Contract Report 604

Diagnostic-Feasibility Study of Wolf Lake, Cook County, Illinois, and Lake County, Indiana

by
Shun Dar Lin, Raman K. Raman, William C. Bogner,
James A. Slowikowski, George S. Roadcap, and David L. Hullinger

Prepared for the
City of Hammond, Indiana
Illinois Environmental Protection Agency, and
Indiana Department of Environmental Management

October 1996

Illinois State Water Survey
Chemistry and Hydrology Divisions
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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This report may be obtained from:

The City of Hammond, Parks and Recreation Department, Hammond, IN; Indiana Department of Environmental Management, Nonpoint Source Section, Box 6015, Indianapolis, IN; Illinois Environmental Protection, Lake and Watershed Unit, Box 19276, Springfield, IL.

The data collected during October 1992 through October 1993 may be obtained from IEPA, address as shown above.

MACROPHYTE (LAKE WEED) CONTROL

Most of those addressing this issue objected to the use of the compound 2-4D as a lake weed control measure because of feared side effects on other parts of the lake ecosystem.

HEALTH OF THE FISHERY

As you know, the Indiana Departments of Environmental Management, Natural Resources, and Health recently revised their criteria for fish consumption advisories. As a consequence, the Department of Health issued the following advisory for Largemouth and White Bass obtained from Wolf Lake, based on concentrations of Polychlorinated Biphenyls (PCBs):

Largemouth Bass

For individual Largemouth Bass 13-17 inches in length, adults should eat no more than one meal each month. Women who are pregnant or who are breastfeeding, women who plan to have children, and children under 15 years old do not eat.

For individual Largemouth Bass over 17 inches in length, adults should not eat more than one meal every two months. Women who are pregnant or beast feeding, women who plan to have children, and children under the age of 15 do not eat.

White Bass

For individual White Bass 13-15 inches long, adults should eat no more than one meal per month. Women who are pregnant or breastfeeding, women who plan to have children, and children under 15 years of age do not eat.

For individual White Bass over 15 inches in length, adults should not consume more than one meal every two months. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.

GROUNDWATER IMPACTS ON WATER QUALITY

Although it is our view that the project contractors fulfilled their responsibilities regarding groundwater, we believe that the impact of groundwater contamination from surrounding sites requires additional study.

SURFACE RUNOFF IMPACTS ON WATER QUALITY

Although the contractors fulfilled the work program requirements for this aspect of the study, we believe that surface water runoff impacts from watershed land uses requires further investigation, as well.

This part of the study should also be expanded in the near future to analyze contaminants from specific land uses/sites, and their impacts. Commentators from the public expressed frustration with the limited coverage of this aspect of both the Wolf and George Lake studies.

Addendum

Page 30 (Paragraph 4): The sentence beginning "The effluent is strictly noncontact...." should read "The effluent is mostly noncontact. . . ." During the Wolf Lake public meeting held on September 16, 1996, Mr. Don Roberts of USEPA pointed out that the lagoon from which the effluent discharge to Wolf Lake Channel occurs also receives process water.

Table 6 (pages 33-35): New table replaces table 6 in the text.

Table 29 (pages 94-95): Units of measurement are ¦Ìg/L.

Appendix B: Station code RH-A06-A-1 (page 279) corresponds to the station designation RHA-1 in the text. Other station codes correspond similarly to station designations in the text.

Table 6. Public Lakes within a 50-Mile Radius of Wolf Lake

Lake	*Area, acres*	*Maximum depth, feet*	*Launching ramps*	*Lake uses**
Cook County, IL				
Axehead Lake	17.0	31.0		F,P,R
Bakers Lake	111.6	12.0		F,P,R,WLR
Beck Lake	38.0	22.0		F,P,R
Belleau Lake	12.0	34.0		F,P,R
Bullfrog Lake	15.2	12.0		F,P,R
Bussee Woods Lake	584.0	16.0	8	F,FC,P,R
Horsetail Lake	11.0	24.0		F,P,R
Ida Lake	10.0	16.0		F,P,R
Maple Lake	55.0	22.0.		F,P,R
Midlothian Reservoir	25.0	14.0		F,FC,P,R
Pappose Lake	18.0	10.0		F,P,R
Powderhorn Lake	34.5	19.0		F,P,R
Sag Quarry-East Lake	13.4	17.0		F,P,R
Saganashkee Slough	325.0	9.0		F.P.R
Skokie Lagoons Lake	190.0	9.0	2	F.P.R
TampierLake	160.0	16.0		F,P,R
Turtlehead Lake	12.0	15.0		F,P,R
Wampum Lake	35.0	14.0		F,P,R
Wolf Lake	419.0	21.0	3	F,P,R,WTF
DuPage County, IL				
Churchill Lagoon	21.0	6.0		F,P,R
Herrick Lake	19.1	10.0		BR,C,F,P,R
Mallard Lake	40.0	20.0		F.P.R
Mallard North Lake	10.0	15.0		F.P.R
Pratts Waynewoods Lake	16.2	21.0		C,F,P,R
Silver Lake	68.0	30.0	8	C,F,P,R
Grundy County, IL				
Dresden Lake	1,275.0	16.0		CO,F
Heidecke Lake	1,955.0	60.0	3	BR,CO,F,P, R,WTF
Kane County, IL				
Jericho Lake	40.0	30.0		F,P,R
Mastodon Lake	22.3	12.0		F,P
Pioneer Lake	6.5	13.0		F,R
Kankakee County, IL				
Birds Park Quarry	7.0	40.0		BR,F,R
Lake County, IL				
Banks Lake	297.0	25.0	6	BR,F,P,R
Diamond Lake	149.0	24.0	2	BR,F,P,R,S
Fox Chain O' Lakes	6,500.0	40.0	56	BR,C,F,JF, IS,P,R,S, WS.WTF
Gages Lake	139.0	48.0	2	BR,C,F,P,R,S

Table 6. Continued

Lake	*Area, acres*	*Maximum depth, feet*	*Launching ramps*	*Lake uses**
Grays Lake	79.0	19.0		F,P,R
Lake Zurich	228.0	32.0	2	F,P,R
Round Lake	215.0	35.0	2	F,P,R,S
South Economy Gravel Pit	18.5	36.0		F,P,R
Sterling Lake	73.9	29.0		F,P,R
Turner Lake	34.0	10.0		C,F,P,R
Will County, IL				
Braidwood Lake	2,640.0	80.0	7	CO,F,WTF
Lake County, IN				
Calmet Park Lake				
Cedar Lake	781.0	16.0	1	F,R
Clay Pits				
Fisher Pond				
Francher Lake	10.0	40.0		
Grand Boulevard Lake	40.0	8.0	1	F,P,R,S
HobartTwp. Lake (Rosser Park)	40.0	26.0		F,R
Independent Lake				
Kennedy Park Oxbow				F,R
Lake George (Hammond)	78.0	4.0		F,R
Lake George (Hobart)	270.0	14.0		
Lemon Lake				
MacJoy Lake				
Marquette Park Lagoon	25.6			F,P,R
Optimist Park Lake				
Oak Ridge Prairie Lake				
Robinson Lake				
Wolf Lake	804.0	18.0	1	BR,F,IF,IS, P,S,WS
LaPotte County, IN				
Clear Lake	17.0	33.0		
Clear Lake	106.0	12.0	1	F,R
Finger Lake				
Fish Lake (Lower)	134.0	16.0		
Fish Lake (Upper)	139.0	24.0	1	C,F,R
Hog Lake	59.0	52.0	1	F,R,
Hudson Lake	432.0	42.0	1	F,R
Lancaster Lake				
Lily Lake	16.0	22.0		
Lower Lake				
Mill Pond	24.0	8.0		
Orr Lake				
Pine Lake	564.0	48.0	(access via Stone Lake)	C,F,IF,R
Round Lake				
Stone Lake	125.0	36.0	1	C,F,IF,R
Tamarack	20.0	8.0	1	C,F,IF,P R,WTF

Table 6. Concluded

Lake	Area, acres	Maximum depth, feet	Launching ramps	Lake uses*
Newton County, IN				
Black Oak Bayour			1	F,IF,R,WTF
Goose Pond Swamp	20.0			F,IF,R,WTF
J.C Murphy Lake	1,515.0	8.0	1	BR,CFJF,P,R, S,WTF
Cory Lake				
Riverside Lake				
Porter County, IN				
Chestnut Lakes				
Chub Lake				
Flint Lake	89.0	67.0	1	F,R
Fisher Pond				
Long Lake	65.0	27.0	1	F,R
Lomis Lake	62.0	55.0		F,R
Mud Lake	26.0			
Pratt Lake				
Round Lake				
Silver Lake				
Spectacle Lake	62.0	30.0		
Wauhob Lake	21.0	48.0		
Starke County, IN				
Bass Lake	1,440.0	30.0	1	C,F,IF,P,R,S,WS
Round Lake	30.0	15.0		F,IF,P,R,WTF

Notes:
Blank spaces indicate that information is not readily available.
* BR = boat rental, C = camping, CO = cooling, F = fishing, FC = flood control, IF = ice fishing, IS = ice skating, P = picnicking, R = recreation, S = swimming, WLR = wildlife refuge, WTF = waterfowl hunting, and WS = water skiing.

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EXECUTIVE SUMMARY

Wolf Lake, located in Cook County, IL, and Lake County, IN, covers 804 acres and has a maximum depth of 18 feet. Although Wolf Lake is a natural lake, many areas were dredged in past years. The lake is separated into eight different sections by dikes constructed during sand-and-gravel dredging for the tollway that crosses the lake.

The Illinois State Water Survey (ISWS) undertook a detailed and systematic diagnostic-feasibility study of Wolf Lake commencing in October 1992. The major objective of the project was to develop an integrated protection/management plan for Wolf Lake and its watershed.

The diagnostic study was designed to delineate the existing lake conditions, to examine the causes of degradation, if any, and to identify and quantify the sources of plant nutrients and any other pollutants flowing into the lake. On the basis of the findings of the diagnostic study, water quality goals were established for the lake. Alternative management techniques were then evaluated in relation to the established goals.

The Illinois portion of the diagnostic-feasibility study of Wolf Lake was funded through the Illinois Environmental Protection Agency (IEPA) by the U.S. Environmental Protection Agency (USEPA), with nonfederal cost-sharing by the IEPA under a Federal Clean Lakes Program Phase I Grant authorized by Section 314 of the Clean Water Act and Clean Lakes Program regulations (40 CFR 35 Subpart H).

The Indiana portion of the study was funded through the Indiana Department of Environmental Management by the USEPA, with nonfederal cost-sharing by the Hammond Park District, Hammond, IN, under a Federal Clean Lakes Program Phase I Grant authorized by Section 314 of the Clean Water Act and Clean Lakes Program regulations (40 CFR 35 Subpart H).

Wolf Lake currently receives industrial cooling water discharges and a few urban stormwater discharges from Hammond on the Indiana side. Because the lake is located within a highly urbanized area, it is used extensively for water-based recreation. There is a swimming beach on the eastern shores of the lake. The lake and surrounding parks are used for picnicking, boating, fishing, sailboating, waterfowl observation, and for such winter sports as ice skating and ice fishing. Swimming and water skiing are permitted only on the Indiana side, and waterfowl hunting is permitted only on the Illinois side. The lake supports a variety of sport fisheries such as largemouth bass, northern pike, walleye, bluegill, redear sunfish, crappie, bullhead, carp, and yellow perch.

The Wolf Lake direct drainage area includes 925 acres of mostly pervious surfaces draining directly into the lake. Runoff from the impervious surfaces (paved areas and rooftops) on the east side of the lake collects in a constructed storm drain system that discharges into Wolf Lake at the Forsythe Park, Sheffield Park, and the Roby Pump Stations of the Hammond Sanitary District. The discharges from these pump stations are regulated by permit under the National Pollution Discharge Elimination System (NPDES).

The pervious surfaces (surfaces that allow water infiltration) in the watershed react slowly to precipitation events. These areas have little or no associated surface runoff.

Discharges into the Wolf Lake system also include noncontact process, evaporator, or site stormwater discharges from the Amaizo and Lever Brothers plants along the Wolf Lake channel. These discharges are also permitted under the NPDES program.

The hydrologic system at Wolf Lake is composed of eight interconnected lake pools with smaller peripheral pools and wetland areas, interconnecting channels between pools, surface drainage from the three stormwater pump stations carrying runoff from impervious surfaces in adjacent neighborhoods and major streets, the Powderhorn Lake area, and undeveloped land around the lake, NPDES discharges from the American Maize processing plant, NPDES discharges from the Lever Brothers plant, and the regional ground-water system.

In general, inflows to the lake include direct precipitation, watershed runoff, ground-water inflow, and pumped input. Outflows include surface evaporation, discharge at the lake outlet, and ground-water outflow. Analyses made for this study indicate that for 1992-1993 study period:

- 19 percent of the inflow volume to the lake originated from direct precipitation onto the lake surface,
- 16 per cent originated from the Hammond Sanitary District's stormwater pump stations,
- 30 percent originated from the Lever NPDES discharge,
- 31 percent originated from the Amaizo NPDES discharges,
- 1 percent originated from the area directly draining into the lake, and
- 4 percent originated from ground-water inflow.

The following is a listing of the distribution of outflow and storage factors:

- 66 percent of the water that flowed into the lake system flowed out through Indian Creek,
- 13 percent of the volume was lost to evaporation,
- 2 percent of the volume remained in storage at the end of the accounting period, and
- 19 percent of the estimated outflow volume could not be explained.

Overall, this analysis indicates that:

- The NPDES permitted discharges are essential to maintaining flows through the lake system,
- In general, the continuous daily discharges from the Lever and Amaizo plants maintain a flow of 13 to 17 cubic feet per second through the lake,
- The questionable accuracy of the Amaizo Lake Michigan excess water discharge is significant in achieving a hydrologic balance on paper but is not a water quality concern as long as the water is unadulterated Lake Michigan water, and
- Leakage of the causeways that compartmentalize the lake are also a likely factor in the sometimes poorly balanced hydrologic analysis.

A bathymetric survey of Wolf Lake was conducted as part of the diagnostic study. The data were collected using a range-range methodology, in which a microwave transponder was set up in the boat to monitor distances to two or three shore-based remote transponders. A total of 148 transects were run to collect the depth and horizontal position data. Bathymetric contour maps for each of the Wolf Lake pools were developed. Average depth in the pools varies from the shallowest in Pool 3 of 3.3 feet to the deepest in Pool 5. In Pool 3, less than 20 percent of the pool has depths greater than 4 feet. In comparison, over 70 percent of the area in Pool 8 has a depth of at least 4 feet.

There were no well-defined hypolimnia during the peak summer period from June-August in deep portions of the lake. The lake system exhibited isothermal conditions except during the summer period when slight temperature gradients existed. The surface and near-surface dissolved oxygen (DO) values observed in the lake met the general use standards of not less than 5.0 mg/L at any time throughout the lake, except in the Wolf Lake Channel, where DO values were less than 5.0 mg/L on four of the 17 occasions monitored.

Significant differences in Secchi disc readings were observed among the eight pools in the lake system. The mean values for all the pools in Illinois were higher than 48 inches, generally indicating no lake use impairment. The average value for the largest pool in Indiana was 40 inches. This pool is heavily used for whole body contact recreation.

With the exception of pH, the chemical quality characteristics for which standards are available in Illinois and Indiana were well within the stipulated limits. The upper limit of acceptable pH of 9.0 was exceeded several times in all the pools except in two pools in Illinois. Elevated pH values were attributable to photosynthesis during algal activity. All the pH values observed were above the minimum acceptable value of 6.5

Mean total phosphorus (TP) concentrations ranged from 0.005 mg/L to 0.038 mg/L in the pools. TP levels in the Illinois side of the lake were significantly lower than those in the Indiana side. The mean dissolved phosphorus concentrations were between 0.001 mg/L and 0.004 mg/L. From the phosphorus concentration values for Wolf Lake, it can be concluded that the lake will not be limited by phosphorus in sustaining biological productivity. The lake is likely to remain eutrophic.

Even the highest observed value for ammonia-N (NH_3-N) was much lower than the 1.5 mg/L considered critical for fish in terms of ammonia toxicity. Maximum NH_3-N concentrations for most stations were less than 4.0 mg/L. For most sampling stations, the concentrations of nitrate/nitrite nitrogen ranged from 0.0 to 0.4 mg/L with a mean of 0.1 mg/L.

Analyses for metals and organics in water samples indicated that concentrations of each organic constituent examined were below the laboratory detectable level and none of the metals exceeded the general use standards.

Bacterial quality in Wolf Lake was generally found to be excellent except in Wolf Lake Channel. The latter is impacted by two stormwater pumpages discharging into this channel.

Algal growths in Wolf Lake do not seem to be a problem either in terms of the densities or the types of algae found in the lake.

Among the 40 sites examined for macrophyte biomass, the values ranged from 8.0 g/m^2 to 698.6 g/m^2. Forty percent of the macrophyte survey sites had biomass greater than 150 g/m^2, which could be classified as heavy growth. Thirty percent of the sites indicated medium-density growth and the rest had low-density growth. The dominant aquatic vegetation in the lake system was found to be Eurasian water milfoil, a non-native species.

The surficial and core sediment samples collected from the different pools of the lake system had characteristics not warranting a hazardous classification. This was true in the case of sediment samples collected from the Wolf Lake Channel with respect to the metals concentrations examined. Evaluation of the sediment characteristics using the Toxicity Characteristics Leaching Procedure indicated that metals concentrations in the leachate were all within the regulatory limits. However, the PCB concentrations in the Wolf Lake Channel sediments were at levels warranting a classification of "high concern."

From the foregoing discussion, it is apparent that the major problems in the lake that need to be addressed are shallow water depths in portions of the lake leading to excessive macrophyte growth, profusion of unbalanced aquatic vegetation, high fecal coliform counts and poor sediment quality in Wolf Lake Channel, and poor lake aesthetics in some parts of the lake area.

Based on the results of this study, it is recommended that the major goals and objectives of a lake management plan should include:

- Selective deepening of the lake for macrophyte control.
- Eradicating the invasive exotic plant, Eurasian water milfoil *(Myriophyltum spicatum),* and preventing its reestablishment by promoting diversity of native macrophytes.
- Reducing bacterial contamination of Wolf Lake Channel and improving water quality at the swimming beach.
- Managing discharges from storm sewer pumping stations in the Hammond Sanitary District.
- Enhancing aesthetic and recreational opportunities in and around the lake by cleaning up debris and improving fish management.

To accomplish these objectives, the following restoration alternatives are proposed:

Alternative I

Dredging and off-site disposal of sediments from the Wolf Lake Channel are required to improve water and sediment quality, aesthetic conditions, and other uses. Improving the water quality of stormwater discharges from the city of Hammond is essential to restore Wolf Lake Channel and to reduce bacterial contamination. The estimated cost for dredging and disposal of sediments and enhancing fishing opportunities in Wolf Lake Channel is $1,269,200.

Alternative II

In addition to the actions proposed under Alternative I, this alternative includes dredging of Pools 6 and 7 in Indiana to increase lake volume and to control the non-native aquatic vegetation dominant in these pools. Use of herbicides or harvesting of macrophytes to control Eurasian water milfoil may also be an option. The estimated costs for this alternative are $2,969,200 or $1,366,400, respectively, depending on whether Pools 6 and 7 are dredged or whether herbicides or harvesting are used in them to control macrophytes.

Alternative III

Alternative III includes all the approaches of Alternative II and some selective dredging of Pool 3. The additional dredging is primarily to improve boating opportunities. The estimated costs for this alternative are $4,877,200 or $3,274,400, respectively, depending on whether Pools 6 and 7 are dredged or whether herbicides are used in them to control macrophytes.

Diagnostic-Feasibility Study of Wolf Lake, Cook County, Illinois, and Lake County, Indiana

PART 1
DIAGNOSTIC STUDY OF WOLF LAKE

INTRODUCTION

The Offices of Water Quality Management and Hydraulics & River Mechanics of the Illinois State Water Survey (ISWS) undertook a detailed and systematic diagnostic-feasibility study of Wolf Lake commencing in October 1992. The major objective of the project was to develop an integrated protection/management plan for Wolf Lake and its watershed.

The diagnostic study was designed to delineate the existing lake conditions, to examine the causes of degradation, if any, and to identify and quantify the sources of plant nutrients and any other pollutants flowing into the lake. On the basis of the findings of the diagnostic study, water quality goals were established for the lake. Alternative management techniques were then evaluated in relation to the established goals.

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Lake Identification and Location

Located in Cook County, IL, and Lake County, IN, Wolf Lake covers 804 acres and has a maximum depth of 18 feet. Although Wolf Lake is a natural lake, many areas were dredged in past years. The lake is separated into eight different sections by dikes constructed during sand and gravel dredging for the tollway that crosses the lake. There are numerous drop-offs. Lake identification and location data for Wolf Lake are summarized in table 1.

Outdoor recreational activities at this publicly owned lake and the surrounding parks are managed in Illinois by the Illinois Department of Natural Resources and in Indiana by the Hammond Park District.

Acknowledgments

This investigation was jointly sponsored and funded by the Hammond Park District, the Illinois Environmental Protection Agency, and the U.S. Environmental Protection Agency, under

Table 1. General Information Pertaining to Wolf Lake

Lake name:	Wolf Lake
STORET lake code:	RH-A06-A
Stale:	Illinois/Indiana
County:	Cook/Lake
Nearest municipalities:	Chicago, Burnham, and Calumet City, IL; Hammond and Whiting, IN
Latitude	41° 40'18" (Pool 1, RHA-1)
	41° 39' 59" (Pool 2, RHA-2)
	41° 39' 41" (Pool 3, RHA-3)
	41° 39'56" (Pool 4, KHA-4)
	41° 39' 28" (Pool 5, RHA-5)
	41° 39'57" (Pool 6, RHA-6)
	41° 40'25" (Pool 7, RHA-7)
	41° 40' 11" (Pool 8, RHA-8)
	41° 41' 14" (Wolf Lake Channel, RHA-9)
Longitude	87° 31'50" (Pool 1, RHA-1)
	87° 32'01" (Pool 2, RHA-2)
	87° 32' 11" (Pool 3, RHA-3)
	87° 31' 39" (Pool 4, RHA-4)
	87° 31'34" (Pool 5, RHA-5)
	87° 31' 16" (Pool 6, RHA-6)
	87° 31' 22" (Pool 7, RHA-7)
	87° 30' 55" (Pool 8, RHA-8)
	87° 30'52" (Pool 9, RHA-9)
USEPA region:	V
USEPA major basin name and code:	Upper Mississippi River, 07
USEPA minor basin name and code:	Chicago-Calumet-Des Plaines River, 13
Major tributary:	Wolf Lake Channel
Receiving water body:	Outfalls from Lever Brothers, American Maize-Products, Hammond Sanitary District storm sewer discharges
Outflowing stream:	Indian Creek
Water quality standards:	General standards promulgated by both the Illinois and Indiana Pollution Control Boards and applicable to water designated for aquatic life and whole body contact recreation
	Illinois: Title 35, Subtitle C, Chapter I, Part 302, Subpart B
	Indiana: Regulation SPC 10R, Water Quality Standards for Wolf Lake, Indiana Stream Pollution Control Board

Section 314 Clean Lakes Program of the Clean Water Act. Tom Davenport and Don Roberts, USEPA Region V in Chicago, were responsible for federal administration of the project. The Indiana Department of Environmental Management (IDEM) and the IEPA were responsible for fiscal and technical oversight of the project.

This final report represents the cooperative efforts of many individuals representing local, state, and federal organizations.

The IDEM Nonpoint Source Section (Office of Water Management), under the direction of Sharon Jarzen was responsible for Indiana state administration and coordination of this investigation. Carol Newhouse provided historical data from old IDEM files for Wolf Lake and made in-depth review of the report. Matt Dye (Indianapolis) and Joe Thomas (Remedial Action Plan Coordinator, Gary, IN) were the project officers.

The IEPA Lake and Watershed Unit (Planning Section, Division of Water Pollution Control), under the direction of Gregg Good, was responsible for overall state administration and coordination of this project. Jeff Mitzelfelt and Steve Kolsto conducted various data entry, management, and interpretation activities necessary to insure the integrity of the monitoring program results. Mr. Mitzelfelt also provided information about publicly owned lakes in Illinois within a 50-mile radius of Wolf Lake.

All of the laboratory analytical work was done by IEPA laboratories in Champaign, Chicago, and Springfield, IL.

John Beckman, initially affiliated with Calumet College, provided historical information for the Indiana side of the project site and subsequently was instrumental in identifying sources of information pertinent to the project site that were needed for the report preparation. His assistance and continued interest in the successful completion of the project are appreciated. Barbara Waxman, Northwestern Indiana Regional Planning Commission, provided information on industrial land use, demographic details relevant to the project, and data about publicly owned lakes in Indiana within a 50-mile radius of the project site. Her assistance is gratefully acknowledged. Franklin Premuda of Hammond Health Department provided bacterial data for the beach area. Samuel Wolfe, Road Operations Engineer, Indiana Department of Transportation, provided information on salt used on the Indiana Toll Road for snow and ice removal in the Wolf Lake area.

Joy Bower, Naturalist, Lake County Parks and Recreation Department, provided excerpts from the TAMS Consultants, Inc. report on the Illinois-Indiana Regional Airport, dealing specifically with the flora and fauna in the area surrounding Wolf Lake. Also, Joseph Ferencak and Mike McCulley, Illinois Department of Natural Resources provided historical information about fisheries and park visitors for Wolf Lake in Illinois; while Bob Robertson, Indiana Department of Natural Resources, provided historical information about Indiana Wolf Lake fisheries. Peter Berrini, Cochran & Wilken, Inc. provided cost information and other details about recent dredging projects. All their valuable input to this project is gratefully acknowledged.

The authors would like to thank Robert Kay, Richard Duwelius, and Lee Watson of the U.S. Geological Survey (USGS) for their professional opinions, assistance, and cooperation in permitting the ISWS to measure USGS wells and for installing the additional well on the north side of Wolf Lake.

Several ISWS personnel contributed to the successful completion of the project. Nancy Johnson and Tim Nathan assisted with the field sampling and surveying. Long Duong picked the macroinvertebrates from benthic samples. Tom Hill identified and enumerated them and evaluated the data. Rick Twait identified the macrophyte samples and determined the biomass. Davis

Beuscher identified and enumerated the algae. Yi Han analyzed the physical characteristics of the lakebed sediments. Curt: Benson helped with the monthly ground-water level measurements. Kingsley Allen supervised mapping and spatial analysis on the Geographic Information System. Linda Hascall and» Dave Cox prepared illustrations. Linda Dexter, Lacie Jeffers, and Kathleen Brown prepared thedrafteand report, and Sarah Hibbeler edited the report. All their efforts and assistance are gratefullyiaeknowledged and appreciated.

Last but not the least, the authors are grateful to all the reviewers for their valuable comments and suggestions; which made this document significantly better than its initial draft.

STUDY AREA

Location

The study area-is located in Section 29 Southeast Township 37 North, Range 15 East of the Principal Meridian, Cook County, IL, and in Sections 7 and 8, Township 37 North, Range 9 West of the 2nd Principal Meridian, Lake County, IN. It is bounded by Avenue O (Chicago) on the west, Calumet Avenue (Hammond) on the east, and lies between 112th and 134th Streets (figure 1). The area is also bounded by residential areas (the Hegewisch neighborhood in Chicago, IL, on the south and southwest; Hammond, IN, on the northeast), industrial developments (on the north and southeast in Indiana), and parks (Eggers Woods Forest Preserve and William W. Powers Conservation Area, EL, on the north and west; Wolf Lake Park and Forsythe Park in the northeast).

Wolf Lake

Wolf Lake lies both within the William W. Powers Conservation Area in the southeast corner of Cook County, EL, and in the northwest corner of Lake County, IN. It is situated at the far southeast edge-of Chicago, IL, and at the northwest edge of Hammond, IN. The Illinois-Indiana state line very nearly bisects the lake system. A remnant of the original Lake Michigan Bay, Wolf Lake is a natural lake although many areas were dredged in the past. The lake consists of eight distinct water bodies (pools) separated by dikes, and there are limited interconnections among the pools and Wolf Lake Channel. (Hydrologically, Wolf Lake Channel is included in Pool 8; however, it is designated as Pool 9 for the purpose of this study.) The total surface area of the lake is 804 acres: 419 acres in Illinois (Pools 1-5 and very small portions of Pools 6 and 7) and 385 acres in Indiana (Pools 6 - 9). The maximum depth in Illinois pools is 18 feet (Pool 5), and in Indiana pools it is 17 feet (Pool 8).

Although Wolf Lake uses the same name on both sides of the border, the Illinois side is bounded by the William W. Powers Conservation Area (580 total acres of which 419 are water), and the lake is sometimes referred to by this name. The Indiana side of the lake (Pools 6 - 9) consists of two large basins, one bounded by State Line Road on the west and the Indiana East-West Toll Road on the east (Pools 6 and 7), and it is sometimes referred to as the Illinois basin, even though the major portion is within the state of Indiana. The other basin (Pool 8) is referred to as the Indiana basin: The Illinois portion of the lake is owned by the state and managed by the Illinois Department of Natural Resources. The remaining portion of the lake is owned by Indiana and managed by the Hammond Park District.

There are significant wetland areas between Pool 8 and Pool 9 (Wolf Lake Channel) and around the south and north ends of the lake basin. These areas are covered with 0.5 to 3 feet of water. The dominant macrophytes are cattails, yellow and white pond lilies, and various aquatic weeds (IDEM, 1986). These wetland areas provide an important habitat for spawning and the protection of fry, especially in shallow areas.

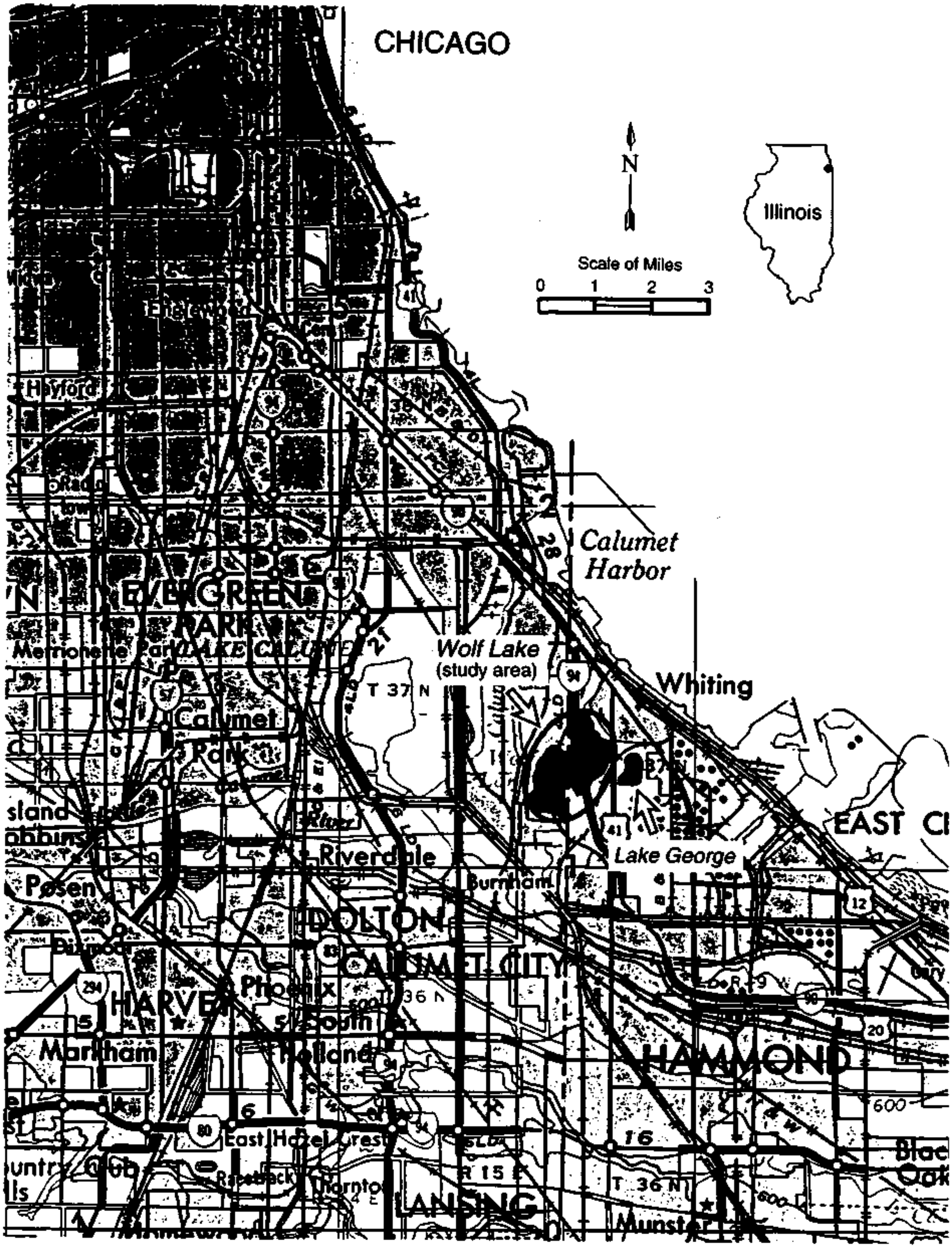


Figure 1. Location of study area

Wolf Lake currently receives industrial cooling water discharges (Wolf Lake Channel) and a few urban stormwater discharges from Hammond on the Indiana side. Because the lake is located within a highly urbanized area, it is used extensively for water-based recreation. There is a swimming beach on the eastern shores of Pool 8. The lake and surrounding parks are used for picnicking, boating, fishing, sailboating, waterfowl observation, and for such winter sports as ice skating and ice fishing. Swimming and water skiing are permitted only on the Indiana side, and waterfowl hunting is permitted only on the Illinois side. The lake supports a variety of sport fisheries such as largemouth bass, northern pike, walleye, bluegill, redear sunfish, crappie, bullhead, carp, and yellow perch (IDOC, 1977). In the past, William Powers personnel have organized summer "Free Fishing Days" activities for children, stocking about 500 pounds of catchable-size channel catfish in the 0.22-acre pond adjacent to the lake to promote fishing.

As indicated earlier, no swimming or water skiing is allowed in Illinois and there is a 10-horsepower restriction for outboard motors. No boat launching fee is levied in Illinois. In Indiana, a maximum 75-horsepower outboard motor is allowed, and boats powered by motors are permitted to operate only between 10:00 a.m. and midnight. All power boats and sailboats on Wolf Lake in Indiana must purchase and display a daily or yearly launching permit.

Climatological Conditions

The Chicago metropolitan area has a temperate continental climate. Warm season (March to November) climate conditions are dominated by maritime tropical air from the Gulf of Mexico. Winters can be severe and represent a distinct cold season with frequent frost and snowfall. The period from November through March is dominated by Pacific air. However, four to six times each winter, cold, dry air from the Canadian Arctic moves south, taking temperatures below 0 degrees Fahrenheit (° F).

The climate of the Chicago metropolitan area is considerably influenced by urbanization and Lake Michigan. Within a few miles of Lake Michigan, the climate is modified by lake breezes, and temperatures are warmer in winter and cooler in summer by 2 to 5° F.

Summer precipitation averages approximately 4 inches per month, mostly in the form of showers and thunderstorms. Summer winds are generally from the southwest. Snowfalls of 6 inches or more occur every year on the average, and snowcover often persists for several weeks.

Long-term records are available from a climatological station at the University of Chicago, 12 miles northwest of the project area. These records indicate that temperatures range from -24° F to 104° F with an average annual temperature of 49.1° F. The average temperature for January, the coldest month of the year, is 31.5° F, while the average temperature for July, the warmest month of the year, is 84.2° F. Average annual precipitation is 37.33 inches, and average annual snowfall is 26.95 inches.

Geological **and Soil** Characteristics of the Drainage Basin

Drainage Area

Definition of the Wolf Lake drainage area is a tenuous process at best. A true surface water divide cannot be accurately defined when surface gradients are extremely low. The low relief in the area also allows the direction of stormwater flow to change with different storm conditions. Previous studies (Ralph E. Price to John N. Simpson, Indiana Department of Natural Resources Departmental Memorandum, February 1, 1980) have declared the natural drainage basin for Wolf Lake to be undefinable.

Figure 2 shows the approximate drainage areas for Wolf Lake, including areas of open drainage to the lake and likely source areas for constructed storm drains. The drainage area of the lake as shown is 2,378 acres.

Drainage from these impervious surfaces shows very little delay in reacting to heavy rainfall events. Pumping from the stations is initiated soon after the start of rainfall events, and runoff is routed quickly through the storm drains. Runoff ends soon after the cessation of rainfall.

The pervious surfaces (surfaces that allow water infiltration) in the watershed react slowly to precipitation events. These areas have little or no associated surface runoff. Instead, precipitation infiltrates the soil, slag, or rubble and discharges slowly to the lake by percolating through soil layers. Runoff from these areas is more closely related to general variations in subsurface water-table levels than to a particular storm event.

Discharges into the Wolf Lake system also include noncontact process, evaporator, or site stormwater discharges from the Amaizo and Lever Brothers plants along the Wolf Lake Channel (figure 2). These discharges are permitted under the National Pollutant Discharge Elimination System (NPDES) program.

Geology, Soils, and Topography

Wolf Lake is situated in a large lake plain that developed around the southern shore of Lake Michigan during the post-glacial period when water levels were higher. The local geology is composed of unconsolidated beach sands and lake sediments overlying glacial tills. Below the tills and roughly 85 feet from the surface is dolomite bedrock. Ground-water flow into Wolf Lake is restricted to the uppermost unit, known as the Equality Formation, and to the man-made fill deposits that cover much of the area.

Numerous reports have been published on the geology and hydrogeology of the Chicago region, which encompasses Wolf Lake. The most comprehensive of these are by Bretz (1939, 1955), Suter *et al*. (1959), and Willman (1971). The geologic framework of the Illinois portion of the region is discussed in Roadcap and Kelly (1994), which details the position and occurrence of the surficial sands. The framework of the surficial deposits in Indiana is discussed in greater detail by Watson *et al*. (1989) and Rosenshein and Hunn (1968).

The uppermost bedrock unit consists of up to 500 feet of Silurian-age dolomites that form a gentle, eastward sloping surface at an elevation of between 500 and 525 feet above mean sea level. This unit forms an aquifer that is widely used by municipalities south of the study area. There is at least one known domestic well, located at a business adjacent to Wolf Lake, that uses this aquifer.

The deposits overlying the dolomite generally consist of two till members of the Wedron Formation. The lower Lemont drift averages roughly 30 feet thick and the upper Wadsworth Till averages roughly 25 feet thick. Both of these units are described as gray silty clays with traces of sand and gravel. The Lemont drift is typically much harder and has a lower moisture content than the Wadsworth Till. The upper surface of the till gently slopes eastward, reflecting an erosional surface at the bottom of Lake Michigan immediately following glaciation.

The Equality Formation comprises beach and lacustrine sands, silts, and clays deposited on the floor of Lake Michigan during the post-glacial period. Strong currents and waves brought in sediments from the retreating glaciers and eroding shorelines to the north, forming a large sand deposit in far southeastern Chicago and northwestern Indiana known as the Dolton Sand Member (Bretz, 1955). As the Lake Michigan water level receded, low beach ridges were formed parallel

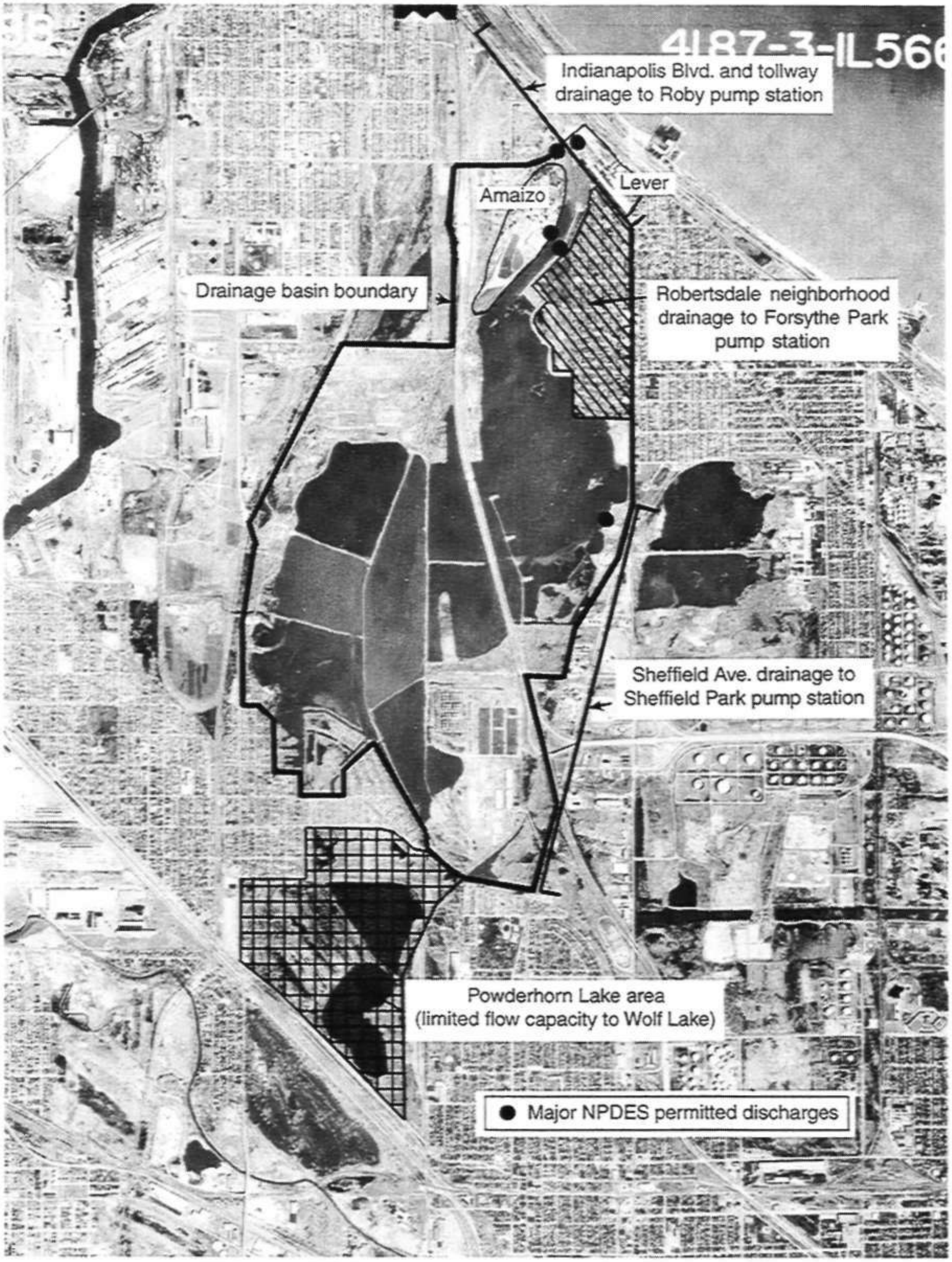


Figure 2. Drainage basin of Wolf Lake and major drainage features

to the present shoreline. Remnants of the beach ridges can be found where sand is the present-day land surface, such as in the forest preserve north of Wolf Lake.

Even though the bottom of the Dolton Sand is clearly defined by the surface of the till units, the thickness of the sand is difficult to map because the top of the sand unit has a very irregular surface. These irregularities are due both to the natural variations in depositional processes of beaches and to quarrying and reworking during industrial development. The sand is generally 15 to 25 feet thick around Wolf Lake. The lake is contained within this sand; however, much of the sand underneath the lake was quarried out for expressway construction, so the deepest portions of the lake may lie directly on top of the glacial till. The sand deposit thickens to the east of the study area where it is known as the Calumet aquifer, and it can have a saturated thickness greater than 45 feet (Watson *et al.*, 1989).

Prior to development in the late 1800s, the region was dominated by extensive wetlands, sluggish rivers, and shallow lakes. To make this region suitable for development, large areas of wetlands were filled. The two main sources of fill were slag wastes from steel production and dredgings from the deepening and channelization of the Calumet River system (Colton, 1985). Lithologic logs from borings in the region show slag to be the most common fill type but also cite material such as garbage, bricks, wood, metal scraps, concrete, and cinders.

The lithologic and hydraulic character of the fill is extremely variable for even short horizontal or vertical distances and cannot be quantified in a single description. This variability was demonstrated in the basement excavations for a group of houses that were built north of Wolf Lake. The fill material removed from one of these excavations consisted of fine reddish clays and yellowish slag, while the neighboring excavation 40 feet to the north contained pinkish slag and paving bricks, and the excavation 40 feet to the south contained what appeared to be natural topsoil. Depositional features could be seen in the sides of the excavation that indicated the fill was dumped in truckloads and was not leveled out until the dumping had stopped. The underlying sand was generally at a depth of about 5 feet.

Due to the variable nature of the fill material, the soils in the region cannot be classified into typical units or associations. Some areas of naturally sandy soil do occur where the old beach ridges are at the surface, such as along the western shore of Wolf Lake and in some of the adjacent older residential areas. The soils on the remaining land adjacent to Wolf Lake consist almost entirely of slag, which can vary dramatically in composition and texture. Many truckloads and railcar loads of slag were dumped while still molten, and then solidified, giving the appearance of natural rock outcrops.

Hydrologic Description of Wolf Lake

Hydrologic System

The hydrologic system at Wolf Lake is composed of the following major units:

- Eight interconnected lake pools with smaller peripheral pools and wetland areas (hydrologically, Wolf Lake Channel or Pool 9 is included in Pool 8);
- Interconnecting channels between pools;
- Surface drainage from the three stormwater pump stations carrying runoff from impervious surfaces in adjacent neighborhoods and major streets, the Powderhorn Lake area, and undeveloped land around the lake;
- NPDES discharges from the American Maize-Products processing plant;
- NPDES discharges from the Lever Brothers plant; and
- The regional ground-water system.

The lake itself is actually a series of eight pools separated by road, railroad, and non-structural causeways with a constricting point separating adjacent pools. Along with figure 3, the following descriptions provide a brief summary of the significant hydrologic parameters for each pool. For the purposes of the water quality monitoring portion of this study, an additional pool - the Amaizo Channel or Wolf Lake Channel portion of Pool 8 - was designated as Pool 9. In terms of areal and volumetric parameters, Pools 8 and 9 are considered together and listed as Pool 8.

Surface flows through the lake system follow the general path shown in figure 3. Flow was sufficiently confined to allow discharge measurements at Indian Creek, the railroad culvert, the State Line Road culvert, and the tollroad culvert.

Pool 1 is in the northwestern corner of the Illinois portion of the lake. It is completely separated from the other pools and generally maintains an independent pool level. Pool 1 has a very limited direct drainage area and the majority of inflow appears to be through ground-water infiltration. Five 12-inch-diameter culverts connect Pool 1 to a small wetlands area immediately north of and across the park access road from the pool. Outflow from the pool is limited to exfiltration through the south causeway (to Pool 2) and the railroad causeway (to Pool 4).

Pool 2 is the middle pool along the west side of the lake. It is along the main flow path through the lake system, receiving water from Pool 4 through the railroad culvert and passing water to Pool 3 through the openings in the concession stand causeway. The pool has a very limited or no direct drainage area.

Pool 3 is in the southwestern portion of the lake. It is the main outflow point from the lake, receiving water from Pool 2 through the concession stand causeway and discharging water through Indian Creek to the Calumet River. Other drainage to Pool 3 includes inflows from Powderhorn Lake and a very limited connection to Pool 5 through a railroad culvert.

Pool 4 is the northern pool in the lake section confined by the railroad culvert on the west and State Line Road on the east. Pool 4 is along the main flow path through the lake and receives water from Pool 6 through the State Line Road culvert and passes water to Pool 2 through the railroad culvert. This pool has a very limited direct surface drainage area immediately to the north of the pool across the park road. Its limited connection to Pool 5 maintains the pools at a common water level but provides a very limited hydraulic interchange.

Pool 5 is the southern pool between the railroad and State Line Road. The main flow of water through the lake system does not significantly effect Pool 5. The pool receives flow across State Line Road from a peripheral pond on the east side of the road. This pond is fed by two ditches that drain the U.S. Government surplus commodities center and the wetlands area along the north side of 136th Street. Pool 5 is connected to Pools 1 and 4, but both connecting openings have a very limited flow capacity.

Pool 6 is the southern pool between State Line Road and the Indiana East-West Toll Road. The pool is along the main flow path through the lake, receiving water from Pool 7 through a causeway opening along the tollroad causeway and discharging to Pool 4 through the State Line Road culvert. Pool 6 has a very limited direct drainage area at its south end but receives some inflow from tollroad drainage.

Pool 7 is the northern pool between State Line Road and the tollroad. It is along the main flow path through the lake, receiving water from Pool 8 through the tollroad culvert and passing water to Pool 6. Pool 7 has a poorly defined direct drainage area from the wetlands at its north end. It also receives inflow from tollroad drainage.

Figure 3. Hydrologic components of the Wolf Lake system

Pool 8 is the largest pool in the lake system and includes most of the lake area east of the tollroad. The main flow path of the lake passes through the pool from Pool 9 (Wolf Lake Channel) to the tollroad culvert. Most of the direct drainage area of the pool is intercepted by Hammond Sanitary District storm drains. The Sheffield Avenue stormwater pump station discharges directly to Pool 8, and a limited area of wetlands along the southeasterly lake shore drains directly to the lake.

Pool 9 is a designation used in this study for the Wolf Lake Channel area. Hydrologically, this is the most significant area because more than 99 percent of the drainage inflow enters through this portion of the lake from Lever Brothers Company, American Maize-Products Company (Amaizo), the Roby stormwater pumping station, and the Forsythe Park stormwater pumping station. The only direct inflow to the pool is very limited stormwater runoff from the Amaizo grounds. Outflow from Pool 9 passes into Pool 8.

With the exception of Pool 1, each of the pools has some form of connection to at least one of the other pools, allowing an interchange of water between the pools. Four of these interconnecting channels are sufficiently confined to permit measurement of interpool flows. Flow rates were measured in each of these channels during every diagnostic program data collection visit. Flow rates were measured at the Indiana Toll Road culvert, the State Line Road culvert, the Indian Harbor Belt Railroad culvert, and the Indian Creek outlet channel.

Other factors that may impact the lake's hydrology include surface inflows to the lake from areas outside the defined drainage basin and localized alteration of the ground-water regime due to pumpage.

Inflow and Outflow Conditions

Inflow to the Wolf Lake system originates from four types of sources:

- Direct precipitation on the lake surface;
- The direct drainage area of the lake, which is defined for this study as stormwater runoff flowing into the lake without mechanical influence, including watershed runoff over land or through ditches that does not pass through a pump system;
- Stormwater pump station drainage that originates in a constructed collection system and is discharged to the lake through the pump station;
- Industrial discharges of water; and
- Flow through the ground-water system.

Discharges from the three stormwater pumping stations and the Amaizo and Lever Brothers discharges are monitored under the NPDES permit program. Inflows from direct drainage and the ground-water system will be evaluated separately.

The rates of NPDES discharges from Lever Brothers and Amaizo are stable; they may vary by plant shift on a daily basis but are not subject to significant seasonal changes. These discharges provide a stable baseflow through the lake system of at least 16.5 cubic feet per second (ft^3/s) or 11 million gallons per day (mgd).

The major surface units in the hydrologic system react in a very predictable manner. Precipitation wets surfaces and then puddles until these initial losses are met. For impervious surfaces (paved surfaces and building roofs), infiltration potential is very low, and runoff begins when initial losses have been met. For pervious surfaces, runoff occurs only during storm events that exceed infiltration capacity. During most precipitation events, runoff occurs only from impervious surfaces.

As runoff enters the lake pools, their water levels rise, increasing the volume of water stored in those pools. This process is complicated only slightly by the restricted interflow between the lake's pools. The increases in the pool levels in turn increase the flow rates in the interconnecting channels, and the temporary storage of stormwater in the pools is released. Stage data collected during the diagnostic portion of this study indicate that the pool levels adjust rapidly to water-level differentials during storm events. The only significant control points for water levels in the system are at Indian Creek, the railroad culvert (intermittently), and the State Line Road culvert. The control point at the Indian Creek outlet varies between the weirs at the outlet itself and a makeshift dam that is occasionally established in the stream channel. This damming structure tends to fail but is restored by unknown parties.

Water levels in Pool 1 are always independent of levels in the other pools. No distinct outlet from Pool 1 exists except for flow through the dikes that separate it from Pools 2 and 4.

Lake levels are generally higher than ground-water levels. The effects of ground water on Wolf Lake water levels are part of a complex series of interrelationships involving precipitation, local sanitary and storm sewer leakage, and water levels in Lake Michigan and Wolf Lake. Wolf Lake generally discharges into the ground-water system at a rate dependent on the differential between the lake level and ground-water levels.

Ground-Water Conditions around Wolf Lake

To assess the influence of ground water on Wolf Lake, monthly water-level elevations were measured in 25 monitoring wells located in the surrounding area. The locations of 9 of these wells immediately adjacent to the lake are shown on figure 4. Most of the wells are part of a regional monitoring well network constructed by the USGS in the greater Calumet watershed of Indiana and Illinois. Fenelon and Watson (1993) used data from this network to construct a ground-water flow model of the Indiana portion of the region. Ten of the wells are clustered in the southwest corner of the lake around well 26 as part of an ongoing ISWS study of the physical interaction between ground water and surface water. Well 28 was constructed in April 1993 with the help of the USGS to fill a major data gap. Well BH-8 along the state line was destroyed by fire in August 1993.

Figures 5 and 6 show the monthly water-level elevations from November 1992 to October 1993 for the wells on the west and east sides of the lake, respectively. The wells shown on the hydrographs, all of which are completed in the shallow sand aquifer, were chosen either because they are the closest to the lake or because they best represent the type of ground-water interaction occurring in a particular direction around the lake. The Wolf Lake data are from the staff gages in Pool 2 on the west side and in Pool 8 on the east side. The November - March readings for the Pool 8 gage were interpolated because they were not taken on the same days as the ground-water readings. Staff gage readings were also affected by waves as great as 0.5 feet. It is important to note that all of the measurements represent only what was occurring for a particular day and may not accurately portray everything that happened during an entire month.

The surrounding ground-water levels are higher than the level of Wolf Lake except where the shoreline is close to older residential neighborhoods to the northeast and the southwest. These lower levels, shown by wells 26, E3, and BH-15 in figures 5 and 6, are due to ground-water infiltration into leaky sanitary and storm sewers that lie below the water table. Lower water levels were also measured in several other wells located even farther into those neighborhoods, such as well BH-24 (figure 5). Fenelon and Watson (1993) estimate that 8 ft^3/s of ground water is discharging to the Hammond sewer system throughout the city. During large or extended precipitation events, ground-water divides can develop between the lake and these

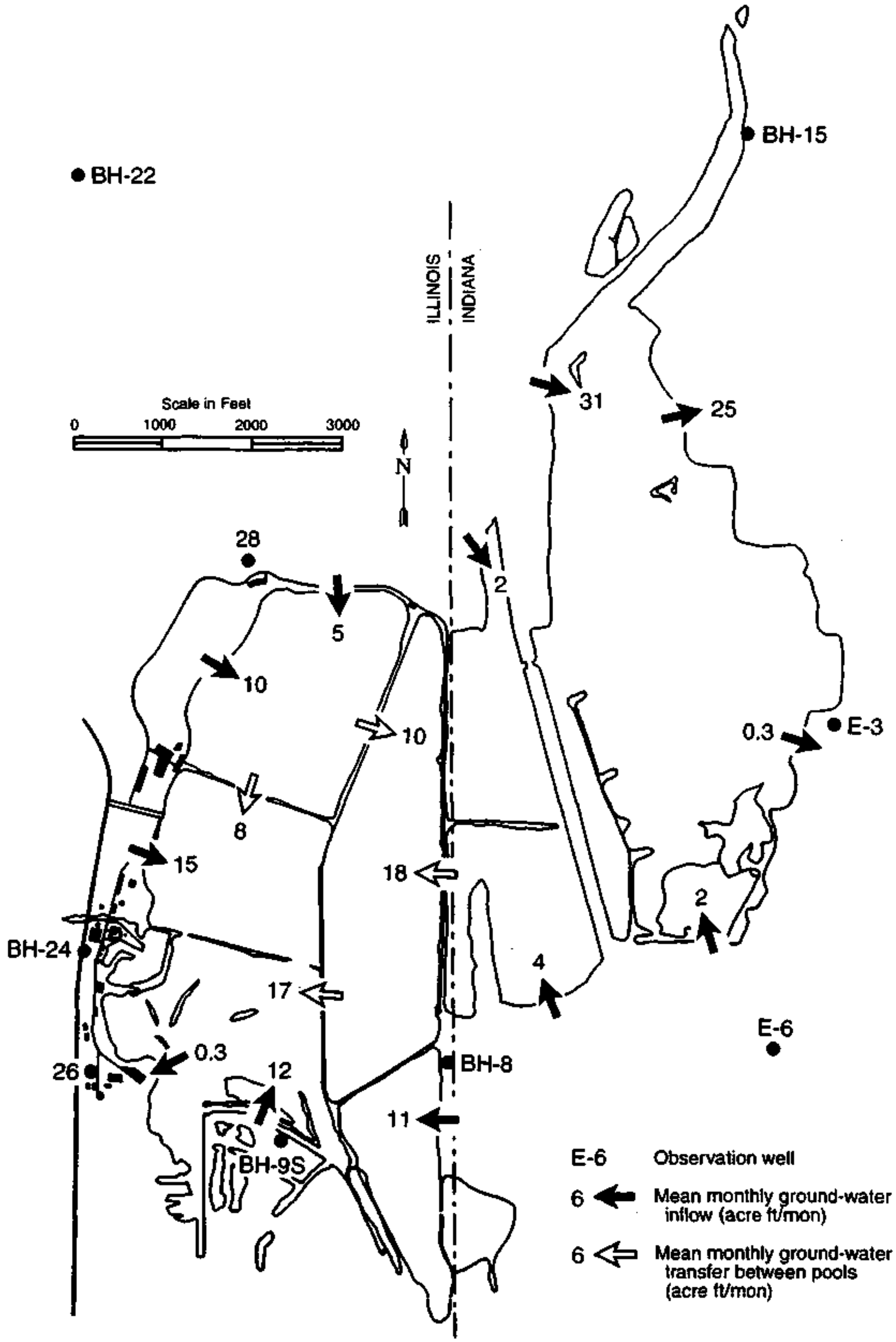


Figure 4. Ground-water measurement and flow conditions for Wolf Lake

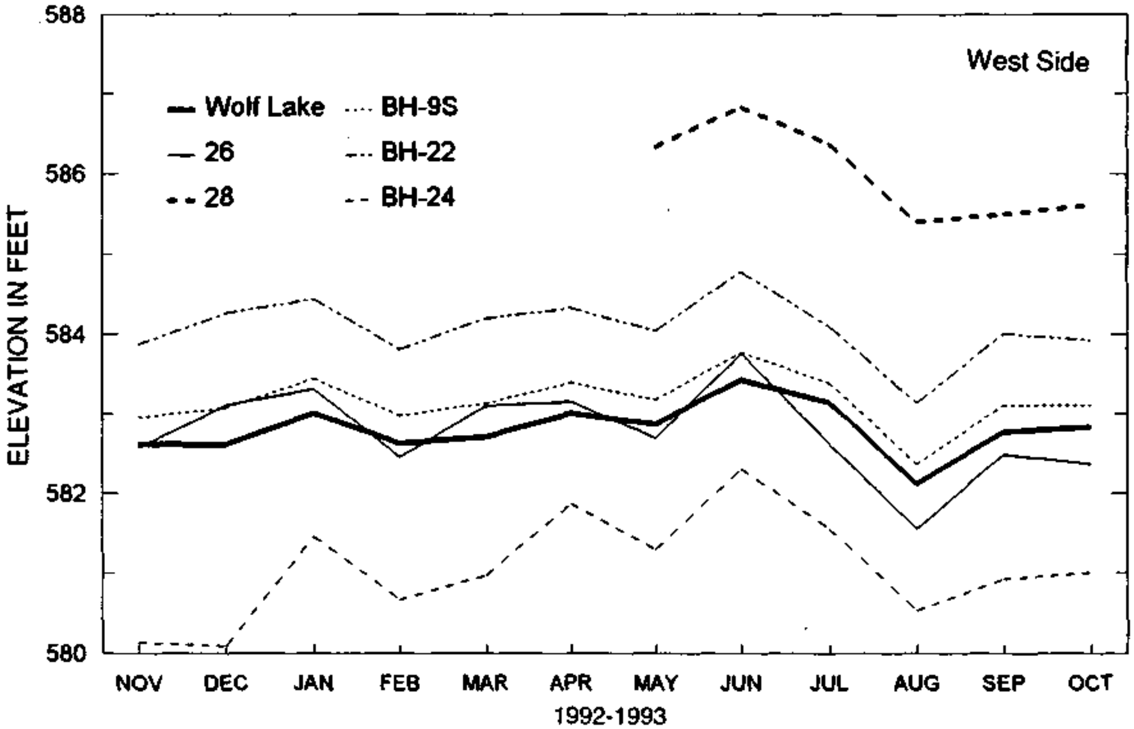


Figure 5. Water-level hydrographs for Wolf Lake and wells on the west side of the lake

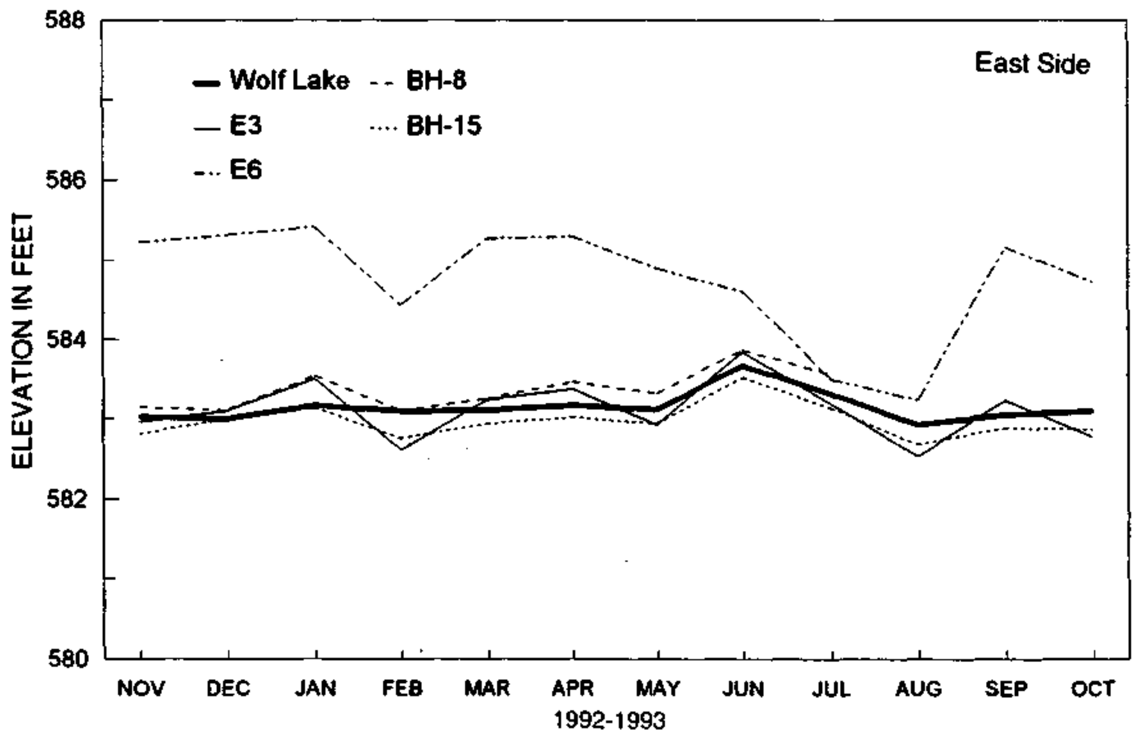


Figure 6. Water-level hydrographs for Wolf Lake and wells on the east side of the lake

neighborhoods, reversing the direction of flow. This mounding is demonstrated by the water level in well 26 (figure 5), which rose above the lake during winter months.

With the exception of well 26, the hydrographs in figure 5 for the wells on the west side of the lake show a uniform trend of ground water rising and falling with the lake. This indicates that the lake level controls the general elevation of the surrounding ground water and that the ground water has a similar response to precipitation and evaporation. The lower ground-water levels in early August were probably caused by evaporation and the interception and subsequent transpiration by plants of the precipitation falling on land. Well 28 did not respond as quickly to this decline because the well is located on a large slag pile and the depth of the ground water below land surface was too great for evaporation to occur.

The hydrographs from wells BH-8 and BH-15 (figure 6), located very close to the east shore of Wolf Lake, closely mimic the lake level. Well BH-15 has a slightly lower level, indicating that ground-water flows from the lake toward the sewers in the adjacent neighborhood. Well E3 is also near the lake, but its water levels are complicated by flow reversals due to fluctuations in Lake George levels mounding between the two lakes, and possible leakage into the sewer system. Well E6 is roughly 1,400 feet from the lake, far enough away from the discharge area that the water level had equilibrated close to the land surface, except during the summer months when evaporation lowered the level 2 feet.

As much as 10 feet of slag was used to fill in the lake along much of its northern, eastern, and southern shoreline. Slag was also used in the construction of the causeways that divide the lake into different pools. Research on the discharge of ground water from a slag pile to a wetland near Lake Calumet shows that the discharge is concentrated in springs (Duwal, 1994). These springs develop where there is a significant hydraulic gradient and presumably where there are gravelly lenses or voids in the slag. The springs may have a somewhat regular spacing and are more concentrated where there is a concave bend in the shore. Seepage meter tests show that the discharge between these springs may be close to zero. Duwal (1994) also demonstrates that the hydraulic conductivity of a slag pile may be much higher than expected due to macropore development.

Public Access to the Lake Area

The major population centers close to the lake are the southeast side of Chicago, Bumham, Calumet City, Lansing, Dalton, and South Holland in Illinois and the cities of Hammond, Whiting, East Chicago, and Gary in Indiana. All these cities are either within walking distance or within easy and convenient driving distances (1 to 10 miles) of the lake.

Illinois Side

In the William W. Powers Conservation Area, Wolf Lake is accessible from Highways I-94, I-90, and U.S. 41. The main park entrance is at 123rd Street and Avenue O, and the entrance to the park ranger office is at 130th Street and Avenue O. There is no public transportation to and from the lake and the state park; however, a wide arterial road (Avenue O) provides very convenient access to the park area.

Figure 7 shows public access points, parking lots, and park facilities. A public road circles the lake, except on the south side of Pools 3 and 5, and provides ready and easy access for such activities as bank fishing, nature study, and the use of park facilities. The access road to Pool 5 is very poor. The park road on the east side runs parallel to the state line. There are three boat launching ramps, one each in Pools 1, 2, and 4, with a capacity sufficient for inland fishing boats. Only motors with 10 horsepower or less are allowed.

The William W. Powers Conservation Area is open to the public year round, except on Christmas Day and New Year's Day, from 5 a.m. to 10 p.m. When weather conditions necessitate the closing of roads during freezing and thawing periods, access to the facilities is by foot only.

Table 2 lists the parking spaces and public access points around Wolf Lake. More than an adequate number of parking spaces are available throughout the state park. There is no fee charged for the use of the park or launch facilities. The main picnic area is located south of the main entrance and parallel to Avenue O. An ample quantity of tables and cast iron grills are provided in shady spots beneath the many willow and Cottonwood trees. Two shelters are available on a first-come basis. Approximately 6 miles of shoreline is available for bank fishing.

The lake on the Illinois side is used for waterfowl hunting during the fall and winter. Hunting must be done from authorized blinds, which are allocated on a two-year basis at a public drawing during the summer of even-numbered years. Unoccupied blinds are available on a daily basis. Information on hunting regulations and blind site locations can be obtained from the park ranger office.

Groups of 25 or more persons will not be admitted to any site unless permission to use the facilities has been obtained from the site manager. In addition, groups of minors must have adequate supervision; at least one responsible adult must accompany each group of 15 minors. All pets must be on a leash (IDOC, 1977).

Indiana Side

The city of Hammond has public bus transportation (Hammond Transit System) running past the lake (along Calumet Avenue) from 6 a.m. to 6 p.m. During peak traffic hours, the services are at 15-minute intervals, tapering off to 45-minute intervals during nonpeak hours. This service connects with Chicago public transportation, travels through the city of Whiting, IN, and into Munster, IN. There are two parking lots (east side of Pool 8) that can accommodate cars and buses. Public access is available in most areas of the lake. Exceptions are the west side of Wolf Lake Channel (Pool 9), where the American Maize-Products Company (Amaizo) is situated, and the southeast corner of the lake, where some commercial enterprises are located. There is a large swimming beach located along the northeast quadrant of the lake.

Given its location in a highly urbanized and industrialized region, the lake has an excellent network of city, state, and interstate freeways and tollways for easy access. Amtrak railroad's nearby Hammond stop is located at 1135 Calumet Avenue, Whiting, IN.

A map of public access and park facilities for the Indiana side is also presented in figure 7. There are several parks and forest preserves around the perimeter of the lake. Forsythe Park on the east side of the Wolf Lake Channel and the area south of the beach offer opportunities and amenities for bank fishing, six ball fields, a playground, parking, and several picnic facilities. There are a public boat launching ramp (fees charged) and a parking lot on the southeast side of the lake near the Sheffield pumping station (Pool 8) and a private marina on the northwest side of Pool 8.

The lake (Pool 8) is heavily used for both ice and warm weather fishing, boating (power and sail), water skiing, swimming, ice skating, wind surfing, and picnicking. All power boats and sailboats using Wolf Lake water must have a yearly or daily launching permit. The launching permit is in the form of a plate that must be displayed on the port (left) side of the bow next to the state plate number.

