

A PRELIMINARY INVESTIGATION
OF TWENTY-FOUR LAKES
LAGRANGE COUNTY, INDIANA

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SURVEY OF 24 LAGRANGE COUNTY LAKES AND THE
IDENTIFICATION OF FACTORS AFFECTING WATER QUALITY-1988

SUMMARY

During 1988, 24 lakes were studied. Tests were performed for total phosphorus, ortho-phosphates, nitrates, dissolved oxygen, and Secchi Disk (clarity), allowing a general description of the water quality of the lakes. In addition, 22 inlet streams were investigated to determine the effects of the streams and their corresponding watersheds on the water quality of the lakes. In addition to chemical testing, cross sections and sediment amounts were determined on each stream.

Lake history was investigated for each lake and its surrounding watershed. This history was gathered mainly from aerial photographs taken in 1938, 1965 and 1986. The study allowed a visual investigation of how each lake was developed and how the changes in the watersheds related to the conditions found in 1988. Testimony was also obtained from area residents and their memories were recorded.

The culmination of this data collection, both past and present, was the determination of present problems found on the lakes, the causes of the problems, and recommendations for improving the water quality of the lakes in LaGrange County.

A determination of the general condition of each lake's water quality was made based mainly on the total phosphorus concentration found in the water column. Also considered in this determination were Secchi Disk readings, ortho-phosphates, nitrates, and dissolved oxygen when this data was available. In addition, the development characteristics, such as placement of septic systems, watershed size and watershed land use, were considered along with the water quality of the inlet streams.

The Indiana Department of Environmental Management published in 1986 the "Indiana Lake Classification System and Management Plan". This publication was also consulted, for the document provides a lake classification of LaGrange County lakes, based on data collected from the early 1970's and into the 1980's. Also, this publication states, "Phosphorus, in particular, is generally charged to be the nutrient most frequently controlling eutrophication."

After considering the above, the LaGrange County Lakes were divided into project categories, relating to water quality improvement projects. When attempting to categorize lakes, it must be remembered that, while the categories are useful in providing guidelines, the categories are never rigorous

enough to permit a high degree of certainty. Again, it must be stressed categories may be used as a guideline.

Although this report concerns the lakes of LaGrange County, similar results could be recorded for most lakes in Indiana. These lakes and their watersheds have been developed in similar ways, and, thus, man's impact on lake water quality has been analogous. Increasing evidence supports decreasing water quality on many Indiana lakes.

PROJECT CATEGORY I

These lakes rarely maintain concentrations of macrophytes or algae. Chemical concentrations are within acceptable limits and there are minimal problems associated with the watershed. Lake development problems generally are not major. Lake uses are not impaired and chemical control programs are not generally necessary. Recommendations are to survey the lakes to assure water quality is maintained.

LaGrange County lakes in PROJECT CATEGORY I are:

1. South Twin
2. Cedar Lake
3. Wall Lake
4. Pretty Lake

PROJECT CATEGORY II

These lakes rarely maintain concentrations of macrophytes or algae, and lake uses are very rarely impaired. Chemical concentrations, especially phosphorus indicate possible problem "areas", either associated with the watershed and/or lake development. Recommendations are to collect information and data to further describe the problem areas, and to support future, required improvement projects.

LaGrange County lakes included in PROJECT CATEGORY II are:

1. Olin Lake
2. Oliver Lake
3. Martin Lake
4. Pigeon Lake
5. Dallas Lake
6. Fish Lake

PROJECT CATEGORY III

These lakes frequently support extensive concentrations

of macrophytes and/or algae, especially in shore areas and, in some instances, lake uses are impaired. Macrophyte growth may necessitate a "weed " control program, especially in beach and dock areas. Chemical concentrations, especially phosphorus, are elevated indicating excessive inputs from the watershed and/or from developed areas of the lake. These lakes are impacted by the activities of man and recommendations are to begin planning of improvement projects to improve or at least maintain water quality. Planning and implementation of the projects should be completed in the near future.

LaGrange County lakes included in PROJECT CATEGORY III are:

1. Big Long Lake
2. Westler Lake
3. Adams Lake
4. Hackenburg Lake

PROJECT CATEGORY IV.

These lakes usually have excessive concentrations of chemicals, especially phosphorus, resulting in extensive concentrations of macrophytes and/or algae. Algae blooms can be quite extensive, with blue-green algae usually being dominant. One or more lake uses may be commonly impaired, although fishing may be excellent because of the lake's productivity. Lake residents usually feel "weed" control programs are necessary to improve lake use. These lakes are highly impacted by the activities of man, either in the watershed or from developed areas around the lakes. Usually both the watershed and the lake's developed area are contributing significantly to the lake's eutrophication. Recommendations are to institute improvement projects as soon as possible to improve water quality.

LaGrange County lakes included in PROJECT CATEGORY IV are:

1. Witmer Lake
2. Little Turkey Lake
3. Messick Lake
4. Appleman Lake
5. Emma Lake
6. Royer Lake

PROJECT CATEGORY V

These lakes are in a condition of extreme eutrophication. Chemical concentrations, especially

phosphorus, are extremely high, resulting in massive concentrations of macrophytes and algae. Algae blooms are dominated by blue-green algae, and are so extensive as to block the sunlight penetration and thus eliminate macrophyte growth. Fish kills caused by oxygen depletion can be expected, if they have not already occurred. Lake use can become nonexistent. These lakes are highly productive and are rapidly moving towards senescence. Recommendations are to begin improvement projects immediately to reduce productivity and improve water quality.

LaGrange County Lakes included in PROJECT CATEGORY V are

1. Shipshewana Lake

Lakes which were investigated but data were incomplete are:

1. Big Turkey Lake
2. North Twin
3. Atwood Lake

The conclusion of this study indicates that projects to improve the water quality are needed for many of the lakes before conditions develop making water quality improvement difficult and cost prohibitive.

LEDGEND OF LAKES STUDIED IN LAGRANGE COUNTY

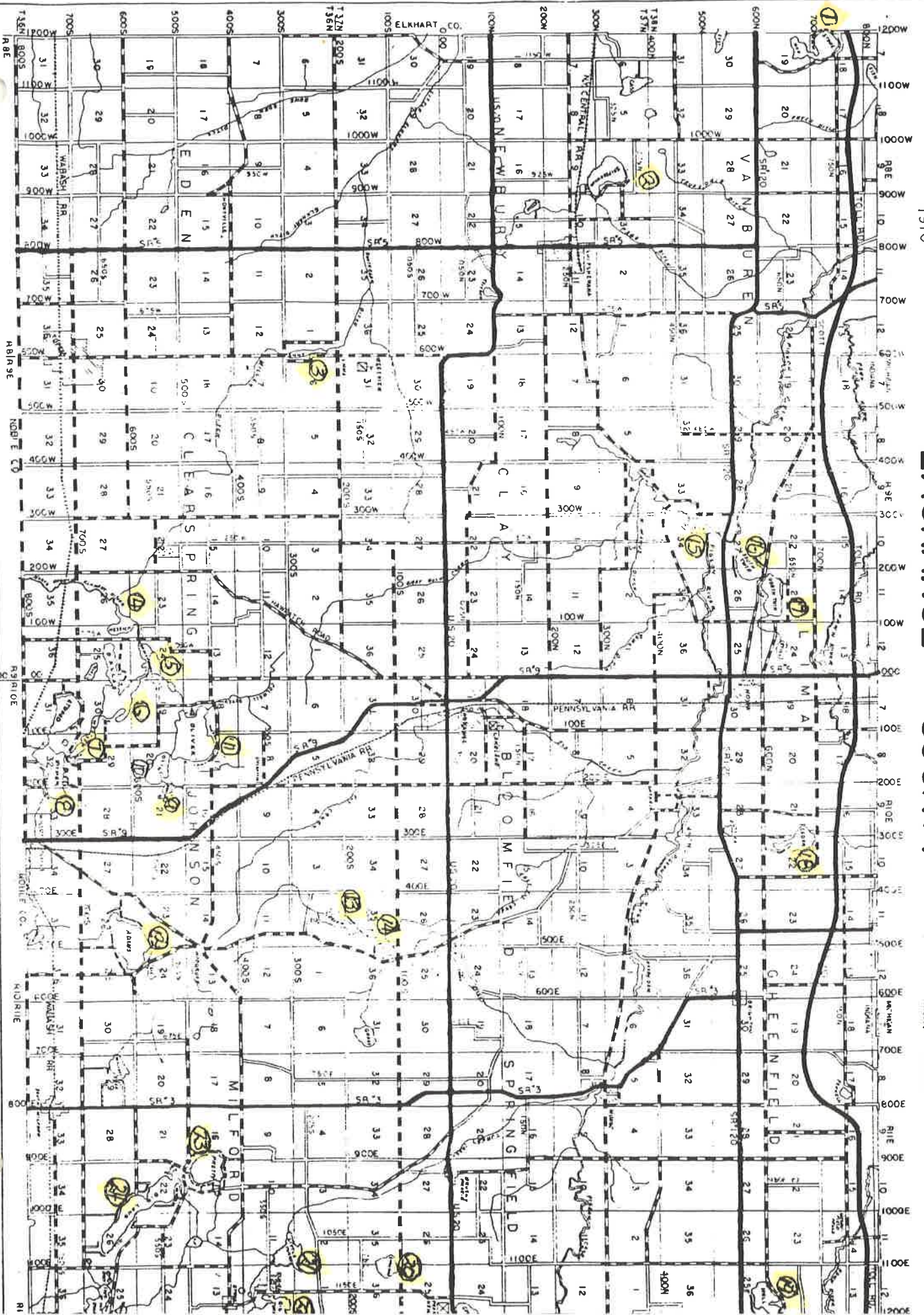
- 1 Stone Lake
- 2 Shipshewana Lake
- 3 Emma Lake
- 4 Messick Lake
- 5 Hackenburg Lake
- 6 Dallas Lake
- 7 Westler Lake
- 8 Witmer Lake
- 9 Martin Lake
- 10 Olin Lake
- 11 Oliver Lake
- 12 Admas Lake
- 13 Royer Lake
- 14 Fish Lake
- 15 Pigeon Lake
- 16 South Twin Lake
- 17 North Twin Lake
- 18 Cedar Lake
- 19 Wall Lake
- 20 Appleman Lake
- 21 Little Turkey Lake
- 22 Big Turkey Lake
- 23 Pretty Lake
- 24 Big Long Lake

EDWIN B. HOUCK
COUNTY ENGINEER & SURVEYOR
1970

LAGRANGE COUNTY

1:1 INCH
= 1 MILE

SCALE 1 MILE



LAGRANGE COUNTY LAKES

SURVEY OF 24 COUNTY LAKES AND THE IDENTIFICATION OF FACTORS AFFECTING WATER QUALITY - 1988

INTRODUCTION

LaGrange County, an agricultural county located in the northeast corner of Indiana, contains 64 lakes. The lakes, ranging in size from 6 to 388 acres, were created during the Wisconsin stage of glacial activity, approximately 14000 years ago. These lakes were undeveloped with the exception of a few scattered summer homes until the 1950's and 1960's. During this time period there was a dramatic increase in summer home construction in and around the lakes. In the 1970's and 1980's, many of the summer homes were converted to year-around homes and the remaining lake front building sites were developed.

During this same time period, various practices in the watersheds of the lakes were experiencing dramatic changes and along with the lake development, created pressures on the water quality of the lakes. Farming practices, including both crop and animal operations, became more intensified and development of industrial and housing projects were expanded.

In the late 1970's and 1980's, noticeable changes became evident in water quality of the County's lakes, and in some cases the changes were severe enough that the concern of County officials and residents for the lakes required action. The preliminary result of that concern is the following document which describes the condition of the water quality found in 21 County lakes, the causes of the declining water quality, and in some instances, possible corrective measures required to maintain or improve the water quality of the lakes.

MATERIAL AND METHODS

SAMPLING - Mid lake samples were obtained using a water sampling bottle from LaMotte Chemical Co., Chestertown, MD. The samples were taken approximately 2 feet from the bottom, at the thermocline, and 1-2 feet below the surface in the deepest part of the lake. Samples from inlet streams were obtained before the stream entered the lake and in some instances in the lake at the stream mouth. Other samples in the lake were obtained as conditions required. Tests were performed at the sampling site or were stored at 4 degrees F. Maximum depth mid-lake sampling sites were determined from U.S.G.S. bathymetric maps obtained from the I.D.N.R. Sampling sites of the streams were determined by reviewing aerial photographs, County drainage maps, and by on site observations.

CHEMICAL ANALYSIS - Concentrations of ortho- phosphates, nitrates, and dissolved oxygen were performed using a HACH DR/2000 Spectrophotometer. Procedures were performed according to the HACH Procedural Manual. (HACH Co., Loveland Colorado) Total phosphorus testing was performed by Dr. Peter Hippensteel of Tri-State University, Angola, Ind.

TURBIDITY - Turbidity was determined with a Secchi Disk or with the DR/2000 Spectrophotometer, using the procedure according to the HACH Procedural Manual.

INVESTIGATION OF SEPTIC EFFLUENT LEACHING To investigate the possibility that septic effluent was leaching into the lake and adding to the nutrient loading of the lake, a septic leachate detector (K-V Associates, Inc., Falmouth,, Mass.) was borrowed from the Elkhart Health Dept. This instrument detects urine or the by-products of urine and is operated from a boat which is maneuvered along the shore.

LAKE AND WATERSHED SURVEYS. Surveys were conducted among the lake residents and the farmers in the watershed of each lake studied. The survey for the lakes was composed by the LaGrange County Health Dept. and the survey for the farmers was completed by the LaGrange County SCS.

SHIPSHSEWANA LAKE

Shipshewana Lake has been in a state of extreme cultural eutrophication for at least four years. According to lake residents a major fish kill occurred during the summer of 1986, most likely caused by oxygen depletion resulting from excessive vegetative growth. In addition massive macrophyte and algal growth has been increasing during the past 3-6 years.

Aerial photographs, taken on 9-25-38, show the lake to be completely surrounded by wetlands, except for the eastern shore which was forest. This area rises immediately from the shore and is the highest elevation immediately around the lake. The immediate southern shore contains a wetland extending 300 foot. from the shore, but the elevation rises into a wooded area. The Cotton Lake Inlet, which presently enters the lake on the southern shore, did not enter Shipshewana Lake in 1938, but flowed into a large wetland area surrounding the outlet of the lake. The 1938 photograph shows the lake to be completely undeveloped without a single home on the lake. The surrounding watershed is almost completely agricultural and contains about 1875 acres.

Aerial photographs of 1965 show the south and east shores to be completely developed including the diversion of the Cotton Lake watershed into the lake. (The Cotton Lake watershed contains about 3100 acres of which about 129 acres is highly erodible land). This increased the watershed of the lake from about 1875 acres to the present 4175 acres.

The Cotton Lake Inlet drains about 87 acres of the town of Shipshewana, with the remaining watershed being agricultural. The town has a large tourist industry, supporting a cattle auction, a large horse auction, and a flea market each week. This increases the population as much as 30,000 each week from May through September. Thus with each rain, the storm drainage from the 87 acres enters the Cotton Lake Inlet watershed and eventually into Shipshewana Lake, carrying with it large amounts of contaminants from this large industry.

The farming community surrounding Shipshewana Lake is mostly Amish. Because their farming practices employ techniques of 80-100 years ago which used animal power, much of the nutrient input into the lake originates from animal manure. Large numbers of animals are allowed access to drainage ditches and streams (especially the Cotton Lake Inlet) which eventually discharge into the lake. Concentrations averaged 0.57 mg/l total phosphates, and 2.2 mg/l nitrates for the Cotton Lake Inlet. Sediment inputs after a rain event were 0.4 mg/l for the Cotton Lake inlet.

The Cotton Lake Inlet enters series of two ponds, the first being about 5 acres and the second about 1 acre, before entering the lake. A large farm supply business, located in the town of Shipshewana, drains its storm water

into the first pond. Also a home on a septic tank is located near the second pond. On a sampling date of 6-14-88, orthophosphate concentrations were 0.12 mg/l before the Cotton Lake Inlet entered the first pond, and the concentration was 0.45 mg/l at the outlet of the ponds and before entering the lake. This indicates an additional large nutrient input entering the ponds.

An aerial photograph, taken in 1986, shows development of the west shore. To complete the development, the large marsh area was drained and to fill in the area to accommodate home sites, the remaining wetland area and the lake bottom was suction-dredged. This removed the wetland filter area for the Mud Lake Inlet. In addition, large channels were dug on the west, northwest, northeast, and southeast areas of the lake to allow lake access for further development, but these areas are partially developed. The Mud Lake Inlet, which enters the lake from the west, has a watershed of about 1075 acres of which 250 acres or 23% is highly erodible land. Land-use practices in this watershed are 100% agricultural.

Sampling completed in 1986 by Dr. Hippensteel showed excessive total phosphorus inputs entering the lake from this watershed. The concentrations were 3.8 mg/l on August 26 and 6.0 mg/l on September 5, 1986.

Because of the extreme drought conditions during the summer of 1988, it was difficult to obtain samples from this inlet, but two acceptable samples were obtained on 6-30-88 and 7-14-88. Total phosphate concentrations were 1.16 mg/l and 3.7 mg/l respectively.

An investigation of the watershed identified the major source of these excessive concentrations as a "duck farm" located next to the Mud Lake Inlet about 3/4 miles from the lake. This operation consists of a large barnyard where 5000-10000 ducks are raised. A open cement drainage ditch directs a constant flow of water across the barnyard into a block holding pit, which settles out the solids carried by the water. The pit empties into a drainage tile which then flows into the nearby stream. This open drainage ditch probably covers less than 1% of the total barnyard surface area, with the remaining area draining directly into the stream. With each rain the Mud Lake Inlet is inundated with massive amounts of nutrients which then flow directly into Shipshewana Lake. In addition, cattle are allowed into the inlet to drink, and a hog operation, close to the lake, also drains into the inlet.

An area of about 800 acres on the northern shore of the lake drains into a large marsh area before entering the lake. The land use in this watershed is 100% agricultural.

Total phosphate concentrations were determined in mid lake on August 2, 1986 by Dr. Hippensteel of Tri-State University. Results were .08 mg/l at the surface and 0.09 mg/l at the

bottom (max. depth of the lakes is 14 foot). In 1988, phosphate concentrations had increased to 0.32 mg/l at the surface, 0.48 mg/l at 6 foot, and 0.32 mg/l at the bottom, for an average column concentration of 0.39 mg/l. This is a four fold increase of the mid-lake total phosphate concentration. Dissolved oxygen concentrations dropped from 9.1 mg/l and 12.6 mg/l at the surface to 0.2 mg/l at the bottom. The oxygen concentrations were representative of conditions found during large algal blooms. Algal blooms were observed from early spring when the ice melted and were continuously observed throughout the summer and fall. The blue green algae, anabaena, was the major species throughout the summer, but during a major bloom occurring the week of 10 7-88, with the water temperature at 54 degrees F., the major species was a thick walled flagellate having a single flagellum. The flagellate could not be identified. This last major bloom occurred several days after the first major rain fall since the 1988 drought began.

Secchi disk readings for the lake ranged from a high of 1.5 foot in May to approximately 6 inches in June through August. Readings close to shore were 2 inches because of algae build-up. Hard crust, created by sun dried algae, covered large areas of the lake surface several times during the summer.

Macrophyte growth in the spring and early summer was so dense that it was impossible to propel a boat across the lake. By July much of the macrophyte growth had subsided because the algae growth was so thick as to block sunlight. The major macrophyte species were coontail and water milfoil.

The possibility of septic tanks leaching into the lake was investigated on the south shore of the lake. Apparently because of high concentrations of urine and urine by-products the leachate detector could not be standardized using the 2% urine standard solution. The instrument continuously went off scale and a base line could not be established.

DISCUSSION

Shipshewana Lake represents the destruction of an ecological resource as a direct consequence of the activities of man. With the exception of fishing, the lake is unusable for activities normally associated with lakes, and even fishing will be threatened in the future because of the extreme eutrophication of the lake. Property values have declined dramatically in the past year and will continue to do so unless the water quality of the lake is improved.

