Lake Surface Area acres	Mean Depth feet	Estimated Volume billion gallons
Witmer	**204**	**35**	**2.3**
Westler	**88**	**20**	**0.6**
Dallas	**283**	**35**	**3.2**
Hackenberg	**42**	**12**	**0.2**
Messick	**68**	**21**	**0.5**

The total surface area of the lakes is 665 acres.
Total volume of the lakes is 6.8 billion gallons
Mean residence time of a gallon of water is as follows:

Witmer	**0.3 yrs (110 days)**
Westler	**0.1 yrs (36 days)**
Dallas	**0.4 yrs (150 days)**
Hackenberg	**0.02 yrs (7 days)**
Messick	**0.05 yrs (18 days)**

B. ENDANGERED, THREATENED AND RARE SPECIES AND HIGH QUALITY NATURAL AREAS

The IDNR Natural Heritage Program catalogues the presence of endangered, threatened, and rare species and high quality natural areas in Indiana. On April 21, 1999 Ronald Hellmich of the Indiana Natural Heritage Data Center provided the following on-file information from the Indian Lakes Chain area:

Species	Status	Location	Date
Wild calla	State endangered	Indian Lakes	1900
Cisco	State special concern	Sec 31, 32, 33	1955
Cisco	State special concern	Sec 24,25,26,30	1975
Bluespotted salamander	State special concern	Sec 31,32	1997
Eastern massasauga	State endangered	Sec 19, 24	1992
Sandhill crane	State endangered	Sec 25 (nest)	1996
Marsh wren	State endangered	Sec 19, 24	1986
River otter	State endangered	Sec 25, 30	1999

Aquatic Habitat	Status	Location	Date
Wetland/Marsh	Significant	Sec 19, 24	1984

LAND AND WATER CONSERVATION FUND SITE - Dallas Lake Park

A map showing more precise locations of these natural heritage items is shown in Figure 2:

C. NUMBERS AND KINDS OF LIVESTOCK IN THE WATERSHED

LaGrange County has one of the highest densities of livestock in Indiana. According to data from the Purdue University agricultural statistic department, LaGrange County ranks in the upper 25% of Indiana counties for overall livestock density. The county has 41,000 cattle, 108,000 hogs, 1500 sheep, and 1.3 million chickens. There are no data specific to the Little Elkhart Creek watershed. However, if livestock density is equally distributed throughout the county, the Little Elkhart Creek watershed would host approximately 5000 cattle, 14,000 hogs, 200 sheep, and 170,000 chickens. Manure production from this amount of livestock would result in approximately 150,000 kg of phosphorus per year. Since the goal of this plan is to reduce phosphorus loading to the lakes to below 3000 kg per year, good manure management is going to be very important. Precise location of these sources was outside the scope of the present project.

D. URBAN STORMWATER - WOLCOTTVILLE

The Town of Wolcottville (population 900) is located directly upstream from the Indian Lakes chain. The town has a stormwater drainage system which flows into Little Elkhart Creek. A map of the stormwater system was provided by the town and is shown in Figure 3. Urban stormwater runoff is an important source of nutrient loading in many lake watersheds. An estimate of phosphorus loading from this source was calculated using the following assumptions:

Urban Area = 140 ha
Annual Precipitation = 1 meter
Average P Concentration = 0.46 mg/l (U.S.EPA [10] average for urban areas)
Runoff Coefficient = 40% (D.M Gray, Principles of Hydrology)

Anual Loading

Total Area	1,400,000 square meters
Total Volume	1,400,000 cubic meters
Total Annual Runoff	600,000 cubic meters per year 60,000,000 liters per year
Total Annual P Loading	30 kg

Target areas for control will be discussed in Section V.

E. LAND OWNERSHIP

Most of the land directly around the lakes is sub-divided into small lots for residential development. A plat map showing land ownership of the larger parcels in the watershed is shown in Figure 4.

F. WETLANDS

There are numerous wetlands in the watershed. A map of wetlands based on the National Wetland Inventory maps is shown in Figure 5. Most of these are "palustrine" (shallow, freshwater, not flowing) with a high potential for sediment and nutrient filtration.