Table 2. Parking and Public Access Points in Wolf Lake

Item	*Type*	*Size, feet*	*Facilities and capacities*
A	Paved, marked parking	60 × 120	Parking for 1 handicap vehicle, 11 cars with trailers
		75 × 150	Parking for 8 cars with trailers, 10 cars, and 1 handicap vehicle
			Concrete boat launch 15 feet wide
B	Paved, unmarked parking	55 × 80	Parking for 8 vehicles
C	Paved, marked parking	65 × 150	Parking for 23 vehicles
D	Boat launches and parking		Two 14-foot-wide boat launches, one for each pool; marked parking for 8 vehicles
E	Paved, marked parking	63 × 198	Parking for 29 vehicles
F	Paved, marked parking	98 × 200	Parking for 47 vehicles
G	Paved, marked parking	28 × 270	Parking for 27 vehicles
H	Paved, marked parking	20 × 340	Parking for 32 vehicles
I	Paved, marked parking	20 × 94	Parking for 9 vehicles
J	Paved, marked parking	140 × 162	Parking for 49 vehicles
K	Area around concession stand	50 × 120	Parking for 3 handicap vehicles
		95 × 62	and 22 other vehicles
L	Paved, marked parking	30 × 54	Parking for 5 vehicles
		30 × 42	Parking for 4 vehicles
		30 × 100	Parking for 10 vehicles
M	Paved, marked parking	70× 95	Parking for 15 vehicles
N	Paved, marked parking	30 × 60	Parking for 6 vehicles
O	Paved, marked parking	60 × 195	Parking for 2 handicap vehicles and 31 other vehicles
P	Roadside parking, unmarked	10 × 990	Many vehicles
Q	Roadside parking, unmarked	10 × 50	Parking for 3 vehicles
R	Roadside parking, unmarked	10 × 50	Parking for 3 vehicles
S	Boat launch and paved parking	110 × 290	Handicap vehicles and 20 vehicles with trailers.
			Concrete boat launch 16 feet wide
	Playground facilities		Children's playground and four picnic shelters
T	Paved parking for beach area	140 × 620	Parking for 270 vehicles
	Beach and swimming area		Concession and bathhouse
	Forsythe Park		Six baseball diamonds with parking facilities

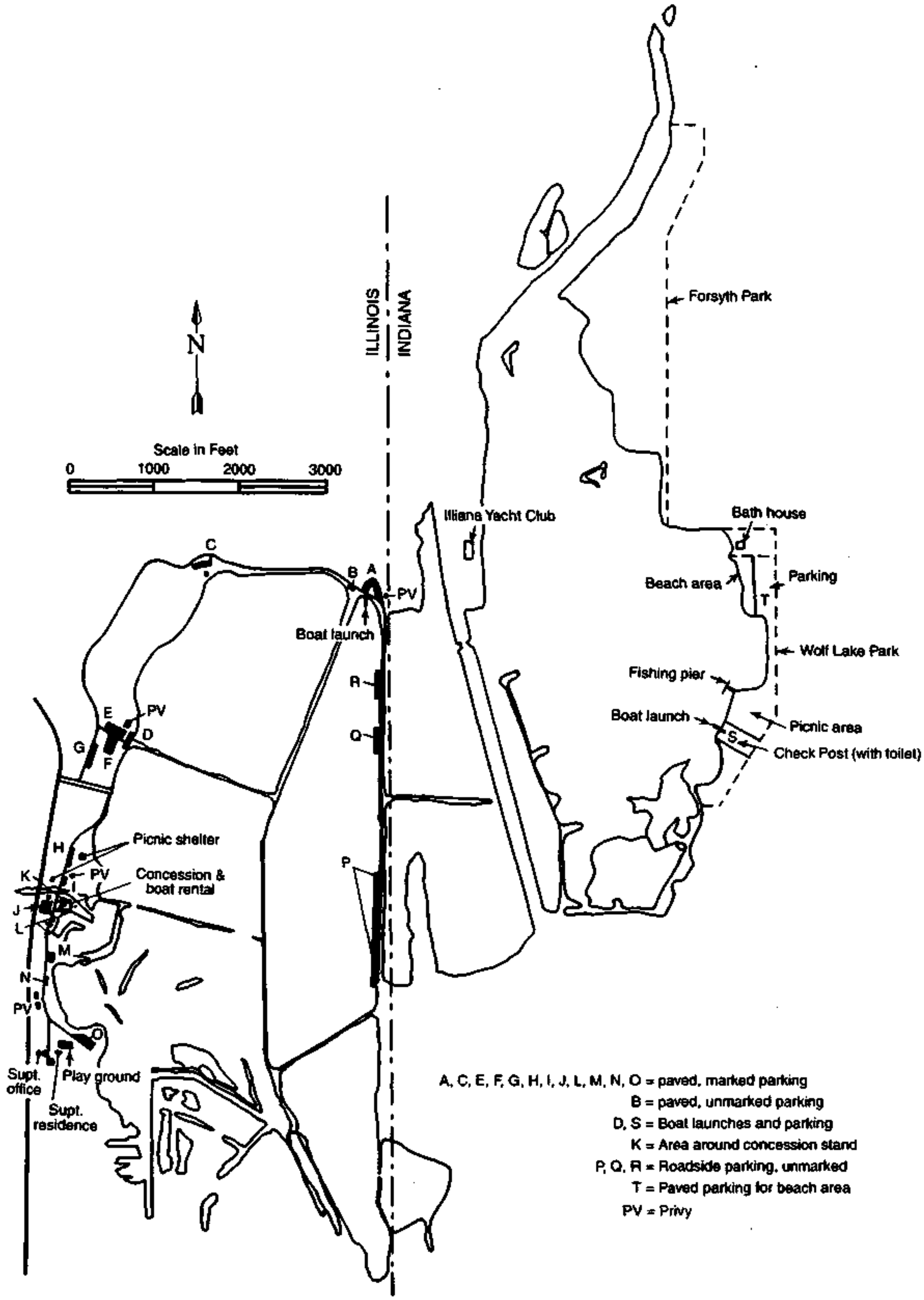


Figure 7. Public access points and parking areas on Wolf Lake

Size and Economic Structure of Potential User Population

Size

On the Illinois side, the resident population at the lake consists of the park ranger's family and residents immediately south of the park. Residential development exists along the shoreline of Pool 3 south of the park office and west of Avenue O. The Illinois Department of Natural Resources estimated that visits to the park exceeded 500,000 in the recent years. In Indiana, residential areas exist immediately next to Forsythe Park (Pools 8 and 9) and along the shoreline north of the swimming beach (Pool 8).

It is difficult to know exactly where the visitors come from. They may be from the southeast end of Chicago, Burnham, Calumet City, Lansing, Dolton, South Holland, Riverdale, other nearby Illinois communities, and from Indiana communities such as Hammond, Whiting, East Chicago, and Gary. The most frequent visitors to Wolf Lake are probably residents of the south end of Chicago (Hegewisch and Altgeld Gardens) and Burnham, IL, and Hammond, IN.

Table 3 presents pertinent population and economic information for cities and towns near Wolf Lake (U.S. Department of Commerce, 1992, 1993). The combined population of these surrounding cities is 3,036,467. Although the potential user population is likely to be from the areas listed in the table, it is believed that most Chicago residents are not potential users.

Economic Characteristics

Tables 4a and 4b show population and economic data for counties within 50 miles (80 kilometers) of the lake and list sources of employment. The potential user population, user demands/needs, etc. are overwhelming since Wolf Lake is situated in the most highly industrialized region of the Midwest. Surrounding counties can be characterized as having middle income levels, plentiful employment sources, low unemployment rates, and adequate housing for individuals.

Historical Lake Uses and Conditions

Illinois Side

It is not known how the area originally became known as Wolf Lake. Some local residents claim Wolf was an early settler or an Indian chief; others say that years ago wolves were abundant around the lake and that the lake itself was in the shape of a wolf. The Chicago Historical Society was unable to verify any of these possibilities.

In 1965, the Illinois Legislature approved changing the name of the conservation area to honor the memory of William W. Powers, a former state legislator, who was well-known for his deep interest in the promotion of recreation for the residents of his district (IDOC, 1977).

As mentioned previously, Wolf Lake is a natural lake with numerous drop-offs. However, many areas were dredged and mined for their underlying sand layer in years past. Today the lake is separated into eight different pools by dikes and roads erected during dredging and construction projects.

In Illinois, the lake areas are being used for boating, fishing, hiking, picnicking, winter sports, and waterfowl hunting. Swimming and camping are not permitted. Historical data on attendance at the William W. Powers Conservation Area are shown in table 5.

Table 3. Demographic and Economic Data for Towns Surrounding Wolf Lake

	Illinois							*Indiana*		
	Burnham	*Calumet City*	*Chicago*	*Dolton*	*Lansing*	*Riverdale*	*South Holland*	*East Chicago*	*Hammond*	*Whiting*
Population	3,916	37,840	2,783,726	23,930	28,086	13,671	22,015	33,892	84,236	5,155
Male	1,796	17,897	1,334,705	11,384	13,393	6,271	10,716	16,109	40,793	2,505
Female	2,120	19,943	1,449,021	12,546	14,693	7,400	11,289	17,783	43,443	2,650
Percent of population under 18	22.1	23.2	18.3	18.6	22.8	20.2	20.1	30.9	26.8	23.7
Percent of population over 65	17.9	15.5	17.1	21.1	15.3	23.9	19.3	13.2	14.3	17.1
Number of households	1,367	15,434	1,025,174	8,337	10,881	5,345	7,437	12,122	32,146	2,137
Persons per household	2.67	2.45	2.67	2.83	2.58	2.56	2.88	2.78	2.61	2.41
Per capita income, dollars	12,951	13,569	12,899	14,063	16,112	12,524	17,352	9,090	11,576	11,664

Source: 1990 census data (U.S. Bureau of the Census, Economic Census and Surveys Division, 1992)

Table 4a. Population and Economic Data for Areas near Wolf Lake

					Manufacturing						
County, County seat	*Other major towns*	*Area, sq. miles*	*Population (thousand)*	*Wholesale ($1,000)*	*Establish-ments*	*Units*	*Employees (thousand)*	*Value added ($1,000)*	*Total number of establish-ments*	*Total number of employees (thousand)*	*Per capita income (dollars)*
Illinois											
Cook, Chicago		946	5105.1	92,995,424	9,450	26,988	491.6	31,463,100	120,330	2,371.3	11,176
DuPage, Wheaton	Naperville	334	781.7	32,087,877	1,857	3,112	67.5	3,628,300	26,012	465.8	21,155
Grundy, Morris		420	32.3	198,268	44	256	2.9	298,800	749	10.3	14,474
Kane, Geneva	Aurora	521	317.5	3,394,851	749	2,268	37.4	2,643,600	8,305	136.0	15,890
Kankakee, Kankakee		678	96.2	530,630	111	520	7.0	606,500	2,005	30.9	12,142
Kendall, Yorkville	Piano	321	39.4	116,513	51	68	1.4	79,500	643	6.2	16,115
Lake, Waukegan		448	516.4	5,398,296	760	2,505	50.9	2,920,700	13,225	208.1	21,765
Will, Joliet		837	357.3	1,590,189	361	1,387	17.6	1,617,300	6,497	90.2	15,186
Indiana											
Jasper, Rensselaer		560	25.0	148,535	23	45	1.3	53,000	601	6.1	11,256
Lake, Crown Point	Gary	497	475.6	2,462,690	379	3,226	42.1	3,760,900	9,200	167.2	12,663
LaPorte, LaPorte	Michigan City	598	107.1	229,228	188	562	11.8	654,600	2,312	36.5	12,973
Newton, Kentland		402	13.6	61,927	13	79	-	-	249	2.5	11,925
Porter, Valparaiso	Portage	418	128.9	339,458	104	1,234	10.7	1,438,300	2,451	39.2	15,059

Table 4b. General Employment Categories for Areas near Wolf Lake

County/county seat (Other major towns)	*Employment categories*
Illinois	
Cook/Chicago	Construction; manufacturing (food and kindred products, tobacco products, textile products, lumber and wood products, furniture and fixtures, paper and allied products, printing and publishing, chemical and allied products, leather products, stone clay and glass products, primary metal industries, fabricated metal products, industrial machinery and equipment, electronic equipment, transportation equipment, instruments and related products); transportation and public utilities; wholesale trade; retail trade; finance, insurance, real estate; services (hotels and motels, automotive, motion pictures, computer and data processing, engineering and management, amusement and recreation, health, management, public relations).
DuPage/Wheaton (Naperville)	Agriculture; construction; manufacturing (food products, paper products, printing and publishing, rubber and plastic products, fabricated metal products, industrial machinery and equipment, electronic products); transportation and public utilities; wholesale trade; retail trade; finance, insurance, real estate; services (hotels and motels, business, computer and data processing, health, automotive, engineering, management, public relations).
Grundy/Morris	Manufacturing (chemical and allied products); transportation and public utilities; retail trade; personal services.
Kane/Geneva (Aurora)	Construction; manufacturing (food products, furniture and fixtures, paper mills and allied products, printing and publishing, chemical products, rubber and plastic products, fabricated metal products, industrial machinery and equipment, electronic equipment; transportation and public utilities; wholesale trade; retail trade; finance, insurance, real eastate; services - business, personal, health, engineering, management).
Kankakee/Kankakee	Construction; manufacturing (food and kindred products, paper and allied products, chemical and allied products; transportation and public utilities; wholesale trade; retail trade; finance, insurance, real estate; services (business, health, educational, social).
Kendall/Yorkville (Piano)	Construction; manufacturing; transportation and public utilities; wholesale trade; retail trade; services (business, auto, health, social).
Lake/Waukegan	Agricultural (veterinary, landscape and horticulture); construction; manufacturing (food and kindred products, paper products, printing and publishing, rubber and plastic products, fabricated metal products, industrial machine and equipment), electronic equipment; transportation and public utility; wholesale trade; retail trade; finance, insuranc, real estate; services (hotels and motels, personal, business, automotive, health, engineering, management).

Table 4b. Concluded

County/county seat (Other major towns)	*Employment categories*
Will/Joliet	Agricultural services; construction; manufacturing (chemical products, rubber and plastic products, fabricated metal products, industrial machinery and equipment); transportation and public utilities; wholesale trade; retail trade; finance, insurance, real estate; services (personal, business, health, membership organizations, engineering, management).
Indiana	
Jasper/Rensselaer	Retail trade and health services.
Lake/Crown Point (Gary)	Construction; manufacturing (food products, printing and publishing, chemical products, primary metal industries, fabricated metal products, industrial machinery and equipment); transportation and public utilities; wholesale trade; retail trade; finance, insurance, real estate; services (personal, business, health, education, social, membership organizations).
LaPorte/LaPorte (Michigan City)	Construction, manufacturing (primary metal industries, fabricated metal products, industrial machinery and equipment); transportation and public utilities; wholesale trade; retail trade; services (business, health).
Newton/Kentland	Manufacturing and retail trade.
Porter/Valparaiso (Portage)	Construction, manufacturing (industrial machinery and equipment, printing and publishing; transportation and public utilities; wholesale trade; retail trade; services (business, health, membership organizations).

Sources: 1990 Census of Population and Housing Characteristics (Illinois, Indiana), Bureau of Census, U.S. Department of Commerce, 1990 Census of Population and Housing (1990); Summary of Social, Economic, and Housing Characteristics (Illinois, Indiana), Bureau of Census, U.S. Department of Commerce; Rand McNally Commercial Atlas and Marketing Guide (1993).

Table 5. Historical Attendance, William Powers Conservation Area

	1989	*1990*	*1991*	*1992*	*1993*	*1994*
January	19,150	17,941	17,299	*18,341	17,875	15,567
February	13,859	23,133	23,382	*23,342	18,230	18,697
March	26,042	41,003	41,695	*43,342	29,474	36,043
April	43,572	58,131	60,532	*48,342	49,185	50,555
May	51,433	60,0%	72,106	67,008	65,895	66,703
June	52,764	61,140	63,196	65,993	67,008	64,722
July	58,077	69,082	71,600	71,848	75,704	74,230
August	36,457	64,211	62,860	70,112	69,364	58,645
September	40,463	45,473	47,354	50,616	39,893	47,100
October	11,245	29,724	31,102	34,260	26,663	28,637
November	12,300	22,092	17,0%	16,888	21,0%	20,745
December	10,540	15,436	67,008	15,609	17,986	18,083
Annual Total	375,902	507,462	600,000	525,701	498,374	499,727

Note:
*   Estimated from known total annual attendance

Indiana Side

Point Source Discharges. Point source effluent discharges to Wolf Lake are located in Wolf Lake Channel (Pool 9) and on the east side of Pool 8, all on the Indiana side. Currently, two industries, Amaizo (a manufacturer of corn products) and Lever Brothers Company (a manufacturer of soap and detergent products), have NPDES discharge permits from the state of Indiana allowing discharge of cooling waters into Wolf Lake. The source of cooling waters for these industries is Lake Michigan. The Hammond Sanitary District has an NPDES permit to discharge stormwater into the lake at three different locations, namely, Sheffield Avenue, Forsythe Park, and Roby pumping stations (figure 8). The first discharge occurs in Pool 8 and the latter two occur in Wolf Lake Channel. In contrast, there are no point source discharges into the lake in Illinois; details of point source discharges are discussed in a later section.

Summary of Historical Conditions. During the period between the 1930s and early 1960s, there were long negotiations among the Health Department of Hammond, Hammond Park Board, Indiana State Board of Health, Indiana State Pollution Control Board, Amaizo, and Lever Brothers Company for the protection of water quality in Wolf Lake, especially at the swimming beach.

In the past, there were instances of adverse impacts from lake water quality degradation. In 1945 and 1946, the beach was closed for swimming due to high bacterial counts. Fish kills occurred in 1947 (Carnow, 1990).

Today, discharges from Lever Brothers Company (6.71 mgd, Class D industrial wastewater treatment plant) are usually within effluent standard limits. Occasional problems with total suspended solids (TSS) have developed when Lake Michigan intake water has elevated TSS levels (Bell and Johnson, 1990). The effluent is strictly noncontact cooling water obtained from Lake Michigan. The cooling water is discharged to a settling lagoon prior to discharge into the northern tip of Wolf Lake Channel.

Amaizo currently is not discharging either industrial or sanitary wastewater into Wolf Lake. The company discharges overflow of Lake Michigan water, which is delivered from its pumping station on the lakefront to the plant process well; noncontact cooling water; and stormwater runoff from its premises.

In 1990, the Indiana Department of Environmental Management found high fecal coliform counts in the Sheffield Avenue station stormwater outfall and suspected the possibility of cross-connections between the sanitary sewer and storm sewer. The Hammond Sanitary District reported that the probable source of pollutants was runoff from the adjacent commercial trucking companies located in the area, but no effort was made to identify the cause of the high fecal coliform levels. Several stormwater discharges to Wolf Lake may have led to high fecal coliform counts, adversely affecting the beach water quality (Carnow, 1990).

On April 16, 1982, the IEPA reported a fish kill in Wolf Lake in Illinois of approximately 60 fish. It was allegedly caused by an illegal discharge from the Wolf Lake Terminal at 3200 Sheffield Avenue, Hammond, IN (Office Memorandum, Indiana Board of Health, April 17, 1982). A lawsuit alleged that the firm released hazardous wastes into Wolf Lake, failed to report under the Hazardous Waste Act, failed to file proper emergency plans for containment, and failed to monitor ground water. The firm was cited for illegal acceptance, storage, sale, and disposal of hazardous wastes. The lawsuit was dismissed in 1986.

Data on the quantity and quality of nonpoint urban runoff into Wolf Lake are not available. The use of road salt on the Indiana Toll Road and other nearby roads may have significant adverse effects on the quality of runoff into Wolf Lake (Bell and Johnson, 1990). The

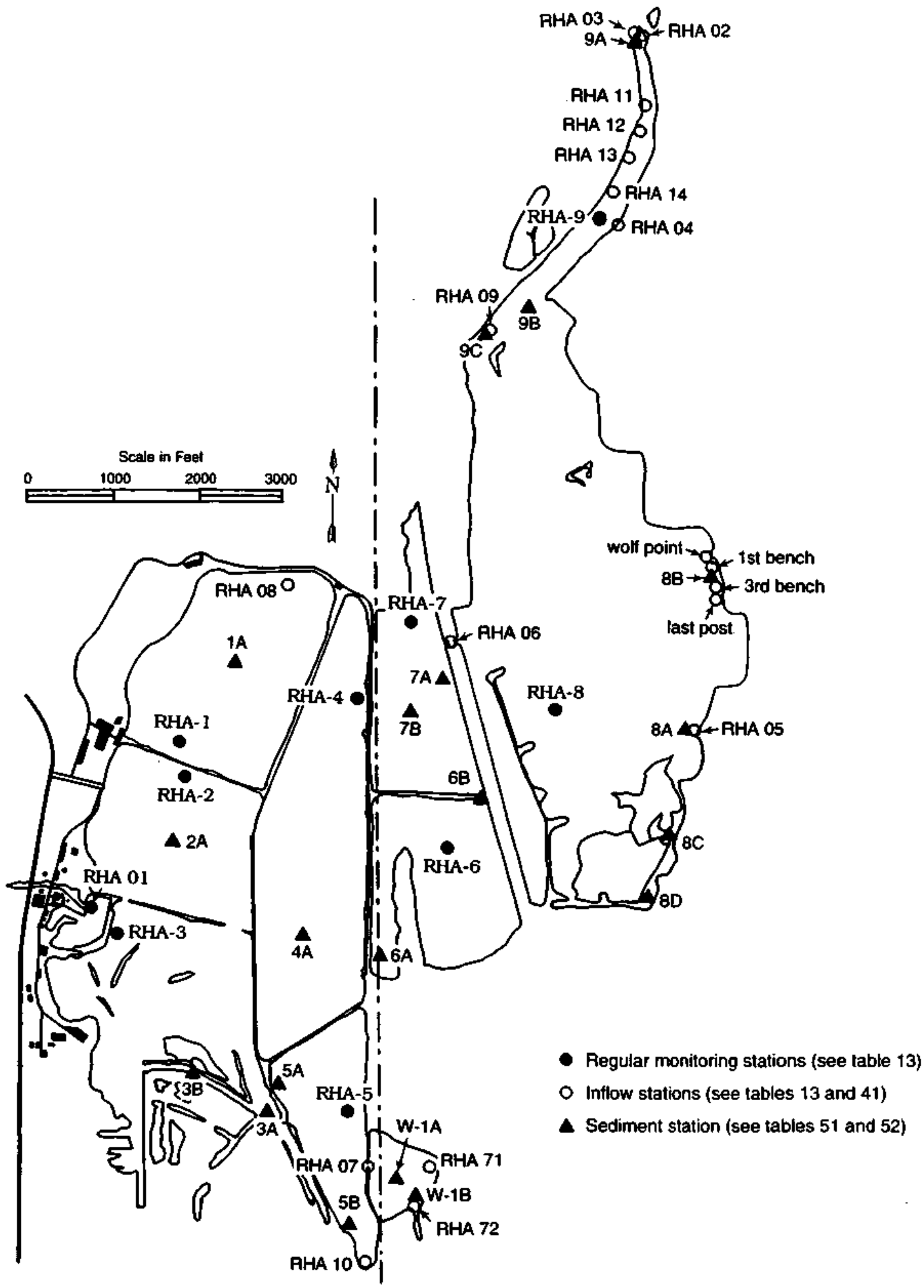


Figure 8. Monitoring stations on Wolf Lake

use of as much as 18 tons of salt per mile per year is common in northern states. There is no attempt to divert salt-laden runoff away from the lake. The authors (ibid.) postulated that if the amount of road salt reaching the lake is significant, it can cause density layers and thus interfere with complete lake mixing. The lake bottom fauna may be subjected to increased salinity and anoxic conditions in the lake may be prolonged.

Current Uses. Wolf Lake and park areas are used heavily for recreation such as bank and boat fishing, ice fishing in season, motor boating, sailboating, canoeing, picnicking, hiking, waterfowl observation, waterfowl hunting, and winter sports. One of the large pools (Pool 8, figure 2) in Indiana is used extensively for wind-surfing and swimming. Wolf Lake Park and Forsythe Park on the perimeter of the lake offer three baseball fields and several picnic areas.

Each year an estimated 40,000 people use the recreational facilities, including beach and picnic areas, managed by the Hammond Park District. The district has held a major festival, "August Fest," every year for the past 11 years in Wolf Lake Park on the southeast shore of the lake. August Fest held from August 11 - 21, 1994, a family-oriented festival, offered food, carnival, entertainment, a beer garden, children's stage, and many other attractions with no admission charges. An estimated 250,000 people took part during the 11 days (C. Blaine, personal communication, 1994).

Population Segments Adversely Affected by Lake Degradation

The lake is situated in a densely populated and highly industrialized area, and straddles the boundary between Illinois and Indiana. It has not been feasible to identify and quantify the population segments adversely affected by lake degradation. The two fish kills reported in the past 25 years would have had a transient impact on sports fishing. Also, there have been complaints about the foul odor of the bottom sediments in Wolf Lake Channel and "off odor" in fish caught from the channel, a popular area for bank fishing. Poor conditions in the Wolf Lake Channel can adversely affect the aesthetic and recreational enjoyment of this segment of the lake system.

Comparison to Other Lakes in the Region

There are numerous public lakes within 50 miles (80 kilometers) of Wolf Lake. Table 6 gives the names of these lakes along with information about size, maximum depth, existence of boat ramps, and lake uses. All of these lakes provide recreational opportunities such as picnicking, fishing, and boating, and none is known to serve as a water supply source. A few lakes afford opportunities for camping, flood control, swimming, wildlife refuge, and waterfowl hunting. One of the world's largest freshwater bodies, Lake Michigan, lies a very short distance north, approximately 0.5 miles, of Wolf Lake Channel. There are 25 lakes in table 6 that are more than 100 acres in area. Of these, nine have surface areas of 500 acres or more. While it is obvious that the region is richly endowed with lacustrine resources, at the same time the demand for water-based recreation in this highly industrialized region is increasing significantly. Hudson *et al.* (1992) reported that outdoor recreational activity continues to increase as more people recreate more often. Between 1960 and 1985, based on days of Illinois residents' participation per year, fishing has increased 125 percent and swimming 200 percent (ibid).

Point Source Discharges

There are no known point source municipal or industrial discharges occurring on the Illinois side of Wolf Lake. Indiscriminate solid waste disposal of such items as tires and building

Table 6. Public Lakes within a 50-Mile Radius of Wolf Lake

Lake	*Area, acres*	*Maximum depth, feet*	*Launching ramps*	**Lake uses*
Cook County, IL				
AxeheadLake	17.0	31.0		F,P,R
Bakers Lake	111.6	12.0		F,P,R,WLR
Beck Lake	38.0	22.0		F,P,R
Belleau Lake	12.0	34.0		F,P,R
Bullfrog Lake	15.2	12.0		F,P,R
Bussee Woods Lake	584.0	16.0	8	F,FC,P,R
Horsetail Lake	11.0	24.0		F,P,R
Ida Lake	10.0	16.0		F,P,R
Maple Lake	55.0	22.0		F,P,R
Midlothian Reservoir	25.0	14.0		F,FC,P,R
Pappose Lake	18.0	10.0		F,P,R
Powderhorn Lake	34.5	19.0		F,P,R
Sag Quarry - East Lake	13.4	17.0		F,P,R
Saganashkee Slough	325.0	9.0		F,P,R
Skokie Lagoons Lake	190.0	9.0	2	F,P,R
Tampier Lake	160.0	16.0		F,P,R
Turtlehead Lake	12.0	15.0		F,P,R
Wampum Lake	35.0	14.0		F,P,R
Wolf Lake	419.0	21.0	3	F,P,R, WTF
DuPage County, IL				
Churchill Lagoon	21.0	6.0		F,P,R
Herrick Lake	19.1	10.0		BR,C,F,P,R
Mallard Lake	40.0	20.0		F,P,R
Mallard North Lake	10.0	15.0		F,P,R
Pratts Waynewoods Lake	16.2	21.0		C,F,P,R
Silver Lake	68.0	30.0	8	C,F,P,R
Grundy County, IL				
Dresden Lake	1,275.0	16.0		CO,F
Heidecke Lake	1,955.0	60.0	3	BR,CO,F,P, R.WTF
Kane County, IL				
Jericho Lake	40.0	30.0		F,P,R
Mastodon Lake	22.3	12.0		F,P
Pioneer Lake	6.5	13.0		F,R
Kankakee County, IL				
Birds Park Quarry	7.0	40.0		BR,F,R
Lake County, IL				
Banks Lake	297.0	25.0	6	BR,F,P,R
Diamond Lake	149.0	24.0	2	BR,F,P,R,S
Fox Chain O' Lakes	6,500.0	40.0	56	BR,C,F,IF, IS,P,R,S, WS.WTF
.Gages Lake	139.0	48.0	2	BR,C,F,P,R, S

Table 6. Continued

Lake	*Area, acres*	*Maximum depth, feet*	*Launching ramps*	**Lake uses*
Grays Lake	79.0	19.0		F,P,R
Lake Zurich	228.0	32.0	2	F,P,R
Round Lake	215.0	35.0	2	F,P,R,S
South Economy Gravel Pit	18.5	36.0		F,P,R
Sterling Lake	73.9	29.0		F,P,R
Turner Lake	34.0	10.0		C,F,P,R
Will County, IL				
Braidwood Lake	2,640.0	80.0	7	CO,F,WTF
Lake County, IN				
Fisher Pond				
Optimist Park Lake				
Oak Ridge Prairie Lake				
Clay Pits				
Lake George	270.0	14.0		
Mac Joy Lake				
Grand Boulevard Lake	40.0			
Robinson Lake				
Independent Lake				
Cedar Lake	781.0	16.0		
Lemon Lake				
Calmet Park Lake				
Francher Lake	10.0	40.0		
WolfLake	804.0	18.0	1	B,F,IF,IS, P,S,WS
LaPorte County, IN				
Clear Lake	17.0	33.0		
Clear Lake	106.0	12.0		
Finger Lake				
Fish Lake (Lower)	134.0	16.0		
Fish Lake (Upper)	139.0	24.0		
Hog Lake	59.0	52.0		
Hudson Lake	432.0	42.0		
Lancaster Lake				
Lily Lake	16.0	22.0		
Lower Lake				
Mill Pond	24.0	8.0		
Orr Lake				
Pine Lake	564.0	48.0		
Round Lake				
Stone Lake	125.0	36.0		
Tamarack	20.0			
Newton County, IN				
Goose Pond Swamp	20.0			
J.C. Murphy Lake	1,515.0	8.0		C,F,IF,P,R, S.WTF

Table 6. Concluded

Lake	*Area, acres*	*Maximum depth, feet*	*Launching ramps*	**Lake uses*
Cory Lake				
Riverside Lake				
Porter County, IN				
Chestnut Lakes				
Chub Lake				
Flint Lake	89.0	67.0		
Fisher Pond				
Long Lake	65.0	27.0		
Lomis Lake	62.0	SS.O		
Mud Lake	26.0			
Pratt Lake				
Round Lake				
Silver Lake				
Spectacle Lake	62.0	30.0		
Wauhob Lake	21.0	48.0		
Starke County, IN				
Bass Lake	1,440.0	30.0		C,F,P,R,S
Round Lake	30.0	1S.0		

* BR = boat rental, C = camping, CO = cooling, F = fishing, FC = flood control, IF = ice fishing, IS = ice skating, P = picnicking, R = recreation, S = swimming, WLR = wildlife refuge, WTF = waterfowl hunting, and WS = water skiing.

Note: Blank spaces indicate that information is not readily available.

and construction materials occurs in secluded areas on the south end of Pools 3 and S and creates aesthetically objectionable conditions near the lake.

The state of Illinois has not issued any NPDES permits allowing discharge to Wolf Lake. On the Indiana side, the industrial discharges to Wolf Lake have historically been located near the Wolf Lake Channel and Pool 8. Currently, Amaizo, Lever Brothers, and the Hammond Sanitary District have NPDES discharge permits from the state of Indiana that allow discharge of effluent waters to Wolf Lake. Bell and Johnson (1990) summarized information on these discharge permits.

American Maize-Products Company

Under NPDES Permit number IN 0000027, Amaizo (a Class C industrial wastewater treatment plant) is authorized to discharge from a facility that manufactures corn products to the receiving water of Lake Michigan and Wolf Lake Channel. Outfall 001 is discharged into Lake Michigan with limitations.

Outfalls 002, 003, 004, and 005 to Wolf Lake Channel are limited solely to noncontact cooling water free from process and other wastewater discharges, except that outfall 002 includes stormwater runoff The pH of these outfalls is limited to between 6.5 and 8.5 and must be monitored by weekly grab samples. Discharges should not cause excessive foam in the receiving waters and must be free of floating and settleable solids. They should not contain oil or other substances in amounts sufficient to create a visible film or sheen on the receiving waters.

Outfall 006 to Wolf Lake Channel contains solely excess Lake Michigan water without water quality limitations but with monitoring requirements. Flow from this outfall is not limited, but weekly flow estimation is required.

A summary of the quality and quantity of discharges from Amaizo for the period October 1992 to September 1993 is presented in table 7. All pH values monitored are within the regulatory limits. Flow estimation for outfall 006 seems high.

Lever Brothers Company

Under NPDES Permit No. IN 0000264, Lever Brothers Company is authorized to discharge from a facility that manufactures soap and detergent products (1200 Calumet Avenue in Hammond, IN) to Wolf Lake Channel in accordance with effluent limitations.

The discharger is licensed as a Class D industrial wastewater treatment plant. Discharge is limited solely to noncontact cooling water except for barometric condensate from oil refining, tallow bleaching, crude glycerine processing, glycerine refining, and stormwater runoff. Discharge limits are set on pH, chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD5), total suspended solids (TSS), oil and grease, total residual chlorine, effluent temperature, and whole effluent toxicity tests. The discharge must essentially be free of floating and settleable solids and not cause excessive foam or oil sheens in the receiving water.

TSS, BOD5, and COD limitations (table 8) include daily maximum and monthly mean loading quantities and daily maximum and monthly mean concentrations. Table 8 summarizes effluent quality, i.e., pH, COD, BOD5, TSS, oil and grease, and total residual chlorine. The number of samples exceeding the limits is also listed in table 8.

Table 7. Effluent Quality of American Maize-Products Company Discharges to Wolf Lake Channel

	Outfall 002			Outfall 003		
	Flow, med*			Flow, med		
Month	Mean	Maximum	pH	Mean	Maximum	pH
1992						
October	.1402	.1440	7.6-8.0	.0149	.0016	7.7-8.0
November	.0472	.1440	7.5-7.9	.0037	.0115	7.5-7.8
December	.0075	.0202	7.7-8.0	0.	0.	
1993						
January	.0048	.0100	7.7-7.9	0.	0.	
February	0.	0.	-	0.	0.	
March	0.	0.	-	0.	0.	
April	0.	0.	-	0.	0.	
May	.0969	.1440	7.7-7.8	0.	0.	
June	.0563	.0864	7.8-8.2	.0288	.0576	7.9-8.0
July	.0684	.0864	7.9-8.1	.1626	.2076	8.1-8.3
August	.0658	.0846	7.8-7.9	.0071	.0173	7.5-7.9
September	.0950	.1440	7.7-8.0	.0080	.0216	7.0-7.9
Annual	.0485	.1440	7.5-8.2	.0188	.2076	7.0-8.3

	Outfall 004			Outfall 005			Outfall 006	
	Flow, med			Flow, med			Flow, med	
Month	Mean	Maximum	pH	Mean	Maximum	pH	Mean	Maximum
1992								
October	.1386	.1728	8.0-8.2	.0522	.0576	7.7-8.2	4.05	6.48
November	.1353	.1728	7.6-8.0	.0691	.0864	7.6-8.0	5.18	6.48
December	.0722	.1411	7.8-8.0	.0542	.0864	7.8-7.9	6.48	6.48
1993								
January	.0298	.0576	7.8-8.1	.0535	.0878	7.8-7.9	4.32	6.48
February	.0886	.0922	7.6-7.8	.0830	.1166	7.6-8.0	4.86	6.48
March	.0852	.0893	7.5-7.9	0	0	-	2.59	6.48
April	.0813	.0821	7.6-7.8	.0432	.0432	7.9-8.0	6.48	6.48
May	.1284	.1728	7.9-8.1	.0498	.0576	7.6-8.0	6.48	6.48
June	.1512	.1728	8.0-8.2	.0414	.0576	7.6-7.9	6.48	6.48
July	.0613	.0876	7.8-8.0	.0576	.0864	8.0-8.2	4.86	6.48
August	.0202	.0864	8.0-8.5	.0652	.1152	8.0-8.2	6.48	6.48
September	.0148	.0475	7.8-8.5	.0697	.0864	7.7-8.2	5.55	6.48
Annual	.0839	.1728	7.5-8.5	.0532	.1166	7.1-8.2	5.32	6.48

Note:
* mgd = million gallons per day

Table 8. Effluent Quality of Lever Brothers Company Discharges to Wolf Lake Channel

		Chemical oxygen demand				*5-day biochemical oxygen demand*			
		Concentration. mg/L		*Quantity. Ib/d*		*Concentration. mg/L*		*Quantity. Ib/d*	
Month	*pH*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
1992									
October	8.0-10.1	6.4	3.2-12.9	349	173-681	0.6	0.3-1.1	34	16-58
November	7.2-9.2	6.0	4.0-9.4	311	168-488	1.1	0.0-2.0	61	0-130
December	7.7-9.0	8.7	4.6-15.5	364	108-898	1.4	0.6-2.4	54	18-92
1993									
January	7.5-8.1	8.1	5.4-11.8	348	188-547	1.4	0.6-2.2	59	26-%
February	7.6-8.6	7.0	3.2-11.2	290	128-413	1.1	0.9-1.4	46	33-59
March	6.5-8.3	8.9	6.0-11.0	477	281-569	1.4	0.3-2.3	63	13-110
April	7.7-8.2	7.6	<5.0-16.0	325	58-763	0.8	0.0-2.0	33	0-67
May	7.6-8.5	11.5	4.6-27.0	389	163-972	2.7	0.0-13.0	84	0-469
June	7.4-8.3	8.0	0.0-16.0	383	0-648	1.0	0.0-5.8	42	0-211
July	7.4-8.2	11.0	7.2-24.0	505	226-1188	1.3	0.02-3.7	54	1-183
August	7.5-8.4	8.0	2.0-20.0	380	90-1067	2.0	1.0-3.0	94	39-178
September	7.4-7.7	5.0	1.0-9.0	244	55-506	2.0	1.0-3.0	90	43-172
NPDES limits	6.0-9.0			1,007	2,014*	10	15*	445	890*
No. of samples exceeding limits /total no. of samples (%)	2/156(1.3)			0/154(0)	(0)	0/154(0)	(0)	(0)	(0)

Note:
* Daily maximum

Table 8. Concluded

	Total suspended solids				Oil and grease				
	Concentration. mg/L		*Quantity. Ib/d*		*Concentration. m%/L*		*Quantity. Ib/d*		*Total residual*
Month	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*chlorine, mg/L*
1992									
October	1.9	0.0-7.4	106	0-407	0.9	0.0-2.7	48	0-142	<0.05-0.09
November	2.6	0.6-6.4	137	31-415	1.2	0.0-3.5	53	0-181	<0.05
December	3.3	0.8-7.0	138	20-327	3.0	0.7-7.8	44	21-296	<0.07
1993									
January	4.3	1.8-7.2	194	78-419	3.3	0.0-6.9	150	40-378	<0.05-0.07
February	5.5	2.4-8.2	234	79-388	1.5	0.0-4.4	65	0-179	<0.05
March	8.8	2.2-15.0	403	65-736	2.6	0.0-4.5	122	0-235	<0.05
April	10.1	4.8-23.0	424	105-1168	2.0	0.0-4.4	86	0-206	<0.05-0.05
May	3.0	1.2-8.0	138	42-390	2.2	0.0-4.2	84	0-152	<0.05
June	5.2	0.2-19.0	249	4-1027	2.0	0.0-5.0	88	0-166	<0.05-0.20
July	2.7	0.0-5.4	133	0-289	2.9	0.5-6.2	128	30-288	<0.05
August	7.0	2.0-17.0	316	78-8%	3.4	2.0-9.0	152	78-378	<0.05
September	8.0	1.0-32.0	436	53-1,960	2.7	1.0-7.0	122	44-225	<0.05
NPDES limits	**10**	**20***	730	**1,460***		10*		**696***	**0.05***
No. of samples exceeding limits /total no. of samples (%)	1/154(0.6)	3/154(1.9)	(0)	1/154(0.6)		0/155(0)		(0)	5/154(3.2)

Note:
* Daily maximum

Hammond Sanitary District

The Hammond Sanitary District operates three pumping stations to collect stormwater runoff for discharging into Wolf Lake Channel and Wolf Lake. The Roby pumping station, outfall 017 (station RHA 03, figure 8), has three 3,300-gallon per minute (gpm) pumps; the Forsythe Park station, outfall 018 (RHA 04), has two 3,500-gpm and one 7,200-gpm pumps; and the Sheffield Avenue station, outfall 019 (RHA 05), has three 8,500-gpm pumps. Under its NPDES permit, the District is required to monitor flow; pH; carbonaceous BOD (CBOD), TSS, volatile solids, fat, oil, and grease (FOG); and fecal coliform (FC) concentrations of discharges from these pumping stations.

Bell and Johnson (1990) cited 1988 data (table 9) from the IDEM that show consistently high CBOD, FOG, and FC concentrations from these discharges. The major cause was the cross-connection between the storm sewer and the sanitary sewer. In order to protect the water quality of Wolf Lake, alleviation of the cross-connection has been recommended by the IDEM.

Tables 10a-10c present the results of monitoring (NPDES monthly reports) for these three pumping stations during this study period (October 1992 to September 1993). The data provided by the IDEM show high TSS, FOG, and FC.

Land Uses and Nonpoint Pollutant Loadings

The Wolf Lake direct drainage area (figure 2) includes 925 acres of mostly pervious surfaces draining directly into the lake, 922 acres of lake surface, and 357 acres in the Powderhorn Lake area, including both land and open water areas that are not included in the previous numbers. The runoff mechanism from the Powderhorn Lake area is not treated in this hydrologic analysis because of the limited hydraulic connection between the two lake systems.

Runoff from the impervious surfaces (paved areas and rooftops) in 174 acres of the Robertsdale subdivision on the west side of Calumet Avenue collects in a constructed storm drain system that discharges into Wolf Lake at the Forsythe Park pumping station of the Hammond Sanitary District. The Sanitary District's Sheffield Park station discharges runoff from the Sheffield Avenue drain system from Calumet Avenue to 136th Street. The Roby pumping station, owned by the State of Indiana and operated by the Sanitary District, discharges runoff from the Indianapolis Boulevard drain system from Calumet Avenue up to and including the interchange drainage at the Indiana East-West Toll Road. The locations of these stormwater pumping stations and their approximate contributing areas are shown in figure 2.

The discharges from these pumping stations are regulated by permit under the NPDES. Restrictions written into this permit limit discharges to stormwater only. No sanitary or industrial discharges are to be associated with these stations.

All nonpoint pollutant loads from watershed storm drainage passes through the Hammond Sanitary District pump stations as "point discharges". Les than 0.5 percent of the inflow to Wolf Lake enters as nonpoint inflow. No pollutant loads have been calculated for this inflow.

Table 9. Hammond Sanitary District Outfalls to Wolf Lake

Month/1988	*Parameters*	*017 Roby Station*	*018 Forsythe Park*	*019 Sheffield*
June	CBOD(mg/L)	13	8	26
	FOG(mg/L)	18.77	1	1
	Fecal col (MOO mL)	740	2,300	1,000
July	CBOD(mg/L)	3	5	34
	FOG(mg/L)	13.4	1.13	403.56
	Fecal col (MOO mL)	66,000	110,000	18,000
August	CBOD(mg/L)	5	3	7
	FOG(mg/L)	2.0	2.0	5
	Fecal col (MOO mL)	7,943	44,000	9,550
Sept.	CBOD(mg/L)	12	10	113
	FOG(mg/L)	2.0	6.6	21.1
	Fecal col (MOO mL)	3,715	52,000	44,000
Oct.	CBOD(mgZL)	2.3	10	14.21
	FOG(mg/L)	8.5	8.1	1,085
	Fecal col (MOO mL)	11,482	4,890	10,472
Nov.	CBOD(mg/L)	13	21	81
	FOG(mg/L)	3.0	1.0	43.0
	Fecal col. (MOO mL)	1,100	100	10,472
Dec.	CBOD(mg/L)	3.0	1.0	2.0
	FOG(mg/L)	6.0	24.0	11.0
	Fecal col (MOO mL)	708	100	100

Notes: CBOD = Carbonaceous biochemical oxygen demand
FOG = Fats, oils, and grease
Fecal col = Fecal coliform bacteria

Source: Bell and Johnson (1990)

Table 10a. Effluent Quality of Roby Pumping Station - Hammond Sanitary District into Wolf Lake Channel

Month	*Flow, mgd* *Mean*	*Range*	*Sampling date*	*pH*	*CBOD, mg/L*	*TSS, mg/L*	*Volatile solids, %*	*FOG, mg/L*	*Fecal coliform. per 100 mL*
1992									
October	0.09	0.04-0.28	10/14	7.52	4	9	99.1	11	220,000
November	0.17	0.10-0.57	11/17	7.35	5	11	63.6	2	55,000
December	0.27	0.06-1.09	12/18	7.23	29	27	63.0	16	17,600
1993									
January	0.24	0.14-0.81	1/29	7.24	5	9	99.9	2	11,250
February	0.13	0.08-0.20	2/25	7.31	2	9	(1?)	1	11,350
March	0.17	0.08-0.67	3/11	7.31	5	19	47.4	4	1,080
April	0.20	0.10-0.67	4/20	7.44	4	55	69.2	3	33,000
May	0.14	0.06-0.38	5/12	7.40	2	11	36.4	1	158,000
June	0.52	0.10-3.17	6/15	7.27	3	11	18.2	0.9	13,000
July	0.24	0.14-0.71	7/21	7.38	8	23	78.3	5	74,000
August	0.25	0.06-1.50	8/17	7.01	2	15	33.3	1	86,000
September	0.26	0.12-1.01	9/22	7.39	7	108	27.8	3	329,000
Mean	0.20				6	26	57.8	4.2	
Maximum	0.52	3.17		7.52	29	108	99.9	16.0	329,000
Minimum	0.09	0.04		7.01	2	9	18.2	0.9	1,080

Notes: mgd = million gallons per day; CBOD = carbonaceous biochemical oxygen demand;
TSS = total suspended solids; FOG = fat, oil, and grease.

Table 10b. Effluent Quality of Forsythe Pumping Station - Hammond Sanitary District into Wolf Lake Channel

Month	*Flow, med* *Mean*	*Range*	*Sampling date*	*pH*	*CBOD, mg/L*	*TSS, mg/L*	*Volatile solids, %*	*FOG, mg/L*	*Fecal coliform, perl00mL*
1992									
October	0.28	0.00-1.47	10/14	7.60	2.0	2	99.1	1	290
November	0.60	0.00-3.28	11/17	7.62	1.9	6	99.9	2	2,400
December	0.44	0.00-4.10	12/18	7.46	1.9	7	57.1	3	10
1993									
January	3.88	0.00-22.89	1/29	7.40	2.0	6	99.9	1	150
February	1.55	0.00-10.71	2/25	7.81	2.0	3	90.0	2	115
March	2.36	0.00-17.22	3/11	7.49	6.0	161	29.8	14	1,800
April	3.09	0.00-22.26	4/20	7.57	5.0	35	99.9	9	2,500
May	1.25	0.00-5.93	5/12	5.98	1.9	30	66.7	1	50
June	7.12	0.00-38.44	6/15	7.55	2.0	27	37.0	-	6,400
July	2.46	0.00-14.53	7/22	7.90	2.0	29	86.2	3	3,600
August	2.51	0.00-16.84	8/17	7.49	2.0	5	40.0	1	5,400
September	3.51	0.00-13.69	9/21	7.65	4.0	19	31.6	1	8,000
Mean	2.42				2.7	28	69.8	3	
Maximum	7.12	38.44		7.90	6.0	161	99.9	14	8,000
Minimum	0.28	0.00		5.98	1.9	2	29.8	1	10

Notes: mgd = million gallons per day; CBOD = carbonaceous biochemical oxygen demand;
TSS = total suspended solids; FOG = fat, oil, and grease.

Table 10c Effluent Quality **of** Sheffield Pumping Station - Hammond Sanitary District into Pool 8

Month	*Flow, med* *Mean*	*Range*	*Sampling date*	*pH*	*CBOD, mg/L*	*TSS, mg/L*	*Volatile solids, %*	*FOG, mg/L*	*Fecal coliform. per 100 mL*
1992									
October	0.04	0.00-0.20	10/14	7.69	2.0	9	33.3	4	130
November	0.15	0.00-0.77	11/17	9.02	1.9	10	70.0	4	9
December	0.11	0.00-1.17	12/18	8.65	2.0	10	80.0	4	80
1993									
January	0.26	0.00-1.38	1/29	8.68	3.0	7	42.9	7	3,000
February	0.06	0.00-0.10	2/25	7.62	8.0	7	(1?)	1	9,800
March	0.17	0.05-0.97	3/11	8.64	3.0	19	36.8	8	2,000
April	0.17	0.00-0.77	4/20	9.29	3.0	55	90.9	4	270
May	0.06	0.00-0.31	5/12	9.13	2.0	12	(99.0)	1	510
June	0.86	0.00-8.36	6/15	8.39	1.9	6	99.9	0.9	1,800
July	0.13	0.00-0.82	7/21	7.29	6.0	68	73.5	3	1,600
August	0.17	0.00-3.01	8/17	7.32	6.0	266	95.9	1	3,100
September	0.24	0.00-0.87	9/21	8.13	3.0	42	14.3	2	3,400
Mean	0.20				3.5	43	61.4	3.3	
Maximum	0.86	8.36		9.29	8.0	266	99.9	8	9,800
Minimum	0.04	0.00		7.29	1.9	6	1	0.9	9

Notes: mgd = million gallons per day; CBOD = carbonaceous biochemical oxygen demand; TSS = total suspended solids; FOG = fat, oil, and grease.

BASELINE AND CURRENT LIMNOLOGICAL DATA

In order to evaluate the lake water quality, both historical and current limnological data were gathered. A sampling program was developed to collect data from the lake and its tributaries for 12 consecutive months from October 1992 through September 1993. These data are referred to as the current baseline data. *In situ* monitoring and water and sediment sample collections were carried out. In addition, monitoring for macrophytes and macroinvertebrates, a bathymetric survey, stage level measurements, and flow determinations were carried out as required. The historical data were obtained from the IEPA, IDEM, other agencies, and publications.

Morphometric Data

The pertinent morphometric details regarding all Wolf Lake pools are listed in table 11.

Bathymetric Survey

A bathymetric survey of Wolf Lake was conducted as part of the diagnostic study. The data were collected using a range-range methodology, whereby a microwave transponder was set up in the boat to monitor distances to two or three shore-based remote transponders. Based on the known coordinates of the shore-based transponders and their relative distances, horizontal coordinates could be determined at any time as the boat moved along a transect. As data for each surveyed point were collected, personnel in the boat simultaneously added an electronic mark to the sounding chart and downloaded horizontal coordinates to a laptop computer. A total of 148 transects were run to collect the depth and horizontal position data.

Data collected during the field survey were processed and plotted using the Water Survey's Geographic Information System (GIS). Depth contours for the lake (appendix A) were digitized from hand-drawn contours prepared on the original survey depth plots. Surface areas for these contours were used for the depth-volume analyses presented in table 12.

Average depth in the pools varies from 3.3 feet in Pool 3 to 8.5 feet in Pool 2. Less than 20 percent of Pool 3 has depths greater than 4 feet. In comparison, more than 70 percent of the area in Pool 8 has a depth of at least 4 feet.

Materials and Methods

Field Measurements

In order to assess the current conditions of the lake, certain of its physical, chemical, and biological characteristics were monitored during the period of October 1, 1992, to October 27, 1993. The lake was monitored monthly from October through April and twice a month during the remaining period, for a total of 17 visits. Because the tributary creeks for the lake are ephemeral in nature, tributary samples were not collected during these regularly scheduled visits to the lake; instead, special trips were made to collect tributary samples during storm events. However, samples were collected routinely from the outflow creek (Indian Creek, RHA 01). The locations of the lake and tributary monitoring stations are shown in figure 8. The regular lake sampling locations are at the deepest point of each water body (pool). In addition to periodic water sample collections, trips were made to the lake for collecting storm event samples, surficial and core sediment samples, and for collection and identification of macrophytes and benthic organisms.

Table 11. Wolf Lake Areal and Volumetric Parameters

Pool	*Surface area, acres*	*Volume, acre-feet*	*Shoreline length, miles*	*Maximum depth, feet*	*Average depth, feet*	*Retention time* years	*Retention time* days
1	99.1	797	1.58	16.2	8.0	0*	0*
2	75.7	645	1.41	15.4	8.5	0.05	18
3	108.2	353	4.39	14.4	3.3	0.03	10
4	123.5	662	2.37	12.0	5.4	0.05	19
5	46.9	373	2.68	18.4	8.0	0*	0*
6	64.1	252	1.89	6.4	3.9	0.02	7
7	57.4	231	1.80	7.2	4.0	0.02	7
8	347.3	2,260	8.65	18.2	6.5	0.18	64

Note:

*No detailed inflow and outflow data were generated for these pools. No retention time can be calculated.

Table 12. Summary of Wolf Lake Hydrographic Survey Results

Pool	*Depth, feet*	*Area, acres*	*Volume, acre-feet*	*Pool*	*Depth, feet*	*Area, acres*	*Volume, acre-feet*
8	0	347	2,260	4	0	123	662
	2	322	1,591		4	109	197
	4	195	1,081		8	6	8
	8	118	462		12	0	0
	12	113	34				
	16	33	22	3	0	108	353
	18	0	0		4	39	69
					8	3	5
7	0	57	231		14.4	0	0
	4	38	41				
	7.2	0	0	2	0	76	645
					4	66	362
6	0	64	252		8	44	160
	4	47	31		12	25	22
	6	0	0		14.8	0	0
5	0	47	373	1	0	99	797
	4	35	210		4	72	457
	8	18	105		8	53	207
	12	12	45		12	30	49
	16	8	6		16	1	0
	18.4	0	0		16.2	0	0

Table 13 outlines the protocol for field data collections, including the type and frequency of observations required during the one-year data gathering effort.

In situ observations for temperature and dissolved oxygen (DO) and Secchi disc readings were made at the sampling sites on the lake. A dissolved oxygen meter, Yellow Springs Instrument model 58, with a 50-foot cable and probe was calibrated at the site using the saturated air chamber standardization procedure. Temperature and DO measurements were obtained in the water column at 1-foot intervals from the surface.

Secchi disc transparencies were measured using an 8-inch diameter Secchi disc, which was lowered until it disappeared from view, and the depth noted. The disc was lowered further, then slowly raised until it reappeared. This depth was also noted, and the average of the two depths was recorded. Secchi disc visibility is a measure of a lake's water transparency or its ability to allow sunlight penetration.

Water Chemistry

Grab samples for water chemistry analyses were collected near the surface (1 foot below) and near the bottom (2 feet above the lake bottom if the water depth is greater than 10 feet) in two 500-milliliter (mL) plastic containers. Water samples for nutrients analyses were collected in 125-mL plastic bottles with and without filtration (0.45-micrometer, urn, membrane filter) that contained reagent-grade sulfuric acid as preservative. These samples were kept on ice until transferred to the laboratory for analyses. Determinations for pH, phenalphthalein alkalinity, and total alkalinity were made at the site before the samples were taken to the laboratory. Samples for metals were collected in 500-mL plastic bottles containing reagent-grade nitric acid as preservative. Samples for organic analyses were collected in 1-gallon dark amber bottles filled to the brim without any headspace. The methods and procedures involved in the analytical determinations are given in table 14.

Chlorophyll and Phytoplankton

Vertically integrated samples for chlorophyll and phytoplankton were collected using a weighted bottle sampler with a half-gallon plastic bottle. The sampler was lowered at a constant rate to a depth twice the Secchi depth, or to 2 feet above the bottom of the lake, and raised at a constant rate to the surface. For chlorophyll analysis, a measured amount of sample was filtered through a Whatman GF/C (4.7-centimeters, cm, glass microfibre filter) using a hand-operated vacuum pump. The chlorophyll filters were then folded into quadrants, blotted with a paper towel, and wrapped in aluminum foil, and the filtrate volume was measured using a graduated cylinder. Filters were kept frozen in the laboratory until analysis. Chlorophyll *a, b, c,* and pheophytin *a* were determined by the IEPA laboratory. For algal identification and enumeration, 380-mL water subsamples were taken, preserved with 20 mL of formalin at the time of collection, and stored at room temperature until they could be examined.

Zooplankton

Vertically integrated 10-liter (L) samples were collected for zooplankton identification and enumeration. The samples were filtered through a Wisconsin net, and the collected zooplankton were placed in a 250-mL bottle with 10 mL of ethyl alcohol and 190 mL of deionized water. In the laboratory, each sample was filtered through a 0.45-µm-pore size filter. The organisms were resuspended in 10 mL of deionized water. One mL of sample was placed in a Sedgwick Rafter Cell and examined using a differential contrast microscope at 100X magnification. Organisms in the five widths of the cell were counted and recorded. The sizes and shapes of various zooplanktons found in water samples are given in table 15.

Table 13. Protocol for Field Data Collections in Wolf Lake

I. In-Lake Monitoring

A. Water (RHA-1 through RHA-9, and RHA 01)
   1. Sites (sampling and *in situ* monitoring)
      a. One site in each of the eight water bodies and Wolf Lake Channel
      b. Deepest point in each water body
   2. Depths
      a. Dissolved oxygen/temperature profile at each site
      b. Sample collected at 1 foot below surface and at 2 feet above bottom
      c. Chlorophyll-a - integrated sample in euphotic zone
   3. Frequency
      a. Core parameters - bimonthly from May to September and monthly from October to April
      b. Organics, metals - once
   4. Parameters
      a. Core (samples each time monitored)
         Field observations, Secchi disc transparency, dissolved oxygen/temperature profiles, pH, total alkalinity, phenolphthalein alkalinity, conductivity, chlorides, total suspended solids, volatile suspended solids, dissolved phosphorus, total phosphorus, ammonia-N, nitrate and nitrite-N, total kjeldahl nitrogen, chemical oxygen demand, and chlorophyll-a, *b, c* and pheophytin
      b. Metals and organics
         Cadmium, chromium, copper, iron, lead, manganese, nickel, silver, zinc, PCBs, aldrin, dieldrin, DDT and analogs, total chlordane and isomers, endrin, methoxychlor, hexachlorocyclohexane, hexachlorobenzene, and pentachlorophenol

B. Sediment
   1. Sites (see figure 8)
      a. Surficial - 20
      b. Core - 10
   2. Frequency - replicate core and sediment samples once
   3. Parameters
      a. Metals listed in A.4.b. above
      b. Organics listed in A.4.b. above
      c. In addition, total phosphorus, total kjeldahl nitrogen, percent total and volatile solids, chemical oxygen demand, total organic carbon, particle size, and density

C. Phytoplankton and Zooplankton
   1. Sites - same as for water in the lake
   2. Depths • integrated euphotic zone, twice Secchi depth
   3. Frequency - monthly from April to October
   4. Parameters
      a. Identification to lowest possible taxon and enumeration
      b. Biovolume

Table 13. Concluded

D. Aquatic Macrophytes
   1. Sites - littoral zone, shoreline to twice Secchi depth
   2. Frequency - once in summer
   3. Parameters
      a. Identification to lowest possible taxon
      b. Mapping of locations and abundance
      c. Biomass

E. Benthic Macroinvertebrates
   1. Sites - same as for lake water
   2. Frequency - spring turnover and peak summer stratification
   3. Parameters
      a. Identification to lowest possible taxon
      b. Biomass

F. Fecal and Total Coliforms and Fecal Streptococci
   1. Sites - same as for lake water plus RHA 02 through RHA 14, RHA 71 and RHA 72
   2. Frequency - monthly

II. Inflows and Outflows

A. Sites
   1. Storm discharges
   2. Industrial discharges
   3. Outflow

B. Depth integrated

C. Frequency - same as for water

D. Parameters
   1. Total and volatile suspended soids, total phosphorus, ammonia-N, nitrate and nitrite-N, for outflows and storm discharges
   2. Metals and organics listed in A.4.b, once for outflows and storm discharges

Table 14. Analytical Procedures

Parameter	*Method of analysis (reference)*	*Unit of measure*	*Detection limits*
Temperature	*In situ* measurement using YSI Model 58 Dissolved Oxygen meter	°C	0.1°
Dissolved Oxygen	*In situ* measurement using YSI Model 58 DO meter	mg/L O_2	0.1 mg/L
pH	On site using Necter model 47 after collection	none	0.05
Alkalinity	Titration of 25-mL sample using Necter Model 47 pH meter with 0.02 N H_2SO_4 to pH 8.3 (phenolphthalein alk) and to pH 4.5 (total alkalinity)	mg/L or Ca CO_3	1 mg/L as $CaCO_3$
Conductivity	EPA 120.1 Wheatstone bridge	umho/cm	1 umho/cm
Chloride	*Standard Methods* 17th edition 4500 Cl B Argertometric	mg/L	5 mg/L
Chemical Oxygen Demand	E1A 410.4 Colorimetric	mg/L	1 mg/L
Chlorophyll	*Standard Methods* 17th edition, 10200 Spectrophotometric	µg/L	2-7 µg/L
Ammonia-N	Potentiometric, ISE	mg/L	0.1 mg/L
Nitrite-N	EPA 353.2 Colorimetric, automated Cd redn	mg/L	0.10 mg/L NO_2-N
Nitrate-N	EPA 353.2 Colorimetric, automated Cd redn	mg/L	0.10 mg/L
Total Kjeldahl-N	EPA 351.4 Potentiometric, mg/L ISF after digestion	mg/L	0.10 mg/L
Oil & Grease, 1R	EPA 413.2 Spectrophometric, IR	mg/L	1.0 mg/L
Phosphorus, total	EPA 365.2 Persulfate digestion Ascorbic acid colorimetric	mg/L	0.05 mg/L
Phosphorus, dissolved	EPA 365.2 after field filtration through 0.45-u filter Persulfate Digestion ascorbic acid colorimetric	mg/L	0.05 mg/L

Table 14. Continued

Parameter	*Method of analysis (reference)*	*Unit of measure*	*Detection limits*
Total Solids	EPA 160.3 Gravimetric, dried at 103-105°C	mg/L	1 mg/L
Total Dissolved Solids	EPA 160.1 Gravimetric Residue, filterable Dry at 180°C	mg/L	1 mg/L
Total Suspended Solids	EPA 160.2 Gravimetric Residue, nonfilterable Dryatl03-105°C	mg/L	1 mg/L
Volatile Suspended Solids	EPA 160.4 Gravimetric Ignition at 550°C	mg/L	1 mg/L
Cadmium	EPA 200.7, ICP	µg/L	<5 µg/L
Chromium	EPA 200.7, ICP	¦Ìg/L	10 ¦Ìg/L
Copper	EPA 200.7, ICP	µg/L	10 µg/L
Iron	EPA 200.7, ICP	µg/L	100 Mg/L
Lead	EPA 239.2, AA Furnace	¦Ìg/L	5 µg/L
Manganese	EPA 200.7, ICP	µg/L	10 µg/L
Nickel	EPA 200.7, ICP	µg/L	20 µg/L
Silver	EPA 200.7, ICP	µg/L	10 µg/L
Zinc	EPA 200.7, ICP	µg/L	20 µg/L
Arochlor - 1016	SW-846/8080	µg/L	0.5 µg/L
1221	"	µ g/L	0.5 µg/L
1232	"	µg/L	0.5 µg/L
1242	"	µg/L	0.5 µg/L
1248	"	µg/L	0.5 µg/L
1254	"	µg/L	1.0 µg/L
1260	"	µg/L	1.0 µg/L
Aldrin	"	µg/L	0.05 µg/L
Dieldrin	"	µg/L	0.10 µg/L
4,4'-DDE	"	µg/L	0.10 µg/L
Endrin	"	µg/L	0.10 µg/L
4,4'-DDD	"	µg/L	0.10 µg/L
4,4'-DDT	"	µg/L	0.10 µg/L
Methoxychlor	"	µg/L	0.50 µg/L

Table 14. Concluded

Parameter	*Method of analysis (reference)*	*Unit of measure*	*Detection limits*
Alpha-chlordane	SW-846/8080	¦Ìg/L	0.5 µg/L
Gamma chlordane	"	µg/L	0.5 µg/L
Hexachlorobenzene	"	µg/L	10 µg/L
a-BHC	SW-846/8080	µg/L	0.05 µg/L
b-BHC	"	µg/L	0.05 µg/L
g-BHC	"	µg/L	0.05 µg/L
d-BHC	"	µg/L	0.05 µg/L
Pentachlorphenol	SW-846/8270	µg/L	50 µg/L

Sources:

1. APHA, AWWA, and WEF. 1992. *Standard methods for the examination of water and wastewater.*

2. U.S.EPA. 1993. *Methods for the determination of inorganic substances in environmental samples.* EPA/600/R-93/100, Washington, DC.

3. U.S.EPA. 1994. *Methods for the determination of metals in environmental samples.* EPA/600/R-94/111, Washington, DC.

4. U.S.EPA. 1991. *Analytical methods for pesticides/aroclors*, Exhibit D in USEPA Contract Laboratory Program: statement of work for organics analysis, multi-media, multi-concentration. Document number OLM01.0 (Dec. 1990) through OLM01.7, pp. D-l/PEST through D-63/PEST.

Table 15. Sizes and Shapes of Zooplankton Used in Biovolume Determination for Wolf Lake

Name	*Shape*	*Size (µn)*
Cladocera (Water Fleas)		
Bosmini coregoni	Spherical	700 diam.
B. longirostris	Spherical	500 diam.
B. pulex	Spherical	2,000 diam.
Daphnia ambigas	Spherical	1,500 diam.
D. catarila	Spherical	2,000 diam.
D. dubia	Spherical	2,000 diam.
D. laevis	Spherical	2,000 diam.
D. pulex	Spherical	2,000 diam.
D. rosea	Spherical	2,000 diam.
Lepotodora rindtii	Spherical	9,000 diam.
Polyphemus pediculus	Spherical	1,500 diam.
Copepoda (Copepods)		
Diaptomus minutus	Cylindrical	100 × 500
Eucyclops speratus	Cylindrical	200 × 900
Ostracoda (Seed shrimps)		
Cyclocypris forbesi	Spherical	500 diam.
Rotifera (Rotifers)		
Ascomorpha saltan	Spherical	150 diam.
Asplanchua priodonta	Cylindrical	200× 500
Brachionus bidentata	Cylindrical	200 × 300
B. quadridentata	Spherical	200 diam.
Chromogaster ovalis	Cylindrical	10x150
Elose woralli	Spherical	90 diam.
Horaella brehmi	Spherical	200 diam.
Keratella quadrata	Cylindrical	50 × 200
K. sp.	Cylindrical	50 × 200
K. stipitata	Cylindrical	75 × 200
Philodina sp.	Cylindrical	10 × 200
Acaris (Water Mites)		
Chelomideopris besselingi	Spherical	2.5 diam.

Algae

For algal identification and enumeration, the sample was thoroughly mixed, and a 1-mL aliquot was pipetted into a Sedgwick Rafter Cell. A differential interface contrast microscope equipped with a 10X or 20X eyepiece, 20X or 100X objective, and a Whipple disc was used for identification and counting purposes. Five short strips were counted. The algae species were identified and were classified into five main groups: blue-greens, greens, diatoms, flagellates, and desmids. For enumeration, blue-green algae were counted by trichomes. Green algae were counted by individual cells except for *Actinastrum, Coelastrum,* and *Pediastrum*, which were recorded by each colony observed. Each cell packet of *Scenedesmus* was counted. Diatoms were counted as one organism regardless of their grouping connections. For flagellates, a colony of *Dinobryon* or a single cell of *Ceratium* was recorded as a unit. The dimensions and shapes of various algae found in the water samples are given in table 16.

Macroinvertebrates

Benthic samples for macroinvertebrate examination were collected using a Petite Ponar dredge (6 × 6 inches). Three grab samples were taken at ten sites, the same in-lake water monitoring stations used for macroinvertebrate analyses. The samples were washed in a 30-mesh screen bucket, and the residue was preserved in 1-quart plastic bottles containing 95 percent ethyl alcohol. In the laboratory, the samples were washed again. The organisms were picked from the bottom detritus, preserved in 70 percent ethyl alcohol, identified, and counted. Then the biomass was determined.

Indicator Bacteria

Bacterial samples from the lake and storm drains were examined for total coliform (TC), fecal coliform (FC), and fecal streptococcus (FS). Procedures from *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association *et al*, 1992) for using 0.45-um membrane filters were employed in the bacterial determinations. For TC density, one-step LES Endo agar at 35° C for 22 + 2 hours was used. Fecal coliforms were grown in M-FC agar in a water bath (44.5 ± 0.2° C) for 22 ± 2 hours. To test for FS, the filter was incubated on KF streptococcus agar at 35° C for 48 + 2 hours.

Macrophytes

The macrophyte survey of the lake was done in two stages. A reconnaissance survey of the macrophyte beds was carried out on June 22-23, 1993, using a boat and a GIS-generated lake map with a square grid. The macrophyte beds were probed thoroughly with a garden rake to determine the presence/absence of macrophytes, type and qualitative assessment of densities of vegetation (dense, medium, sparse, etc.), and so forth. The grid made it easy to mark the boat position on the map. The reconnaissance survey enabled the delineation of the areal extent and abundance of macrophytes in the lake and the tentative selection of sites for quantitative sampling of macrophytes.

Macrophyte samples were collected at several locations with the aid of scuba divers on July 22-23, 1993, using 18- or 12-inch quadrats, depending on whether the site had sparse or dense growth. At each sampling site, observations were made and recorded for water depth, plant length, depth and character of the sediments, etc. All the plants within the quadrat were collected with roots intact and placed in plastic bags, which were then sealed. These samples were then examined with a stereo microscope and identified. Next, all the plants from each sampling site were air-dried, then dried at 105° C in a drying oven to constant weight, and finally weighed to determine the biomass.

Table 16. Sizes and Shapes of Algae Used in Biovolume Determination for Wolf Lake

Name	*Shape*	*Size (urn)*
Blue-Greens		
Anabaena planctonica	Flat, rectangular	11× 9
A. spiroides	Spherical, filamentous	10 diam., 100
Anacystis thermolis	Spherical, colony	5 diam., 6 to 16 in a colony
Aphanizomenon flos-aquae	Cylindrical, filamentous	4.5 × 90
Oscillatoria chlorina	Cylindrical	9 × 67.5
O. sp.	Cylindrical	8 × 55
Greens		
Actinastrum haratschii	Spherical	42 diam.
Closteriopsis longissima	Flat, rectangular	5 × 210
Coelastrum microporum	Spherical	24 diam.
Crucigenia rectangulahs	Flat, rectangular, colony	4.5 × 24, 250 in a colony
Oocystis borgei	Spherical	22 diam.
Pediastrum biradiatum	Spherical	15 diam.
P. duplex	Cylindrical	3 × 150
P. simplex	Cylindrical	10 × 22
P. tetras	Spherical	9 diam.
Scenedesmus carinatus	Flat, rectangular	3 × 12
S. dimorphus	Flat, rectangular	5 × 19
Ulothrix variabilis	Cylindrical, filamentous	5 × 10, 10
U. zonata	Flat, rectangular	31 × 55
Diatoms		
Amphiprora ornata	Flat, rectangular	44 × 60
A. paludosa	Flat, rectangular	44 × 60
Amphora ovalis	Flat, rectangular	13 × 65
Asterionella formosa	Flat, rectangular	2 × 125
Caloneis amphisbaena	Flat, rectangular	5 × 8
Cylotella atomus	Spherical	4 diam.
C. meneghiniana	Spherical	21 diam.
C. ocellata	Spherical	11 diam.
Cymatopleura solea	Flat, rectangular	22 × 155
Cymbella affmis	Cylindrical	12 × 60
C. prostrata	Cylindrical	25 × 85
Diatoma vulgare	Flat, rectangular	11 × 45
Diploneis smithii	Cylindrical	15 × 8
Fragilaria virescens	Flat, rectangular	9 × 88
Gomphonema olivaceum	Flat, rectangular	7 × 20
Gyrosigma kutzingii	Cylindrical	7 × 20
Melosira granulata	Cylindrical	12 × 60
Navicular cryptocephala	Cylindrical	5 × 25
N. cuspidata	Cylindrical	22 × 120
N. gastrum	Cylindrical	12 × 45
Neidium dubium	Cylindrical	12 × 33
Nitzschia dentecula	Cylindrical	5 × 51

Table 16. Concluded

Name	*Shape*	*Size (µm)*
Diatoms		
Rhoicosphenia cruvata	Cylindrical	7 × 45
Stephanodiscus niagarae	Spherical	52 diam.
Synedra actinastroides	Spherical, colony	3 diam., 55
S. acus	Cylindrical	4.5 × 200
S. delicatissima	Cylindrical	3 × 220
S. ulna	Cylindrical	4.5 × 200
Tabellaria fenestrata	Cylindrical	6 × 90
Flagellates		
Carteria multifilis	Spherical	14 diam.
Ceratium hirundinella	Triangular	48 × 48 × 200
Chlamydomonas reinhardi	Spherical	7 diam.
Dinobryon sertularia	Cylindrical	30 × 60
Eudorina elegans	Flat, rectangular, colony	10x21,135
Eugtena gracilis	Cylindrical	6 × 45
Phacus pleuronectes	Cylindrical	40 × 87
Trachemonas crebea	Spherical	18 diam.
Desmids		
Closterium sp.	Flat, rectangular	20 × 110
Staurastrum cornutum	Flat, rectangular	18 × 32

Sediment

Sediment samples were collected from the 19 locations shown in figure 8 and from the ten regular water quality monitoring sites, for a total of 29 sampling sites. Core samples were collected either from a boat or by wading, using a 2-inch hand-driven sediment corer thrust into the lake bottom to the point of refusal. Wildco (Wildlife Supply Company, Saginaw, MI) clear plastic core-liner tube was used to collect the sediment samples, which were subsequently divided into three equal parts, designated top, middle, and bottom. Each of these portions was examined in the laboratory for heavy metals and trace organics.

Surficial sediment samples were collected using an epoxy-coated Petite Ponar dredge. Portions of each sample were placed in a 250-mL plastic bottle for metal and nutrient analysis and in a specially prepared 200-mL glass bottle for trace organics and toxicity characteristics leaching procedure (TCLP) tests according to the IEPA *Quality Assurance and Field Methods Manual* (IEPA, 1987). Particle-size analyses of the surficial sediments were carried out using the hydrometer analyses procedure, American Society of Testing and Materials (ASTM) D422-63. USEPA method 1311, published in the Federal Register, 40 CFR 261, March 29, 1990, was used for the TCLP extraction of the surficial sediment sample (USEPA, 1990a).