The causes of the decline of the lake environment are listed below and are not necessarily in order of their impact on the lake's water quality:

INLET NUTRIENT INPUTS - Two major inlets drain into Shipshewana Lake and are described as the COTTON LAKE INLET and the MUD LAKE INLET. Both these inlets are inputting excessive amounts of nutrients into the lake, especially phosphorus. The input from the Mud Lake Inlet derives mainly from a duck raising operation close to the stream about 3/4 mile from the lake. In addition to this operation, cattle and hogs are allowed to enter this stream to drink, and a large "barnyard" produces run-off into the stream. Total phosphorus concentrations of 3.7 mg/l were found entering the lake from this stream after a rain. The impact of phosphorus input from the Mud Lake Inlet was probably reduced because of the severe drought during the summer of 1988, which reduced the volume of water entering the lake. Even when considering this abnormal situation, the lowest phosphorus concentration detected was 1.16 mg/l.

The inlet, now called Cotton Lake Inlet, did not originally enter the lake, but instead entered the outlet of Shipshewana Lake. By 1965 this stream was redirected and now enters the lake on the southwest shore. As discussed below, the Cotton Lake Inlet is most likely the major contributor to the eutrophication of the lake, and when it was diverted into the lake, it redirected the problems of 2300 acres of watershed to the lake.

The Cotton Lake Inlet had flowing water all summer (Mud Lake Inlet was dry for much of the summer), and thus the impact of phosphorus inputs into the lake may have been greater than the Mud Lake Inlet, even though the phosphorus concentrations were lower. The total phosphorus concentrations ranged from 0.31 to 0.82 mg/l for the Cotton Lake Inlet. Much of this input is the result of allowing animals into the stream to drink and also several hog operations in the watershed of the stream.

In addition storm water from the town of Shipshewana drains into the Cotton Lake Inlet which introduces additional inputs into the stream. The town hosts a large, weekly flea market and a livestock sale which possibly expands the population as much as 30,000 people per week. This expansion of people and livestock, including a large number of horse drawn Amish buggies, was not anticipated to have an adverse impact on Shipshewana Lake.

The Cotton Lake Inlet enters two ponds before entering the lake. On a sampling day, ortho-phosphates were 0.12 mg/l entering the first pond, but the concentration at the outlet of the ponds, just before entering the lake, was 0.45 mg/l. While investigating the reason for this increase, it was noted that the storm water from a large, commercial farm fertilizer business entered the first pond.

During a rain event on 11-13-88 a sample from a culvert draining this business was obtained. Ortho-phosphate concentration was 0.75 mg/l and nitrate concentration was 3.2 mg/l.

Thus, in addition to the already varied sources of nutrient inputs along the Cotton Lake Inlet, this fertilizer input source only adds complexity to an already complex situation. Thus the Cotton Lake Inlet is the most complex and the major contributor to the eutrophication of Shipshewana Lake.

RESIDENTIAL DEVELOPMENT - By 1965 the lake shore had been developed into a small town, and all the homes utilize septic tanks to dispose of sewage. The majority of these septic systems were constructed in areas with high watertables, and some of them actually are sitting in water. The leachate from these septs enters the groundwater, and because this groundwater enters the lake, many of the contaminants found in the leachate are carried into the lake.

To emphasize the high concentrations of contaminants that can be found in septic effluent, a sample obtained from a septic system which was draining out the side of a bank (the system was not on Shipshewana Lake) contained 33.0 mg/l ortho-phosphates. This compares to the highest concentration found for ortho-phosphates in any lake or stream of 0.81 mg/l. Thus, the septic system effluent was 41 times higher than the next highest concentration.

Is there evidence that this leachate is reaching the lake? Yes there is. In July we planned to survey the lake shore area with a leachate detector to investigate this possibility, but because of the high concentrations of leachate in the lake water, we could not establish a base line for the instrument. The readings continuously went off the graph, indicating concentrations above the limits of the instrument.

From this information, it can be concluded that the development of housing on the lake, which was almost completely unplanned, is a major contributor to the eutrophication of the lake.

WETLAND DESTRUCTION - Wetlands originally surrounded Shipshewana Lake, except for the east shore. These wetlands filtered and cleaned not only the lake water, but the water entering the lake from the watershed. With these wetlands gone, the only remaining filter for the water is the lake itself.

Thus nutrients and sediments enter the lake where they are retained and contribute to the eutrophication of the lake.

RECOMMENDATIONS

To improve the water quality of Shipshewana Lake several projects must be implemented. Because of the severe eutrophication of the lake and the complex nature of the problems in the watershed, the cost of the improvements will be expensive and the resulting improvement in water quality may not equal people's expectations.

I. WATERSHED IMPROVEMENTS

MUD LAKE INLET

Storm water run-off from animal operations must be reduced or even eliminated. In addition, access to the inlet by farm animals, including cattle, hogs and horses, must be restricted. To reduce storm water run-off, holding lagoons, grassed buffer strips, and wetlands should be constructed in strategic places to contain and treat the water before it enters the inlet waterway. To keep animals out of the inlet, the inlet banks should be fenced and restricted access areas should be constructed to allow the animals to drink, while keeping them out of the water. In addition, the banks of the inlet should be seeded with grass and possibly trees and shrubs.

COTTON LAKE INLET

The recommendations concerning animal operations and farm animals are the same as for the Mud Lake Inlet. In addition, the storm water from the town of Shipshewana should be diverted away from the Cotton Lake Inlet or should at least be treated before entering the inlet. This may require the improvement of storm sewers for the town of Shipshewana, a project that should be investigated by the town anyway as it plans for its present and future growth. The fertilizer plant, mentioned above, should be included in the storm sewer project. Although other alternatives may be available instead of a storm sewer, the town, and those people in the immediate area, must realize the benefits of growth are not free. In the future the price may be more than the loss of Shipshewana Lake.

LAKE IMPROVEMENTS AND IMPROVING SEWAGE DISPOSAL -

In the immediate term, those living on the lake should institute the following:

- A. Chemical weed control should be discontinued. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
- C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
- D. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:
 - 1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
 - 2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
 - 3. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
 - 4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

For the long term, sanitary sewers must be installed around the lake, and every home must be connected. Because of the time involved to complete such a project, investigations into how to best complete such a project should be started as soon as possible. A possible beginning is to request incorporation into the town of Shipshewana and when the town expands their sewage plant, the lake could be included.

Indiana LCS: 1975

Class: 3

Index: 51.0

SHIPSHEWANA LAKE

Size: 202 Ac.

Max. Depth: 14'

Mean Depth: 7'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	5/23						1.5	
	6/21	1.0	0.38	0.17	0	9.1	0.5 to 1.5	
		6.0	0.48	0.32	0	6.0		
		10.0	0.32	0.01	0	0.2		
Cotton Lake Inlet (6)	6/14			0.12	3.0			
	6/14			0.45	1.4			
	6/30		0.82					
	7/14		0.31					
	7/27							0.4
	8/11			0.10	1.3			
Mud Lake Inlet (7) SW Channel	6/14			0.20	0.90			
	6/30		1.16					
	7/14		3.70					
	7/27							0.4
	5/23			0.54	2.3	4.9	2.0	
	6/21			0.05	0.7	7.0	1.0	
(8) Page - 800 West	6/21			0.25	2.1			
	6/29		0.19	0.03	1.5			
	8/15			2.5	1.6			

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

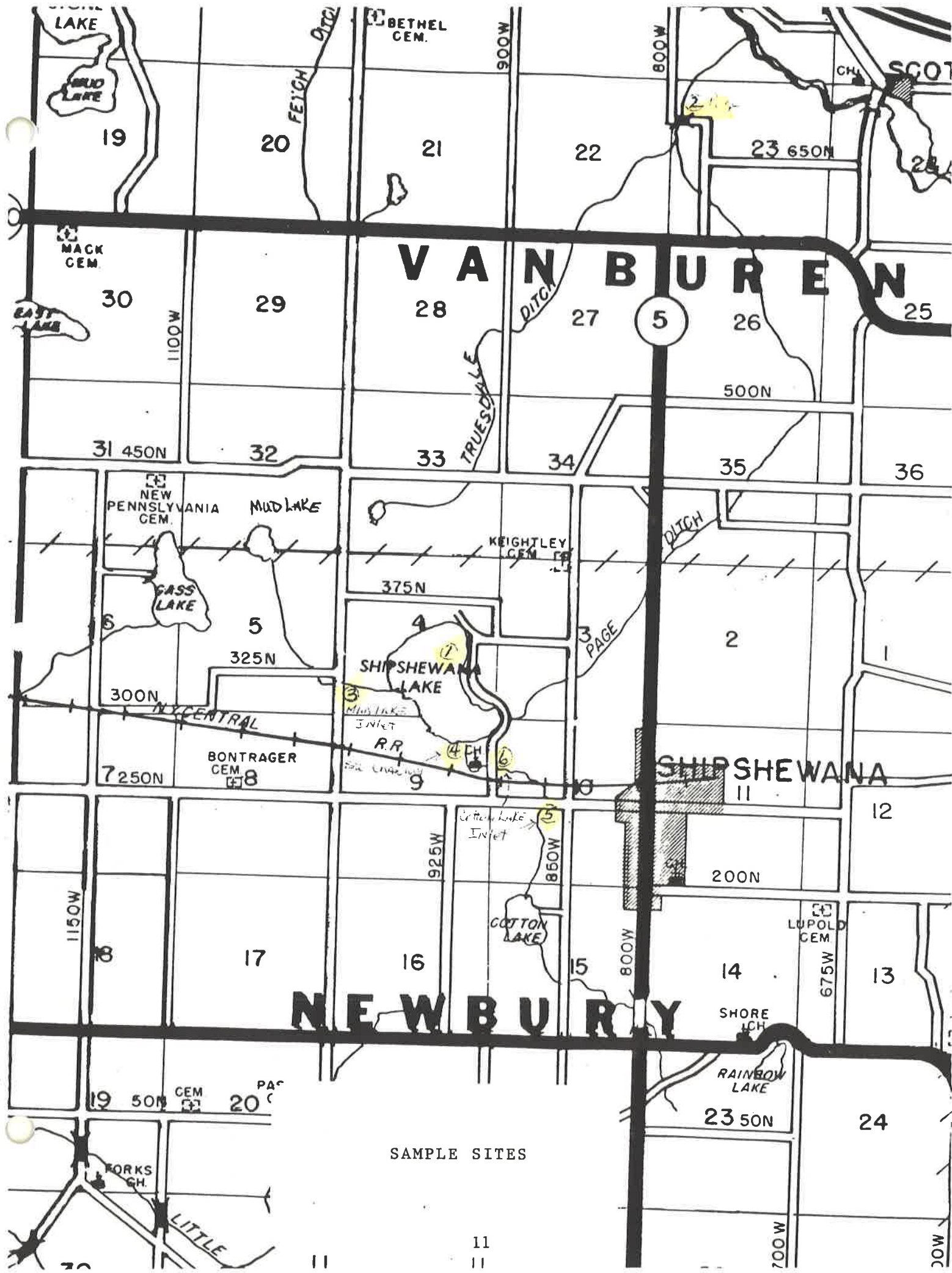
4. Dissolved Oxygen

5. Secchi Disk

6. Pond Outlet Before Lake

7. Channel Where Cotton Lake Inlet
Enters Lake

8. Lake Outlet Stream 3-4 miles
from Lake



ROYER LAKE

Royer Lake is located in the central part of LaGrange County, and is the southern lake in a two lake chain, Fish Lake being the northern lake. The watershed flows from south to north. The lake is contained in a long narrow basin with a small upper basin and a large southern basin. The surface area of the lake is 69 acres, and its maximum depth is 59 feet, with a mean depth of 23.6 feet.

An aerial photograph, taken 9-26-1938, shows the lake to be completely undeveloped, with small areas of wetlands covering about half of the shore area. The remaining shore area contains narrow strips of brush which separates the lake from near-by farm fields. Farm fields are extended almost to the lake, thus sediment entering the lake from these operations was likely.

An aerial photograph, taken in 1965, shows the west shore to be completely developed along with about 1/3 of the eastern shore. A circular channel has been dug on the eastern shore, creating an island, thus allowing additional homes access to the lake. A wetland area, covering about 1/4 of the eastern shore in the 1938 photograph, is now supporting the growth of small trees, as is a wetland area on the southwest shore. Why the succession of vegetation occurred is not known, but may be the result of drainage practices. The farming fields next to the lake are now further from the shore, as compared to the 1938 photograph, to allow for development. A large horseshoe shaped pond has been dug about 150 yards from the northeast shore, and the dirt from this excavation was apparently used to fill a wetland along the shore. Two homes have been built in this area.

In the 1986 aerial photograph, development has remained in the same areas as in the 1965 photograph, but the number of homes has approximately doubled. The filled wetland on the northeast side of the lake has not been further developed. No other changes from 1965 to 1986 are noted.

The watershed flows from the south and east into Royer lake, and encompasses an area of about 3650 acres of which about 700 acres or 19% is classified as highly erodible by the SCS. The land use of the watershed is 100% agricultural except for the developed area around the lake.

An inlet stream, draining the southern watershed, flows through a wetland on the southern shore of the lake before entering the lake. Aside from extensive crop land, several animal operations are maintained in close proximity of this stream. Total phosphate concentrations averaged 0.34 mg/l for this stream before it entered the lake, and nitrates were 0.04 mg/l.

The inlet which flows into the northeastern end of the lake

is mainly an open ditch without wetland protection. Animal operations are also maintained close to this stream. Total phosphate concentrations averaged 0.48 mg/l, ortho-phosphates were 0.18 and nitrates were 1.9 mg/l. Sediment inflow from this stream were 0.4 mg/l after a rain event.

Mid-lake samples were obtained from the smaller upper basin and the much larger southern basin. Samples taken on 7-6-88 from the upper basin averaged 0.22 mg/l total phosphorus, while the lower basin averaged 0.25 mg/l. The lower basin was again sampled on 8-18-88 and the total phosphorus averaged 0.29 mg/l. Nitrates ranged from 1.2 to 1.8 mg/l for both sampling sites during the sampling period.

An algal bloom persisted in the lake from the first part of June until mid-August. Major species were oscillatoria, chlamydomonas, volvox, chlorococcum, and eudorina. Dissolved oxygen was 10.2 mg/l at the surface, 9.8 mg/l at 8 feet, and only 0.5 mg/l at 13 feet. This reflects the oxygen depletion normally found during algal blooms. Secchi disk readings ranged from 2.5 feet. in June to 5.5 feet in July. After the bloom subsided in August, total phosphorus concentrations in the epilimnion showed a corresponding drop as compared to the 7-6-88 sampling date, when the bloom was in progress. The concentrations dropped from 0.17 to 0.08 mg/l, but the average total phosphorus for the water column remained high at 0.029 mg/l.

Royer Lake is indicative of a lake approaching extreme culture eutrophication, and it is just a matter of time before normal usage of the lake will be inhibited. An algal bloom persisted for much of the summer reducing disk readings to 2.5 feet. Various algal species were found, but the major species were Oscillatoria and a Chlorocuccum-like species which was not identified. Because the bloom was persistent for at least 2 months during the summer, indications are the lake is receiving excessive nutrient inputs.

Total phosphorus concentrations for mid-lake samples averaged 0.23 mg/l on 7-6-88 and 0.29 mg/l on 8-18-88. In addition, ortho-phosphate concentrations were 0.22 mg/l on 6-23-88. Because of these high concentrations, efforts were made to try to identify the source of the high nutrient loading.

The causes of the nutrient inputs are as follows:

INLET NUTRIENT INPUTS

The east inlet stream had flowing water all summer even though the drought reduced the flow of the stream below normal flow rates. In July and August, total phosphorus concentrations averaged 0.32 mg/l with a range of 0.16mg/l to 0.57 mg/l. This indicates a significant phosphorus contribution from this stream. Samples taken after a rain event on 10-17-88 resulted in total phosphorus concentrations

of 0.20 mg/l and sediments of 0.8 mg/l, indicating watershed erosion. Possible sources of this input are a dairy operation and a hog operation about 1 mile from the lake. From this information, it would be necessary to implement improvement projects for these operations to restrict animals from the stream and to reduce the storm run-off entering the stream.

The south inlet also had flowing water all summer, but the flow was greater than the east inlet. The lake is somewhat protected from this stream by a wetland area which surrounds the mouth of the inlet. But because of high total phosphorus concentrations, which averaged 0.34 mg/l and ranged from 0.29 to 0.39 mg/l, the impact of nutrient inputs from this stream are of significant concentration to require improvement projects also. Sources of these concentrations are hog confinement and feedlot operations in addition to a dairy farm.

In addition, the total watershed of 3650 acres has 19% highly erodible soil. Because of the intensive farming in this area, projects reducing the amount of erosion would reduce the nutrient inputs into the lake.

RESIDENTIAL DEVELOPMENT

About half of the shore area of the lake in 1938 was surrounded with wetlands. When these were filled and drained, homes were built on these areas, and septic tanks were installed in an area with high water tables.

Although Royer Lake was not investigated for leachate from these tanks, it can be assumed, because of similar circumstances of development found on lakes which were checked for leachate, that septic systems are contributing to the nutrient input. Based on the findings of other lakes and reports from agencies such as the U.S.E.P.A relating to septic problems on other lakes, the possibility of septic leachate entering the lake would be a cause of the eutrophication of this lake.

WETLAND DESTRUCTION

Approximately half the shore of Royer Lake was wetland. These wetlands protected the lake from watershed nutrients and sediments by filtering the water before it reached the lake. In addition, the wetland areas in the lake absorbed nutrients from the water and reduced the nutrient available to algae. With the destruction of these wetlands, the delicate balance found in freshwater ecosystems shifted and now the lake is like a holding area for these materials. Unwittingly, we fertilized the lake, and are now experiencing increased production of an unwanted crop.

RECOMMENDATIONS

To improve the water quality of Royer Lake, several projects must be implemented. Many of these projects will be simple in design and inexpensive, but some may be expensive and complex. If improvements are not made, the water quality of Royer Lake will continue to deteriorate.

WATERSHED IMPROVEMENTS

Storm water run-off from animal operations must be reduced or even eliminated. In addition, access to the stream inlets of the lake by farm animals must be restricted. Because of the amount of highly erodible land in the watershed, practices should be implemented to reduce erosion on crop land.

To reduce storm water run-off from animal operations, holding lagoons, grassed buffer strip, and, in some cases, wetlands should be constructed in strategic areas to contain and treat the water before it enters stream. To keep animals out of the streams, stream banks should be fenced and restricted access areas should be constructed to allow the animals to drink without directly entering the streams. In addition the stream banks should be seeded with grass and possibly small trees and shrubs.

To reduce sediment inputs into the lake, good farming practices must be implemented. Whether conservation tillage, terraces, grassed buffer strips, contour tillage, or other measures are used depends on individual needs and requirements. But, whatever the practice implemented, a reduction of sediment inputs into the lake will help preserve the water quality of Royer Lake.

LAKE IMPROVEMENTS AND IMPROVING SEWAGE DISPOSAL

In the immediate term, those living on the lake should institute the following:

- A. Chemical weed control should not be started. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
- C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
- D. Reduce the use of septic tanks as much as

possible by reducing water usage. Follow these simple suggestions:

1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
3. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

For the long term, sanitary sewers may be needed around the lake, and every home must be connected. Because of the time involved to complete such a project, investigations into how to best complete such a project should be started as soon as possible. A possible beginning is to request incorporation into a county-wide sewer or conservancy district. Although none presently exists, the county should begin proceedings as soon as possible to establish such districts.

Indiana LCS: 1975

Class: 2

Index: 26.0

ROYER LAKE

Size: 69.0 Ac.