G. IDENTIFICATION OF SEDIMENT NUTRIENT "HOTSPOTS"

Single samples of bottom sediments where tributaries fed the lakes were sampled for nitrogen and phosphorus during the summer of 1999 to help determine whether sediment traps or dredging would be beneficial. Sites with elevated levels of nutrients (greater than the mean for Illinois lakes, as reported by Illinois EPA) are noted. The sites and sampling results are shown in the Appendix and summarized below:

Table 1. Nutrient Levels in Bottom Sediments at Channel Inlets

Site	Nitrogen mg/kg	Phosphorus mg/kg	Elevated?
Illinois Mean [7]	3400	600	
Witmer trib. (SE)	2000	640	yes
Witmer trib. (NE)	1600	1500	yes
Witmer trib. (SW)	4300	820	yes
Mill Pond (U/S Witmer)	4800	950	yes
Dallas drainage pipe	920	73	no
Westler ditch	1400	160	no
Westler channel	4400	1500	yes
Hackenburg inlet	2200	140	no

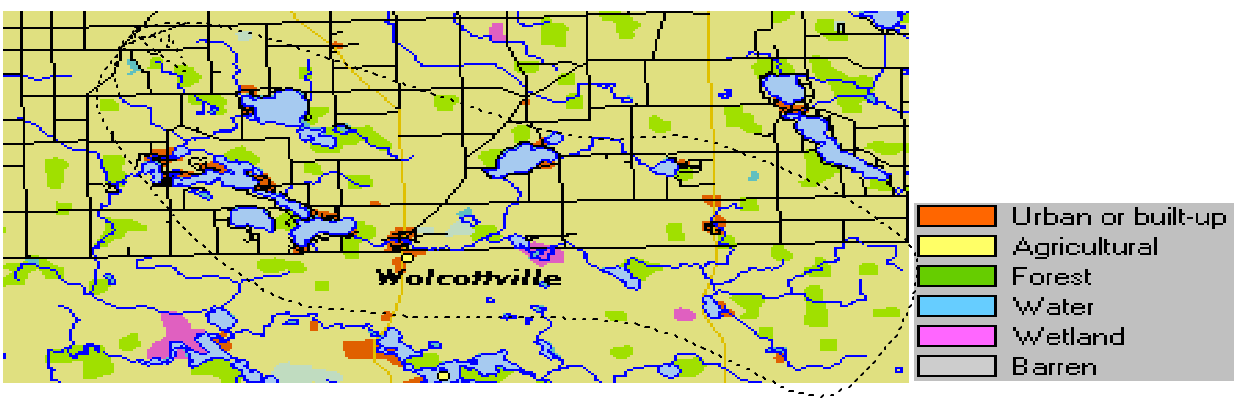
H. WASTEWATER TREATMENT PRACTICES UPSTREAM FROM WOLCOTTVILLE

The Adams Lake Regional Sewer District has a waste stabilization lagoon system serving a population of approximately 850. The system discharges treated sanitary wastewater to Little Elkhart Creek upstream from Wolcottville. The lagoons were installed in 1992 and discharge seasonally. There are no other sewered communities in the watershed. Wastewater flow from the Adams Lake Regional Sewer District is approximately 25 million gallons annually. The Adams Lake RSD has an NPDES permit which requires total phosphorus in the wastewater to be below 1 mg/l. If the RSD meets this limit consistently, the annual phosphorus loading from this source will be 100 kg. As the lagoons age, the 1 mg/l limit will be increasingly difficult to meet. A typical waste stabilization lagoon discharges approximately 6 mg/l total phosphorus [9]. At this rate, the annual loading from the Adams Lake RSD will be 600 kg.

I. LAND USE INFORMATION IN THE WATERSHED

Land uses, obtained from the Indiana Geological Survey spatial database for the Wolcottville area, are shown in Figure 6. Nearly 90% of the land use in the watershed is agricultural, including livestock production, row crop agriculture, and pasture.

Fig. 6. Watershed land use



J. BACTERIA UPDATE

Local resident Robert Christen volunteered to conduct a study of potential disease-causing bacteria in the lakes. He used a modification of the fermentation tube technique with EC media (Standard Method 908 C). One milliliter of lake water was pipetted into each fermentation tube. A fresh sterile pipette was used for each sample. Incubation was allowed to occur at 30 degrees C for 48 hours. Positive tubes were identified by the presence of cloudy media and formation of a gas bubble. A positive reading in this test corresponds to a coliform bacteria level greater than 100 cells per 100 ml. Since Indiana water quality standards for whole body contact require a long-term average concentration of E. coli less than 125 cells per 100 ml, this presence-absence estimate is a good approximation of the level at which health risks associated with swimming in the water begin to occur.