Hydrologic Data

Hydrologic data were collected for the period October 1, 1992, to September 30, 1993, to evaluate the inflow, outflow, and interflow conditions in the lake. Hydrologic data collection for this diagnostic phase of the study included water-level monitoring for nine staff gages on at least a monthly basis and discharge measurements in the pool connecting channels at the Tollway culvert, the State Line Road culvert, the railroad culvert, and the Indian Creek outlet. Stage and discharge measurements made during the diagnostic phase of the study are listed in table 17. During summer 1993, water levels in Pools 8 and 3 were monitored by 5-pounds per square inch (psi) Druck pressure transducers connected to an Omnidata Data Pod II electronic data logger. Each data logger was programmed to measure water levels at hourly intervals and then record the levels once every 12 hours. The data logger also monitored for a specific water-level change at each hourly reading and recorded a date and time listing for major water-level rise or fall.

In-Lake Water Quality Characteristics

Wolf Lake has been monitored for its water quality characteristics under two statewide programs: the IEPA's Volunteer Lake Monitoring Program (VLMP) and the Ambient Lake Monitoring Program (ALMP). The VLMP enlists volunteers who monitor lake conditions (Secchi disc reading and field observations) twice a month from May through October and transmit the collected data to the IEPA for analysis and report preparation. The ALMP performs a much more comprehensive set of chemical analyses on the collected water samples than the VLMP.

Appendix B lists the limnological data obtained from the current one-year (October 1992 through September 1993) monitoring and the historical ALMP. Appendix C presents the statistical summaries of each parameter measured for each station. The printout was prepared by IEPA staff. The historical and current conditions of each parameter monitored were compared. Spatial (within pools) and temporal (seasonal) differences were evaluated. The results of water quality analyses in Pools 1-5 were compared to the applicable General Use Water Quality Standards for the state of Illinois, as promulgated by the Illinois Pollution Control Board. The results of the monitoring program in Pools 6 through 8 and Wolf Lake Channel were evaluated against the standards established by the Indiana Water Quality Standards, 327 1AC 2, from 1993 version of Indiana Administrative Code which was incorporated in IDEM's rules (1995).

Table 17a. Staff Gage Readings Collected during the Wolf Lake Diagnostic Study

	Wolf Lake Pool (Units in feet)								
Date	1	2	3	4	5	6	7	8	9
8/13/92			1.63						
8/14/92	1.58	1.57		1.78		1.58	1.56	1.60	1.59
9/1/92								1.49	
9/2/92	1.56		1.89			1.41	1.40	1.47	1.47
9/3/92								1.53	
9/4/92								1.5	1.49
10/13/92	1.74						1.38	1.47	
11/9/92	1.96	2.01	2.04	2.07		1.53	1.54	1.62	1.61
11/12/92	2.07	2.11	2.14	2.17		1.69	1.65		
11/13/92						1.65		1.77	
12/21/92	2.08	2.08	2.15	2.15		1.55	1.66	1.65	1.60
1/19/93			2.48			1.77	1.76		
1/20/93		1.84	2.46	2.48		1.77	1.72		
2/4/93			2.33	2.30		1.64	1.64		
2/10/93			2.24	2.22		1.58	1.57		
3/3/93			2.16	2.17		1.59	1.58		
3/8/93			2.21	2.23		1.58	1.58		
3/16/93			2.25	2.24		1.58			
3/30/93	2.83	2.30	2.39	2.36	2.36	1.63	1.64		1.54
4/13/93	3.01	2.35	2.46	2.40	2.43	1.62	1.62		1.52
4/14/93		2.35	2.40	2.38		1.60	1.62		
5/10/93	3.11	2.22	2.33	2.29	2.29	1.61	1.63	1.63	1.54
5/11/93		2.20	2.29	2.24		1.62		1.59	0
5/25/93		1.84	1.90	1.95		1.50	1.52	1.49	
5/26/93	2.80	1.78	1.88	1.90	1.90	1.48	1.50	1.48	1.42
6/7/93		2.26	2.36	2.35		2.10	2.10	2.29	
6/9/93	3.35	2.86	2.92	2.94	2.92	2.23	2.28	2.28	2.21
6/10/93	3.37	2.90	2.98	2.96	2.97	2.20	2.23	2.20	
6/21/93	3.61	3.05	3.13	3.09	3.12	2.26	2.28	2.24	
6/22/93	3.60	3.02	3.10	3.08	3.08	2.21	2.26	2.21	2.16
7/7/93	3.57	2.60	2.68	2.66	2.68	1.88	1.90	1.86	1.84
7/8/93	3.54	2.56	2.65	2.63	2.64	1.85	1.83	1.86	1.79
7/19/93	3.32	2.31	2.40	2.35	2.36	1.62		1.62	1.56
7/20/93	3.28	2.34	2.43	2.36	2.39	1.60	1.60		1.54
7/21/93	3.24	2.35	2.46	2.38	2.42	1.62	1.61	1.58	
8/2/93	2.88	1.61	1.68	1.81	1.87	1.42	1.41	1.41	1.34
8/4/93	2.82	1.57	1.64	1.76	1.82	1.41	1.43	1.42	
8/17/93		1.57	1.66	1.77	1.80	1.44	1.45	1.42	1.35
8/18/93	2.55	1.57	1.64	1.76	1.80	1.43	1.45		1.35
9/8/93	2.67	2.24	2.32	2.32	2.32	1.61	1.63	1.6	1.55
9/9/93	2.62	2.17	2.27	2.28		1.55	1.58	1.61	1.55
9/28/93	2.65	2.38	2.47	2.44	2.48	1.76	1.74	1.74	1.68
10/1/93		2.39	2.46	2.44		1.68	1.70	1.70	
10/25/93	2.54	2.42	2.50	2.47	2.49	1.70		1.69	1.63
11/30/93	2.62	2.58	2.66	2.61	2.65	1.83	1.86	1.84	. 1.78

Table 17b. Discharge Measurements Collected during the Wolf Lake Diagnostic Study

	Discharge measurements, cfs			
Date	*Indiana Toll Road*	*State Line Road*	*Railroad*	*Indian Creek*
11/9/92	16.5	14.8	14.1	20.0
12/22/92	13.6	16.1	13.5	17.6
1/20/93	18.6	17.9	17.1	23.0
2/4/93	14.0	15.6	13.8	17.9
3/8/93	15.4	14.6	13.1	16.6
4/14/93	12.5	13.6	13.1	16.5
5/11/93	130.0	15.3	14.6	16.7
5/25/93	10.4	13.4	14.1	15.4
6/7/93	50.84	36.0	22.4	12.3
6/10/93	27.8	28.3	28.8	25.9
6/21/93	23.5	24.6	24.2	29.3
7/8/93	17.8	19.9	24.0	26.3
7/21/93	14.6	13.5	10.1	5.9
8/2/93	13.1	11.4	11.8	14.8
8/17/93	13.1	11.9	11.2	11.9
10/1/93	18.0	15.8	13.2	14.8

Physical Characteristics

Temperature and Dissolved Oxygen. Lakes in the temperate zone generally undergo seasonal variations in temperature throughout the water column. These variations, with their accompanying phenomena, are perhaps the most influential controlling factors within the lakes.

The temperature of a deep lake in the temperate zone is about 4° C during early spring. As air temperatures rise, the upper layers of water warm up and are mixed with the lower layers by wind action. Spring turnover is complete mixing of a lake when the water temperature is uniform from top to bottom. By late spring, differences in thermal resistance cause the mixing to cease, and the lake approaches the thermal stratification of the summer season. Almost as important as water temperature variations is the physical phenomenon of increasing density with decreasing temperature. These two interrelated forces are capable of creating strata of water of vastly different characteristics within the lake.

During thermal stratification, the upper layer (epilimnion) is isolated from the lower layer of water (hypolimnion) by a temperature gradient (thermocline). Temperatures in the epilimnion and hypolimnion are essentially uniform. The thermocline will typically have a sharp temperature drop per unit depth from the upper to the lower margin. When thermal stratification is established, the lake enters the summer stagnation period, so named because the hypolimnion becomes stagnated.

With cooler air temperatures during the fall season, the temperature of the epilimnion decreases and density of the water increases. This decrease in temperature continues until the epilimnion is the same temperature as the upper margin of the thermocline. Successive cooling through the thermocline to the hypolimnion results in a uniform temperature throughout the water column. The lake then enters the fall circulation period (fall turnover) and is again subjected to a complete mixing by the wind.

Declining air temperatures and the formation of ice cover during the winter produce a slightly inverse thermal stratification. The water column is essentially uniform in temperature at about 3 to 4° C, but slightly colder temperatures of 0 to 2° C prevail just below the ice. With the advent of spring and gradually rising air temperatures, the ice begins to disappear, and the temperature of the surface water rises. The lake again becomes uniform in temperature, and spring circulation occurs (spring turnover).

The most important phase of the thermal regime from the standpoint of eutrophication is the summer stagnation period. The hypolimnion, by virtue of its stagnation, traps sediment materials such as decaying plant and animal matter, thus decreasing the availability of nutrients during the critical growing season. In a eutrophic lake, the hypolimnion becomes anaerobic or devoid of oxygen because of the increased content of highly oxidizable material and because of its isolation from the atmosphere. In the absence of oxygen, the conditions for chemical reduction become favorable and more nutrients are released from the bottom sediments to the overlying waters.

However, during the fall circulation period, the lake water becomes mixed, and the nutrient-rich hypolimnetic waters are redistributed. The nutrients that remained trapped during the stagnation period become available during the following growing season. Therefore, a continuous supply of plant nutrients from the drainage basin is not mandatory for sustained plant production. After an initial stimulus, the recycling of nutrients within a lake might be sufficient to sustain highly productive conditions for several years.

Impoundment of running water alters its physical, chemical, and biological characteristics. The literature is replete with detailed reports on the effects of impoundments on various water quality parameters. The physical changes in the configuration of the water mass following impoundment reduce reaeration rates to a small fraction of those of free-flowing streams. Where the depth of impoundment is considerable, thermal stratification acts as an effective barrier for the wind-induced mixing of the hypolimnetic zone. Oxygen transfer to the deep waters is essentially confined to the molecular diffusion transport mechanism.

During the period of summer stagnation and increasing water temperatures, the bacterial decomposition of the bottom organic sediments exerts a high rate of oxygen demand on the overlying waters. When this rate of oxygen demand exceeds oxygen replenishment by molecular diffusion, anaerobic conditions begin to prevail in the zones adjacent to the lake bottom. Hypolimnetic zones of man-made impoundments were also found to be anaerobic within a year of their formation (Kothandaraman and Evans, 1983a, 1983b).

The isothermal and iso-dissolved oxygen concentration plots for Wolf Lake at stations RHA-1, RHA-2, RHA-3, RHA-4, RHA-5, and RHA-8 are shown in figures 9a - 9f, respectively. Maximum depths at these stations were greater than 10 feet. Figures 10a - 10c show DO and temperature profiles on selected dates for stations RHA-6, RHA-7, and RHA-9, respectively. All the observed data for DO and temperature in Wolf Lake are included in appendix D.

An examination of the isothermal plots reveals that the lake system does not experience typical lake thermal stratification. There were no well-defined hypolimnia even during the peak summer period from June - August. The system exhibits isothermal conditions except during the period May - August when temperature gradients exist. The maximum surface temperatures noted at stations RHA-1, RHA-2, RHA-3, RHA-4, RHA-5, and RHA-8 were 27.1, 26.4, 27.7, 26.9, 26.7, and 26.1° C, respectively. The first four of these maxima occurred in August and the last two occurred in July. The maximum temperature differences between the surface and bottom observations at these stations were 5.3, 5.7, 5.6, 6.8, 7.9, and 5.2° C, respectively.

The iso-dissolved oxygen plots indicate that the lake exhibited a very weak stratification with respect to DO during the months May through August. Anoxic conditions (DO < 1.0 mg/L) in the lake were encountered occasionally, but they were transitory. Generally, DO concentrations greater than 2.0 mg/L were encountered at depths 2 to 3 feet above the lake bottom. At station RHA-1 where the lake bottom is sandy gravel, the lowest DO measured was 3.1 mg/L on June 22, 1993. At station RHA-8, which has a maximum depth of 18 feet, the anoxic zone extended 3 to 5 feet from the lake bottom on two different occasions. The exertion of a high rate of DO demand by organically rich sediment at RHA-8 during summer was the cause of the oxygen depletion.

The DO and temperature profiles for stations RHA-6 and RHA-7 (figures 10a and 10b) indicate that the water bodies are well mixed and the DO in the bottom waters was more than 5.0 mg/L. However, the DO conditions at station RHA-9 (Wolf Lake Channel) presented in figure 10c reveal significant DO depletions in the lower strata of the water column during summer months. DO concentrations observed at this station were generally lower than those at other stations in the lake system. On four different occasions the DO at this station was less than 5.0 mg/L from top to bottom of the water column (appendix C-8). Such conditions did not exist in any other station monitored. The bottom sediment at this station was found to be dark, gritty, and malodorous.

The surface and near surface DO values observed in the lake met the Illinois Pollution Control Board's general use standards with respect to minimum level, viz: not less than 5.0 mg/L at any time, with the exception of the observations at RHA-9, where DO values were less than 5.0 mg/L on four of the 17 occasions monitored. The Indiana Stream Pollution Control Board's

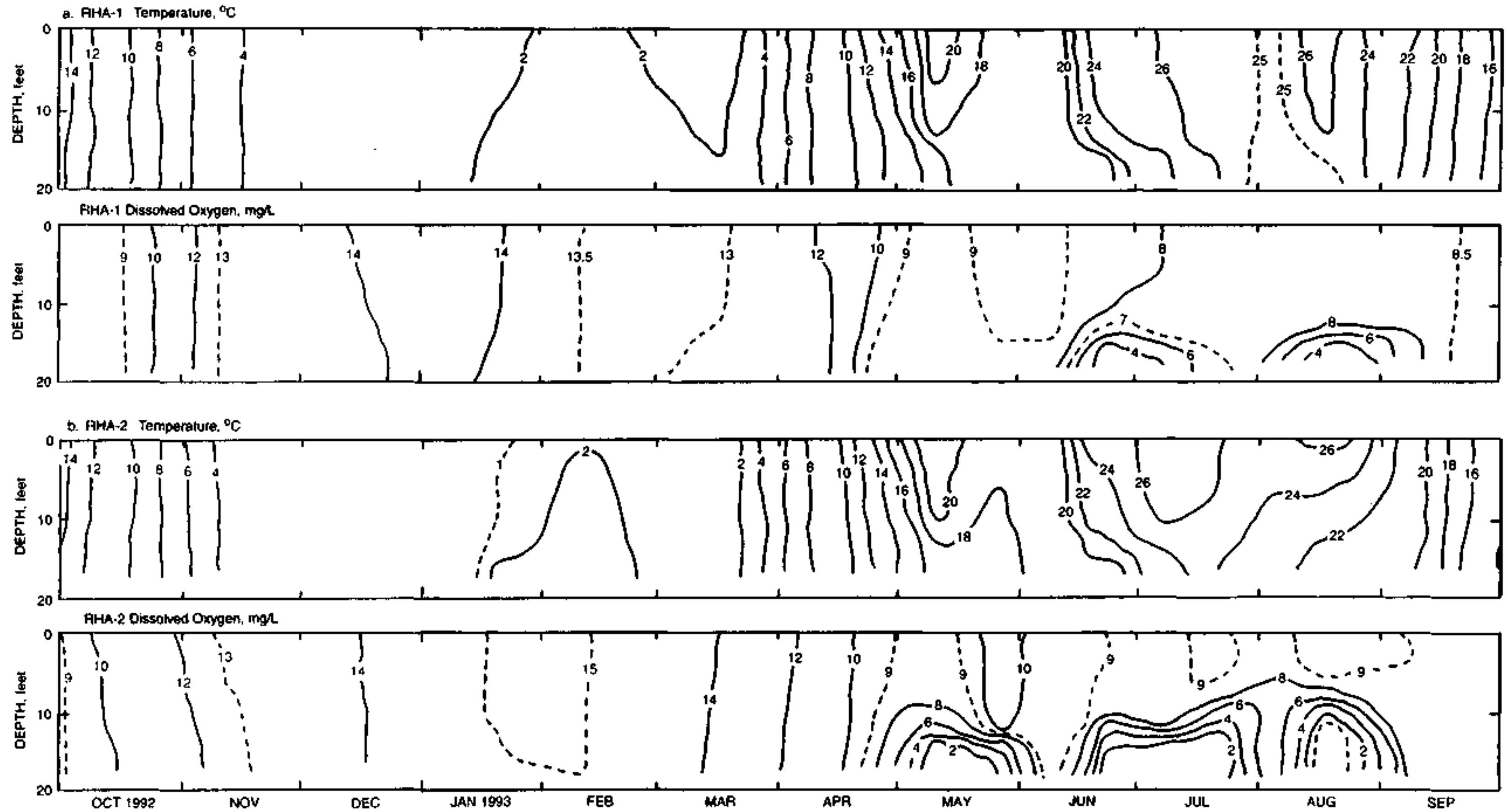


Figure 9. Isothermal and iso-dissolved oxygen plots for the deep stations at Wolf Lake: a) RHA-l,b) RHA-2, c) RHA-3, d) RHA-4, e) RHA-5, and f) RHA-6

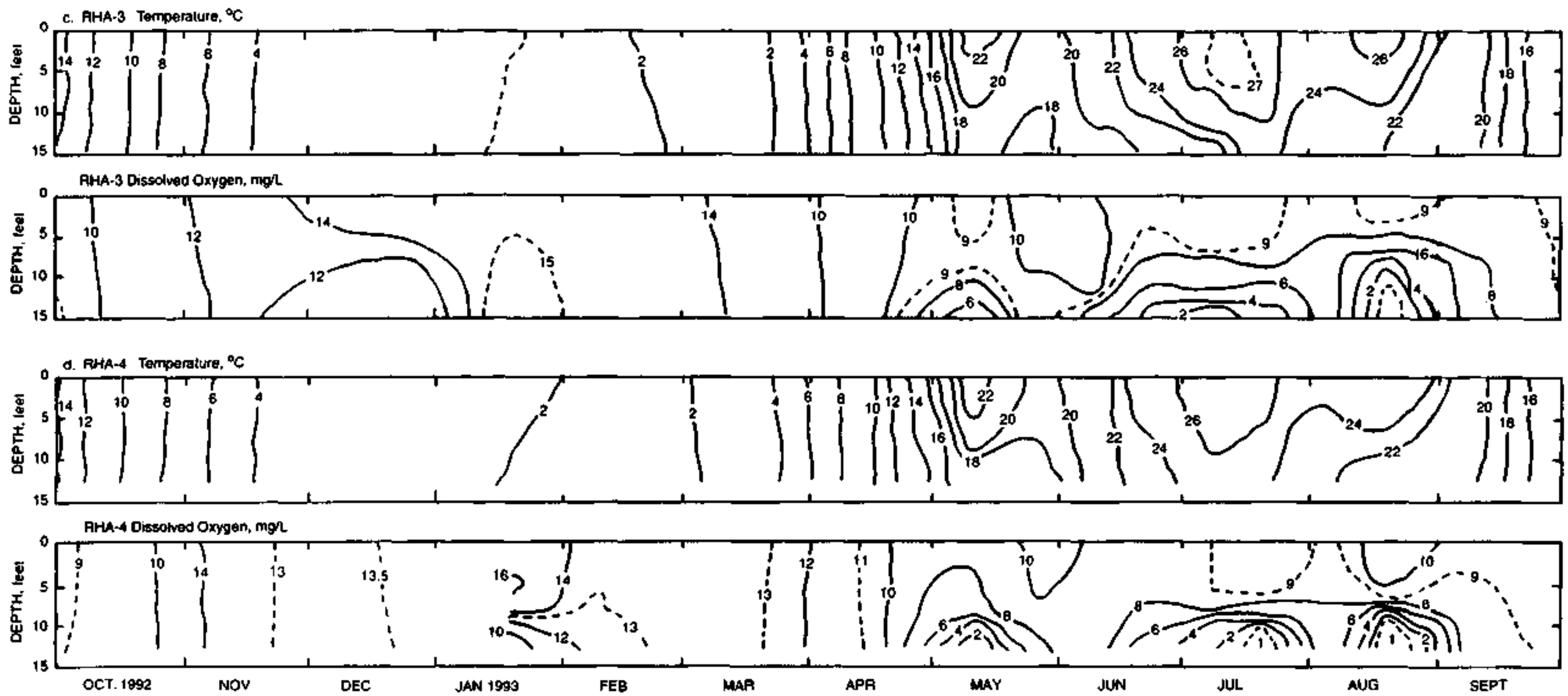


Figure 9. Continued

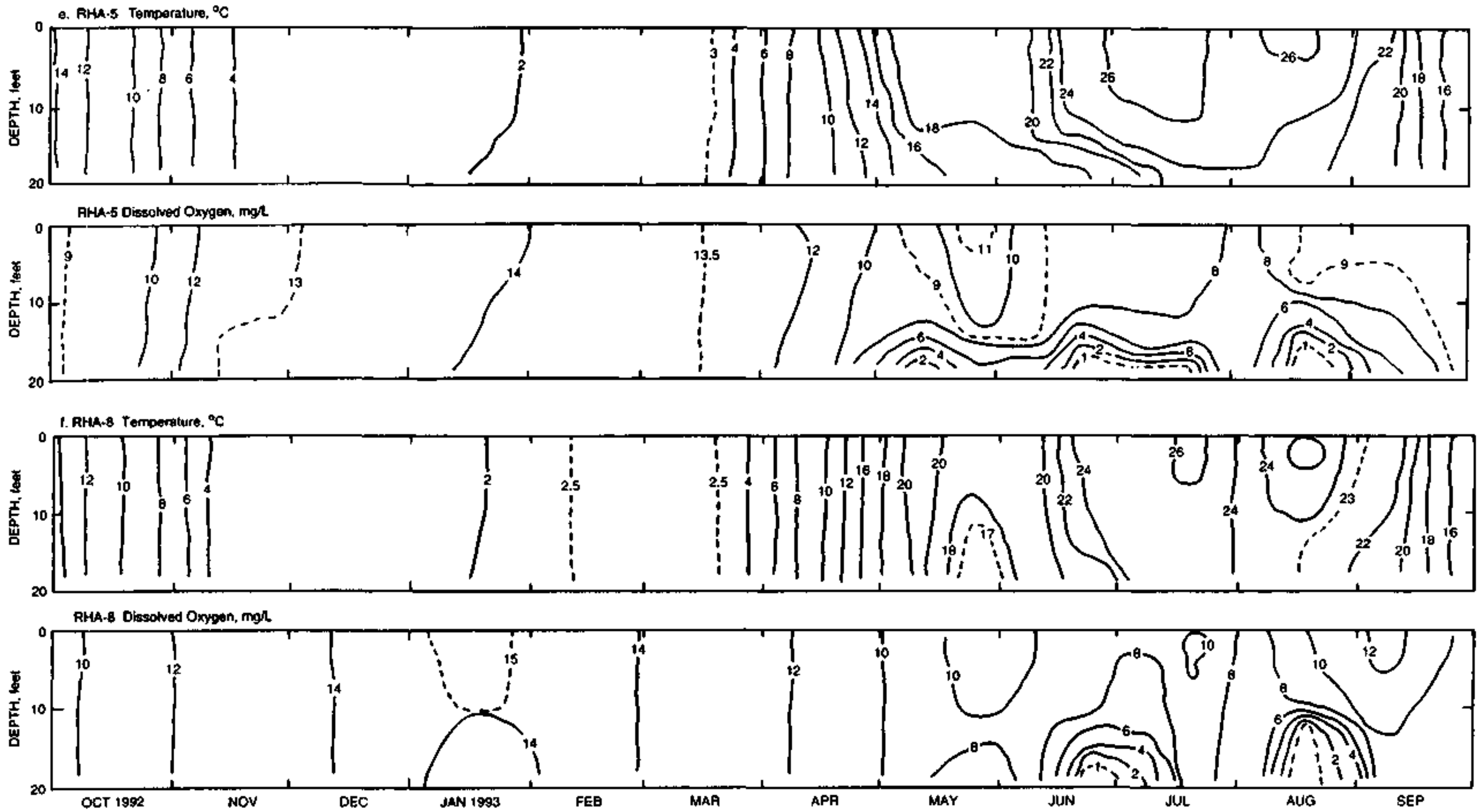


Figure 9. Concluded

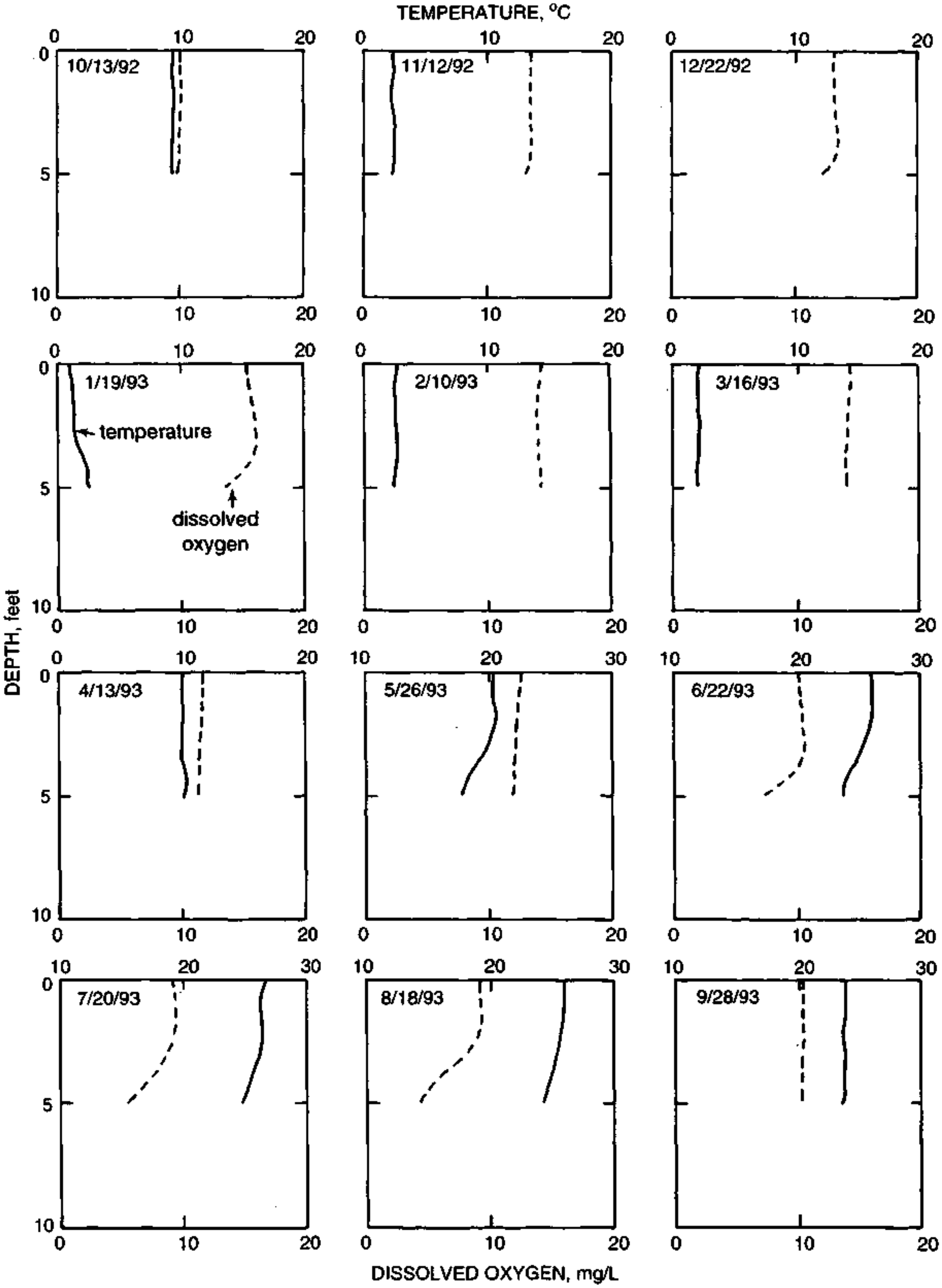


Figure 10a. Temperature and dissolved oxygen profiles for RHA-6 at Wolf Lake

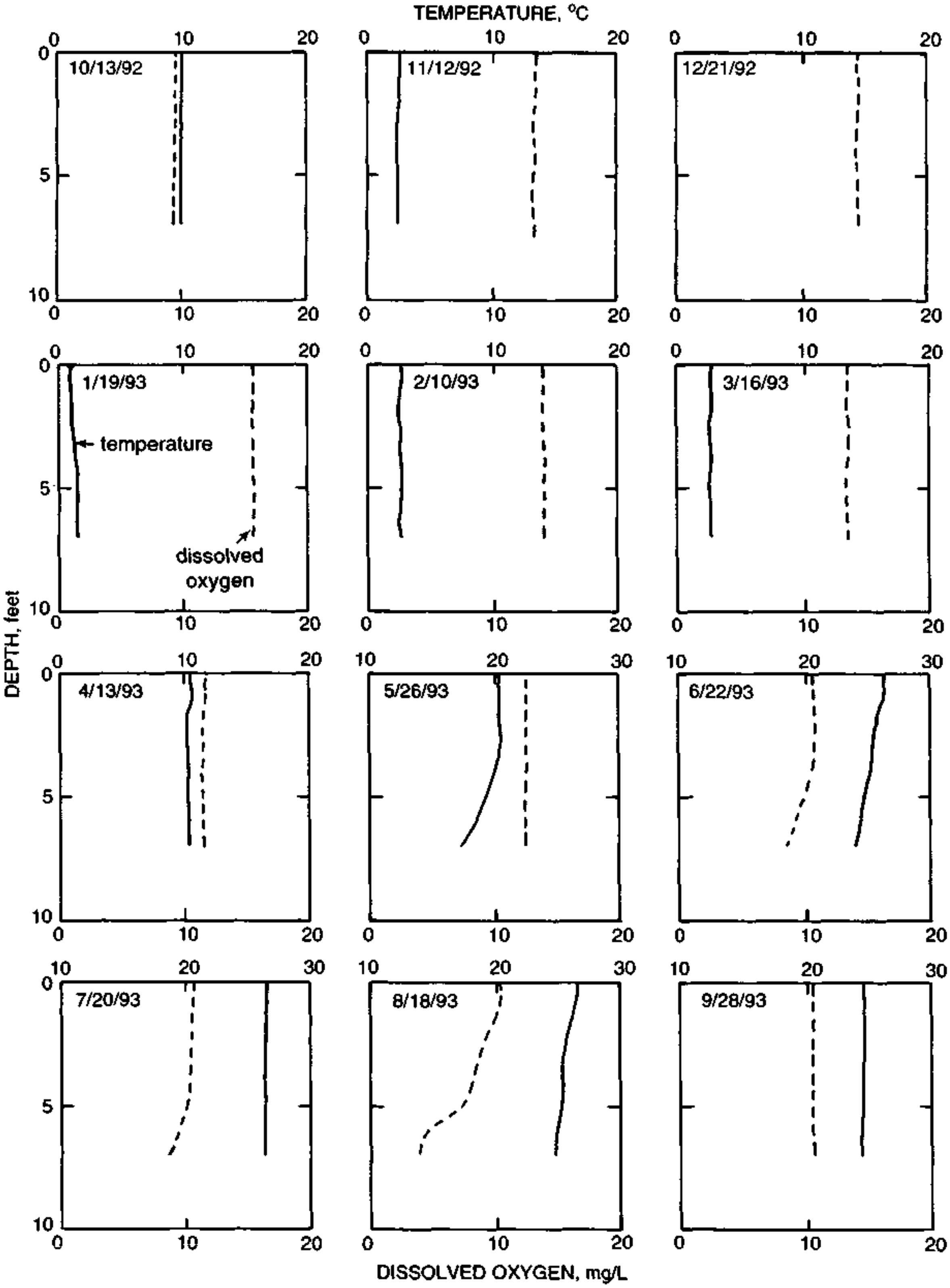


Figure 10b. Temperature and dissolved oxygen profiles for RHA-7 at Wolf Lake

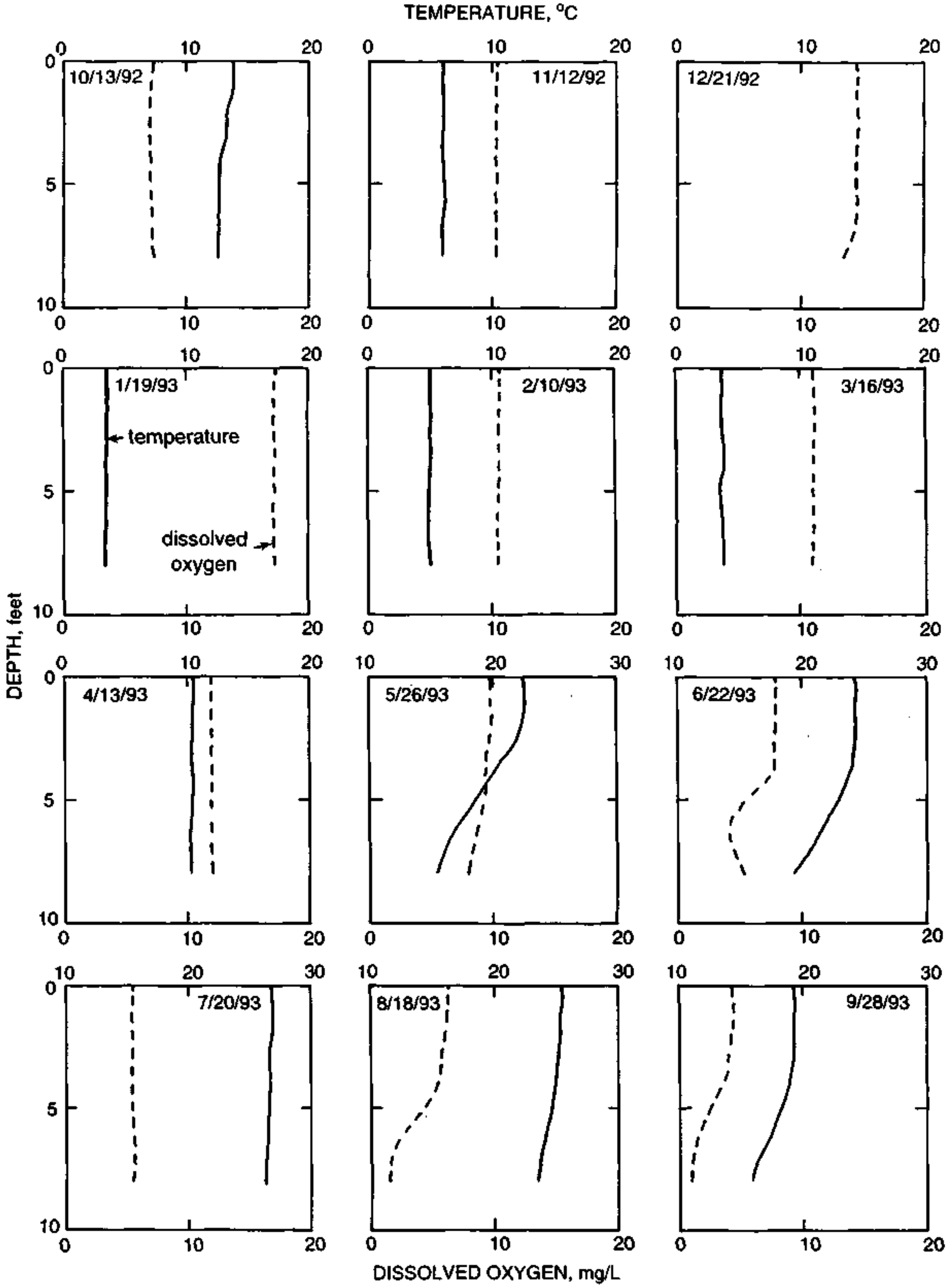


Figure 10c. Temperature and dissolved oxygen profiles for RHA-9 at Wolf Lake

regulation stipulates that DO shall average at least 5.0 mg/L per calender day and shall not be less than 4.0 mg/L at any time. The surface DO at station RHA-9 was less than 4.0 mg/L on three different occasions.

Percent DO saturation values are determined for the observed DO and temperature and are given in appendix E. Saturation DO values were computed using the formula (Committee on Sanitary Engineering Research, 1960):

$$DO = 14.652 - 0.410022T + 0.0079910T^2 - 0.000077774T^3$$

where

DO = the saturation dissolved oxygen, mg/L

T = water temperature, °C

The highest saturation levels computed at stations RHA-1 through RHA-9 are 105, 131, 130, 138, 127, 144, 139, 142, and 129, respectively. It should be pointed out that supersaturation conditions at stations RHA-1 to RHA-8 occurred during warm periods. The saturation condition at station RHA-9 (Wolf Lake Channel) was noted during January. Also, significantly lower saturation values are readily discernible at this station during June - October compared to all other stations. The tabulations of percent saturation in appendix E provide an excellent basis for judging the oxygen resources in the lake system. DO levels are excellent throughout the water column at RHA-1. The lake exhibits anoxic conditions up to 2 to 3 feet from the bottom during June - August at RHA-2, whereas anoxic conditions at stations RHA-3, RHA-4, RHA-5, and RHA-8 were minimal or sporadic. Oxygen conditions in the two shallow water bodies (RHA-6 and RHA-7) were excellent with no anoxic conditions in the near-bottom waters. Overall, oxygen conditions in the lake system are excellent everywhere, except in the Wolf Lake Channel, for sustaining sports fisheries.

Secchi Disc Transparency. Secchi disc visibility is a measure of a lake's water transparency, which suggests the depth of light penetration into a body of water (its ability to allow sunlight penetration). Even though the Secchi disc transparency is not an actual quantitative indication of light transmission, it provides an index for comparing similar bodies of water or the same body of water at different times. Since changes in water color and turbidity in deep lakes are generally caused by aquatic flora and fauna, transparency is related to these entities. The euphotic zone or region of a lake where enough sunlight penetrates to allow photosynthetic production of oxygen by algae and aquatic plants is taken as two to three times the Secchi disc depth (USEPA, 1980).

Suspended algae, microscopic aquatic animals, suspended matter (silt, clay, and organic matter), and water color are factors that interfere with light penetration into the water column and reduce Secchi disc transparency. Combined with other field observations, Secchi disc readings may furnish information on 1) suitable habitat for fish and other aquatic life, 2) the lake's water quality and aesthetics, 3) the state of the lake's nutrient enrichment, and 4) problems with and potential solutions for the lake's water quality and recreational use impairment.

Figures 11-14 show the temporal variations in Secchi disc transparency, along with the other physical, chemical, and biological parameters for Pools 2 (RHA-2), 6 (RHA-6), 8 (RHA-8), and Wolf Lake Channel (RHA-9), respectively. Statistical summaries of the historical and currently observed Secchi disc transparency data are presented in tables 18-20. It should be noted that historical data cover only a few of the pools in the lake system. Table 18 summarizes the results of the study carried out on ten dates between May 4 and September 14, 1983, under the IEPA's Volunteer Lake Monitoring Program (IEPA, 1984). It should also be noted that the

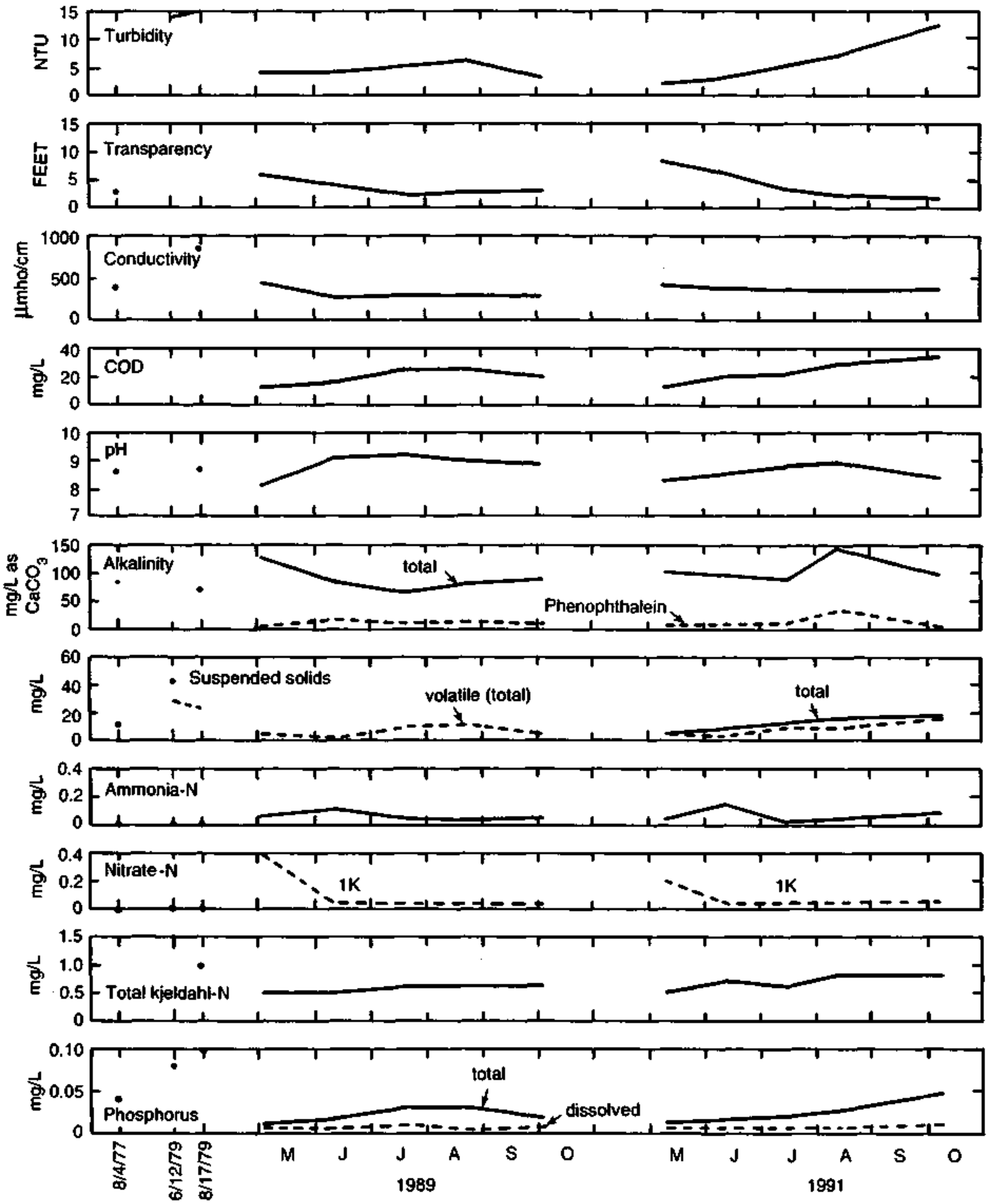


Figure 11a. Historical observations of surface water characteristics at RHA-2, Wolf Lake

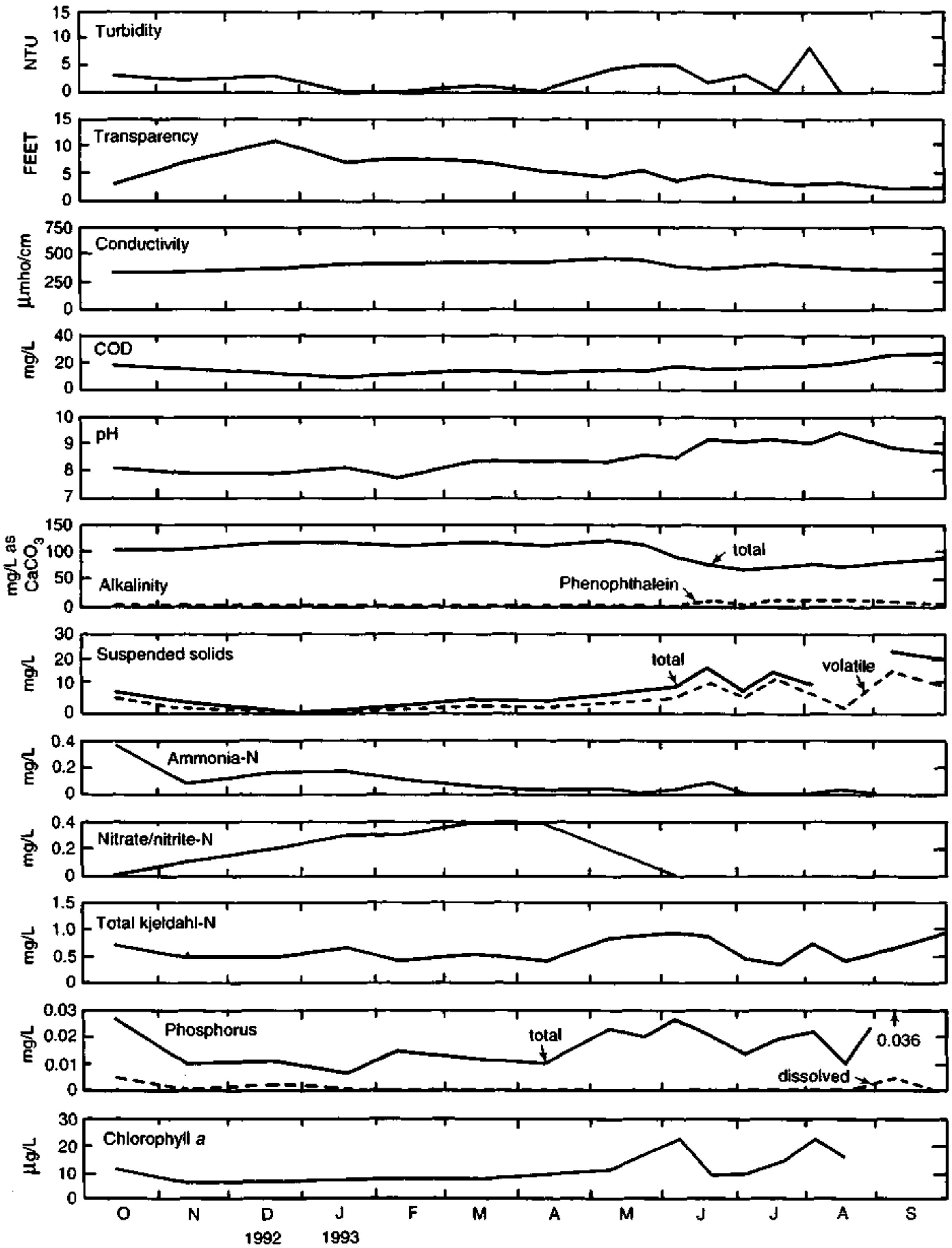


Figure 1 lb. Temporal variations of surface water characteristics at RHA-2, Wolf Lake

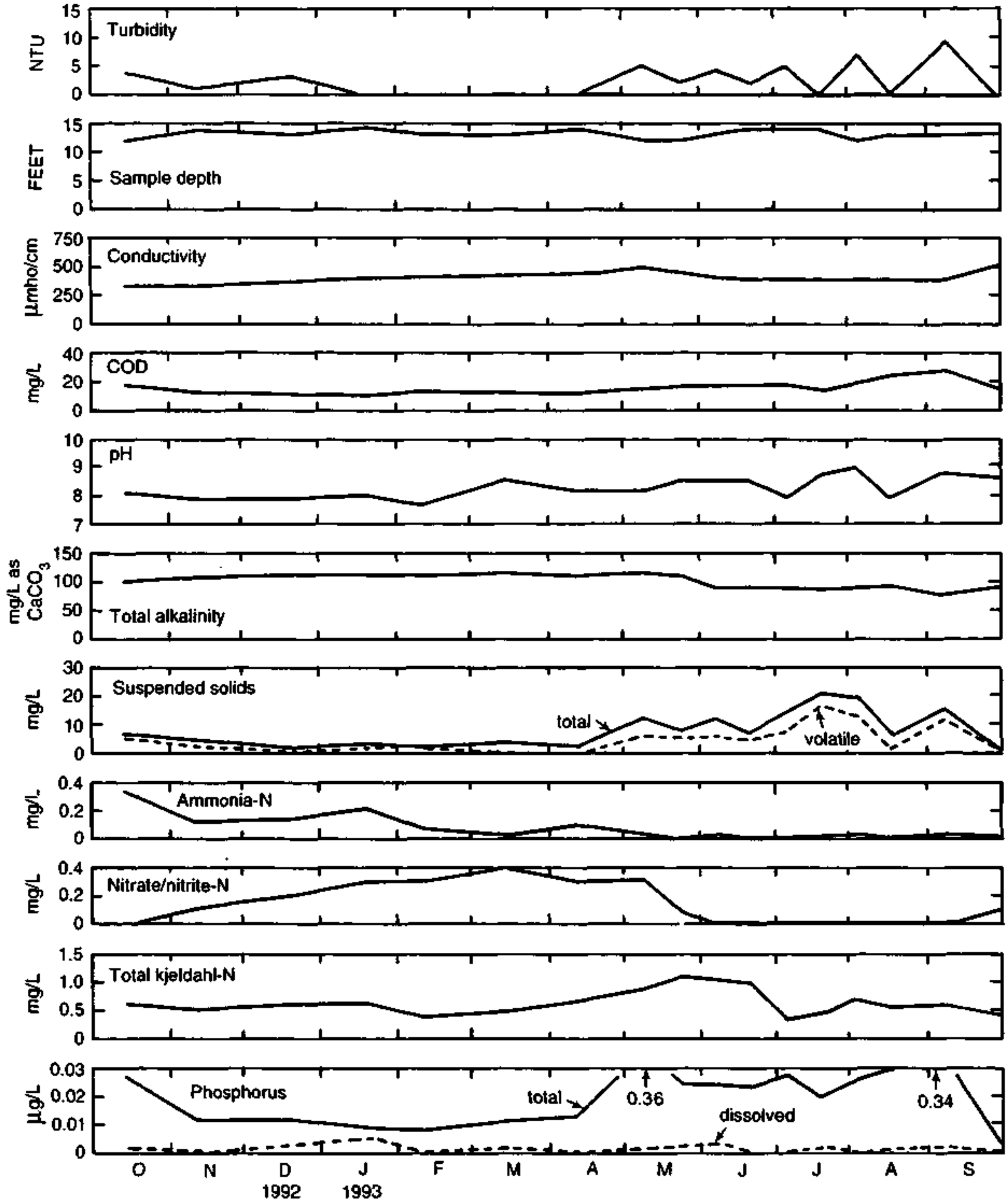


Figure 11c. Temporal variations of near-bottom water characteristics at RHA-2, Wolf Lake

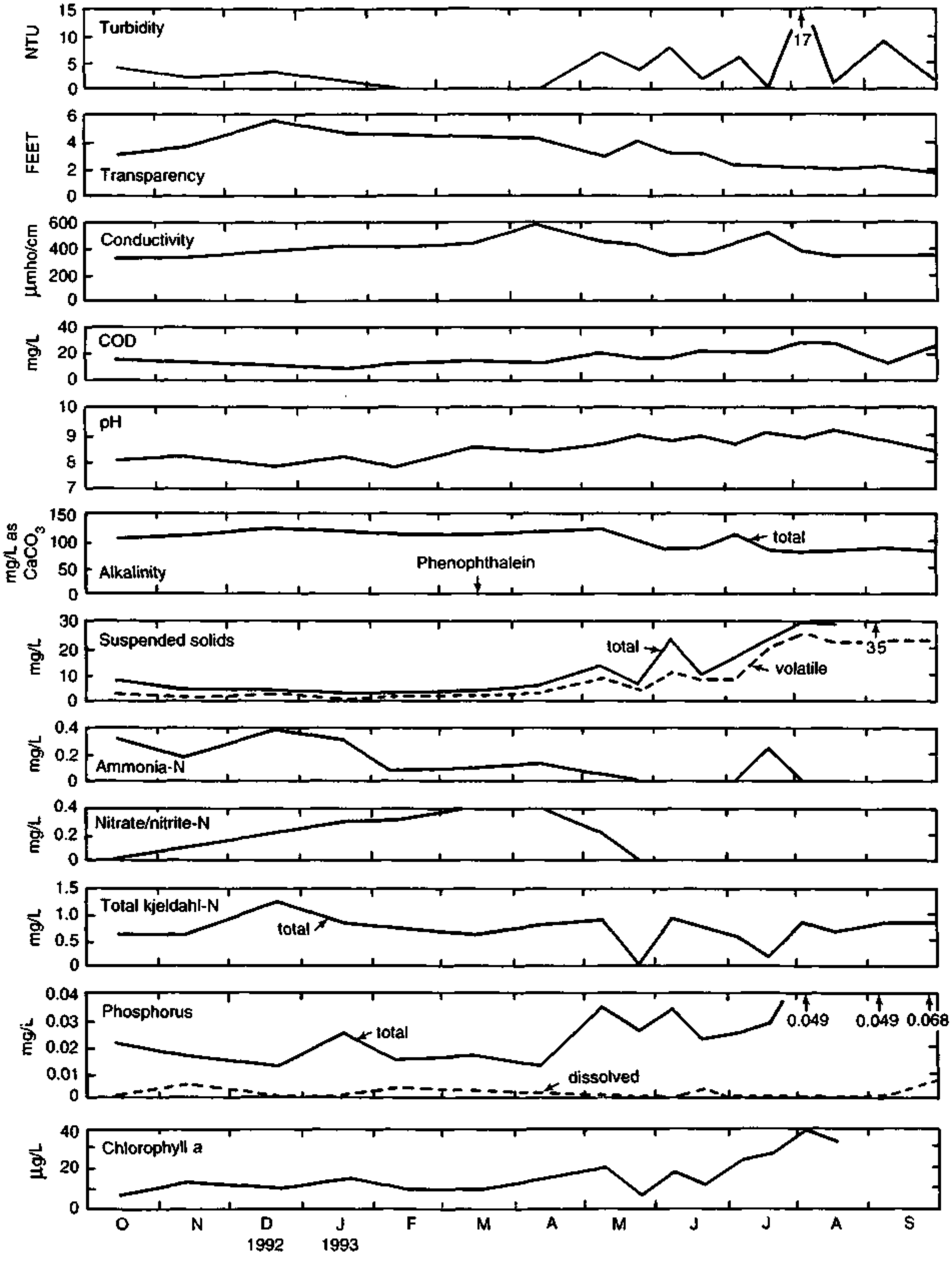


Figure 12. Temporal variations in surface water characteristics at RHA-6, Wolf Lake

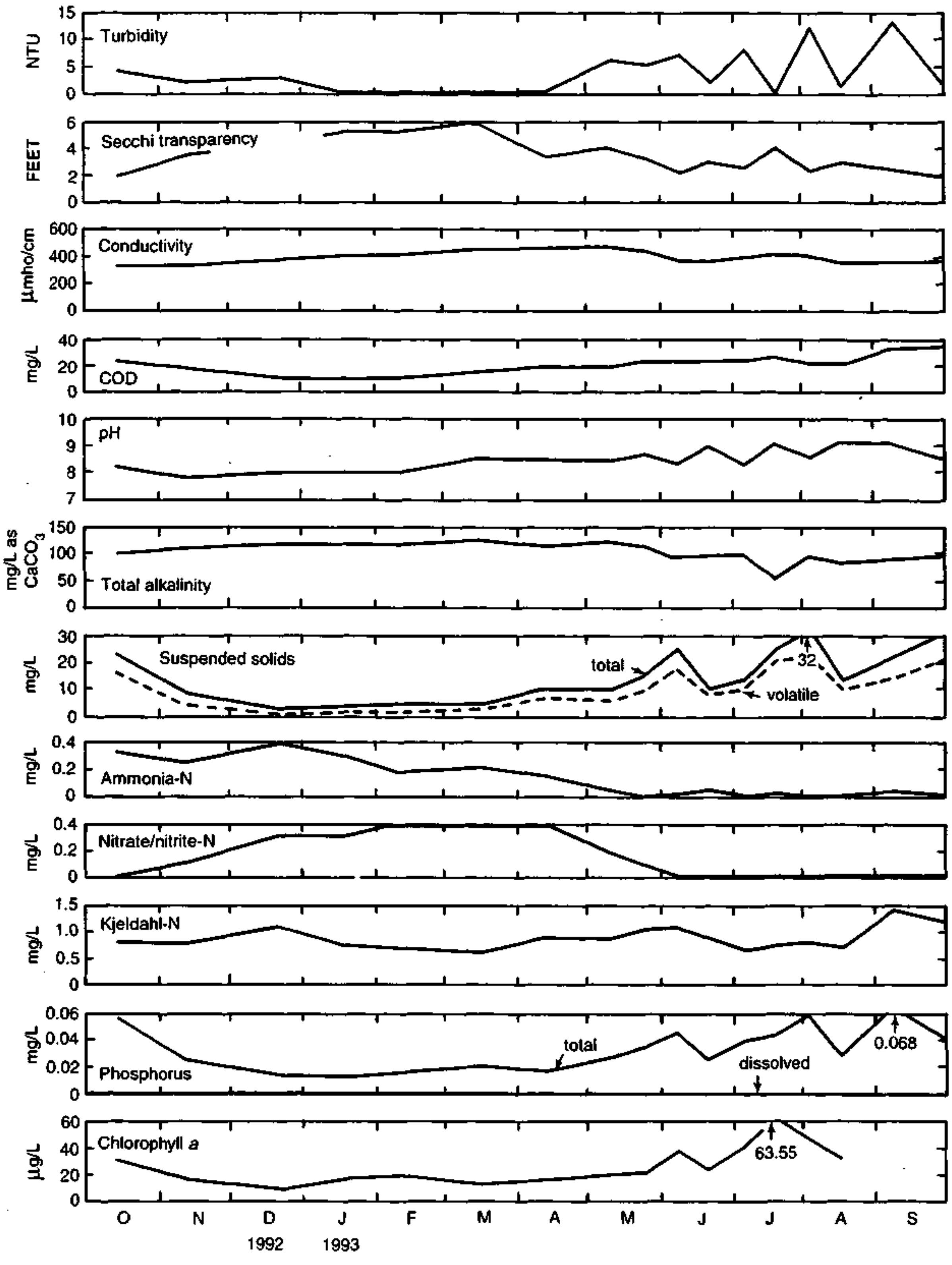


Figure 13. Temporal variations in surface water characteristics at RHA-8, Wolf Lake

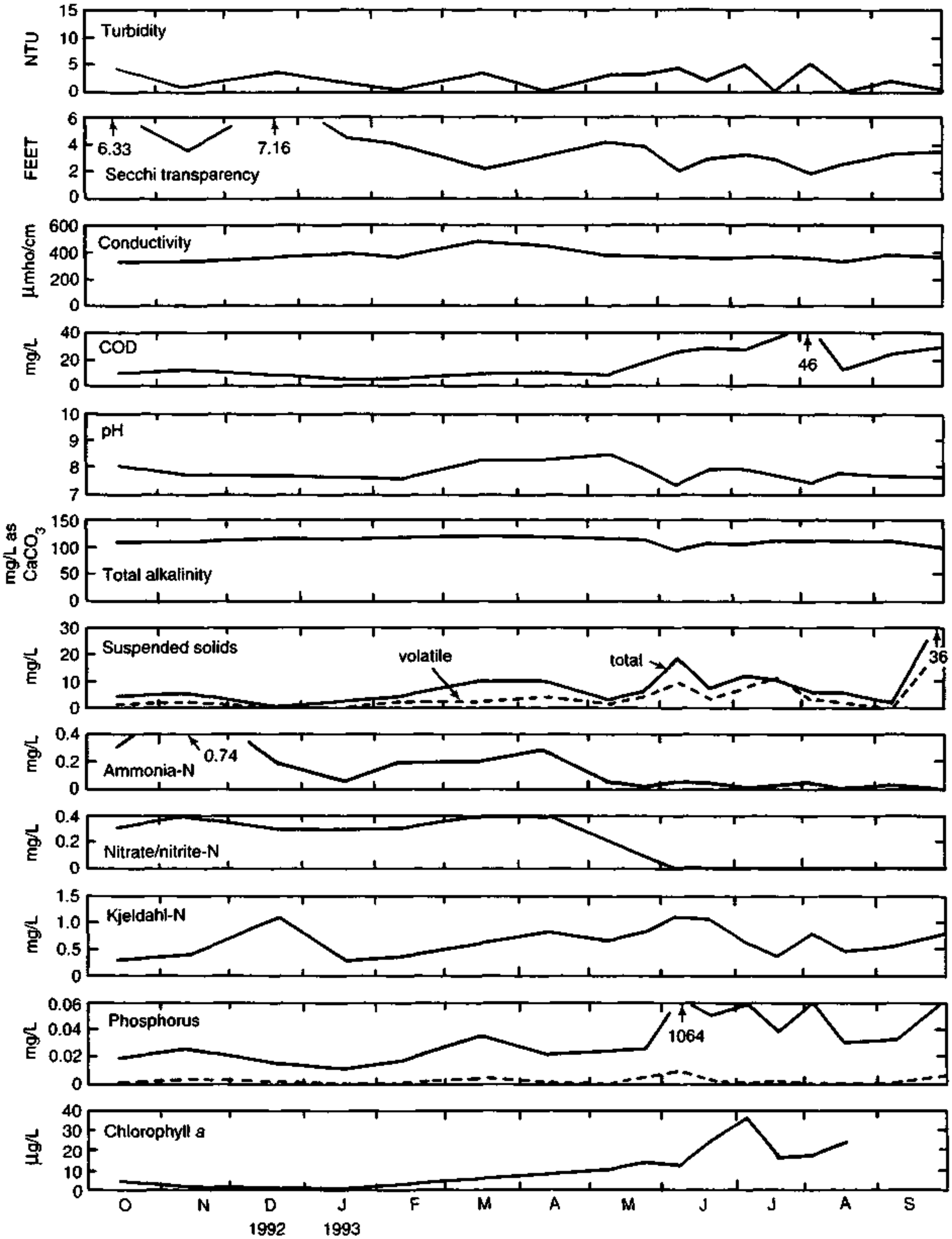


Figure 14. Temporal variations in surface water characteristics at RHA-9, Wolf Lake

Table 18. Summary of Secchi Disc Transparency in Wolf Lake, May - September 1983

Station	*Average depth, feet*	*Minimum, inches*	*Maximum, inches*	*Mean, inches*	*Standard deviation, inches*
Pool 1, center	14.3	66	168	97	37
Pool 2, center	14.0	18	42	21	9
Pool 3, center	5.3	16	52	29	12
Pool 4, near center	4.6	12	48	23	12

Table 19. Summary of Historical Secchi Disc Transparency Data in Wolf Lake at RHA-1, RHA-2, and RHA-3

	Minimum		*Maximum*			
Station	*Inches*	*Date*	*Inches*	*Date*	*Mean, inches*	*Standard deviation, inches*
RHA-1	96	7/16/91	159	5/9/91	128	29
RHA-2	12	8/17/79	99	5/9/91	41	25
RHA-3	24	10/6/91	120	5/2/89	59	36

Table 20. Summary of Secchi Disc Transparency in Wolf Lake, 1992-1993

		Minimum		*Maximum*			
Station	*Average depth. feet*	*Inches*	*Date*	*Inches*	*Date*	*Mean, inches*	*Standard deviation, inches*
RHA-1	16.0	91	4/13/93	188	11/12/92	129	29
RHA-2	15.1	25	9/28/93	131	12/21/92	58	28
RHA-3	13.1	31	9/28/93	130	2/10/93	75	32
RHA-4	11.3	21	9/8/93	134	12/21/92	56	33
RHA-5	17.1	32	8/4/93	132	12/21/92	79	34
RHA-6	4.8	20	9/28/93	66	12/21/92	40	14
RHA-7	5.8	23	7/20/93	62	1/19/93	38	14
RHA-8	16.7	23	10/13/92	70	3/17/93	40	15
RHA-9	6.8	24	6/9/93	86	12/22/92	43	17

sampling locations in the four pools were at the center of each pool rather than at the deepest point of each pool as in the current study. Excluding the 1983 data, historical Secchi disc transparency data prior to 1992 (appendix B) were used to develop the summary in table 19. Each of the other water quality parameters will be evaluated in a similar manner.

Mean values observed for Secchi disc transparency at the nine stations in Wolf Lake were 129, 58, 75, 56, 79, 40, 38, 40, and 43 for RHA-1 through RHA-9, respectively. An examination of the data in tables 18-20 shows that Pool 1 has the highest (best) Secchi disc transparency among the pools at all times. The mean values of historical and current observed transparency for RHA-1 are nearly identical (tables 19 and 20). At stations RHA-2 and RHA-3, the mean values of current transparency data were greater than those of historical data (IEPA, 1984). These differences are attributable to differences in the water depths of sampling sites.

Higher transparencies occurred in May for the historical data (table 19) and during cold weather periods for the study data (table 20). The highest value, 188 inches, was recorded at RHA-1 on November 2, 1992. During this study, the lowest Secchi disc readings in different pools were obtained between mid-April and mid-October, generally coinciding with the period of high biological activity (algae and macrophytes) in the lake. Overall, the lowest Secchi disc transparency, 20 inches, occurred at RH-6 on September 28, 1993.

The IEPA's Lake Assessment Criteria state that Secchi depths less than 18 inches indicate substantial lake use impairment and depths between 18 and 48 inches indicate moderate lake use impairment (IEPA, 1978). The minimum recommended Secchi transparency set by the Illinois Department of Public Health for bathing beaches is 48 inches. Nevertheless, a lake that does not meet the transparency criteria does not necessarily constitute a public health hazard, as long as it is not used for swimming. The Indiana Stream Pollution Control Board (1973) has established that all waters of Wolf Lake should be maintained for whole body contact recreation and all waters of Wolf Lake Channel should be maintained for partial body contact recreation.

Significant spatial differences in water clarity (Secchi disc reading) were observed among the pools. The mean values for stations RHA-1 through RHA-5 (all in Illinois) were higher than 48-inches, generally indicating no lake use impairment based on transparency. Using the 48-inch visibility criteria for whole body contact recreation, stations RHA-6 through RHA-9 (all in Indiana) fall under the moderate lake use impairment category. Pool 8 is heavily used for whole body contact recreation. Twelve out of 16 (75 percent of) Secchi readings obtained during this study at RHA-8 were less than 48 inches. The average value for RHA-8 was 40 inches (appendix **B).**

Turbidity. Turbidity is an expression of the property of water that causes light to be scattered and absorbed by a turbidimeter, and it is expressed as nephelometric turbidity units (NTU). Turbidity in water is caused by colloidal and suspended matter, such as silt, clay, finely divided inorganic and organic materials, soluble colored organic compounds, and plankton and other microorganisms. Generally, turbidity in lake waters is influenced by sediment in runoff from the lake's watershed, shoreline erosion, algae in the water column, and resuspension of lake bottom sediments by wind or wave action, or by bottom-feeding fish, power boat, etc. Elevated turbidity values make the appearance of the lake less pleasing from an aesthetic standpoint.

Table 21 summarizes the historical data on turbidity and other water quality parameters for RHA-1 (surface), RHA-2 (surface and bottom), and RHA-3 (surface). These data are listed in appendix B and were collected during 1977, 1979, 1989, and 1991 under the ALMP by the IEPA. A statistical summary of turbidity data collected during this diagnostic study for all the stations is presented in table 22. During the current study, zero turbidity values were encountered in many samples in each of the nine lake stations. The highest turbidity was observed in Indian Creek (RHA 01) on November 12, 1992 (table 22). High turbidity in this shallow water body was

Table 21. Summary of Historical Water Quality Characteristics in Wolf Lake (Illinois)

Parameters	*RHA-1 Surface* Number of samples	Mean	Range	Standard deviation	*RHA-3 Surface* Number of samples	Mean	Range	Standard deviation
Turbidity, NTU	5	1	1-2	1	11	5.5	1-18	5.3
Conductivity, umho/cm^2	6	584	560-670	43	11	363	295-440	46
COD.mg/L	5	15	17-23	8.0	10	20.7	9-29	6.8
pH	6		7.60-8.60		11		8.30-9.00	
T. alkalinity, mg/L as $CaCO_3$	6	115	92-140	16	11	87	66-150	34
Total suspended solids, mg/L	6	4.5	2-9	2.5	12	8.9	1K-40	10.5
Volatile SS, mg/L	5	3.2	1-5	1.8	11	6.5	1K-24	6.6
Ammonia-nitrogen, mg/L	6	0.075	0.02-0.13	0.045	12	0.055	0.02-0.12	0.037
T. kjeldahl nitrogen, mg/L	5	0.58	0.50-0.70	0.08	11	0.71	0.5-1.5	0.28
Total phosphorus, mg/L	6	0.013	0.006-0.040	0.013	11	0.017	0.000-0.090	0.0086
Dissolved phosphorus, mg/L	4	0.0055	0.002-0.007	0.0024	11	0.0076	0.000-0.016	0.0041

Parameters	*RHA-2 Surface** Number of samples	Mean	Range	Standard deviation	*RHA-2 Bottom** Number of samples	Mean	Range	Standard deviation
Turbidity, NTU	12	6.7	3-15	4.5	8	7.0	4-16	4.0
Conductivity, umho/cm^2	12	386	280-860	156	8	406	291-830	175
COD, mg/L	10	20.7	12-32	6.6	7	24.0	14-33	6.4
pH	11		8.35-9.20		8		8.10-8.90	
T. alkalinity, mg/L as $CaCO_3$	12	91	70-140	22	8	94	65-140	26
Total suspended solids, mg/L	13	12.7	2-43	11.3	8	11.6	4-26	7.6
Volatile SS, mg/L	13	10.0	2-28	8.3	8	9.5	3-23	6.5
Ammonia-nitrogen, mg/L	13	0.045	0.01-0.14	0.041	8	0.049	0.00-0.13	0.049
T. kjeldahl nitrogen, mg/L	12	0.725	0.50-1.50	0.286	8	0.713	0.50-0.90	0.146
Total phosphorus, mg/L	13	0.0335	0.010-0.100	0.0276	8	0.0338	0.015-0.090	0.0244
Dissolved phosphorus, mg/L	12	0.0056	0.000-0.011	0.0031	8	0.0060	0.000-0.009	0.0037

Note:
* Surface = 1 foot below surface; Bottom = 2 feet above bottom

Table 22. Summary of Turbidity in Wolf Lake, 1992-1993

Station	*Sample**	*Maximum* *NTU*	*Maximum* *Date*	*Mean NTU*	*Standard deviation, NTU*
RHA-1	S	13	5/10/93	3	4
	B	4	11/12/92	1	1
RHA-2	S	14	9/28/93	3	4
	B	9	9/8/93	2	3
RHA-3	S	7	9/8/93	2	2
	B	7	8/4/93	2	2
RHA-4	S	14	9/8/93	3	4
	B	13	9/8/93	3	4
RHA-5	S	16	9/8/93	2	3
	B	9	9/8/93	2	3
RHA-6	S	17	8/4/93	4	4
RHA-7	S	16	8/4/93	5	6
RHA-8	S	13	9/8/93	4	4
	B	12	8/4/93	4	4
RHA-9	S	5	7/7/93 and 8/4/93	2	2
RHA 01	S	24	11/12/92	3	5

Note:
* S = 1 foot below surface; B = 2 feet above bottom

caused by a four-day continuous precipitation event prior to this date. For other lake stations, high turbidity readings were observed on either August 4 or September 8, 1993. The mean turbidity for each station was between 1 and 5 NTU. In terms of mean turbidity, there was no significant difference between surface and bottom samples at any given station.

For station RHA-1, high turbidity values were found on November 12, 1992 (4 NTU), for the near-bottom sample and on May 10, 1993 (13 NTU), for the surface sample. The cause of high turbidity in the May sample is unknown. Except for these two samples, other observations were comparable to the historical data (very low turbidity). At station RHA-2, current mean turbidity tends to be lower than the historical values for both surface and bottom waters. In comparison with historical data, surface turbidity at RHA-3 has improved (tables 21 and 22).