Max. Depth: 59'

Mean Depth: 23.6'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake Upper Basin	6/23	0.5				9.4	2.5	
		5.0		0.22	1.2	9.5		
		10.0				7.1		
		15.0				0.7		
	7/6	0.5	0.14			10.2	5.5	
		8.0				9.8		
		13.0	0.12			0.5		
		27.0	0.42					
Lower Basin	7/6	.5	0.17				5.5	
		20.0	0.12					
		40.0	0.46					
	8/18	0.5	0.08					
		23.0	0.29					
<u>East Inlet</u> Lower Youngs Junction	6/7			0.81	0			
				0.12	2.6			
				0.23	2.4			
	At Lake							
	6/23			0.1	2.4			
	7/7		0.22					
	7/14		0.57					
	7/27							0.4
	8/15			0.2	1.3			
	8/18		.16					
	10/17		0.2					0.8
South Inlet	7/7		0.35					
	7/22		0.31					
	8/15		0.39	0.20	1.3			
	8/18		0.29					

1. Total Phosphorus

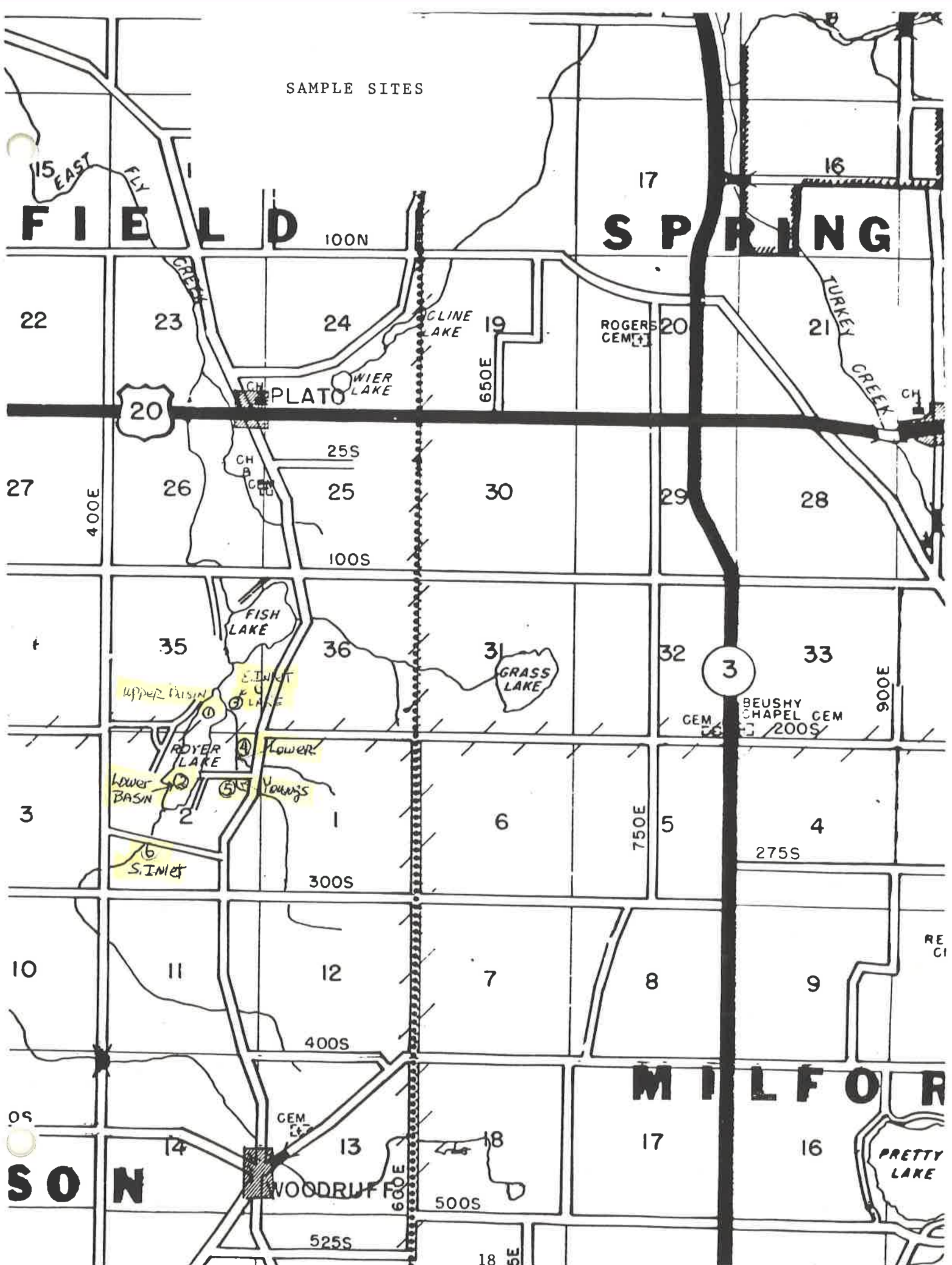
2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

SAMPLE SITES



FISH LAKE

This is the northern lake of a two lake chain, the southern lake being Royer Lake. This lake has a surface area of 100 acres, with the deepest area being 89 feet, and a mean depth of 40.5 feet. This mean depth makes it the deepest lake in LaGrange County.

An aerial photograph, taken on 9-26-38, indicates no development on the lake with the exception of a small building on the southeastern shore and two farm homes on the northern shore, each being about 300 feet from the lake. Approximately 3/4 of the eastern and southern shores were narrow wetlands extending about 100 - 400 feet from the lake. Approximately 1/4 of the western shore was dense woodland with the remaining shore being farm land which extends down to the shore of the lake. The northern shore is mainly farm land.

An aerial photograph taken in 1965 shows the lake shore to be completely developed with homes, except for a few small areas on the east and west shores. The wetlands have either been drained or filled and two channels have been dug, one on the southwestern shore and the other on the northeastern shore. The public access site occupies what once was the largest wetland on the lake and the northeast channel was dug in this area to obtain fill for this purpose. The southwest channel was dug in the woodland area on the west side of the lake and is now occupied by a trailer court. The horseshoe shaped pond which was dug to fill in the wetland on Royer Lake's northern shore was also used to fill the same wetland where it extended to Fish Lake's southern shore.

While a 1986 aerial photograph shows most of the development was completed by 1965, additional homes were built during these 21 years. Comparisons of the '65 and '86 photographs do not indicate any other major changes on the lake.

Fish Lake has two inlets. The southern inlet is the outlet of Royer Lake and is a navigable channel between the lakes. The eastern inlet drains approximately 4075 acres east of the lake, and this watershed contains about 700 acres or 17% highly erodible soil. The land use in this eastern watershed is 100% agricultural and contains few animal operations. The major land use is crop farming.

Inputs from this inlet for total phosphorus averaged 0.11 mg/l, 0.09 mg/l for ortho-phosphates, and 3.1 mg/l for nitrates. The highest sediment input was 0.2 mg/l on 7-27-88, but inputs were drastically reduced because of the drought. It is evident this stream has contributed large amounts of sediment to the lake in the past for a extensive delta has been formed at the mouth of the inlet and out into the lake.

This delta is larger than any found on other lakes in the County. Also the lake at the stream mouth was so heavy with the growth of macrophytes that it was impossible to enter this area with a boat, and the beaches of this area were completely unusable.

Mid-lake samples taken on 7-6-88 averaged 0.1 mg/l and on 8-18-88 were 0.14 mg/l total phosphorus. These figures compare with 1975 concentrations of the Indiana Lake Classification System of 0.04 mg/l. Ortho-phosphates averaged 0.11 mg/l for two sampling dates in June. On the 6-23-88 sampling date, an agal bloom was in progress (species unidentified) and Secchi Disk readings dropped from 12 foot on 6-17-88 to 6.5 foot on this date. By the 7-6-88 sampling date, Secchi Disk readings had again increased to 9.5 foot for the bloom had subsided.

Fish Lake represents a lake that has fair over-all water quality, but is experiencing nutrient inputs which, if not corrected, will have adverse effects on the water quality. Between 1975 and 1988, total phosphorus concentrations increased significantly from 0.04 to 0.14 mg/l, and this increase can be expected to continue in the future.

The causes of the nutrient inputs are as follows:

INLET NUTRIENT INPUTS

The east inlet had flowing water all summer even though the drought reduced the flow of the stream below normal rates. In June total phosphorus concentrations were 0.13 mg/l and in July were 0.14 mg/l. As the drought continued the values for total phosphorus dropped to 0.06 mg/l and eventually to 0.01 mg/l, indicating reduced inputs from the surrounding watershed. Also, as noted before, a large delta has formed at the mouth of the stream from past sediment inputs into the lake. The above data hints that improvements in certain practices in the watershed may be worthwhile in reducing the over-all, yearly inputs from this stream.

The southern inlet, which is the outlet of Royer Lake, involves a more complex situation. Because of the more extreme eutrophication associated with Royer Lake and the mid-lake total phosphorus concentrations (0.29 mg/l), this inlet has a major impact on the water quality of Fish Lake. Thus, the sources of the problems from this inlet are the very same sources affecting Royer Lake.

RESIDENTIAL DEVELOPMENT

Again, development on the lake was completely unplanned. Many of the homes were built on filled-in wetlands, and, with the exception of the west shore, have septic systems built in areas of high water tables. This is especially true of the eastern shore.

Although Fish Lake was not investigated for leachate from these tanks, it can be assumed, because of similar circumstances of development found on lakes which were checked for leachate, that septic systems are contributing to the nutrient input. Based on the findings of other lakes and reports from agencies such as the U.S.E.P.A relating to septic problems on other lakes, the possibility of septic leachate entering the lake would be a cause of the eutrophication of this lake.

WETLAND DESTRUCTION

As discussed earlier, large areas of the shore of Fish Lake were wetland. These wetlands protected the lake from watershed nutrients and sediments by filtering the water before it reached the lake. In addition, the wetland areas in the lake absorbed nutrients from the water and reduced the nutrient availability to vegetation. With the destruction of these wetlands, the delicate balance found in freshwater ecosystems shifted and now the lake is like a holding area for these materials. Unwittingly, we fertilized the lake, and are now experiencing increased production of an unwanted crop.

RECOMMENDATIONS

To insure the present water quality of Fish Lake, Royer Lake must be considered in the planning for the over all implementation of improvement projects for Fish Lake. It will be difficult to expect improved water quality on Fish Lake unless the water quality of Royer Lake is simultaneously improved. For recommendations for improvements on Royer Lake refer to the document on Royer Lake. Recommendations for Fish Lake are as follows:

WATERSHED IMPROVEMENTS

Animal operations are not the severe problem here as in the watershed of other lakes, although in some instances minor improvements can be made. The major problem in this watershed relates to crop farming and erosion. Along the length of the east inlet, several areas have cultivation down to the stream bank. This is also true for the tributaries of this stream.

To reduce the volume of sediment in this stream, grassed buffer strips should be planted along this stream according to the specifications of the SCS. In addition the possibility of constructing a wetland area as close to the lake as possible should be investigated. The wetland would further reduce the sediments and nutrients entering the lake.

LAKE IMPROVEMENTS AND SEWAGE DISPOSAL

In the immediate term, those living on the lake should

institute the following:

- A. Chemical weed control should not be started. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
- C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
- D. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:
 - 1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
 - 2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
 - 3. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
 - 4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

For the long term, sanitary sewers must be installed around the lake, and every home must be connected. Because of the time involved to complete such a project, investigations into how to best complete such a project should be started as soon as possible. A possible beginning is to request incorporation into a Sanitary Sewer District sponsored by the county.

The water quality of Fish Lake is, in part, dependent on the water quality of Royer Lake. With the two lakes approximately 1/4 mile apart, and the outlet of Royer Lake being the major inlet of Fish Lake, this is obvious. What may not be obvious is the lakes can almost be considered as one lake when considering water quality improvement projects.

The people living on the two lakes consider each to be separate entities and have two lake associations which do not readily combine efforts for solving problems. These two lake associations should combine efforts.

Indiana LCS: 1975

Class: 2

Index: 39

FISH LAKE

Size: 100 Ac.

Max. Depth: 78.0'

Mean Depth: 40.5'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/17	10.0		0.12	2.5	7.0	12	
	6/23	5.0		0.1	2.4	6.9	6.5	
		20.0				6.7		
	7/6	.5	0.09				9.5	
		20.0	0.1					
		40.0	0.1					
	8/18	.5	0.06					
		40	0.29					
		76	0.06					
East Inlet	6/16		0.13	0.07	4.6			
	6/17			0.1	2.7			
	7/7		0.14					
	7/11		0.06					
East Inlet	7/14		0.01					
	7/27							0.2

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



SAMPLE SITES

15 EAST FLY

FIELD

SPRING

20

PLATO

GLINE LAKE

WIER LAKE

ROGERS CEM

TURKEY CREEK

CH A CEM

FISH LAKE

GRASS LAKE

ROYER LAKE

BEUSHY CHAPEL CEM

CEM

WOODRUFF

PRETTY LAKE

SON

MILFORD

APPLEMAN LAKE

This lake is located in the mid-eastern part of LaGrange County and is probably a true example of a kettle lake formed by a melted, buried ice block of the retreating glaciers. The surrounding shore area is 20 - 25 feet higher than the lake surface with the exception of the southeastern shore area which appears to be about 10 -15 feet lower than the remaining shore area. This area drains about 400 acres to the southeast of the lake, but the drainage area is not clearly defined with a drainage stream. The lake does not have an inlet or outlet. The lake is thus a seepage lake with water levels being maintained by groundwater.

An aerial photograph, taken 12-4-38, shows the lake to be undeveloped with narrow areas of trees surrounding the shore. A large wetland encompasses the entire eastern shore and is the most noticeable feature of the lake. A small bay on the northeast side of the lake has apparently been isolated from the main body of water by the encroachment of the eastern wetland across the mouth of the bay. The surrounding farm land appears to be almost entirely cropland with areas of considerable erosion visible.

An aerial photograph taken in 1965 shows few changes on the lake. A home has been built on the west shore and the bay on the northeast side appears to be completely filled with vegetation.

A 1986 aerial photograph shows no changes from the 1965 photograph with two notable exceptions. First the bay on the northeast side has lost much of the vegetation that had filled in the bay in the 1965 photograph and now the bay has open water. Second the extensive wetland on the east shore has separated from the shore proper and has formed an island in the lake. In previous photographs the lake is kidney shaped, but with the entire wetland separation, the lake is now almost oval shaped.

The watershed of this lake seems to be confined to the immediate area surrounding the lake with the exception of the southeast area previously mentioned. The total watershed is probably not more than 600 acres. One concern about the watershed is that it is composed of about 80% highly erodible soils. Even though there are no inlet streams to drain this watershed, the immediate area surrounding the lake has a 15 - 25% slope and erosion into the lake is evident in several areas.

Total phosphorus in mid-lake averaged 0.23 ppm, ortho-phosphates were 0.08 ppm and nitrates were 1.2 ppm. Secchi Disk measurement was 4 foot.

Appleman lake is one of more unique lakes in LaGrange County. First, the lake is contained in a deep depression, as much as 25 feet below the surrounding watershed. Second the lake has

no inlets or outlets, thus it's water volume is completely supplied by groundwater and rain.

These two features make this lake very susceptible to contaminating material from the surrounding watershed. If these materials are introduced into the lake, their retention time is longer than lakes with inlets and outlets. Thus, because of the retention time, inputs from the surrounding watershed can have a dramatic and severe effect on the water quality.

Data on Appleman Lake from the 1986 Indiana Lake Classification System (ILCS) indicates a dramatic increase in total phosphorus concentrations in the lake. (The data was most likely obtained after 1975, but before 1986.) The total phosphorus was 0.035 mg/l and the Secchi Disk reading was 6.0 feet. In 1988 the average total phosphorus concentration had increased to 0.23 mg/l, an increase of 6.6 times. In addition the concentration of total phosphorus in the hypolimnion was 0.64 mg/l, the highest concentration found in the 21 lakes studied. The Secchi Disk reading, in 1988, was 4 feet, a reduction of 1/3.

Appleman Lake supported a tremendous macrophyte growth during the summer of 1988. The major species was coontail. Also algal blooms were a reoccurring problem during the summer. This increased vegetative growth resulted in reduced dissolved oxygen concentrations below 10 feet.

Appleman Lake was the only lake studied where the problems could not be at least partially attributed to development of residential areas around the lake. There are only two homes on the lake, and one of these is a considerable distance from the lake. Thus it appeared the problems of Appleman Lake relate to agricultural practices in the surrounding watershed. There are several animal operations in close proximity to the lake. In addition most of the farm ground in the watershed is cropland. Both of these practices contribute to the nutrient input of the lake.

One modifying consideration of the above conclusions would be the 1988 drought, which may have had a more dramatic effect on Appleman Lake as compared to lakes with inlets and outlets. This effect may have increased the concentrations of nutrients found in the lake. Continued study will settle this question, but there is no doubt, even with the drought, that the water quality of this lake must be improved.

RECOMMENDATIONS

Because of the unique features of this lake, the farmers in the watershed of Appleman Lake should be acutely aware of the effects certain farming practices can have on this lake. Practices acceptable in other farming areas may have severe

consequences if employed around Appleman Lake.

Farm animals should not be allowed in the lake to drink, and they should be restricted from the area around the lake with fencing. If large numbers of farm animals are allowed to pasture on the steep banks surrounding the lake, provisions should be made to assure the storm run-off from this area does not reach the lake. This may be accomplished by planting wide buffer strips between the lake and the pasture fields. Any confinement operations or large barnyard areas should be designed properly to eliminate run-off from these areas into the lake. In addition, a system of terraces would also help reduce run-off from entering the lake.

Tile drains from barnyards should not run directly to the steep areas around the lake, thus allowing this material to enter the lake. Water from these drains should be diverted away from the lake or, if not possible, the water should be collected into a series of holding ponds containing wetland areas. In addition, any human sewage (if there is any) entering such drains must be eliminated, and septic tanks must be installed for those homes not having them.

Fertilizer applications on crop fields in the watershed should be applied according to soil tests, thus reducing fertilizer run-off and reducing costs to the farmer.

CONCLUSION

Appleman Lake is a lake in trouble. If it is possible to improve the water quality of this lake, it should be done immediately, for time will only escalate the expense. The more severe the eutrophication, the more difficult and expensive the solutions.

Indiana LCS: 1975

Class: 2

Index: 30

APPLEMAN LAKE

Size: 52 Ac.