Bacteria samples were collected and analyzed on August 15, 1999 at 10 sites on Witmer, Westler, and Dallas lakes and 1 site on Little Elkhart Creek as it flows into the Indian Lakes chain. The sites are shown in Figure 7 and listed below:

Little Elkhart Creek in Wolcottville
Witmer Lake - by island
Witmer Lake - at main inlet
Witmer Lake - northeast end
Witmer Lake - north side
Witmer Lake - Troyer channel
Witmer Lake - Coody Browns
Westler Lake - inlet from Witmer Lake
Westler Lake - channel near marina
Westler Lake - 2^{nd} channel on west side
Dallas Lake - inlet from Westler Lake

Only the Little Elkhart Creek sample was positive. Based on samples collected that day, health risks associated with swimming in the lakes appeared to be low.

Figure 7. E coli Sampling Sites
Each black dot represents a site sampled on 8/15/99

IV. IDENTIFICATION OF PROBLEMS

A. NUTRIENT LOADING BASED ON MEASURED CONCENTRATIONS

According to the Vollenheider Model of nutrient loading, an accumulation of 0.7 grams of phosphorus per square meter per year would be acceptable for Dallas Lake (a normal rate of eutrophication would occur at this input). A level higher than this would be excessive. Data presented by Spacie and Loeb [3] indicated that the loading to Dallas Lake in the 1980s was approximately 1.3 grams per square meter per year, which is about 2 times higher than the acceptable level.

Where is the phosphorus coming from? Data from the F.X. Browne study [4] suggest that Little Elkhart Creek contributes most of the phosphorus, primarily because of its large watershed size. A typical phosphorus value for this stream was 0.12 mg/l (50% lower during baseflow, 50% higher during stormflow). Other streams had higher P values but were much smaller watersheds (Table 2).

Table 2. Estimated phosphorus loadings from various sources

	Annual Flow liters x 10^9	Phosphorus mg/l	Phosphorus kg/yr
Little Elkhart Creek	28	0.12	3,340 (61%)
Unnamed Tributary 1	3	0.30	900 (17%)
Unnamed Tributary 2	1	0.30	300 (5%)
Atwood Lake Tributary	1	0.05	50 (1%)
Local Runoff *	1	0.80	800 (15%)
Precipitation	1	0.01	10 (<1%)
TOTAL			5,400

* local runoff includes areas immediately surrounding the lakes but where no distinct channels for runoff occur.

Since the F.X. Browne study was completed, the Town of Wolcottville has moved its wastewater treatment plant discharge to Little Elkhart Creek downstream from Messick Lake. Approximately 0.1 mgd of phosphorus-containing wastewater is no longer added to the Indian Lakes Chain from this source. This has resulted in an estimated decreased phosphorus loading of 700 kg/yr from Little Elkhart Creek. Now, the estimated loading (in kg/yr and relative percentages) is:

Little Elkhart Creek	**2640 (56%)**
Unnamed Tributary 1	**900 (19%)**
Unnamed Tributary 2	**300 (6%)**
Atwood Lake Tributary	**50 (1%)**
Local Runoff	**800 (17%)**
Precipitation	**10 (<1%)**
TOTAL	**4700 kg/yr**

B. NUTRIENT LOADING BASED ON MODELING

The EUTROMOD model developed by Duke University allows estimates of nutrient loading based on land use in the watershed. The following data were used in the model:

Agricultural Land Use	6700 ha
Forest Land Use	800 ha
Urban Land Use	200 ha
Feedlots	20 ha
Number of Septic Tanks	1000

For Witmer Lake, the following items were also added to the model:

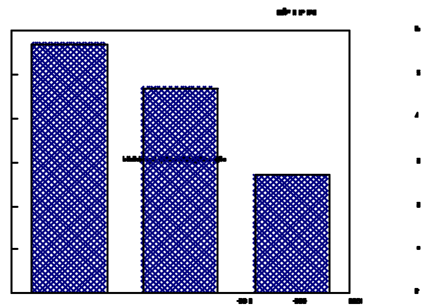
Lake Area	0.85 sq. km
Mean Depth	10.5 m

The model predicts the following results for Witmer Lake with present land uses (actual measurements from F.X. Browne are also shown for comparison):

	Predicted	Actual
Feeder stream Phosphorus	0.12 mg/l	0.12 mg/l
Feeder stream Nitrogen	2.5 mg/l	4 mg/l
Water column Phosphorus	0.06 mg/l	0.09 mg/l
Water column Nitrogen	0.6 mg/l	1.1 mg/l
Chlorophyl a	10 ug/l	7 ug/l
Secchi Depth	2.1 m	2 m
Trophic Status Index	58	57

The predicted vs. actual values are reasonably close for almost all parameters. The model also predicts a phosphorus loading rate of about 4000 kg/yr. This compares favorably with the rate predicted by instream measurements (4700 kg/yr, see above). Based on these data, the Eutromod model appears to be very effective at predicting lake responses to various changes in land use in the Indian Lakes watershed. A summary of the model results is included in the Appendix.