Chemical Characteristics

pH. The pH value, or hydrogen ion concentration, is a measure of the acidity of water; values below 7.0 indicate acidic water, and values above 7.0 indicate basic (or alkaline) water. A pH of 7.0 is exactly "neutral". pH values are influenced by the concentration of carbonate in water. One species of carbonate, carbonic acid, which forms as a result of dissolved carbon dioxide, usually controls pH to a great extent. Carbonic acid is also consumed by photosynthetic activity of algae and other aquatic plants after the free carbon dioxide in water has been used up. A rise in pH can occur due to photosynthetic uptake of carbonic acid, causing water to become more basic. Decomposition and respiration of biota tend to reduce pH and increase bicarbonates.

It is generally considered that pH values above 8.0 in natural waters are produced by a photosynthetic rate that demands more carbon dioxide than the quantities furnished by respiration and decomposition (Mackenthun, 1969). Although rainwater in Illinois is acidic (pH about 4.4), most of the lakes can offset this acidic input by an abundance of natural buffering compounds in the lake water and the watershed. Most Illinois lakes have a pH between 6.5 and 9.0. The IPCB (JEPA, 1990) general-use water quality standard for pH is also in a range between 6.5 and 9.0, except for natural causes.

Indiana Surface Water Quality Standards (IDEM, 1995) state that no pH values below 6.0 nor above 9.0, except for daily fluctuations which exceed pH 9.0 and are correlated with photosynthetic activity, shall be permitted.

The minimum and maximum pH values and their occurrence dates are shown in table 23. Low pH levels were generally found during cold weather periods with few exceptions. The lowest pH, 7.3, was observed at RHA-1 and RHA-9. The maximum pH for most stations occurred during July - September. The highest pH observed was 9.50 at RHA-4 (surface) on August 18, 1993. Elevated pH is attributable to photosynthesis during times of heavy algal activity. All pH values observed at the ten stations were above the minimum acceptable value of 6.5, as published in the General Use Water Standards for Illinois and in the Indiana Water Quality Standards for surface water. The upper limit of acceptable pH (9.0 in both Illinois and Indiana) was exceeded several times in all the pools except Pools 1 and 5.

Comparison of historical and current pH data (tables 21 and 23) shows that the current pH values at RHA-1 were similar to the historical values. Water samples from stations RHA-2 (surface and bottom) and RHA-3 (surface) showed wide ranges of pH during this study period, whereas no pH value below 8.0 had been reported for these sampling stations in the past.

Alkalinity. The alkalinity of a water is its capacity to accept protons, and it is generally imparted by bicarbonate, carbonate, and hydroxile components. The species makeup of alkalinity is a function of pH and mineral composition. The carbonate equilibrium, in which carbonate and

Table 23. Summary of pH and Total Alkalinity in Wolf Lake, October 1992 - September 1993

		pH				Total Alkalinity. me/L as $CaCO_3$					
		Minimum		*Maximum*		*Minimum*		*Maximum*			*Standard*
Station	*Sample**	*Value*	*Date*	*Value*	*Date*	*Value*	*Date*	*Value*	*Date*	*Mean*	*deviation*
RHA-1	S	7.38	2/10	8.75	8/18	98	9/28	180	12/21	109	19
	B	7.35	2/10	8.74	8/18	90	5/10	180	12/21	108	20
RHA-2	S	7.75	2/10	9.38	8/18	67	7/7	120	5/10	%	20
	B	7.70	2/10	8.95	8/4	72	7/7	118	5/10	97	17
RHA-3	S	7.70	11/12	9.30	8/18	72	7/20	121	12/21	97	17
	B	7.65	2/10	8.97	7/20	75	7/7,20	118	12/21	96	16
RHA-4	S	7.75	2/10	9.50	8/18	66	7/7	118	12/21	93	20
	B	7.68	2/10	9.1	7/20	67	7/7	120	5/10	96	20
RHA-5	S	7.77	2/10	8.84	8/18	73	6/9,22	98	3/16	85	8
	B	7.67	8/18	8.57	7/20	75	6/9	117	3/16	88	10
RHA-6	S	7.80	2/10	9.14	8/18	79	8/4	122	12/21	100	16
RHA-7	S	7.82	2/10	9.10	8/18	85	8/18	123	4/13	106	13
RHA-8	S	7.80	11/13	9.10	8/18	51	7/20	123	5/10	103	18
	B	7.68	8/18	8.95	9/8	89	8/18	122	3/17	107	12
RHA-9	S	7.38	8/4	8.45	5/10	94	6/9	120	3/17 & 4/13	112	7
RHA 01	S	7.55	2/10	9.42	8/18	71	7/19	119	12/21	95	17

Note:
* S = 1 foot below surface; B = 2 feet above bottom

bicarbonate ions and carbonic acid are in equilibrium, is the chemical system present in natural waters.

Alkalinity is a measure of water's acid-neutralizing capacity. It is expressed in terms of an equivalent amount of calcium carbonate ($CaCO_3$). Total alkalinity is defined as the amount of acid required to bring water to a pH of 4.5, and phenolphthalein alkalinity is measured by the amount of acid needed to bring water to a pH of 8.3 (APHA *et al.*, 1992).

Lakes with low alkalinity are, or have the potential to be, susceptible to acid rain damage. However, midwestern lakes usually have high alkalinity and thus are well buffered from the impacts of acid rain. Natural waters generally have a total alkalinity between 20 to 200 mg/L (APHA, era/., 1992).

Total Alkalinity. Table 23 shows the ranges and average total alkalinity for 16 locations in Wolf Lake. Overall, it ranged from a low of 51 mg/L as $CaCO_3$ in the RHA-8 surface sample on July 20, 1993, to a high of 180 mg/L as $CaCO_3$ in RHA-1 surface and bottom samples on December 21, 1992. The smallest range (73 to 98 mg/L as $CaCO_3$) was found at the RHA-5 surface. Low alkalinity was generally observed in summer, and higher alkalinity during cooler periods. Concomitant with an increase in pH due to active photosynthesis in summer was a significant decrease in alkalinity values in the lake. Mean total alkalinity in Wolf Lake ranged from 85 mg/L as $CaCO_3$ at RHA-5 (surface) to 112 mg/L as $CaCO_3$ at RHA-9 (surface). These waters were found to be well buffered, which is typical of lakes in this region. The mean total alkalinities at the surface and bottom waters for each pool were almost identical. Alkalinity values from historical (table 21) and current data (table 23) for RHA-1 (surface), RHA-2 (surface and bottom), and RHA-3 are comparable.

Phenophthalein Alkalinity. Phenophthalein alkalinity in lake waters was generally found only in low concentration during summers with high pH periods. The highest phenophthalein alkalinity observed was 11 mg/L as $CaCO_3$ at RHA-3 on August 18, 1993. Historical data show higher phenophthalein alkalinity at RHA-1, RHA-2, and RHA-3 than the current results (appendix **B).**

Conductivity. Specific conductance provides a measure of a water's capacity to convey electric current and is used as an estimate of the dissolved mineral quality of water. This property is related to the total concentration of ionized substances in water and the temperature at which the measurement is made. Specific conductance is affected by factors such as the nature of dissolved substances, their relative concentrations, and the ionic strength of the water sample. The geochemistry of the soils in the drainage basin is the major factor determining the chemical constituents in the waters. The higher the conductivity reading, the higher the concentration of dissolved minerals in the lake water. Practical applications of conductivity measurements include determination of the purity of distilled or deionized water, quick determination of the variations in dissolved mineral concentrations in water samples, and estimation of dissolved ionic matter in water samples.

It can be seen from table 24 that conductivity in Wolf Lake ranged from 320 micromhos per centimeter (umho/cm) at RHA-4 (surface) on June 20, 1993, to 640 umho/cm at RHA-1 (bottom) on May 10, 1993. The mean conductivity values for the lake water samples were between 373 umho/cm at RHA-9 and 545 umho/cm at the RHA-1 surface. (A high mean value was also observed at the RHA-1 bottom). These values are typical for northern Illinois lake waters and similar to those found in Herrick Lake, DuPage County, Illinois (Hill *et al.*, 1994). However, these values are much less than that reported for Lake George (712 umho/cm, Raman *et al.*, 1995) and higher than that in Lake Le-Aqua-Na and Johnson Sauk Trail Lake (Kothandaraman and Evans, 1983a, 1983b). The Illinois General Use Water Quality Standard for

Table 24. Summary of Conductivity in Wolf Lake, October 1992 - September 1993

		Minimum		*Maximum*		*Mean,*	*Standard deviation,*
Station	*Sample**	*µmho/cm*	*Date*	*µmho/cm*	*Date*	*µmho/cm*	*µmho/cm*
RHA-1	S	490	9/28	600	4/13	545	28
	B	370	9/28	640	5/10	528	68
RHA-2	S	336	9/8	470	5/10	395	37
	B	337	10/13	500	5/10	402	49
RHA-3	S	346	10/13	540	7/20	403	47
	B	346	10/13	470	5/10	398	36
RHA-4	S	320	6/22	470	5/10	386	44
	B	330	6/22	510	9/28	393	53
RHA-5	S	390	9/28	530	3/16	483	41
	B	370	9/28	530	3/16	498	40
RHA-6	S	337	10/13	590	4/13	408	71
RHA-7	S	331	10/13	490	4/13	394	46
RHA-8	S	324	10/13	450	4/13 & 5/10	384	44
	B	326	10/13	510	9/28	399	52
RHA-9	S	322	10/13	480	3/17	373	41

Note:
* S = 1 foot below surface; B = 2 feet above bottom

total dissolved solids is 1,000 mg/L, which is approximately equivalent to a conductivity of 1,700 μmho/cm. The obtained conductivity results did not exceed this criterion.

In comparing the historical and current data on conductivity for sampling sites RHA-1 (surface), RHA-2 (surface), and RHA-3 (surface), no significant change with time could be discerned.

The use of salt on the Indiana Toll Road for snow and ice removal in the area of Wolf Lake does not appear to have any long-term impact on Pools 6, 7, and 8. The toll road straddles the east side of Pool 8 and the west side of Pools 6 and 7. The average salt applications during the 1991-1992, 1992-1993, and 1993-1994 winter seasons were, respectively, 86.8, 150.0, and 167.5 tons (Samuel Wolfe, personal communication, September 14, 1994). The Department of Transportation's policy for salt usage on the Indiana Toll Road and Mr. Wolfe's correspondence are included in appendix F. The minimum observed conductivity values in these three pools were lower than the values for the other pools with the exception of Pool 9. The maximum observed and mean conductivity values observed in Pools 6, 7, and 8 were lower than those observed for Pool 1 and are very similar to the values observed for the other pools (table 24). Based on the conductivity observations, it can be concluded that road salt usage has had no long-term effect on Wolf Lake. No deleterious impact has been discerned in the lake system due to the application of road salt on the Indiana Toll Road.

Total Suspended Solids. Total suspended solids (TSS) are the portion of total solids retained by a filter ≤ 2.0 μm nominal pore size. Total solids is the term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at 103-105°C. Total solids include TSS and total dissolved solids, the portion that passes through the filter (APHA *et al.*, 1992).

Total suspended solids represent the amount of all inorganic and organic materials suspended in the water column. Typical inorganic components originate from the weathering and erosion of rocks and soils in a lake's watershed and from resuspension of lake sediments. Organic components are derived from a variety of biological origins, but in a lacustrine environment are mainly composed of algae and resuspended plant and animal material from the lake bottom.

Generally, the higher the TSS concentration, the lower the Secchi disc reading. A high TSS concentration results in decreased water transparency, which can reduce photosynthetic activities beyond a certain depth in the lake and subsequently decrease the amount of oxygen produced by algae, possibly creating anoxic conditions. Anaerobic water may limit fish habitats and potentially cause taste and odor problems by releasing noxious substances such as hydrogen sulfide, ammonia, iron, and manganese from the lake bottom sediments. A high concentration of TSS may also cause aesthetic problems in the lake.

The amount of suspended solids found in impounded waters is small compared with the amount found in streams because solids tend to settle to the bottom in lakes. However, in shallow lakes, this aspect is greatly modified by wind and wave actions and by the type and intensity of uses to which these lakes are subjected.

As shown in table 25, higher TSS occurred at RHA-1 on June 9, 1993, after a three-day storm event. However, the TSS in other RHA-1 samples were 4 mg/L or less. For other sampling stations, high TSS values were observed during summer months. The minimum TSS values were 1 mg/L or lower for all stations. The mean TSS values for all stations were 15 mg/L or less.

On the basis of Illinois Lake Assessment Criteria (IEPA, 1978), water with TSS > 25 mg/L is classified as having a high lake-use impairment, while TSS between 15 and 25 mg/L

Table 25. Summary of Suspended Solids in Wolf Lake, October 1992 - September 1993

		Total suspended solids. mg/L				*Volatile suspended solids. mg/L*			
		Maximum			*Standard*	*Maximum*			*Standard*
Station	*Sample**	*Value*	*Date*	*Mean*	*deviation*	*Value*	*Date*	*Mean*	*deviation*
RHA-1	S	53	6/9	6	13	6	6/9	2	1
	B	23	9/28	5	6	17	9/28	3	4
RHA-2	S	23	9/8	9	9	16	9/8	6	5
	B	21	7/20	8	6	17	7/20	5	5
RHA-3	S	29	8/4	8	8	18	9/28	5	5
	B	30	8/4	8	8	15	9/28	4	4
RHA-4	S	30	9/28	10	9	21	9/8	7	6
	B	32	9/28	12	10	23	9/8	8	7
RHA-5	S	30	9/28	7	8	22	9/28	4	6
	B	31	9/28	7	8	22	9/28	5	6
RHA-6	S	35	9/8	14	11	25	8/4	10	9
RHA-7	S	37	7/20	15	11	26	9/8	10	8
RHA-8	S	32	8/4	15	10	22	8/3	10	7
	B	37	9/8	15	11	26	9/8	9	7
RHA-9	S	36	9/28	8	8	23	9/28	5	6
RHA 01	S	20	7/19	7	5	16	7/19	4	4

Note:
* S = 1 foot below surface; B = 2 feet above bottom

indicates moderate use impairment. Water with TSS < 15 mg/L is considered to have minimal impairment. In this study, the number of samples that exceeded TSS levels of 25 mg/L were 1,1, 0, 0, 1, 1, 2, 3, 1, 1, and 0 at RHA-1 (surface and bottom), RHA-2 (surface and bottom), RHA-3 (surface and bottom), RHA-4 (surface and bottom), RHA-5 (surface and bottom), and RHA 01, respectively. At these same stations, the number of samples having TSS values between 15 and 25 mg/L were, respectively, 0, 0, 3, 2, 3, 2, 2, 3, 2, 1, and 1 (appendix B). On the basis of mean TSS concentrations, all the pools on the Illinois side can be considered to have minimal impairment.

The historical and current TSS values (tables 21 and 25) are similar for stations RHA-1 (surface), RHA-2 (bottom), and RHA-3 (surface). However, the historical TSS results were higher than current TSS values for station RHA-2 (surface).

Volatile Suspended Solids. Volatile suspended solids (VSS) are the portion of TSS lost to ignition at 500 ± 50° C. VSS represent the organic portion of TSS, such as phytoplankton, zooplankton, other biological organisms, and other suspended organic detritus. Resuspended sediments and other plant and animal matter resuspended from the lake bottom either by bottom-feeding fish, wind action, human activities, can be major contributors of VSS and TSS.

Volatile suspended solids levels in the surface and bottom samples at any given sampling site did not differ. Mean VSS ranged from a low of 2 mg/L at RHA-1 surface to 10 mg/L at RHA-6, RHA-7, and RHA-8 (table 25). Relatively high VSS in these pools might have been due to the abundance of macrophytes. The percentage of TSS composed of VSS ranged from 17 to 100 percent, with a majority of pools in the range of 40 to 70 percent.

Tables 21 and 25 reveal that the historical VSS values are comparable to the current VSS values for RHA-1 and RHA-3. Nevertheless, for both surface and bottom samples at RHA-2, current VSS values are approximately 40 percent lower than the historical values.

Phosphorus. The term total phosphorus (TP) represents all forms of phosphorus in water, both particulate and dissolved forms, and includes three chemical types: reactive, acid-hydrolyzed, and organic. Dissolved phosphorus (DP) is the soluble form of TP (filterable through a 0.45-um filter).

Phosphorus as phosphate may occur in surface water or ground water as a result of leaching from minerals or ores, natural processes of degradation, or agricultural drainage. Phosphorus is an essential nutrient for plant and animal growth and, like nitrogen, it passes through cycles of decomposition and photosynthesis.

Because phosphorus is essential to the plant growth process, it has become the focus of attention in the entire eutrophication issue. With phosphorus being singled out as probably the most limiting nutrient and the one most easily controlled by removal techniques, various facets of phosphorus chemistry and biology have been extensively studied in the natural environment. Any condition which approaches or exceeds the limits of tolerance is said to be a limiting condition or a limiting factor.

In any ecosystem, the two aspects of interest for phosphorus dynamics are phosphorus concentration and phosphorus flux (concentration times flow rate) as functions of time and distance. The concentration alone indicates the possible limitation that this nutrient can place on vegetative growth in the water. Phosphorus flux is a measure of the phosphorus transport rate at any point in flowing water.

Unlike nitrate-nitrogen, phosphorus applied to the land as a fertilizer is held tightly to the soil. Most of the phosphorus carried into streams and lakes from runoff over cropland will be in the particulate form adsorbed to soil particles. On the other hand, the major portion of phosphate-phosphorus emitted from municipal sewer systems is in a dissolved form. This is also true of phosphorus generated from anaerobic degradation of organic matter in the lake bottom. Consequently, the form of phosphorus, namely particulate or dissolved, is indicative of its source to a certain extent. Other sources of dissolved phosphorus in the lake water may include the decomposition of aquatic plants and animals. Dissolved phosphorus is readily available for algae and macrophyte growth. However, the DP concentration can vary widely over short periods of time as plants take up and release this nutrient. Therefore, TP in lake water is the more commonly used indicator of a lake's nutrient status.

From his experience with Wisconsin lakes, Sawyer (1952) concluded that aquatic blooms are likely to develop in lakes during summer months when concentrations of inorganic nitrogen and inorganic phosphorus exceed 0.3 and 0.01 mg/L, respectively. These critical levels for nitrogen and phosphorus concentrations have been accepted and widely quoted in scientific literature.

To prevent biological nuisance, the IEPA (1990), stipulates, "Phosphorus as P shall not exceed a concentration of 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more or in any stream at the point where it enters any reservoir or lake."

Total Phosphorus. Table 26 summarizes the data obtained for total and dissolved phosphorus in the lake, and figures 11-13 depict the temporal variations in phosphorus contents at RHA-2, RHA-6, RHA-8, and RHA-9. High TP values were generally observed in the summer, and low TP values in the winter. Mean TP concentrations were between 0.005 mg/L at RHA-1 (surface) and 0.038 mg/L at RHA-8 (bottom). Relatively high mean TP values were also found at RHA-7, RHA-8 (surface), and RHA-9. TP levels in the Illinois side of the lake were significantly lower than those in the Indiana side.

On the Illinois side, out of 187 surface and bottom lake samples collected during the study period, only two individual samples had a TP level greater than the 0.05 mg/L standard. The two samples were taken at RHA-5 (surface and bottom) on September 28, 1993 (appendix B). An examination of TP results in Tables 21 and 26 indicates that the historical TP concentrations for all four stations - RHA-1 (surface), RHA-2 (surface and bottom), and RHA-3 (surface) - were higher than the current results, indicating a water quality improvement.

In Indiana, 17 water samples were collected for TP analysis from each of five stations. An examination of TP data in appendix B shows that high TP levels occurred from May through October. TP standard is not stipulated in Indiana Environmental Rules: Water (Rules 327, IDEM, 1995).

Bell and Johnson (1990) reviewed the literature and stated the following:

> The phosphorus levels in Wolf Lake have been known to be a problem for some time. Tests conducted in the spring of 1974, while the lake was still in complete circulation from annual turnover, showed that the concentration of total phosphorus in the lake waters averaged 0.090 mg/L. In 1978, several studies conducted by Lever Brothers Company showed the average concentrations of phosphorus in the water column to be: 0.163 mg/L in May, 0.123 mg/L in October, and 0.147 mg/L in November. In 1980, a limnological survey of the lake conducted by the Indiana State Board of Health confirmed the high phosphorus readings. Concentrations of phosphorus at the surface of the lake ranged from 0.08 to 0.17 mg/L. However, two sampling stations showed phosphorus concentrations just above the lake bottom to exceed 0.35 mg/L in 1981. This would indicate that the lake sediments are serving as a possible source of phosphorus. Indeed, the sediment phosphorus concentration has

Table 26. Summary of Total and Dissolved Phosphorus in Wolf Lake, October 1992- September 1993

		Total phosphorus. mg/L						*Dissolved phosporus.+ mg/L*			
		Minimum		*Maximum*			*Standard*	*Maximum*			*Standard*
Station	*Sample**	*Value*	*Date*	*Value*	*Date*	*Mean*	*deviation*	*Value*	*Date*	*Mean*	*deviation*
RHA-1	S	.001	8/18	.010	5/26	.005	.003	.004	12/21	.001	.001
	B	.001	8/4,18	.039	9/28	.010	.009	.007	6/9	.002	.002
RHA-2	S	.007	1/19	.036	9/8	.018	.008	.005	9/8 & 10/13	.002	.001
	B	.005	9/28	.036	5/10	.020	.010	.005	1/19	.002	.001
RHA-3	S	.005	3/16	.036	9/28	.015	.009	.004	5/26	.002	.001
	B	.007	1/19	.033	9/28	.018	.008	.004	5/26	.002	.001
RHA-4	S	.006	1/19	.041	9/8	.021	.010	.004	5/26	.002	.001
	B	.009	2/10	.044	9/8	.025	.011	.005	6/9	.002	.001
RHA-5	S	.009	4/13	.058	9/28	.017	.012	.004	5/26	.002	.001
	B	.010	7/7	.055	9/28	.018	.011	.004	6/9 & 5/26	.002	.001
RHA-6	S	.012	12/21	.068	9/28	.029	.015	.007	9/28	.002	.002
RHA-7	S	.008	1/19	.061	8/4	.035	.017	.040	6/9	.004	.009
RHA-8	S	.013	1/20	.068	9/8	.033	.016	.018	9/28	.003	.004
	B	.010	2/10	.068	9/8	.038	.017	.006	5/26	.002	.001
RHA-9	S	.011	1/20	.064	6/9	.035	.018	.011	6/9	.003	.003
RHA 01	S	.008	1/19	.034	9/28	.016	.006	.010	6/23	.002	.002

Note:
* S = 1 foot below surface; B = 2 feet above bottom
+ Minimum concentration of dissolved phosphorus was 0.01 mg/L in one or more samples for all stations

been found to be extremely high; the 1980 study by the State Board of Health showed that total phosphorus concentrations in the sediment of the Lake Channel reached as high as 2,700 mg/kg. Wolf Lake is in almost constant violation of this standard (p. 13).

From the TP concentration values for Wolf Lake, it can be concluded that the lake (especially in Indiana) will not be limited by phosphorus in sustaining high biological productivity. The major portion of the lake is likely to remain eutrophic with high biological productivity.

Dissolved Phosphorus. The dissolved phosphorus (DP) results listed in appendix B indicate that many samples collected from each location have DP concentrations below the detectable limit of 0.001 mg/L. Thus, the percentage of DP to TP in samples is not determined, but it is generally very low. Observed DP levels were also generally low, especially in the Illinois portion of the lake. Most maximum DP values for sampling stations in Illinois were 0.004 and 0.005 mg/L (table 26). In Wolf Lake, the highest DP concentration observed was 0.040 mg/L at RHA-7 on June 9, 1993.

Mean DP concentrations for all stations except RHA-1 (surface) were between 0.002 and 0.004 mg/L. The mean DP for RHA-1 (surface) was 0.001 mg/L.

Nitrogen. Nitrogen is generally found in surface waters in the form of ammonia (NH3), nitrite (NO_2), nitrate (NO_3), and organic nitrogen. Organic nitrogen is determined by subtracting NH_3 nitrogen from the total kjeldahl nitrogen (TKN) measurements. Organic nitrogen content can indicate the relative abundance of organic matter (algae and other vegetative matter) in water, but has not been shown to be directly used as a growth nutrient by planktonic algae (Vollenweider, 1968). Total nitrogen is the sum of nitrite, nitrate, and TKN. Nitrogen is an essential nutrient for plant and animal growth, but it can cause algal blooms in surface waters and create public health problems at high concentrations. The Illinois Pollution Control Board (IEPA, 1990) has stipulated that nitrate not exceed 10 mg/L nitrate nitrogen or 1 mg/L nitrite nitrogen for public water-supply and food processing waters.

Nitrates are the end product of the aerobic stabilization of organic nitrogen, and as such they occur in polluted waters that have undergone self-purification or aerobic treatment processes. Nitrates also occur in percolating ground waters. Ammonia-nitrogen, being a constituent of the complex nitrogen cycle, results from the decomposition of nitrogenous organic matter. It can also result from municipal and industrial waste discharges to streams and lakes.

The concerns about nitrogen as a contaminant in water bodies are twofold. First, because of adverse physiological effects on infants and because the traditional water treatment processes have no effect on the removal of nitrate, concentrations of nitrate plus nitrite as nitrogen are limited to 10 mg/L in public water supplies. Second, a concentration in excess of 0.3 mg/L is considered sufficient to stimulate nuisance algal blooms (Sawyer, 1952). The IEPA (1990) stipulates that ammonia-nitrogen and nitrate plus nitrite as nitrogen should not exceed 1.5 and 10.0 mg/L, respectively.

Nitrogen is one of the principal elemental constituents of amino acids, peptides, proteins, urea, and other organic matter. Various forms of nitrogen (for example, dissolved organic nitrogen and inorganic nitrogen such as ammonium, nitrate, nitrite, and elemental nitrogen) cannot be used to the same extent by different groups of aquatic plants and algae.

Vollenweider (1968) reports that in laboratory tests, the two inorganic forms of ammonia and nitrate are, as a general rule, used by planktonic algae to roughly the same extent. However, Wang *et al.* (1973) reported that during periods of maximum algal growth under laboratory conditions, ammonium-nitrogen was the source of nitrogen preferred by planktons. In the case of higher initial concentrations of ammonium salts, yields were noted to be lower than with equivalent concentrations of nitrates (Vollenweider, 1968). This was attributed to the toxic effects of ammonium salts. The use of nitrogenous organic compounds has been noted by several investigators, according to Hutchinson (1957). However, Vollenweider (1968) cautions that the direct use of organic nitrogen by planktons has not been definitely established, citing that not one of 12 amino acids tested with green algae and diatoms was a source of nitrogen when bacteria-free cultures were used. But the amino acids were completely used up after a few days when the cultures were inoculated with a mixture of bacteria isolated from water. He has opined that in view of the fact that there are always bacterial fauna active in nature, the question of the use of organic nitrogen sources is of more interest to physiology than to ecology.

Ammonia Nitrogen. The statistical summary for ammonia (NH3) and TKN is shown in table 27, and temporal variations in these parameters for some stations are included in figures 11-14. Concentrations of NH3-N less than the detectable limit of 0.01 mg/L occurred in one or more samples at all the stations. Maximum NH3-N concentrations for most stations were less than 0.40 mg/L and were observed in samples from October - December 1992. The highest NH3-N concentration found was 0.89 mg/L at RHA-8 (bottom) on November 13, 1992. Even the highest observed value for NH3-N is much lower than the 1.5 mg/L considered critical for fish in terms of ammonia toxicity. Ammonia nitrogen contents in the surface and bottom samples for Pools 1 - 5 were practically the same.

The Illinois General Use Water Quality Standards for NH3-N vary according to water temperature and pH value, with the allowable concentration of NH3-N decreasing as temperature and pH rise. High water temperatures and higher pH of water increase the toxicity of NH3-N for fish and other aquatic organisms. The allowable concentration of NH3-N varies from 1.5 to 13.0 mg/L, depending on the temperature and pH values.

An examination of appendix B and tables 21 and 27 suggests that the ranges of NH3-N values for RHA-1 (surface), RHA-2 (surface and bottom), and RHA-3 (surface) in the current study were greater than the historical data. All mean values were comparable.

Regarding historical NH3-N in Wolf Lake in Indiana, Bell and Johnson (1990) state the following:

> The previous surveys cited show that NH3-N levels have been below 0.12 mg/L except in the vicinity of the bottom sediments where they can be as high as 0.90 mg/L. This is most likely due to high levels of nitrogen in the sediment, which, similar to phosphorus, may serve as a source for many years. Total nitrogen levels in the sediments are highest in the region of the lake channel where they have registered as high as 8,900 mg/kg (page 16).

Indiana Environmental Rule: Water (IDEM, 1995) sets ammonia standard as a function of pH and temperature. Under the conditions of pH 8.1 and temperature 20° C and above, the maximum ammonia limit and 24-hour average ammonia concentration are set at 0.2137 and 0.0294 mg/L of unionized ammonia as N, respectively. It corresponds to a total ammonia nitrogen of 4.260 and 0.583 mg/L, respectively. Inspection of table 27 reveals Pools 6-9 (0.38 to 0.74 mg/L) did not exceed the maximum limit. There was no 24-hour average data gathered to compare with standard. The annual mean ammonia concentrations were 0.11 to 0.14 mg/L for Pools 6-9.

Nitrate/Nitrite Nitrogen. Historical and current results of nitrate/nitrite nitrogen concentrations are included in appendix B, and their statistical summaries are shown in appendix C. Many samples from historical and current studies have nitrate and nitrite concentrations under the detectable level of 0.1 mg/L, especially during the warm weather period. For most stations, the concentrations of nitrate/nitrite nitrogen ranged from 0.0 to 0.4 mg/L with a mean of 0.1 mg/L

Table 27. Summary of Ammonia Nitrogen and Total Kjeldahl Nitrogen in Wolf Lake, October 1992 - September 1993

		Ammonia nitrogen.[+] *mg/L*				*Total kjeldahl nitroeen. mg/L*					
		Maximum			*Standard*	*Minimum*		*Maximum*			*Standard*
Station	*Sample**	*Value*	*Date*	*Mean*	*deviation*	*Value*	*Date*	*Value*	*Date*	*Mean*	*deviation*
RHA-1	S	0.38	10/13	0.05	0.09	0.1K	4/13	0.78	6/9	0.51	0.20
	B	0.37	10/13	0.06	0.09	0.28	7/20	0.94	6/22	0.58	0.19
RHA-2	S	0.36	10/13	0.07	0.09	0.32	7/20	0.93	6/9	0.63	0.20
	B	0.34	10/13	0.07	0.09	0.35	7/7	1.08	5/26	0.64	0.23
RHA-3	S	0.32	10/13	0.06	0.08	0.29	7/7	0.96	6/9	0.62	0.17
	B	0.26	10/13	0.06	0.08	0.20	2/10	0.90	5/26	0.64	0.18
RHA-4	S	0.33	10/13	0.08	0.09	0.35	7/20	0.99	5/26	0.65	0.23
	B	0.41	10/13	0.10	0.10	0.41	2/10	1.24	10/13	0.75	0.25
RHA-5	S	0.34	10/13	0.12	0.10	0.28	9/8	1.06	9/28	0.63	0.22
	B	0.35	7/7	0.13	0.10	0.26	7/7	1.08	5/26	0.64	0.23
RHA-6	S	0.38	12/21	0.11	0.13	0.1K	5/26	1.20	12/21	0.70	0.27
RHA-7	S	0.39	10/13	0.14	0.14	0.49	2/10	1.17	6/9	0.79	0.20
RHA-8	S	0.40	12/22	0.12	0.13	0.62	3/17	1.40	9/8	0.89	0.21
	B	0.89	11/13	0.17	0.23	0.47	7/7	1.28	5/26	0.83	0.22
RHA-9	S	0.74	11/13	0.13	0.19	0.29	1/20	1.10	6/9	0.65	0.27
RHA 01	S	0.77	11/13	0.10	0.17	0.28	2/10	0.82	5/26	0.38	0.14

Note:>
* S = 1 foot below surface; B = 2 feet above bottom
\+ Minimum concentration of ammonia nitrogen was less than the detectable level of 0.01 mg/L occurred in one or more samples for all stations
K = less than detection value

except at RHA-5 (surface and bottom) and RHA-9. At these three sites, the mean values were 0.2 mg/L. The ranges for RHA-1 (surface and bottom) were 0.0 mg/L to 0.2 mg/L.

Inorganic nitrogen (ammonia plus nitrate and nitrite nitrogen) concentrations in excess of 0.30 mg/L are known to stimulate nuisance algal blooms. For the surface samples at stations RHA-1 through RHA-9 and RHA 01, inorganic nitrogen exceeded 0.30 mg/L in one (6 percent), six (35 percent), seven (41 percent), six, eight (50 percent), six, six, six, seven, and six samples, respectively.

Total Kjeldahl Nitrogen. TKN was not detected in two samples: at RHA-1 (surface) on April 13, 1993, and at RHA-6 on May 26, 1993. Excluding these samples, TKN values found in Wolf Lake ranged from 0.2 mg/L at RHA-3 (bottom) on February 10, 1993 to 1.40 mg/L at RHA-8 (surface) on September 8, 1993 (table 27). Unlike NH3-N, which fluctuated with season, TKN levels in the lake varied without any pattern. Mean TKN ranged from 0.38 mg/L (RHA 01) to 0.89 mg/L (RHA-8 surface).

An examination of the NH3-N and TKN data reveals that suspended matter in the water column was predominantly of organic origin (algae, zooplankton, bacteria, plant fragments, etc.). Organic nitrogen constituted 74 to 90 percent of the TKN determined for the water samples.

In general, TKN concentrations measured during this study were lower than the historical results at RHA-1 (surface) and RHA-2 (surface and bottom) and higher at RHA-3 (surface) (appendix B and tables 21 and 27).

Chemical Oxygen Demand. When organic material decomposes within a lake's water column, the feeding bacteria consume oxygen. Thus, the concentration of DO in the water may be reduced significantly if the amount of decomposing organic material is large. The measurement of the amount of oxygen consumed by these bacteria is termed biochemical oxygen demand (BOD). A less costly substitute for monitoring DO trends is to test for chemical oxygen demand (COD). Rather than directly measuring the amount of oxygen consumed by bacteria, COD tests measure the amount of potassium dichromate required to completely oxidize the organic materials present in the water. COD represents the amount of oxygen needed to oxidize all the oxidizable organic and inorganic constituents (biota and other organic matter, iron, manganous compounds, ammonia, etc.) under specified conditions. It is an indirect but efficient method of assessing the BOD exerted on the oxygen resources of the water body under ambient conditions.

COD values are generally higher than BOD values, because COD may indicate the presence of materials that are not biologically degradable (inorganic nitrogen, metals, etc.). However, higher BOD or COD indicate greater potential for depletion of DO.

Results in table 28 indicate that COD levels at 16 sampling stations in the lake ranged from 8 mg/L at three locations to 46 mg/L at RHA-9 on August 4, 1993. Low COD concentrations occurred in the winter (January 1993), and high COD concentrations in late summer (August and September 1993). The mean COD concentrations were found to be in a narrow range between 15 and 19 mg/L.

These COD values were much lower than those in Lake George in Lake County, IN. A diagnostic-feasibility study of Lake George was carried out concomitantly with this investigation.

The mean COD values for the north and south basins of Lake George were 31 and 58 mg/L, respectively, ranging from 1 to 65 mg/L and 22 to 200 mg/L. The COD of the two water samples collected in the south basin at the beginning of the investigation (October and November 1992) was very high - 200 and 133 mg/L, respectively - compared to that of the other samples,

Table 28. Summary of Chemical Oxygen Demand in Wolf Lake, October 1992 - September 1993

		Minimum		*Maximum*			*Standard*
Station	*Sample**	*mg/L*	*Date*	*mg/L*	*Date*	*Mean, mg/L*	*deviation. mg/L*
RHA-1	S	14	6 dates	17	10/13,4/13,8/18	15	1
	B	13	10/21	25	9/28	17	3
RHA-2	S	9	1/19	25	9/28	16	4
	B	10	1/19	27	9/28	16	4
RHA-3	S	11	12/21,6/9	25	9/28	16	5
	B	10	1/19	24	9/28	16	4
RHA-4	S	9	12/21, 1/19	30	9/8	17	6
	B	10	1/19,2/10	31	9/8	17	6
RHA-5	S	12	12/21, 1/9,8/18	28	9/28	15	4
	B	10	1/19	24	8/28	16	4
RHA-6	S	8	1/19	27	8/4	17	6
RHA-7	S	10	1/19	28	9/28	19	6
RHA-8	S	8	1/20	28	9/28	19	6
	B	8	1/20	29	9/8	18	6
RHA-9	S	6	1/20,2/10	46	8/4	18	12
RHA 01	S	10	1/19	23	9/28	16	4

Note:
* S = 1 foot below surface; B = 2 feet above bottom

which had COD ranging from 22 to 70 mg/L. In the north basin, COD in samples ranged from 11 to 65 mg/L, except for two samples collected on June 10, 1993, and September 18, 1993, which showed values of 2 mg/L and less (Raman *et al.,* 1995).

Under its lake assessment criteria, the EEPA (1978) considers that COD values greater than 30 mg/L indicate a high degree of "organic enrichment," while values between 20 and 30 mg/L indicate moderate enrichment. RHA-1 (surface) can be classified as having minimal organic enrichment for all dates. On the basis of mean COD, all other sampling locations in Illinois can also be considered as having minimal enrichment, although one sample taken from RHA-4 (bottom) on September 8, 1993, was 31 mg/L. In fact, one (6 percent), three (18 percent), three, three, four (24 percent), four, four, three, and three samples, respectively, collected from RHA-1 (bottom), RHA-2 (surface and bottom), RHA-3 (surface and bottom), RHA-4 (surface and bottom), and RHA-5 (surface and bottom) have COD levels between 20 and 30 mg/L. No difference in COD concentration was noted between the surface and bottom samples where such measurements were made.

A comparison of current COD values with the historical data indicates that they are identical for RHA-1 (surface); and lower for RHA-2 (surface and bottom), and for RHA-3 (appendix B, tables 21 and 28).

Chlorophyll. All green plants contain chlorophyll *a*, which constitutes approximately one to two percent of the dry weight of planktonic algae (APHA *et al.,* 1992). Other pigments that occur in phytoplankton include chlorophyll *b* and *c,* xanthophylls, phycobilius, and carotenes. The important chlorophyll degradation products in water are the chlorophyllides, pheophorbides, and pheophytines. The concentration of photosynthetic pigments is used extensively to estimate phytoplanktonic biomass. The presence or absence of the various photosynthetic pigments is used, among other features, to identify the major algal groups present in the water body.

Chlorophyll α is a primary photosynthetic pigment in all oxygen-evolving photosynthetic organisms. Extraction and quantification of chlorophyll *a* can be used to estimate biomass or the standing crop of planktonic algae present in a body of water. Other algae pigments, particularly chlorophyll *b* and *c*, can give information on the type of algae present. Blue-green algae (Cyanophyta) contain only chlorophyll *a*, while both the green algae (Chlorophyta) and the euglenoids (Euglenophyta) contain chlorophyll *α* and *c*. Chlorophyll *a* and *c* are also present in the diatoms, yellow-green and yellow-brown (Chrysophyta), as well as dinoflagellates (Pyrrhophyta). These accessory pigments can be used to identify the types of algae present in a lake. Pheophytin *a* results from the breakdown of chlorophyll a, and a large amount indicates a stressed algal population or a recent algal die-off. Because direct microscopic examination of water samples was used to identify and enumerate the type and concentrations of algae present in the water samples, the indirect method of making such assessments was not employed in this investigation.

The observed, mean, and range of values for chlorophyll *a* and other pigments are given in table 29. The mean concentrations of chlorophyll *a* in the nine water bodies (RHA-1 to RHA-9) were 3.69, 11.57, 8.77, 12.01, 8.66, 17.15, 24.49, 28.02, and 12.52 μg/L, respectively. Higher chlorophyll concentrations were observed in the Indiana portion of Wolf Lake, especially in Pools 6, 7, and 8, than in the other pools in the lake system. Chlorophyll concentrations in most Wolf Lake pools were higher than those in nearby Lake George. The mean concentration of chlorophyll *a* in the north basin of Lake George was 5.32 μg/L and ranged from 0.90 to 15.5 μg/L; values in the south basin had a mean of 10.95 μg/L and ranged from 3.00 to 48.3 μg/L (Raman *et al.,* 1995). The highest chlorophyll *a* concentration of 63.55 μg/L was found in Pool 8 on July 20, 1993, while Pool 9 had the lowest chlorophyll *a,* 0.00 μg/L on January 19, 1993. Nevertheless, the chlorophyll *a* concentrations observed in Wolf Lake are typical of Midwestern lakes.

Table 29. Chlorophyll Concentrations in Wolf Lake, October 1992 - September 1993

	RHA-1				*RHA-2*				*RHA-3*			
Date	*Cha*	*Chb*	*Che*	*Pha*	*Cha*	*Chb*	*Che*	*Pha*	*Cha*	*Chb*	*Che*	*Pha*
10/13/92	2.51	0.49	0.00	0.00	10.68	1.32	0.00	0.00	6.41	1.06	0.00	0.00
11/12/92	2.14	0.49	0.04	0.10	6.94	0.58	0.91	0.00	3.74	0.41	0.00	0.37
12/21/92	1.60	0.35	0.42	0.00	6.94	0.48	1.16	0.00	7.48	0.83	1.22	0.00
1/19/93	3.20	0.75	1.36	0.00	7.48	1.46	0.85	0.00	6.41	1.21	0.83	0.00
2/10/93	5.34	0.82	0.53	0.00	7.48	0.99	0.00	0.00	6.41	1.01	0.03	0.00
3/16/93	8.01	1.92	0.93	0.00	7.48	1.57	0.88	0.00	5.87	0.80	0.25	0.00
5/10/93	2.67	0.12	0.00	0.00	10.15	0.00	0.00	0.00	6.41	0.00	0.25	0.00
5/26/93	6.94	1.21	0.00	0.00	13.35	1.13	0.13	0.00	6.94	1.05	1.28	0.00
6/9/93	4.27	1.29	0.91	0.21	22.43	1.94	0.77	0.00	8.01	1.19	0.25	0.00
6/22/93	3.20	0.00	0.00	0.00	9.08	0.00	0.22	0.00	6.94	0.42	0.00	0.00
7/7/93	2.14	0.00	0.12	0.85	9.61	0.22	0.24	0.00	9.61	0.71	0.00	0.00
7/20/93	3.20	0.26	0.70	0.16	12.82	0.86	0.55	0.00	10.15	0.49	0.83	0.00
8/3/93	3.74	0.00	0.00	0.00	22.03	0.08	0.59	0.00	19.76	0.44	0.48	0.00
8/18/93	2.67	0.00	0.12	0.00	15.49	0.00	0.49	0.00	18.69	0.51	0.27	0.00
Mean	3.69	0.55	0.37	0.09	11.57	0.76	0.49	0.00	8.77	0.72	0.41	0.03
Minimum	1.60	0.00	0.00	0.00	6.94	0.00	0.00	0.00	3.74	0.00	0.00	0.00
Maximum	8.01	1.92	1.36	0.85	22.43	1.94	1.16	0.00	19.76	1.21	1.28	0.37
Standard deviation	1.87	0.59	0.45	0.23	5.21	0.66	0.39	0.00	4.70	0.36	0.45	0.10

	RHA-4				*RHA-5*				*RHA-6*			
Date	*Cha*	*Chb*	*Che*	*Pha*	*Cha*	*Chb*	*Che*	*Pha*	*Cha*	*Chb*	*Che*	*Pha*
10/13/92	9.61	1.44	0.00	0.00	10.68	2.37	0.00	0.00	6.41	0.98	0.00	2.00
11/12/92	5.34	0.34	0.16	0.00	5.87	0.70	0.22	0.00	13.35	1.64	0.45	0.00
12/21/92	5.87	0.70	1.23	0.00	4.27	0.56	1.24	0.00	8.54	1.23	1.51	0.00
1/19/93	8.01	2.23	1.76	0.00	4.27	0.61	0.75	0.00	13.88	2.62	3.18	0.00
2/10/93	7.48	1.10	0.79	0.00	5.87	0.60	0.47	0.00	10.15	1.88	1.09	0.32
3/16/93	5.87	1.95	0.49	0.85	3.20	0.53	0.28	0.00	9.08	1.39	1.05	0.00
5/10/93	4.27	0.00	0.00	0.00	4.27	0.26	0.70	0.00	19.76	0.93	1.14	0.00
5/26/93	13.35	1.60	1.23	0.00	6.94	1.04	0.00	0.91	5.87	1.06	0.55	0.00
6/9/93	21.36	2.31	1.11	0.00	9.61	0.19	0.29	0.00	18.16	0.81.	0.42	0.00
6/22/93	12.82	0.14	0.16	0.00	7.48	0.26	0.08	0.00	11.75	0.16	0.44	0.00
7/7/93	14.95	0.62	0.00	0.00	8.54	0.49	0.83	0.00	24.03	1.59	0.10	0.00
7/20/93	13.35	0.84	0.99	0.00	12.28	1.49	0.18	0.00	26.70	1.90	1.32	0.00
8/3/93	27.23	0.64	0.77	0.00	19.22	1.19	0.43	0.00	39.31	0.17	0.22	0.00
8/18/93	18.69	0.40	0.24	0.00	18.69	1.30	0.46	0.00	33.11	1.42	1.06	0.00
Mean	12.01	1.02	0.64	0.06	8.66	0.83	0.42	0.07	17.15	1.27	0.90	0.17
Minimum	4.27	0.00	0.00	0.00	3.20	0.19	0.00	0.00	5.87	0.16	0.00	0.00
Maximum	27.23	2.31	1.76	0.85	19.22	2.37	1.24	0.91	39.31	2.62	3.18	2.00
Standard deviation	6.79	0.77	0.57	0.23	5.10	0.60	0.35	0.24	10.29	0.67	0.81	0.53

Note: Ch *a* = chlorophyll *a;* Ch *b* = chlorophyll *b;* Ch *c* - chlorophyll c; Ph *a* = pheophytin *a*

Table 29. Concluded

Date	RHA-7				RHA-8				RHA-9			
	Cha	*Chb*	*Che*	*Pha*	*Ch a*	*Chb*	*Che*	*Pha*	*Ch a*	*Chb*	*Che*	*Pha*
10/13/92	19.22	2.13	0.00	0.00	30.66	1.77	0.00	0.00	4.45	0.45	0.00	0.00
11/12/92	11.21	1.24	0.16	0.00	16.02	1.86	0.91	0.00	2.14	0.27	0.00	0.85
12/21/92	5.87	0.81	1.26	0.00	8.54	1.60	1.85	0.00	1.07	0.65	0.60	1.17
1/19/93	0.53	0.46	0.09	0.21	17.09	2.35	3.99	0.00	0.00	0.52	0.61	0.75
2/10/93	16.02	2.64	1.10	0.00	19.76	2.91	2.81	0.00	3.20	0.44	0.53	0.00
3/16/93	14.95	2.18	1.01	0.00	12.28	1.86	1.53	0.00	5.87	0.86	0.00	0.00
5/10/93	35.78	1.55	1.05	0.00	18.16	0.85	0.66	0.00	10.88	0.59	0.58	0.00
5/26/93	20.83	1.53	1.21	0.00	21.89	1.53	1.21	0.00	13.88	1.68	0.69	0.00
6/9/93	30.97	1.25	1.12	0.00	35.78	1.56	0.32	0.00	12.28	0.67	0.04	0.00
6/22/93	21.89	0.76	0.29	0.00	24.56	0.08	0.54	0.00	25.10	2.57	0.80	0.00
7/7/93	41.65	2.32	1.45	0.00	44.86	2.86	1.00	0.00	37.38	2.87	1.51	0.00
7/20/93	51.26	3.24	1.40	0.00	63.55	3.87	1.21	0.00	17.09	2.83	0.60	0.00
8/3/93	45.39	1.70	0.63	0.00	46.46	1.40	1.06	0.00	18.69	1.13	1.48	0.93
8/18/93	27.23	0.87	0.10	0.00	32.57	1.20	1.00	0.00	23.50	4.78	1.08	0.00
Mean	24.49	1.62	0.78	0.02	28.01	1.84	1.29	0.00	12.52	1.45	0.61	0.26
Minimum	0.53	0.46	0.00	0.00	8.54	0.08	0.00	0.00	0.00	0.27	0.00	0.00
Maximum	51.26	3.24	1.45	0.21	63.55	3.87	3.99	0.00	37.38	4.78	1.51	1.17
Standard deviation	15.02	0.80	0.54	0.06	15.39	0.94	1.03	0.00	10.93	1.33	0.50	0.44

Note: Cha = chlorophylls; ChA = chlorophyll*b*\ Che = chlorophyllc; Pha = pheophytina

Chlorophyll *b* and *c* and pheophytin *a* in the lake were found to be generally low, below 4.8 µg/L. For many samples at each station, no pheophytin *a* was found (table 29).

Metals. On August 4, 1995, surface and bottom water samples were taken for metals and organic analyses from nine regular lake sampling locations and Indian Creek. The results of 21 metals analyses for those samples and a field blank are presented in table 30. At all stations, concentrations of beryllium, cadmium, lead, nickel, silver, and zinc were found to be less than the detectable values. Aluminum, chromium, cobalt, copper, and vanadium were below detectable limits for most of the samples. Unexpectedly, the nickel concentration in the field blank was 19 µg/L, which was higher than any lake water sample.

The IPCB (IEPA, 1990) stipulated the chemical constituents for secondary contact and indigenous aquatic life standards as follows: arsenic, 1,000 µg/L; barium, 5,000 µg/L; cadmium, 150 µg/L; chromium, 1,000 µg/L; copper, 1,000 µg/L; iron, 2,000 µg/L; lead, 100 µg/L; manganese, 1,000 µg/L; silver, 1,100 µg/L; and zinc, 1,000 µg/L. The metal contents of Wolf Lake water samples were much lower than these standards.

According to Bell and Johnson (1990), the IDEM analyzed surface water in 1966 for metal concentrations at the State Line Road culvert monthly. Metals concentrations are usually below detection limits and are even within drinking water standards. The USEPA STORET database contains information on metal concentrations in Wolf Lake in Illinois for 1977, 1979, and 1989. None of the metals exceeded the general use standards.

Organics Table 31 presents the results of analyses for 19 organic constituents in Wolf Lake samples collected on August 4, 1993. It can be seen that the concentrations of each organic constituent examined were below the laboratory detectable level for all samples.

Biological Characteristics

Indicator Bacteria. Pathogenic bacteria, pathogenic protozoan cysts, and viruses have been isolated from wastewaters and natural waters. The sources of these pathogens are the feces of humans and of wild and domestic animals. Identification and enumeration of these disease-causing organisms in water and wastewater are not recommended because no single technique is currently available to isolate and identify all the pathogens. In fact, concentrations of these pathogens are generally low in water and wastewater. In addition, the methods for identification and enumeration of pathogens are labor intensive and expensive.

Instead of direct isolation and enumeration of pathogens, total coliform (TC) has long been used as an indicator of pathogen contamination of a water that poses a public health risk. Fecal coliform (FC), which is more fecal-specific, has been adopted as a standard indicator of contamination in natural water in Illinois, Indiana, and many other states. Both TC and FC are used in standards for drinking water and natural waters. Fecal streptococcus (FS) is used as a pollution indicator in Europe. FC/FS ratios have been employed for identifying pollution sources in the United States. Fecal streptococci are present in the intestines of warm-blooded animals and of insects, and they are present in the environment (water, soil, and vegetation) for long periods of time.

The Illinois Department of Public Health (IDPH) has promulgated the indicator bacteria standards for recreational-use waters as follows:

- A beach will be posted "Warning - Swim At Your Own Risk" when bacterial counts exceed 1,000 TC per 100 mL or 100 FC per 100 mL.

Table 30. Metal (Total) Concentrations in Wolf Lake Waters, August 4, 1993

	RHA-1		*RHA-2*		*RHA-3*		*RHA-4*		*RHA-5*		*RHA-6*	*RHA-7*	*RHA-8*		*RHA-9*	*RHA01*	*Field*
*Metal**	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*S*	*S*	*B*	*S*	*S*	*Blank*
Aluminum	100K	100K	100K	270	100K	100K	200	100	260	350	100K	100K	100K	130	100K	100K	100K
Arsenic	1.0	1K	3.7	2.5	2.5	1.6	2.8	4.0	4.2	2.2	1K	2.0	1K	1.0	1.0	3.2	1K
Barium	54	54	28	33	28	28	29	26	39	40	28	27	26	34	26	25	6
Beryllium	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K
Boron	460	460	140	140	140	140	140	130	180	170	51	39	28	37	10K	130	10K
Cadmium	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K
Calcium, mg/L	41	41	23	25	24	24	24	23	46	46	25	28	30	32	38	23	2.4
Chromium	5K	5K	5K	5K	5K	5K	5K	5K	5K	6	5K	5K	5K	5K	5K	5K	5K
Cobalt	5K	5	5K	5K	5K	5K	5K	5K	5K	5	5K	5K	5K	5K	5K	5K	5K
Copper	9	7	5K	5K	8	5K	5K	5K	5K	5K	5K	6	5K	5K	5K	7	5K
Iron	50K	50K	120	65	89	120	140	170	110	330	150	250	250	360	340	77	50K
Lead	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K	50K
Magnesium, mg/L	20	20	12	12	11	11	11	11	8	8	11	11	11	11	11	11	0.8
Manganese	29	30	120	180	150	150	130	130	160	180	130	120	100	120	59	110	15K
Nickel	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	19
Potassium, mg/L	13	12	4.4	4.2	3.6	3.6	2.9	2.9	11	11	2.1	2.2	2.3	2.3	1.7	3.6	1.0K
Silver	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K
Sodium, mg/L	35	36	35	35	29	29	28	28	41	40	26	25	23	24	14	29	47
Strontium	220	220	140	140	140	130	130	130	220	210	130	130	130	130	130	130	27
Vanacium	5K	5K	5K	5K	5K	5K	5K	5K	6	8	5K	5K	5K	5K	5K	5K	5K
Zinc	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K	100K

Notes: S = surface samples collected 1 foot from surface
B = bottom samples collected 2 feet from lake bottom
K = less than detection value

* All metals in μg/L, except where noted otherwise.

Table 31. Organic Concentrations in Wolf Lake, August 4, 1993

Organic, mg/L	*RHA-1* S	B	*RHA-2* S	B	*RHA-3* S	B	*RHA-4* S	B	*RHA-5* S	B	*RHA-6* S	*RHA-7* S	*RHA-8* S	B	*RHA-9* S	*RHA01* S	*Field blank*	*(11/30/93) 1 3*
Aldrin	.01k	.01k	01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	.01k	.01k	.01k	01k	01k	.01k	01k
Alpha-BHC	.01k	.01k	.01k	01k	.01k	.01k	.01k	01k	01k	01k	.01k	01k	01k	01k	.01k	.01k	.01k	01k
Gamma-BHC (lindane)	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	.01k	.01k	.01k	01k	.01k	01k
Chlordane, CIS isomer	01k	.01k	01k	.01k	01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k
Chlordane, trans isomer	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	.01k	01k	.01k	.01k	01k	.01k	.01k	01k
Chlordane, total	.02k	.02k	.02k	.02k	.02k	.02k	02k	.02k	.02k	.02k	02k	.02k	.02k	.02k	.02k	02k	.02k	02k
O.P'-DDD	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	01k	.01k	.01k	01k	.01k	.01k	01k	.01k	01k	.01k
P.P'-DDD	.01k	.01k	01k	01k	.01k	.01k	01k	.01k	.01k	.01k	.01k	.01k	01k	01k	.01k	01k	.01k	.01k
O.P'-DDE	.01k	01k	01k	01k	.01k	01k	01k	.01k	.01k	.01k	01k	.01k	.01k	.01k	.01k	01k	01k	.01k
P.P'-DDE	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k
0,P'-DDT	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k
P.P'-DDT	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	01k	.01k	.01k	.01k	.01k	.01k	.01k
Total DDT	01k	.01k	01k	01k	01k	01k	01k	.01k	.01k	.01k	01k	01k	.01k	.01k	.01k	01k	01k	.01k
Dieldrin	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	01k	.01k	.01k	.01k	.01k	01k	.01k	.01k
Endrin	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k
Hexachlorobenzene	.01k	.01k	.01k	01k	.01k	.01k	01k	.01k	.01k	.01k	01k	01k	.01k	.01k	.01k	01k	01k	01k
Methoxychlor	.05k	.05k	.05k	.05k	.05k	.05k	.05k	.05k	.05k	.05k	05k	.05k	.05k	.05k	.05k	.05k	.05k	.05k
PCBs-total	01k	.01k	01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k
Pentachlorophenol	.01k	.01k	.01k	01k	.01k	.01k	.01k	.01k	.01k	.01k	.01k	.10k	.01k	.01k	.01k	.01k	.01k	01k

Note: S = surface samples collected 1 foot from surface
B = bottom samples collected 2 feet from lake bottom
k = less than detection value

- A beach will be closed when bacterial densities exceed 5,000 TC per 100 mL or 500 FC per 100 mL in water samples collected on two consecutive days.

The Illinois Pollution Control Board has adopted rules regarding FC limits for general-use water quality standards applicable to lakes and streams. The rules of Section 302.209 are (IEPA, 1990):

a. During the months May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliforms (STORET number 31616) shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10 percent of the samples during any 30-day period exceed 400 per 100 mL in protected waters. Protected waters are defined as water that, due to natural characteristics, aesthetic value, or environmental significance, are deserving of protection from pathogenic organisms. Protected waters must meet one or both of the following conditions:

    1) They presently support or have the physical characteristics to support primary contact.

    2) They flow through or adjacent to parks or residential areas.

The IDEM (1995) stipulates (Title 327) that for recreational uses, bacteriological quality during April - October should be such that *Escherichia coli (E. coli)* bacteria shall not exceed 125 per 100 mL (using a membrane filter method) as a geometric mean based on not less than five samples equally spaced over a 30-day period, nor shall it exceed 235 per 100 mL in any one sample in a 30-day period.

Tables 32 and 33 present the indicator bacteria analyses results from the monthly in-lake monitoring in Wolf Lake and periodic sampling in its tributaries and other specific locations. All sampling locations are plotted in figure 8. Bacterial quality in Wolf Lake was generally found to be excellent except in Wolf Lake Channel.

Excluding RHA-9, the highest TC density was 1,900 per 100 mL at RHA-8 on November 12, 1992; almost all samples had TC less than 100 per 100 mL. In addition, FC and FS were not detected in many samples (table 32).

For the five pools (RHA-1 to RHA-5) and at RHA 01 in Illinois, the FC results obtained during the one-year monitoring period could not be evaluated with the IPCB's moving geometric mean standard. (A five-sample minimum was not collected over the prescribed 30-day period). It is believed, however, that the bacterial quality in Wolf Lake's Illinois pools would meet the IPCB's standard (200 FC/100 mL). On the basis of in-lake FC density, no violation of the 400 FC/100 mL limit occurred in five Illinois pools.

No *E. coli* enumerations were made; therefore bacterial quality in the Indiana side of Wolf Lake could not be evaluated with the EDEM's *E. coli* standards

An examination of the data in table 32 shows that FC counts at RHA-9 in Wolf Lake Channel varied widely and had a yearly geometric mean of 260 per 100 mL. However, 42 percent (5 out of 12) of the samples exceeded 2,000 FC per 100 mL; only ten percent of the samples are allowed to exceed this limit. Poor bacterial quality and violations at RHA-9 could be traced to high bacterial counts at RHA 02 (discharge from Lever Brothers Company), RHA 03 (Roby pumping station), and RHA 04 (Forsythe Park pumping station) (table 33, figure 8).

Table 32 also shows that the Wolf Lake outlet (RHA 01) had good bacterial quality and should meet the IPCB's ambient bacteria standard.

Table 32. Indicator Bacterial Densities in Wolf Lake

	RHA-1			*RHA-2*		
Date	*TC*	*FC*	*FS*	*TC*	*FC*	*FS*
10/13/92	21	2	1	12	nd	nd
11/12/92	1	nd	nd	170	23	15
12/21/92	2	nd	nd	8	1	nd
1/19/93	2	nd	nd	1	nd	nd
2/10/93	24	4	1	33	3	nd
3/16/93	14	1	nd	14	<1	nd
4/10/93	16	1	1	4	nd	3
5/9/93	2	<1	<1	5	1	<1
6/9/93	100	33	37	53	26	13
7/7/93	6	2	2	68	20	25
8/4/93	2		1 1	8	4	< 1
9/8/93	5	3	1	13	2	<1
10/27/93	11	4	2	6	2	<1

	RHA-3			*RHA-4*		
Date	*TC*	*FC*	*FS*	*TC*	*FC*	*FS*
10/13/92	10	nd	7	17	2	4
11/12/92	36	3	10	34	8	21
12/21/92		(bottle broken)		9	1	nd
1/19/93	2	nd	nd	10	nd	nd
2/10/93	19	3	<1	50	2	nd
3/16/93	15	nd	nd	40	1	<1
4/10/93	1 4	1	5	4		1 3
5/9/93	5	2	nd	10	3	2
6/9/93	24	16	7	62	30	24
7/7/93	3	2	2	30	10	19
8/4/93	13	4	1	70	25	nd
9/8/93	9	2	<1	15	4	2
10/27/93	11	3	<1	4	2	nd

	RHA-5			*RHA-6*		
Date	*TC*	*FC*	*FS*	*TC*	*FC*	*FS*
10/13/92	19	2	6	10	3	6
11/12/92	14	6	9	20	6	20
12/21/92	31	nd	nd	5	2	1
1/19/93	4	nd	nd	2	nd	nd
2/10/93	48	13	nd	26	12	nd
3/16/93	20	1	1	30	nd	nd
4/10/93	2		1 2	2 0	2	1
5/9/93	4	<1	nd	10	3	nd
6/9/93	53	36	5	30	20	1
7/7/93	28	15	13	16	6	4
8/4/93	8	2	1	6	2	nd
9/8/93	4		1 1	9	2	< 1
10/27/93	3	1	nd	7	2	nd

Table 32. Concluded

Date	RHA-7 TC	RHA-7 FC	RHA-7 FS	RHA-8 TC	RHA-8 FC	RHA-8 FS
10/13/92	50	10	9	20	4	4
11/12/92	98	6	13	1,900	46	20
12/21/92	16	nd	1	70	2	nd
1/19/93	8	nd	nd	2	nd	nd
2/10/93	82	9	nd	10	6	nd
3/16/93	16	1	nd	34	2	1
4/10/93	11	<1	2	45	<1	2
5/9/93	12	1	nd	8	<1	<1
6/9/93	1,800	480	37	540	88	37
7/7/93	130	20	60	55	10	10
8/4/93	34	20	1	32	14	1
9/8/93	23	6	2	9	4	nd
10/27/93	33	5	<1	170	22	2

Date	RHA-9 TC	RHA-9 FC	RHA-9 FS	RHA01 TC	RHA01 FC	RHA01 FS
10/13/92	58,000	-		9	3	nd
11/12/92	44,000	4,400	730	25	4	8
12/21/92	700	60	10	7	<1	1
1/19/93	110	4	nd	3	nd	nd
2/10/93	2,100	63	2	14	<1	nd
3/16/93	210	7	nd	31	nd	nd
4/10/93	130	3	2	7	nd	2
5/9/93	170	25	nd	20	13	nd
6/9/93	190,000	68,000	310	54	35	31
7/7/93	7,000	300	100	51	22	23
8/4/93	27,000	7,000	100	38	20	7
9/8/93	23,000	4,300	67	22	2	1
10/27/93	34,000	3,600	100	8	4	4

Notes: Density in bacteria per 100 mL;
TC = total coliform; FC = fecal coliform; FS = fecal streptococcus;
nd = not detected.

Table 33. Indicator Bacterial Densities in Wolf Lake Tributaries and Storm Sewer Discharges

Station	*Date*	*Time*	*Total coliform. per 100 mL*	*Fecal coliform, per 100 ml*	*Fecal streptococcus per 100 ml*
RHA 02	4/20/93		1,200	70	160
	6/7/93	13:45	21,000	220	510
	8/8/93	18:55	500,000	36,000	1,500
	7/7/93		960	40	10
	7/24/93	19:05	2,000	300	100
	8/4/93	08:05	3,700	360	8
	8/19/93	09:50	2,900	420	38
	10/27/93		300	80	4
RHA 03	2/21/93	12:30	85,000	2,900	900
	3/16/93		230,000	21,000	5,600
	4/10/93		100,000	2,000	1,900
	4/20/93		13,000	3,100	750
	5/9/93		480,000	50,000	13,000
	6/7/93	15:45	70,000	7,500	14,000
	6/8/93	11:00	86,000	9,600	5,200
	6/8/93	20:03	58,000	12,000	750
	7/7/93		760,000	180,000	69,000
	8/4/93		17,000,000	1,600,000	15,000
	8/19/93	09:30	2,000,000	140,000	21,000
	9/9/93		1,200,000	130,000	5,500
RHA 04	5/10/93		3,100	380	57
	6/8/93	11:00	130,000	42,000	23,000
	6/8/93	15:10	35,000	8,800	12,000
	6/8/93	18:55	140,000	570	1,900
	6/8/93	21:00	39,000	2,100	840
	7/7/93		310,000	9,800	1,700
	8/4/93	07:40	10,000,000	1,100,000	110,000
	8/19/93	09:20	200,000	11,000	320
	9/9/93		91,000	520	110
RHA 05	4/20/93		2,800	800	250
	5/10/93		3,600	420	320
	6/7/93	11:50	22,000	2,200	6,800
	6/8/93	11:25	21,000	2,000	7,200
	6/8/93	19:00	620,000	3,800	3,100
	6/8/93	20:50	1,300	120	680
	7/7/93		64,000	13,000	1,800
	8/4/93	11:30	1,900,000,000	340,000,000	6,200,000
	8/19/93	09:00	3,600,000	500,000	1,700
	9/9/93		28,000	1,400	170
RHA 06	6/8/93	09:05	15,000	1,500	2,100
	6/8/93	19:40	9,000	1,200	700

Table 33. Concluded

Station	*Date*	*Time*	*Total coliform. per 100 mL*	*Fecal coliform. perl 00 mL*	*Fecal streptococcus per 100 mL*
RHA 07	6/8/93	14:08	2,100	310	510
	6/8/93		2,300	160	80
RHA 08	6/8/93	13:45	2,600	730	1,600
	6/8/93	22:57	2,300	95	40
RHA 09	6/8/93	10:20	47,000	4,600	12,000
	6/8/93	19:27	26,000	1,900	1,800
	10/27/93		380	38	2
RHA 10	6/8/93	12:50	15,000	3,700	2,800
	6/8/93	22:33	2,800	200	70
	7/7/93		2,600	890	74
	7/19/93	18:35	1,200	310	260
	9/9/93	10:45	1,200	290	260
RHA 11	8/19/93	10:15	20	6	nd
	10/27/93		1,800	430	110
RHA 13	9/8/93	16:35	nd	nd	nd
	10/27/93		1,900	230	15
RHA 14	8/19/93	10:30	nd	nd	nd
	9/18/93	16:24	130	10	1
	10/27/93		nd	nd	1
RHA 71	6/8/93	14:20	600	370	470
	6/8/93	21:30	2,200	360	57
RHA 72	6/8/93	14:25	4,600	820	1,200
	6/8/93	21:40	400	45	40
	6/10/93	17:05	66	30	20
	7/7/93		640	25	15
Swimming beach					
Center	8/4/93		2,700	53	5
N portion	9/10/93		150	120	56
S portion	9/10/93		610	270	16
Center	10/27/93		670	170	22

In Wolf Lake Channel, indicator bacterial samples were also collected from seven tributaries or discharges (RHA 02, RHA 03, RHA 04, RHA 09, RHA 11, RHA 13, and RHA 14), shown in figure 8. As shown in table 33, stations RHA 02, RHA 03, RHA 04, and RHA 09 exceeded the limit of". . . . 2,000 FC per 100 mL in more than ten percent of the samples". The FC geometric mean values for these four stations were, respectively, 310, 26,000, 6,000, and 690 per 100 mL. Only stations RHA 03 and RHA 04 violated the FC geometric mean limit. RHA 02 is at the discharge from Lever Brothers Company, which manufactures soaps and detergent products. Samples at RHA 03 represent Roby station stormwater pumpages, while RHA 04 samples represent stormwater pumped from the Hammond Sanitary District's Forsythe Park station. RHA 09 samples were collected at the confluence of an unnamed creek and Wolf Lake Channel. FC counts at the other three stations in Wolf Lake Channel, RHA 11, RHA 13, and RHA 14, met the Indiana Stream Pollution Control Board's limits. These three stations received minor discharges from Amaizo.

An extremely high bacterial count (TC, FC, and FS) was reported for RHA 05 in an August 4, 1993, sample. This was not a stormwater sample pumped from the Sheffield Avenue station, but rather a sample taken from stagnant water in the deep-well inside the pumping house. This sample was excluded from geometric mean calculations. The observed geometric mean FC density for RHA 05 was 2,600 per 100 mL.

On June 7 and 8, 1993, bacterial samples were collected at different times from the three pumping stations (RHA 03, 04, and 05). It can be seen from table 33 that during a storm event, variations in bacterial densities were more pronounced at RHA 04 and RHA 05, and less so at RHA 03.

The geometric mean of FC densities for station RHA 06 (connecting channel between Pools 7 and 8) was 1,300 per 100 mL. During this study period, four bacterial samples were taken at the beach area (northeast corner of Pool 8). The bacterial results are shown in table 33. The geometric mean of FC counts was 130 per 100 mL. However, one sample collected on September 10, 1993, exceeded 200 FC/100 mL, which is the IDPH set guideline whether to permit public swimming or not. Table 34 presents the ten-year historical summer FC densities at four locations (figure 8) along the swimming beach, (data obtained from the Hammond Health Department). In general, FC counts were low and ranged from undetectable to too numerous to count (TNTC). However, 9.6 (12/125), 2.4 (3/125), 1.6 (2/126), and 4.0 (5/126) percent of samples exceeded the 200 FC per 100 mL limit. The third bench station showed the best FC quality in the beach area (table 34). On August 18, 1992, all four locations were reported to have very high bacterial counts (TNTC).

Bacterial samples were also collected at locations RHA 08, RHA 07, RHA 71, RHA 72, and RHA 10, all on the Illinois side (figure 8). These stations are located at the northeast end of Pool 1 (RHA 08), at the wetland area next to Pool 5 (RHA 7, 71, and 72), and at the southern tip of Pool 5. During the June 8, 1993, storm event, bacterial counts were initially elevated but tapered off later at all of these stations (table 33). Four of the 15 samples obtained from these locations exceeded the FC limit of 400 per 100 mL.

The use of FS in conjunction with FC was first suggested by Geldreich *et al.* (1964). In applying the FC/FS ratio to a natural stream system, best results are obtained if the stream samples are collected within a 24-hour streamflow time of a pollution source. A series of studies (Geldreich, 1967; Geldreich *et al.,* 1964; Geldreich and Kenner, 1969) determined that ratios greater than 4.0 are indicative of a pollution source primarily of human origin, such as domestic wastewater: whereas ratios less than 0.7 suggest that the pollution source is likely waste from warmblooded animals other than humans, i.e., livestock, poultry, wild animals, etc. Intermediate values between 0.7 and 4.0 represent a mixed pollution source.