Max. Depth: 26'

Mean Depth: 11.3'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	7/1	.5 5.0 10.0 15.0		0.08	1.2	7.7 8.3 6.5 3.0	4	
Mid-Lake	8/24	.5 13.0 26.0	0.05 0 .64					
Mid-Lake	5/24						8.0	
Mid-Lake	6/1	5.0		0.14	1.5	8.5	4.0	
Mid-Lake	6/28	5.0	0.15	0.03			5.0	
Mid-Lake	8/19	26 53	0.06 0.51					
Inlet	6/16 7/14 10/17 10/21		0.36 0.34 0.26	0.12	1.7			0.8 0.02

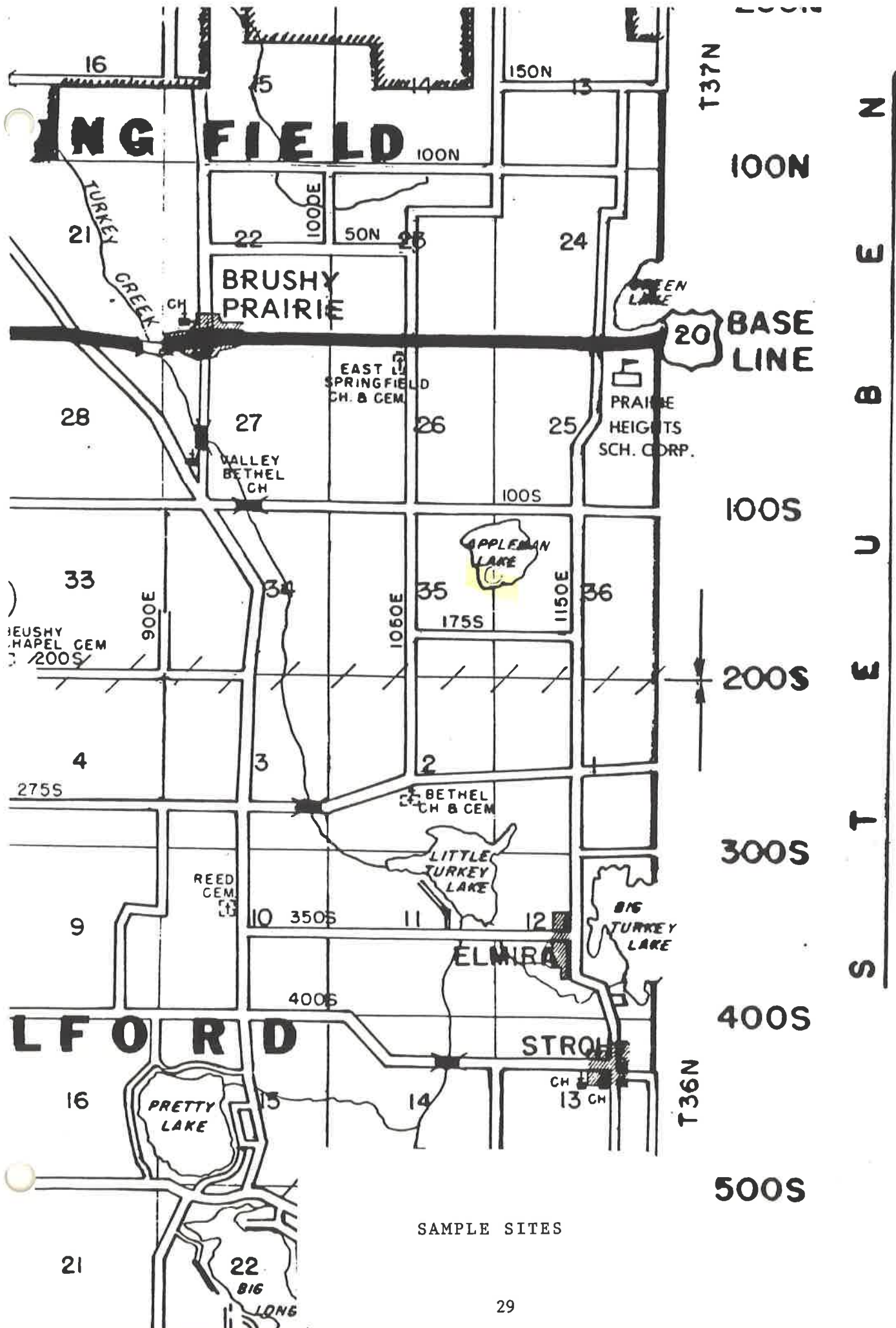
1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



SAMPLE SITES

FIVE LAKES

The Five Lakes are located in the south central area of LaGrange County. These lakes are Witmer (204 acres), Westler (88 acres), Dallas (283 acres), Hackenburg (42 acres), and Messick (68 acres), and together they have a combined surface area of 685 acres. These lakes are interconnected by natural, navigable channels or streams.

A 1938 aerial photograph shows one cottage on Dallas Lake with the other lakes being completely undeveloped. Extensive wetland areas encompassing hundreds of acres surround all of the lakes. These wetland areas were probably the largest remaining remnant of the vast wetland areas found in LaGrange County before 1938. Estimates of the per cent of shore being wetlands are: Witmer - 70%; Westler - 40%; Dallas - 40%; Hackenburg - 100%; Messick - 25% .

Watershed landuse is agricultural, except for the town of Wolcottville, and the farm fields do not extend down to the shore areas of the lakes as found on other lakes in the county, mainly because of the wetlands. Only two county roads enter the lakes area, one on east and one on the west side of the lakes area, leaving a vast, undisturbed lake-wildlife area.

A 1965 aerial photograph shows extensive development on all the lakes. With the exception of the north sides of Dallas and Hackenburg lakes and the east side of Witmer Lake all the wetland areas around the lakes are gone and are replaced by houses. Channels have been dug (32 channels can be counted) and several of the channels are so massive that they are the most noticeable feature of the area, dwarfing even the width of the North Branch of the Elkhart River, which is the outlet river for the Five Lakes. On just Witmer Lake alone channels have added approximately 18,000 feet of shore line to the lake.

Almost all of the shore has been converted to campgrounds, trailer parks, and building lots. Some areas, especially on Dallas Lake, were developed into subdivisions with large lots, but many areas are subdivided into small 50 foot lots. Because these homes have been converted to year around homes and sewage disposal has not been improved to compensate for this increased use, septic tank leaching is creating a water quality problem for these lakes. Septic effluent leaching was investigated, using the leachate detector, and several areas were shown to be leaching septic effluent into the lakes.

A 1986 aerial photograph shows the development of the lakes was completed by 1965. Further development since 1965 has mainly been the conversion of cottages to year around homes.

A second very noticeable feature in the 1986 photograph,

aside from the changes in development, is the large, extensive wetland-wildlife area north of Dallas and Hackenburg Lakes. This area is the largest undisturbed wetland area left in LaGrange County and covers several hundred acres. Its value is immeasurable not only to wildlife, but as water quality protection for Hackenburg, Messick, and to a lesser extent, Dallas Lakes.

Except for Dallas Lake, which is the largest and the third lake in the five lake chain, water quality data is generally similar. Average total phosphorus was 0.20 mg/l for Witmer Lake, 0.19 mg/l for Westler Lake, 0.11 mg/l for Dallas Lake, 0.19 mg/l for Hackenburg Lake, and 0.23 mg/l for Messick Lake. Ortho-phosphates were 0.14 mg/l for Witmer, 0.16 mg/l for Westler, 0.06 mg/l for Dallas, 0.15 mg/l for Hackenburg, and 0.17 mg/l for Messick. Nitrates generally averaged about 1.5 mg/l.

Secchi disk readings indicate there is pressure from boating activities. Readings were taken six days before the Memorial Day weekend and again two days after the weekend. Witmer Lake readings dropped from 8 foot to 4 foot after the holiday, Westler dropped from 9 foot to 4.5 foot, while Dallas Lake readings remained at 12 foot for both readings. Later in the summer (6-28-88) both Westler and Dallas Lakes improved with readings of 9 foot and 15 foot respectively, but Witmer Lake, with a reading of 5 foot, did not improve.

In addition, on Witmer Lake, a major problem exists because of the number of residents who are by-passing their septic tanks and dumping laundry water into the lake.

The major inlet stream for the Five Lakes is the Little Elkhart Creek, and the stream enters the first lake of the chain, Witmer Lake. This stream drains a water shed of about 23,000 acres, making Witmer Lake the largest lake-watershed complex in the county. Highly erodible soils in this watershed do not account for more than 10% of the land area, but, because of the size of the watershed, can have a sizable impact on the lake's water quality. Sediments for this inlet were 0.8 mg/l after a rain event. Total phosphorus concentrations averaged 0.32 ppm for three sampling periods (0.26 to 0.36 ppm).

The watershed supports multiple farming operations and several confined feeding operations are established in this watershed. The Wocottville, Ind. sewer plant also releases effluent into the Little Elkhart Creek about 2700 feet from Witmer Lake. Records from the IDEM indicate this plant has problems meeting permit requirements for BOD and suspended solids concentrations. Tests using the Leachate Detector also indicate the leaching of septic tanks into this stream from the homes located on the banks of the stream immediately before it enters the lake.

Hackenburg Lake receives water from the other major watershed for the Five Lakes. Hackenburg Lake has an immediate watershed of about 3000 acres, and, if the Oliver Lake watershed is included, the watershed is about 10,000 acres. This watershed flows through the large wetland area north of the lake before it enters the lake. Because of the difficulty of entering the wetland area and the extreme drought, samples were not obtained from this inlet stream.

Problems associated with this watershed are mainly connected with farming operations, especially animal operations. Several people have related an incident of a manure holding pit being pumped into a drainage ditch which flows into Hackenburg Lake. Also because of the wetness of the surrounding area, large drainage projects were completed to allow the land to be farmed, and the drained water enters the lake. Highly erodible land is estimated to comprise about 17% of this watershed.

The immediate watershed areas of Westler, Dallas, and Messick Lakes are small with the largest not being much more than 1000 acres. Several drainage tiles enter these lakes.

The Westler Lake watershed drains about 800 acres and contains about 7% highly erodible land. Samples taken from a tile entering this lake resulted in concentrations of 0.08 ppm ortho-phosphate and 1.8 ppm nitrates. Sediment buildup is evident in the area of entree of this drainage tile.

The total watershed area of the Five Lakes is over 36,000 acres and comprises about 15% of the total land area of LaGrange County. Because of this size, the watershed exerts a major influence on the water quality of the lakes.

The general complaint of the residents of the lakes is the increasing macrophyte growth which interferes with lake use. Shore areas of all the lakes support concentrated growth of coontail and a filamentous algae, and in some cases the growth is heavy enough to make it almost impassible for boats. Lake residents have adopted a weed spray program to combat this problem.

The causes of decreasing water quality on the Five Lakes are multiple and complex. Just the sheer size of both the water area and the watershed, and the problems associated with both, requires this report to be considered as a survey of general water quality. A more detailed analysis will require "several" additional years of study.

While realizing the complexity of the problems, several conclusions can be made. These causes affecting water quality have been categorized into general, discussion categories and are as follows:

RESIDENTIAL DEVELOPMENT

The Five Lakes area has the second highest population density

found in LaGrange County. The highest density is the Shipshewana area, the result of the popular tourist attraction. But while the density of Shipshewana is more transient, the population density of the Five Lakes region is more permanent, at least during the summer. This area may have an estimated 20,000 people congregating in or around the lakes on any single day. With the influx of people comes the associated problems which affects the water quality of the lakes:

SEWAGE DISPOSAL

Many of the homes, built on the lakes, were not planned as year around residences. As the homes were improved and made year around, the septic systems were not. Even those systems which were upgraded and improved still were inefficient, and in some cases, inoperable, because of the high watertables found around the lakes. As these systems are used, the effluent leaches into the groundwater, which then carries the associated nutrients into the lake.

Through use of the leachate detector, areas on Witmer and Westler were found to have leachate entering the lake from septic systems. This leachate was not coming from pipes running into the lake, for none were found, but from septic systems.

How much of an impact could this leachate be having on the lakes? Each person, it is estimated, contributes one pound of phosphorus per year through a septic system. With the total phosphorus concentration of 0.19 mg/l found in Witmer Lake, and estimating the number of people on the lakes for one day at 20,000, the total available phosphorus through the septics would be 130 million times the amount found in Witmer Lake. Now all this available phosphorus does not enter the lake. If the amount reaching the lake is one million times less than the amount available, the concentration reaching the lake is still 130 times the amount found in Witmer Lake! Even if the number of people using the septics around the lakes is less, the impact of this phosphorus source would still be enormous.

LAKE USAGE

The possibility of excessive boat usage on the lakes may be contributing to the reduction of water quality of the lakes. There was a marked reduction in the Secchi Disk readings on Witmer and Westler Lakes over the Memorial Day weekend. Because there were no rain events during this time period, the increase in water turbidity was attributed to the turbulence created by boat props.

ATTITUDES OF LAKE RESIDENTS

This section relates to impressions formulated as I visited the lakes for sampling or to talk to the Lake Associations across the county. I sampled a total of 26 lakes and presented 28 meetings for the residents of the lakes this last summer.

From this association, the following must be expressed -- the attitude of the residents of the Five Lakes is the worst encountered anywhere in the county. This, of course, does not include all the people living on these lakes, for many are very concerned and want to contribute, however possible, to the improvement of the lakes. But the number of people knowingly discharging wash water into the lakes, especially Witmer, is totally inexcusable. So is the fact that individuals throw trash and garbage the lakes. Some of these individuals may be visitors to the lakes, but I can't imagine visitors bringing plastic bags of garbage with them so they can dispose of them in the lakes.

In addition, the Lake Association must evolve from a social club, attended by a few individuals, to an organization which represents all the residents of the lakes. And the meetings should be attended by those same residents. It will be difficult to engage improvement projects for the Five Lakes without a strong, viable Lake Association which can lend a legal identity for this unincorporated area. In fact, a strong Lake Association can contribute, through the unique abilities of it's members, to self-help programs on the lakes which are now just imagined.

WATERSHED NUTRIENT INPUTS

Because the Five Lakes watershed is so huge (53 times larger than the surface area of the lakes), the impact of this watershed on lake water quality is significant. To maintain the present water quality, or hopefully to improve it, will require improvement of certain practices performed in the watershed.

The nutrient and sediment inputs from the Little Elkhart Creek, which enters Witmer Lake, are a major source of loading for the lakes. Contributors of this loading are the town of Wocottville and farming practices in the watershed.

The sewer plant at Wocottville is, most likely, a major contributor, for the plant, according to the IDEM, apparently is not functioning correctly. In addition, the plant does not have the equipment necessary to reduce the concentrations of phosphorus contained in the effluent released into the creek, and thus may be part of the reason the total phosphorus for this inlet averaged 0.32 mg/l.

Wocottville's storm water also enters this inlet. This water can include many materials, including nutrients, which can adversely affect water quality. After each storm event, the materials which have accumulated on the roads, parking lots, yards, roof tops and other areas frequented by people, are carried in the storm water run-off to the Little Elkhart Creek, and then into the lakes. Because water is a universal solvent, any number of materials, some which may be toxic, are dissolved in this water.

Farming practices, especially animal practices, are also a concern. Large numbers of animals are allowed access to streams and drainage ditches through out this huge watershed of the Five Lakes. Also several containment areas are maintained in the watershed, and as mentioned previously, at least one has contributed large amounts of manure and nutrients to inlet streams.

Drop farming also has an impact on water quality through erosion and increased use of chemicals, and of course, when compared to areas which are not farmed, always will. Although improved practices need to be implemented, a major reason of this adverse impact is the destruction of the wetland areas once found along the streams and around the lakes. Their destruction allowed the sediments and nutrients to proceed unimpeded into the lakes.

RECOMMENDATIONS

If for no other reason, the economic viability of these lakes must be preserved. It is estimated the value of the property in and around the Five Lakes to be \$40-50 million. If each household on the lake spent just \$100.00 per week for the summer (12 weeks), the economic impact to the county would be \$8.4 million per summer. If we want to preserve this important economic base, improvements must be completed in the watershed and on the lakes themselves.

And of course, the lakes offer other benefits in addition to economic. Boating, fishing, swimming, wildlife, water quality protection, and, as is often stated, "Its a good place to raise a family", are all reasons for preservation of this unique area.

LAKE IMPROVEMENTS AND SEWAGE DISPOSAL

In the immediate term, those living on the lake should institute the following:

1. Chemical weed control should be discontinued. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
2. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers

- should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
3. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
 4. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:
 - a. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
 - b. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
 - c. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
 - d. Fix leaky faucets. This can save as much as 200 gallons of water per day.
 5. For the long term, sanitary sewers must be installed around the lakes, and every home must be connected. A possibility is to petition the town of Wocottville for incorporation of the Five Lakes area. When the town begins plans to update their sewer facility, ask to be included in those plans. This may also be to the town's advantage, for the increased number of hook-ups may solve some of the present problems with this facility.
 6. Boat usage, especially on Witmer, may be affecting the water quality of the lake. Considerable areas of the lake are shallow, and motor props stir the bottom material. This material contains nutrients and these are made available to the plants. People should restrict boat usage in these areas as much as possible, and when they enter the shallow areas, the boats should be slowed to a speed that does not create a wake.
 7. The residents of the lakes should form a Lake Association which will allow participation of all lake residents. One possibility is to form an association for each lake, but, because the lakes form an interdependent chain and affect each other, the individual associations should be coordinated by a board representing all the lakes.

WATERSHED IMPROVEMENTS

The major source of nutrient inputs is from the Little

Elkhart Creek, thus projects to reduce this input should be planned.

1. The town of Wocottville should begin improvements on their sewer plant as soon as possible. Any improvements must address the problem of phosphorus contained in the effluent. In addition, storm water run-off should be diverted from the creek, or should be treated before it enters the creek.

As the town plans the sewer improvements, they should explore the possibility of incorporating the Five Lakes area with the goal of providing sewers to the lakes. This would spread the cost incurred over a larger base, and as mentioned before, may help solve the problem, as indicated by the sewer plant manager, of the present over capacity of the plant.

2. Farming practices in the watershed, especially methods of handling manure, must be improved. A 1400 pound steer produces about 37 pounds of phosphorus per year, while each person produces about one pound. Thus, in this case, each steer is equal to 37 people, and a farmer who allows the manure of a herd of 50 animals to enter an inlet stream, is contributing the same as 1850 people.

For the crop farmer, there are many practices available for erosion reduction which are not only simple to implement, but are also inexpensive. Information about these practices are available from the LaGrange County SCS office, and in many cases the farmer can be paid for implementation of these projects. Some of these practices are conservation tillage, terraces, grassed buffer strips and crop rotation.

Indiana LCS: 1986

Class: 2

Index: 27

WITMER LAKE

Size: 204 Acs.

Max. Depth: 54.0'

Mean Depth: 34.5'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	5/24						8.0	
	6/1	5.0		.14	1.5		4.0	
	6/28	5.0	.15	0.03			5.0	
	8/19	26.0	0.06					
		53.0	0.51					
East Inlet (Little Elkhart River)	6/16		0.36	0.12	1.7			
	7/14		0.34					
	10/17		0.26					0.8

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

6. Pond Outlet Before Lake

7. Channel Where Cotton Lake Inlet
Enters Lake

8. Lake Outlet Stream 3-4 miles
from Lake

Indiana LCS: 1975

Class: 2

Index: 25

WESTLER LAKE

Size: 88.0 Ac.

Max. Depth: 38.0'

Mean Depth: 20.1'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	5/24						9.0	
	6/1	5.0		0.06	1.6		4.5	
	6/28	1.0	0.14	0.16			9.0	
	8/19	0.5	0.03					
		16.5	0.03					

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

Indiana LCS: 1975

Class: 2

Index: 28

DALLAS LAKE

Size: 283 Ac.

Max. Depth: 96.0'

Mean Depth: 35.2'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	5/24						12	
	6/1	5.0		0.04	1.8	7.5	12	
	6/28	2.0	.12	0.06			15	
	8/19	.5	.03					
		40.0	0.03					
		83.0	0.27					

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

Indiana LCS: 1975

Class: 2

Index: 29

HACKENBURG LAKE

Size: 42 Ac.

Max. Depth: 38.0'

Mean Depth: 12.1'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/19	0.5 16.5 33.0	0.03 0.03 0.51					

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

5. Secchi Disk

Indiana LCS: 1975

Class: 2

Index: 34/26

MESSICK LAKE

Size: 68 Ac.