Figure 8.



V. Proposed Solutions to Excessive Phosphorus Loading

To keep the Indian Lakes chain healthy for years to come, we need to reduce phosphorus loading by 50% from the levels measured in 1992. At that time, annual loading was estimated to be 5600 kg/yr. Therefore, our goal would be to reduce phosphorus loading by 2800 kg/yr. How do we most effectively reduce phosphorus loading? First, we need to identify where the largest or most concentrated sources are located within the watershed. These will be the most cost-effective to control. Based on available land use data, the following sites were probably among the most concentrated phosphorus sources in 1992:

Wolcottville Wastewater Treatment Plant	700 kg/yr	15%
Adams Lake Regional Sewer District	600 kg/yr	13%
Lakeshore septic tanks	350 kg/yr	7%
Concentrated Livestock (Feedlots)	250 kg/yr	5%
Lakeshore lawn runoff	200 kg/yr	4%
Wolcottville Stormwater Runoff	30 kg/yr	1%

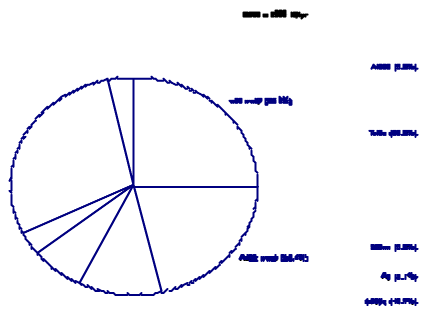
Phosphorus inputs from the Wolcottville Wastewater Treatment Plant were eliminated in 1997 by moving the discharge downstream of the lakes. In addition, sewers have been installed around Witmer Lake, eliminating about 250 septic tanks. These two improvements have already removed about 800 kg/yr (almost 30% of our original goal). The new goal is to find and remove an additional 2000 kg/yr of phosphorus inputs to the lakes.

Table 3 summarizes a plan for eliminating some of the remaining sources of phosphorus loading to the Indian Lakes Chain. Each method is discussed in more detail below.

Table 3. Annual Phosphorus Removal Methods and Goals

LARE Land Treatments	400 kg/yr
Adams Lake RSD Phosphorus Removal	600 kg/yr
Nutrient-enriched Sediment Dredging	500 kg/yr
Eliminate Remaining Septic Systems	350 kg/yr
Wolcottville Urban Runoff Control	30 kg/yr
Algae Harvest	100 kg/yr

Figure 9



VI. PRELIMINARY COST ESTIMATES OF ELEMENTS OF THE PLAN

BEST MANAGEMENT PRACTICES FOR LAND TREATMENT

The following are estimated costs to remove one kilogram of phosphorus from urban stormwater (based on data presented by Brown and Schueler in [5]):

0.2 acre pond	$250
1.4 acre pond	$180
Organic filter	$790

There is no reason to believe that phosphorus removal in urban and agricultural stormwater is significantly different, so at least $200 per kg seems to be a reasonable estimate for nonpoint source phosphorus control costs. If our goal is to reduce phosphorus loading in the watershed by 2000 kg per year, an annual cost of about $400,000 would necessary to simply treat stormwater runoff. The Lake and River Enhancement program is currently involved with installation of various land treatments in the watershed (these include grassed waterways, filter strips, and water and sediment control basins). Project areas currently active are shown in yellow in Fig. 10, which was produced by the Noble County SWCD. A total of $54,000 has been dedicated to this project through1999. However, it is doubtful that enough resources could be allocated to land treatment alone to reach the 2000 kg per year goal.

ALUM TREATMENT OF WASTEWATER

Alum treatment of domestic wastewater originating from waste stabilization lagoons is accomplished by pumping liquid aluminum sulfate from a boat directly into the water to be treated. This type of treatment costs approximately $8 per kg of phosphorus removed. This price is based on the use of 25 drums of alum per year at $80 per drum and applicator labor costs of approximately $3000 per year. The total cost to remove the 600 kg/yr of phosphorus originating from the Adams Lake Regional Sewer District, based on this figure, is approximately $5,000 per year. The only potential negative effect from alum treatment is the need to dredge the lagoons somewhat more frequently due to the accumulation of additional aluminum phosphate in the sediments.