Table 34. Long-Term Fecal Coliform Densities (per 100 mL) at Wolf Lake Park Swimming Beach

Date	*Wolf Point*	*First bench*	*Third bench*	*Last post*
6/19/85	1	3	7	11
6/26/85	31	5	3	0
7/03/85	19	6	5	12
7/10/85		1 3 5		4
7/17/85	2	4	0	2
7/24/85	18	10	2	12
7/31/85	500	200	12	6
8/07/85	26	84	8	22
8/14/85	%	6	14	0
8/21/85	2	12	4	6
8/28/85	7	10	6	2
6/11/86	56	22	10	38
6/18/86	14	4	4	6
6/25/86	4	2	6	0
7/02/86	16	20	12	20
7/09/86	250	50	30	24
7/23/86	34	12	0	18
7/30/86	0	3	14	0
8/06/86	52	0	0	0
8/13/86	0	0	2	2
8/20/86	24	4	0	2
8/27/86	0	0	0	0
6/17/87	4	No sample	6	0
6/24/87	0	0	0	0
7/01/87	0	50	3	21
7/08/87	1	12	0	1
7/15/87	32	2	2	6
7/22/87	58	42	58	264
7/29/87	400	0	0	0
8/05/87	2	0	6	0
8/12/87	8	18	32	32
8/19/87	0	20	4	0
8/26/87	0	0	18	1,000
9/02/87	2	0	0	4
6/09/88	0	4	4	6
6/15/88	8	4	0	0
6/22/88	0	0	0	10
6/29/88	6	12	0	0
7/06/88	6	0	0	0
7/14/88	24	2	0	2
7/20/88	0	2	0	0
7/27/88	20	0	0	0
8/03/88	68	12	0	0
8/10/88	0	0	0	0
8/17/88	54	28	0	44

Table 34. Continued

Date	*Wolf Point*	*First bench*	*Third bench*	*Last post*
8/24/88	0	0	0	0
8/31/88	30	0	0	0
6/06/89	0	0	0	0
6/13/89	7	8	10	12
6/20/89	10	10	2	0
6/27/89	84	96	22	36
7/03/89	20	5	2	0
7/11/89	44	4	35	26
7/18/89	222	8	4	2
7/25/89	6	20	138	76
8/01/89	12	2	14	40
8/08/89	29	16	8	8
8/15/89	26	14	0	8
8/22/89	112	20	6	12
8/29/89	112	68	32	12
6/05/90	70	8	2	2
6/19/90	12	24	10	6
6/26/90	18	TNTC	200+	0
7/03/90	4	120	10	2
7/10/90	50	26	130	276
7/17/90	2	94	6	4
7/24/90	0	18	4	4
7/31/90	No sample	34	24	4
8/07/90	0	0	0	0
8/14/90	12	24	6	20
8/21/90	60	156	125	72
8/28/90	18	62	18	8
5/07/91	130	178	6	10
5/21/91	28	16	4	8
6/04/91	21	20	2	21
6/11/91	TNTC	64	10	60
6/20/91	8	16	22	30
6/25/91	2	12	74	14
7/09/91	200+	8	16	8
7/11/91	320	114	16	8
7/16/91	42	10	8	12
7/23/91	38	38	24	20
7/30/91	22	18	-	2
8/06/91	43	16	1	0
8/20/91	%	124	73	104
8/27/91	42	20	4	6
9/10/91	18	60	62	14
9/17/91	12	20	24	6

Table 34. Concluded

Date	*Wolf Point*	*First bench*	*Third bench*	*Last post*
5/19/92	14	6	0	2
5/26/92	20	25	11	7
6/02/92	0	4	12	4
6/09/92	200	50	10	18
6/16/92	20	14	4	8
6/23/92	154	6	2	4
6/30/92	4	10	4	20
7/07/92	264	16	2	6
7/14/92	54	22	38	42
7/21/92	70	12	10	62
7/28/92	354	56	0	8
8/04/92	4	6	8	12
8/11/92	1	6	8	10
8/18/92	TNTC	TNTC	TNTC	TNTC
8/25/92	72	18	30	12
9/01/92	26	2	14	2
6/08/93	194	190	108	110
6/15/93	10	52	20	36
6/22/93	46	64	12	36
6/29/93	88	18	58	54
7/06/93	56	42	28	36
7/13/93	194	18	22	36
7/20/93	62	58	134	68
7/27/93	200+	178	144	200+
8/03/93	190	36	14	26
8/10/93	30	54	42	56
8/17/93	24	50	76	106
8/24/93	106	22	26	18
5/24/94	6	14	12	54
5/31/94	14	2	6	6
6/07/94	20	16	6	16
6/14/94	38	26	32	48
6/21/94	48	36	16	22
6/28/94	TNTC	28	32	18
7/05/94	10	12	8	8
7/12/94	8	22	28	18
7/19/94	200+	20	24	20
7/26/94	28	40	46	42

Note: TNTC = too numerous to count
Source: Dr. Franklin F. Premuda, Health Officer, Hammond Health Department

Tables 32 and 33 indicate that FS densities in Wolf Lake (not Wolf Lake Channel) were generally very low and even undetectable on many occasions. Geldreich *et al*. (1964) also suggested that FC/FS ratios should not be used if FS counts are less than 100 per 100 mL. Therefore, only samples from RHA-9, tributaries, and storm sewer discharges with FS densities greater than 100 per 100 mL were evaluated.

For stormwater discharges (RHA 03, RHA 04, and RHA 05) high bacterial densities were found during and after storm events. This was also true for site RHA-9. On the basis of FC/FS ratios, RHA-9 samples indicate that the pollution sources are of human origin. Samples from Wolf Lake Channel locations, namely, RHA 02, RHA 03, RHA 04, RHA 05, RHA 06, RHA 09, and RHA 10, suggest mixed pollution sources. At stations RHA 07, RHA 08, and RHA 72 in Illinois, the FC/FS ratios for samples taken on June 8, 1993, were low (<0.7) indicating a nonhuman, warm-blooded animal pollution source.

Algae. Phytoplanktonic algae form the base of the aquatic food web and provide the primary source of food for fish and other aquatic insects and animals. The algae produce oxygen and remove carbon dioxide from the water through photosynthesis. Nevertheless, excessive growths (blooms) of algae can degrade water quality and cause problems such as bad taste and odor, increased color and turbidity, decreased filter run at a water treatment plant, unsightly surface scums and aesthetic problems, and even oxygen depletion after die-off.

Sampling of plankton (algae and zooplankton) communities was carried out monthly during the period from April - October 1993. Algal densities (standing crops) expressed as the total number of counts per milliliter (cts/mL), frequency of occurrence, species distribution, and biovolumes, are presented for nine stations in Wolf Lake in table 35a-i. Chlorophyll values are also listed in the table. Traditionally, two significant digits are used for reporting total algal density. The total number of algae listed in table 35a-i can be rounded off to two digits to follow this convention.

Ranges of algal densities for stations RHA-1 through RHA-9 were 59 to 2,100; 140 to 940; 130 to 2,400; 170 to 840; 130 to 720; 200 to 7,400; 52 to 5,300; 310 to 6,700; and 180 to 4,300 cts/mL, respectively. For RHA-1 to RHA-4, the lowest algal densities occurred in September 1993, and the highest densities in April and August 1993. For RHA-5, observed algal densities were generally low compared to other stations, with high algal counts in July and April. For the Indiana side, in contrast, highest algal densities were observed in September 1993 for RHA-6 and RHA-7, and in July 1993 for RHA-8 and RHA-9. Relatively high algal densities also occurred in September 1993 for RHA-8. The lowest algal counts were observed in June 1993 for RHA-7 and RHA-9 and in August 1993 for RHA-8. For Lake George in Lake County, IN (Raman *et al.,* 1995), high algal counts occurred in April 1993 in both north and south basins. This trend in algal growth was not observed in any Illinois lakes investigated by the authors. In general, high algal densities are found in early spring and during the summer months (Kothandaraman and Evans, 1983a, 1983b; Raman and Bogner, 1994).

There were between 2 and 15 algal species found in each of the samples collected from different stations in the lake. There were in all 22, 27, 26, 24, 27, 27, 26, 26, and 29 different algal species identified at different times at stations RHA-1 through RHA-9, respectively. A total of 60 different species were found in all of the 63 algal samples examined. These species included 6 blue-greens (Cyanophytes), 13 greens (nonmobile Chlorophytes), 31 diatoms (Bacillariophytes), 8 flagellates (Chrysophytes, Euglenophytes, etc.), and 2 desmids. At all these sampling stations, diatoms and greens were generally the predominant algae present, not the problem-causing blue-green algae.

Table 35a. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-1,1993

Algal species	*Density*							*%of time*
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*occurred*
Blue-greens								
Anabaena planctonica								
A. spiroides			88					14
Anacystis thermolis		189	174			48		43
Aphanizomenon Jlos-aquae					38			14
Oscillatoria chlorina								
0.sp.								
Greens								
Actinustrum hantzchii								
Closteriopsis longissima								
Coelsatrum microporum				17				14
Crucigenia rectangularis								
Oocystis borgei		88			6			29
Pediastrum biradiatum								
P. duplex	16	25	11	61		11		71
P. simplex								
P. tetras								
Scenedesmus carinatus				29				14
S.dimorphus	69	8	11		59		74	71
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionellaformosa	721	25	23				63	57
Caloneis amphisbaena								
Cyclotella atomus								
C. meneghiniana								
C. ocellata								
Cymatopleura solea			*2*					14
Cymbella affinis								
C. prostrata					2			14
C. **sp.**								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens		25						14
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35a. Concluded

Algal species	*4/13*	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*% of time occurred*
	Density							
Diatoms								
Melosira granulata			50				82	29
Navicula cryptocephala					17			14
N. cuspidata								
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus								
S. delicatissima								
S. ulna			8					14
Tabellariafenestrata			92		15			29
T. sp.								
Flagellates								
Carteria multifilis					11			14
Ceratium hirundinella			8	17	55			43
Chlamydomonas reinhardi								
Dinobryon sertularia	1,283	17	126				185	57
Eurorina elegans								
Euglena gracilis			8					14
Phacus pleuronectes								
Trachemonas crebea		8						14
Desmids								
Closterium sp.								
Staurastrum cornutum		13	4					29
Total algal density	2,069	398	605	124	203	59	404	
Number of species	4	9	13	4	8	2	4	
Biovolume, mm^3/L	54.60	1.54	35.09	8.04	5.41	0.01	8.56	
Chlorophyll-a, µg/L		6.94	3.20	3.20	2.67			
Chlorophyll-*b*, µg/L		1.21	0.00	0.26	0.00			
Chlorophyll-c, µg/L		0.00	0.00	0.70	0.12			
Pheophytin *a*, µg/L		0.00	0.00	0.16	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35b. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-2,1993

Algal species	*Density*							*%of time*
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*occurred*
Blue-greens								
Anabaena planctonica					407			14
A. spiroides								
Anacystis thermolis		116	336	237	330	88	151	86
Aphanizomenon flos-aquae				99				14
Oscillatoria chlorina								
O. sp.			65					14
Greens								
Actinustrum hantzchii						11		14
Closteriopsis longissima								
Coelsatrum microporum							11	14
Crucigenia rectangularis								
Oocystis borgei		36	6				11	43
Pediastrum biradiatum								
P. duplex	8	17		32	4	15	4	86
P. simplex					11			14
P. tetras		8	4					29
Scenedesmus carinatus								
S.dimorphus		44		48	8		8	57
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora omata						*2*		14
A. paludosa								
Amphora ovalis								
Asterionella formosa		17	13					29
Caloneis amphisbaena								
Cyclotella atomus	86							14
C. meneghiniana								
C. ocellata					153			14
Cymatopleura solea								
Cymbella affmis								
C. prostrata								
C. sp.								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens		34						14
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35b. Concluded

Algal species	*Density* *4/13*	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*%of time occurred*
Diatoms								
Melosira granulata							32	14
Navicula cryptocephala							11	14
N. cuspidata								
N. gastrum						4		14
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus							13	14
S. delicatissima			53					14
S. ulna							2	14
Tabellaria fenestrata								
T.sp.								
Flagellates								
Carteria multifilis								
Ceratium hirundinella	447	11	8			11		57
Chlamydomonas reinhardi	21							14
Dinobryon sertularia	158	53	50				275	57
Eurorina elegans								
Euglena gracilis			11	15				29
Phacus pleuronectes								
Trachemonas crebea								
Desmids								
Closterium sp.								
Staurastrum comutum					23	8	4	43
Total algal density	720	336	546	431	936	139	522	
Number of species	5	9	9	5	7	7	11	
Biovolume, mm^3/L	212.69	7.82	6.14	0.24	0.69	5.61	12.12	
Chlorophyll-*a*, µg/L		13.35	9.08	12.82	15.49			
Chlorophyll-*b*, µg/L		1.13	0.00	0.86	0.00			
Chlorophyll-*c*, µg/L		0.13	0.22	0.55	0.49			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35c Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-3, 1993

Algal species	*4/13*	*5/26*	*6/22*	*7/20* (*Density*)	*8/18*	*9/28*	*10/27*	*% of time occurred*
Blue-greens								
Anabaena planctonica					53			14
A. spiroides				63				14
Anacystis thermolis	122	71	229	191	405	50	162	100
Aphanizomenon Jlos-aquae			63	101				29
Oscillatoria chlorina								
O. sp.								
Greens								
Actinustrum hantzchii			6					14
Closteriopsis longissima								
Coelsatrum microporum		6	8			4		43
Crucigenia rectangularis							61	14
Oocystis borgei				17				14
Pediastrum biradiatum			6					14
P. duplex	32	8	38			11	8	71
P. simplex					8	15	8	43
P. tetras						25		14
Scenedesmus carinatus								
S.dimorphus	*74*		8	17			13	57
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionella formosa	1,256							14
Caloneis amphisbaena								
Cyclotella atomus								
C. meneghiniana		32		19				29
C. ocellata								
Cymatopleura solea								
Cymbella qffinis						4		14
C. prostrata								
C. sp.								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii						4		14

Table 35c Concluded

Algal species	*4/13*	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*% of time occurred*
				Density				
Diatoms								
Melosira granulata					38			14
Navicula cryptocephala								
N. cuspidata								
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides	21							14
S. acus							6	14
S. delicatissima			48					14
S. ulna								
Tabellaria fenestrata			8	15				29
T. sp.								
Flagellates								
Carteria multifilis								
Ceratium hirundinella		13	11			15		43
Chlamydomonas reinhardi								
Dinobryon sertularia	912	86	105				151	57
Eurorina elegans								
Euglena gracilis								
Phacus pleuronectes								
Trachemonas crebea							8	14
Desmids								
Closterium sp.								
Staurastrum cornutum		13			4		6	43
Total algal density	2,417	229	530	423	508	128	423	
Number of species	6	7	11	7	5	8	9	
Biovolume, mm^3/L	40.01	9.%	10.08	3.71	0.48	7.02	6.98	
Chlorophyll-*a*, µg/L		6.94	6.94	10.15	18.69			
Chlorophyll-*b*, ng/L		1.05	0.42	0.49	0.51			
Chlorophyll-*c*, µg/L		1.26	0.00	0.83	0.27			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35d. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-4, 1993

Algal species	*Density* 4/13	5/26	6/22	7/20	8/18	9/28	10/27	*%of time occurred*
Blue-greens								
Anabaena ptanctonica					288			14
A.spiroides			57	13		48	13	57
Anacystis thermotis		155	313	204	443	11	137	86
Aphanizomenon flos-aquae				48	63			29
Oscillatoria chlorina								
O. sp.			23		6	13		43
Greens								
Actinustrum hantzchii						6	4	29
Closteriopsis longissima								
Coelsatrum microporum								
Crucigenia rectangularis								
Oocystis borgei		38						14
Pediastrum biradiatum			8					14
P. duplex	15	21	8	6		11		71
P. simplex								
P. tetras								
Scenedesmus carinatus								
S.dimorphus	17	19	132			4	6	71
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata						*2*		14
A. paludosa					8			14
Amphora ovalis				4	4			29
Asterionella formosa	376	65	6					43
Caloneis amphisbaena								
Cyclotella atomus								
C. meneghiniana								
C. ocellata								
Cymatopleura solea								
Cymbella affinis								
C. prostrata								
C. sp.								
Diatoma vulgare							6	14
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum		4						14
Gyrosigma kutzingii								

Table 35d. Concluded

Algal species	4/13	5/26	6/22	7/20	8/18	9/28	10/27	%of time occurred
	Density							
Diatoms								
Melosira granulata						34		14
Navicula cryptocephala								
N. cuspidata								
N. gastrum								
Neidium dubium					*2*			14
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus							11	14
S. delicatissima								
S. ulna								
Tabellaria fenestrata		76				36		29
T. sp.								
Flagellates								
Carteria multifilis								
Ceratium hirundinella			8		8			29
Chlamydomonas reinhardi								
Dinobryon sertularia	267	168	67		8		378	71
Eurorina elegans								
Euglena gracilis					8			14
Phacus pleuronectes								
Trachemonas crebea								
Desmids								
Closterium sp.								
Staurastrum cornutum		6	6		6			43
Total algal density	675	552	630	275	844	165	555	
Number of species	4	9	10	4	11	9	7	
Biovolume, mm^3/L	11.47	7.67	9.93	0.77	4.50	3.13	17.17	
Chlorophyll-*a*, µg/L		13.35	12.82	13.35	18.69			
Chlorophyll-*b*, µg/L		160	0.14	0.84	0.40			
Chlorophyll-*c*, µg/L		1.23	0.16	0.99	0.24			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35e. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-S, 1993

Algal species	Density							%of time
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*occurred*
Blue-greens								
Anabaena plane tonica								
A. spiroides				29				14
Anacystis thermolis		50	88	405	306	151	86	86
Aphanizomenon flos-aquae				193	113	34		43
Oscillatoria chlorina								
O.sp.					27	32		29
Greens								
Actinustrum hantzchii			13					14
Closteriopsis longissima					*2*			14
Coelsatrum microporum							8	14
Crucigenia rectangularis				55		29		29
Oocystis borgei		11		11		4	8	57
Pediastrum biradiatum								
P. duplex	23	21	21	15	11	8	17	100
P. simplex						8	4	29
P. tetras								
Scenedesmus carinatus					15			14
S. dimorphus	15					11		29
Ulothrix variabilis								
U. zonata			44					14
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionella formosa	477	25						29
Caloneis amphisbaena								
Cyclotella atomus								
C. meneghiniana								
C.ocellata						36	65	29
Cymatopleura solea								
Cymbella qffinis								
C. prostrata	11							14
C. sp.						4		14
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35c Concluded

Algal species	4/13	5/26	6/22	7/20	8/18	9/28	10/27	% of time occurred
	Density							
Diatoms								
Melosira granulata					40	126	32	43
Navicula cryptocephala								
N. cuspidata								
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata						4		14
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus								
S. delicatissima								
S. ulna								
Tabellariafenestrata		17					53	29
T. sp.								
Flagellates								
Carteria multifilis								
Ceratium hirundinella		6	11		11			43
Chlamydomonas reinhardi			55					14
Dinobryon sertularia	105					27	181	43
Eurorina elegans								
Euglena gracilis					8	6		29
Phacus pleuronectes								
Trachemonas crebea				8		8	8	43
Desmids								
Closterium sp.								
Staurastrum cornutum						4		14
Total algal density	631	130	232	716	533	492	462	
Number of species	5	6	6	7	9	16	10	
Biovolume, mm^3/L	5.09	2.90	5.61	3.35	5.64	3.23	8.23	
Chlorophyll-*a*, µg/L		6.94	7.48	12.28	18.69			
Chlorophyll-*b*, µg/L		1.04	0.26	1.49	1.30			
Chlorophyll-*c*, µg/L		0.00	0.08	0.18	0.46			
Pheophytin *a*, µg/L		0.91	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35f. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-6, 1993

Algal species	*Density*							*%of time*
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*occurred*
Blue-greens								
Anabaena planctonica								
A. spiroides					46	210		29
Anacystis thermolis		128	134	397	36	1,512	19	86
Aphanizomenon flos-aquae				433	78	147		43
Oscillatoria chlorina						95		
O. sp.								
Greens								
Actinustrum hantichii						32	13	29
Closteriopsis longissima								
Coelsatrum microporum								
Crucigenia rectangularis						4,368		14
Oocystis borgei		11				42		29
Pediastrum biradiatum								
P. duplex	13	2	36	8	17	74	36	100
P. simplex						32		14
P. tetras	6					32		29
Scenedesmus carinatus								
S.dimorphus	21	11	13	6		42	13	81
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionellaformosa	307	118						29
Caloneis amphisbaena								
Cyclotella atomus	44							14
C. meneghiniana								
C. ocellata						200		14
Cymatopleura solea				*2*				14
Cymbella qffinis		*2*						14
C. prostrata								
C. sp.								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35f. Concluded

Algal species	*4/13*	*5/26*	*6/22*	*7/20* (*Density*)	*8/18*	*9/28*	*10/27*	*%of time occurred*
Diatoms								
Melosira granulata			11			116	53	43
Navicula cryptocephala								
N. cuspidata	13			2				29
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae						32	17	29
Synedra actinastroides								
S. acus	8							14
S. delicatissima							57	14
S. ulna						63		14
Tabellaria fenestrata								
T.sp.					11	74		29
Flagellates								
Carteria multifilis								
Ceratium hirundinella			13			32		29
Chlamydomonas reinhardi								
Dinobryon sertularia	132	111		8		179	384	71
Eurorina elegans				4				14
Euglena gracilis								
Phacus pleuronectes								
Trachemonas crebea						74		14
Desmids								
Closterium sp.								
Staurastrum cornutum		13	4		8	53	11	71
Total algal density	544	396	211	860	196	7,409	603	
Number of species	8	8	6	8	6	20	9	
Biovolume, mm^3/L	6.35	4.95	6.17	2.11	2.63	153.77	18.64	
Chlorophyll-*a*, µg/L		5.87	11.75	26.70	33.11			
Chlorophyll-*b*, µg/L		1.06	0.16	1.90	1.42			
Chlorophyll-*c*, µg/L		0.55	0.44	1.32	1.06			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

Table 35g. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-7, 1993

Algal species	*Density* *4/13*	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*%of time occurred*
Blue-greens								
Anabaena planctonica					164			14
A.spiroides				494		168		29
Anacystis thermolis		183	15	2,195	210	431	197	86
Aphanizomenon flos-aquae				2,762				14
Oscillatoria chlorina								
O.sp.					27	147		29
Greens								
Actinustrum hantzchii						74	23	29
Closteriopsis longissima					4			14
Coelsatrum microporum							11	14
Crucigenia rectangularis						4,001		14
Oocystis borgei		29	6			74		43
Pediastrum biradiatum								
P. duplex	15		29		11	32	15	71
P. simplex								
P. tetras								
Scenedesmus carinatus								
S.dimorphus	15	11			8	53	32	71
Ulothrix variabilis	13							14
U. zonata								
Diatoms								
Amphiprora ornata							4	14
A. paludosa								
Amphora ovalis								
Asterionella formosa	552	25						29
Caloneis amphisbaena							*2*	14
Cyclotella atomus								
C. meneghiniana								
C. ocellata								
Cymatopleura solea								
Cymbella qffinis			2					14
C. prostrata						21		14
C. sp.								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35g. Concluded

Algal species	Density 4/13	5/26	6/22	7/20	8/18	9/28	10/27	% of time occurred
Diatoms								
Melosira granulata					59			14
Navicula cryptocephala								
N. cuspidata	15							14
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae					4		6	29
Synedra actinastroides								
S. acus								
S. delicatissima								
S. ulna								
Tabellariafenestrata		86				63	166	43
T. sp.					13			14
Flagellates								
Carteria multifilis								
Ceratium hirundinella		11						14
Chlamydomonas reinhardi								
Dinobryon sertularia	187			116	8	95	344	71
Eurorina elegans								
Euglena gracilis								
Phacus pleuronectes								
Trachemonas crebea								
Desmids								
Closterium sp.								
Staurastrum cornutum		13			36	116		43
Total algal density	297	358	52	5,567	544	5,275	800	
Number of species	6	7	4	4	11	12	10	
Biovolume, mm^3/L	8.80	5.60	0.08	34.88	1.65	121.92	16.52	
Chlorophyll-*a*, µg/L		20.83	21.89	51.26	27.23			
Chlorophyll-*b*, µg/L		1.53	0.76	3.24	0.87			
Chlorophyll-*c*, µg/L		1.21	0.29	1.40	0.10			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: densities in cts/mL, except where noted otherwise.

Table 35h. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-8, 1993

Algal species	*Density*							*%of time*
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*occurred*
Blue-greens								
Anabaena planctonica					57			14
A.spiroides			218	462		179		43
Anacystis thermolis	128	250		3,035	111	651	76	86
Aphanizomenon flos-aquae				2,625	15	116		43
Oscillatoria chlorina								
O. **sp.**						63	13	29
Greens								
Actinustrum hantzchii							27	14
Closteriopsis longissima					6			14
Coelsatrum microporum		6						14
Crucigenia rectangularis						903	50	29
Oocystis borgei		23		200	8	84		57
Pediastrum biradiatum								
P. duplex	6	4	13		2			57
P. simplex					4	53	8	43
P. tetras								
Scenedesmus carinatus								
Sdimorphus	17	17				53	8	57
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionella formosa	252	50				21		43
Caloneis amphisbaena								
Cyclotella atomus	19							14
C. meneghiniana								
C. ocellata								
Cymatopleura solea								
Cymbella qffinis								
C.prostrata		2					6	29
C. **sp.**								
Diatoma vulgare								
Diploneis smithii	*2*							14
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35h. Concluded

Algal species	*4/13*	*5/26*	*6/22*	*7/20* *Density*	*8/18*	*9/28*	*10/27*	*%of time occurred*
Diatoms								
Melosira granulata				**126**		**74**		**29**
Navicula cryptocephala								
N. cuspidata								
N. gastrum								
Neidium dubium								
Nitzschia dentecula								
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus								
S. delicatissima								
S. ulna								
Tabellariafenestrata		**88**	**74**			**63**	**17**	**57**
***T.* sp.**					**25**			**14**
Flagellates								
Carteria multifllis								
Ceratium hirundinella				**32**	**11**	**21**		**43**
Chlamydomonas reinhardi								
Dinobryon sertularia	**162**			**137**			**143**	**43**
Eurorina elegans				**32**				**14**
Euglena gracilis								
Phacus pleuronectes								
Trachemonas crebea	**8**		**6**	**11**		**21**		**57**
Desmids								
***Closterium* sp.**					**4**			**14**
Staurastrum cornutum					**15**	**11**		**29**
Total algal density	**594**	**440**	**311**	**6,660**	**258**	**2,313**	**348**	
Number of species	**8**	**8**	**4**	**9**	**11**	**14**	**9**	
Biovolume, mm^3/L	**7.04**	**0.55**	**11.63**	**57.83**	**5.55**	**20.88**	**8.78**	
Chlorophyll-a, µg/L		**21.89**	**24.56**	**63.55**	**32.57**			
Chlorophyll-*, µg/L		**1.53**	**0.08**	**3.87**	**1.20**			
Chlorophyll-c, µg/L		**1.21**	**0.54**	**1.21**	**1.00**			
Pheophytin *a*, µg/L		**0.00**	**0.00**	**0.00**	**0.00**			

Note: densities in cts/mL, except where noted otherwise.

Table 35i. Algal Types and Densities, Biovolume, and Chlorophyll in Wolf Lake at RHA-9, 1993

Algal species	*Density* 4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	*% of time occurred*
Blue-greens								
Anabaena planctonica								
A. spiroides				924		25	15	43
Anacystis thermolis		160		1,229		78	44	57
Aphanizomenon Jlos-aquae				1,334				14
Oscillatoria chlorina								
O.sp.				95		55		29
Greens								
Actinustrum hantzchii					17			14
Closteriopsis longissima								
Coelsatrum microporum		11			15			29
Crucigenia rectangularis								
Oocystis borgei		57						14
Pediastrum biradiatum			2					14
P. duplex		29	36	53	19	17		71
P. simplex								
P.tetras		11						14
Scenedesmus carinatus		19						14
S.dimorphus	13		13	116	11	25	8	86
Ulothrix variabilis								
U. zonata								
Diatoms								
Amphiprora ornata								
A. paludosa								
Amphora ovalis								
Asterionella formosa	255	46						29
Caloneis amphisbaena								
Cyclotella atomus		172						14
C. meneghiniana								
C.ocellata					193		86	29
Cymatopleura solea								
Cymbella qffinis								
C. prostrata						8		14
C.sp.								
Diatoma vulgare								
Diploneis smithii								
Fragilaria virescens								
Gomphonema olivaceum								
Gyrosigma kutzingii								

Table 35i. Concluded

Algal species	Density							% of time occurred
	4/13	*5/26*	*6/22*	*7/20*	*8/18*	*9/28*	*10/27*	
Diatoms								
Melosira granulata					74	48	59	43
Navicula cryptocephala								
N. cuspidata				11				14
N. gastrum					2			14
Neidium dubium								
Nitzschia dentecula			4					14
Rhoicosphenia curvata								
Stephanodiscus niagarae								
Synedra actinastroides								
S. acus								
S. delicatissima								
S. ulna				21				14
Tabellaria fenestrate!		15		74		21	8	57
T. sp.								
Flagellates								
Carteria multifilis								
Ceratium hirundinella				32				14
Chlamydomonas reinhardi								
Dinobryon sertularia	92		122	242	27	40	137	86
Eurorina elegans				21				14
Euglena gracilis	6	57		95	8			57
Phacus pleuronectes				11			4	29
Trachemonas crebea					6	11		29
Desmids								
Closterium sp.								
Staurastrum cornutum		11		21				29
Total algal density	366	588	177	4,279	378	328	361	
Number of species	4	11	5	15	11	10	8	
Biovolume, mm^3/L	4.00	0.67	5.25	82.85	2.64	3.98	7.53	
Chlorophyll-*a*, µg/L		13.88	25.10	17.09	23.50			
Chlorophyll-*b*, µg/L		1.68	2.57	2.83	4.78			
Chlorophyll-*c*, µg/L		0.69	0.80	0.60	1.08			
Pheophytin *a*, µg/L		0.00	0.00	0.00	0.00			

Note: Densities in cts/mL, except where noted otherwise.

The most frequently occurring algae were *Pediastrum duplex* (green) at all stations, *Scenedesmus dimorphus* (green) at all stations except RHA-5, *Anacystis thermolis* (blue-green) at all stations but RHA-1, and *Dinobryon sertularia* (flagellate) at all stations except RHA-5, RHA-6, and RHA-8. *Asterionella formosa* (diatom) and *Ceratium hirundinella* (flagellate) also frequently occurred at stations RHA-1 and RHA-2, respectively. *Oocystis borgei* (green) was frequently found at RHA-5 and RHA-8. Although a high number of diatom species were observed, very few diatoms occurred frequently. *Asterionella formosa* was found 57 percent of the time at RHA-1 and another diatom, *Tabellaria fenestrata,* occurred frequently at RHA-8 and RHA-9. It should be noted that *Crucigenia rectangularis* (green) predominated with very high densities at stations RHA-6 and RHA-7 on September 28, 1993, although it was not frequently observed. The species mentioned above were also the most frequently occurring algae in Lake George (Raman *et al*, 1995) and in two central Illinois lakes, Lake Bloomington and Lake Evergreen (Raman and Twait, 1994).

Inspection of tables 35a-i indicates that there is no correlation between total algal density and chlorophyll ***a*** concentrations. The reason for this is unknown, but it was also the case for Lake George (Raman *et al.,* 1995). High chlorophyll *a* contents were found in July and August samples for almost all stations. The highest observed chlorophyll *a* concentration was 63.55 μg/L for RHA-8 on July 20, 1993.

The calculated biovolume values showed a wide range at all stations. The highest range (0.24 to 212.69 cubic millimeters per liter, mm^3/L) was found at stations RHA-2. The highest observed biovolumes occurred at different times for different sampling sites: April 13, 1993, for stations RHA-1, RHA-2, and RHA-3; October 27, 1993, for RHA-4 and RHA-5; September 28, 1993, for RHA-6 and RHA-7; and on July 20, 1993, for RHA-8 and RHA-9.

Algal growths in Wolf Lake do not seem to be a problem either in terms of the densities or the types of algae found in the lake.

Zooplankton. The term "plankton" refers to those microscopic aquatic forms having little or no resistance to currents and living free-floating and suspended in open or pelagic waters (American Public Health Association *et al.,* 1992). Plankton can be divided into planktonic plants or phytoplankton (microscopic algae) and planktonic animals (zooplankton). The zooplankton in freshwater comprise principally protozoans, rotifers, cladocerans, copepods, and ostracods; a greater variety of organisms occur in marine waters. Since a Wisconsin plankton net was used for collecting plankton samples, protozoans (microplanktons) were not detected. In this report, protozoans are not included in the zooplankton.

Zooplankton densities in Wolf Lake are presented in tables 36a-i. Total observed zooplankton densities ranged from 100 to 1800 cts/L, from 300 to 2,800 cts/L, 200 to 2,800 cts/L, 300 to 2,400 cts/L, 400 to 1,800 cts/L, 200 to 2,500 cts/L, 400 to 3,500 cts/L, 500 to 6,300 cts/L, and 200 to 1,200 cts/L at RHA-1 through RHA-9, respectively. Generally, high zooplankton counts were observed in April through July depending on the pool. Highest densities occurred in May at RHA-6, RHA-7, and RHA-8, and in June at RHA-1, RHA-2, and RHA-3. The temporal variations of zooplankton communities in each of the pools did not show the same trend with time.

At the nine sampling stations, 26 zooplankton species were found, comprising 11 cladocerans, 2 copepods, 1 ostracod, 11 rotifers, and 1 acaris. Dominant zooplanktons were found to be either cladocera or copepoda based on their densities and frequency of occurrence. The dominant species for all stations were *Bosmina longirostris* and *Diatomus minutus,* which are similar to the dominant species in Lake George (Raman *et al.,* 1995). *Daphnia pulex* is one of the dominant zooplankton in Lake George, it is significant only at RHA-8 and RHA-9 in Wolf Lake. *Eucyclops speratus*, a copepod, was the dominant zooplankton at RHA-9 in Wolf Lake Channel

Table 36a. Zooplankton Densities in Wolf Lake at RHA-1, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		100						14
B. longirostris			1,300	100			400	43
B. pulex	300							14
Daphnia ambigus								
D. catavila								
D. dubia								
D. laevis				100				14
D. pulex			300					14
D. rosea								
Leptodora kindtii								
Polyphemus pedicuius		100						14
Copepoda								
Diaptomus minutus	400	100	100	100	100			71
Eucyclops speratus						100		14
Ostracoda								
Cyclocypris forbesi								
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta								
Brachionus bidentata	100		100					29
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaella brehmi				200				14
Keratella quadrata								
K.sp.								
K. stipitata								
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	800	300	1,800	500	100	100	400	
Number of species	3	3	4	4	1	1	1	
Biovolume, mm^3/L	1,260	195	1,340	427	0.4	2.8	2.6	

Note: Density in counts/L

Table 36b. Zooplankton Densities in Wolf Lake at RHA-2, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		200	900					29
B. longirostris	300		1,300	100		100	200	71
B. pulex								
Daphnia ambigus								
D. catavila								
D. dubia								
D. laevis					200			14
D. pulex					100			14
D. rosea								
Leptodora kindtii			100					14
Polyphemus pediculus	500	100						29
Copepoda								
Diaptomus minutus	700	200		200			200	57
Eucyclops speratus			300			100		29
Ostracoda								
Cyclocypris forbesi								
Rotifera								
Ascomorpha sattam							200	14
Asplanchna priodonta								
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaella brehmi	400						100	29
Keratella quadrata								
K.sp.								
K.stipitata		100	200	200	200	100		71
Philodina sp.		100						
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	1,900	700	2,800	500	500	300	700	
Number of species	4	5	5	3	3	3	4	
Biovolume, mm^3/L	907	213	432	7.4	1,260	9.4	14.6	

Note: Density in counts/L

Table 36c Zooplankton Densities in Wolf Lake at RHA-3,1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni	100	500	600		100			57
B. longirostris			1,700	100	200	100	700	71
B. pulex								
Daphnia ambigus								
D. catavila								
D. dubia								
D. laevis								
D. pulex								
D. rosea	100							14
Leptodora kindtii			100					14
Polyphemus pediculus								
Copepoda								
Diaptomus minutus	200	300	100	100	100		200	86
Eucyclops speratus							100	14
Ostracoda								
Cyclocypris forbesi					100			14
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta								
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaella brehmi	100			100		100		43
Keratella quadrata					200			14
K. sp.								
K.stipitata		200	300					29
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	500	1,000	2,800	300	700	200	1,000	
Number of species	4	3	5	3	5	2	3	
Biovolume, mm^3/L	438	91.1	38,600	184	38.1	7.0	49.4	

Note: Density in counts/L

Table 36d. Zooplankton Densities in Wolf Lake at RHA-4, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni	400	200						29
B. longirostris			700	100	200	100	500	71
B. pulex								
Daphnia ambigus		200						14
D. catavila								
D. dubia								
D. laevis	200							14
D. pulex				200	100		100	43
D. rosea	600	100						29
Leptodora kindtii								
Polyphemus pediculus								
Copepoda								
Diaptomus minutus	700		200	100	100			57
Eucyclops speratus		300				100	100	43
Ostracoda								
Cyclocypris forbesi								
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta								
Brachionus bidentata								
B. quadridentata							200	14
Clomogaster ovalis								
Elose woralli								
Horaella brehmi	500	100	400	200	300	100		86
Keratella quadrata				100				14
K. sp.								
K. stipitata								
Phitodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	2,400	900	1,300	700	700	300	900	
Number of species	5	5	3	5	4	3	4	
Biovolume, mm^3/L	3430	817	48.3	845	456	9.8	455	

Note: Density in counts/L

Table 36e. Zooplankton Densities in Wolf Lake at RHA-S, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni	400	100						29
B. longirostris				1,200	200	300	300	57
B. pulex								
Daphnia ambigus								
D. catavila								
D. dubia			600					14
D.laevis				100		100		29
D. pulex			100					14
D. rosea	200	200			100			43
Leptodora kindtii			100					14
Polyphemus pediculus								
Copepoda								
Diaptomus minutus			400	100	300			43
Eucyclops speratus	200					100	100	43
Ostracoda								
Cyclocypris forbesi			200					14
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta						100	100	29
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaetla brehmi	200			400	200			43
Keratella quadrata								
K.sp.								
K.stipitata					100	100	100	43
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	1,000	400	1,300	1,800	900	700	600	
Number of species	4	3	4	4	5	5	4	
Biovolume, mm^3/L	916	1,270	40,700	676	963	442	22.7	

Note: Density in counts/L

Table 36f. Zooplankton Densities in Wolf Lake at RHA-6, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		1,900					200	29
B. longirostris	200		700	100		100	200	71
B. pulex								
Daphnia ambigus								
D. catavila								
D. dubia								
D. laevis					100			14
D. pulex		400						14
D. rosea	300							14
Leptodora kindtii			100					14
Polyphemus pediculus	200							14
Copepoda								
Diaptomus minutus	300	200		200	100			57
Eucyclops speratus	100		200			100	100	57
Ostracoda								
Cyclocyprisforbesi							100	14
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta								
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaella brehmi	200		200		300			43
Keratella quadrata								
Ksp.								
K. stipitata								
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi			400					14
Total zooplankton density	1,300	2,500	1,600	300	500	200	600	
Number of species	6	3	5	2	3	2	4	
Biovolume, mm^3/L	1,630	2,020	38,200	7.3	420	9.4	58.4	

Note: Density in counts/L

Table36g. Zooplankton Densities in Wolf Lake at RHA-7, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		2,400						14
B. longirostris -	200		600	300	100	200	200	86
B. pulex								
Daphnia ambigus								
D. catavUa		200						14
D. dubia			300					14
D. taevis				100				14
D. pulex		600	200		100			43
D. rosea								
Leptodora kindtii			100					14
Polyphemus pediculus								
Copepoda								
Diaptomus minutus	200	300	200	100	100		100	86
Eucyclops speratus						200	100	29
Ostracoda								
Cyclocyprisforbesi						100	100	29
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta								
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli					100			14
Horaella brehmi			200		300			29
Keratella quadrata								
Ksp.								
K. stipitata							200	14
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density-	400	3,500	1,600	500	700	500	700	
Number of species	2	4	6	3	5	3	5	
Biovolume, mm^3/L	13.9	3,300	40,300	197	427	25.3	23.0	

Note: Density in counts/L

Table 36h. Zooplankton Densities in Wolf Lake at RHA-8, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		2,300						14
B. longirostris			100	100	100	400	400	71
B. pulex								
Daphnia ambigus	200							14
D. catavila								
D. dubia								
D. laevis					100			14
D. pulex	200	1,800	200	100				57
D. rosea	100	1,100	200					43
Leptodora kindtii			100					14
Polyphemus pediculus								
Copepoda								
Diaptomus minutus	300	900		300	300			57
Eucyclops speratus						< 100	100	29
Ostracoda								
Cyclocypris forbesi								
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta							100	14
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis		100						14
Elose woralli								
Horaella brehmi		100		200	300		100	57
Keratella quadrata					100			14
K. sp.	100							14
AT. stipitata							100	14
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi			100	100				29
Total zooplankton density	900	6,300	700	800	900	500	800	
Number of species	5	6	5	5	5	2	5	
Biovolume, mm^3/L	1,620	12,600	39,900	427	840	290	31.1	

Note: Density in counts/L

Table 36i. Zooplankton Densities in Wolf Lake at RHA-9, 1993

Species	*4/13*	*5/26*	*6/22*	*Density* *7/20*	*8/18*	*9/28*	*10/27*	*Percent occurrence*
Cladocera								
Bosmina coregoni		400						14
B. longirostris	300		200		200	100	200	71
B. pulex								
Daphnia ambigus								
D. catavila								
D. dubia								
D. laevis								
D. pulex	200	100	300	100				57
D. rosea				100				14
Leptodora kindtii			100					14
Polyphemus pediculus					100			14
Copepoda								
Diaptomus minutus				100				14
Eucyclops speratus	700	100		100	100	100	100	86
Ostracoda								
Cyclocyprisforbesi			400		100			29
Rotifera								
Ascomorpha sattam								
Asplanchna priodonta					200			14
Brachionus bidentata								
B. quadridentata								
Clomogaster ovalis								
Elose woralli								
Horaella brehmi				100	200			29
Keratella quadrata								
K.sp.								
K. stipitata			200					14
Philodina sp.								
Acaris (water mites)								
Chelomideopris besselingi								
Total zooplankton density	1,200	600	1,200	500	900	200	300	
Number of species	3	3	5	5	6	2	2	
Biovolume, mm^3/L	877	493	39,500	841	203	9.4	15.9	

Note: Density in counts/L

(table 36i), while RHA-2, *Keratella stipitata* was found most frequently (table 36b). *Horaella brehmi*, a rotifer, was the most frequently (86 percent) observed species at RHA-4 (table 36d).

Biovolumes of zooplankton found in the samples were computed using the shape and size information provided in table 15 and included in tables 36a-i for RHA-1 through RHA-9, respectively. A wide variation in biovolumes was observed from sample to sample for each station, and from station to station. Overall, they ranged from a low of 0.4 mm^3/L at RHA-1 on August 18, 1993, to a high of 40,700 mm^3/L at RHA-5 on June 22, 1993. On this latter date, the highest zooplankton biovolumes were also found for other stations, except for RHA-2 and RHA-4 for which the highest biovolumes were recorded in August and April samples, respectively.

Macrophytes. Macrophytes are commonly called aquatic vegetation (or weeds). The macrophyton consists principally of aquatic vascular flowering plants. It also includes aquatic mosses, liverworts, ferns, and larger macroalgae APHA *et al.,* 1992). Macrophytes may include submerged, emerged, and floating plants; and filamentous algae. In most lakes and ponds, aquatic vegetation is found that may beneficially and/or adversely impact the natural ecosystem. Reasonable amounts of aquatic vegetation improve water clarity by preventing shoreline erosion, stabilizing sediment, storing nutrients, and providing habitat and hiding places for many small fish (fingerlings, bluegill, sunfish, etc.). They also provide food, shade, and oxygen for aquatic organisms; block water movement (wind wave); and use nutrients in the water, reducing the excessive growth of phytoplankton.

However, excessive growth of aquatic vegetation generally interferes with recreational activities (fishing, boating, surfing, etc.); adversely affects aquatic life (overpopulation of small fish and benthic invertebrates); causes fish kills; produces taste and odor in water due to decomposition of dense weed beds; blocks water movement and retards heat transfer, creating vertical temperature gradients; and destroys aesthetic value to the extent of decreasing the economic values of properties surrounding a lake. Under these circumstances, aquatic plants are often referred to as weeds.

Historical Data. More than two decades ago, on June 18-21, 1974, the Illinois Department of Conservation conducted an aquatic vegetation survey in Pools 1-4 of Wolf Lake. Common species of aquatic plants observed in Pool 3 (15 percent of bottom covered) are listed in table 37. Macrophyte maps for Pools 1 - 4 are reproduced in figures 15a-d, respectively. These maps were prepared by fishery biologist, Harry Wight. The survey information was furnished by the Illinois Department of Conservation.

Current data. The macrophyte survey for this investigation was conducted on July 22-23, 1993. Table 38 presents the types of macrophytes observed and their biomass expressed in terms of grams of dry weight of macrophytes per square meter of lake bottom (g/m^2). The locations of the quantitative macrophyte sampling stations are shown in figure 16a-i. The areal extent of macrophyte beds as determined by the reconnaissance survey and dominant species observed are also plotted in the figure. The quadrat size used, water depth, sediment characteristics at the sampling location, and plant heights are described in table 37. Figure 17 shows some views of the lake taken during the macrophyte survey. The probing of the lake bottom for macrophytes, the quadrat used in sample collection, the nylon bag containing the collected sample, and the dense growth in the lake that interferes with boating can all be noted in this figure.

Seventeen species of macrophytes were found in Wolf lake at 40 sampling locations (table 38). *Chlodophora,* a filamentous algae, American lotus *{Nelumbo lutea),* and water lily *(Nymphae* spp.) pads were also observed in some places in Wolf Lake. Eurasian water milfoil *(Myriophyllum spicatum)* is the most frequently occurring (33 out of 40 stations, 82.5 percent) and dominant species in all pools except Pool 1. This plant constituted nearly 100 percent of the vegetative mass recovered at sites 2-1, 2-III, 3-1, 3-VII, 5-II, 6-II, 6-V, 6-IX, 6-X, 7-III, 8-V, 9-

Table 37. Common Species of Aquatic Plants in Pool 3, Wolf Lake, June 18-21, 1974

Common name	*Scientific name*	*Where found in lake*	*Depth found. feet*	*Percent covered*
Emergents				
Cattail	Typhaspp.	scattered north end	2	1
White water lilly	Nymphaea tuberosa	scattered north end	2	1
Spatterdock	Nupharadvena	scattered north end	2	1
Bulrush	Scirpusspp.	scattered north end	1	nr
Arrowhead	Sagittaria latifolia	scattered north end	1	nr
Submersed				
Coontail	Ceratophyllum spp.	scattered south end	5	2
Water milfoil	Myriophyllum spp.	scattered south end	5	2
American elodea	Elodea canadensis	scattered south end	5	2
Curlyleafpondweed	Potamogeton crispus	scattered south end	5	2
Sago pondweed	P. percinatus	scattered south end	5	2
Leafy pondweed	P. foliosus	scattered south end	5	nr
Richardson pondweed	P. richardsonii	scattered south end	5	nr
Slender naiad	Najas flexilis	scattered south end	5	Rare
Fel grass	Vallisneria americana	scattered south end	3	nr
Floating				
Duckweed	Lemnaspp.	scattered	-	Rare
Algae				
Algae	Filamentous & Planktonic	scattered	-	Abundant at times
Chara	Chara	scattered south end	5	2

Notes: Some dense beds of submersed vegetation are present in the southern and eastern portion of the lake.

Emergents are no problem at present,

nr = not reported

Source: Formerly Illinois Department of Conservation

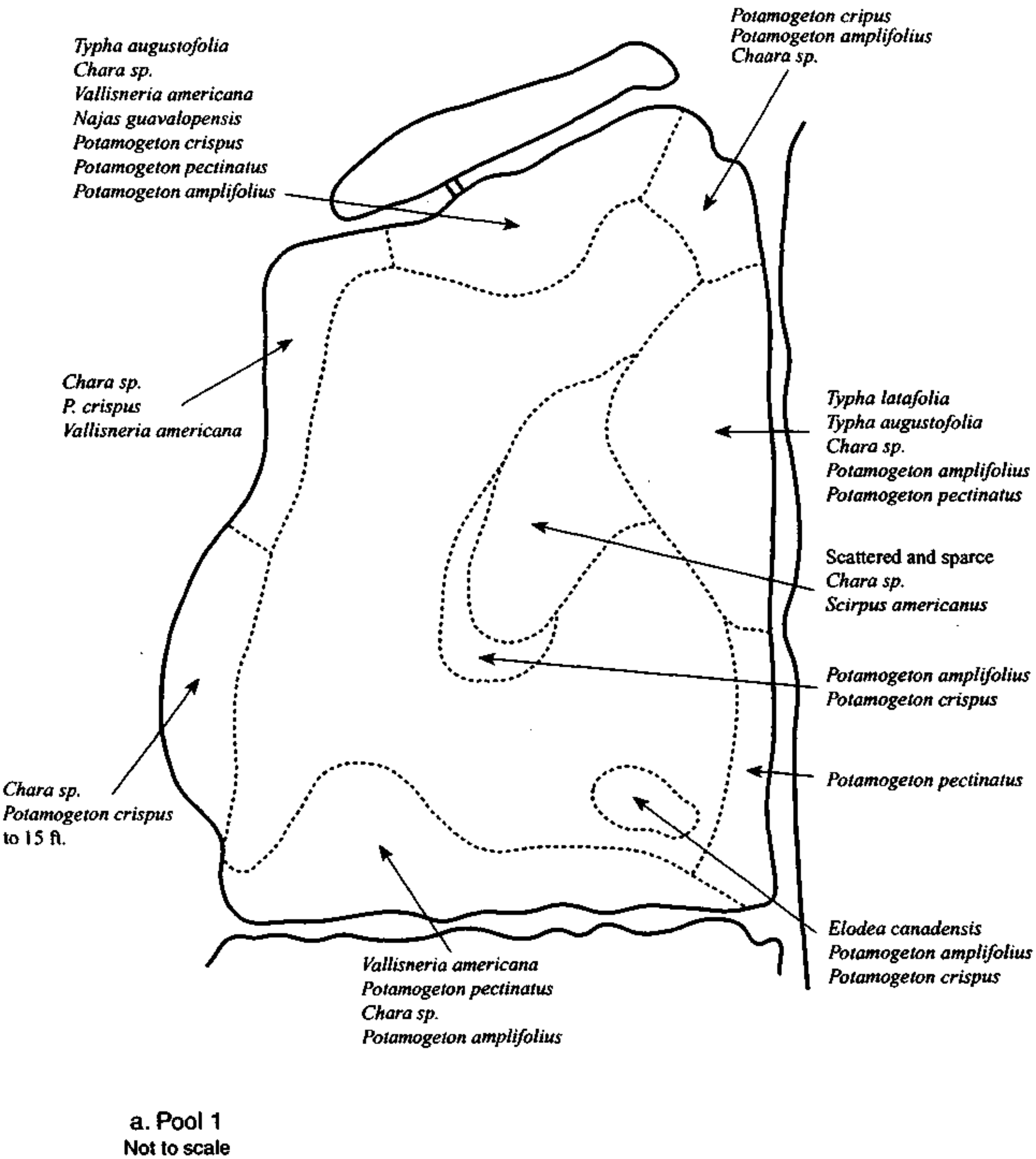


Figure 15a. Aquatic vegetation map for Pool 1, Wolf Lake on July 8, 1974

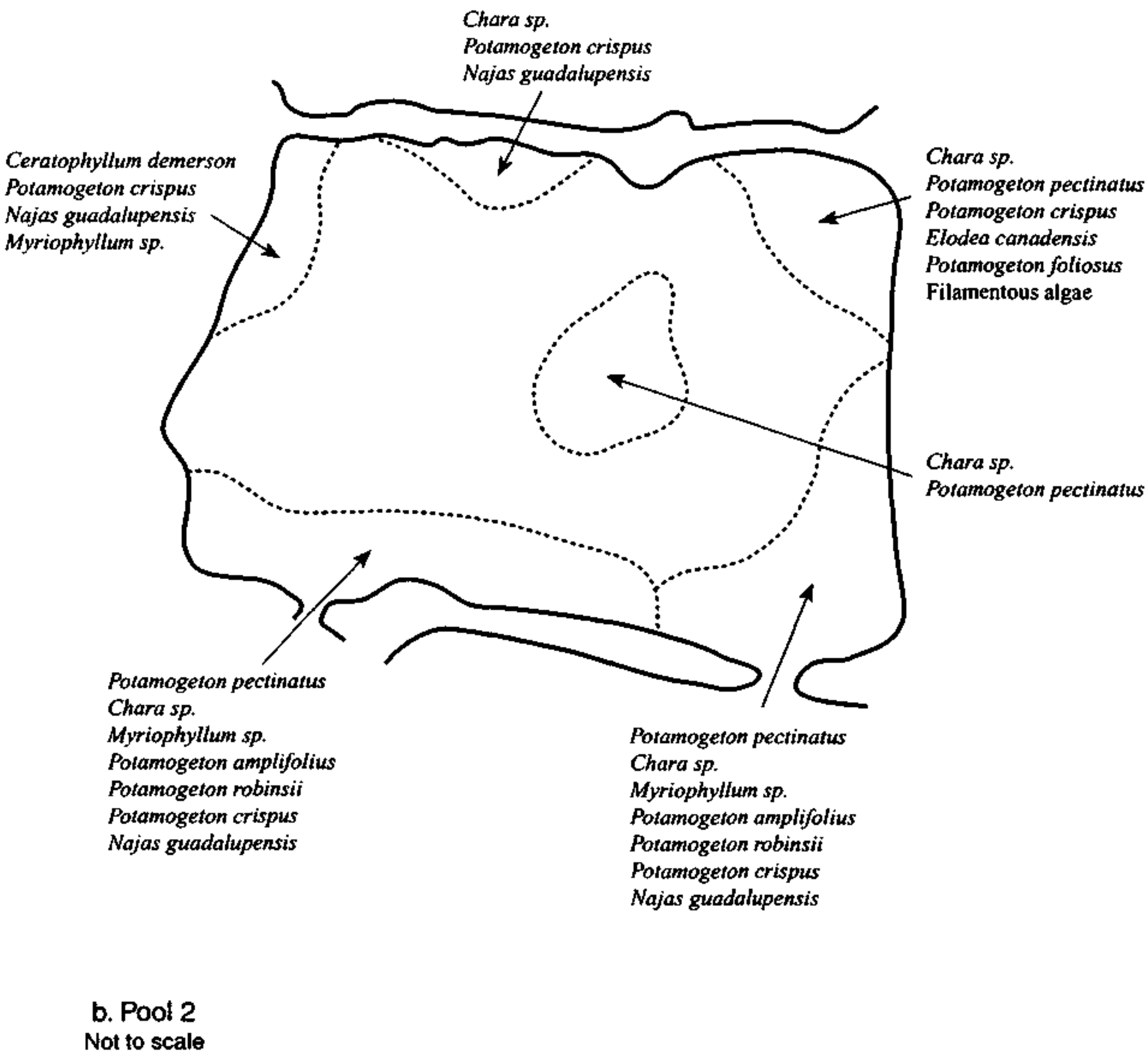


Figure 15b. Aquatic vegetation map for Pool 2, Wolf Lake on July 8, 1974

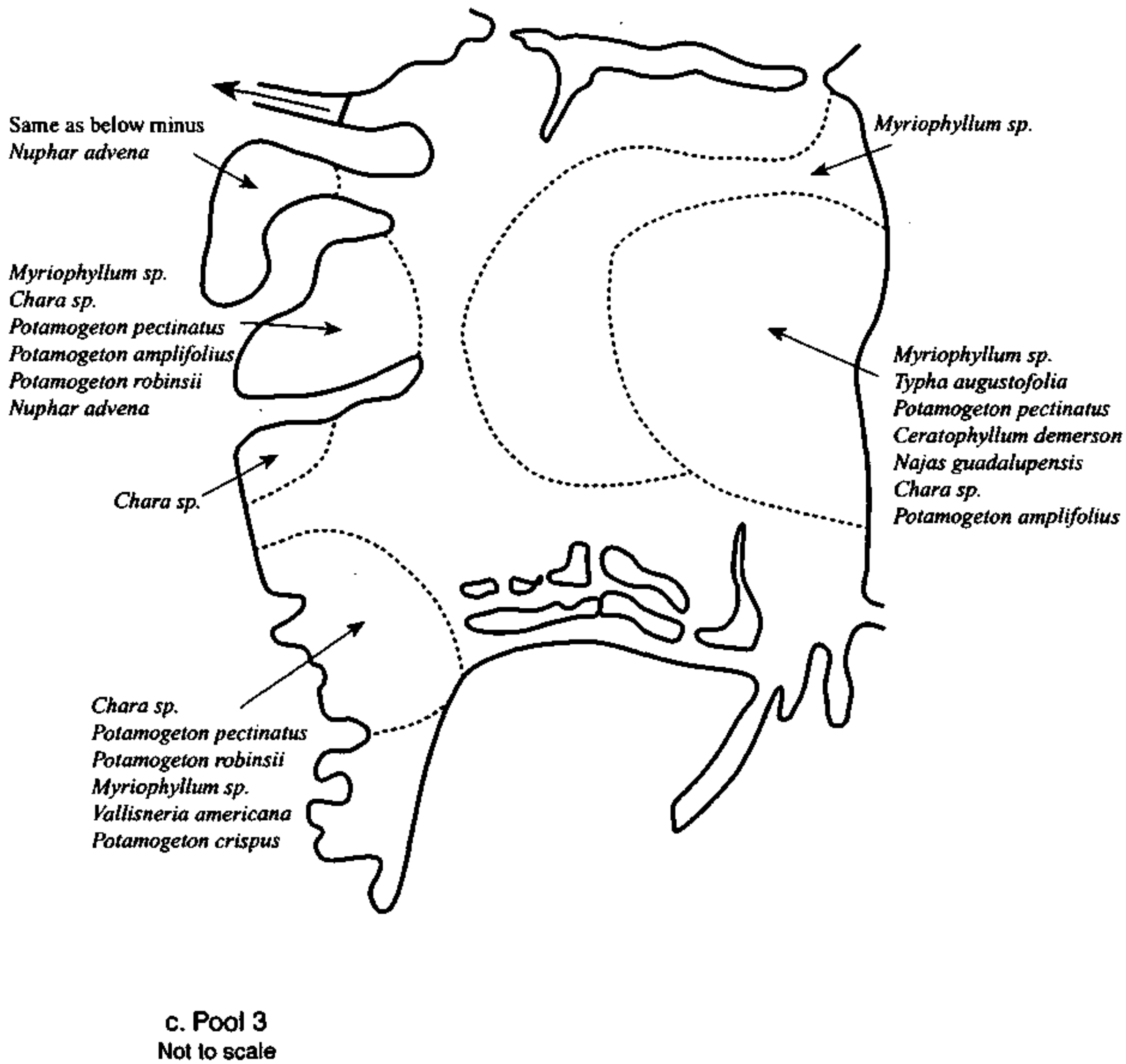


Figure 15c. Aquatic vegetation map for Pool 3, Wolf Lake on July 8, 1974

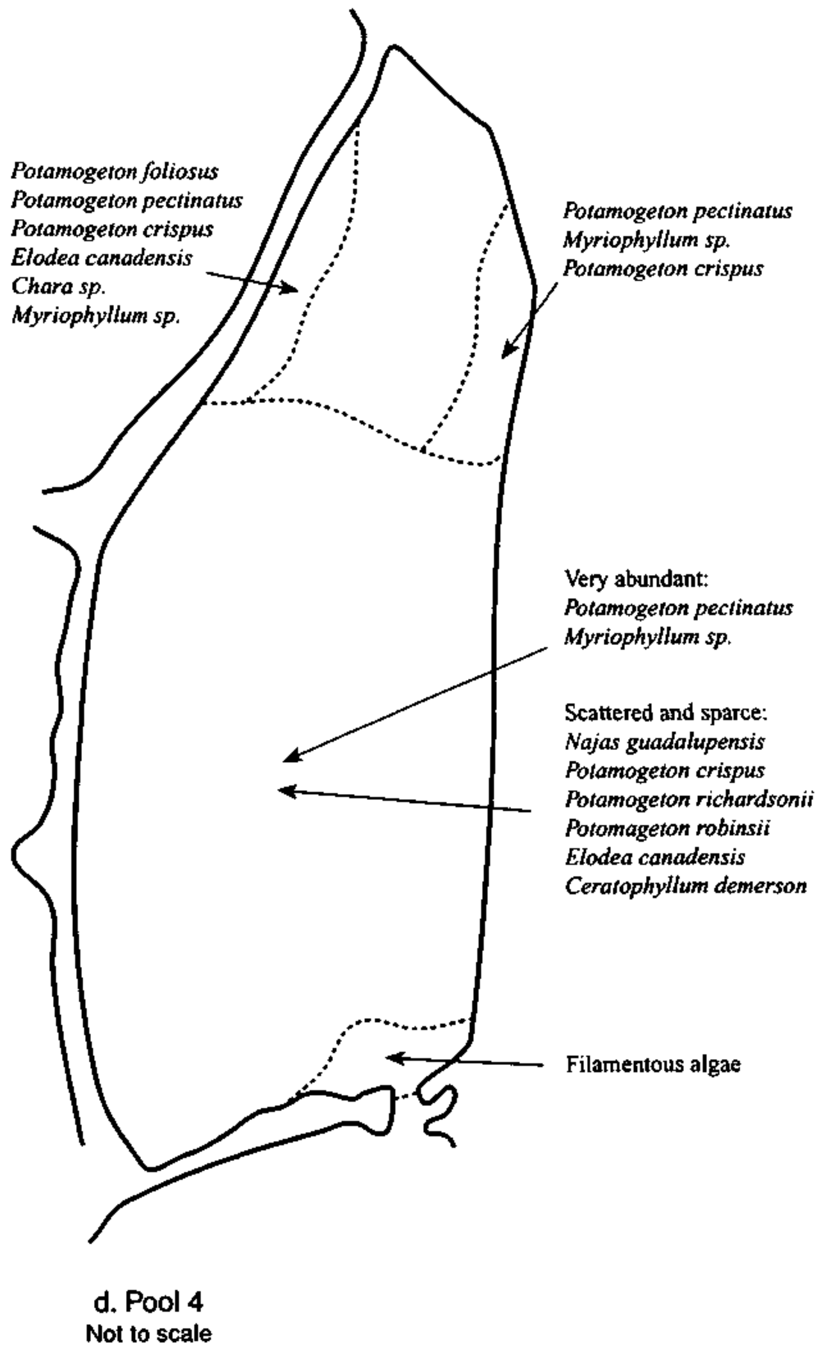


Figure 15d. Aquatic vegetation map for Pool 4, Wolf Lake on July 8, 1974

Table 38. Percent Composition of M acrophytes Collected in Wolf Lake (Illinois and Indiana)

Macrophyte	*Pool 1* *I*	*II*	*Pool 2* *I*	*II*	*III*	*Pool 3* *I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*Pool 4* *I*	*II*
Eurasian water milfoil	20		100	50	100	100	1	2	tr			96		75
Chara (Stonewart)		48		50			40	80		.98	80		90	
Naiad	80						tr		tr				8	
Pondweeds														
Sago pondweed											2			25
Broadleafpondweed		1					4					3		
Pondweed								6						
Small pondweed														
Curlyleaf pondweed														
Flatstem pondweed														
American elodea								2	100	2	3			
Tapegrass		1					5	10			10	1		
Waterstargrass											5		2	
Coontail														
Spatterdock							50							
Water lily														
Arrowhead														
Bulrush		50												
Numberoftaxa	2	4	1	2	1	1	6	5	4	2	5	3	3	2
Biomass, g/m^2	73.4	395.7	84.8	102.6	25.0	41.4	352.7	688.8	550.3	73.4	29.3	38.3	313.8	224.8

Note: tr = trace

Table 38. Continued

Macrophyte	Pool 4 IV	Pool 5 I	II	Pool 6 I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Eurasian water milfoil	40		98	75	99	70	8	94	1	25		98	92	1
Chara (Stonewart)		95							1	25	67			
Naiad	60			3				4	98	5	33			99
Pondweeds														
Sago pondweed			1	15	1	30	66			25		2	4	
Broadleaf pondweed														
Pondweed				7			26						4	
Small pondweed								tr		20				
Curlyleaf pondweed														tr
Flatstem pondweed														
American elodea		5	1					2						
Tapegrass														
Waterstargrass														
Coontail														
Spatterdock														
Water lily														
Arrowhead														
Bulrush														
Number of taxa	2	2	3	4	2	2	3	4	3	5	2	2	3	3
Biomass, g/m^2	186.3	55.3	20.7	50.8	104.1	16.6	87.1	260.3	161.4	8.9	276.4	175.6	197.2	100.3

Table 38. Concluded

Macrophyte	*Pool 7*			*Pool 8*						*Pool 9*			*Number of stations found*
	I	*11*	*III*	*1*	*II*	*III*	*IV*	*V*	*VI*	*I*	*II*	*III*	
Eurasian water milfoil	4	50	100	47	20	2	5	100	tr		98	65	31
Chara (Stonewart)	35			2		33	80						16
Naiad	40			50		33	4		tr				16
Pondweeds													
Sago pondweed		15											11
Broadleafpondweed					80	9							5
Pondweed													4
Small pondweed				1									3
Curly leaf pondweed												1	2
Flatstem pondweed		30											1
American elodea	10	5					1			25	2		12
Tapegrass	10					3	10			15		34	10
Waterstargrass										10			3
Coontail	1											tr	2
Spatterdock									100				2
Water lily										50			1
Arrowhead						20							1
Bulrush													1
Number of taxa	6	4	1	4	2	6	5	1	3	4	2	4	
Biomass, g/m^2	100.3	68.1	63.5	12.0	314.6	299.1	598.1	33.9	698.6	117.6	53.3	99.4	

Note: tr = trace; Pool 9 = Wolf Lake Channel

Key for Figures 16a through 16i

Macrophyte species:

1. Eurasian water milfoil *(Myriophyllum spicatum)*
2. Chara, stonewart, muskgrass *(Chara sp.)*
3. Naiad *(Naias flexilis)*
4. Sago pondweed *(Potamogeton pectinatus)*
5. Broad leaf pondweed *(Potamogeton amplifolious)*
6. Pondweed *(Potamogeton filiformis)*
7. Small pondweed *(Potamogeton pusillus)*
8. Curly leaf pondweed *(Potamogeton crispus)*
9. Flat stem pondweed *(Potamogeton) zosteriformis)*
10. Elodea or American elodea *(Elodea canadensis)*
11. Tape grass *(Vallisneria americana)*
12. Water stargrass *(Heteranthera dubia)*
13. Coontail *(Ceratophyllum demersum)*
14. Spatterdock *(Nuphar variegatum)*
15. Water lily *(Nyphae sp.)*
16. Arrowhead *(Sagittaria sp.)*
17. Bulrush *(Scirpus sp.)*
18. Chlodophora

Density legend:

Dense

Moderate

Sparse

Lily pad

Roman Numerals = Macrophyte sampling stations

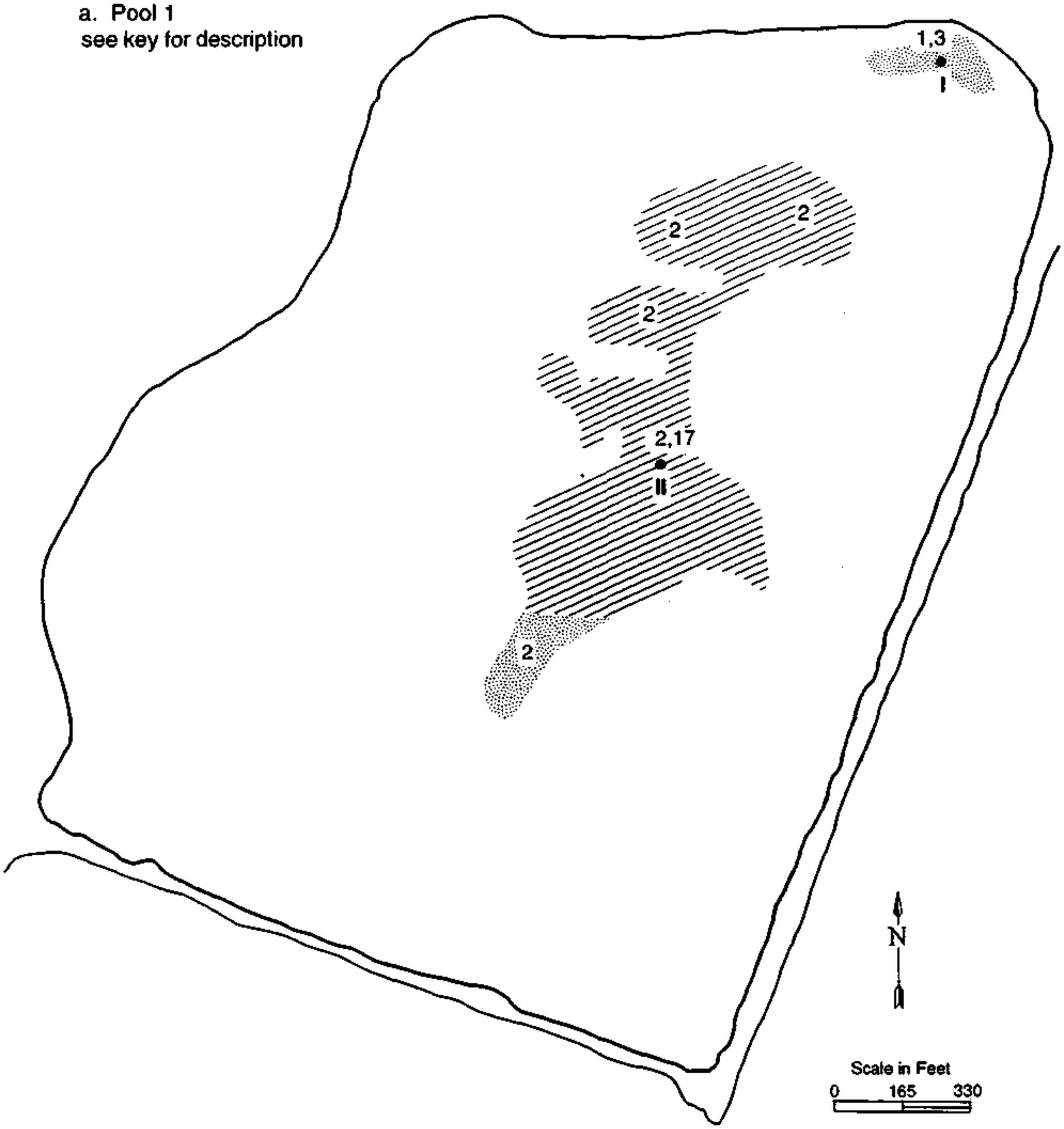


Figure 16a. Aquatic vegetation map for Pool 1, Wolf Lake on July 22, 1993

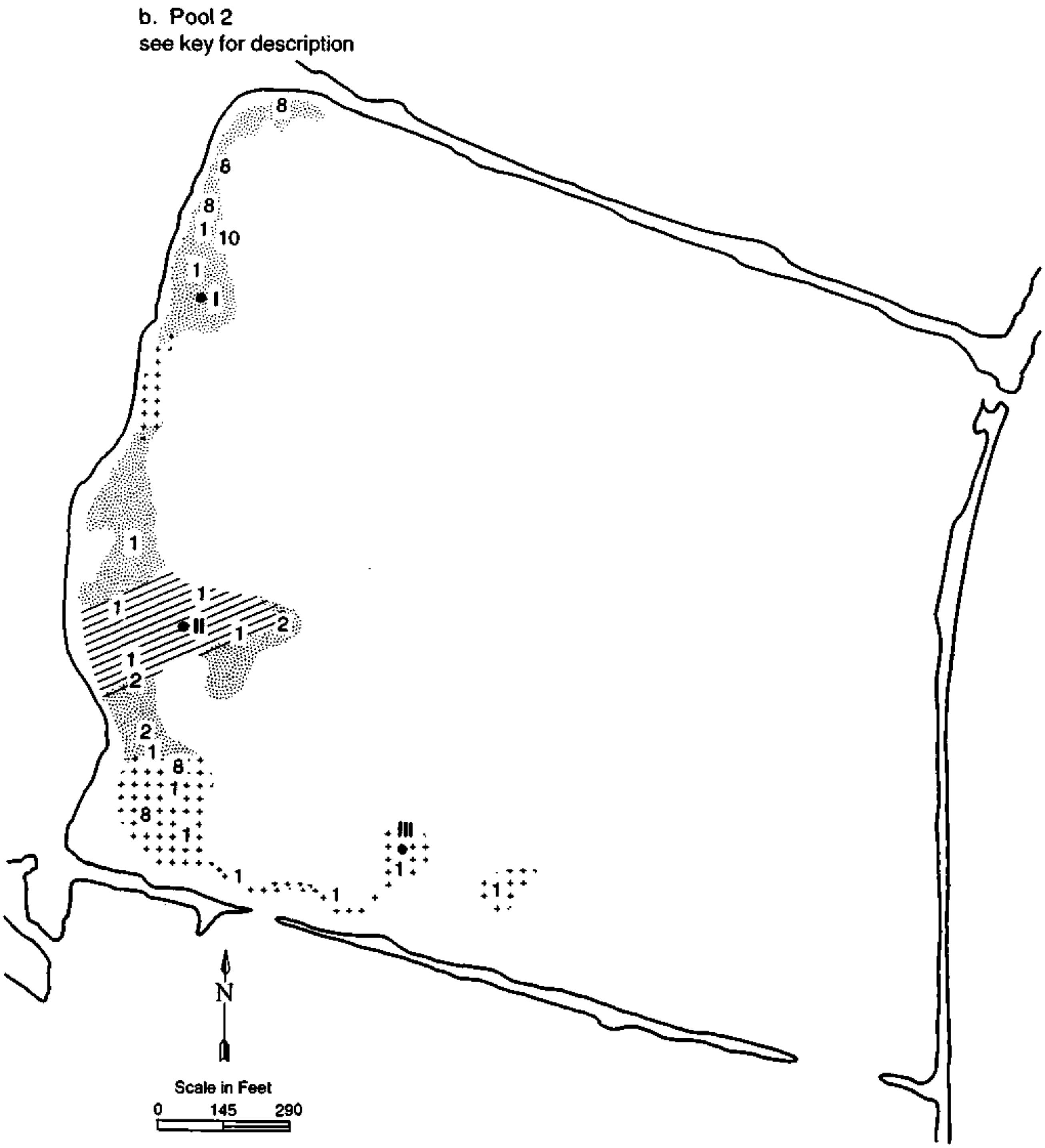


Figure 16b. Aquatic vegetation map for Pool 2, Wolf Lake on July 22, 1993

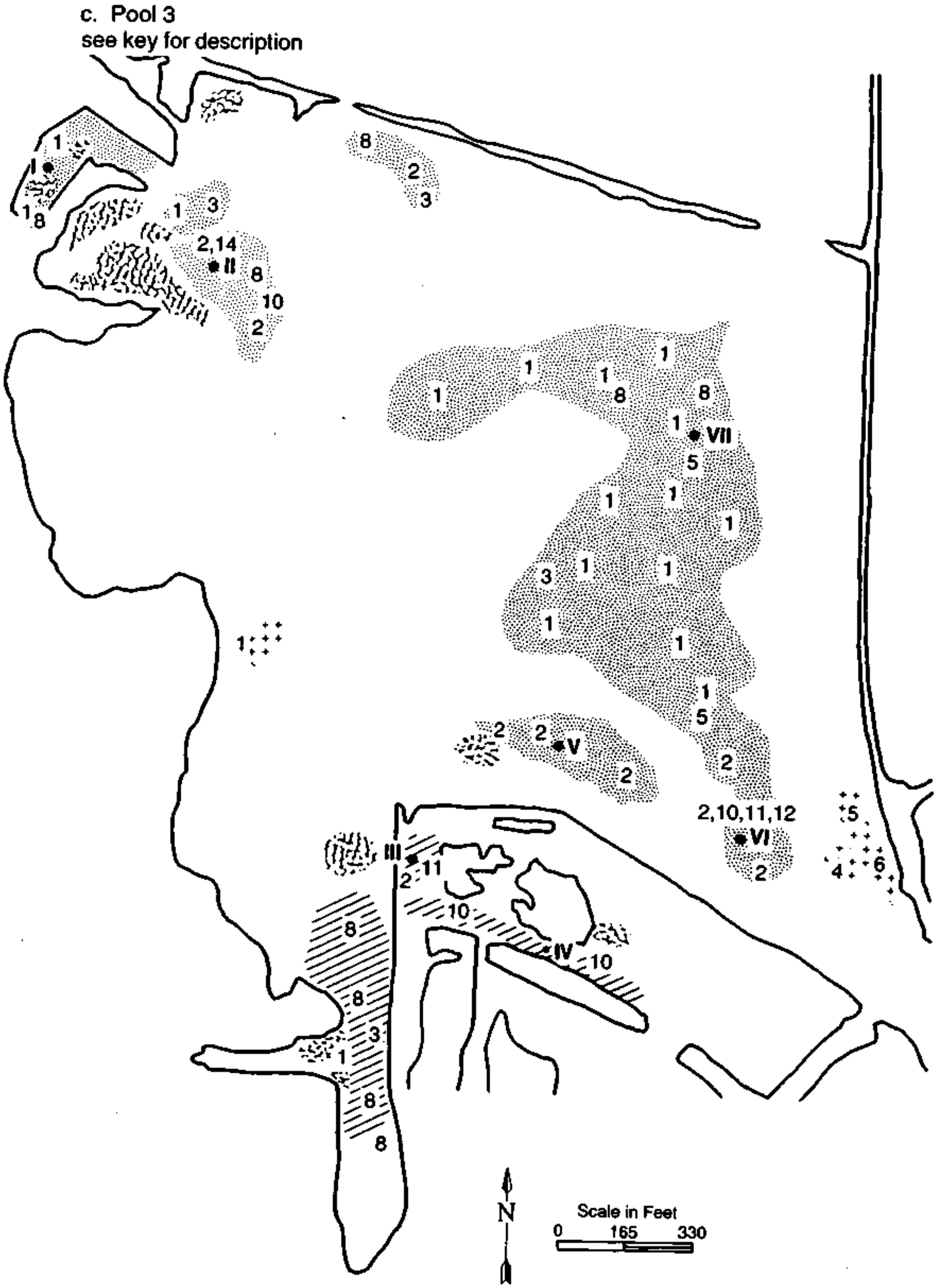


Figure 16c. Aquatic vegetation map for Pool 3, Wolf Lake on July 22, 1993

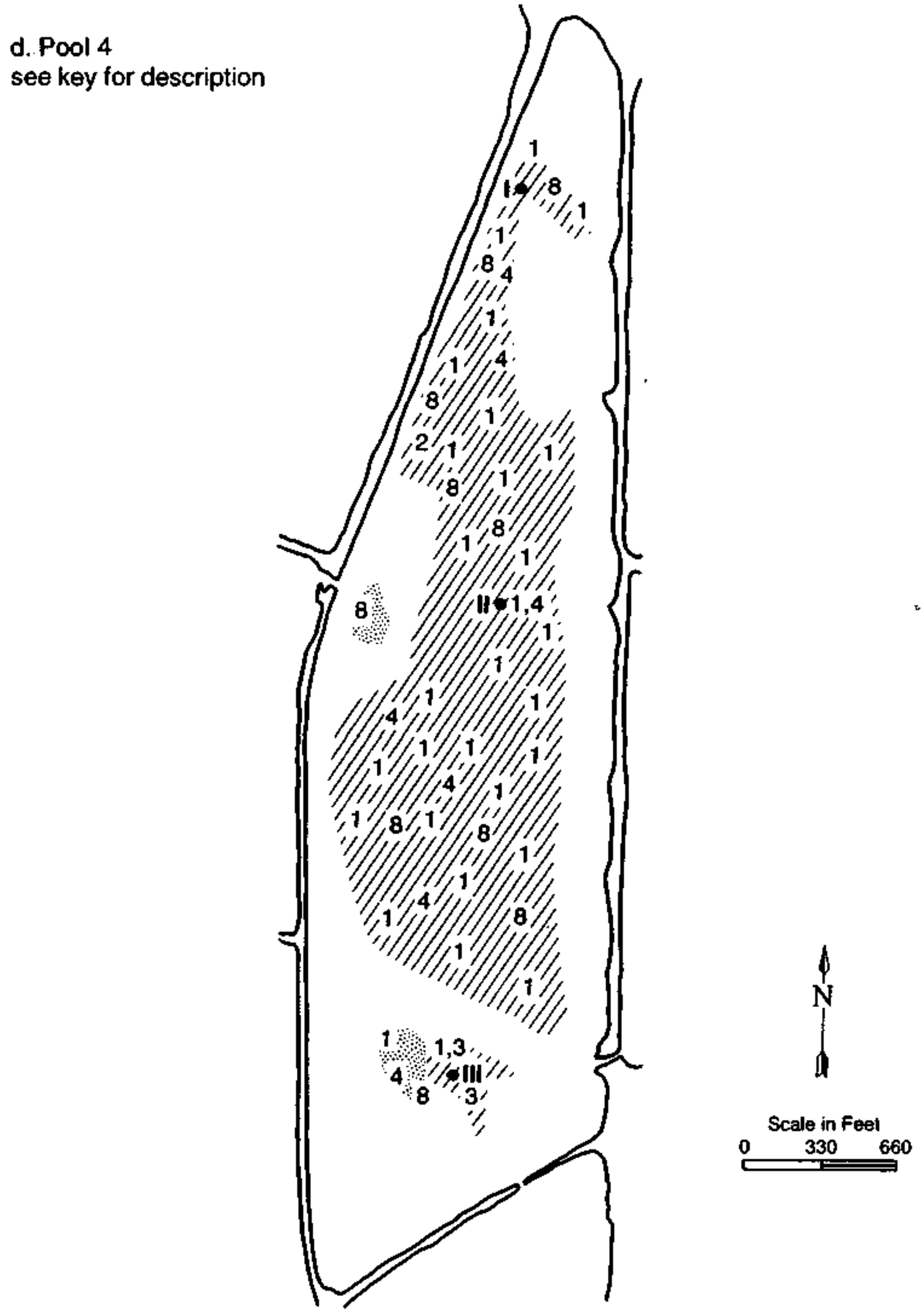


Figure 16d. Aquatic vegetation map for Pool 4, Wolf Lake on July 22, 1993

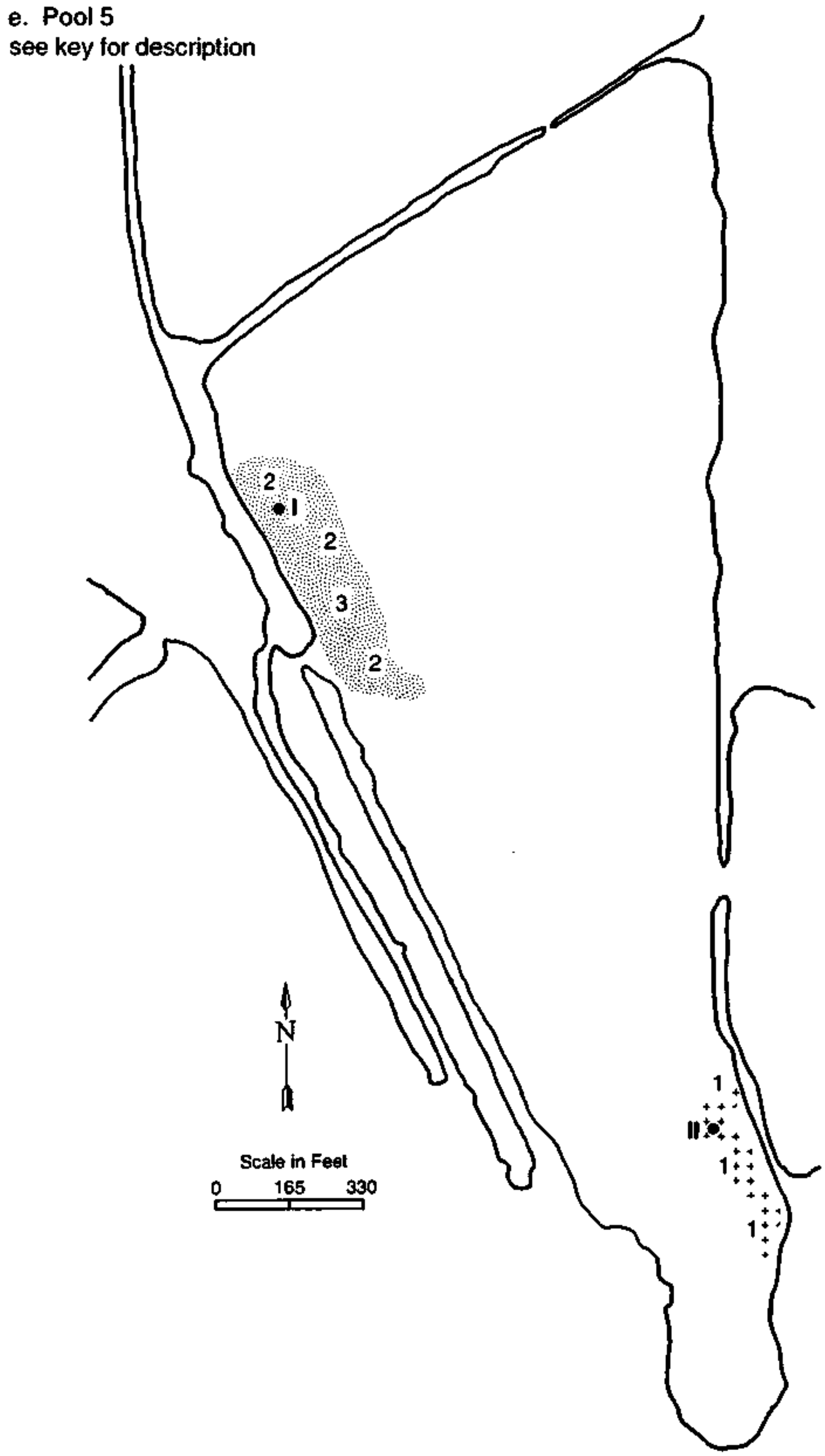


Figure 16e. Aquatic vegetation map for Pool 5, Wolf Lake on July 23,1993

f. Pool 6
see key for description

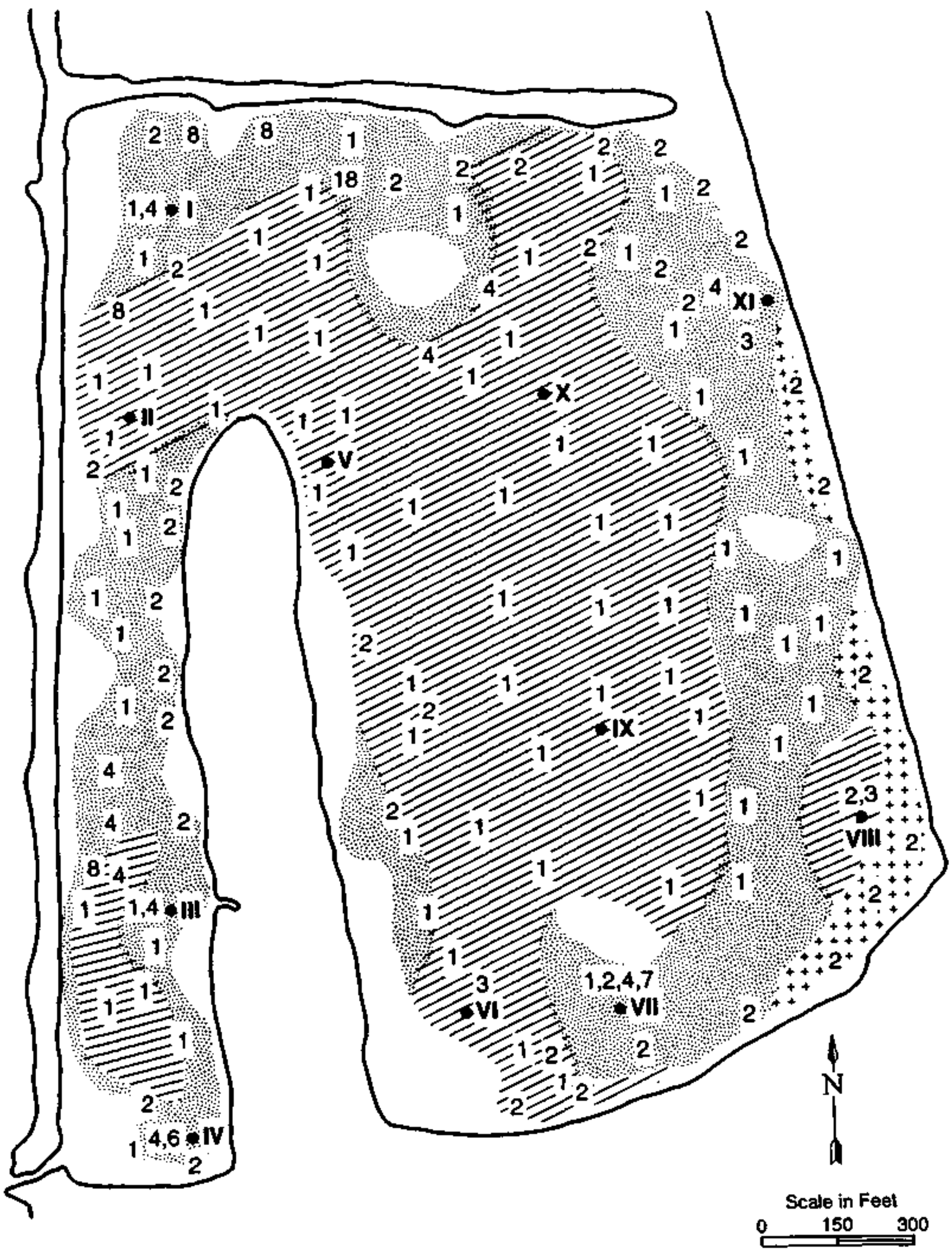


Figure 16f. Aquatic vegetation map for Pool 6, Wolf Lake on July 23, 1993

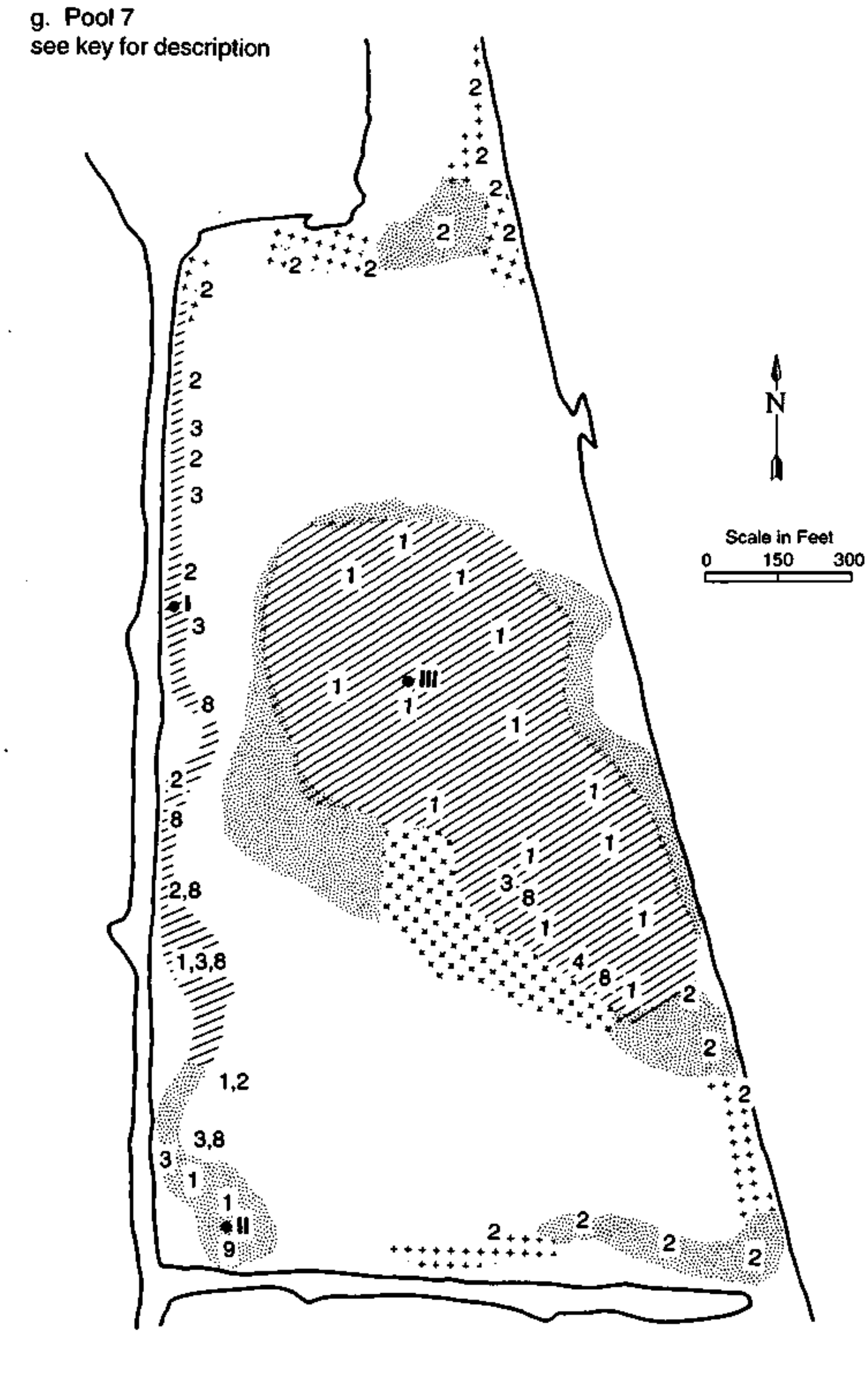


Figure 16g. Aquatic vegetation map for Pool 7, Wolf Lake on July 23, 1993

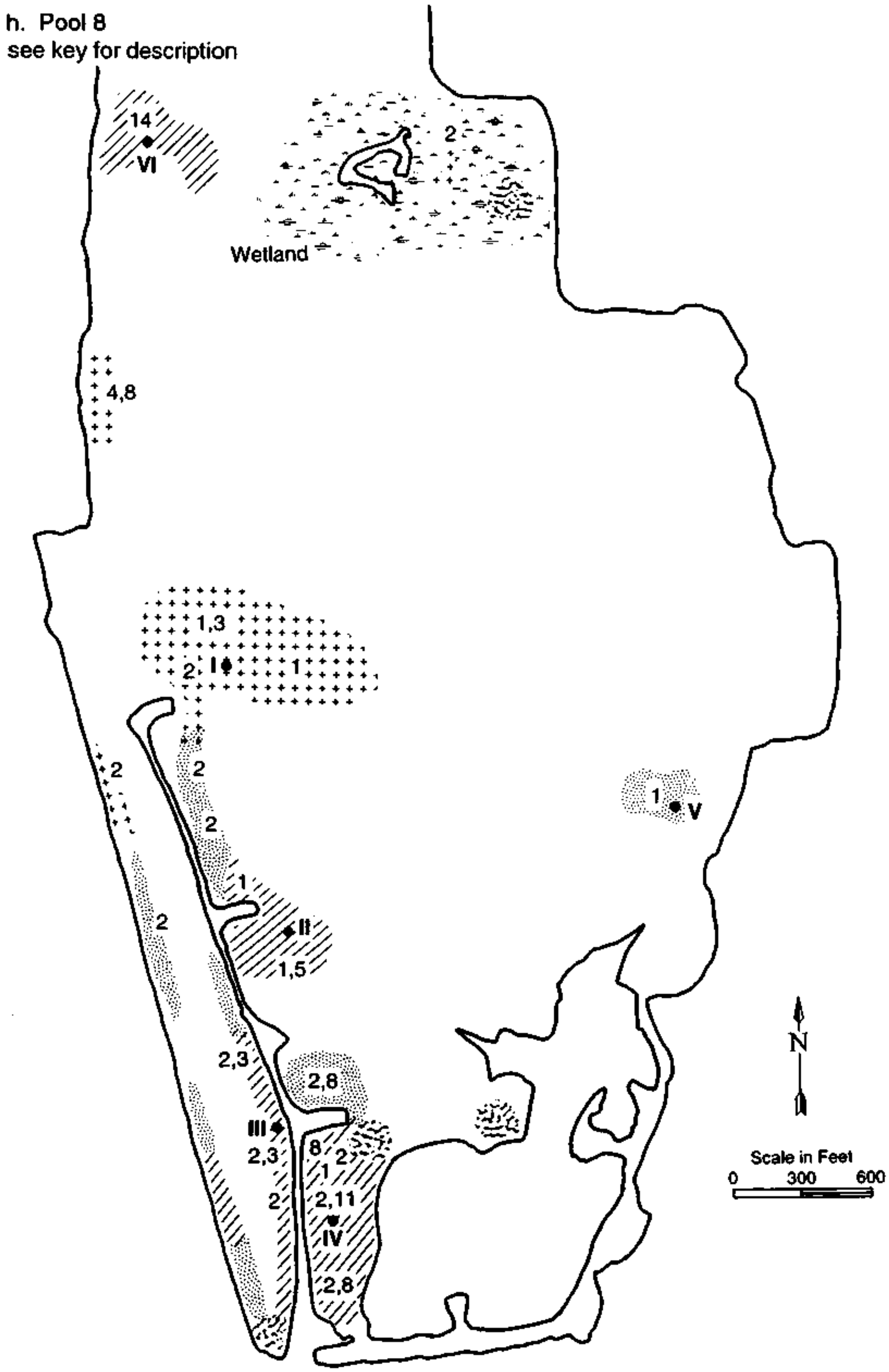


Figure 16h. Aquatic vegetation map for Pool 8, Wolf Lake on July 22, 1993

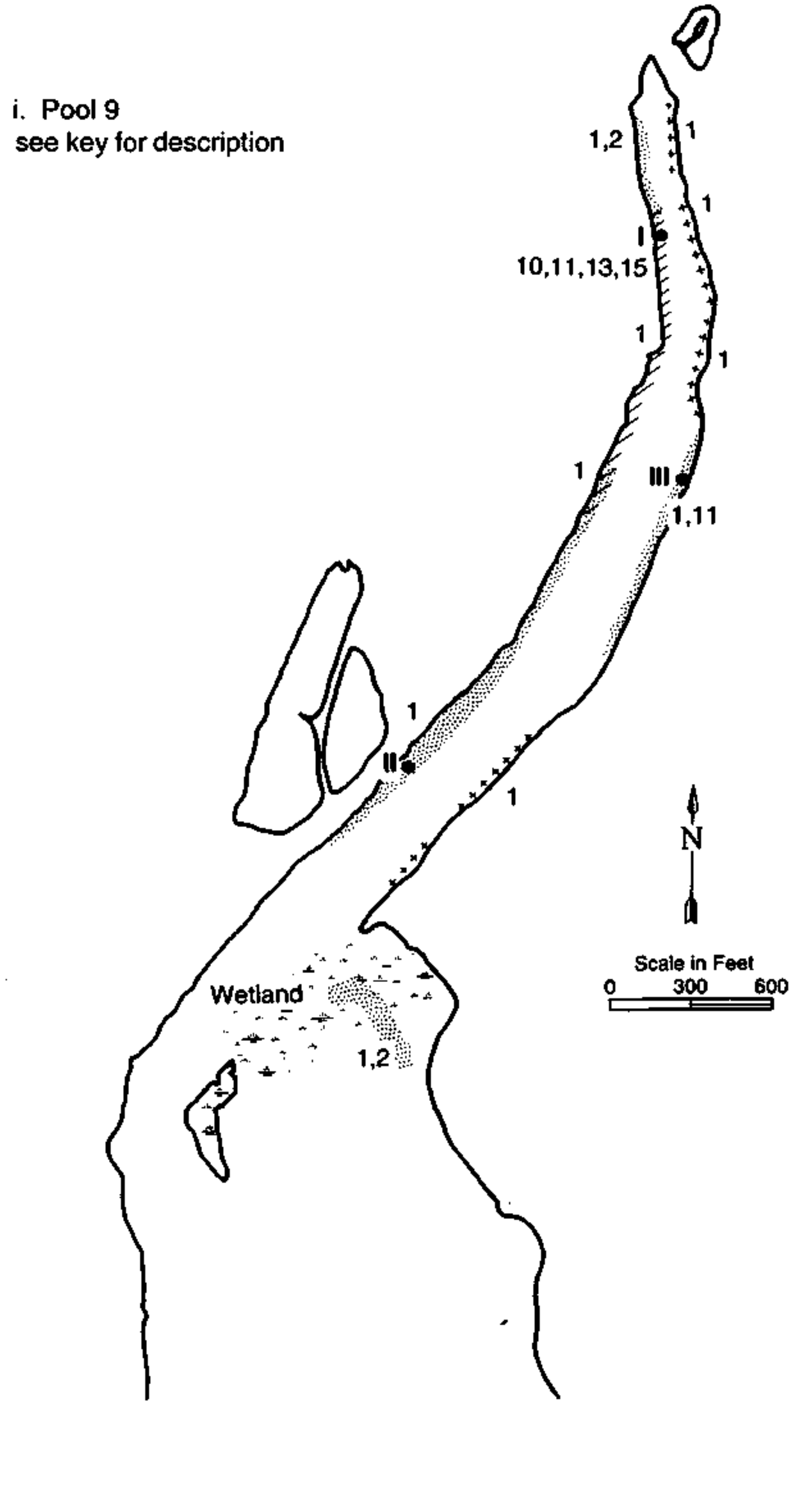


Figure 16i. Aquatic vegetation map for Pool 9, Wolf Lake on July 22, 1993

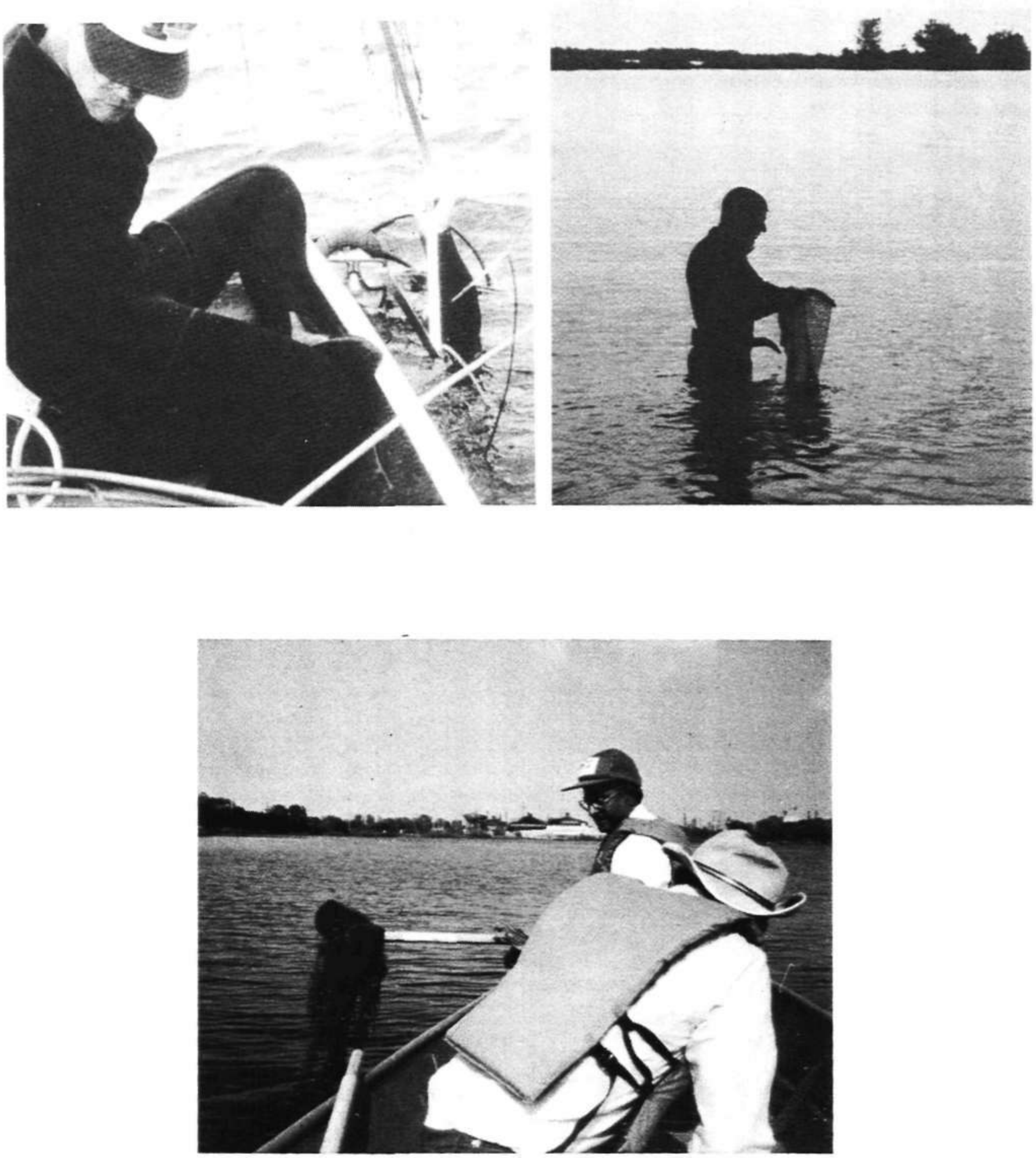


Figure 17. Views taken during the macrophytes survey

II, and 9-III. Chara, an algae, is the second dominant species in all pools except Pool 9. Chara is important in Pool 3 (3-II, 3-V, 3-VI) and at sites 4-1, 5-1, 6-VIII, and 8-IV. Naiad *(Najasflexilis)* was dominant at 1-1, 6-VI, 4-III, 6-VI, 6-XI, 7-1, and 8-1. This macrophyte was also important at some other sites in Pools 6 and 8. Engel (1988, 1990) reports that Eurasian water milfoil, naiad, and chara are also commonly found in Wisconsin lakes.

It can be seen from table 38 that sago pondweed *(Potamogeton pectinatus),* American elodea *{Elodea canadensis),* and tapegrass *(Vallisneria americana)* also occurred frequently in Wolf Lake. Sago pondweed was an important species in Pool 6 at sites 6-IV (where it was the dominant species), 6-IV, 6-III, and 6-VIII. American elodea was found in Pools 3 and 9; it constituted nearly 100 percent of the vegetative mass at site 3-IV. Tapegrass was also observed frequently in Pools 3 and 9, and it was the codominant species at site 9-III. Spatterdock *(Nuphar variegatum)* was the dominant species at sites 3-II and 8-VI while bulrush *(Scirpus* sp.) and water lily *(Nymphae* spp.) were, respectively, the dominant macrophytes at sites 1-II and 9-1.

Eurasian water milfoil is a non-native aquatic plant that has become a widespread problem throughout North America. It has fine, featherlike leaves and produces a dense canopied bed. It can impact extensive areas because of this dense canopylike growth form and its highly aggressive and weedy characteristics. Eurasian water milfoil spreads both within and between lakes by the formation of vegetative autofragments, which are stem pieces that break off the plant through stem abscission. Dense colonies may also spread locally by the growth of root crowns. It grows entirely under water, possibly at depths of 8 to 10 feet, and it will usually become the dominant species in the lake (Pullman, 1992; Madsen, 1993).

Chara is an advanced form of algae that grows from the lake bottom with stems and branches. It feels bristly, has a musky odor, and is usually found in hard water. Common names are chara, muskgrass, and stonewart. Like Eurasian water milfoil, chara is often difficult to control even when proper herbicides are used (Illinois Department of Conservation, 1990).

Water depths at the macrophyte sampling stations ranged from 2.0 feet to 6.5 feet (table 39). At sites where chara was the dominant species, measured plant heights were between 0.3 to 0.8 feet lower than the water depths. However, plant heights at the sites where Eurasian water milfoil was dominant were from 3.0 to 5.5 feet taller than water depths, and the plants tended to form a thick canopy. Generally, the soft sediment in the lake was black in color and not more than 9 inches thick. There was no putrid odor emanating from the bottom when disturbed. This soft sediment is underlain by a firm, gritty, and sandy bottom.

Comparison of historical and current macrophyte areal extent maps (figures 15a-d versus figures 16a-d) indicates that current macrophyte growth in Pool 1 is much smaller in terms of species diversity and areal extent. In Pool 2, macrophytes were prevalent almost everywhere along the shorelines and in the center; however, in the current study, macrophytes were found only along the west and southwest shorelines of Pool 2. For Pool 3, the areas of macrophyte beds were similar except that no macrophyte growth was found along the southwest shore of the main pool and dense growth was found in the southwest bay during the current study period. In a 1974 study, macrophytes existed in almost the entire area of Pool 4 except the north-central portion, whereas in the current survey, macrophytes did not occur around shorelines except in the northern one-half of the west shore, which had dense growth. Drastic changes in macrophyte beds were observed in Wolf Lake. The densities of macrophytes were not determined in the 1974 survey.

Schloesser and Manny (1984) provided guidelines for defining density of macrophyte growths in lakes. They considered growths of 20 to 80 g/m^2 low density, 60 to 160 g/m^2 medium density, and 150 to 220 g/m^2 high density. Based on this scale, the relative denseness of macrophyte beds is plotted in figures 16a-i. Among the 40 sites examined, the biomass of the macrophytes ranged from 8.9 g/m^2 at site 6-VII to 698.6 g/m^2 at site 8-VI (table 36). Extremely

Table 39. Observations in Wolf Lake during Macrophytes Survey, July 22-23,1993

Station, pool-site	*Quadrat size, inches*	*Water depth, feet*	*Plant height, feet*	*Sediment characteristics/notes*
1-I	18	2.5	1-1.5	Black, sandy, gritty, firm
l-II	18	5.5	9-10	Black, soft muck, semi-firm
2-I	18	6	3	Dark brown, organic silt, semi-firm, no odor
2-II	18	5	0.5-1	Dark brown, sandy clay, semi-soft, no odor
2-III	18	6	0.5	Light, brown, sandy, firm hard bottom, no odor
3-I	18	5	4-5	Black, clayey sand, no odor
3-II	18	3	3	Black, silty, lots of plant fibers, partial root of lily plant was retrieved
3-III	18	3	0.5-1.5	Black, sandy clay, soft, musty odor
3-IV	18	3	2	Black, silt-clayey muck, septic, gas bubbles (one huge clump of chara was pulled)
3-V	18	2	0.25	Firm, rock, stone, sand, clay, silt (fine gravel, shell, etc. in the sample)
3-VI	18	3.5	0.5	Black organic clay, lots of plant fibers, musty odor
3-VII	18	5	2.5	Clayey sandy muck, dark, no odor
4-I	12	2.8	1	Fine sand, black mud, no odor
4-II	18	4.5	3	Black, organic silt, semi-firm
4-III	12	5.5	2.5	Organic silt, black, musty
5-I	12	4.3	6.7	Muck, loose, soft, organic silt, black, nonodorous
5-II	18	5.5	•	Dark brown, fine soft silty muck, sediment thickness > 3 feet
6-I	18	4	2.5-3.5	Black, organic muck, loose, gray sand and gravel, sediment 1.3 feet
6-II	18	5	3-4	Black, organic muck, loose, gray sand and gravel, sediment 1 foot
6-III	18	5	2-3	Black, organic muck overlays gray sand and gravel, hard bottom, sediment 6 inches
6-IV	12	5	2-3	Black, organic muck overlays gray sand and gravel, hard bottom, sediment 6 inches
6-V	18	4.3	4	Black, oozy, organic muck, sediment 3.3 feet
6-VI	12	4.8	4.3	Black, fine sandy muck, gray sandy bottom, sediment 6 inches
6-VII	18	4.3	2	Fine sand grained muck, hard gray sandy bottom, sediment 4 inches
6-VIII	18	3.5	1.5	Fine sand grained muck, hard gray sandy bottom, sediment 3 inches
6-IX	18	4.8	3	Black fine muck, hard gray sandy bottom, odoroless, sediment 6 inches
6-X	18	5	4.5	Black fine muck, hard gray sandy bottom, odorless, sediment 1 foot
6-XI	18	4.8	4.2	Black fine muck, hard gray sandy bottom, odorless, sediment 3 inches
7-I	18	3.3	6.7	Fine sandy muck, semi-firm bottom, sediment 2 feet
7-II	18	4.8	2	Black muck, hard bottom, sediment depth 9 inches

Table 39. Concluded

Station, pool-site	*Quadrat size, inches*	*Water depth, feet*	*Plant height, feet*	*Sediment characteristics/notes*
7-III	18	5	4	Black fine loose muck, clayey sandy bottom, sediment 9 inches
8-I	18	4	1.5	No muck, fine sandy firm bottom
8-II	18	3	3	Loose fine muck, sandy and gravelly bottom, sediment 1 foot
8-III	18	3	0.5	Black fine sandy organic muck, gray sandy bottom, sediment 4 inches
8-IV	12	2.3	-	Black, gritty organic fine muck, sandy firm bottom
8-V	18	6.5	5	Sandy organic muck, no septic odor, sediment 2.3 feet
8-V1	18	2	4-5	At lily pad bed, collected 2 lily plants for biomass determination; counted 7 plants with 84 stems in 4 feet × 4 feet area
9-I	12	4	4	Firm bottom, lots of brush, branches, twigs, oily and greasy smell in the 6-inch deep sediment
9-II	12	3	4-5	Gravelly substrate (pebbles), a dug channel
9-III	12	3	4-5	Rip-rap bottom, opposite to Forsyth Park

dense biomass also occurred at sites 3-III, 3 -VI, and 8-IV. Forty percent (16 out of 40) of the macrophyte survey sites had biomass greater than 150 g/m^2, which could be classified as heavy growth. Thirty percent (12) of the sites experienced medium-density growth and 30 percent had low-density growth. It is apparent that the excessive macrophyte growths in the lake could adversely impact recreational opportunities such as boating, fishing, and surfing (Pools 6 and 7). Without a doubt, the massive growths of macrophytes decrease the aesthetic value of the water body.

If lake dredging is carried out in Pools 6, 7, and 9, the quantity of macrophytes removed can be estimated. From the areal extent of macrophyte beds, it is estimated that approximately 95, 60, and 20 percent of Pools 6, 7, and 9, respectively, were covered by macrophytes (figures 16f, 16g, and 16i). On the basis of biomass data and the areal extent of macrophyte beds, it is estimated that approximately 315.5 metric tons (695,000 pounds or 348 tons), 57.1 metric tons (126,000 pounds or 63 tons), and 4.9 metric tons (10,800 pounds or 5.4 tons) of macrophytes existed (dry-weight basis) in Pools 6, 7, and 9, respectively. Information about the areal extent of macrophyte coverages in other pools is included in the segment of this report titled *Lake Use Support Analysis.*

Benthic Macroinvertebrates. Benthic macroinvertebrates are animals within the aquatic system visible to the unaided eye and capable of being retained by a U.S. Standard No. 30 mesh sieve. These common, easily collected organisms have limited mobility and are present throughout the growing season. An abundant and diverse community of macroinvertebrates is important for a reliable source of food for fish. Macroinvertebrates are sensitive to changes in the aquatic environment.

The benthic macroinvertebrate communities in Wolf Lake were sampled on May 10, 1993, and August 3, 1993. These samples were taken at the regular sampling stations representing the deepest part of each pool (RHA-1 through RHA-9).

The numbers of individuals, taxa, and biomass collected are listed in table 40. The benthic population observed were quite different among the stations and between the two sampling dates. On May 10, 1993, total observed benthic macroinvertebrates ranged from none at RHA-1 to a high of 1,594 cts/m^2 at RHA-6; while on August 3, 1993, the benthic populations were between 28 cts/m^2 at stations RHA-4 and RHA-5 and 545 cts/m^2 at RHA-1.

Results in table 40 indicate that the taxa observed in Wolf Lake were between 0 and 5 for all stations. High diversities occurred at RHA-3 in the May sample and at RHA-6 in the August sample. These were less diverse than the taxa observed in Lake George (Raman *et al.,* 1995). On May 10, 1993, at RHA-1, good grab samples could not be obtained even after nine attempts. The lake bottom at RHA-1 is mostly rocky gravel and sand lacking any macrophytes. Fewer taxa (1 or 2) were found at RHA-9, which has an oily bottom sediment. At this station, sediment was composed of gritty, black, granular, unnatural particles.

Excluding RHA-1, biomass in the lake ranged from a low of 0.013 g/m^2 in an August sample at RHA-2 to a high of 0.690 g/m^2 for a May sample at RHA-6. Both the benthic population and biomass were higher in May collections than in August collections for all stations except RHA-1. This is probably due to the emergence of mature insects in May and fish predation rather than to low DO conditions in August.

The benthos community was dominated by relatively intolerant members of the Chironomidae *(non-Chironomus),* and tolerant members of *Chironomus* (bloodworm), and Oligochaeta (aquatic worms). The benthos in this lake is more diverse and pollution sensitive than that found in most stratified lakes. The abundant macrophytes provide a more complex habitat for aquatic macroinvertebrates.

Table 40. Benthic Macroinvertebrates in Wolf Lake

Organism	Station, individuals/m"								
	RHA-1	*RHA-2*	*RHA-3*	*RHA-4*	*RHA-5*	*RHA-6*	*RHA-7*	*RHA-8*	*RHA-9*
5/10/93									
Chironomus (bloodworm)		230	172	273	258	474	187	273	
Chironomidae *(mm-Chironmus)*		43	316	172	86	732	301	416	201
Chaoborus (phantom midge)		244	14		43			14	
Oligochaeta (aquatic worm)		86	43	344			330	316	402
Amphipoda (scud)						388			
Ceratopogonidae (biting midge)			57	14					
Total number	0	603	602	803	387	1,594	818	1,019	603
Total dry weight, g/m^2	0	0.471	0.442	0.647	0.517	0.690	0.498	0.398	0.210
8/3/93									
Chironomus (bloodworm)	301				14	57	115	86	
Chironomidae *(non-Chironomus)*	158		244			43	244	14	
Chaoborus (phantom midge)								29	
Oligochaeta (aquatic worm)	86	43	14				158	29	445
Amphipoda (scud)			29			201			
Hirudinea (leech)				14	14	14			
Physa (snail)				14		43			
Total number	545	43	287	28	28	358	517	158	445
Total dry weight, g/m^2	0.334	0.013	0.023	0.251	0.033	0.119	0.099	0.159	0.095

Surface Inflow Water Quality Data

Monitoring of tributaries to a lake system, both for quantity and quality characteristics, is generally routinely carried out for base flows and storm event flows. These data are used for developing a hydraulic budget and flow-weighted nutrient and sediment budgets for the lake. The details of the methodology for developing hydraulic, sediment, and nutrient budgets are discussed elsewhere. Storm event samples were collected primarily for assessing the water quality characteristics of the inflows to the lake.

All surface inflow points to Wolf Lake were identified and sampled. The monitoring stations are shown in figure 8. The inflow stations were RHA 02 through RHA 14, and RHA 71 and RHA 72. Station RHA 01 provides information about the outflow from the lake. Water quality samples were collected during routine sampling trips and during storm events. Water samples were taken for physical, chemical, and bacteriological analyses. In addition, one set of water samples was collected from several locations on June 7, 1993, for metals and organic analyses. All inflow water quality samples were grab samples. The numbers of samples collected varied with location. Station RHA 03 was the most frequently sampled station, whereas limited numbers of samples were collected at RHA 06, 07, 08, 09, 11, 13, and 14. Storm event samplings were conducted at various stations on April 19-20 and June 7-8, 1993.

Thirteen rainwater samples were collected using the Water Survey's raingaging station at Grayco Corporation near Wolf Lake. Rainwater samples were analyzed for nutrient concentrations. The results of physical and chemical analyses of rainwater and inflow water are presented in tables 41a-k. The results of metal and organic analyses for storm event samples are shown in tables 42 and 43, respectively. Indicator bacterial densities in the inflows are presented in table 33 and discussed elsewhere in this report.

Inflow point RHA 02 is the outfall at Lever Brothers. Inflows RHA 03, RHA 04, and RHA 05 are stormwater pump discharges at the Roby station (outfall 017), the Forsythe Park station (outfall 018), and the Sheffield Avenue station (outfall 019) of the Hammond Sanitary District, respectively. Inflows RHA 11, RHA 12, RHA 13, and RHA 14 are, respectively, outfalls 002, 003, 004, and 005 of Amaizo. The monthly NPDES data for one year (the study period) for the outfalls mentioned above are summarized in tables 7, 8, 9, 10a, 10b, and 10c. The results are discussed in detail in the section on point source discharges.

As shown in table 41b, the discharges from Lever Brothers at RHA 02 exhibit fairly stable water quality characteristics that are unaffected by storm events.

During any storm event, the greatest number of samples collected at any site was three, which was not enough, especially at the three pumping stations, to identify any trend. An automatic sampler with more frequent sampling would have provided additional information, but the high costs of such a scheme precluded this effort.

Chloride, fluoride, sulfate, cyanide, oil, and phenol were analyzed in some storm event samples. The data for these were sporadic (see tables 41a-k) and will not be discussed here. The following discussion covers only turbidity, total and volatile suspended solids, conductivity, chemical oxygen demand, pH, alkalinity, nutrients, metals, and organics.

Physical Characteristics

Turbidity. Turbidity values equal to or greater than 15 NTU are indicative of the presence of substantial suspended sediments. This value was exceeded in most of the storm event

Table 41a. Rainwater Quality at Grayco Corporation, Rain gage G19, near Wolf Lake

	Nitrogen. me/L			*Phosphorus, me/L*	
Date	*Ammonia*	*Nitrite/nitrate*	*Kjeldahl*	*Dissolved*	*Total*
6/8/93	0.37	0.47	0.72		0.322
6/29/93	0.79	0.57			0.159
7/6/93	0.91	1.00			0.358
7/12/93	0.75	0.94			0.200
7/20/93	0.71	0.77			0.108
7/27/93	0.51	1.60			0.128
8/9/93	0.92	1.40		0.049	
9/9/93	0.52	0.66		0.06	
9/9/93	0.67	2.40		0.15	
9/9/93	0.33	0.54		0.03	
9/14/93	0.37	0.68			0.122
10/4/93	0.55	0.63			0.077
9/28/93	0.37	0.59			0.037
Mean	0.60	0.94		0.072	0.168

Table 41b. Summary of **Water** Quality Characteristics at Inflow Point RHA 02, **Wolf** Lake

	1993											
Parameters	*2/21*	*4/14*	*5/10*	*5/27*	*6/23*	*7/8*	*7/19*	*8/3*	*8/19*	*9/9*	*10/1*	*Mean*
Turbidity, NTU	5.9	2.3	1.8	0.3	2.1	1.1	0.2	0.5	1	0.8	0.1	1.5
Conductivity, umho/cm	900	350	330	320	310		340	320	300	310	340	382
COD		1 1	6 8	2 6		7	9	6	5	6	7	9
pH, units	7.7	8.1	8.0	8.2		8.6	9.3		8.4	8.0		
Total alkalinity	115	114	106	105		107	71	107	107	114		105
Phenolphthalein alkalinity	0	0	0	0		2.4	7.1	0	2	0		3.8
Total suspended solids	3	2	3	2	4	4	4	4	6	1	1	3
Volatile suspended solids	2	1	1	1	2	1K	1	1	2	1K	1K	1
Ammonia-N	0.05	.04	01K	.09	.02	.01K	.01	.01K	.01	.03	.05	0.03
Total kjeldahl nitrogen-N	.139	.456	.76	.52	1.05	.38	.33	.42	.43	.23	.29	0.37
Nitrate-nitrite-N	0.37	.41	.30	.26	.23	.21	.25	.20	.17	.21	.26	0.26
Total phosphate-P	.045	.015	.006	.010	.005	.009	.009	.003	.009	.005	.009	0.011
Chloride	37											
Sulfate	26											
Water temperature, ° C	7.0	13.1		19.0								
Dissolved oxygen	10.9	8.5		7.7								

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41c Summary of Water Quality Characteristics at Inflow Point RHA 03, Wolf Lake

Parameters	*Date. 1993*							
	2/21	*3/3*	*3/9*	*3/17*	*4/14*	*4/20*	*5/11*	*6/7* (15:45)
Turbidity, NTU	65	46	20	37	9.4	41	21	96
Conductivity, umho/cm	1,600	2,400		2,200	2,300	1,100	1,700	210
COD	71	36	18	29	21	30	28	190
pH, units	7.7	7.6	7.7	7.7	7.5	7.7	7.4	8.5
Total alkalinity	208	295	299	299	303	136	295	46
Phenolphthalein alkalinity	0	0	0	0	0	0	0	0
Total suspended solids	255	72	19	66	21	68	44	440
Volatile suspended solids	75	22	6	32	7	22	15	170
Ammonia-N	1.3	1.7		1.7	1.6	.52	1.3	.25
Total kjeldahl nitrogen-N	.627	1.875	1.446	1.82	1.61	1.06	1.40	.91
Nitrate-Nitrite-N		.24	.13	.28	.37	.39	.23	.13
Total phosphate-P	.213	.147	.085	.131	.094	.110	.107	.306
Chloride	5,300							
Sulfate	124							
Fluoride			0.74	0.83				.17
Cyanide			.01K					
Oil								3
Phenol				10K				

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41c Concluded

Parameters	6/8 (11:00)	6/8 (20:03)	6/8 (22:57)	6/22	7/8	8/8	8/19	9/9	10/1	Mean
	Date. 1993									
Tuibidity, NTU	75	24	1.6	13		30	.7	15	4.5	30.9
Conductivity, umho/cm	300			1,900		1,300	1,400	1,500	1,600	1,500
COD	140	54	33	22		29	19	19	19	48
pH, units	8.2			7.5	7.7		7.5	7.5		
Total alkalinity	64			307	294	107	295	310		233
Phenolphthalein alkalinity	0	0	0	0	0	0	0	0	0	0
Total suspended solids	300	122	3	12	14	49	12	13	8	89
Volatile suspended solids	100	3 8	1	7		3 1	7 7		6 2	3 1
Ammonia-N	.20	.29	.22	1.0	1.1	1.3	1.1	1.1	1.0	.99
Total kjeldahl nitrogen-N	.78	1.63	1.44	1.45	.89	.99	1.3	.94	1.42	1.18
Nitrate-Nitrite-N	.04	.16	.09	.37	.27	.17	.52	.41	.41	.26
Total phosphate-P	.359	.206	.113	.080	.071	.125	.112	.069	.062	.140

Note: Concentrations are in mg/L except where noted.
Blanks indicate values not determined.

Table 41d. Summary of Water Quality Characteristics at Inflow Point RHA 04, Wolf Lake

	Date. 1993										
		6/8	*6/8*								
Parameters	*5/11*	*6/7*	*(11:00)*	*(21:00)*	*6/22*	*7/8*	*8/3*	*8/19*	*9/9*	*10/1*	*Mean*
Tuibidity, NTU	5.6	6.3	6.6	2.5	12	2.4	11	0.1	1.6	0.6	4.9
Conductivity, umho/cm	1300	130	270		1200		470	700	880	1100	756
COD	14	31	50	34	15	20	59	32	15	18	29
pH, units	7.9	7.4	7.5		8.1,	9.1		7.9	8.0		
Total alkalinity	217	45	77		25	239		153	231		141
Phenolphthalein alkalinity	0	0	0	0	0			0	0		
Total suspended solids	8	92	184	48	9	4	28	98	2	5	48
Volatile suspended solids	4	34	78	14	6	3	12	39	1	1	19
Ammonia-N	.68	.35	.10	.29	.61	.75	.43	.15	.28	.37	.40
Total kjeldahl nitrogen-N	.85	.87	1.05	1.56	1.30	.76	1.10	.82	.69	.75	.98
Nitrate-Nitrite-N	1.0	.21	.24	.64	1.30	1.2	.51	.51	1.20	1.40	.82
Total phosphate-P	1.21	.160	.218	.130	.087	.156	.238	.194	.138	.114	.156
Fluoride		0.1K									
Oil		1									

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41c Summary of Water Quality Characteristics at Inflow Point RHA 05, Wolf Lake

	Date. 1993											
Parameters	*4/19*	*5/11*	*6/7*	*6/8 (11:25)*	*6/8 (20:50)*	*6/22*	*7/8*	*8/4*	*8/19*	*9/9*	*10/1*	*Mean*
Turbidity, NTU	78	11	35	26	11	12	3.1	11	0.3	1.6	0.7	17.2
Conductivity, umho/cm	880	1,800	240	230		1,400		1,300	1,100	1,300	1,300	1,061
COD	73	61	55	32	36	25	29	82	39	25	25	44
pH, units	9.9	8.2	8.4	9.2		8.7	8.5		7.8	8.6		
Total alkalinity	57	180	52	49		166	189	156	136	149		126
Phenolphthalein alkalinity	18	0				8	5	0	0			
Total suspended solids	240	222	190	340	54	12	7	12	37	8	7	102
Volatile suspended solids	48	54	40	62	14	5	2	6	10	2	2	22
Ammonia-N	.84	1.50	.39	.28	.35	1.70	1.30	.73	.83	1.50	1.50	.99
Total kjeldahl nitrogen-N	2.05	1.81	6.19	.53	1.06	2.63	1.00	1.20	1.60	1.30	1.53	1.90
Nitrate-Nitrite-N	.54	.14	.15	.18	.01K	.77	1.90	2.10	1.80	2.00	1.70	1.03
Total phosphate-P	.258	.281	.324	.197	.159	.045	.085	.273	.161	.042	.042	.170
Fluoride			.32									
Oil			3									

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41f. Summary of Water Quality Characteristics at Inflow Points RHA 06 and **RHA** 07, **Wolf** Lake

Parameters	*RHA 06*					*RHA 07*						
	2/21/93		*6/8/93*							*6/8/93*		
	13:50	*17:10*	*09:05*	*19:40*	*Mean*	*3/16/93*	*4/13*	*5/10*	*6/7*	*14:08*	*21:20*	*Mean*
Turbidity, NTU	49	110	8.1	2.1	42.3	.4	.3	5.8	7.4	4.5	5.9	4.1
Conductivity, umho/cm	2,800	2,700	120		1,873	820	1,100	960	760			910
COD	230	295	16	18	140	10	13	15	22	17	16	16
pH, units	7.6	7.4	7.7			9.3			8.5		8.3	8.0
Total alkalinity	42	44			43	34	40	42	53			43
Phenolphthalein alkalinity	0	0	0			4		1 0	0			
Total suspended solids	445	550	33	38	267	2	11	17	27	3	17	13
Volatile suspended solids	85	125	17	13	60	1	5	5	12	2	5	5
Ammonia-N	.96	1.10	.22	.20	.62	.82	.43	.10	.09	.21	.36	.34
Total kjeldahl nitrogen-N	.435	.980	.31	.86	.646	.85	.852	.83	.46	.84	.99	.80
Nitrate-Nitrite-N	-	2.00	.13	.34	.82	.75	.67	.37	.23	.36	.36	.46
Total phosphate-P	.107	.312	.027	.068	.129	.013	.014	.040	.046	.046	.039	.039
Chloride	10,100	9,300			9,700							
Sulfate	163	159			161							
Fluoride			0.1K						.70			
Oil			1						1			

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
- Blanks indicate values not determined.

Table 41g. Summary of Water Quality Characteristics Inflow Point RHA 71, Wolf Lake

	Date. 1993							
Parameters	*4/13*	*4/20*	*6/7*	*6/8 (14:20)*	*6/8 (21:30)*	*6/10*	*6/23*	*Mean*
Turbidity, NTU	.1	11	12	6.8	9.2	2.4	6.3	6.8
Conductivity, umho/cm	1,400	960	240				1,100	925
COD	13	18	13	12	23	19	17	16
pH, units	9.9	9.9	8.1					
Total alkalinity	37	57	23					39
Phenolphthalein alkalinity	19	18	0					12
Total suspended solids	10	136	56	41	59	10	7	46
Volatile suspended solids	2	4	14	10	9	2	4	6
Ammonia-N	.72	.80	.27	.31	.41	.85	1.20	.65
Total kjeldahl nitrogen-N	1.07	1.38	.29	.88	.74	1.35	2.56	1.18
Nitrate-Nitrite-N	.53	.67	.33	.36	.41	.24	.16	.39
Total phosphate-P	.009	.027	.068	.058	.061	.026	.007	.037
Flouride			.17					
Oil			1K					

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41h. Summary of Water Quality Characteristics at Inflow Point RHA 72, Wolf Lake

	Date. 1993									
Parameters	*4/13*	*4/20*	5/10	6/7	*6/8* (14:25)	*6/8* (21:40)	6/10	6/23	7/8	Mean
Turbidity, NTU	.1	5.2	2.2	5.8	5.5	2.6	2.8	5.0		3.7
Conductivity, µmho/cm	890	630	900	260				590		654
COD	12	12	13	15	17	25	17	17	14	16
pH, units	9.5	9.8	9.6	9.0					9.9	
Total alkalinity	31	40	35	35					44	37
Phenolphthalein alkalinity	9	12	9						19	12
Total suspended solids	1K	7	16	46	80	3	11	5	3	19
Volatile suspended solids	1K	2	3	11	12	1K	2	3	2	4
Ammonia-N	.89	1.10	.47	.47	.47	.41	.60	.40	.45	.58
Total kjeldahl nitrogen-N	1.21	1.74	.86	.56	.90	.83	1.20	1.46	.68	1.05
Nitrate-Nitrite-N	.51	.73	.52	.42	.45	.41	.31	.25	.23	.43
Total phosphate-P	.007	.012	.018	.032	.042	.032	.043	.017	.012	.024
Fluoride				.23						
Oil				1K						

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41i. Summary of Water Quality Characteristics at Inflow Points RHA 08 and RHA 09, Wolf Lake

Parameters	*RHA 08* 6/7/93				*RHA 09* 6/8/93 (10:20)		
	6/7/93	*6/8/93*	*6/10/93*	*Mean*	*6/8/93 (10:20)*	*6/8/93 (19:27)*	*Mean*
Turbidity, NTU	3.4	6.2	2.1	3.9	16	1.9	9
Conductivity, µmho/cm	160			160	590		590
COD	28	47	36	23	24	39	32
pH, units	7.6				7.6		
Total alkalinity	50				74		
Phenolphthalein alkalinity	0			0	0		0
Total suspended solids	6	10	5	7	96	13	55
Volatile suspended solids	5	5	2	4	40	5	23
Ammonia-N	.16	.19	.45	.27	.34	.70	.52
Total kjeldahl nitrogen-N	.49	1.14	1.42	1.02	.56	1.85	.71
Nitrate-Nitrite-N	.15	.06	.01K	.07	.29	.24	.27
Total phosphate-P	.123	.086	.072	.094	.146	.201	.174
Fluoride	.16				.29		
Oil		1K			1K		

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41j. Summary of Water Quality Characteristics at Inflow Point RHA 10 (1993), Wolf Lake

	6/8								
Parameters	*12:50*	*22:33*	*6/10*	*6/23*	*7/8*	*7/22*	*9/9*	*10/1*	*Mean*
Turtridity, NTU	4.9	.6	4	4.7	.7	.1	.5	.8	2.6
Conductivity, µnho/cm	420			550		630	630	660	578
COD	29	44	25	25	26	27	30	29	29
pH, units	7.9				7.6	8.2	7.6		
Total alkalinity	118				279	109	213		180
Phenolphthalein alkalinity	0				0	0	0		0
Total suspended solids	18	15	2	3	3	5	6		17
Volatile suspended solids	10	11	1K	3	2	5	2	1K	5
Anunonia-N	.10	.13	.06	.05	.01	.06	.17	.09	.08
Total kjeldahl nitrogen-N	.59	1.22	.92	1.15	.57	.54	.91	.77	.83
Nitrate-Nitrite-N	.15	.03	.01	.02	.04	.06	.08	.06	.06
Total phosphate-P	.069	.046	.027	.029	.031	.033	.032	.023	.036
Fluoride	.39								

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 41k. Summary of Water Quality Characteristics at Inflow Points RHA11, RHA 13, and RHA 14 (1993), Wolf Lake

	RHA11			*RHA 13*				*RHA 14*			
Parameters	*8/19*	*10/1*	*Mean*	*9/8*	*10/1*	*11/30*	*Mean*	*8/19*	*9/8*	*10/1*	*Mean*
Tuibidity, NTU	.3	2.4	1.4	.2	.1	.2	.2	.1	.1	.3	.2
Conductivity, µmho/cm	980	380	680	300	320		310	380	310	320	337
COD	6	7	7	23	8		16	6	6	7	6
pH, units	7.7			8.0				8.3	8.0		
Total alkalinity	282			99				108	102		105
Phenolphthalein alkalinity	0			0				0	0		
Total suspended solids	22	15	19	1K	6	3	4	1	1K	4	2
Volatile suspended solids	6	2	4	1K	2	1	1	1K	1K	1	1
Ammonia-N	2.8	01K	1.41	.01	01K		0.1	.01K	.05	.02	.03
Total kjeldahl nitrogen-N		.26		.26	.24	.14	.21	.52		.39	.45
Nitrate-Nitrite-N	.01K	.33	.17	.21	.24	.32	.26	.18	.21	.26	.22
Total phosphate-P	2.88	.043	.166	.004	.012	.003	.006	.004	.003	.007	.005

Note: Concentrations are in mg/L except where noted;
K = less than detection value;
Blanks indicate values not determined.

Table 42. Metal Concentrations in Inflow Waters, Wolf Lake (1993)

		RHA03		*RHA 04*	*RHA OS*	*RHA 06*	*RHA 07*	*RHA 71*	*RHA 72*	*RHA 08*	*RHA 09*	*RHA 10*
Parameter	*3/9*	*3/17*	*6/7*	*6/7*	*6/7*	*6/8*	*6/7*	*6/7*	*6/7*	*6/7*	*6/8*	*6/8*
Aluminum	150K	15K	3300	1100	3700	570	290	1200	690	100K	280	100K
Arsenic	6.3	6.3	-	1K	1K	1K	1K	1K	1K	1K	1K	1.9
Barium	69	81	180	33	100	45	41	28	24	11	53	35
Beryllium	1K	1K	3	3	3	2	2	3	1K	1K	1K	1K
Boron	340	320	34	20	72	10K	260	18	65	120	69	210
Cadmium	5K	5K	6	3K	3K	3	3K	3K	3K	3K	3K	3K
Calcium, mg/L	170	170	51	14	59	16	70	24	27	12	46	25
Chromium	5K	5K	55	9	39	5K	5K	8	56	5K	5K	5K
Cobolt	5K	5K	85	17	60	29	5K	12	7	5K	8	7
Copper	5K	5K	5K	5	5K	5K	5K	5K	5K	5K	6	7
Iron, mg/L	4.5	5.8	12	2.4	7.5	1.4	.24	1.2	.53	.14	1.8	.62
Lead	50K	50K	400	70	100	50K	50K	120	180	50K	50K	50K
Magnesium, mg/L	32	33	11	3.8	9.3	3.0	2.9	2.0	2.2	5.9	4.6	18
Manganese	520	580	1400	320	1400	240	96	400	200	24	140	48
Nickel	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K	15K
Potassium, mg/L	10	11	1.4	1K	1.8	1K	22	1.5	5.8	4.7	7.2	7.8
Silver	5K	5K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K
Sodium, mg/L	270	330	9.3	1.6	15	1.8	64	2.7	14	3.9	77	25
Strontium	560	580	98	22	74	51	360	45	100	54	170	95
Vanadium	5K	6	41	7	34	5K	8	5K	8	5K	5K	5K
Zinc	100	65	550	150	250	380	100K	140	100K	100K	100	100K

Note: All parameters expressed as µg/L except where noted;
K = less than detection level.

Table 43. Organic Concentrations in Inflow Waters, Wolf Lake (1993)

Organic, µg/L	RHA 03		RHA 04	RHA 05	RHA 06	RHA 07	RHA 71	RHA 72	RHA 08	RHA 09	RHA 10	RHA 13
	3/17	6/8	6/7	6/7	6/8	6/7	6/7	6/7	6/7	6/8	6/8	11/30
Aldrin	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K
Alpha-BHC	"	"	"	"	"	"	"	"	"	"	"	"
Gamma-BHC (lindane)	"	"	"	"	"	"	"	"	"	"	"	"
Chlordane, CIS isomer	"	"	"	"	"	"	"	"	"	"	"	"
Chlordane, trans isomer	"	"	"	"	"	"	"	"	"	"	"	"
Chlordane, total	.02K	.02K	.02K	.02K	.02K	.02K	.02K	.02K	.02K	.02K	.02K	.02K
O,P'-DDD	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K
P,P'-DDD	"	"	"	"	"	"	"	"	"	"	"	"
O,P'-DDE	"	"	"	"	"	"	"	"	"	"	"	"
P,P'-DDE	"	"	"	"	"	"	"	"	"	"	"	"
O,P'-DDT	"	"	"	"	"	"	"	"	"	"	"	"
P,P'-DDT	"	"	"	"	"	"	"	"	"	"	"	"
Total DDT	-	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K
Dieldrin	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K
Endrin	"	"	"	"	"	"	"	"	"	"	"	"
Hexachlorobenzene	"	"	"	"	"	"	"	"	"	"	"	"
Methoxychlor	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K	.05K
PCBs - total	-	2.0	0.2K	0.2K	0.2K	0.2K	0.2K	0.2K	0.2K	0.2K	0.2K	0.2K
Pentachlorophenol	10K	0.27	0.20	0.22	0.02	.01K	0.10	0.04	.01K	.031	.02	.01K

Note: K = less than detection value.

samples collected at RHA 03 (table 41c), and the highest turbidity observed was 96 NTU on June 7, 1993. Subsequent sampling at this site, on July 8, 1993, indicated a lower value. High turbidity was also found at RHA 05 for samples on April 19 and June 7, 1993. At RHA 06, a winter storm event caused high turbidity on February 21, 1993 (table 4If).

For a moderate amount of sediment, Illinois Lake Assessment Criteria set turbidity values between 7 and 14 NTU (IEPA, 1978). On the basis of mean turbidity values, only RHA 09 belongs in this category. Inflows RHA 03, RHA 05, and RHA 06 are considered to have substantial amount of sediment; the other inflows (RHA 02, 04, 07, 71, 72, 08, 10, 11, 13, and 14) as having a small amount of sediment.

Chemical Characteristics

Total and Volatile Suspended Solids. High TSS and VSS occurred during storm events when turbidity values were high. At RHA 03, high TSS (255 to 440 mg/L, table 41c) was recorded during February and June 7-8 storm events. During other storm events, however, TSS did not exceed 100 mg/L at RHA 03. Although no high turbidity values were observed at RHA 04 during the June 7-8 storm event, maximum TSS concentrations (184 mg/L) were recorded. High TSS (98 mg/L, table 41d) was found in the August 19 sample from RHA 04.

Inspection of table 41e indicates high TSS (190 to 340 mg/L) in association with April, May, and June 6-7 storm events at RHA 05. And table 41f shows that very high TSS (445 to 550 mg/L) was found at RHA 06 in February 21, 1993, samples. At RHA 09, maximum TSS (96 mg/L) was recorded on June 8, 1993 (table 41 i). TSS values at the other nine inflow stations are consistently lower, with mean concentrations between 2 and 19 mg/L.

For the samples with high TSS at RHA 03, 04, 05, and 06, VSS were approximately 20 to 25 percent of TSS (tables 41c-f). At RHA 09, approximately 40 percent of TSS were volatile. For the other nine-inflow points samples, VSS averaged approximately 25 to 70 percent of TSS; however, VSS concentrations were generally low. Generally, the suspended sediments are inorganic in nature.

Conductivity and COD. Very high conductivity values (2,700-2,800 μmho/cm) were observed in the February 21, 1993, samples taken from RHA 06 (table 4If) during a snowmelt runoff from the Interstate Tollway 90. This was due to the use of salt on the interstate. High COD values (230 to 295 mg/L) were also measured for these samples. At RHA 06, however, conductivity and COD values in June 8 samples (summertime storm event samples) were very low (120 umho/cm).

Generally, a strong linear correlation can be discerned between conductivity and total dissolved solids (TDS). TDS can be estimated to be approximately 0.6 times the conductivity. The Illinois general use water quality standard for TSS is 1,000 mg/L, which is approximately equivalent to a conductivity value of 1,700 umho/cm. Five out of 13 samples (38 percent) collected at RHA 03 had conductivity levels exceeding 1,700 umho/cm. Only one sample (11 percent) exceeded 1,700 umho/cm of conductivity at RHA 05. At both of these inflow points, the conductivity values were found to be very low (130 to 270 umho/cm) during the June 7-8 storm event. The reason for this is unknown. Excluding RHA 03, 05, and 06, the other inflow points had mean values of conductivity between 160 umho/cm (RHA 08) and 926 umho/cm (RHA 71).