Max. Depth: 55.0/54.0'

Mean Depth: 21.3'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
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Mid-Lake

5/24
8/19

0.5
20
46

0.01
0.17
0.51

0.17

13.5

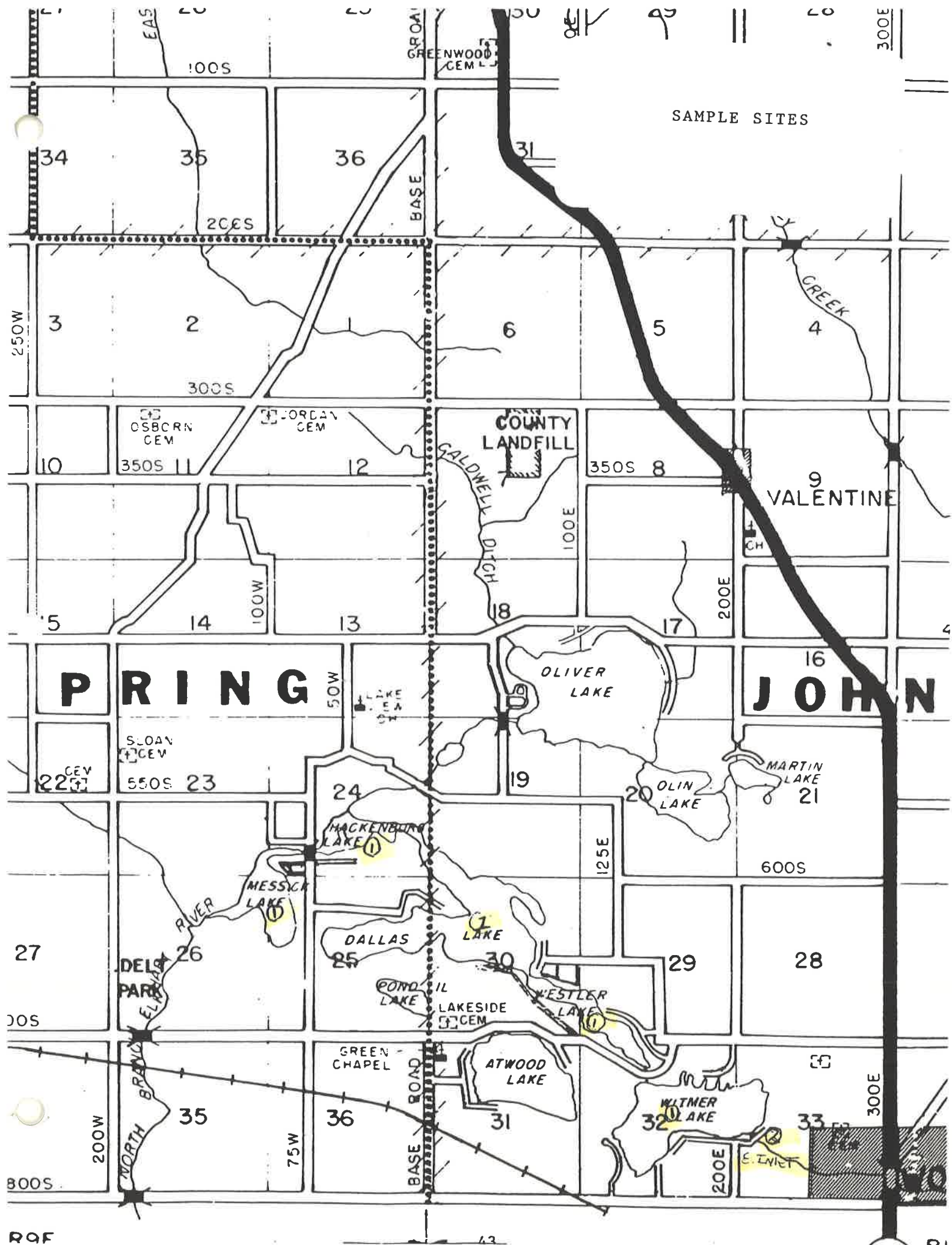
1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



SAMPLE SITES

PRING

JOHN

ADAMS LAKE

Adams Lake is a 308 acre lake in south central LaGrange County. The deepest area of the lake is 91 feet and the mean depth is 25 foot. The major watershed drains about 2600 acres to the east of the lake with the remaining 700 acres of the watershed being confined to the more immediate area of the lake. The eastern watershed, drained by the only inlet to the lake, contains about 700 acres of highly erodible soil representing about 27% of the watershed. The watershed immediately surrounding the lake contains about 70 acres or 10% highly erodible soil.

A 1938 aerial photograph shows approximately 20-25 cottages had been constructed on the shore of the lake making this one of the first lakes in the county to be developed. A possible reason for this early development could be accessibility, for the lake is surrounded by roads in the immediate vicinity of the lake. This accessibility has a long history, for survey maps from 1831 show a trail or road was in use at the east and west sides of the lake. Before this the trails were probably used by Indians.

The 1938 photograph indicates the lake has almost no wetlands around the shore of the lake with the exception of a small wetland on the southwestern shore of the lake. Also the lake has shallow water around all of the sandy shore allowing for extensive swimming. In the northeast part of the lake is a large, shallow, sandy area comprising about 5-6% of the lake area.

A 1965 aerial photograph shows the lake to be completely developed. Channels have been dug on the southwest and southeast shores and homes and cottages completely surround the lake with the exception of a small area around the outlet.

A 1986 photograph is very similar to the 1965 photograph, thus development of the lake was basically completed by 1965.

Total phosphorus concentrations for the inlet stream on the east side of the lake averaged 0.43 mg/l for five samples, with the highest reading being 0.59 mg/l. The average ortho-phosphate concentration for three samples was 0.33 mg/l with the highest concentration being 0.41 mg/l. The nitrate concentration for these same three samples averaged 2.6 mg/l with the highest concentration being 5.4 mg/l. This inlet also brings large amounts of sediment into the lake. The channel which receives the water from this inlet has been dredged three times in the past 10 years, and during a rain event sediment was 0.8 mg/l. Total phosphorus concentration for a mid-lake sampling averaged 0.15 mg/l for the water column.

Two problems threaten the water quality of Adams Lakes. First is the high density of homes on the lake, and second, the inlet stream on the east side of the lake.

RESIDENTIAL DEVELOPMENT

Adams Lake has about 330 homes, many of which are year around. Although the homes were improved during the transition from summer cottages to permanent residences, the septic systems are basically the same systems which served the summer cottages.

Although Adams Lake was not investigated for leachate from these tanks, it can be assumed, because of similar circumstances of development found on lakes which were checked for leachate, that septic systems are contributing to the nutrient input. Based on the findings of other lakes and reports from agencies such as the U.S.E.P.A relating to septic problems on other lakes, the possibility of septic leachate entering the lake would be a cause of the eutrophication of this lake.

INLET NUTRIENT INPUTS

This inlet stream contributes extremely high concentrations of nutrients to the lake. Of the five samples on this inlet, total phosphorus averaged 0.43 mg/l with the highest reading being 0.59 mg/l. and nitrates, at a concentration of 5.4 mg/l, were the highest found of any of the 22 inlet streams checked. Thus, this inlet stream is a major contributor to the declining water quality of Adams Lake.

The major contributors to the nutrient inputs of this stream, which drains about 2595 acres, are several animal operations in the watershed, and crop farming.

RECOMMENDATIONS

Adams Lake is part of the huge watershed which supplies Five Lakes, three miles away from Adams Lake. Thus, the water quality of Adams Lake also affects the water quality of the Five Lakes, especially Witmer Lake, the first lake of the five lake chain.

LAKE IMPROVEMENTS AND SEWAGE DISPOSAL

In the immediate term, those living on the lake should institute the following:

- A. Chemical weed control should be discontinued. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot

or more, and should be planted with small shrubs and low ground cover

C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.

D. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:

1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
3. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

For the long term, sanitary sewers must be installed around the lake, and every home must be connected. The lake residents have applied for a grant from the State for sewer installation, and this avenue should vigorously be pursued. The installation of sewers would be of extreme value in protecting the water quality of this lake.

WATERSHED IMPROVEMENTS

Nutrient inputs from the east inlet stream must be dramatically reduced, or the deterioration of the water quality of the lake will persist.

The handling of animal wastes must be improved and programs implemented to reduce storm water run-off. Access to the stream by farm animals must be restricted. Because of the amount of highly erodible land in the watershed, practices should be implemented to reduce erosion on crop land.

To reduce storm water run-off from animal operations, holding lagoons, grassed buffer strip, and, in some cases, wetlands should be constructed in strategic areas to contain and treat the water before it enters stream. To keep animals out of the streams, stream banks should be fenced and restricted access areas should be constructed to allow the animals to drink without directly entering the streams. In addition the stream banks should be seeded with grass and possibly small trees and shrubs.

To reduce sediment inputs into the lake, good farming practices must be implemented. Whether conservation

tillage, terraces, grassed buffer strips, contour tillage, or other measures are used depends on individual needs and requirements. But, whatever the practice implemented, a reduction of sediment inputs into the lake will help preserve the water quality of Adams Lake.

Indiana LCS: 1975

Class: 1

Index: 28

ADAMS LAKE

Size: 308 Ac.

Max. Depth: 91.0'

Mean Depth: 25.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/23	0.5	0.03				8.0	
		40	0.06					
		82.5	0.38					
East Inlet	6/16		0.34	0.21	5.4			
	6/22			0.41	1.7			
	7/11		0.24					
	7/14		0.59					
	7/27							0.2
	8/15			0.38	0.6			
	8/18		0.40					
	10/17		0.56					0.8

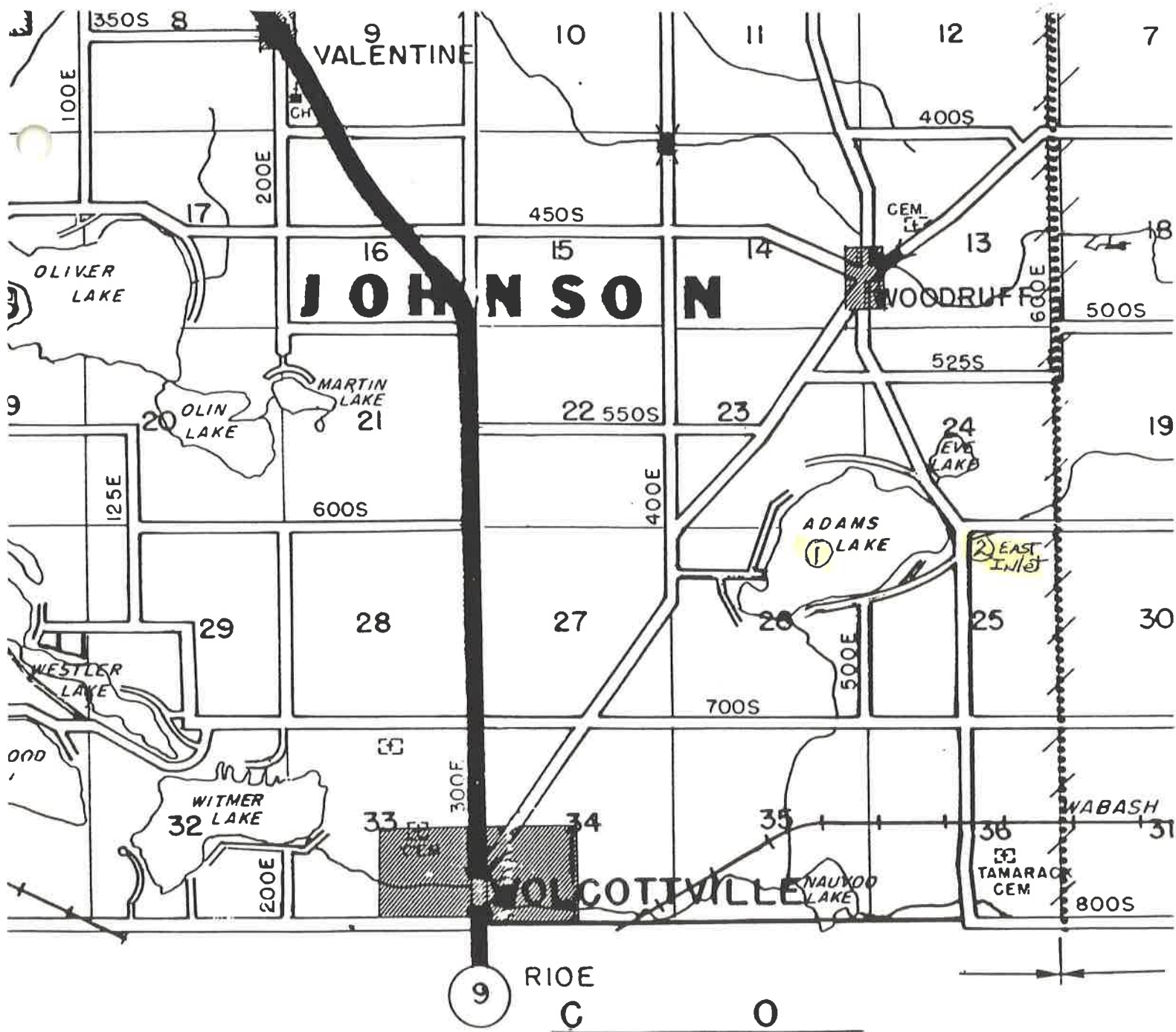
1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



SAMPLE SITES



SCALE IN MILES

LAGRA

SHOWING:
ROAD INTER:
FEDERAL, ST
TOWNSHIPS—
CREEKS—RI

OLIVER, OLIN AND MARTIN LAKE CHAIN

This chain of lakes is located in the south, central part of LaGrange County about one mile north of the Five Lakes chain of lakes. The lakes are Martin Lake (26 acres), Olin Lake (103 acres), and Oliver Lake (362 acres). The lakes have a combined surface area of 491 acres, making it the second largest lake complex in the county. Also Oliver Lake is the second largest lake in the county, being only 26 acres smaller than Big Long's 388 acres.

A 1938 aerial photograph shows the beginning of development on Oliver Lake with about 15 homes and the Purdue University Limberlost Nature Camp occupying areas of the north and east shores. Olin and Martin Lakes remain completely undeveloped and isolated for roads have not been constructed to these lakes.

Wetland areas surround about 50% of Olin and about 75% of Martin Lakes. Large wetland areas surround the western half of Oliver Lake, and the wetland surrounding the outlet of the lake extends into the massive wetland area on the north side of the Five Lakes area. To the northwest of the outlet is a second wetland area of several hundred acres, and this area contains two large ponds covering about 25 acres. This wetland area is also part of the wetland complex north of the Five Lakes area.

On the north side of Oliver Lake several farm fields approach the shore of the lake and areas of severe erosion can be identified which are eroding into the lake. The remainder of the lake is buffered by either trees or wetlands and thus farming is removed from the immediate lake area. Both Martin and Olin Lakes are protected from farming activity by woods or wetlands, with the exception of one field on the north of Martin Lake. Erosion from this field has "flowed" from the field and covered the wetland around the shore in several distinct areas. One of these erosion areas has completely covered the wetland area and is most likely directly adding sediment to the lake.

The watershed land use is farming, with all available land under cultivation. The two inlets on the east side of Martin Lake are surrounded by wetlands of several hundred acres. The two inlets on the eastern side of Oliver Lake are farmed "down to the creek banks", and the lake is not protected from this inflow by wetlands. The large inlet stream on the northwest side of Oliver Lake (known as the Caldwell Ditch) flows into a large wetland area before entering the lake. The major inlet for Olin Lake is the outlet of Martin Lake, although two other small inlets enter the lake.

A 1965 aerial photograph shows Oliver and Martin Lakes to be developed with homes. On Oliver Lake all but the south shore has been developed, and eight channels have been dug on the west side to accommodate about 35 additional homes. Martin

Lake has been developed on the north shore only, and no channels have been dug on the lake. Olin Lake remains undeveloped.

Approximately 25% of the wetland north - northwest of the outlet of Oliver Lake has been drained, and a system of eight, large drainage ditches have been constructed in this area to allow farming. It appears sediment from this drainage system is filling in a large pond, for the pond is smaller than in 1938.

Wetland areas on Oliver Lake have been drained except two small areas on the northwest side and the wetland areas on the south side which is undeveloped. The wetland areas on the north shore on Martin Lake are now housing developments. The large wetlands surrounding the eastern inlets of Martin Lake are still intact as are the small wetlands on the south shore. Many of these surviving wetland areas indicate an accelerated vegetative succession possibly caused by drainage practices in the area surrounding the wetlands.

A 1986 aerial photograph shows most of the development was completed on the lakes by 1965. Additional homes have been built on the west shore of Oliver Lake and a campground or trailer court has been completed on a channel on the northwest shore of the lake. Additional homes have been constructed on the north shore of Martin Lake, but no other major changes are noted on either lake. Olin Lake is still completely undeveloped, thus this lake, with a surface area of 103 acres, is now the largest undeveloped lake in the state of Indiana. The drainage system, which drains part of the wetland area north of the Oliver Lake outlet, has been dredged out since 1965, making the drainage more efficient.

Water quality data indicates these lakes are superior to many of the county lakes. Total phosphorus averaged 0.1 mg/l for Martin, 0.07 mg/l for Olin, and 0.08 mg/l for Oliver Lake. Nitrates concentrations were about 2.0 mg/l for the three lakes. Secchi Disk readings, recorded on the same day, were 15 foot for Martin, 10 foot for Olin, and 10 foot for Oliver Lake. Oxygen concentrations were good in all three lakes.

Data from inlet streams indicate potential problems for these lakes, especially Oliver Lake. The northwest inlet stream on Oliver Lake (Caldwell Ditch) drains about 1300 acres, with about 175 acres or 13.5% classified as highly erodible. This inlet also drains the area around the county landfill, which may increase the potential impact on the lake. Total phosphorus concentrations for this inlet averaged 0.22 mg/l for three samples (0.12 - 0.34 mg/l). Sediment was 0.8 mg/l after a rain event. A sample taken on 6-20-88 recorded a concentration of 0.24 mg/l for ortho-phosphate. Total phosphorus was not run on this sample.

Two inlet streams enter the east side of Oliver Lake and drain a watershed area of about 800 acres with about 60 acres

or 7.5% being highly erodible. The most northern inlet averaged 0.09 mg/l total phosphorus for three sampling dates, while ortho-phosphates were 0.01 mg/l. One sample, taken after a rain event, was 0.24 mg/l total phosphorus.

Sediments did not prove to be a problem on this inlet with the highest reading being 0.4 mg/l. The southern inlet stream, entering the eastern side of the lake, averaged 0.26 mg/l total phosphorus for four sampling dates (range 0.10-0.48 mg/l) and ortho-phosphates on one occasion were beyond the limits of the test of 2.5 mg/l. Sediments were 1.0 mg/l after a rain event.

Oliver Lake has a direct watershed of about 3300 acres, with about 130 acres or 4% highly erodible land. If the watershed of Martin and Olin Lakes are included in the watershed of Oliver, the total watershed of this lake is about 7100 acres.

The Olin Lake watershed has only about 560 acres with about 30 acres or 5% highly erodible land. Olin Lake is completely surrounded with a large stand of hardwoods, and of the 560 acres, about 200 acres is forest and wetland. If the Martin Lake watershed is included, the total watershed of Olin is about 3700 acres.

Martin Lake has a watershed of about 3150 acres, with approximately 150 acres or 4.8% highly erodible land. This huge watershed is 121 times larger than the lake and must have significant influence on the lake's water quality.

This three lake chain is one of the most unique lake systems in the state of Indiana. First, Martin and Oliver Lakes are both undeveloped on their southern shores which has reduced the effects of development found on many other lakes in the county. Second, Olin Lake, the second lake in the chain, is the largest undeveloped lake in the state, creating a window into the past, and allowing a visualization of the pristine, undisturbed lakes as they once were.

But even this isolation of Olin Lake may not protect this lake forever. There are indications the water quality is declining as indicated in the table below. The table compares total phosphorus concentrations and Secchi Disk readings from 1975 vs 1988.

	TOTAL PHOSPHORUS (mg/l)		SECCHI DISK (feet)	
	1975*	1988	1975*	1988
MARTIN	0.04	0.1	10.5	15.0
OLIN	<0.03	0.07	9.0	10.0
OLIVER	<0.03	0.08	10.0	10.0

* Indiana Lake Classification System - IDEM ;1986

Although the Secchi Disk readings are similar, the phosphorus concentrations have at least doubled for all three lakes. To determine a definite trend, these lakes will be investigated in future years.

From this preliminary data, some conclusions as to the causes of the declining water quality can be made.

INLET NUTRIENT INPUTS

Inputs for Olin Lake are mainly from Martin Lake. Even though Olin has two other, very small inlet streams, each are surrounded by forest and wetlands. Thus Martin Lake has a major impact on the water quality of Olin Lake.

Martin Lake, which has the highest phosphorus concentrations of the three lakes, has a very large watershed, and a large portion of the nutrient input must originate here. The lake has only 15 homes built on the shore, and, even though the lake was not investigated with the leachate detector, it seems unreasonable to suspect septic leaching to be a major cause of the phosphorus input. Further investigations of the inlet streams of Martin Lake will be completed during normal years, for the 1988 investigations were curtailed by the drought.

Oliver Lake is influenced by inputs from Olin Lake and three inlet streams. The major inlet is the Caldwell ditch which enters the northwest side of the lake. Because of its volume and the high concentrations of phosphorus and sediments, the Caldwell ditch is probably the major contributor of inputs from the three inlets. The major sources of inputs are farming practices and possibly the county landfill, but additional studies must be completed to further identify the exact sources.