The sewer district management is not required by any permit to do phosphorus removal beyond 1 mg/l or to pay for additional removal. However, a 1 mg/l limit is extremely difficult to meet with a lagoon wastewater treatment system and the district is interested in allowing alum treatment on an experimental basis.

URBAN STORM FILTERS

Storm filters for treatment of urban runoff are capable of removing 90% of fine sediment in the water. An example of such a filter and its use is shown in the Appendix. Assuming, as shown in other studies of urban runoff [11], that half of the phosphorus in stormwater runoff is particulate, it is possible to remove approximately 30 kg of phosphorus per year by installing storm filters in the Town of Wolcottville. Several storm filters placed strategically in town could treat two-thirds of the runoff in Wolcottville. This would remove approximately 30 kg of phosphorus. The estimated annual cost for this treatment is approximately $200 per kg ($6000 per year). Although this is only a small fraction of the total annual P-loading in the watershed, an added benefit of an urban stormwater filter would be the removal of other floatables (trash), often present in urban areas, before they entered Little Elkhart Creek and the Indian Lakes Chain. An example of a storm filter and its possible use is shown in the Appendix.

NUTRIENT REMOVAL BY SEDIMENT DREDGING

Sediments from agricultural areas often contain high levels of nutrients. These can be carried by streams and deposited in the still water areas of lakes. Nutrient-enriched sediments can be trapped before they reach the lakes. In the Indian Lakes chain, there are several channels which act as natural sediment deposition areas. Sediments accumulated there can be dredged out periodically and returned to the land as fill or fertilizer. Based on estimates provided by several contractors, it costs about $15 per cubic meter to remove, transport, and dispose of sediment. If the sediment contains 1 g/kg of phosphorus and a cubic meter of sediment weighs 1000 kg, each cubic meter contains 1 kg of phosphorus. Based on these figures, the cost for phosphorus removal by sediment excavation is $15 per kg. An additional cost is necessary if a sediment trap has to be constructed.

Several sites which contain nutrient-enriched sediments have been identified (Table 1). A photograph of a typical site is shown in Figure 11. These sites have easy access for heavy equipment and no structures will need to be built. A summary of the sites is shown below. A permit application to remove sediments from these sites was submitted to IDNR Division of Water on March 9, 2000 (see Appendix).

Table 4. Sediment Removal - Site Dimensions

	Width (m)	Length (m)	Depth (m)	Volume (m^3)
SE Witmer	7	10	0.65	200
SW Witmer	10	30	0.65	200
N Witmer	10	30	0.65	200
Channels Witmer	10	210	0.65	1360
NE Westler	7	40	0.65	200
Main Westler	20	20	0.65	240

TOTAL SEDIMENT TO BE REMOVED 2400 m^3

ESTIMATED COST (@ $15 per cubic meter) $36,000 + $4000 oversight

Phosphorus removed $1\ g/kg * 1000\ kg/m^3 * 2400\ m^3 = 2400\ kg$

The rate of sediment accumulation has not been estimated. However, if sediment is removed once every 5 years, the annual phosphorus removal rate will be approximately 500 kg/yr.

Additional sediment removal from a mill pond upstream from Wolcottville is economically feasible. This privately-owned pond (named Wolcott Lake in the Indiana Lakes guide published by IDNR) acts as an efficient trap for sediments generated in the 30 square miles upstream from the Indian Lakes chain. No permit has been sought for this site yet. The 25 acre pond has accumulated approximately 2000 cubic meters of nutrient-rich sediment which could be periodically excavated and removed from the watershed.

Sediment disposal will occur on an upland site. One landowner has been identified as willing to accept this sediment. A verbal agreement has been made but no legal documents have been signed. A copy of the “easement” letter explaining the project to the landowner is shown in Section VII below.

ALGAE HARVESTING

Volunteer labor could be effective in reducing some of the phosphorus loading. Algae cells typically contain a large amount of phosphorus. A pound of dried algae may contain as much as 3 grams of phosphorus. Lakeshore property owners on channels which develop severe algae blooms (“moss”) could manually remove and compost the algae each summer. Composting is necessary so the nutrients do not run back into the lake as the algae decompose. There is no financial cost for this method of phosphorus removal. A hundred volunteers each harvesting 300 pounds of algae per summer could potentially remove up to 100 kg of phosphorus from a waterbody in the course of a year.

This type of phosphorus removal is effective both as a treatment and as an educational tool. Getting local lake associations personally involved with the project could serve as a way to get landowners along the lake shore to manage their property in more water-friendly ways. Organizing local "moss-harvest" competitions would help stimulate involvement.