High COD concentrations (140 to 190 mg/L) were found in the samples taken at RHA 03 during the June 7-8 storm event (table 41c). Moderate COD concentrations (25 to 82 mg/L) with a mean of 44 mg/L were measured at RHA 05 (table 41e). COD represents the amount of oxygen required to completely oxidize all oxidizable organic and inorganic material present in the water. Hence, the higher the COD concentration, the greater the potential for depletion of DO in the water. The mean COD concentrations at 11 other inflows (excluding RHA 03, 05, and 06) ranged from 6 mg/L at RHA 14 to 32 mg/L at RHA 09.

pH and Alkalinity. The range (or one reading) of pH values observed at inflows RHA 02, 03, 04, 05, 06, 07, 71, 72, 08, 09, 10, 11, 13, and 14 were 7.7 to 8.6, 7.4 to 8.5, 7.4 to 9.1, 7.8 to 9.9, 7.4 to 7.7, 8.0 to 9.3, 8.1 to 9.9, 9.0 to 9.9, 7.6, 7.6, 7.6 to 8.2, 7.7, 8.0, and 8.0 to 8.3, respectively. High pH levels were found at RHA 71 and RHA 72. pH for April 13 and April 20, 1993, samples at RHA 71 were both 9.9. High pH in this wetland area is probably influenced by the U.S. Army's nearby storage facilities. pH levels of samples at RHA 07 were relatively higher than at other inflows. However, high pH of flows at RHA 07, RHA 71, and RHA 72 did not significantly affect the pH values of Pool 5 at RHA-5.

In Indiana, the recommended pH values for Wolf Lake are between 6.5 and 8.5. However, inflows at RHA 02, 04, 05, 07, 71, and 72 had pH values exceeding 8.5 respectively, in 25 (2 out of 8 samples), 14 (1/17), 50 (4/8), 14 (1/7), 67 (2/3), and 100 (5/5) percent of samples examined.

Samples collected from RHA 71 and 72 had high pH and low total alkalinity. Mean total alkalinity for these two inflows were 39 and 37 mg/L as $CaCO_3$, respectively. Both mean phenolphthalein alkalinity values were 12 mg/L as $CaCO_3$. Mean total alkalinity for RHA 06, 07, 08, and 09 was also low (43 to 74 mg/L as $CaCO_3$). Other inflow stations showed total alkalinity values above 100 mg/L as $CaCO_3$.

Nitrogen. Ammonia and nitrate are readily used by algae and other aquatic plants as growth nutrients. A concentration of inorganic nitrogen (ammonia plus nitrite and nitrate) in excess of 0.3 mg/L is considered to be a sufficient to stimulate algal growth (Sawyer, 1952). An examination of tables 41a-k indicates that concentrations of mean inorganic nitrogen for rainwater inflows, RHA 03, 04, 05, 06, 07, 71, 72, 08, 09, and 11, exceeded the suggested critical value (0.3 mg/L). An unexpectedly very high ammonia level of 2.8 mg/L was observed in August 19, 1993, sample from RHA 11 (table 41k). The reason for this elevated ammonia level is unknown. For the inflow points mentioned above, all except RHA 08 had ammonia levels greater than 0.3 mg/L. The mean inorganic nitrogen levels at RHA 02, 10, 13, and 14 were below the critical concentration.

In Illinois, the allowable ammonia nitrogen level varies from 1.6 to 13.0 mg/L depending upon the water temperature and pH values. Inflows RHA 07, 08, and 10 did not exceed the 0.3 mg/L ammonia nitrogen limit. However, on the Indiana side, any single daily concentration of ammonia nitrogen is limited to 0.12 mg/L (Indiana Stream Pollution Control Board, 1973). Except for one sample from RHA 04, all samples taken from RHA 03, 04, 05, 06, 71, and 72 exceeded the ammonia nitrogen limit. Concentrations of ammonia nitrogen at RHA 02 were very low, even under the detectable limit in many samples.

Organic nitrogen is determined by subtracting ammonia nitrogen from the total kjeldahl nitrogen measurements. Organic nitrogen in inflow samples varied widely from zero to approximately 90 percent.

Total Phosphorus. As with in-lake TP levels, the IEPA (1990) limits TP concentrations for any stream at the point where it enters a reservoir or lake to no more than 0.050 mg/L. TP in the rainwater samples exceeded this limit 89 percent of the time (eight out of nine samples) (table 41a). All six samples collected from RHA 07 met the TP standard (table 41b). All three samples taken at RHA 08 had TP exceeding 0.050 mg/L, with an average of 0.094 mg/L (table 41i). At RHA 10, seven out of eight samples (88 percent) had TP below 0.050 mg/L (table 41j).

The TP standard for Wolf Lake set by the Indiana Stream Pollution Control Board (1973) is 0.04 mg/L. However, all inflow samples collected from RHA 03, 04, 05, 09, and 11 had TP values above 0.04 mg/L, with mean TP concentrations of, respectively, 0.140, 0.156, 0.170, 0.174, and 0.166 mg/L. In addition, samples taken at RHA 02, 06, 71, and 72 exceeded the TP standard 9, 75, 43, and 22 percent of the time, respectively, with mean concentrations of 0.011, 0.129, 0.037, and 0.024 mg/L, respectively. The concentrations of TP at RHA 13 and 14 were low, with mean values of 0.006 and 0.005 mg/L, respectively.

Metals. During the June 7-8, 1993, storm event, one grab stormwater sample was taken at each of the ten inflow sites for metal analyses. In addition, two more samples at RHA 03 were collected in March 1993 for metal analyses. The results of analyses on the 12 samples are listed in table 42, which indicates that arsenic, cadmium, copper, nickel, and silver are under detectable levels for all or almost all samples. As expected, metal concentrations are higher at the urban storm water discharges, RHA 03, 04, and 05.

Concentrations of metals for secondary contact and indigenous aquatic life standards stipulated by the IPCB (1990) are as follows: arsenic, 1,000 µg/L; barium, 5,000 µg/L; cadmium, 150 µg/L; chromium, 1,000 µg/L; copper, 1,000 µg/L; iron, 2,000 µg/L; lead, 100 µg/L; manganese, 1,000 µg/L; nickel, 1,000 µg/L; silver, 1,100 µg/L; and zinc, 1,000 µg/L. Three inflow sites, RHA 07, 08, and 10, are in Illinois. The metal concentrations at these three locations were much lower than the IPCB's standards.

Applying the IPCB's standards to Indiana sites, only RHA 03, 04, and 05 exceeded iron standards. Lead limits were exceeded at RHA 03, 05, 71, and 72.

Organics. Samples for organic analyses were collected from nine inflows during the June 7-8, 1993, storm event. In addition, a sample was collected at RHA 03 on March 17, 1993, and at RHA 13 on November 30, 1993. Nineteen organic analyses were performed for each sample, and the results of these analyses are shown in table 43. The table suggests that concentrations of 17 parameters tested were below detection levels in all samples. Total PCBs at RHA 03 on June 8, 1993, were 2.0 µg/L; while PCBs were not detected at the other ten inflows. Pentachlorophenol was present in eight samples ranging from 0.02 µg/L at RHA 06 and 10 to 0.27 µg/L at RHA 03.

Trophic State

Eutrophication is a normal process that affects every body of water from its time of formation. As a lake ages, the degree of enrichment from nutrient materials increases. In general, the lake traps a portion of the nutrients originating in the surrounding drainage basin. Precipitation, dry fallout, and ground-water inflow are the other contributing sources.

A wide variety of indices of lake trophic conditions have been proposed in the literature. These indices have been based on Secchi disc transparency; nutrient concentrations; hypolimnetic oxygen depletion; and biological parameters, including chlorophyll a, species abundance, and diversity. In its *Clean Lake Program Guidance Manual*, the USEPA (1980) suggests the use of four parameters as trophic indicators: Secchi disc transparency, chlorophyll *a*, surface water total phosphorus, and total organic carbon.

In addition, the lake trophic state index (TSI) developed by Carlson (1977) on the basis of Secchi disc transparency, chlorophyll a, and surface water total phosphorus can be used to calculate a lake's trophic state. The TSI can be calculated from Secchi disc transparency (SD) in meters (m), chlorophyll *a* (CHL) in micrograms per liter (µg/L), and total phosphorus (TP) in µg/L as follows:

on the basis of SD, $TSI = 60 - 14.4 \ln(SD)$ (1)

on the basis of CHL, $TSI = 9.81 \ln(CHL) + 30.6$ (2)

on the basis of TP, $TSI = 14.42 \ln(TP) + 4.15$ (3)

The index is based on the amount of algal biomass in surface water, using a scale of 0 to 100. Each increment of ten in the TSI represents a theoretical doubling of biomass in the lake. The advantages and disadvantages of using the TSI were discussed by Hudson *et al*. (1992). The accuracy of Carlson's index is often diminished by water coloration or suspended solids other than algae. Applying TSI classification to lakes that are dominated by rooted aquatic plants may indicate less eutrophication than actually exists.

The values of TSI for Wolf Lake were calculated using formulas (1 through 3) for each basin, based on Secchi disc transparency, TP, and chlorophyll *a* concentrations of each sample. The TSI results, average range of TSI values, and trophic state are listed in table 44. Categorizing the trophic state of a lake can be accomplished using TSI values and the information provided in table 45.

Lakes are generally classified by limnologists into one of three trophic states: oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes are known for their clean and cold waters and lack of aquatic weeds or algae, due to low nutrient levels. There are few oligotrophic lakes in the Midwest. At the other extreme, eutrophic lakes are high in nutrient levels and are likely to be very productive in terms of weed growth and algal blooms. Eutrophic lakes can support large fish populations, but the fish tend to be rougher species that can better tolerate depleted levels of DO. Mesotrophic lakes are in an intermediate stage between oligotrophic and eutrophic. The great majority of Midwestern lakes are eutrophic. A hypereutrophic lake is one that has undergone extreme eutrophication to the point of having developed undesirable aesthetic qualities (e.g., odors, algal mats, and fish kills) and water-use limitations (e.g., extremely dense growths of vegetation). The natural aging process causes all lakes to progress to the eutrophic condition over time, but this eutrophication process can be accelerated by certain land uses in the contributing watershed (e.g., agricultural activities, application of lawn fertilizers, and erosion from construction sites). Given enough time, a lake will grow shallower and will eventually fill in with trapped sediments and decayed organic matter, such that it becomes a shallow marsh or emergent wetland.

The mean calculated TSI values shown in table 44 suggest that the mean Secchi disc TSI (SD-TSI) was the highest for each station except for RHA-8; and the mean total phosphorous TSI (TP-TSI) was the lowest for each station except RHA-9. For the channel and all pools other than Pool 1 (RHA-1), low values of SD-TSI, TP-TSI, and CHL-TSI were observed in the winter and high values in the summer (table 44). There was no hypereutrophic condition noted in the lake system. Pools 6 and 7 had excessive growths of macrophytes. According to Carlson (1977), applying the TSI to classification of lakes that are dominated by rooted aquatic plants may indicate less eutrophication than actually exists.

The overall average TSI values for Pools 1-8 and Wolf Lake Channel using the average of mean SD-TSI, TP-TSI, and CHL-TSI, were 37.0, 51.4, 48.0, 52.2, 48.4, 56.3, 57.7, 58.6, and 54.0, respectively. These indicate Pools 1-8 and Wolf Lake Channel could be classified respectively as oligotrophic, eutrophic, mesotrophic, eutrophic, mesotrophic, eutrophic, eutrophic, eutrophic, and eutrophic.

When considering the results of TSI calculations, one should keep in mind the assumptions on which the Carlson formulae are based: 1) Secchi disc transparency is a function of phytoplankton biomass; 2) phosphorus is the factor limiting algal growth; and 3) total phosphorus concentration is directly correlated with algal biomass. These assumptions will not

Table 44. Trophic State Index and Trophic State of Individual Pools of Wolf Lake

	RHA-1			*RHA-2*			*RHA-3*		
Date	*SD*	*TP*	*CHL*	*SD*	*TP*	*CHL*	*SD*	*TP*	*CHL*
10/13/92	46.2	37.4	39.6	61.8	51.7	53.8	56.6	51.1	48.8
11/12/92	38.1	20.0	38.1	49.4	37.4	49.6	48.3	34.1	43.5
12/21/92	43.2	30.0	35.2	43.2	38.7	49.6	43.5	32.2	50.3
1/19/93			42.0	49.6	32.2	50.3	47.3	30.0	48.8
2/10/93	39.7	24.2	47.0	48.3	43.2	50.3	43.4	34.1	48.8
3/16/93	43.8	34.3	51.0	49.3	38.7	50.3	45.2	27.4	48.0
4/13/93	48.3	30.0	40.2	52.8	37.4		49.4	37.4	
5/10/93	43.1	27.5		56.6	49.4	53.3	51.2	40.0	48.8
5/26/93	47.6	4.2	49.6	53.6	47.3	56.0	46.6	43.2	49.6
6/9/93	48.3	36.0	44.8	57.8	51.1	60.1	53.6	45.0	51.0
6/22/93	41.2	20.0	42.0	55.2	48.0	52.2	49.8	37.4	49.6
7/7/93	43.1	20.0	38.1	59.2	42.2	52.8	54.2	41.1	52.8
7/20/93	44.7	24.2	42.0	61.4	46.6	55.6	56.9	34.1	59.9
8/4/93	45.9	20.0	43.3	61.4	48.7	60.9	59.2	48.0	59.3
8/18/93	40.1	4.2	40.2	61.0	37.4	57.5	61.4	47.3	51.9
9/8/93	41.9	30.0		65.6	55.8		61.4	53.2	
9/28/93	44.9	34.3		66.7	52.7		63.5	55.8	
Maximum	48.3	37.4	35.2	66.7	55.8	60.1	63.5	55.8	59.9
Minimum	38.1	4.2	51.0	43.2	32.2	49.6	43.4	27.4	43.5
Mean TSI	43.7	24.8	42.4	56.0	44.6	53.7	52.4	40.7	50.9
Trophic State (Overall)	Mesotrophic	Oligotrophic (Oligotrophic, 37.0)	Mesotrophic	Eutrophic	Mesotrophic (Eutrophic, 51.4)	Eutrophic	Eutrophic	Mesotrophic (Mesotrophic, 48.0)	Eutrophic

Notes: SD = Secchi disc transparency TSI; TP = total phosphorus TSI; CHL = chlorophyll *a* TSI.

Table 44. Continued

Date	RHA-4 SD	RHA-4 TP	RHA-4 CHL	RHA-5 SD	RHA-5 TP	RHA-5 CHL	RHA-6 SD	RHA-6 TP	RHA-6 CHL
10/13/92	62.3	52.2	52.8	59.2	50.6	53.8	61.4	48.0	48.8
11/12/92	53.2	44.1	47.0	49.2	42.2	48.0	58.4	44.1	56.0
12/21/92	42.9	35.8	48.0	43.0	38.7	44.8	52.8	40.0	51.6
1/17/93	51.0	30.0	51.0	47.8	37.4	44.8	54.9	50.6	56.4
2/10/93	44.1	32.2	50.3	43.1	37.4	48.0	55.8	43.2	53.3
3/10/93	49.4	38.7	48.0	45.1	38.7	42.0	56.0	45.0	52.2
4/13/93	53.9	38.7		50.0	35.8		56.2	41.1	
5/10/93	59.2	48.0	44.8	46.2	40.0	44.8	61.8	55.4	59.9
5/26/93	53.6	48.7	56.0	44.5	42.2	49.6	56.6	51.1	48.0
6/9/93	60.0	53.7	60.6	54.6	45.0	52.8	60.0	55.4	59.0
6/22/93	52.6	47.3	55.6	50.8	40.0	50.3	60.0	49.4	54.8
7/7/93	61.8	48.0	57.1	49.4	43.2	51.6	65.6	50.6	61.8
7/20/93	64.0	46.6	56.0	56.2	41.1	55.2	66.2	52.7	62.8
8/4/9/93	64.5	52.2	63.0	63.0	46.6	59.6	66.2	60.3	66.6
8/18/93	64.0	46.6	59.3	56.7		59.3	67.9	57.0	64.7
9/8/93	69.2	57.6		57.5	50.0		66.2	60.3	
9/28/93	68.5	57.0		62.6	62.6		70.0	65.0	
Maximum	69.2	57.6	63.0	63.0	62.6	59.6	70.0	65.0	66.6
Minimum	42.9	30.0	44.8	43.0	35.8	42.0	52.8	40.0	48.0
Mean YSI	57.3	45.7	53.5	51.7	43.2	50.3	60.9	51.1	56.9
Trophic state (Overall)	Eutrophic	Mesotrophic (Eutrophic, 52.2)	Eutrophic	Eutrophic	Mesotrophic (Mesotrophic, 48.4)	Eutrophic	Eutrophic	Eutrophic (Eutrophic, 56.3)	Eutrophic

Notes: SD = Secchi disc transparency TSI; TP = total phosphorus TSI; CHL = chlorophyll *a* TSI.

Table 44. Concluded

Date	RHA-7 SD	RHA-7 TP	RHA-7 CHL	RHA-8 SD	RHA-8 TP	RHA-8 CHL	RHA-9 SD	RHA-9 TP	RHA-9 CHL
10/13/92	62.3	57.3	59.6	67.9	61.4	64.2	50.8	45.8	45.2
11/12/92	56.0	47.3	54.3	58.4	50.6	57.8	58.8	51.1	38.1
12/21/92	53.9	40.0	48.0		42.2	51.6	49.2	44.1	31.3
1/19/93	53.6	34.1	24.4	53.4	41.1	58.4	55.8	38.7	8.1
2/10/93	54.2	42.2	57.8	53.6	43.2	59.9	57.5	45.0	42.0
3/16/93	55.8	51.1	57.1	52.0	47.3	55.2	66.2	55.8	48.0
4/13/93	60.0	50.6		60.0	45.0		61.0	48.7	
5/10/93	64.5	59.7	65.7	58.1	51.1	59.0	56.2	50.0	53.8
5/26/93	58.1	52.2	60.4	60.7	55.0	60.9	57.5	51.1	56.4
6/9/93	63.5	62.6	64.3	66.7	58.7	65.7	67.3	64.1	55.2
6/22/93	62.6	52.7	60.9	61.8	51.7	62.0	61.8	61.1	62.2
7/7/93	66.2	60.0	66.6	64.0	57.3	67.9	64.5	63.2	66.1
7/20/93	67.9	61.1	69.2	57.2	58.7	71.3	61.8	53.7	58.4
8/4/93	65.6	63.4	68.0	65.0	62.9	68.3	63.0	63.4	59.3
8/18/93	66.7	58.7	63.0	62.3	52.7	64.8	63.5	53.2	61.6
9/8/93	65.6	61.7		64.5	65.0		59.2	54.6	
9/28/93	67.3	50.0		67.3	57.6		58.8	63.4	
Maximum	67.9	63.4	69.2	67.9	65.0	71.3	67.3	64.1	66.1
Minimum	53.6	34.1	24.4	52.0	41.1	51.6	49.2	38.7	8.1
Mean TSI	61.4	53.2	58.5	60.8	53.0	61.9	59.6	53.4	49.0
Trophic state (Overall)	Eutrophic	Eutrophic (Eutrophic, 57.7)	Eutrophic	Eutrophic	Eutrophic (Eutrophic, 58.6)	Eutrophic	Eutrophic	Eutrophic (Eutrophic, 54.0)	Mesotrophic

Notes: SD = Secchi disc transparency TSI; TP = total phosphorus TSI; CHL = chlorophyll *a* TSI.

Table 45. Quantitative Definition of Lake Trophic State

Trophic state	*Secchi disc transparency* (inches)	(meter)	*Chlorophyll a* (µg/L)	*Total phosphorus, lake surface* (µg/L)	*TSI*
Oligotrophy	>157	>4.0	<2.6	<12	<40
Mesotrophic	79-157	2.0-4.0	2.6-7.2	12-24	40-50
Eutrophic	20-79	0.5-2.0	7.2-55.5	24-%	50-70
Hypertrophic	<20	<0.5	>55.5	>96	>70

necessarily hold where suspended solids other than algal biomass are a major source of turbidity; where short retention times prohibit a large algal standing crop from developing; or where grazing by zooplankton affects algal populations.

Lake Use Support Analysis

Definition

An analysis of Wolf Lake's use support was carried out employing a methodology developed by the IEPA (1994). The degree of use support identified for each designated use indicates the ability of the lake to: 1) support a variety of high quality recreational activities, such as boating, sport fishing, swimming, and aesthetic enjoyment; 2) support healthy aquatic life and sport fish populations; and 3) provide adequate, long-term quality and quantity of water for public or industrial water supply (if applicable). Determination of a lake's use support is based upon the state's water quality standards as described in Subtitle C of Title 35 of the State of Illinois Administrative Code (IEPA, 1990). Each of four established use designation categories (including General Use, Public and Food Processing Water Supply, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life) has a specific set of water quality standards.

For the lake uses assessed in this report, the General Use standards - primarily the 0.05 mg/L TP standard - were used. The TP standard has been established for the protection of aquatic life, primary-contact (e.g., swimming) and secondary-contact (e.g., boating) recreation, agriculture, and industrial uses. In addition, lake-use support is based in part on the amount of sediment, macrophytes, and algae in the lake and how these might impair designated lake uses. The following is a summary of the various classifications of use impairment:

Full = full support of designated uses, with minimal impairment

Full/threatened = full support of designated uses, with indications of declining water quality or evidence of existing use impairment

Partial/minor = partial support of designated uses, with slight impairment

Partial/moderate = partial support of designated uses, with moderate impairment

Nonsupport = no support of designated uses, with severe impairment

Lakes that fully support designated uses may still exhibit some impairment, or have slight to moderate amounts of sediment, macrophytes, or algae in a portion of the lake (e.g., headwaters or shoreline); however, most of the lake acreage shows minimal impairment of the aquatic community and uses. *It is important to emphasize that if a lake is rated as not fully supporting designated uses, it does not necessarily mean that the lake cannot be used for those purposes or that a health hazard exists*. Rather, it indicates impairment in the ability of significant portions of the lake waters to support either a variety of quality recreational experiences or a balanced sport fishery. Since most lakes are multiple-use water bodies, a lake can fully support one designated use (e.g., aquatic life) but exhibit impairment of another (e.g., swimming).

Lakes that partially support designated uses have a designated use that is slightly to moderately impaired in a portion of the lake (e.g., swimming impaired by excessive aquatic macrophytes or algae, or boating impaired by sediment accumulation). So-called nonsupport lakes have a designated use that is severely impaired in a substantial portion of the lake (e.g., a large portion of the lake has so much sediment that boat ramps are virtually inaccessible, boating is nearly impossible, and fisheries are degraded). However, in other parts of the same nonsupport lake (e.g., near a dam), the identical use may be supported. *Again, nonsupport does not necessarily mean that a lake cannot support any uses, that it is a public health hazard, or that its use is prohibited.*

Lake-use support and level of attainment were determined for aquatic life, recreation, swimming, and overall lake use, using methodologies described in the IEPA's *Illinois Water Quality Report 1992-1993* (IEPA, 1994).

The primary criterion in the aquatic life use assessment is an Aquatic Life Use Impairment Index (ALI); while in the recreation use assessment the primary criterion is a Recreation Use Impairment Index (RUI). While both indices combine ratings for TSI (Carlson, 1977) and degree of use impairment from sediment and aquatic macrophytes, each index is specifically designed for the assessed use. ALI and RUI relate directly to the TP standard of 0.05 mg/L. If a lake water sample is found to have a TP concentration at or below the standard, the lake is given a "full support" designation. The aquatic life use rating reflects the degree of attainment of the "fishable goal" of the Clean Water Act; whereas the recreation use rating reflects the degree to which pleasure boating, canoeing, and aesthetic enjoyment may be obtained at an individual lake.

The assessment of swimming use for primary-contact recreation was based on available data using two criteria: 1) Secchi disc transparency depth data and 2) Carlson's TSI. The swimming use rating reflects the degree of attainment of the "swimmable goal" of the Clean Water Act. If a lake is rated "nonsupport" for swimming, it does not mean that the lake cannot be used or that health hazards exist. It indicates that swimming may be less desirable than at those lakes assessed as fully or partially supporting swimming.

Finally, in addition to assessing individual aquatic life, recreation, and swimming uses, the overall use support of the lake was assessed. The overall use support methodology aggregates the use support attained for each of the individual lake uses assessed. Values assigned to each use-support attainment category are summed and averaged, and then used to assign an overall lake-use attainment value for the lake.

Wolf Lake Use Support

Support of designated uses in Wolf Lake was determined based on Illinois' lake-use support assessment criteria. Table 46 presents basic information along with assessed lake-use support information. The use-support analysis results for both Pools 1 and 5 are the same: for aquatic life, recreation, swimming, and overall use, they are classified as full support. For aquatic life use, Pools 2, 3, and 8 are also classified as full support; while Pools 4, 6, 7, and 9 (Wolf Lake Channel) are full/threatened. For recreation use, five pools (Pools 2, 3, 4, 8, and 9) were determined to be partial-use support with minor impairment; Pools 6 and 7 are partial-use support with moderate impairment. For swimming use, five pools in Illinois are considered full support, and four pools in Indiana are classified as partial support with minor impairment. It should be noted that Pool 8 was evaluated with data obtained at RHA-8, rather than at the beach area in Pool 8. For overall use, there are two full support pools (Pools 1 and 5), three full/threatened support (Pools 2, 3, and 4), and four partial support with minor impairment (Pools 6, 7, 8, and 9). The results of analyses suggest that the water quality of Wolf Lake in Illinois is better than that on the Indiana side.

Even though the IEPA's methodology for lake-use impairment assessment indicates that Pools 6 and 7 have a recreation classification of partial-use support with moderate impairment, a major portion of these pools was found to be impaired and not conducive for high quality recreational opportunities such as boating, sailing, surfing, and fishing. The RUI point (weight) assigned for macrophyte impairment is 15 on a scale of 0 to 15 (for macrophyte coverage > 25

Table 46. Assessment of Use **Support in Wolf Lake**

	RHA-1		*RHA-2*	
	Value	*ALI points**	*Value*	*Allpoints**
I. Aquatic life use				
1. Mean trophic state index	37.0	40	51.4	40
2. Macrophyte impairment	15%	0	15%	0
3. Mean nonvolatile suspended solids	4 mg/L	0	3 mg/L	0
Total points:		40		40
Criteria points:		<75		<75
Use **Support:**		**Full**		**Full**
	Value	*RUIpoints**	*Value*	*RUI points**
II. Recreation use				
1. Mean trophic state index	37.0	37	51.4	51
2. Macrophyte impairment	15%	10	15%	10
3. Mean nonvolatile suspended solids	4 mg/L	5	3 mg/L	5
Total points:		52		66
Criteria points:		RUI <60		60≤RUI<75
Use **Support:**		**Full**		**Partial/Minor**
	Value	*Degree of use support*	*Value*	*Degree of use support*
III. Swimming use				
1. Secchi depth < 24 inches	0%	Full	0%	Full
2. Fecal coliform > 200/100 mL	0%	Full	0%	Full
3. Mean trophic state index	30.7	Full	51.4	Full
Use **Support:**		**Full**		**Full**
IV. Overall use	**5.0**		**4.3**	
Use **Support:**		**Full**		**Full/Threatened**

Note:
* ALI: Aquatic life use impairment index;
RUI: Recreation use impairment index.

Table 46. Continued

	RHA-3			RHA-4		
	Value	*ALI*	*points**	*Value*	*ALI*	*points**
I. Aquatic life use						
1. Mean trophic state index	48.0	40		52.2		40
2. Macrophyte impairment	45%	5		60		10
3. Mean nonvolatile suspended solids	3 mg/L	0		4 mg/L		0
Total points:		45				50
Criteria points:		<75				<75
Use Support:		**Full**				**Full/Threatened**
	Value	*RUIpoints**		*Value*		*RU1points**
II. Recreation use						
1. Mean trophic state index	48.0	48		52.2		52
2. Macrophyte impairment	45%	15		60		15
3. Mean nonvolatile suspended solids	3 mg/L	5		4 mg/L		5
Total points:		68				72
Criteria points:		60≤RU1<75				60≤RUI<75
Use Support:		**Partial/Minor**				**Partial/Minor**
	Value	*Degree of use support*		*Value*		*Degree of use support*
III. Swimming use						
1. Secchi depth < 24 inches	0%	Full		8%		Partial/Minor
2. Fecal coliform > 200/100 mL	0%	Full		0%		Full
3. Mean trophic state index	48.0	Full		52.2		Full
Use **Support:**		**Full**				**Full**
IV. Overall use	**4.3**			**4.0**		
Use Support:		**Full/Threatened**				**Full/Threatened**

Note:
* ALI: Aquatic life use impairment index;
RUI: Recreation use impairment index.

Table 46. Continued

	RHA-5		RHA-6	
	Value	*All points**	*Value*	*ALIpoints**
I. Aquatic life use				
1. Mean trophic state index	48.4	40	56.3	40
2. Macrophyte impairment	10%	5	85%	15
3. Mean nonvolatile suspended solids	2 mg/L	0.	4 mg/L	0
Total points:		45		55
Criteria points:		<75		<75
Use **Support:**		**Full**		**Full/Threatened**
	Value	*RUIpoints**	*Value*	*RUJpoints**
II. Recreation use				
1. Mean trophic state index	48.4	48	56.3	56
2. Macrophyte impairment	10%	5	85%	15
3. Mean nonvolatile suspended solids	2 mg/L	0	4 mg/L	5
Total points:		53		76
Criteria points:		RUI<60		75<RUI<90
Use **Support:**		**Full**		**Partial/Moderate**
	Value	*Degree of use support*	*Value*	*Degree of use support*
III. Swimming use				
1. Secchi depth < 24 inches	0%	Full	16%	Partial/Minor
2. Fecal coliform > 200/100 mL	0%	Full	0%	Full
3. Mean trophic state index	48.4	Full	56.3	Partial/Minor
Use **Support:**		**Full**		**Partial/Minor**
IV. Overall use	**5.0**		**3.0**	
Use Support:		**Full**		**Partial Minor**

Note:
* ALI: Aquatic life use impairment index;
RUI: Recreation use impairment index.

Table 46. Continued

	RHA-7			RHA-8		
	Value	*ALI*	*points**	*Value*	*ALI*	*points**
L Aquatic life use						
1. Mean trophic state index	57.7		40	58.6		40
2. Macrophyte impairment	60%		10	14%		5
3. Mean nonvolatile suspended solids	5 mg/L		0	5	mg/L	0
Total points:			50			45
Criteria points:			<75			<75
Use **Support:**			**Full**			**Full**
	Value	*RUIpoints**		*Value*	*RUI*	*points**
EL **Recreation use**						
1. Mean trophic state index	57.7		58	58.8		59
2. Macrophyte impairment	60%		15	14%		5
3. Mean nonvolatile suspended solids	5 mg/L		5	5 mg/L		5
Total points:			78			69
Criteria points:			75≤RUI<90			60≤RUI<75
Use Support:			**Partial/Moderate**			**Partial/Minor**
	Value	*Degree of use support*		*Value*		*Degree of use support*
III. Swimming use						
1. Secchi depth < 24 inches	8%	Partial/Minor		8%		Partial/Minor
2. Fecal coliform > 200/100 mL	8%	Full		0%		Full
3. Mean trophic state index	57.7	Partial/Minor		58.8		Partial/Minor
Use Support:		**Partial/Minor**				**Partial/Minor**
IV. Overall use	**3.0**			**3.7**		
Use Support:		**Partial/Minor**				**Partial/Minor**

Note:
* ALI: Aquatic life use impairment index;
RUI: Recreation use impairment index.

Table 46. Concluded

	RHA-9		
	Value	*ALI*	*points**
I. Aquatic life use			
1. Mean trophic state index	54.0		40
2. Macrophyte impairment	55%		10
3. Mean nonvolatile suspended solids	3 mg/L		0
Total points:			50
Criteria points:			<75
Use Support:			Full/Threatened
	Value		*RUIpoints**
II. Recreation use			
1. Mean trophic state index	54.0		54
2. Macrophyte impairment	55%		15
3. Mean nonvolatile suspended solids	3 mg/L		5
Total points:			74
Criteria points:			60≤RUI<75
Use Support:			Partial/Minor
	Value		*Degree of use support*
III. Swimming use			
1. Secchi depth < 24 inches	0%		Full
2. Fecal coliform > 200/100 mL	50%		Partial/Minor
3. Mean trophic state index	54.0		Partial/Minor
Use Support:			Partial/Minor
IV. Overall use	3.3		
Use Support:			Partial/Minor

Note:
* ALI: Aquatic life use impairment index;
RUI: Recreation use impairment index.

percent of the lake surface). The mean TSI, especially Secchi disc TSI, at these two pools was also relatively high, (table 44).

Sediment Characteristics

Lake sediment can act both as sinks and as potential pollution sources (for pollutants such as phosphorus and metals) affecting lake water quality. Its metal and/or organic chemical toxicities can directly affect the presence of aquatic animals and plants on the lake bottom. Lake sediments, if and when dredged, should be carefully managed to prevent surface water and ground-water contamination.

Sediment monitoring is becoming increasingly important as a tool for detecting pollution loadings in lakes and streams. The reasons are as follows: 1) Many potential toxicants are easier to assess in sediments because they accumulate there at levels far greater than those normally found in the water column. 2) Sediments are less mobile than water and can be used more reliably to infer sources of pollutants. 3) Nutrients, heavy metals, and many organic compounds can become tightly bound to the fine particulate silts and clays of the sediment deposits where they remain until they are released to the overlying water and made available to the biological community through physical, chemical, or bioturbation processes. Remedial pollution mitigation projects may include the removal of contaminated sediments as a necessary step (IDEM, 1992).

Sediment Quality Standards

While there are no regulatory agencies that promulgate sediment quality standards, sediment quality in Illinois is generally assessed using data by Kelly and Hite (1981). For the study in question, they collected 273 individual sediment samples from 63 lakes across Illinois during the summer of 1979. On the basis of each parameter measured, they defined "elevated levels" as concentrations of one to two standard deviations greater than the mean value, and "highly elevated levels" as concentrations greater than two standard deviations from the mean. A statistical classification of Illinois lake sediment developed by Kelly and Hite is shown in table 47. It should be noted that in this classification, lake sediment data are considered to be elevated based on a statistical comparison of levels found in 1979 and not on toxicity data. Therefore, elevated or highly elevated levels of parameters do not necessarily indicate a human health risk.

In Indiana, the maximum sediment background concentrations were determined from the analyses of sediment samples from 83 "non-contaminated" sites throughout the state (IDEM, 1992). Each sediment sample was collected from a lake or from a small stream at a location upstream of all known point sources of pollution, including municipal or industrial discharges and combined sewer overflows. Aerial sources of contaminants and contamination from nonpoint urban and agricultural runoff may have affected those sampling sites. While it is unlikely that any areas of the state are free of inputs from these sources, the background concentrations calculated are considered to represent the best possible estimate of "unpolluted" sediment in Indiana. The maximum background levels of constituents of Indiana lake and stream sediments determined by the study are shown in table 48. Sediments containing less than two times the maximum background concentration for each constituent are classified as "uncontaminated."

In Indiana, lake (reservoir) and stream sediments were also grouped into four levels of concern - high, medium, low, and unknown - based on the presence and concentration of priority pollutants measured. The criteria for such groupings are listed in table 49. If background concentrations of particular contaminants found were not known, the water body was placed into the "unknown" category of concern.

Table 47. Classification of Illinois Lake Sediments

Constituent	*Below normal*	*Normal*	*Elevated*	*Highly elevated*
Chemical oxygen demand	<32,500	32,500-162,000	162,000-226,000	>226,000
Total kjeldahl nitrogen	<1,650	1,650-5,775	5,775-7,850	>8,750
Total phosphorus	<225	225-1,175	1,175-1,650	>1,650
Volatile solids (%)	<5	5-13	13-17	>17
Total organic carbon	<26,500	26,500-65,000	65,000-85,100	>85,100
Arsenic		<27	27-41	>41
Cadmium		<1.8	1.8-2.6	>2.6
Chromium	<14	14-30	30-38	>38
Copper		<100	100-150	>150
Iron	<18,000	18,000-36,000	36,000-45,000	>45,000
Lead	<15	15-100	100-150	>150
Manganese		<3,000	3,000-3,900	>3,900
Mercury		<0.25	0.25-0.40	>0.40
Zinc	<50	50-175	175-250	>250

Note: Constituents measured in mg/kg except where noted otherwise.
Source: Kelly and Hite (1981)

Table 48. Maximum Background Concentrations of Pollutants in Indiana Stream and Lake Sediments

Parameter	*Maximum background (mg/kg)*	*Parameter*	*Maximum background (mg/kg)*
Aluminum	9,400	Silver	<0.5
Antimony	0.49	Strontium	110
Arsenic	29	Thallium	<3.8
Beryllium	0.7	Zinc	130
Boron	8.0	Phenol	<0.2
Cadmium	1.0	Cyanide	<0.1
Chromium	50	PCB (Total)	0.022
Cobalt	20	Chlordane	0.029
Copper	20	Dieldrin	0.033
Iron	57,000	DDT (Total)	0.020
Lead	150	BHC (Total)	0.014
Manganese	1,700	Pentachlorophenol	0.003
Mercury	**0.44**	Heptachlor	0.002
Nickel	21	Aldrin	0.0007
Nitrogen (TKN)	1,500	HCB	0.001
Phosphorus	610	Methoxychlor	<0.001
Selenium	0.55	Endrin	<0.001

Source: Indiana Department of Environmental Management (1993)

Table 49. Indiana Criteria for Grouping Sediments into Levels of Concern

High Concern:
Any contaminant present in concentrations greater than 100 times background

Medium Concern:
Any contaminant present in concentrations 10 to 100 times background

Low Concern:
Any contaminant present in concentrations 2 to 10 times background

Unknown Concern:
Contaminants present for which background concentration has not been established

Historical Sediment Data

The available historical data on sediment in Wolf Lake are presented in table 50. These data are adopted from the report of Bell and Johnson (1990). The sources are from the IEPA STORET database sediment data taken in 1977, 1979, and 1989, and from sediment data (five studies, 1980-1990, see p. 31 of Bell and Johnson, 1990) compiled by the IDEM. Each sample usually represents a composite of at least three grabs. The number (N) of samples listed in table 50 is not necessarily the same as the number of sampling locations. Some locations had repeat sampling.

The results in table 50a suggest that the metal concentrations in the sediment of Wolf Lake tend to vary from place to place, with the highest concentration being found in the vicinity of the northern Wolf Lake Channel. In fact, the highest concentration for each metal measured occurred at or near RHA-8 and RHA-9 for Pools 8 and 9, respectively. The reason for high concentrations of metals in the vicinity of RHA-8 is unknown. In fact, the highest chromium concentration (1,200 mg/kg) in the lake was found north of RHA-8 and east of the yacht club.

The Water and Sewage Laboratory of Indiana State Board of Health received four bottom sediment samples from Wolf Lake - Hammond, IN on February 13, 1980 (no sampling date was given). The results of analyses for volatile solids, TKN, phosphorus, COD, lead, zinc, mercury, oil and grease, and PCBs are listed in appendix G (March 28, 1980 letter).

On July 22, 1981, sediment and water samples were collected from five locations in Wolf lake (Indiana side) for heavy metals analyses. Those results are shown in tables II, IIB, and III of appendix G.

On July 16, 1982, sediments from various locations in Wolf Lake were collected by the Water Pollution Control Division of the Indiana State Board of Health. Samples were named #1 - Discharge, #2 - Indiana Pond, #3 - Illinois Pond, #3 A - Illinois Pond (duplicate), Wolf Lake #1, Wolf Lake #1A (duplicate), Wolf Lake #3, Wolf Lake #4, and Wolf Lake #5. Unfortunately, the exact sampling locations could not be ascertained. Extensive analyses of total solids, 6 metals (mercury, chromium, cadmium, copper, lead, and arsenic), and 35 organic compounds were performed for each sediment sample (appendix G). The concentrations of most of the organics were below the detectable levels.

On July 16, 1986, sediment samples were collected from Wolf Lake Channel, West Basin, and East Basin for metals and organic analyses. Exact locations in the lake are unknown. Extensive analyses were performed for metals, extractable compounds (acid, base, and neutral), pesticides, and other organic compounds and the results are included in appendix G.

Wente (1994) used an iterative maximum likelihood estimate method for estimating sediment background concentration distributions of 23 inorganic and 149 organic chemicals in Indiana. All 172 chemical distributions have estimates based on a single statewide distribute model (with no consideration for spatial variability). Fifteen of the inorganic chemical distributions have background estimates by spline techniques that account for some spatial variability. Maps of the mean and 95th percentile (on individual county basis) for each of the 15 spatially variable distributions are presented in the appendices of his report. Table 50b lists the statewide mean concentration, estimated northwest tip of the state mean (Wolf Lake area), and maximum 95th percentile in Lake County for 15 inorganics.

Current Study Data

During this study, sediment samples (both surficial and core) were taken at 30 sites (figure 8) on September 29 and 30, 1993. The sampling locations and water depths are also listed in

Table 50a. Concentration of Metals in Wolf Lake Sediments (1977,1979, and 1989)

	Pool 2		*Pool 3*		*Pool 7*		*Pool 8*		*Wolf Lake Channel*	
Parameter	*N*	*Range*	*N*	*Range*	*N*	*Range*	*N*	*Range*	*N*	*Range*
Arsenic	3	6.4-18	3	21-23	5	1.7-11	6	1.5-15	5	2.1-17
Cadmium	2	1.0-2.0	3	<0.1-3.0	3	0.78-<2	10	<0.4-2.5	5	0.7-7.2
Chromium	3	8-26	3	23-24.8	3	10-29	10	5-1200	5	34-160
Copper	3	3-32	3	37-50	4	23-160	10	3.5-110	5	10-340
Iron	3	9,800-18,000	3	20,000-22,600	1	10,000	3	5,700-25,000	1	37,000
Lead	3	16-120	3	95-150	3	35-110	10	8.8-290	9	19-1,000
Manganese	3	550-1100	3	810-1136	1	440	3	330-690	1	740
Mercury	3	<.0005-07	3	.003-.08		-	7	<.02-0.046	8	<02-1.40
Nickel	1	5.8	1	13		-	5	3.7-22	2	23-46
Selenium		-		-	1	0.81	1	0.87	1	1.80
Zinc	3	53-220	3	240-270	2	100-240	5	60-600	6	52-1,300

Note: N = number of samples; all parameters expressed in mg/kg.

Table 50b. Sediment Background Concentration Distributions of Metals in Indiana

Element	*Indiana statewide meant*	*Northwest corner of state mean**	*Maximum 95th percentile in Lake Count†*
	Concentration, mg/kg		
Aluminum	7,284	6,400	16,000
Arsenic	6.433	18	S4.4
Barium	89.3	90	230
Calcium	40,466	22,000	121,000
Chromium	16	62	346
Copper	20	110	505
Iron	15,633	33,000	83,000
Lead	24	440	1,539
Magnesium	6,840	7,300	22,000
Manganese	495	680	1,600
Mercury	0.0577	0.32	1.521
Nickel	13.2	24	101
Potassium	939	1,160	2,500
Vanadium	14.6	22	54
Zinc	84	620	2,780

Source: Wente, S.P. (1994)

Note: * = from table A1, appendix A of the source
* = estimated from figures B la through B 15a, appendix B of the source
† = from tables C1 and C2, appendix C of the source

table 51. The surficial sediment samples were collected using a Petite Ponar dredge, and the core samples were taken using a 2-inch Wildco sediment corer with liner tubes. Each core sediment sample could be divided into three equal parts - top, middle, and bottom - and each portion thoroughly mixed and then analyzed. However, because of funding constraints, the whole core sample was homogenized and a subsample analyzed. The sediment qualities of surficial and core samples analyzed are presented in table 52.

Nutrients. For the purposes of comparison, Illinois maximum normal background concentrations and Indiana maximum concentrations of metals and nutrients are listed in table 52. For the Illinois side, the values that exceeded the maximum normal concentrations are shown in bold type and the values that exceeded the maximum elevated concentrations are underscored.

For the Illinois side of Wolf Lake, TP levels in the 13 sediment samples were between 116 milligrams per kilogram (mg/kg) at station 1A and 952 mg/kg at station 5 (RHA-5), below the Illinois maximum normal concentration of 1,175 mg/kg.

TKN nitrogen concentrations in the 13 Illinois sediment samples were generally high and ranged from 286 mg/kg at station 1A to 13,898 mg/kg at station 4 (RHA-4). In fact, TKN levels at stations 3 (RHA-3), 3B, 4, 5, and 5B exceeded the maximum elevated concentration of 1,650 mg/kg; while TKN concentrations in station 5A sediment exceeded the maximum normal concentration of 1,175 mg/kg.

For the Indiana side, TP concentrations in 14 sediment samples ranged from 121 mg/kg at station 8B to 1,848 mg/kg at station 9C. Underscored values (table 52) are in the category of "low concern" (i.e., greater than two times the background concentration, but less than ten times). Table 52 shows that TP concentrations in sediments collected from stations 9 (RHA-9), 9B, and 9C exceeded two times the Indiana maximum background concentration of 610 mg/kg. TP at station 6 (RHA-6) is more representative for Pool 6. Average TP values for Pools 7 and 9 are, respectively, 162 and 1,280 mg/kg. TP values of 431, 162, and 1,280 mg/kg are the best available estimate and can be used for calculating TP removed from Pools 6, 7, and 9, respectively, if they are dredged.

TKN levels in 14 Indiana sediments ranged from less than detectable at station 9C to 10,393 mg/L at station 6. TKN concentrations at sites wetland IB, 6, 6A, 8 (RHA-8), 8A, 8D, and 9B were found to be three to seven times greater than the Indiana maximum background concentration.

Metals. For the Illinois side, table 52 shows that arsenic levels at stations 4 and 5 exceeded the maximum normal concentration. Cadmium concentrations at all three stations of Pool 3 were greater than the maximum normal concentration; those at stations 4 and 5 were higher than the maximum elevated concentration. Chromium levels exceeded the maximum elevated concentration at stations 1 (RHA-1), 3, 3B, 4, and 5. Copper levels in stations 4 and 5 samples were above the maximum normal concentration. Lead values at stations 3, 3B, 4, and 5 exceeded the maximum elevated concentration; and those at stations 4A and 5B exceeded the maximum normal concentration. The mercury concentration at station 4 was higher than the maximum normal concentration; and at station 5B it was extremely high, exceeding the maximum elevated value. Concentrations of zinc in many pools were high: zinc levels at stations 1 and 3 A exceeded the maximum normal concentration; levels at stations 3, 3B, 4, 4A, 5, and 5A were much greater than the maximum elevated concentration.

For the Indiana side (table 52), cadmium concentrations at stations 8A, 9, and 9B are classified as low concern. Copper levels in sediment samples taken from many stations (wetland 1B, 8, 8 A, 8D, 9, 9A, 9B, and 9C) were elevated. Concentrations of copper at stations 9 and 9B were nearly 10 and 12 times the maximum background concentration, respectively. These are

Table 51. Sediment Samples Collected in Wolf Lake

Station	*Date*	*Time*	*Depth, feet*	*Core sample*	*Remarks*
RHA-1	9/30/93	18:15	16		
1A	9/30/93	18:30	9	X	Center of lake
RHA-2	9/30/93	18:00	15		
2A	9/30/93	17:45	5	X	Center of lake
RHA-3	9/30/93	17:25	13		
3A	9/30/93	17:00	2.5	X	H_2S, southeast end
3B	9/30/93	17:15	8	X	H_2S, south channel
RHA-4	9/30/93	15:20	11		
4A	9/30/93	15:30	5	X	1/4 south of Pool, center
RHA-5	9/30/93	12:30	17		
5A	9/30/93	12:40	4	X	Near RR bridge
5B	9/30/93	13:10	4	X	Southend
W-1A	9/30/93	13:30	4	X	Center of wetland near Army installation
W-1B	9/30/93	13:50	5		Near creek
RHA-6	9/30/93	09:50	5.5	X	
6A	9/30/93	10:10	5	X	Southwest edge
6B	9/30/93	10:20	4		Between Pools 6 & 7
RHA-7	9/30/93	11:05	6.5	X	
7A	9/30/93	10:45	4		50'offhwy culvert between Pools 7 & 8
7B	9/30/93	10:50	4	X	Center of lake
RHA-8	9/30/93	08:50	16		
8A	9/29/93	17:15	10	X	200'off CSO outfall
8B	9/29/93	18:50	4	X	Near beach
8C	9/30/93	09:00	2		South of pumping station at wetland
8D	9/30/93	09:30	3	X	South end side channel
RHA-9	9/29/93	17:45	3	X	
9A	9/29/93	18:00	8	X	Near RHA-03
9B	9/29/93	18:15	8	X	North of wetland
9C	9/29/93	18:30	5	X	At RHA-09
RHA 01	9/30/93	16:10	4	X	At hwy bridge

Table 52. Sediment Quality Characteristics of Wolf Lake (September 29-30, 1993)

	Pool 1		*Pool 2*		*Pool 3*			*Pool 4*		*Illinois maximum concentration*	
*Parameter**	*1*	*1A*	*2*	*2A*	*3*	*3A*	*3B*	*4*	*4A*	*Normal*	*Elevated*
Water depth, ft	16	8	15	5	13	2.5	8	11	5		
Phosphorus	288	116	191	213	521	140	554	738	429	1175	1650
Kjeldahl nitrogen	1264	286	1230	5064	*12063*	5508	*12276*	*13898*	902	5775	8750
Solids, % wet	34.6	59.6	47.7	30.2	16.9	33.9	12.1	11.7	22.5		
Volatile solids, %	5.7	2.5	4.2	7.1	16.6	10.2	*21.8*	*20.0*	11.2	13	17
Arsenic	11.1	7.8	3.4	12.2	26.8	21.4	22.8	29.1	20.5	27	41
Barium	34	12	21	35	70	54	143	101	83		
Cadmium	1	1K	1K	1K	2	2	2	5	2	1.8	2.6
Chromium	40	6	28	23	*39*	14	*43*	*52*	22	30	38
Copper	26	4	16	21	63	37	79	108	60	100	150
Iron	18000	5700	11000	12000	27000	13000	28000	34000	20000	36000	45000
Lead	26	13	34	66	*171*	94	*215*	*256*	**131**	100	150
Manganese	1200	338	921	600	1100	465	1100	1300	799	3000	39000
Mercury	0.1K[+]	0.1K	0.1K	0.1K	0.14	0.13	0.20	0.26	0.15	0.25	0.40
Nickel	18	5	9	12	22	11	23	27	16	-	-
Potassium	1000K	1000K	1000K	1000K	1000K	1000K	1000K	1000	1000K		
Silver	1K	1K	1K	1K	1K	1K	1	1K	1K		
Zinc	208	36	100	142	*352*	**214**	*423*	*550*	*322*	175	250
Classification/ concern	Normal	Below Normal	Normal	Normal	Highly elevated	Normal	Highly elevated	Highly elevated	Elevated		

* Units = mg/kg, unless specified;
\+ K = less than detection value.
Note: Values in bold = greater than Normal limit; values in italics = greater than Elevated limit

Table 52. Continued

*Parameter**	Pool 5: *5*	*5A*	*5B*	*Outlet (Indian Creek)*	*Illinois maximum, concentration: Normal*	*Elevated*	*Indiana maximum background Concentration*	*Wetland 1B*	Pool 6: *6*	*6A*	*6B*
Water depth, ft	17	4	4	4				5	5.5	5	4
Phosphorus	952	87	284	151	1175	1650	610	344	431	377	143
Kjeldahl nitrogen	*12774*	6927	*8983*	894	5775	8750	1500	7850	<u>10393</u>	<u>9290</u>	371
Solids, % wet	13.1	46.8	30.5	56.4	-	-	-	23.6	26.5	27.7	50.8
Volatile solids, %	19.2	3.9	9.3	7.3	13	17	-	10.7	9.6	9.0	1.6
Arsenic	**28.1**	15.9	22.9	15.4	27	41	29	11.9	14.5	20.6	5.7
Barium	121	112	95	44			-	320	59	77	23
Cadmium	3	1 K	1	1 K	1.8	2.6	1.0	2		1 1	1 K
Chromium	49	23	25	27	30	38	50	53	28	31	13
Copper	**101**	12	48	22	100	150	20	84	38	39	8
Iron	33000	13000	23000	17000	36000	45000	57000	19000	26000	6300	
Lead	*270*	37	**118**	31	100	150	150	259	109	104	20
Manganese	1300	1200	797	656	3000	39000	1700	3300	574	765	368
Mercury	0.22	0.1K	*0.87*	0.1K	0.25	0.40	0.44	0.16	0.10	0.11	0.1K
Nickel	29	8	15	19	-	-	21	19	16	17	5
Potassium	1400	1000K	1000K	1100	-	-	-	2800	1000K	1000K	1000K
Silver	1K	1K	1K	1K	-	-	<0.5	1	1K	1K	1K
Zinc	*484*	71	*264*	95	175	250	130	495	271	267	72
Classification/ concern	Highly elevated	Normal	Elevated	Normal				Low concern	Low	Low	No

* Units = mg/kg, unless specified;
\+ K = less than detection value.
Note: for Indiana, values with underline = low concern; values in the parenthesis = medium concern

Table 52. Concluded

Parameter*		Pool 7				Pool 8				Pool 9			Indiana background concentration
	1	1A	7B	8	8A	8B	8C	8D	9	9A	9B	9C	
Water depth, ft	6.5	4	4.5	16	10	4	2	3	8	3	8	5	
Phosphorus	690	170	154	591	790	121	96J	524	1309	632	1331	1848	610
Kjeldahl nitrogen	12670	798	860	5727	8105	144	144	6084	1677	1076	5546	81K	1500
Solids, % wet	20.1	44.1	44.4	22.0	17.2	66.2	7.9	24.3	19.6	54.2	14.0	20.5	
Volatile solids, %	14.3	4.9	2.6	11.1	20.1	1.0	0.34	11.3	24.0	21.4	24.1	16.4	
Arsenic	2.4	5.0	5.3	7.4	8.4	1.6	1.9	6.1	8.1	8.7	8.9	28.1	29
Barium	84	27	17	47	129	5	149	64	101	147	99	144	
Cadmium	3	1K	1K	1	3	1K	6	2	3	1K	4	2	1.0
Chromium	52	22	8	31	95	2	777	29	97	56	96	51	50
Copper	108	16	15	64	161	1K	167	56	(1%)	66	(247)	113	20
Iron	33000	7600	6200	18000	33000	2700	52000	19000	34000	19000	43000	56000	57000
Lead	206	48	29	142	246	10K	454	162	388	294	361	135	150
Manganese	895	527	287	660	1800	126	1100	838	774	919	728	648	1700
Mercury	0.26	0.1K	0.1K	0.21	0.27	0.1K	0.34	0.12	0.80	0.1K	0.98	0.44	0.44
Nickel	25	7	7	18	23	5K	31	15	43	41	50	32	21
Potassium	1000K	1000K	1000K	1000K	1000K	1000K	1000K	1000K	1200	1000K	1400	1000K	
Silver	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	0.5
Zinc	543	116	85	333	558	11	1100	394	870	283	932	450	130
Classification/ concern	Low	No	No	Low	Low	No	Low	Low	Medium	Low	Medium	Low	

* Units = mg/kg, unless specified;
\+ K = less than detection value.
Note: for Indiana, values with underline = low concern; values in the parenthesis = medium concern

considered medium concern. Concentrations of lead and nickel at these two stations (9 and 9B) and mercury concentrations at 9B were all greater than two times the maximum background concentrations. Zinc concentrations in sediments collected from stations wetland IB, 6, 6 A, 8, 8A, 8D, 9, 9 A, 9B, and 9C were of "low concern." In Wolf Lake Channel, the concentrations of zinc at stations 9, 9B, and 9C are greater than, respectively, six, seven, and five times the maximum background concentration.

Examination of tables 50a and 52 reveals that the concentrations of heavy metals in Pool 2 and Pool 7 sediments decreased since the earlier studies (1987, 1979, 1989). However, there were no changes, generally, in the heavy metals levels in Pools 3 and 8.

Comparing Tables 50b and 52, one can conclude that the observed heavy metal concentrations in Wolf Lake sediments are comparable to the regional mean concentrations indicated by Wente (1994).

Organic Compounds. Chlorinated hydrocarbon compounds consist of a group of pesticides that are no longer in use but are persistent in the environment. These compounds, such as polychlorinated biphenyls (PCBs), chlordane, dieldrin, and DDT, present a somewhat unique problem in aquatic systems, due to their potential for bioaccumulation in fish in the food web. Organochlorine compounds are relatively insoluble in water but highly soluble in lipids where they are retained and accumulated. Minute and often undetectable concentrations of these compounds in water and sediment may ultimately pose a threat to aquatic life and then possibly to human health.

The observed concentrations of tested organochlorine compounds are presented in table 53. In Illinois, standards for organochlorine compounds in lake sediments have not been developed. The Indiana maximum background levels for several compounds tested are listed in table 53, which shows that the majority of compounds in Wolf Lake sediments were below detection limits. Total and P,P'-DDT; P,P'-DDE; and P,P'-DDD were detected in Pools 1 through 7; however, concentrations were low and can be classified as nonelevated.

Total PCBs were found at all locations sampled. On the Illinois side, they ranged from 27 micrograms per kilogram (ug/kg) at RHA 01 (Indian Creek) to 170 ug/kg at RHA-3 and RHA-4. On the Indiana side, very high concentrations of total PCBs (1,000 to 4,000 ug/kg) were found in the sediments at station 8A and four stations in Pool 9 (Wolf Lake Channel). Total PCBs at stations 9, 9A, and 9B were classified as "high concern;" at stations 7, 8A, 8C, 9C, and wetland 1B as "medium concern;" at stations 6, 6A, 7 A, 8, and wetland 1A as "low concern;" and at stations 6B, 7B, 8B, and 8D as "no concern."

Sediment Classification and Concern. On the basis of sediment data on nutrients and heavy metals, classifications of lake sediment in Illinois and levels of concern in Indiana are also listed in table 52. In Illinois, only sediment at station 1A is classified as "below normal." For the purpose of this study, if at least three of 12 parameters evaluated at a station exceed the Illinois maximum normal concentrations, then sediment quality at the station will be considered "elevated;" otherwise that station will be classified as "normal." Thus, sediment qualities at stations 1, 2, 2A, 3A, 5A, and Indian Creek are classified as "normal." Sediment samples collected from 4A and 5B are considered "elevated." Four stations (3, 3B, 4, and 5) have "highly elevated" constituent concentrations in sediments.

On the Indiana side of Wolf Lake, the quality of sediments collected from stations 6B, 7 A, 7B, and 8B falls in the category of "no concern." The sediment qualities for wetland 1B, 6, 6A, 8, 8A, 8D, 9 A, and 9C are classified as "low concern." In this study, the worst sediment characteristics were found at stations 9 and 9B, which are considered as "medium concern."

Table 53. Organic Concentrations in Wolf Lake Sediments (September 29-30, 1993)

									Chlordane		
Pool	*Station*	*Total PCBs*	*Aldrin*	*Dieldrin*	*Total DDT*	*P,P' -DDE*	*P,P' -DDD*	*P,P' -DDT*	*Total*	*CIS isomer*	*Trans isomer*
1	1	110	1.0K	1.0K	23	8.9	14	1.0K	5.0K	2.0K	2.0K
2	2	51	"	"	10K	3.3	4.7	"	"	"	"
	2A	62	"	"	"	4.3	5.4	"	"	"	"
3	3	170	"	"	36	14	20	2.2	"	"	"
	3A	33	"	"	11	4.8	5.6	1.0K	"	"	"
	3B	160	"	"	58	28	26	4.2	"	"	"
4	4	170	"	"	38	13	12	13	"	"	"
	4A	55	"	"	11	4.1	3.8	2.9	"	"	"
5	5	130	"	"	22	11	9	2.2	"	"	"
	5A	23	"	"	10K	1.0K	17	1.0K	"	"	"
	5B	71	"	"	16	6.6	9.8	"	"	"	"
6	6	64	"	"	10K	3.2	2.6	2.6	"	"	"
	6A	56	"	"	"	2.7	2.5	2.8	"	"	"
	6B	22	"	"	"	1.0K	1.0K	1.0K	"	"	"
7	7	240	"	"	25	6.7	"	18	"	"	"
	7A	88	"	"	10K	1.9	1.8	1.8	"	"	"
	7B	35	5.0K	5.0K	25K	5.0K	5.0K	5.0K	25K	10K	10K
8	8	180	"	"	"	"	"	"	"	"	"
	8A	1200	"	"	"	"	"	"	"	"	"
	8B	25K	1.0K	1.0K	10K	1.0K	1.0K	1.0K	5.0K	2.0K	2.0K
	8C	400	5K	5K	25K	5K	5K	5K	25K	10K	10K
	8D	42	"	"	"	"	"	"	"	"	"
9	9	4000	10K	10K	"	10K	10K	10K	25K	"	"
	9A	3200	"	"	"	"	"	"	"	"	"
	9B	2900	"	"	"	"	"	"	"	"	"
	9C	1000	"	"	"	"	"	"	"	"	"
RHA	01	21	1.0K	1.0K	10K	1.0K	1.0K	1.0K	5.0K	1.0K	1.0K
W	1A	210	10K	10K	25K	10K	10K	10K	25K	10K	10K
W	1B	670	"	"	"	"	"	"	"	"	"
Indiana max. background level:		22	0.7	33	20				29		

Notes: Concentrations in μg/kg; K = less than detection value; W = wetland.

Table 53. Concluded

Pool	*Station*	*Endrin*	*Methoxy -chlor*	*Alpha -BHC*	*Gamma -BHC (Lindane)*	*Hexa-chloro-benzene*	*Hepta-chlor*	*Hepta-chlor epoxide*	*Water depth, feet*
1	1	1.0K	5.0K	1.0K	1.0K	1.0K	1.0K	1.0K	16
2	2	"	"	"	"	"	"	"	15
	2A	"	"	"	"	"	"	"	5
3	3	"	"	"	"	"	"	"	13
	3A	"	"	"	"	"	"	"	2.5
	3B	"	"	"	"	"	"	"	8
4	4	"	"	"	"	"	"	"	11
	4A	"	"	"	"	"	"	"	5
5	5	"	"	"	"	"	"	"	17
	5A	"	"	"	"	"	"	"	4
	5B	"	"	"	"	"	"	"	4
6	6	"	"	"	"	"	"	"	5.5
	6A	"	"	"	"	"	"	"	5
	6B	"	"	"	"	"	"	"	4
7	7	"	"	"	"	"	"	"	6.5
	7A	"	"	"	"	"	"	"	4
	7B	5.0K	5.0K	5.0K	5.0K	5.0K	5.0K	5.0K	4.5
8	8	"	"	"	"	"	"	"	16
	8A	"	"	"	"	"	"	"	10
	8B	1.0K	"	1.0K	1.0K	1.0K	1.0K	1.0K	4
	8C	5K	"	5K	5K	5K	5K	5K	2
	8D	"	"		"	"	"	"	3
9	9	10K	10K	10K	10K	10K	10K	10K	8
	9A	"	"	"	"	"	"	"	3
	9B	"	"	"	"	"	"	"	8
	9C	"	"	"	"	"	"	"	5
RHA	01	1.0K	5.0K	1.0K	1.0K	1.0K	1.0K	1.0K	4
W	1A	10K	10K	10K	10K	10K	10K	10K	4
W	1B	"	"	"	"	"	"	"	5
Indiana maximum background level:		<1	<1	14 (total)	<1	2			

Notes: Concentrations in µg/kg; K = less than detection level; W = wetland.

As expected, sediment quality varied from location to location. The results of sediment data indicate that the deepest location of each pool exhibited the worst sediment quality, i.e., high concentrations of nutrients and heavy metals.

TCLP Results. The cornerstone of safe waste management and disposal practices in determining whether or not the waste in question is considered "hazardous." The process of determining a waste's toxicity and subsequently classifying it as "hazardous" or "nonhazardous" involves various state-of-the-art analytical procedures. The Extraction Procedure (EP) Toxicity Characteristics has been used for years.

The TCLP was driven by the Federal Resource Conservation and Recovery Act (RCRA) and its amendments. The "Identification and Listing of Hazardous Waste" Rule was originally proposed in June 1986, designed to replace the EP Toxicity Characteristics. Over a four-year period, the USEPA has significantly changed the actual procedure; they replaced the EP Toxicity Test with the TCLP in 1990. The effective date of the TCLP rule for all large-quantity generators was September 25, 1990, and for all small-quantity generators was March 29, 1991.

The TCLP test is designed to simulate the leaching action that would occur in a conventional municipal landfill and to give an indication of what contaminants might migrate to the ground water under these conditions. It consists of performing an extraction procedure on the sample using a weak acid (acetic) similar to what may be generated by organic decomposition in a municipal landfill. Allowable maximum levels for metals (and pesticides) in the leachate are set at 100 times the chronic toxicity reference level. This hundred-fold dilution is an arbitrary determination made by the USEPA in an attempt to account for the undetermined amount of dilution that the leachate would experience before reaching a ground-water source. Since the TCLP is designed to simulate landfill conditions, it is not indicative of the conditions *in situ* at the lake, but can only be taken as an indicator of whether or not the sediment (if dredged) could be taken to a conventional landfill. Furthermore, the final decision as to where the sediment can be disposed of would reside with each state's environmental protection authority. The TCLP test is intended to simulate the potential release of contaminants from sediments that might occur during dredging operations or be encountered in leachate from a disposal area of dredged lake sediment

If solid waste such as sludge or, in this case, sediment is to be land-applied in such a manner that it will not be subjected to the leaching action experienced in a municipal landfill, then different criteria can be applied. For land application to agricultural land, the IEPA mandates maximum hydraulic application rates as well as total accumulation of metals and organics. States may apply these criteria to nonagricultural land if they have reason to believe that the land may someday revert to agricultural use. In most states, such application requires a permit and is decided on a case-by-case basis. The limitations on land application of the lake sediment in the same area would probably hinge on the high water table and/or the organic contaminant concentrations.

Table 54 presents the concentration of metals determined by TCLP tests of ten sediment samples collected from six pools in Wolf Lake. PCBs and pesticides were not determined. Not all parameters determined were required by the regulatory agency; only five of 11 parameters are in the TCLP regulatory list (table 54). TCLP test concentrations of barium, cadmium, chromium, lead, and silver were all under the regulatory limits for the ten sediments. In fact, most metal concentrations were below the detectable levels. The pH values of the sediments were acidic and ranged from 5.40 at station 9B to 6.50 at station 7B.

If any dredging is to be conducted in a lake, the amount of nutrients removed with the lake sediments can be estimated using the collected data.

Table 54. Results of Toxicity Characteristics Leaching Procedure for Wolf Lake Sediments, November 9, 1993

Parameter	*Station*										*Regulatory limit, mg/L*
	3A	*3B*	*5B*	*RHA-6*	*7B*	*8A*	*RHA-9*	*9A*	*9B*	*9C*	
pH-final, units	5.52	6.29	6.39	6.13	6.50	6.48	5.49	5.78	5.40	6.12	
Barium	0.52	0.53	0.46	0.34	0.27	0.43	0.27	0.54	0.25	0.35	100
Cadmium	0.009	.005K .	.005K	.005K	.005K	005K	0.013	.005K	0.022	.005K	1.0
Chromium	.005K	.005K	.005K	.005K	.005K	0.005	0.006	.005K	005K	0.005	5.0
Copper	.005K	.005K	.005K	.005K	.005K	.005K	0.028	0.007	0.089	.005K	
Iron	05K	.05K	.05K	.05K	0.31	.05K	0.11	0.19	0.13	106.8	
Lead	0.17	.05K	05K	.05K	.05K	.05K	0.24	.05K	0.39	.05K	5.0
Manganese	4.7	3.2	2.5	3.0	1.1	8.6	2.6	12.3	1.9	2.2	
Nickel	0.026	.015K	015K	.015K	015K	.015	0.060	0.034	0.070	015K	
Silver	.01K	.01K	01K	.01K	.01K	01K	.01K	01K	.01K	01K	5.0
Zinc	1.7	0.28	0.11	0.29	0.17	.34	4.0	1.5	4.1	.05K	
Water depth, feet	3.5	10	6	6	5.5	9	9	3	7	4	

Note: Parameters in mg/L unless otherwise noted.

Lakebed Characteristics. Lakebed conditions in Wolf Lake were evaluated by collecting samples of bed materials from the lake bottom through dredge sampling and shallow coring. This sampling was supplemented by probing of the lake bottom with a 1-inch-diameter pole.

The bed material sampling indicated that in general the lakebed is composed of a sandy base material intermixed with fine and decomposed organic matter. In limited areas, the surface muck layer was thicker, particularly in Pool 5 and the Wolf Lake channel. The thickest deposits probed by the pole were 7 feet thick at the main sampling station in Wolf Lake Channel (RHA-9). Other probe measurements in the channel and Pool S indicated muck deposits ranging from 1 to 3.5 feet thick.

Particle-size distributions of the bed material samples are plotted in smaller sets by lake segments in figures 18a-18f (the legends for these plots also list applicable unit weights for these samples where available). These analyses show that bed materials range from sandy silt to silty sand. The figures portray the particle size distribution for the inorganic portion of the samples: no organic content analysis was done for this sample set. Unit weight values below 30 pounds per cubic foot are generally associated with materials of high organic content. At Wolf Lake, these low unit weights are associated with unusually coarse particle-size fractions.

Based on particle-size distribution, unit weight values, and field observations, the Wolf Lake bed materials appear to be highly organic material that has mixed with the original glacial sand deposits. Where the organic muck layer is thicker, fine grit is still found either from atmospheric deposition or in-lake resuspension and transport of sand materials.

Lake Budgets

Hydrologic Budget

The hydrologic budget of Wolf Lake or any other lake system takes the general form:

Storage change = Inflows - outflows

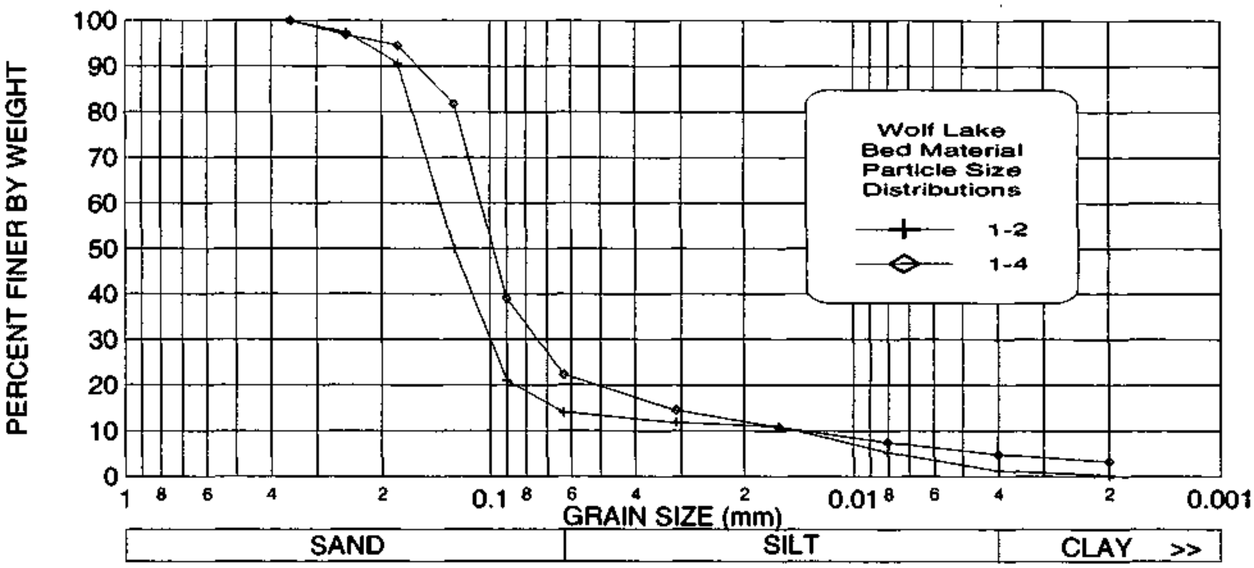
In general, inflows to the lake include direct precipitation, watershed runoff, ground-water inflow, and pumped input. Outflows include surface evaporation, discharge at the lake outlet, ground-water outflow, and withdrawals. For Wolf Lake, withdrawals are not a factor.

Various parameters necessary to develop a hydrologic budget for Wolf Lake were monitored for a one-year period (October 1992 to September 1993) during the diagnostic phase of the project. Table 55 presents monthly results of this monitoring for the total lake system. Figure 19 presents continuous stage plots for the Pool 1, Pool 3, and Pool 8 staff gages and water-level recorders. All other staff gage readings fell in the generally narrow range between the Pool 3 and Pool 8 levels and are not presented. The most significant water-level drops occured at State Line Road with an occasional significant drop at the railroad culvert.