The east inlet #2 watershed also contributes high concentrations of nutrients and sediments to the lake. Because this stream does not have the flow of Caldwell Ditch, the over-all amounts are not as high. The main source of inputs on this stream are mainly from animal operations.

The east inlet #1 did not show excessive concentrations of nutrients or sediments except for the 10-17-88 sampling date. The total phosphorus concentration was 0.24 mg/l and sediments were 0.4 mg/l. The source of these concentrations are most likely farm operations in the upper area of this stream.

Although the three inlets of Oliver Lake and the two of Martin Lake have buffer strips of either wetlands or wooded strips along the first half mile of their banks, the farm fields further from the lake are farmed close to

the banks of the stream. In addition, there are several animal operations of varying intensity throughout the watershed of all the streams.

The wetlands, especially on the east end of Martin Lake, have very visible "streams" flowing through them. This indicates that channels were either dug or developed because of surrounding drainage practices through the middle of these wetlands. This allows the water to flow through the wetlands uninhibited, and thus the water is not filtered by the wetland.

RESIDENTIAL DEVELOPMENT

Again, development was unplanned. On the west end of Oliver Lake, the homes are built either on low lying areas or in filled in wetlands. This may have created problems for sewage disposal. Although the area was not checked with the leachate detector, several problems with poorly operating septic systems have been reported. A similar situation exists on the northeast shore of Martin Lake.

Generally, the residential development on both Martin and Oliver Lakes has had some impact on lake water quality, especially the septic systems mentioned before. Some lots on both lakes are small and several systems may not conform to codes concerning set-backs. Also, some systems should be updated, for there is concern that some of these old systems are not functioning properly.

Also several other practices along the lake shore are having adverse affects on the lake water quality. Several lake residents have removed aquatic vegetation from the shoreline even though the vegetation did not interfere with lake use. Landscaping practices, especially on steep banks, have left areas of exposed soil which then erodes into the lake. Several large trees have been cut on these "bank" areas to allow the sun to penetrate to grass and flower bed areas. Lawn fertilizer and weed killers have been used extensively in some areas.

RECOMMENDATIONS

To assure the maintenance of the water quality in this chain of lakes, the following is recommended:

WATERSHED IMPROVEMENTS

Farming practices in the watershed of this three lake chain are the major watershed contributor to the nutrient and sediment inputs of the lakes.

- A. Stream banks should be seeded with grass and low growing shrubs, and farm fields should not be planted close to the stream.

- B. Animal operations must be maintained so manure and run-off is diverted from the streams. Where animals are allowed to pasture, the streams should be fenced and limited access drinking areas constructed. In addition confinement operations and barnyards should either be moved from areas close to the streams or run-off treatment, such as holding pits or diversion ditches, should be constructed.

Many of these ideas and others, too numerous to mention, are available from the LaGrange County Extension and SCS Offices. In addition to technical information, financial assistance may be available from the LaGrange County ASCS Office.

LAKE IMPROVEMENTS AND SEWAGE DISPOSAL

The lake residents can also initiate many improvements which will preserve and improve the water quality of the lakes.

In the immediate term, those living on the lake should institute the following:

- A. Chemical weed control should not be started. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats. Disturb as little of the vegetation as possible.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
- C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
- D. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:
 - 1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
 - 2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
 - 3. Install water saving shower heads and toilet valves. These items can save at least 1/3 of water normally used.
 - 4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

- E. When landscaping, disturb only the area being landscaped. Construct barriers to exposed soil erosion and leave as many trees as possible.

For the long term, sanitary sewers should be investigated, especially for those homes built on low areas or filled wetlands. Such a study may prove sewers are not necessary for the entire lake area, but it may be possible to improve a sewage problem with alternate systems.

Indiana LCS: 1975

Class: 1

Index: 10

OLIVER LAKE

Size: 362 Ac.

Max. Depth: 91.0'

Mean Depth: 40.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/20	12.0		0.03	1.9	8.0	10.0	
	8/18	0.5	0.03					
		40.0	0.12					
		82.5	0.1					
NW Inlet	6/20			0.24	0.01			
	7/22		0.20					
	10/17		0.34					0.8
East Inlet #1	6/22			0.01				
	6/28			0.01				
	7/11		0.12					
	8/15			0.02	0.5			
	8/18		0.01					
	10/17		0.24					0.4
	10/21							0.01
East Inlet #2	6/22			0.22	1.5			
	6/28		0.48	0.32				
	7/11		0.22					
	8/18		0.23					
	10/17		0.1					1.0
	10/21							0.025

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

Index: 10

OLIN LAKE

Size: 103 Ac.

Max. Depth: 82.0'

Mean Depth: 38.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/20	10		0.02	2.2	8.0	10	
	8/18	0.5	0.01					
		43.00	0.01					
		80.0	0.21					

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

- ## 5. Secchi Disk

Indiana LCS: 1975

Class: 1

Index: 35

MARTIN LAKE

Size: 26 Ac.

Max. Depth: 56.0'

Mean Depth: 34.2'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/20	10		0.09	2.1	8.1	15.0	
	8/18	0.5	0.03					
		26	0.05					
		53	0.23					
600 S. Inlet	8/12		0.03					

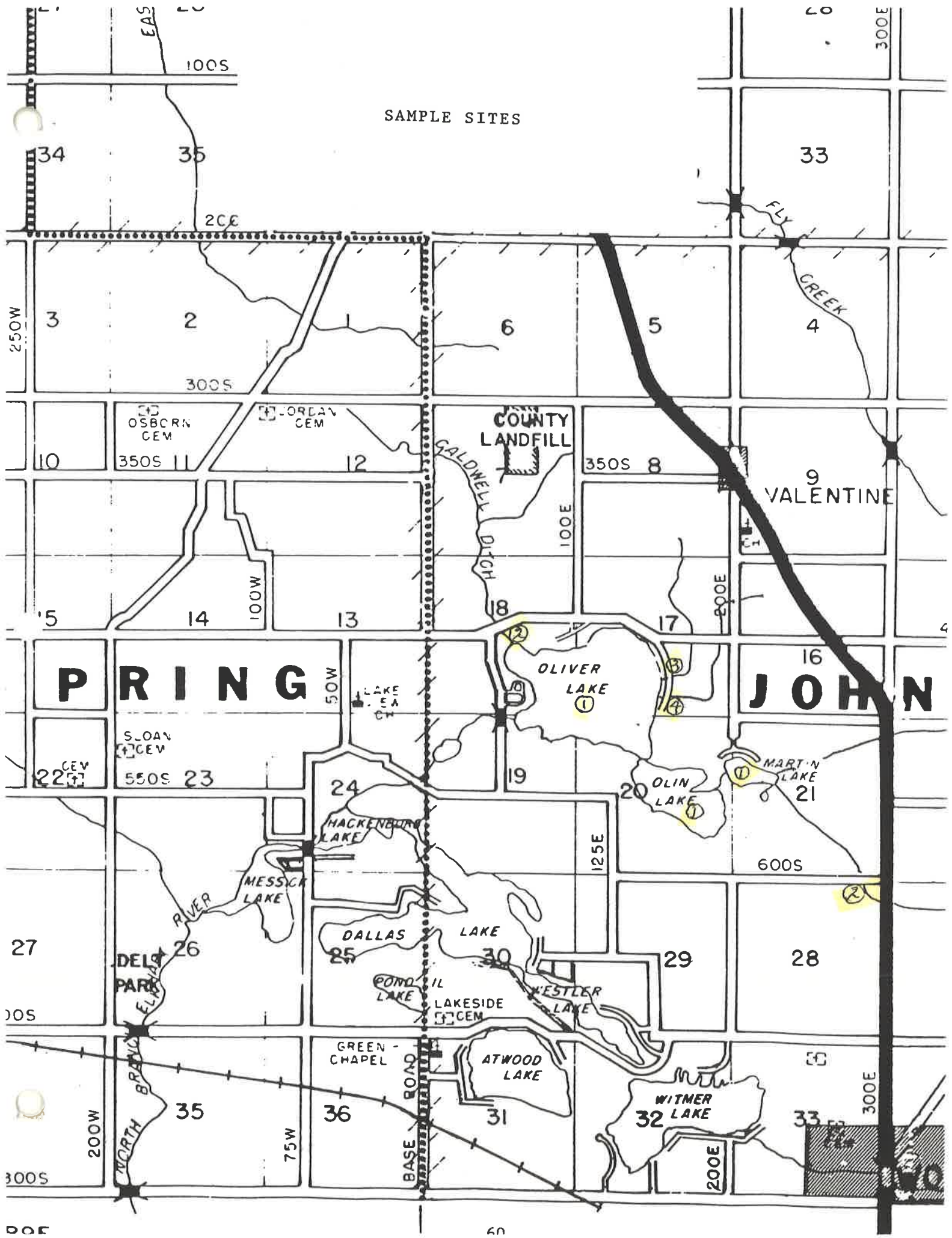
1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



BIG LONG LAKE

This lake is located in the southeastern corner of LaGrange County, and at 388 acres is the largest lake in the County. The maximum depth of the lake is 82 feet and mean depth is 40 feet, making this lake the third deepest lake in the County.

A 1938 aerial photograph shows several areas of the shore were developed with county roads leading to several hundred homes. Wetland areas are visible on the northwest, south and southeast areas of the lake. The watershed landuse is agriculture, and the fields extend down to the water's edge except in the developed areas. These fields show evidence of extensive erosion especially in the watershed surrounding the northwestern inlet stream.

A 1965 aerial photograph shows the lake to be completely developed with the exception of a small area in the southwest part of the lake. Channels have been dug on the northwest and southeast shores, and trailer courts have been developed along these channels. Two wetland areas remain in the southeast area of the lake, and have been undisturbed except for a small channel dug to one side of a wetland area. These wetland areas are also evident in the 1938 photograph as is the small wetland area around the northwest inlet stream. Thus, Big Long Lake never had an extensive wetland system as found on other lakes of the county.

A 1986 aerial photograph indicates lake development had been completed by 1965, for there is little noticeable difference between the two photographs. An exception is the northwest inlet stream has apparently been dredged during this time period for the stream boundaries are much more defined.

The watershed of about 3000 acres is small in comparison to the lake and is only 7.7 times larger than the lake itself. Approximately 700 acres or 23% of the watershed is classified as highly erodible, most of which surrounds the northwest inlet stream.

Total phosphorus at a mid-lake sampling site averaged 0.18 ppm, while ortho-phosphates averaged .03 ppm. Samples obtained in the lake at the northwest inlet stream had a total phosphorus concentration of 0.37. Samples obtained from the inlet stream itself were 0.10 ppm total phosphorus, while sediments were 0.6 mg/l. This inlet enters a bay on the northwest part of the lake, and the inflows of nutrients and sediments from this inlet may be affecting the water quality of the bay.

An area described as the southwest pond inlet also is a problem area for the lake with excessive macrophyte growth. Ortho-phosphates averaged 0.1 ppm, nitrates averaged 2.0 ppm and the DO averaged 14.9 ppm for this sampling site.

Generally for the lake as a whole, lake residents have noticed an increase in macrophyte growth over the past several years and have begun a weed spray program to combat this problem.

BIG LONG LAKE

Big Long Lake is a puzzle. Secchi Disk readings were as much as 20 foot in mid June, but had declined to only 10 foot by the end of August. Macrophyte growth was never a extreme problem except in the northwest bay, the southwest pond inlet area, and several areas on the southern shore. Because of the drought, the watershed did not contribute normal inputs of water or nutrients, and, in fact, the outlet had no water flow for about 1 1/2 months during the summer. Still total phosphorus concentrations averaged 0.18 mg/l at the mid lake sampling site. This is the 10th highest concentration of the 21 lakes studied.

One possible explanation is the 850 homes on the lake. As on most lakes, these were once summer homes which were converted to year around homes. When these homes were improved, the septic systems were not, thus many of the septic systems may be the original systems built at the same time as the summer home. Although the lake was not tested with the leachate detector, it is suspected many of these septic systems are leaching into the lake. Several lake residents have indicated that septic systems over flow and run into the lake.

Inputs from the watershed are a problem in some areas, but nutrient inputs from these areas do not account for the phosphorus concentrations found. For example, inputs from the northwest inlet stream may not have a significant impact on lake phosphorus levels, for the water from the bay flows towards the lake outlet, which is close by. Also this bay is over one mile from the mid-lake sampling site, and the water of the lake flows from the site towards the bay.

Although macrophyte growth is an extreme problem in the northwest bay, causes, other than the inputs from the inlet, must be contributing to this growth. Because of the drought, this stream had no flow during the summer. In October, after a storm event, the total phosphorus concentration from this stream was 0.1 mg/l and sediments were 0.6 mg/l. These concentrations do not seem to account for the extreme problem found in this bay. Of course, nutrient concentrations, large enough to support the macrophyte growth found, may be the results of inputs from past years. A lake sample, taken from the lake near the mouth of the stream, had 0.37 mg/l total phosphorus, indicating high past inputs from the inlet.

A 1925 survey map of the lake hints at another possibility for the cause of the vegetation problem in the bay. In 1925 this area was very shallow and was mostly a wetland area. When a dam was installed at the outlet and the water level of the lake raised, the increased water depth destroyed the

wetland, but, because of the bottom nutrients and the still shallow water depth, macrophytes succeeded the succulent plants of the wetland.

The southwest bay pond inlet is also an area of high nutrient input. Although total phosphorus concentrations were not determined, excessive macrophyte growth in this area indicated high nutrient inputs. Ortho-phosphates in the bay were 0.14 mg/l, and the dissolved oxygen at the surface was 14.9 mg/l. The high dissolved oxygen alludes to the high photosynthetic activity in this area stimulated by the available nutrients entering the lake in this area.

What ever the causes of the high nutrient levels found in the lake, definition of the causes must await further study.

RECOMMENDATIONS

LAKE IMPROVEMENTS AND SEWAGE DISPOSAL

First, a septic system inspection program should be implemented for identification of septic contribution to nutrient inputs. This should include a septic dye program in conjunction with investigations using a leachate detector. Second, if the above investigation proves positive, a program for sewer installation should be implemented.

In the immediate term, those living on the lake should institute the following:

- A. Chemical weed control should be discontinued. Weeds should be harvested either by hand or by mechanical harvesters. Only nuisance weeds should be removed such as those which interfere with swimming or docking of boats.
- B. Buffer strips should be planted along the shore to help contain storm water run-off. These buffers should be as wide as possible preferably 10 foot or more, and should be planted with small shrubs and low ground cover
- C. Lawn fertilizers and weed killers should not be used unless necessary for the health of the lawn. When they are used, amounts should be minimal.
- D. Reduce the use of septic tanks as much as possible by reducing water usage. Follow these simple suggestions:
 - 1. Because each flush of the toilet uses 5 gallons of water follow this advice -- If its yellow let it mellow. If its brown flush it down.
 - 2. Take a shower instead of a bath. And shower long enough to get clean, instead of long showers to relax.
 - 3. Install water saving shower heads and toilet

valves. These items can save at least 1/3 of water normally used.

4. Fix leaky faucets. This can save as much as 200 gallons of water per day.

In addition, further studies of the bay areas should be completed to determine other sources of nutrient inputs, especially the northwest bay area. This is also true for the pond inlet area. Progress of the lake's water quality should be surveyed each year.

WATERSHED IMPROVEMENTS

The watershed of Big Long Lake surrounds the lake as a narrow band of land, and only on the south and west sides does the watershed extend more than one mile from the lake. The watershed drains onto the lake mainly through drainage tiles, found all around the lake, and four small inlet streams. All of the streams are on the west side of the lake.

Two of these inlets, discussed in the results, most likely require attention, especially the northwest inlet stream. Construction of a nutrient-sediment trap or wetland on this northwest inlet stream may be corrective measures to be consider. Proposals, such as dredging the bottom of the bay, would require further study, including bottom core samples, to assure corrective measures do not create additional problems for the lake.

Construction of nutrient-sediment traps may also reduce the inputs from the southwest bay pond inlet. A wetland, constructed on the shore of the pond at the inlet mouth, may be another possibility, but construction further from the lake-pond area may not be feasible because of the low stream flow normally associated with the stream.

Indiana LCS: 1975

Class: 2

Index: 33

BIG LONG LAKE

Size: 388 Ac.

Max. Depth: 82.0'

Mean Depth: 40.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/13	8.0		0.03	1.2	7.0	20.0	
	8/23	0.5	0.06				10.0	
		33.0	0.17					
		66.0	0.31					
SW Channel	6/16		0.37	0.08	0.6			
SW Bay Pond	6/13			0.14	1.7	14.9		
NW Inlet	10/17		0.1					0.6

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

BIG AND LITTLE TURKEY

Big and Little Turkey Lakes are located in the southeast part of LaGrange County near the town of Stroh. Less than half of Big Turkey is in LaGrange County with the remainder being in Stuben County. These lakes are about 1/2 mile apart and are connected by a non-navigable stream.

Little Turkey Lake covers an area of 135 acres, with a maximum depth of 30 feet and a mean depth of 11.5 feet. Big Turkey Lake is 450 acres, with a maximum depth of 65 feet and a mean depth of 16.2 feet.

The 1938 aerial photograph of Big and Little Turkey Lakes show both lakes to be completely undeveloped with the exception of a cement manufacturing plant on the northwest shore of Big Turkey Lake. The cement plant dredged marrow from the northwest part of the lake, creating several large bay areas in this part of the lake. A 1830 survey map shows that Little Turkey Lake did not even exist and was created by the removal of marrow from a large wetland area between the lakes. This very large wetland area had been drained by 1938.

Small wetland areas surrounded the eastern and western shores of Little Turkey Lake, and the northern and southern shores of Big Turkey Lake. For its size, Big Turkey Lake has few wetlands.

A 1965 aerial photograph shows Big Turkey Lake to be completely developed around the shore. Several channels are visible, and the homes are several rows deep. This lake is one of the most intensely developed lakes in the county. Development on Little Turkey Lake has been confined to 3/4 of the southern shore. The remainder of the lake is surrounded by wetland areas. No channels have been constructed.

A 1986 aerial photograph shows development had been completed by 1965, with additional development confined to construction of vacant lots.

The watershed of Little Turkey Lake is about 13,500 acres with about 2500 or 19% being highly erodible. This watershed includes the town of Elmira and parts of Stroh, with the remaining land use being farming. The southeast inlet of the lake is the outlet of Big Turkey Lake and is about 1/2 mile long. The southwest inlet drains most of the watershed and has been extensively dredged creating a large drainage ditch. This ditch has changed little since the 1938 photograph. Total phosphorus for this inlet averaged 0.26 ppm and sediments were 0.8 mg/l. Total phosphorus for the southeast inlet was 0.07 ppm.

Mid lake total phosphorus concentrations averaged 0.19 ppm for Little Turkey. The most frequent complaint of the lake residents was excessive macrophyte growth, although no weed spray program had been started. The total phosphorus tests for Big Turkey Lake were incomplete.

Both of these lakes show evidence of high eutrophication. Mid-lake total phosphorus concentrations of Little Turkey Lake are among some of the highest of the lakes tested in 1988 (0.39 mg/l). Complete data for Big Turkey Lake was not received, but the total phosphorus concentration of 0.88 mg/l at 26 foot was the highest recorded at that depth.

This data indicates both lakes require immediate attention for these concentrations of phosphorus can only stimulate excessive macrophyte and algae growth forcing the lakes into a condition of extreme eutrophication.

The southwest inlet on Little Turkey Lake was the only inlet investigated sufficiently for nutrient inflows to allow any conclusion to be made. With total phosphorus concentrations of 0.16 and 0.36 mg/l and sediments of 0.8 mg/l, this inlet requires improvement. Because other recommendations require additional data, they will be made when the data is available.

Size:

Max. Depth:

Mean Depth:

BIG TURKEY LAKE

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

5. Secchi Disk

Size: 135 Ac.