SUMMARY OF POTENTIAL PROJECT COSTS

Land Treatments	$54,000 in 1999 (IDNR on-going project)
Sediment Removal	$40,000 each time, as necessary, for channels
	$30,000 each time, as necessary, for mill pond
Wastewater Treatment	$ 5,000 annually
Storm Filters	$ 6,000 annually
Algae Harvest	No cost

VII. EASEMENTS

EXAMPLE LETTER SENT TO LANDOWNERS OF CRITICAL PROPERTY

23 August 1999

Homeowner
Street Address
Wolcottville IN 46795

Dear Homeowner:

I am helping the Five Lakes Conservation Club design a plan to improve water quality in the Indian Lakes chain of lakes near Wolcottville. The local plat book shows that you may own property in the lake watershed which could be a critical area in the club's plan to reduce nutrient inputs to the lakes.

First, I want you to know there is no obligation whatsoever on your part to participate in this project. Everything in the club's plan is strictly voluntary and if you choose not to participate, the plan will not include your property in any way. However, if you want to learn more about the plan, I would be happy to contact you with information. Funding may be available to pay you in some way to help manage your property to benefit the lakes' water quality.

A self-addressed, stamped card is enclosed. If you respond by mailing this card back in the next week or so, I will contact you with more information. If I don't receive your card, I will assume you don't want to participate and no one will contact you in any way. In any case, thanks for your time!

Sincerely,

VIII. PUBLIC PARTICIPATION

A public meeting was held June 19, 1999 at the Wolcottville Elementary School. Twenty-five people attended (see participant list in the Appendix). A flier explaining the purpose of the project was prepared by Commonwealth Biomonitoring and passed out to each person attending the opening meeting (a copy is included in the Appendix). There was a question and answer period. Bob Christen and Tom Patterson of the Five Lakes Conservation Club fielded questions about local concerns. Greg Bright of Commonwealth answered questions about how the project was funded, what it hoped to accomplish, and when it was to be completed.

Approximately 100 copies of the Michigan State University brochure "Managing Shoreline Property to Protect Water Quality" were passed out at the first meeting. The 4-page brochure included three assessments individual property owners could make to determine the degree of risk to water quality associated with their use of land. Bob Christen and Tom Patterson volunteered to collect these forms and return them to Commonwealth when completed.

The first set of brochures was returned within 4 weeks from a group of 33 landowners on Dallas Lake. The brochures assign a degree of risk from 1 (low) to 3 (high) for three different land uses. The following results were obtained:

	Mean Risk	
Septic Systems	1.3	
Lawn Care	1.5	
Erosion	1.8	(walkways, seawalls, storm runoff)

The activity with the largest potential to adversely affect water quality, based on these "self-audit" results, is from abrupt concrete seawalls on many properties. The second highest risk was associated with stormwater runoff being allowed to flow directly into the lake in many places. Remedial measures for these type of projects are strictly voluntary for each lakeshore landowner. The exercise was useful for getting local lot owners to consider how their use of the land affects the lakes.

A second public meeting was held at the same location on Saturday, October 2, 1999. Another flier was passed out. This flier (a copy is in the Appendix) explained what the study was finding out about lake quality and how local people could help keep pollutants out of the water.

The first outlines of a lake management plan were presented. Included in the plan were the possibilities of sediment removal, wetland restorations, stormwater filters, and wastewater treatment. The ultimate goal of the plan is to reduce phosphorus loading to the lakes by 50%. The meeting was attended by 36 people from all five lakes. An attendance roster is attached in the Appendix.

IX. PROJECT CONSTRAINTS

As with most environmental restoration projects on public and private land, there are constraints which could keep the plan from being implemented. Some of the major potential constraints are listed in Table 5.

Table 5. Potential Project Constraints and Remedies

Proposed Action	Potential Constraints	Potential Remedies
Sediment Removal	High cost Permits required Contamination	Public assistance grants
Wastewater Treatment	Disinterest by RSD	Cost-sharing with RSD
Storm Filters	Maintenance Filter costs	Provide volunteer labor Buy the filters as needed
Algae Harvesting	Lack of interest	Competitions

The Five Lakes Conservation Club submitted an early draft of this report as a basis for a second LARE grant to carry out these proposals in January 2000. The club also submitted a Build Indiana Fund grant request for mill pond dredging to the Indiana Legislature in January 2000. Copies of these grant requests are included in the Appendix.