Class: 2

Max. Depth: 30.0'

Index: 36

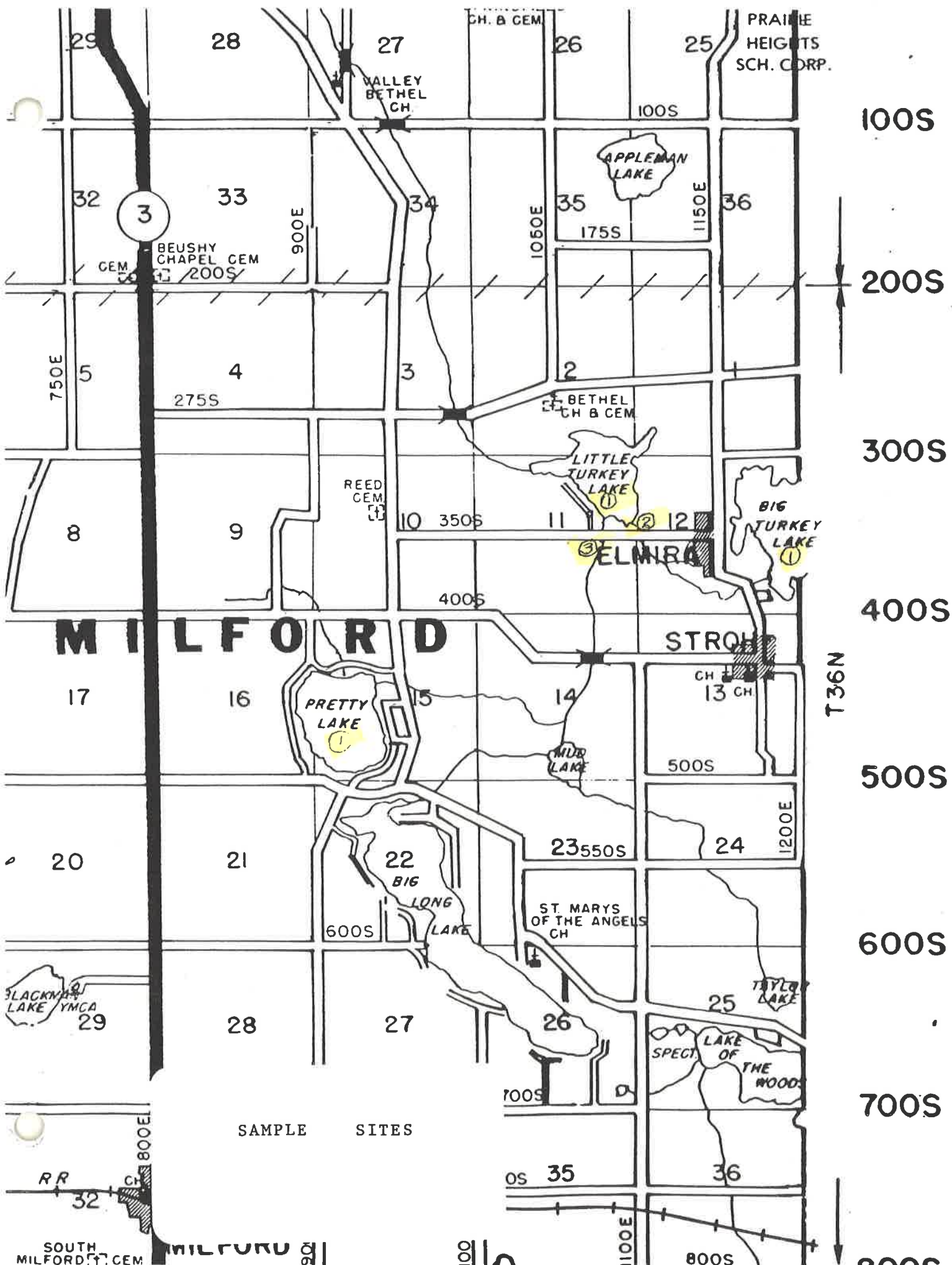
Mean Depth: 11.5'

LITTLE TURKEY LAKE

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/22	0.5 13.0	0.1 0.6 0.49				3.0	
SW Inlet	8/5 10/17		0.16 0.36	0.02	< 0.01			0.8
SE Inlet			0.07	0.05	0.9			

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

- ## 5. Secchi Disk



EMMA LAKE

Emma Lake is a 42 acre lake located in the southwest part of LaGrange County. The lake has a maximum depth of 34 feet and a mean depth of 16.7 feet.

A 1938 aerial photograph shows the lake to be undeveloped, but farm fields are extended down to the shore. Erosion from these fields is apparently not a problem as with other lakes in 1938, for the surrounding area is very flat. A small wetland surrounds the immediate, southern shore area of the lake where two inlet streams enter the lake.

A 1965 aerial photograph shows the east shore to be developed with about 20 homes. The remainder of the lake has changed little since 1938. Even the farm fields are the same as in 1938 and they still approach the lake's shore. While other lakes show some drastic changes from 1938 to 1965, this lake has changed little (with the exception of the eastern shore).

A 1986 aerial photograph shows little change since 1965 with the exception of the addition of a few homes on the eastern shore.

The watershed of this lake is its most prominent feature. This watershed is about 8700 acres and thus is 207 times larger than the lake. Although only about 200 acres or 2% of the watershed is classified as highly erodible, the sheer size of this watershed represents a problem for the lake. There are many animal operations in this watershed and animals have access to the two inlet streams throughout the watershed. The farming operations have noticeably increased in size since the 1938 and 1965 photographs.

Two inlet streams drain this southern watershed and enter the lake at the southern shore about 100 feet apart. Ortho-phosphates for the southwestern inlet averaged 0.32 ppm and for the southeastern inlet 0.43 ppm. Nitrates were about 1.0 for both inlets (average values for two sampling dates). A single, separate sample was taken for total phosphorus. Concentrations were 0.16 ppm for the S.E. inlet and 0.03 ppm for the S.W. inlet. Ortho-phosphates and nitrates were not tested on these samples.

Total phosphorus for mid-lake samples were 0.27 ppm, and 0.19 ppm. for a sample taken from the outlet.

The preliminary results on Emma Lake indicate its drift towards extreme eutrophication are the results of agricultural practices in the watershed. This does not mean that development in and around the lake shore has not had an input, but more data needs to be collected to determine development's contribution.

Thus at this point in time, the only recommendation is to begin improvement of agricultural practices, especially the handling of animal wastes.

Indiana LCS: 1975

Class: 2

Index: 44

EMMA LAKE

Size: 42 Ac.

Max. Depth: 34.0'

Mean Depth: 16.7'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/25	0.5 16.5 33.0	0.12 0.1 0.59					
SE Inlet	8/12			0.62	2.0			
	8/15			0.24	1.1			
8/18			0.16					
SW Inlet	8/12		0.03	0.26	0.9			
	8/15			0.38	0.9			

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



PIGEON LAKE

Pigeon Lake is a 61 acre lake located in the north - central part of LaGrange County. The maximum depth of the lake is 35 feet and the mean depth is 19 feet.

A 1938 aerial photograph shows the lake to be undeveloped with no access roads leading to the lake. Approximately 1/3 of the west shore and the entire southern shore are surrounded by wetlands, and this southern wetland extends at least five miles south of the lake. This wetland was originally 4000 -4500 acres, but large areas had been drained and probably was no more than 2000 acres by 1938. Farm fields extended down to the shore except where wetlands excluded farming.

By 1965 about 1/4 of the shore had been developed with homes. The remainder of the lake appears much as it was in 1938, but the southern wetland immediately adjacent to the lake has been drained. Shrubs and small trees have replaced much of the wetland grasses found in 1938, because drainage in the surrounding area has reduced the water available to the wetland. The large wetland which extended several miles south of the lake in 1938 has been drained to just several hundred acres.

A 1986 aerial photograph shows few changes on the lake except the construction of a few homes on vacant lots on the west shore. The wetland immediately south of the lake shows further vegetative succession with 90% of this wetland covered with trees and scrubs. The previous vast wetland, which extended several miles south of the lake, has been further reduced by drainage practices. Large, complex drainage ditches have been constructed throughout the wetland area, and most of the wetland is now farmland.

The watershed of Pigeon Lake is simply huge. The southern watershed is at least 20,000 acres. Because the Pigeon River enters the lake on the north shore, the river adds at least an additional 150,000 acres to the lake watershed. Because of the watershed size, the amount of highly erodible soil in the watershed could not be determined. Land use in the watershed is mainly agricultural, but also includes the towns of Mongo, Ontario, and Howe.

Samples taken at a mid - lake sampling site resulted in a total phosphorus concentration of 0.11 ppm.

The only test performed on Pigeon Lake was one mid-lake total phosphorus test, resulting in an average concentration of 0.11 mg/l. The only conclusion to be made is this one test shows the phosphorus concentration to be slightly higher than one would like to see. Further tests may show this conclusion must be modified.

Indiana LCS: 1975

Class: 2

Index: 27

PIGEON LAKE

Size: 61 Ac.

Max. Depth: 35.0'

Mean Depth: 19.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
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Mid-Lake

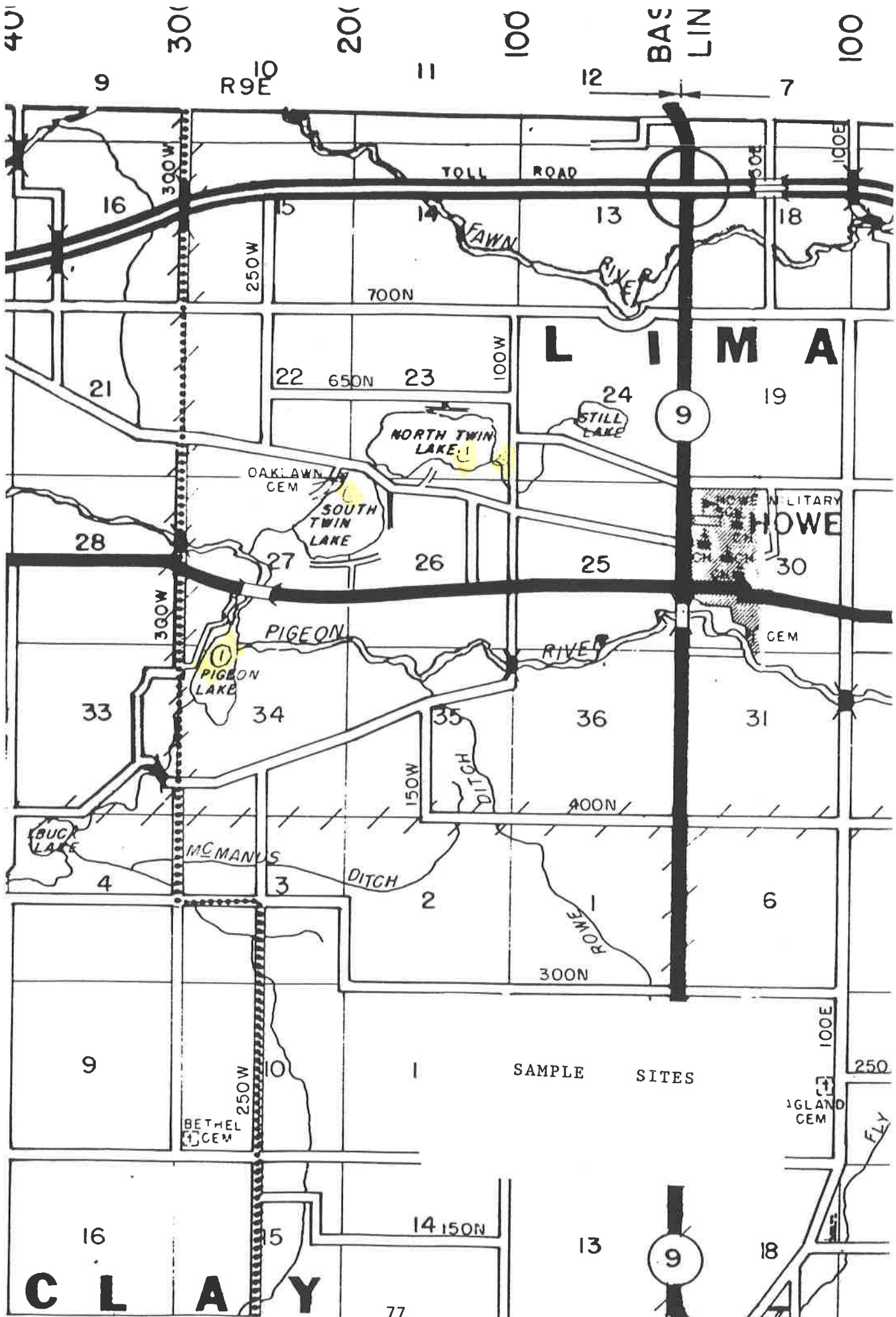
8/25

.5
16.5
33.0

0.05
0.06
0.23

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

5. Secchi Disk



CEDAR LAKE

Cedar Lake is located in the north central part of LaGrange County. The lake covers 120 acres with a maximum depth of 30 feet and a mean depth of 8.5 feet, making this lake the second most shallow, major lake in the county.

A 1938 aerial photograph does not reveal major development on the lake although it is difficult to tell because of the extensive wooded area surrounding the shore. A very large wetland area, covering hundreds of acres, extends from the southern shore of the lake to the Pigeon River, a distance of 2 miles. Other wetland areas surround the remainder of the lake, but are separated from the lake shore by a high ridge of forested land.

A 1965 aerial photograph shows the lake to be extensively developed except for portions of the southwestern shore and half of the eastern shore. The wetland on the eastern shore has been filled and homes have been built on the wetland. Large areas of the southern wetland have been drained for farm ground, but the wetland close to the lake remains. Several marrow pits have been dug 500-600 feet from the southern shore. Much of the wetland bordering the remainder of the lake also remains undrained.

A 1986 aerial photograph shows few changes in the immediate area of the lake since the 1965 photograph. The major change is the extensive drainage network constructed in the southern wetland beginning about 1/2 mile south of the lake. Thus the drainage of this extensive wetland has been intensified since 1965.

The watershed area of the lake is about 1000 acres with about 115 or 11.5% highly erodible. Land use is farming, and the marrow pit operation. The only inlet stream to the lake drains the southern watershed and enters the lake on the southern shore. Total phosphorus concentrations averaged 0.01 ppm, as did ortho-phosphates, and nitrates averaged 3.0 ppm for the inlet stream. Sediments are not a problem on this stream, for this stream flows through the southern wetland before entering the lake.

Total phosphorus concentrations for mid-lake samples averaged 0.01 mg/l, ortho-phosphates were 0.01 ppm and nitrates were 2.4 ppm. Dissolved oxygen was 5.2 ppm at 20 foot and the Secchi Disk reading was 6.5 foot. A diatom bloom was in progress when the disk reading was taken, and because of this the water had a creamy-green color. In addition, the lake water has a copper concentration of 0.05 ppm which may account for the green color.

Indiana LCS: 1975

Class: 1

Index: 9

CEDAR LAKE

Size: 120 Ac.

Max. Depth: 30.0'

Mean Depth: 8.5'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	6/24	0.5		0.01	2.4	7.0	6.5	
		10				7.2		
		20				5.2		
	8/26	.5	0					
		16.5	0					
		33	0.03					
East Inlet	6/24			0.01	3.2			
	8/5		0.01	0.02	2.8			
	8/12		0.01					

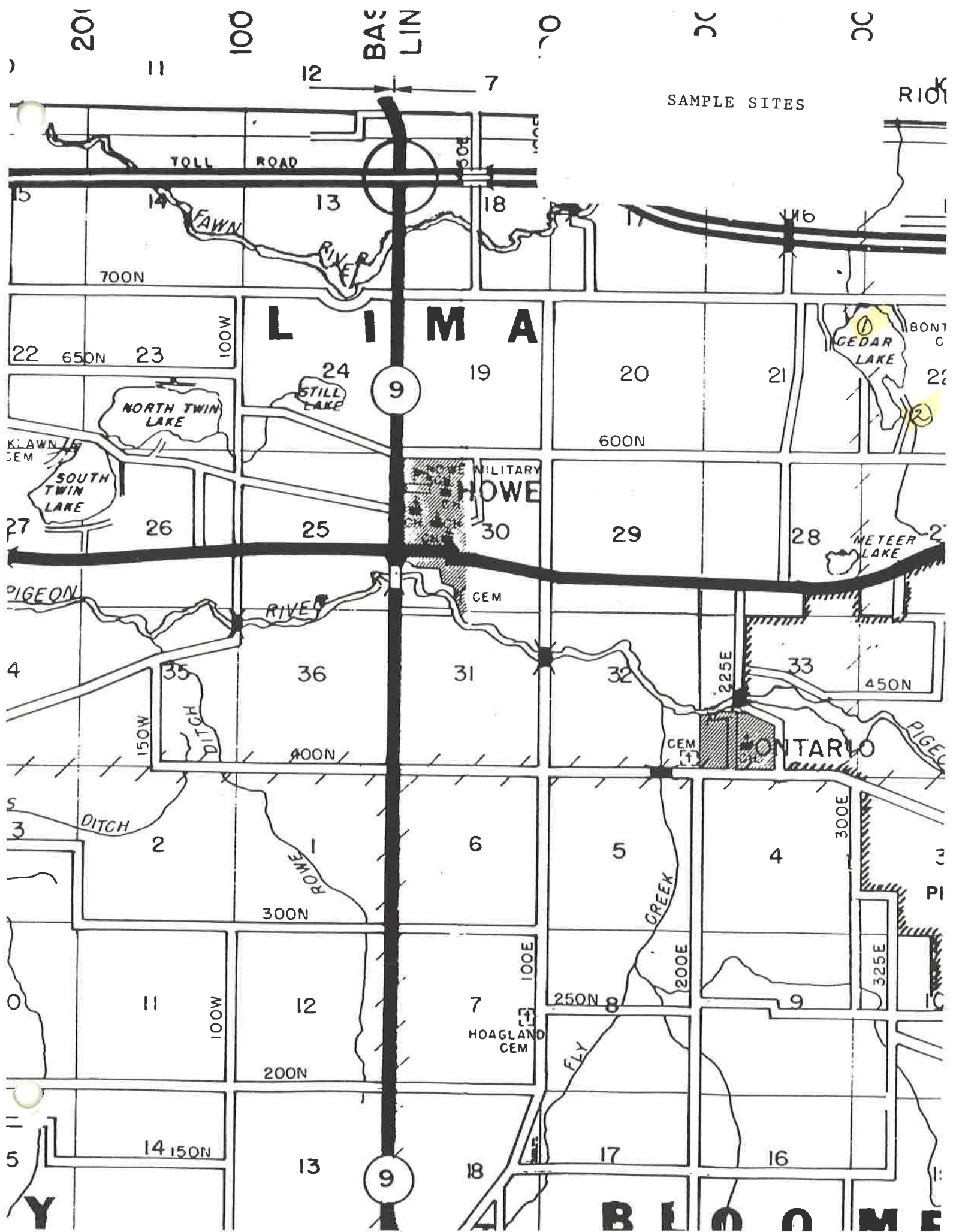
1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk



NORTH AND SOUTH TWIN LAKES

North and South Twin Lakes are located in the north central part of LaGrange County. North Twin's outlet is about 200 feet long and flows directly into South Twin Lake. North Twin is a 135 acre lake with a maximum depth of 30 feet and a mean depth of 15.7 feet. South Twin covers a 116 acres and has a maximum depth of 52 feet and a mean depth of 31 feet.

A 1938 aerial photograph shows both lakes have a few scattered cottages along the shore with the remainder of the shore being undeveloped. One third of North Twin is surrounded by wetland with the remaining shore area lined with a narrow band of trees. Wetland areas on South Twin are confined to the outlet on the southwest part of the lake. Farm fields extend down to the shore on the rest of South Twin.

A 1965 aerial photograph shows North Twin to be developed except for the wetland areas and about half of the southern shore. South Twin is completely developed except for the wetland area around the outlet, and a small campground has been built several hundred feet from the east shore.

A 1986 aerial photograph shows little difference from the 1965 photograph, except for the addition of several homes on lots which were vacant in 1965. The campground on South Twin has been expanded to about four times the size found in the 1965 photograph, but the campground proper is over 1000 feet from the lake.

The watershed of North Twin is 986 acres with about 40 acres or 4% being highly erodible. The land use is agricultural. An inlet stream, which originates at Still Lake, drains this watershed and enters the lake on the east shore of North Twin. Total phosphorus for this inlet stream was 0.01 ppm and nitrate was 4.2 ppm.

The watershed of South Twin is 435 acres with about 60 acres or 14% being highly erodible. The land use of the watershed is agriculture with the exception of the large campground on the east shore. There are no inlets of any significance on South Twin except for the North Twin outlet.

Total phosphorus at mid lake for South Twin averaged 0.01 ppm., and dissolved oxygen was 9.4 ppm at 27 feet. Secchi Disk readings were 12.5 feet compared to 8 feet in the 1986 Indiana Lake Classification System.

Indiana LCS: 1975

Class: 1

Index: 13

NORTH TWIN LAKE

Size: 135 Ac.

Max. Depth: 30.0'

Mean Depth: 15.7'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/29	3.0 22.0 26.0 30.0		0.02 0.07 0.01 0.01	1.5 1.3 1.5 1.0	5.2 6.3 5.5 1.2	12.0	
East Inlet	8/5 8/11		0.01	0.28 0.02	4.1 4.2			

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

Index: 8

SOUTH TWIN LAKE

Size: 116 Ac.

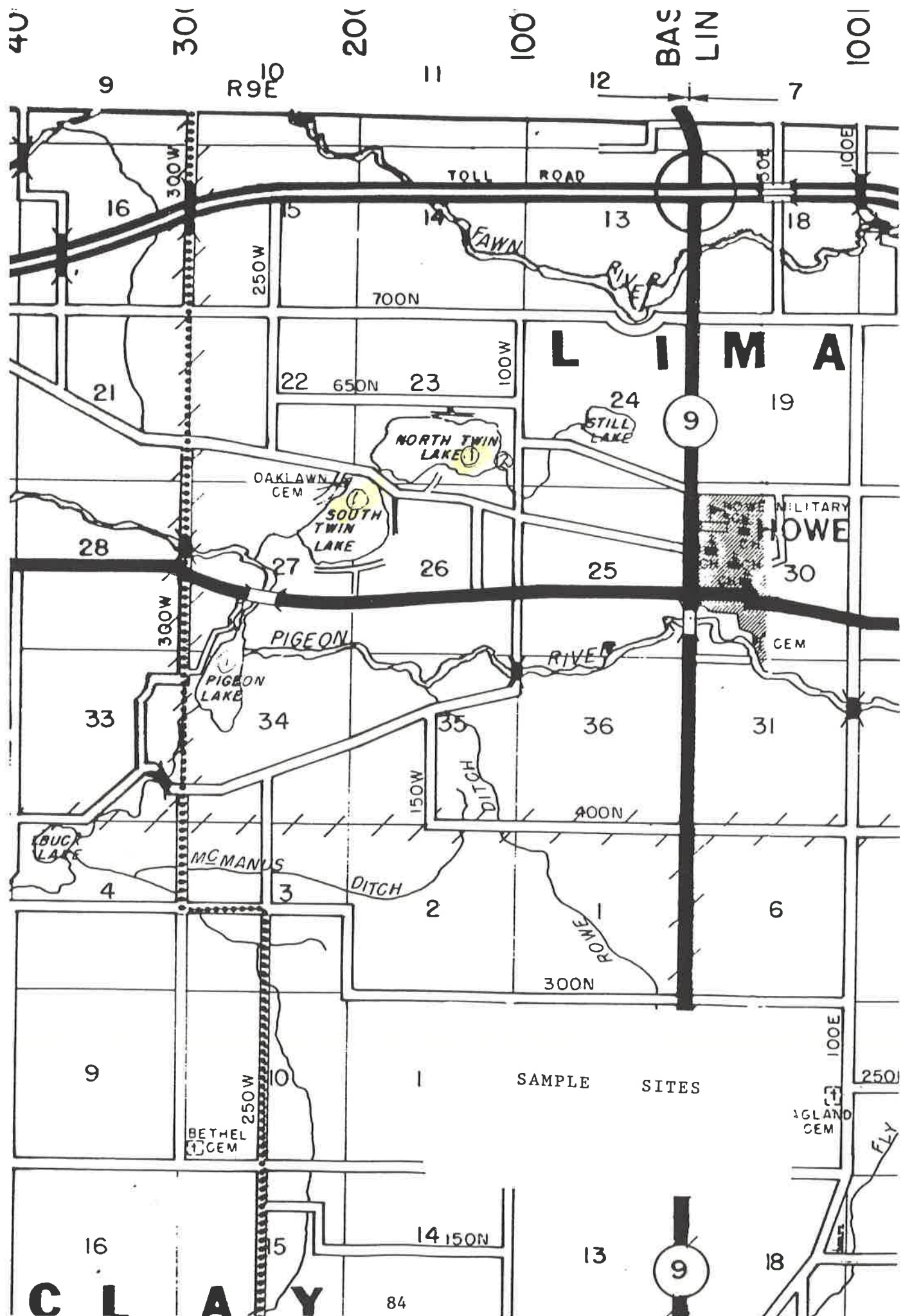
Max. Depth: 52.0'

Mean Depth: 31.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
Mid-Lake	8/29	3.0	0.01	0.01	1.2	6.8	12.5	
		23.0	0.01	0.08	1.3	6.3		
		27.0	0.01	4 0.01	1.3	9.4		
		35.0	0.01	4 0.01	1.3	3.2		

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

- ## 5. Secchi Disk



PRETTY LAKE

Pretty Lake is a 184 acre lake located in the southeastern part of LaGrange County. The water level of the lake has one of the highest elevations in the county at 964 feet above sea level. Pretty Lake has a maximum depth of 84 feet, with a mean depth of 25.7 feet

A 1938 aerial photograph shows the lake to be developed with about 60 cottages. Only about 2/3 of the western shore is undeveloped, and this shore area is buffered by narrow, scattered wetland areas. No other wetlands are visible.

A 1965 aerial photograph shows the lake to be completely developed with cottages and a trailer court. Only several hundred of feet of shore line remain on the southwest side, and the scattered wetlands have been filled. Some areas have cottages several rows deep.

A 1986 aerial photograph shows little change since 1965, except homes have been built on the remaining vacant lots.

Pretty Lake has a watershed of about 1800 acres with about 1600 acres or 89% highly erodible. Aside from the immediate shore area, the land use in the watershed is agricultural. A single inlet drainage ditch, which originates in a wetland area north of the lake, enters the lake on the north side. Because of the drought in 1988 samples were not obtained from this inlet.

Mid-lake concentrations for total phosphorus averaged 0.05 ppm, and Secchi Disk readings were 9 foot. This compares to the 1986 Indiana Lake Classification System of 0.08 ppm total phosphorus and a Secchi Disk reading of 10 foot.

Indiana LCS: 1975

Class: 1

Index: 25

PRETTY LAKE

Size: 184 Ac.

Max. Depth: 84.0'

Mean Depth: 25.7'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
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Mid-Lake

8/22

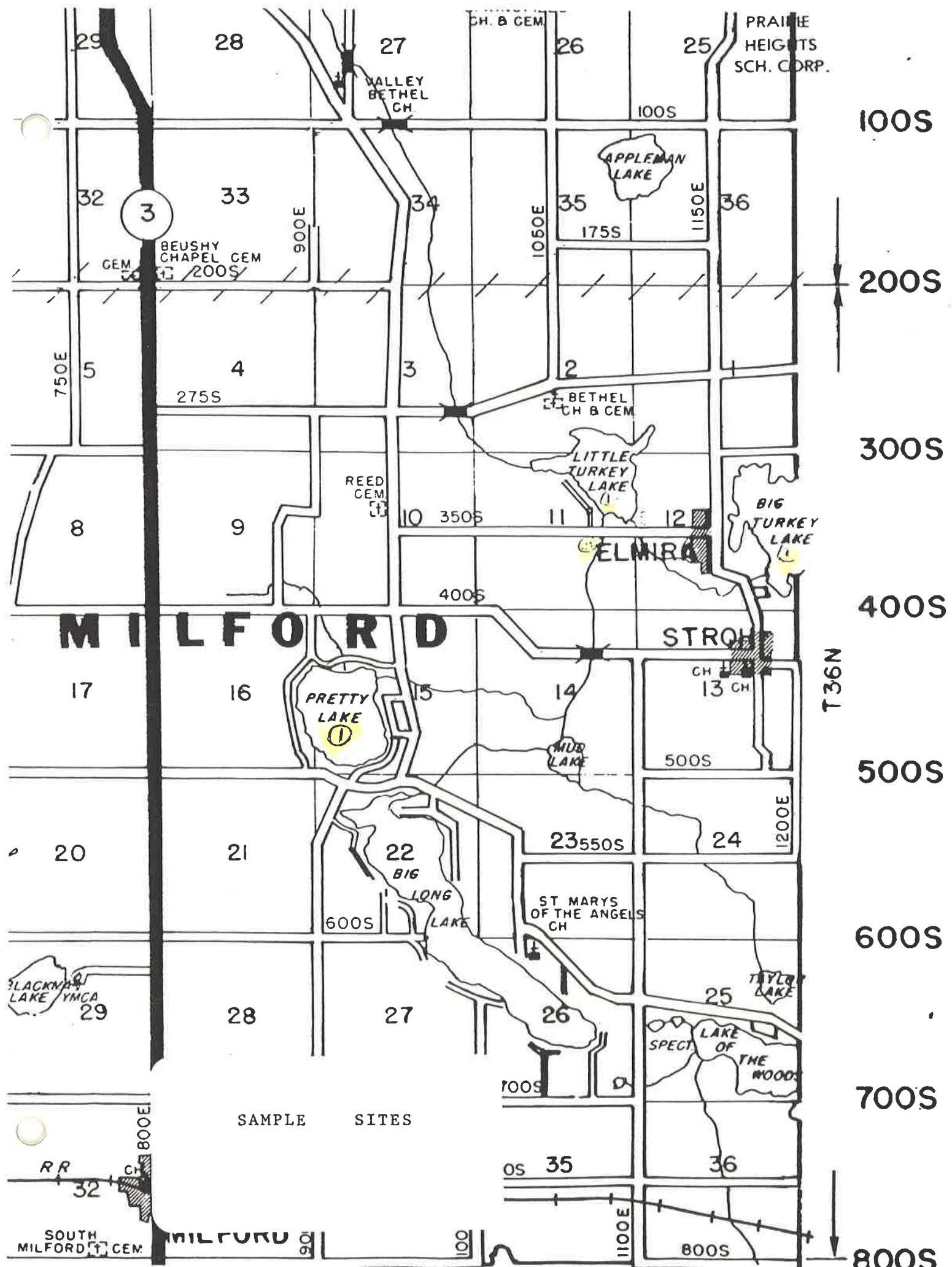
0.5
33.0
66.0

0.03
0.06
0.06

9.0

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

5. Secchi Disk



STONE LAKE

Stone Lake is a 152 acre lake in the northwest corner of LaGrange County and has a maximum depth of 58 feet and a mean depth of 14.7 feet. The lake is the most northern lake in a three lake complex, the second lake being Mud Lake, and the most southern lake called Goose Pond. These two smaller lakes are privately owned, and are within 1/2 mile of Stone Lake.

A 1938 aerial photograph shows the shore of Stone Lake to be about 50-60% developed with cottages. This development occurred because a county road, which surrounds the lake, allowed access to the lake. The only visible wetland is a small area surrounding the mouth of the inlet stream on the south shore. The most outstanding feature in the 1938 photograph is the areas of extreme erosion in the watershed of the lake. Deep gullies are visible in almost every field, and some large fields are eroded over their entirety. One erosion area is so large that soil has been washed through a woods, which borders the field, and the erosion has begun to fill in a wetland area on the other side of the woods.

A 1965 aerial photograph shows additional homes have been constructed on the shore of the lake. Because the county road was built along the shore of the lake, many of these homes have been constructed back from the lake shore, and the congestion of homes close to the lake is not a problem as on other lakes in the county. The greatest change from 1938 is the increase in forested land in the watershed, and many of the eroded farm fields are now woods.

A 1986 aerial photograph shows an increase in housing away from the lake, including small subdivisions and trailer courts within 1/2 mile of the lake. Few other changes are noted.

The watershed of Stone Lake is small, being only about 950 acres. About 800 acres or 84% is classified as highly erodible land. Most of the watershed drains into Goose Pond and Mud Lake, thus the direct immediate watershed of Stone Lake is only about 100 acres.

Samples taken at a mid-lake site indicate minimal eutrophication of the lake. Ortho-phosphates were 0.02, and dissolved oxygen concentrations were good below the thermocline. Secchi Disk readings were 14.5 feet.

Index: 2

STONE LAKE

Size: 116 Ac.

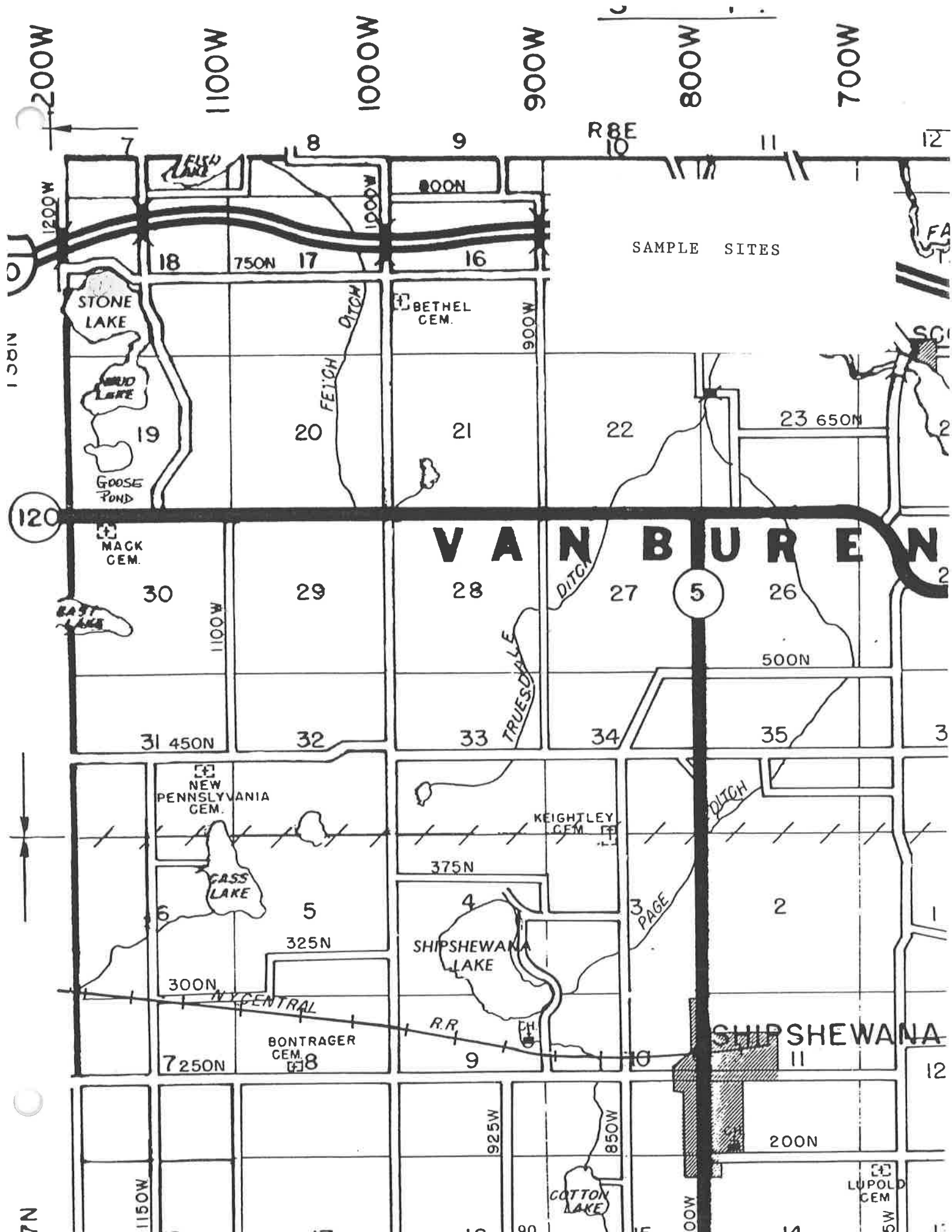
Max. Depth: 58.0'

Mean Depth: 14.7'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)			
Mid-Lake	7/12	5.0	0.03	0.01	1.3	6.9	14.5				
		14.0				6.4					
		20.0				3.8					
	8/26	0.5				0					
		16.5									

1. Total Phosphorus
2. Ortho-Phosphates
3. Nitrates
4. Dissolved Oxygen

- ## 5. Secchi Disk



WALL LAKE

Wall Lake is a 141 acre lake located in the northeastern part of LaGrange County. The maximum depth of the lake is 34 feet and the mean depth is 11.6 feet.

A 1938 aerial photograph shows 13 summer cottages were built close to the shore of the lake. Access to the lake was provided by a county road which was constructed close to the north and west shores of the lake. A large wetland of several hundred acres extends southward from the southeast shore and surrounds the inlet stream entering the lake in this area. The only other wetland on the lake is in the area of a peninsula on the north shore which is the most noticeable feature of the lake. Agricultural fields have been extended down to the shore on the south side of the lake, and several areas of soil erosion are visible in these fields.

A 1965 aerial photograph shows the lake to be completely surrounded with homes except for the west shore, which is a Boy Scout camp. Even the peninsula, which was wetland in the 1938 photograph, has been developed, and a subdivision, estimated to be about 50 acres, has been developed on the east side of the lake. A large channel has been dug on the southeast shore, and homes have been built on what was once wetland. Channels have also been dug in the peninsula to facilitate drainage.

In a 1986 aerial photograph, the lake shore area has changed little from the 1965 photograph, except for the addition of several homes on vacant lots. Thus development of the lake was completed by 1965.

The watershed of the lake is about 1000 acres, and except the area immediately surrounding the lake, the land use is agricultural. Approximately 75 acres or 7.5% of the watershed is classified as highly erodible. The only inlet to the lake drains the southern watershed, and this inlet originates from a large wetland area. Samples were not taken from this inlet because of the summer drought.

Samples obtained from a mid - lake sampling site indicate the water quality to be good. Total phosphorus averaged 0.03 ppm., thus indicating the lake to be one of the better lakes in the county.

Indiana LCS: 1975

Class: 1

Index: 13

WALL LAKE

Size: 141 Ac.

Max. Depth: 34.0'

Mean Depth: 11.0'

LOCATION	DATE	DEPTH (feet)	TP ⁽¹⁾ (mg/l)	O-PO ⁽²⁾ (mg/l)	NO ₃ ⁽³⁾ (mg/l)	DO ⁽⁴⁾ (mg/l)	S. DISK ⁽⁵⁾ (feet)	SEDIMENT (mg/l)
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Mid-Lake

8/24

0.5
16.5
33.0

0.01
0.03
0.06

1. Total Phosphorus

2. Ortho-Phosphates

3. Nitrates

4. Dissolved Oxygen

5. Secchi Disk

A N

SAMPLE SITES

B R A N C H

700E

800E

900E

1000E

1100E

8

9

10

11

12

12

800N

800N

TOLL ROAD

80

750N

FAWN RIVER

GREENFIELD MILLS

FENNELLY LAKE

650N

600N

WALL LAKE

700N

T38N

600N

120

500N

HTON

31

32

33

34

35

36

6

5

7

17

19

4

2

1

12

13

24

16

15

22

23

93

ROGERS CEM.

TURKEY CREEK

BRUSHY PRAIRIE

GREEN LAKE

BASE

ENFIELD

SPRINGFIELD

MONGO

400N

300N

200N

100N

O

C

N

E

APPENDIX