An IDNR permit application in accordance with the "Lakes Preservation Act" was submitted on March 8, 2000 (see Appendix). This application is for the removal of nutrient-enriched sediments in six channels. The permit request was modified in July 2000 for sediment removal in only three of the channels (two on Westler Lake, one on Witmer Lake) because fewer than 100% of the affected landowners returned forms acknowledging the project on three other channels. Verbal permission to dispose of the sediments on agricultural ground has been obtained.

The Town of Wolcottville has indicated verbally that they will help with the installation and maintenance of storm filters. They do not have any money to allocate to this program. Financial help will be required, possibly through volunteers or through donations from the Five Lakes Conservation Club. The LARE grant application asked for $5000 for this purpose. This request is not contingent on the sediment removal proposal.

The Adams Lake Regional Sewer District has expressed a desire to participate in an experimental phosphorus treatment project. It is not clear yet who will pay for this. The LARE grant request asked for $5000 for this purpose. The request is not contingent on the sediment removal proposal.

There do not appear to be any biological resource constraints. The Department of Natural Resources does not have any significant wetland areas on the channels of Witmer Lake (Figure 12) and no threatened species are known to be in the project area (Figure 2). No changes in water level are required. No construction beyond the physical removal of sediments is required.

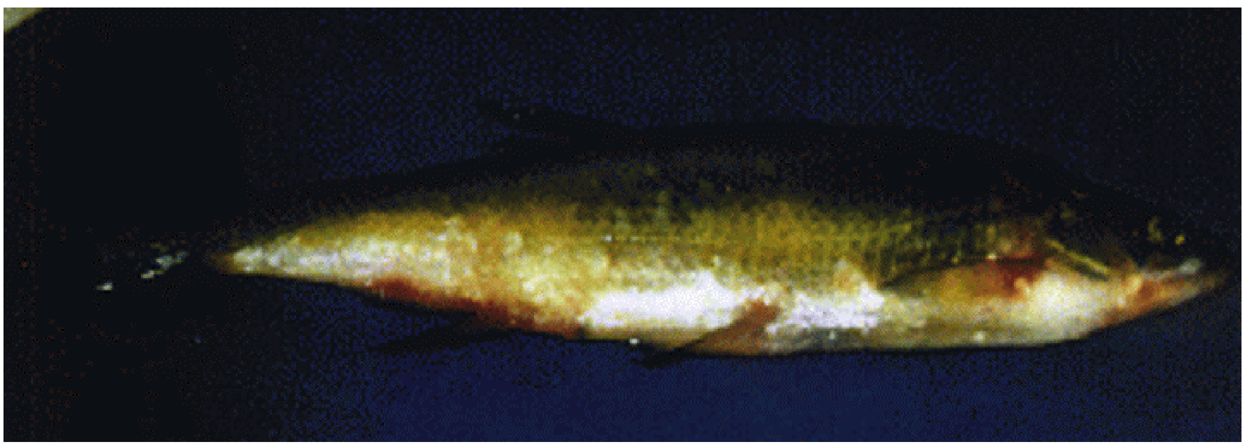
Fig. 12. Significant wetland areas on Witmer Lake (IDNR Division of Water)

X. SIGNS OF SUCCESS

As noted previously, the Indian Lakes chain once supported a thriving population of cisco (Coregonus artedii), a native fish in the trout family that requires good water quality. The last cisco reported from the Indian Lakes chain was collected in 1975. Cicso had been thought to have been extirpated entirely from the Indiana Lakes since then [8]. Many other Indiana lakes which once supported cisco have suffered the same fate as the lakes became more rapidly eutrophic in the 1960s.

However, in July 1998, local resident Phil Terwilliger caught a mature cisco in Dallas Lake. A photograph of the fish is shown in Figure 13. Most likely, a new population of cisco has been able to become established once more from fish migrating downstream from Oliver Lake where they still exist. The re-establishment of cisco in Dallas Lake is a positive sign of water quality improvements in the watershed.

Figure 13. Cisco from Dallas Lake - 1998



XI. REFERENCES

1. **Hoggatt, R.E. 1975. Drainage areas of Indiana streams. U.S. Geological Survey, Water Resources Division, Indianapolis, IN.**

2. **Arvin, D.V. 1989. Statistical summary of streamflow data for Indiana. U.S. Geological Survey Open-file Report 89-62, Indianapolis, IN.**

3. **Spacie, A. and S. Loeb, 1990. Long-term trends in trophic state of Indiana lakes following phosphorus reduction. Verh. Internat. Verein. Limnol. 24: 464-469.**

4. **F.X. Browne, 1992. Diagnostic study of 10 lakes in LaGrange County. Report for the IDNR Lake and River Enhancement Program, Indianapolis, IN.**

5. **Brown, W. and T. Schueler, 1997. National pollutant removal performance database for stormwater BMPs. Center for Watershed Protection, Silver Spring, MD.**

6. **Wetzel, R.G. 1975. Limnology. W.B. Saunders Company, Philadelphia PA. 743 pp.**

7. **Kelly, M.H. and R.L. Hite, 1981. Chemical analysis of surficial sediments from 63 Illinois lakes, summer 1979. Illinois EPA, Division of Water Pollution Control, Springfield IL. 92 pp.**

8. **Whitaker, J.O. and J.R. Gammon, 1988. Endangered and threatened vertebrate animals of Indiana: their distribution and abundance. Ind. Acad. Sci. Monograph Number 5. Indianapolis, IN.**

9. **Culp, R.L., G.M. Wesner, and G.L. Culp, 1978. Handbook of Advanced Wastewater Treatment. Van Nostrand Reinhold, NY.**

10. **U.S.EPA, 1983. Results of the Nationwide Urban Runoff Program. Vol. I . Final Report. EPA Water Planning Division, WH-554, Washington, D.C.**

11. **Harper, H.H. et al., 1992. The use of wetlands for controlling stormwater pollution. Woodward-Clyde Consultants, Portland, Ore. Prepared for US EPA Region V Watershed Management Unit, Chicago, IL.**

EUTROMOD - Witmer Lake Calculations
Surface Water Runoff & Soil Loss

```
        Land Use Category   Runoff Coeff   USLE: RE     USLE:
K
     É?????????????????????????????????????????????
??????????
     º   Agriculture1      º       0.25  º       400   º
0.34         º   Agriculture2      º       0.22  º       400   º
    0.34         º   Agriculture3      º 1.469E-39  º       400
  º 1.47E-39
     º   Agriculture4      º 1.469E-39  º       400   º
1.47E-39
     º   Agriculture5      º 1.469E-39  º       400   º
1.47E-39
     º   Forest            º       0.15  º       400   º
0.34
     º   Urban1            º        0.3  º             º

     º   Urban2            º        0.4  º             º

     º   Feedlots          º 1.469E-39  º             º

     º   Other1            º 1.469E-39  º       400   º
1.47E-39
     º   Other2            º 1.469E-39  º       400   º
1.47E-39
     º   Other3            º 1.469E-39  º       400   º
1.47E-39

?????????????????????????????????????????????????????????????¼
     º Precipitation Mean  º       100 cm  º
     º Precipitation CV    º      0.25     º
     ??????????????????????????????????????¼
```

Phosphorus Concentration Estimates

```
        Land Use Category     Dissolved  Sed-Attach      Total
     É?????????????????????????????????????????????
??????????
     º   Agriculture1      º        0.1  º       220   º
*****
     º   Agriculture2      º        0.1  º       220   º
*****
     º   Agriculture3      º 1.469E-39  º 1.47E-39   º
*****
```

Agriculture4	1.469E-39	1.47E-39	*****
Agriculture5	1.469E-39	1.47E-39	*****
Forest	0.01	220	*****
Urban1	1	*****	0.2
Urban2	1	*****	0.1
Feedlots	4	*****	1.47E-39
Other1	1.469E-39	1.47E-39	*****
Other2	1.469E-39	1.47E-39	*****
Other3	1.469E-39	1.47E-39	*****
Precipitation	0.01	*****	0.05

??¼

?????????????????????????????????¼

Phosphorus Loading Estimates - By Category

Loading (kg/yr)		Expected
Agriculture		3419
Forest		13
Urban		16.5
Feedlots		250
Precipitation		42.5
Septic Tanks		375
Point Sources		0
Other		0

Estimated Total = 4016 (kg/yr)

Predicted Lake Trophic State Variables - Based on Hydrologic Variability

Variable (units)	5th %ile	Expected	95th %ile
Total P-in (mg/l)		0.1255	
Total N-in (mg/l)		2.5266	
Total P (mg/l)	0.0460	0.0591	0.0758
Total N (mg/l)	0.5952	0.6203	0.6465

Chlor a (ug/l)	8.3317	10.1448	12.3525
Secchi Depth (m)	2.1837	2.0981	2.0208
Prob Hypo Anoxia	0.0000	0.0075	0.0000
Prob BG Dominant	0.0000	0.0000	0.0000
THMs	0.0000	0.0000	0.0000
TSI	55.3852	58.1480	60.9108