Changes in basin storage were estimated by multiplying the monthly change in lake stage (recorded during the diagnostic monitoring site visits) by the lake surface area to determine net monthly inflow or outflow volume in acre-feet.

Inputs to the lake system are the NPDES permit discharges, direct watershed runoff, and direct precipitation on the lake surface. Discharges for the NPDES sites were determined using the monthly reporting system under the permitting program. Discharges for all of the permittee-discharges are estimated on a monthly basis by the permit holder and reported to the IDEM. These discharges are listed for each permitted discharge in table 55. Most of the overland

a. SITE: Wolf Lake Pools 1
DATE: July 6, 1994
COLLECTED BY: Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September.October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:



b. SITE: Wolf Lake Pools 2 and 3
DATE: July 6, 1994
COLLECTED BY: Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September.October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:

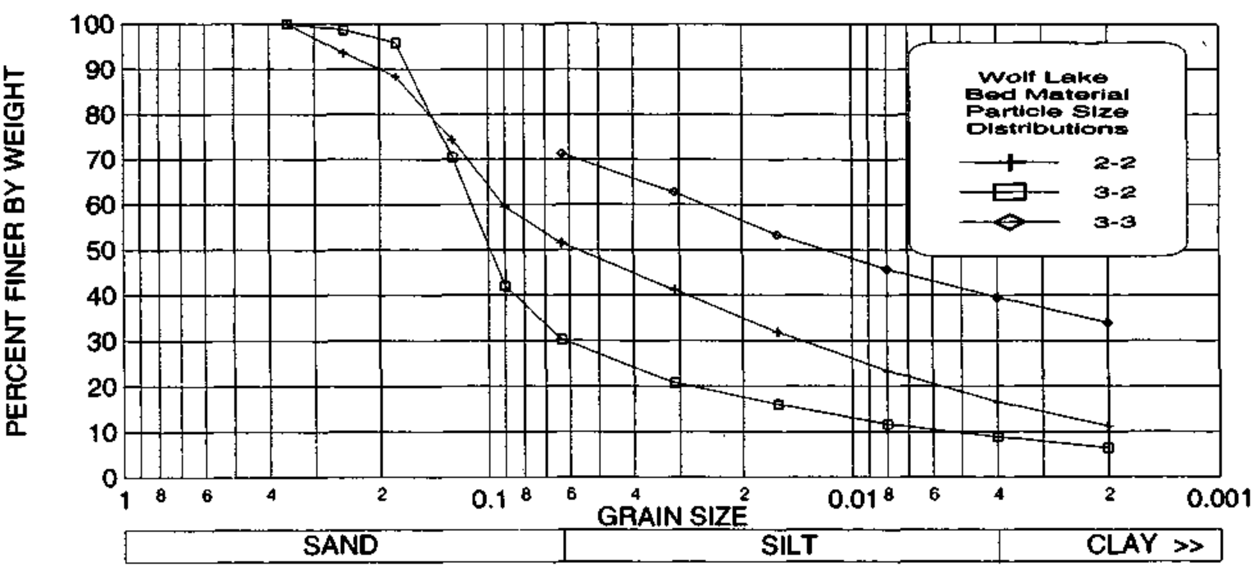
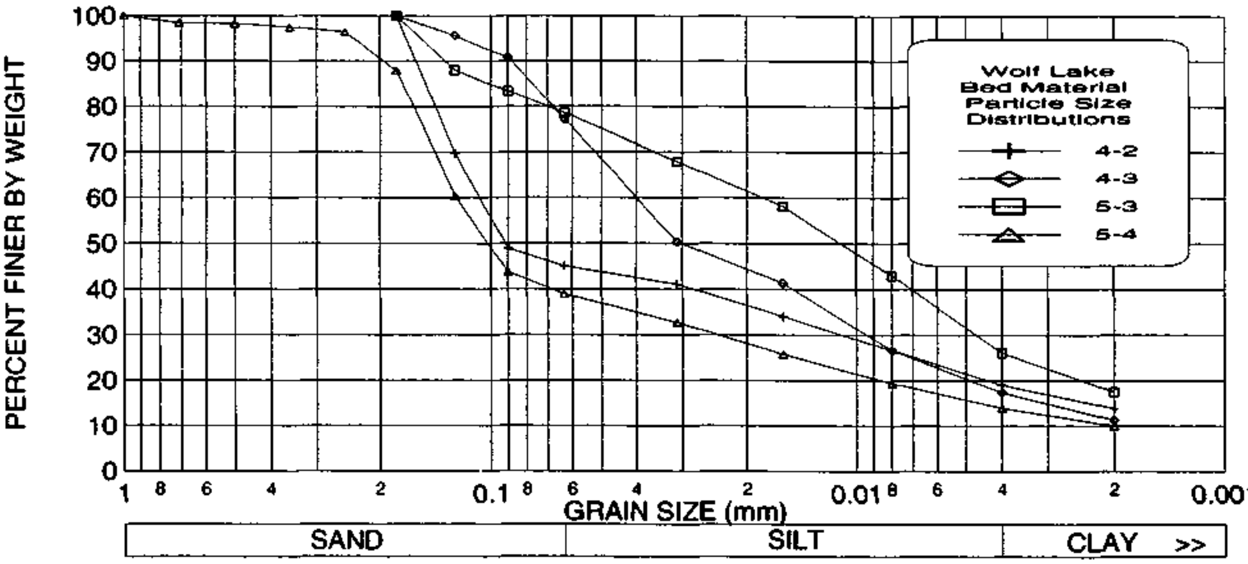


Figure 18. Particle size distribution plots for Wolf Lake pools

c. SITE: Wolf Lake Pools 4 and 5
DATE: July 6, 1994
COLLECTED BY: Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September, October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:



d. SITE: Wolf Lake Pools 6 and 7
DATE: July 6, 1994
COLLECTED BY: Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September, October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:

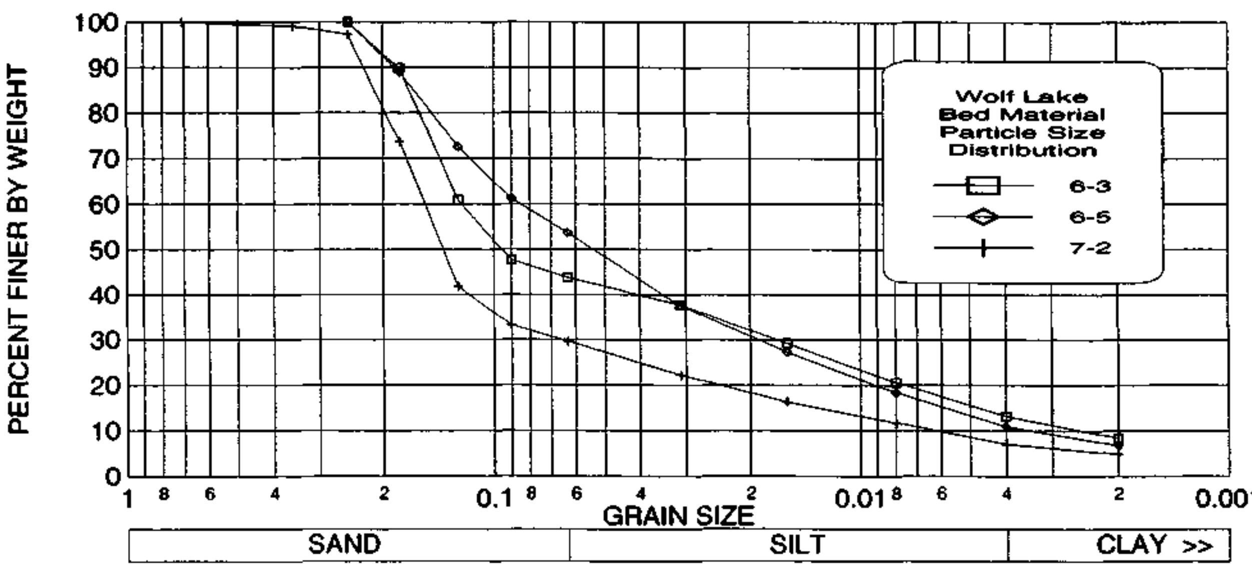
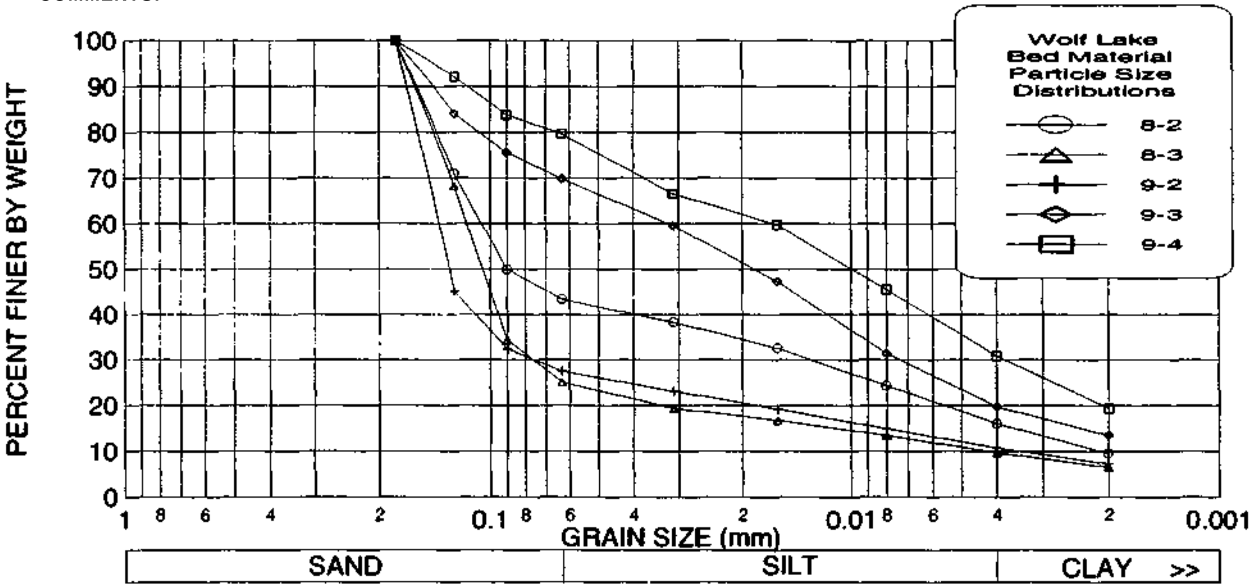


Figure 18. Continued

e. SITE: Wolf Lake Pools 8 and 9
DATE: July 6, 1994
COLLECTED BY:Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September .October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:



f. SITE: Wolf Lake All Data
DATE: July 6, 1994
COLLECTED BY:Bill Bogner, Tim Nathan
ANALYZED BY: Yi Han DATE: September.October 1994
PROJECT: Wolf Lake Clean Lakes Phase I
COMMENTS:

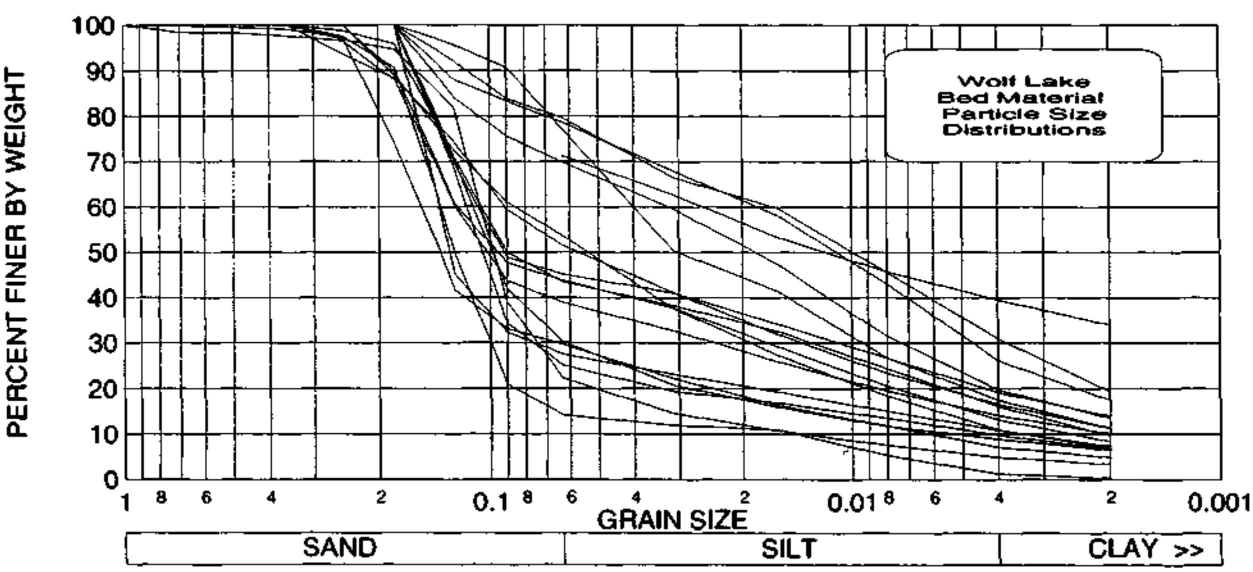


Figure 18. Concluded

Table 55. Monthly Summary of NPDES Discharges to Wolf Lake in acre-feet, October 1992-September 1993

Month	*Roby Station*	*Forsythe Park Station*	*Sheffield Avenue Station*	*Lever Brothers*	*American Maize*	*All NPDES discharges*
October	8	27	3	633	431	1,103
November	15	54	14	572	500	1,156
December	15	42	10	498	629	1,194
January	23	368	24	504	419	1,339
February	12	133	5	435	432	1,018
March	17	225	16	500	255	1,012
April	18	284	16	450	608	1,377
May	13	119	6	420	643	1,201
June	48	655	79	498	622	1,903
July	23	234	13	496	496	1,261
August	24	239	16	519	632	1,429
September	24	323	22	540	528	1.437

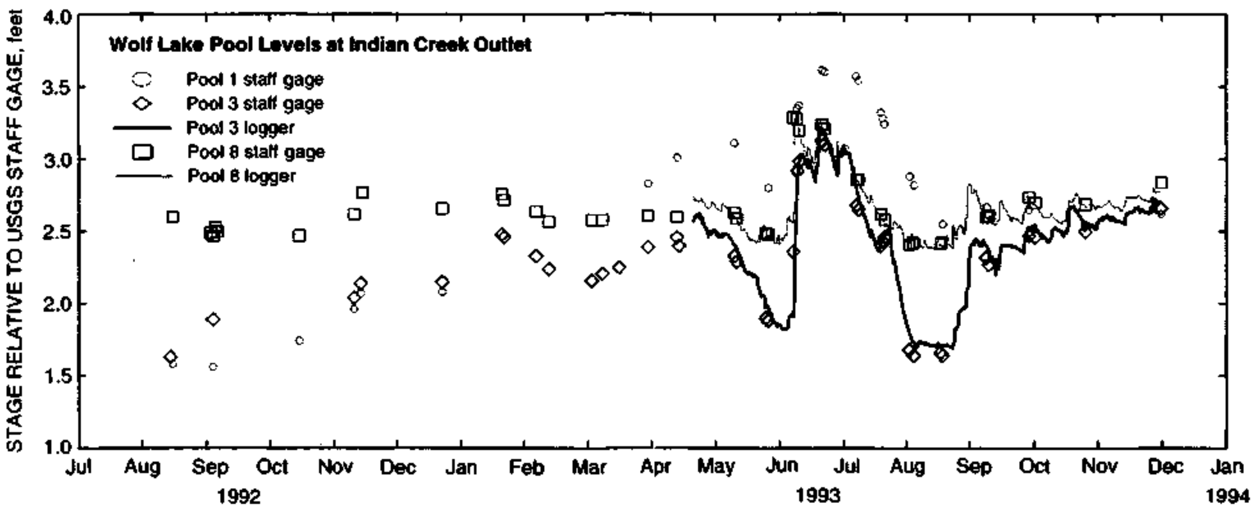


Figure 19. Water-level variation and differentials in the Wolf Lake system

stormwater discharge to the lake is included in the Hammond Park District stormwater pumping station reports.

Direct watershed surface runoff rates were not measured during this study. Surface inflow volume was evaluated by using the daily precipitation rates from the two raingage sites as inputs to the Soil Conservation Service (SCS) watershed runoff algorithm. For this analysis, a Curve Number value of 50 was used for the 925 acres of pervious surfaces that drain directly to the lake. It was determined that there are no significant areas of impervious surfaces in the watershed that are not artificially drained. Results indicated that the direct inflow to the lake occurred during June and August 1993. These runoff values have been added as noted in table 56.

The volume of direct precipitation input to the lake is based on the monthly precipitation data for the Hammond Sanitary District raingage at the Robertsdale pump station and an Illinois State Water Survey raingage located on the property of Grayco Corporation on Highway O, 0.5 miles north of Frank Powers State Park. The precipitation data from these two stations were averaged and the depth was multiplied by the lake surface area to determine inflow volume in acre-feet.

Monthly evaporation rates are the long-term average monthly evaporation rates for Chicago as presented by Roberts and Stall (1967). These rates do not vary significantly from year to year, and they are representative of normal lake evaporation rates in the area. Monthly lake surface evaporation volume was determined for the study period by multiplying the long-term average monthly evaporation depth by the lake surface area.

A budget of the amount of ground water flowing into and out of each pool of Wolf Lake was developed using Darcy's Law, which states that flow is proportional to hydraulic conductivity (permeability), gradient, and cross-sectional area. The hydraulic conductivity was assumed to be 75 feet per day (ft/d) based on slug tests, flow-net analysis from the wells clustered around well 26, and the modeling efforts of Fenelon and Watson (1993). The hydraulic conductivity was lowered to 50 ft/d near wells 28 and BH-8 based on lower values from slug tests. Because the vertical permeability of the aquifer was lower than the horizontal permeability, the gradients calculated for the wells within 400 feet of the aquifer were reduced to reflect the true gradient based upon the relationship found around well 26. The net ground-water inflow was computed to be 781 acre-feet per year or 1.08 cubic feet per second (cfs). This estimate closely matches estimates by Fenelon and Watson (1993) of 1.0 cfs and 2.2 cfs for cases in their regional computer model in which the hydraulic conductivity was assigned values of 50 ft/d and 100 ft/d, respectively.

Table 57 summarizes the hydrologic budget on a monthly basis for the one-year monitoring period. During this period, total measured inflow to the lake was 19,350 acre-feet and was distributed as shown in table 57. For the purpose of comparing inflow volumes to and outflow volumes from the lake system, it was assumed that outflow volume combined with an overall increase in storage for the study period should be exactly equal to the inflow volume. A listing of the distribution of outflow and storage factors is given in table 57.

In this analysis the unaccounted factor has been allocated to the outflow portion of the flow balance. It can be treated as a positive factor since calculated inflows exceeded calculated outflows and storage. This factor is more correctly considered as an unbalanced sum of error factors for all measured, estimated, or unmeasured inflow and outflow values. All of the flow values in this analysis contain an error factor, and several known small inflows could not be adequately monitored.

The flow volume estimate for Amaizo discharge 6 (inflow 12 for this study) appears to be substantially overestimated. This flow is a discharge of excess Lake Michigan water that is

Table 56. Annual Summary of the Hydrologic Budget for Wolf Lake, October 1992-September 1993

Source	*Inflow volume, acre-feet*	*Inflow percent*	*Outflow volume. acre-feet*	*Outflow percent*
Lever NPDES discharge	6,063	30%		
Hammond Sanitary District pump stations	3,170	16%		
American Maize NPDES discharge	6,196	31%		
Direct watershed runoff	115	1%		
Direct precipitation fall on lake surface	3,806	19%		
Ground-water inflow	781	4%		
Indian Creek			12,851	66%
Lake surface evaporation			2,509	13%
Pool storage			452	2%
Unaccounted factors			4,320	19%
Total	20,131		20,132	

Table 57. Summary of the Hydrologic Analysis for the Wolf Lake System, October 1992-September 1993

Month	*Inflow from NPDES sites*	*Precipitation*	*Ground-water inflow*	*Outflow at Indian Creek*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	1,103	52	53	1,230	155	70	-177	247
November	1,156	326	92	1,190	66	144	318	-174
December	1,194	228	117	1,082	29	74	427	-354
January	1,339	283	39	1,414	29	54	217	-164
February	1,018	47	64	994	48	-96	87	-183
March	1,012	344	83	1,021	113	124	305	-181
April	1,377	231	66	1,016	213	86	445	-359
May	1,201	124	61	953	334	-329	98	-427
June*	1,903	1,068	60	1,315	414	767	1,356	-589
July	1,261	197	38	1,112	468	-766	-83	-683
August*	1,429	530	56	729	382	263	965	-702
September	1,437	376	52	796	257	61	813	-752
Annual	15,430	3,806	781	12,852	2,508	452	4,771	-4,321

Note:

All units in acre-feet

June and August net inflow increased by 53.7 and 61.7, respectively, for direct surface runoff withdrawn for plant usage but not used in the plant. The discharge volume to Wolf Lake is not closely monitored and the resulting estimates are questionable. Since the quality of Lake Michigan water is presumed to be far superior to the quality of Wolf Lake water, the impact of this discharge is positive for Wolf Lake regardless of volume. Its impact on this hydrologic balance analysis may be the large unaccounted flow volume and the possible hiding of other small flow factors.

A separate hydrologic analysis was prepared for the lake section from the Toll Road to Indian Creek. This analysis is based completely on parameters that were physically measured during the field data collection phase of the study without influence from the NPDES permit discharge tallies. Table 58 presents the results of this analysis using the measured flows at the Indiana East-West Toll Road opening as input, Indian Creek flows as output, and precipitation and evaporation as previously described. This analysis greatly reduces the unaccounted system flows. Annually, less than five percent of the Pool 1-7 outflow was unaccounted. The greatest unaccounted volume was less than 25 percent of total outflow for the month of August 1993.

Interpool flow patterns were evaluated to better define the hydrologic operation of the lake system. The lake was divided into five discrete basins on the basis of the available interpool discharge measurements at the Indiana East-West Toll Road, State Line Road, the Indiana Harbor Belt Railroad causeways, and Pool 1, which has no direct connection to the other lake pools. The hydrologic operation of each of these pool segments is summarized in tables 59a-e.

Of these segmental pool analyses, the analysis for Pool 1 (table 59a) is obviously the simplest and least subject to unaccounted flows because of limited or no surface inflows. All the other pool analyses are subject to uncertainty in the number of inflow and outflow measurements and errors associated with extrapolating these limited data to monthly discharges. Much of the unaccounted flow can be traced to limitations in the NPDES flow estimates and the monthly and bimonthly flow measurements between pools.

The water balance for Pools 8 and 9 (table 59b) is very poor. This accounting includes all of the NPDES discharges as inflows and the flow under the Indiana Toll Road as an outflow. Given the highway's width, the presumption of a well-compacted base for the highway, and the low head differential between Pools 8 and 7, it is assumed that the highway causeway has a very low permeabilty.The main reason for the imbalance is presumed to be the inadequate accounting of the Lake Michigan overflow from the Amaizo NPDES discharge. The estimated discharge of 6.48 mgd for significant periods of time is believed to be greatly exaggerated since this discharge was never observed to operate during the 17 lake monitoring visits. No other discrepancies in the inflows or outflows to Pools 8 and 9 were apparent.

For Pools 6 and 7 (table 59c), the flow from the Toll Road is the only inflow and flow at the State Line Road opening the only outflow. The fill materials and compaction used in constructing the road causeway are suspected of allowing leakage into Pools 4 and 5. Since the nature of the unaccounted flow for these pools alternates between inflows and outflows, it is presumed that the source of the discrepancies is in the accuracy of the individual elements of the estimates, primarily the extrapolation of the measured discharges to monthly values.

For Pools 4 and 5 (table 59d) the State Line Road opening is the inflow and the railroad culvert is the outflow. Some additional inflow is likely from the area on the east side of Pool 4 where drainage from a wetland area and the Federal Surplus Commodities Facility enters the lake system. Small amounts of flow were observed from these sites on an intermittent basis, but were not measured. Potential leakage from the State Line Road causeway was discussed previously and would be an additional source of inflow to the pools. The causeway for the railroad along the west side of these pools is a very likely source of additional leakage out of the pools. Details about the construction of this causeway are not known, but numerous low points provide

Table 58. Summary of the Hydrologic Analysis for Pools 1-7 of the Wolf Lake System, October 1992-September 1993

Month	*Toll Road inflow*	*Precipitation*	*Ground-water inflow*	*Outflow at Indian creek*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	1,015	33	47	1,230	97	39	-233	272
November	982	203	55	1,190	41	81	9	73
December	836	142	80	1,082	18	63	-42	106
January	1,144	176	69	1,414	18	64	-43	107
February	778	29	57	994	30	-65	-160	95
March	947	215	70	1,021	70	89	141	-51
April	786	144	61	1,016	133	34	-158	192
May	729	77	52	953	208	-236	-303	68
June*	1,729	665	61	1,315	258	534	936	-402
July	1,038	123	44	1,112	292	-540	-199	-341
August*	823	330	44	729	238	128	292	-164
September	923	235	53	796	160	110	255	-145
Annual	11,729	2,372	692	12,851	1,564	302	494	-192

Note:

All units in acre-feet

June and August net inflow increased by 53.7 and 61.7, respectively, for direct surface runoff

Table 59a. Summary of the Hydrologic Analysis for Pool 1 of the Wolf Lake System, October 1992-September 1993

Month	*Inflow*	*Precipitation*	*Ground-water inflow*	*Outflow*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October		6	17		17	20	6	14
November		35	18		7	18	45	-28
December		24	19		3	22	41	-19
January		30	9		3	33	36	-4
February		5	-1		5	10	-1	11
March		37	2		12	10	27	-17
April		25	-11		23	25	-9	34
May		13	-21		36	-28	-44	16
June		115	-3		45	78	67	11
July		21	-27		50	-70	-56	-14
August		57	-36		41	-25	-20	-5
September		40	-4		28	2	9	-7
Annual		409	-38		270	94	101	-7

Note: All units in acre-feet

Table 59b. Summary of the Hydrologic Analysis for Pools 8 and 9 of the Wolf Lake System, October 1992-September 1993

Month	*Inflow from NPDES sites*	*Precipitation*	*Ground-water inflow*	*Outflow at Toll Road Culvert*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	1,103	20	7	1,015	58	31	56	-25
November	1,156	123	37	982	25	63	309	-246
December	1,194	86	37	836	11	10	470	-459
January	1,339	107	-31	1,144	11	-10	260	-271
February	1,018	18	7	778	18	-31	247	-278
March	1,012	130	12	947	43	35	165	-130
April	1,377	87	5	786	80	52	602	-550
May	1,201	47	10	729	126	-94	402	-495
June	1,903	402		1,729	156	233	420	-187
July	1,261	74	-5	1,038	176	-226	116	-342
August	1,429	200	12	823	144	135	673	-538
September	1,437	142	-1	923	97	-49	558	-607
Annual	15,429	1,434	89	11,729	945	149	4,278	-4,128

Note: All units in acre-feet

Table 59c. Summary of the Hydrologic Analysis for Pools 6 and 7 of the Wolf Lake System, October 1992-September 1993

Month	*Inflow at Toll Road*	*Precipitation*	*Ground-water inflow*	*Outflow at Stateline Road*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	1,015	7	-21	910	20	10	70	-60
November	982	43	-21	881	9	21	114	-94
December	836	30	-13	990	4	6	-140	146
January	1,144	37	-8	1,101	4	-6	68	-74
February	778	6	-12	866	6	-7	-101	93
March	947	45	-9	898	15	5	70	-65
April	786	30	-5	809	28	-2	-26	24
May	729	16	-11	873	44	-16	-183	167
June	1,729	141	-6	1,570	55	69	239	-170
July	1,038	26	-5	1,053	62	-77	-57	-20
August	823	70	-24	739	50	16	79	-64
September	923	50	9	824	34	16	123	-107
Annual	11,729	501	-127	11,514	330	34	258	-224

Note: All units in acre-feet

Table 59d. Summary of the Hydrologic Analysis for Pools 4 and 5 of the Wolf Lake System, October 1992-September 1993

Month	*Inflow at State Line*	*Precipitation*	*Ground-water inflow*	*Outflow at Indian Creek*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	910	10	19	867	29		43	-43
November	881	60	20	839	12	15	110	-95
December	990	42	18	830	5	17	214	-197
January	1,101	52	10	1,051	5	15	106	-90
February	866	9	23	766	9	-31	123	-154
March	898	64	18	805	21	32	153	-120
April	809	43	25	780	39	-7	58	-65
May	873	23	31	867	62	-72	-2	-70
June	1,570	197	18	1,405	77	165	304	-138
July	1,053	36	32	1,067	86	-174	-33	-141
August	739	98	22	690	71	34	99	-65
September	824	70	17	726	48	66	137	-71
Annual	11,514	703	252	10,695	463	63	1,311	-1,248

Note: All units in acre-feet

Table 59e. Summary of the Hydrologic Analysis for Pools 2 and 3 of the Wolf Lake System, October 1992-September 1993

Month	*Inflow at Railroad*	*Precipitation*	*Ground-water inflow*	*Outflow at Indian Creek*	*Evaporation*	*Storage change*	*Net inflow*	*Unaccounted inflow (+); outflow (-)*
October	867	10	32	1,230	31	9	-351	360
November	839	65	38	1,190	13	28	-261	288
December	830	45	56	1,082	6	18	-157	175
January	1,051	56	59	1,414	6	22	-253	275
February	766	9	47	994	10	-37	-181	144
March	805	69	60	1,021	23	42	-109	152
April	813	46	53	1,016	42	18	-147	165
May	867	25	53	953	67	-120	-75	-46
June	1,405	213	51	1,315	83	222	272	-51
July	1,067	39	45	1,112	93	-220	-54	-166
August	690	106	81	729	76	103	72	31
September	726	75	49	796	51	26	3	23
Annual	10,728	759	623	12,851	500	111	-1,241	1,352

Note: All units in acre-feet

opportunity for leakage through the ballast stone of the railbed itself. All of the unaccounted flows for this pool area indicate additional outflow from the pools. Since several potential sources of undocumented inflows have been noted it should be assumed that leakage through the railroad causeway is probably underestimated given the unaccounted outflows.

For Pools 2 and 3 (table 59e) the railroad culvert is the only inflow point and Indian Creek is the only outflow point. Inflow from the Powderhorn Lake area passes through a 12-inch-diameter culvert under 136th Street, then through a small wetland strip before entering the southeast corner of Pool 3. During the storm event in early June 1993, the roadway at 136th Street flooded. Under the flooded conditions, flow moved in both directions at different times. The probable leakage of the railroad causeway was discussed previously and would act as an additional inflow to these two pools. The western side of the pools is composed of relatively undisturbed original soil materials and is not a likely source for major inflow or outflow seepage. The relatively high unaccounted inflow values from October 1992 to April 1993 as compared to the last five months of the monitoring period have not been explained.

Overall, this analysis indicates that:

- The NPDES permitted discharges are essential to maintaining flows through the lake system.
- In general, the continuous daily discharges from the Lever Brothers and Amaizo plants maintain a flow of 13 to 17 cfs through the lake.
- The questionable accuracy of the Amaizo plant's excess Lake Michigan water discharge is significant in achieving a hydrologic balance on paper but is not a water quality concern as long as the water is unadulterated Lake Michigan water.
- Leakage of the causeways that compartmentalize the lake are likely a factor in the sometimes poorly balanced hydrologic analysis.

Sediment and Nutrient Budgets

The results of the hydrologic budget of the lake were combined with an analysis of the sediment and nutrient concentrations in the inflowing and outflowing water to estimate sediment and nutrient budgets for the lake.

For each of the inflow and outflow sources for the lake a monthly data table was prepared to show water flow volume and the representative monthly concentrations of the major nutrients and suspended sediment from samples collected during the monitoring period. When multiple samples were collected during a monthly period, samples were averaged. When no sample data were collected during a monthly period, an annual average value was used. Site 12 (Amaizo discharge 6) was never observed to run during the site visits and could not be sampled. Water quality data for the city of Hammond's water intake were substituted to represent an unadulterated Lake Michigan source for the water.

Table 60 presents a summary of the measurable-source sediment and nutrient loading into and out of the lake. Site 1 is the outflow from the lake at Indian Creek, and all other sites are inflows to the lake. Evaporation, pool storage, and the "unaccounted" outflow make up the 33 percent of the lake outflow not passed by Indian Creek and were not included in the sediment nutrient analysis.

All of the loading values noted in table 60 are very low for a lake of this size. Annual loading of suspended sediment is unmeasurable in terms of sediment deposition on the lakebed.

Table 60. Annual Sediment and Nutrient Loading to Wolf Lake

Parameter	*Indian Creek outflow*	*Lever NPDES discharge*	*Roby Station NPDES discharge*	*Forsythe Park Station NPDES discharge*	*Sheffield Avenue Station NPDES discharge*	*American Maize small volume NPDES discharges*	*American Maize Lake Michigan excess NPDES discharges*	*Direct precipitation*	*Totals*
Annual discharge, (acre-feet)	12,851	6,063	241	2,705	224	242	5,954	3.806	19.235
Ammonia-ammonium-N, (pounds)	5,530	499	671	3,344	635	273	1,618	6,183	13,224
Kjeldahl nitrogen, (pounds)	18,399	6,986	792	7,481	1,218	188	0		16.665
Nitrate-nitrite-N, (pounds)	5,061	4,635	188	7,274	616	145	3.776	9.748	26,382
Total phosphorous, (pounds)	503	287	74	1,022	92	30	971	1,737	4.212
Total solids, (tons)	91.6	71.9	20.3	86.0	28.7	2.2	0.0		209.1
Volatile solids, (tons)	57.9	15.3	7.1	33.9	6.2	0.6	0.0		63.1
Sediment and nutrient loads as a percent of total input									
Monthly discharge	66.8	31.5	1.3	14.1	1.2	1.3	31.0	19.8	
Ammonia-ammonium-N	41.8	3.8	5.1	25.3	4.8	2.1	12.2	46.8	
Kjeldahl nitrogen	110.4	41.9	4.8	44.9	7.3	1.1			
Nitrate-nitrite-N	19.2	17.6	0.7	27.6	2.3	0.5	14.3	37.0	
Total phosphorous	11.9	6.8	1.8	24.3	2.2	0.7	23.1	41.2	
Total solids	43.8	34.4	9.7	41.1	13.7	1.0			
Volatile solids	91.7	24.2	11.3	53.7	9.8	1.0			

For assessing the internal regeneration of nutrients from lake bottom sediments, reliance was placed on values reported in the literature. USEPA's *Clean Lakes Program Guidance Manual* (1980) suggests values of 0.5 to 5 g/m^2/year under aerobic conditions and 10 to 20 g/m^2/year under anaerobic conditions. Nurnberg (1984) compiled and reported phosphorus release rates in anoxic and oxic core tubes for lake sediments of several lakes. The release rates under anoxic conditions are reported to vary from 1.2 to 34.3 mg/m^2/day and under oxic conditions to vary from -16.0 to 15.0 mg/m^2/day for the same sediments. The negative release rates are indicative of adsorption of phosphorus to sediments under aerobic conditions. Generally, phosphorus release rates were found to be 2 to 10 times higher under anoxic conditions compared to under aerobic conditions for the same core sediments.

Analyses of Wolf Lake bottom sediments except those of Wolf Lake Channel indicate that phosphorus concentrations were below the levels found in other lake sediments (table 52). Assuming a phosphorus release rate of 2 mg/m^2/day for the aerobic conditions that prevailed in the lake, phosphorus loading to the lake due to internal regeneration is 1,500 pounds/year. The release rate assumed for Wolf lake is in the mid-range of values reported by Nurnberg and the low end of the range suggested in USEPA's Clean Lakes manual.

The contribution of phosphorus from internal regeneration during summer months to the total lake loading was computed as 1,500 pounds which is significant (26.3 percent) taking into account all the other sources of phosphorus to the lake. The total annual phosphorus loading to the lake was found to be 0.69 g/m^2. Vollenweider (1968) suggested that for lakes with mean depths of 5 meters (16.4 feet) or less, a permissible level of phosphorus loading is 0.07 g/m^2/year. For the same average depth, loading rate greater than 0.13 g/m^2/year is considered excessive from the point of view of eutrophication. The actual level of 0.69 g?m^2/year for Wolf Lake is about fivefold higher than the critical level. It should be pointed out that the phosphorus input to the lake from natural causes (precipitation and internal regeneration) account for 57 percent of the total.

A more significant factor in analyzing the loadings to the lake may be the localized impact of the discharges to the Amaizo/Wolf Lake Channel area. In an area that includes only two percent of the lake surface area and less than two percent of the volume, 99 percent of the inflow to the lake is discharged. This concentration of inflows to the lake increases the sedimentation rate in the channel area to a still small 0.01 foot per year, but significantly increases the impact of nutrient loading. This impact may be slightly reduced by the high flow rates and resulting low retention time in the channel.

BIOLOGICAL RESOURCES AND ECOLOGICAL RELATIONSHIPS

Lake Fauna

Detailed and systematic records of the fisheries management efforts are available from the Illinois Department of Natural Resources. These records provide details of periodic fish population surveys, installation offish attractors, macrophyte surveys, herbicide applications, fish kills, fish stocking, etc. The annual reports summarize major activities such as fish population surveys, and stocking, and make recommendations for fisheries management for the following year.

In one of the fish surveys conducted on June 18-21, 1974, by the IDOC, 829 fish representing 21 species were collected. Game species included bluegill, yellow perch, largemouth bass, crappie, northern pike, and channel catfish. The types and percent distribution of fish collected during this survey were: bluegill, 34.0; alewife, 22.6; yellow perch, 12.6; golden shiner, 8.6; warmouth, 4.2; largemouth bass, 4.1; pumpkinseed sunfish, 3.9; gizzard shad, 3.0; carp, 1.8; black bullhead, 0.9; longear sunfish, 0.7; common shiner, 0.7; northern pike, 0.6; yellow bullhead, 0.5; grass pickerel, 0.5; lake chubsucker, 0.5; green sunfish, 0.4; black crappie, 0.2; bowfin, 0.1; bluntnose minnow, 0.1; and channel catfish, 0.1.

The lake system is known to have desirable underwater structures conducive to good fisheries. In a 1975 article, Don Natonski, an avid fisherman, observes that "[Wolf Lake] has many weedy bars with some sheltered weedy bays which provide good spawning ground for northern pike. Most of the bottom is covered by a soft, black muck which rapidly changes to hard sand and rock bars with a lot of gravel, especially at the north end of the Illinois side of Wolf Lake . . . . There are a few exceptionally good bars having weed growth called tobacco and broad leaf cabbage associated with other good changing types of weed growth running down to the deepest water. These bars provide excellent northern pike and bass fishing all year long."

Historical records indicate that there were two fish kills in the past 20 years. The first was in April 1975, with an estimated 1,958 fish killed for a total value of about $680.00. Fish species observed in the kill were largemouth bass, bluegill, pumpkinseed, black crappie, warmouth, brown bullhead, black bullhead, alewife, gizzard shad, and carp. The cause of the fish kill was undetermined.

The second fish kill was reported in April 1982 and was attributed to industrial discharge from the Wolf Lake terminals, adjacent to Wolf Lake in Indiana. The IDOC/Division of Fisheries Wolf Lake Supplemental Survey, dated April 17, 1982, states that "an inspection of the area revealed numerous dead carp along the shoreline of section G. These fish appeared to have been dead for a considerable period of time; all fish were severely decomposed. An inspection of the east shoreline of section F revealed only two dead gizzard shad near the wooden walk bridge. No other relatively fresh dead or moribund fish were observed."

A newspaper article (Anon., appendix H) reports on the significant fishing success in Wolf Lake. According to the article, the lake was known to provide for better fishing in terms of numbers of fish caught than another area lake long regarded as a premier bass fishing lake. Fishing pressure was heavy, more than 600 person-hours per acre. More than 98 percent of the anglers came from within a radius of 25 miles. Fishermen managed to catch an average of 0.69 fish per hour; a catch rate of 0.5 fish per hour is regarded by fishery biologists as indicative of decent fishing when that catch rate is reflective of all fishermen at a lake over an entire summer.

The 1982 annual report by the IDOC district fishery biologist (file copy) indicates that heavy algal blooms reduced and limited macrophyte plant growth, and that unseasonable weather encountered during the fall survey reduced sampling efficiency, resulting in a poor sample. However, the report noted that spawning success was relatively good for largemouth bass as evidenced by a substantial number of fingerlings collected.

The 1983 IDOC annual report (file copy) indicates an improved sampling efficiency and notes that the most significant change in the fishery over the previous four years was the deterioration of bluegill, crappie, and northern pike populations due primarily to habitat degradation. It also notes that the largemouth bass fishery benefitted as evidenced by an improvement in spawning success and the recruitment of quality size fish.

Fish surveys carried out during 1989 to 1992 lead to the general conclusion that largemouth bass continue to be the dominant sports fish population followed by bluegill, yellow perch, other centrarchids, and channel catfish. Gizzard shad remained the dominant forage species.

Austen *et al*. (1993) listed nongame fish found in Wolf Lake were alewife, bluntnose minnow, emerald shiner, gizzard shad, golden shiner, goldfish, grass pickerel, Johnny darter, lake chubsucker, orangespotted sunfish, and pumpkinseed.

The Illinois portion of Wolf Lake has been stocked every year since 1975. Appendix I summarizes the fish stocking record for the period 1963 to 1992, giving the date of stocking; number, size, and type offish; and the location of stocking. Walleye, northern pike, and channel catfish were the species stocked in large numbers.

Use of Christmas trees as fish attractors has been practiced in the Illinois portion of the lake. The 1985 JDOC annual report indicates that nine Christmas tree fish attractors were installed in Pools 2 and 3 in an effort to enhance existing natural cover. Each attractor consisted of six to ten trees bundled together, weighted, and installed at depths between 10 and 15 feet beyond the range of anglers.

Records of the fishery biologists at the Indiana Department of Natural Resources indicate that fisheries surveys were carried out in Wolf Lake in 1969, 1974, 1977, and 1987.

During the August 4-8, 1969, survey, a total of 1,113 fish (25 species) were examined. Relative abundance (in percent) of the major species were: bluegill, 26.3; alewife, 19.9; yellow perch, 14.5; golden shiner, 11.7; largemouth bass, 6.5; pumpkinseed, 5.8; warmouth, 3.8; black crappie, 3.5; and carp, 2.5. Additional fish of importance included hybrid sunfish, bullheads, northern pike, walleye, sauger, and channel catfish. The survey summary concluded that submersed aquatic weeds were present in some locally dense beds. The waters entering the lake from the Wolf Lake Channel exhibited color and offensive odor. Although many people complained that fish from Wolf Lake had disagreeable taste, fish sampled at the time of the survey were found to be edible. However, this did not eliminate the possibility that some fish may have had a bad flavor.

During the June 18-21, 1974, fish survey, a total of 829 fish (21 species) were examined. Relative abundance of the major species (in percent) were: bluegill, 34.0; alewife, 22.6; yellow perch, 12.6; golden shiner, 8.6; warmouth, 4.2; largemouth bass, 4.1; pumpkinseed, 3.9; gizzard shad, 3.0; and carp, 1.8. Additional fish of importance included bullhead (both black and yellow), northern pike, black crappie, and channel catfish.

Similar information is available for the 1977 and 1987 fish surveys. In 1987, the Wolf Lake fish population was dominated by nongame fish. Alewife, gizzard shad, carp, and golden shiner made up 66 and 58 percent of the fish collected by number and weight, respectively. In 1977, these four species accounted for 71 and 74 percent of the fish collected by number and weight. Despite the abundance of nongame fish, Wolf Lake continues to support fishing as a recreational resource. Fisheries records indicate that 10,000 northern pike fingerlings were stocked during May 1976 and 7,180 channel catfish varying in lengths from 6 to 10 inches were stocked during September 1977.

Fish Flesh Analyses

The primary concern in fish flesh analyses regards the possibility of the bioaccumulation of toxic substances like mercury, organochlorine, and other organochemicals in fish, which may prove detrimental to higher forms of life in the food chain, including humans, the ultimate consumers. In taking a preventive approach, the U.S. Food and Drug Administration (FDA) has adopted cancer risk assessment guidelines as well as guidelines for other health effects. To protect the public from such long-term health effects, states have used the FDA guidelines to establish threshold concentrations for organics and metals in fish tissues above which an advisory will be issued that the fish not be consumed. The federal action levels are:

Contaminants	*Federal Action Levels (parts per million)*
Heptachlor epoxide	0.3
PCBs	2.0
Chlordane	0.3
Total DDT	5.0
Dieldrin	0.3
Mercury	1.0

Table 61 (file copies, Illinois Department of Conservation) provides details of past fish flesh analyses carried out on Wolf Lake fish including fish species, weight, type of sample, and individual weight. Fish flesh samples were analyzed for pesticides, organochlorines, and mercury. Species offish examined were black crappies, bluegills, carp, largemouth bass, and northern pike. The highest concentrations of total DDT, PCBs, and mercury were 0.80, 0.84, and 0.30 parts per million, respectively. These were all well below the federal action levels. Other parameters for which analyses were reported showed values at or below their detection limits. The levels of mercury, pesticides, and other organochemicals found in the fish flesh samples were not cause for concern.

Data for fish flesh analyses of fish samples (whole carp and carp fillets without skin) collected on June 16, 1982, and reported by Bureau of Laboratories, Indiana State Board of Health dated August 8, 1983, are included in appendix G. Results are reported for pesticides and other organic compounds. DDT was not detected and PCB concentrations in whole samples were within limits.

Also, data for fish flesh analyses of whole fish samples (carp, largemouth bass, and white bass) collected from Wolf Lake Channel, east basin, and west basin on July 16, 1986 are included in appendix G. Analyses for metals, pesticides, extractable organic compounds (acid, base, and neutral), PCBs; and other organic compounds are reported. Again, PCBs, DDT, dieldrin, and mercury levels were lower than the regulatory limits.

Terrestrial Vegetation and Animal Life

A wealth of information is available on local plant, animal, and avian life, prepared by TAMS Consultants, Inc. (1991) as part of the site selection report for the proposed Illinois-Indiana regional airport. The inventory of natural and cultural resources prepared by TAMS is based on available existing data and field data collected over a one-year period at five of the proposed sites. The information in this segment of the report was gleaned from the TAMS report (1991). Information pertaining to avian life is the only item specific to Wolf Lake; whereas plant and animal life information pertains to Wolf Lake and Eggers Woods.

Plant Communities

The vegetation existing at the sites of interest was categorized into ten community types: forest, prairie, savanna, dune complex, wetland, open water, primary, cave, and cultural and urban types of vegetation or land use. Field inventories of vegetation emphasized the forest, prairie, savanna, dune complex, and wetland community types, plus selected cultural and urban community classes. The community classes associated with Eggers Woods and Wolf Lake are

Table 61. Results of Fish Contaminant Analyses from Wolf Lake

Date	*Species*	*Weight, pounds*	*Type of sample*	*Dieldrin*	*Heptachlor Epoxide*	*Total DDT*	*PCBs*	*Chlordane*	*Mercury*
2/10/78	BKS	0.11	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.03
	BKS	0.16	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	BKS	0.22	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	BKS	0.11	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	BGS	0.26	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.06
	BGS	0.30	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.03
	BGS	0.16	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.02
	BGS	0.16	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	BGS	0.11	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.03
	C	6.50	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.06
	C	9.75	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.06
	C	3.53	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	C	3.10	Fillet	0.01k	0.01k	0.01k	"0.01k	-	0.05
	C	2.25	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.04
	LMB	4.90	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.30
	LMB	0.45	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.06
	LMB	1.40	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.10
	LMB	2.35	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
	LMB	3.52	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.10
	NP	8.75	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.30
	NP	5.75	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.10
	NP	2.70	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.15
	NP	6.75	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.10
	NP	1.60	Fillet	0.01k	0.01k	0.01k	0.01k	-	0.05
5/4/82	C	4.78	Whole	0.02	0.01k	0.09	0.26	0.01k	
	C	2.36	Whole	0.02	0.01k	0.08	0.18	0.03	
	C	1.18	Whole	0.01k	0.01k	0.06	0.10	0.01k	
	LMB	1.82	Whole	0.01	0.01k	0.07	0.30	0.01k	
	LMB	1.20	Whole	0.01	0.01k	0.12	0.41		
	LMB	0.44	Whole	0.01k	0.01k	0.07	0.24		
	CHC	2.72	Whole	0.02	0.01k	0.18	0.56	0.02	
	CHC	1.62	Whole	0.02	0.01k	0.27	0.83	0.03	
	CHC	0.49	Whole	0.03	0.01k	0.80	0.84	0.02	
	NP	7.75	Whole	0.03	0.01k	0.26	0.77	0.03	
9/7/88	C	3.54	Whole	0.01k	0.01k	0.68	0.51	0.08	
	C	3.47	Fillet	0.01k	0.01k	0.28	0.28	0.02	
10/8/92	CHC	1.14	Whole	0.01	0.01k	0.09	0.29		
	C	5.13	Fillet	0.01	0.01k	0.11	0.11		
	LMB	1.75	Fillet	0.01	0.01k	0.02	0.10		

Notes: Concentrations are in ppm; k - value below detection limit;
BKS - black crappies; BGS - blue gills; C - carp;
LMB - largemouth bass; NP - northern pike.

Source: File copies, Illinois Department of Conservation sand forest, marsh, shrub swamp, and prairie. Characteristic species for these vegetation classes are listed below in alphabetical order by genus and then by species within genera.

Sand Forest. This forest community has 80 percent or greater canopy cover and occurs on sandy soil. Black oak *(Quercus velutina)* is typically the dominant tree. Associates include Pennsylvania sedge *(Carex pennsylvanica)*, flowering spurge *(Euphorbia corollata)*, witch hazel *(Hamamelis virginiana)*, woodland sunflower *(Helianthus divaricates)*, round-headed bush clover *(Lespedeza capitata)*, panic grass *(Panicum villosissimum pseudopubescens)*, choke cherry *(Prunus virginiana)*, bracken fern *(Pteridium aquilinum latiusculum)*, white oak *(Quercus alba)*, sassafras *(Sassafras albidum)*, starry false Solomon's seal *(Smilacina stellata)*, old-field goldenrod *(Solidago nemoralis)*, showy goldenrod *(Solidago speciosa)*, spiderwort *(Tradescantia ohioensis)*, and early low blueberry *(Vaccinium angustifolium laevifolium)*.

Prairie. Prairies occur on black soil (including clayey morainal soils), within a wide variety of soil moisture conditions. This community is distinguished from the cultural vegetation classes discussed below by the presence of native grassland species, including lead plant *(Amorpha canescens)*, big bluestem grass *(Andropogon gerardi)*, little bluestem grass *(Andropogon scoparius)*, shooting star *(Dodecatheon meadia)*, rattlesnake master *(Eryngium yuccifolium)*, flowering spurge *(Euphorbia corollata)*, prairie alum root *(Heuchera richardsonii)*, yellow star grass *(Hypoxis hirsuta)*, round-headed bush clover *(Lespedeza capitata)*, hoary puccoon *(Litospermum canescens)*, switch grass *(Panicum virgatum)*, wild quinine *(Parthenium integrifolium)*, purple prairie clover *(Petaolstemum purpureum)*, prairie phlox *(Phlox pilosa)*, yellow coneflower *(Ratibida pinnata)*, compass plant *(Silphium laciniatum)*, prairie dock *(Silphium terebinthinaceum)*, Indian grass *(Sorghastrum nutans)*, prairie dropseed *(Sporobolus heterolepis)*, porcupine grass *(Stipa sported)*, spiderwort *(Tradescantia ohioensis)*, and Culver's root *(Veronicastrum virginicum)*, silverweed *(Potentilla anserina)*, among many others.

Marsh. This emergent wetland community is usually dominated by common cattail *(Typha latifolia)* or common reed *(Phragmites communis berlandieri)*. Many marshes in the Gary, IN, and Lake Calumet, IL, search areas are becoming infested with purple loosestrife *(Lythrum salicaria)*, an aggressive non-native species. Associate marsh species include common water plantain *(Alisma subcordatum)*, swamp milkweed *(Asclepias incarnata)*, blue joint grass *(Calamagrostis canadensis)*, marsh shield fern *(Dryopteris thelypteris pubescens)*, common boneset *(Eupatorium perfoliatum)*, blue flag *(Iris virginica shrevei)*, Chairmaker's rush *(Scirpus americanus)*, great bulrush *(Scirpus validus creber)*, water parsnip *(Sium suave)*, and prairie cord grass *(Spartina pectinata)*.

Shrub swamp. This permanent or semipermanent wetland contains at least SO percent shrub cover. Typical shrub species include buttonbush *(Cephalanthus occidentalis)*, red-osier dogwood *(Cornus stolonifera)*, silky dogwood *(Cornus obliqua)*, and sandbar willow *(Salix interior)*. Herbaceous associates include many marsh and wet prairie species, some of which are listed above. This community occurs sporadically throughout the study region.

Mammals

Two distinctly different communities were originally present within the general study area; examples of each remain intact. The black soil prairies and marshes are inhabited by masked shrews *(Sorex cinereus)*, deer mice *(Peromyscus maniculatus)*, and meadow voles *(Microtus pennsylvanicus)*. These species have survived even in severely disturbed sites, including slag-filled areas, but in such locations they coexist with the non-native house mouse *(Mus musculus)* and Norway rat *(Rattus norvegicus)*. Sand savannas support species such as the gray squirrel *(Sciurus carolinensis)* and white-footed mouse *(Peromyscus leucopus)*.

The rare Franklin's ground squirrel *(Spent ophilus franklinii)* has been trapped or observed at three locations within the Lake Calumet area. It is most often seen in dry sand prairie, but also occurs in sand savanna and black soil prairie. One of the Lake Calumet sightings was in a disturbed area where slag fill is more prevalent than soft soil. Lake Calumet is in close proximity to the study lake. Details of trapping results from Eggers Woods can be found in the report by TAMS Consultants, Inc. (1991, p. 72).

During their field work, some of the authors have observed the presence of muskrats, beavers, raccoons, opossums, and evidence of white-tailed deer.

Birds

According to the TAMS report (1991), mute swans nested along the shores of Wolf Lake, and the following species were seen during spring migration: wood ducks, green-winged teal, American coots, American wigeons, Canada geese, canvasbacks, gadwalls, mallards, pied-billed grebes, redheads, red-breasted mergansers and ring-necked ducks. Great blue herons, green-backed herons, and least bitterns hunted in the marshes, and semipalmated plovers and least sandpipers foraged along the marshes' margins. A flock of Caspian terns was seen in August 1991 at the lake. Yellow-billed and black-billed cuckoos were seen in the upland forest used by many migrants, including American redstarts, bay-breasted warblers, black-and-white warblers, black-throated blue warblers, black-throated green warblers, Canada warblers, chestnut-sided warblers, golden-crowned kinglets, magnolia warblers, Nashville warblers, northern parulas, palm warblers, ruby-crowned kinglets, Tennessee warblers, white-crowned sparrows, white-throated sparrows and yellow-rumped warblers. Table 62 lists the types of birds sighted in Wolf Lake, along with their breeding information and status in Indiana.

Reptiles and Amphibians

Thirteen species of amphibians and reptiles occur in the vicinity of the Lake Calumet site. Some sensitive species are believed to have disappeared from the immediate vicinity within historic times, possibly because of habitat destruction and fragmentation. The smooth green snake *(Opheodrys vernalis)* was once the second most abundant snake in the Lake Calumet prairies, but now survives in only one location.

Black soil prairie and marsh inhabitants include American toads *(Bufo americamus)*, western chorus frogs *(Pseudacris triseriata)*, northern leopard frogs *(Rana pipiens)*, and plains garter snakes *(Thamnophis radix)*. In the sand savannas near the eastern and southern edges of Lake George, the plains garter snake becomes less common and the Chicago garter snake *(Thamnophis sirtalis)* and midland brown snake *(Storeria dekayi)* are the dominant species (Raman *et al.*, 1995). Both types of garter snake and the brown snake are quite adaptable, and they are often abundant in urban vacant lots. They are usually simple to collect in such areas because of their habit of hiding under boards, roofing shingles, sheet metal, and other debris from human activities.

Table 62. Birds Sighted in Wolf Lake Area

		*Breeding Status**			*Indiana*
Common name	*Scientific name*	*Conf.*	*Prob.*	*Pos.*	*status+*
Pied-billed Grebe	*Podilymbus podiceps*				
Least Bittern	*Ixobrychus exilis*			X	SSC
Great Blue Heron	*Ardea herodias*				WL
Green-backed Heron	*Butorides striatus*			*X*	
Mute Swan	*Cygnus olor*	*X*			
Canada Goose	*Branta canadensis*				
Wood Duck	*Aixsponsa*			X	
Green-winged Teal	*Anas crecca*				
Mallard	*Anas platyrhynchos*				
Gadwall	*Anas strepera*				
American Wigeon	*Anas americana*				
Canvasback	*Aythya valisineria*				
Redhead	*Aythya americana*				
Ring-necked Duck	*Aythya collaris*				
Red-breasted Merganser	*Mergus serrator*				
Virginia Rail	*Rallus limicola*			*X*	SSC
Sora	*Porzana Carolina*			*X*	
American Coot	*Fulica americana*				
Semipalmated Plover	*Charadrius semipalmatus*				
Killdeer	*Charadrius vociferus*				
Spotted Sandpiper	*Actitis macularia*				
Least Sandpiper	*Calidris minutilla*				
Caspian Tern	*Sterna caspia*				
Rock Dove	*Columba livia*				
Mourning Dove	*Zenaida macroura*		*X*		
Black-billed Cuckoo	*Coccyzus erythropthalmus*			*X*	
Yellow-billed Cuckoo	*Coccyzus americanus*			*X*	
Belted Kingfisher	*Ceryle alcyon*			*X*	
Red-bellied Woodpecker	*Melanerpes carolinus*				
Downy Woodpecker	*Picoides pubescens*				
Northern Flicker	*Colaptes auratus*			*X*	
Great Crested Flycatcher	*Myiarchus crinitus*			*X*	
Tree Swallow	*Tachycineta bicolor*	*X*			
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	*X*			
Blue Jay	*Cyanocitta cristata*				
Black-capped Chickadee	*Parus atricapillus*				
House Wren	*Troglodytes aedon*			*X*	
Marsh Wren	*Cistothorus*	*palustris*		*X*	SSC
Golden-crowned Kinglet	*Regulus satrapa*				
Ruby-crowned Kinglet	*Regulus calendula*				
Blue-gray Gnatcatcher	*Polioptila caerulea*				
Hermit Thrush	*Catharus guttatus*				
American Robin	*Turdus migratorius*		X		
Gray Catbird	*Dumetella carolinensis*		*X*		
Red-eyed Vireo	*Vireo olivaceus*			*X*	
Tennessee Warbler	*Vermivora peregrina*				
Nashville Warbler	*Vermivora ruficapilla*				
Northern Parula	*Parula americana*				

Table 62. Concluded

Common name	*Scientific name*	*Breeding Status** *Conf.*	*Prob.*	*Pos.*	*Indiana status+*
Yellow Waibler	*Dendroica petechia*				
Chestnut-sided Waibler	*Dendroica pensylvanica*				
Magnolia Waibler	*Dendroica magnolia*				
Black-throated Blue Warbler	*Dendroica caerulescens*				
Yellow-rumped Warbler	*Dendroica coronata*				
Black-throated Green Warbler	*Dendroica virens*				
Palm Warbler	*Dendroica palmarum*				
Bay-breasted Warbler	*Dendroica castanea*				
Black-and-white Warbler	*Mniotilta* ***varia***				**SSC**
American Redstart	*Setophaga ruticilla*				
Common Yellowthroat	*Geothlypis trichas*			X	
Wilson's Warbler	*Wilsonia pusilla*				
Canada Warbler	*Wilsonia canadensis*				SSC
Northern Cardinal	*Cardinalis cardinalis*			*X*	
Rufous-sided **Towhee**	*Pipilo erythropthalmus*			X	
Field Sparrow	*Spizella pusila*				
Fox Sparrow	*Passerella iliaca*				
Song Sparrow	*Melospiza melodia*				
White-throated Sparrow	*Zonotrichia albicollis*				
White-crowned Sparrow	*Zonotrichia leucophrys*				
Dark-eyed Junco	*Junco hyemalis*				
Red-winged Blackbird	*Agelaius pheoniceus*		X		
Eastern Meadowlark	*Sturnella magna*				
Common Grackle	*Quiscalus quiscula*		X		
Northern Oriole	*Icterus galbula*		X		
American Goldfinch	*Carduelis tristis*				
House Sparrow	*Passer domesticus*		X		

Note:
*** Breeding Status: Conf. = Confirmed, Prob. = Probable, Pos. = Possible**
+ Indiana Status: SSC = State Special Concern, WL = Watchlist

PART 2: FEASIBILITY STUDY OF WOLF LAKE

INTRODUCTION

On the basis of the information obtained and the conclusions derived from the diagnostic portion of this lake restoration and protection study (see Part 1), a feasibility study was undertaken to investigate potential alternatives for restoring the environmental quality and enhancing the recreational and aesthetic value of Wolf Lake. The feasibility portion of this Phase I study extends the diagnostic study. Its purposes are to identify and evaluate possible alternative techniques for restoring and/or protecting the lake water quality to maximize public benefits; to provide sufficient technical, environmental, socioeconomic, and financial information to enable decision-makers to select the most cost-effective techniques; and to develop a technical program for using the techniques selected.

Alternative methods to address various problems at Wolf Lake are identified and evaluated. The proposed restoration plan is presented for consideration as a Phase II project under the Clean Lakes Program. The anticipated benefits, cost estimates, and time schedule of the proposed lake restoration program are also presented.

EXISTING LAKE QUALITY PROBLEMS

On the basis of the detailed and systematic study of the lake ecology, which covered a period of more than 12 months, an assessment of the physical, chemical, and biological characteristics of the lake water and sediment was made. Additionally, factors affecting the lake's aesthetic and ecological qualities were assessed, and the causes of its use degradation were determined. The lake's hydraulic, sediment, and nutrient budgets were estimated using the data collected for precipitation, lake-level fluctuations, and the water quality characteristics of ephemeral runoffs into the lake after storm events.

The dissolved oxygen (DO) conditions in the lake were very good throughout the investigation, except in Wolf Lake Channel, and at no time did anoxic conditions prevail. Station RHA-9 exhibited a high degree of DO depletion. However, DO at or near the surface met the 5.0 mg/L standard at all stations. This is primarily because of the profuse aquatic vegetation present in the lake. Because of macrophyte competition for nutrients, phytoplankton densities were low except for some samples collected in April and September at only a few stations. The obnoxious blue-green algae were not dominant at any time. The benthic macroinvertebrate survey revealed that the benthos community was dominated by relatively pollution-intolerant members of the *Chironomidae*. The benthos in this lake is more diverse and pollution sensitive than that found in most stratified lakes. Secchi disc transparencies in Wolf Lake were less than 48 inches on the Indiana side and greater than 48 inches on the Illinois side.

The chemical quality characteristics of parameters for which standards are set either in Illinois or in Indiana were generally all within the stipulated limits especially on the Illinois side. Mean chemical oxygen demand (COD) was less than 20 mg/L. Ammonia levels met the Illinois standard at all times, but there were a few violations on the Indiana side during the cold period from October 1992 - April 1993. Similar to ammonia nitrogen, total phosphorus concentrations on the Illinois side were all below the 0.05 mg/L limit, while those in Indiana waters had few violations. Total phosphorus values found in Wolf Lake were significantly lower than the values observed for lakes in agricultural watersheds.

Based on the diagnostic results for this study, it is apparent that the major problems in the lake that need to be addressed are shallow water depths, the profusion of unbalanced aquatic macrophytes, high fecal coliform (FC) counts and poor sediment quality in Wolf Lake Channel, and poor lake aesthetics in some parts of the lake area.

Shallow Water Depths

Pools 3, 6, 7, and 9 (Wolf Lake Channel) are relatively shallow. Their maximum depths are 14.4, 6.4, 7.2, and 8.0 feet, respectively. The average water depths of these four pools are, respectively, 3.3, 3.9, 4.0, and 4.0 feet. Shallow lakes are more susceptible to some lake management problems, such as bottom sediment resuspension, rooted macrophyte growth, and limited recreational activities.

Bottom sediment resuspension is greater in shallow lakes because the wind forces can cause agitation along the sediment/water interface to a depth of 6 feet or more (Wagner, 1990). Large portions of Pools 6, 7, and 9 have water depths less than 6 feet.

Extensive macrophyte growth can also be stimulated in shallow pools because a greater proportion of the lake bottom is in water sufficiently shallow to allow sunlight to reach the plant seedings on the lake bottom.

As mentioned in the diagnostic study, the water bodies appear well mixed in Pools 6 and 7 based on DO and temperature profiles (figures 10a and 10b). This is primarily because of the large unprotected areal extent and shallowness of these water bodies. However, the DO level in Wolf Lake Channel (figure 10c) indicates significant DO depletion in the lower strata of the water column. Low DO levels are caused by the large oxygen demand of lake bottom sediments and the oxygen demands of the organic matter in the water.

Boating, fishing, and other recreational activities in Pools 6 and 7 are very limited because of the extensive and dense macrophyte growths. In Wolf Lake Channel, the water is slightly oily and odorous. It is not suitable for whole-body contact water sports and it exhibits degraded aesthetic conditions.

Excessive **Macrophyte Growth**

A lake ecosystem should be diverse and balanced. The plant community in Wolf Lake encompasses phytoplankton (algae) and macrophytes, which are competing for nutrients in the lake. An overabundance of macrophytes can lead to overpopulation and stunting of panfish due to decreased predation success by predatory fish. In addition, decomposition of a large macrophyte crop emits taste and odor in water and can even cause fish kills. Dense vegetation blocks water movement, retards heat transfer, and decreases recreational uses.

The results (table 38) of the macrophyte survey conducted during the diagnostic study indicate that approximately 85, 60, and 55 percent of the lakebed in Pools 6, 7, and 9, respectively, supported macrophyte growth. Pools 3 and 4 also had a relatively high percentage of macrophyte growths (45 and 60 percent, respectively); however, water milfoil and chara were the dominant species, and aquatic vegetation was more diverse in these two pools. Power boaters have difficulty making their way through the dense growth of Eurasian water milfoil *(Myriophyllum spicatum)* in Pools 6 and 7. Heavy macrophyte growths occurred along both banks in Wolf Lake Channel. Fishing enjoyment has been impaired by extensive growth of macrophytes in which hooks and lines become tangled.

Several of the fish management reports prepared by Mr. Bob Robertson, fishery biologist, Indiana Department of Natural Resources, made the following recommendations and observations as early as the late 1960s (Internal Reports):

1. Water quality in the channel area of the lake should be improved. Foul smelling sediment and a lower dissolved oxygen content is characteristic of the channel area. The area may be the source of the "bad tasting" fish occasionally reported in Wolf Lake. The channel also sustained a large fish kill during the winter of 1974-1975.

2. Fishing access to Wolf Lake should be increased by establishing shoreline paths, piers, and a row-boat rental.

3. The dense area of submersed vegetation should be controlled. A city-sponsored weed control program should be initiated to reduce weed beds near the shore which presently hinder shore fishing.

Eurasian water milfoil is considered to be an extreme exotic nuisance species due to its prolific rate of growth and spread. Often, the plant will completely dominate a lake's plant community and obliterate most native vegetative species. This reduction in vegetative species diversity in turn affects the diversity of the lake's other aquatic life. Eurasian water milfoil can sprout a new plant from even a very tiny plant fragment. If broken apart by watercraft or other recreational activities, the plant can be inadvertently transported or drift to remote areas of the lake where it can then develop roots and start a new colony.

High Fecal Coliform Counts

In general, FC densities in all Wolf Lake pools met Illinois and Indiana standards, except in Wolf Lake Channel and the stormwater discharges to the lake and to the channel. At RHA-9 in Wolf Lake Channel, high bacteria (TC and FC) counts were observed during warm weather periods. In fact, 42 percent (5 out of 12) of the samples exceeded 2,000 FC per 100 mL (table 32); the Indiana Stream Pollution Control Board allows only ten percent of samples to exceed that limit. Poor FC quality at RHA-9 could be traced to high bacterial counts in discharges from Lever Brothers Company (RHA 02), Roby pumping station (RHA 03), and Forsythe Park pumping station (RHA 04) of the Hammond Sanitary District (table 33).

In addition, samples collected during storm events at RHA OS (the Sheffield Avenue pumping station of the Hammond Sanitary District) violated FC geometric mean standards and density standards for Wolf Lake waters (discharge to Pool 8). Also, frequent violations of FC standards at the swimming beach in Pool 8 were recorded.

As Bell and Johnson (1990) pointed out, high FC densities in stormwater discharges may be the result of cross-connections of the sanitary sewers and the storm sewers. In 1989, tests showed that another source of pollution was industrial runoff along Sheffield Avenue.

Poor Sediment Quality in Wolf Lake Channel

As mentioned earlier, the worst sediment characteristics were observed at Wolf Lake Channel, particularly at stations 9 and 9B. As shown in table 52, high total phosphorus levels (1,309 to 1,848 mg/kg) occurred at stations 9, 9B, and 9C. Concentrations of copper (60 to 247 mg/kg) and zinc (283 to 932 mg/kg) in all four sediment samples collected from Wolf Lake

Channel were elevated. In fact, copper levels at stations 9B and 9 were greater than, respectively, 12 and nine times of the Indiana maximum background concentration of 20 mg/kg. Zinc levels at these two stations were also greater than seven and six times, respectively, of the background concentration of 130 mg/kg. At stations 9 and 9B, concentrations of cadmium, lead, and nickel were also elevated. In addition, total kjeldahl nitrogen and mercury levels in sediment collected from station 9B were elevated. The sediment characteristics of Wolf Lake Channel were found to be generally of "medium concern." Very high concentrations (1,000 to 4,000 ug/kg) of total PCBs were found at station 8A and in Wolf Lake Channel (table 53). Total PCBs at stations 9, 9A, and 9B were classified as "high concern," as they were greater than 100 times the Indiana maximum background level of 22 µg/kg. Dredging is needed to remove poor quality sediment and to control macrophytes.

Because of high concern of PCB levels in Wolf Lake Channel, the sediments are considered hazardous and consequently the dredging and disposal of these sediments warrant special considerations. Evaluation of the sediment characteristics using the TCLP indicates that heavy metals concentrations in the leachate were all well within the regulatory limits.

Lake Aesthetics

In general, the appearance of the pools of Wolf Lake vary from poor to excellent (e.g. Pool 9 and Pool 1). However, urban debris such as tires, shopping carts, and construction materials strewn in and around the lake creates aesthetic and pollution problems, particularly in the southern ends of Pools 3 and 5.

At times, fragments of aquatic plants (macrophytes) floated on the lake surface or along certain sections of shorelines. This reduced the visual appeal of the lake.

There is a wide unpaved road (section of 129th Street, south of Pool 6 and west of Sheffield Avenue). The road surface is bumpy, making it very difficult to drive through that segment, and thus limiting access to Pool 5. Trash and debris were found illegally dumped and piled in this location. These not only detract from the lake's aesthetic appeal, but may also be a source of pollution.

WATER QUALITY AND ECOSYSTEM MANAGEMENT TECHNIQUES

This section provides a review of the techniques for mitigating the existing problems in Wolf Lake. Most of the information was compiled from a few excellent published reports dealing with in-lake and watershed management techniques. The most significant of these are by Dunst *et al*. (1974), Peterson (1981), Cooke *et al*. (1986), and USEPA (1973, 1988, 1990b).

Shallow Lake Dredging

Sediment removal in freshwater lakes is usually undertaken to increase lake water volume, improve sport fishery habitats, enhance overwinter fish survival, remove nutrient-rich sediments and/or hazardous materials, reduce the abundance of rooted aquatic plants, reduce the sediment's oxygen demand on the overlying water, reduce the potential for sediment resuspension, and control algae.

Advantages of sediment-removal techniques include the ability to selectively deepen parts of a lake basin, increase the lake volume, recover organically rich sediment for soil enrichment, and improve limnetic water quality. Disadvantages include high cost, possible phosphorus release from sediment, increased phytoplankton productivity, noise, lake drawdown, temporary reduction in benthic fish food organisms, and the potential for release of toxic materials to the overlying water and environmental degradation at the dredged material disposal site (Peterson, 1981). In addition, the nutrient content of the sediments may remain high at a considerable depth, thus making it impossible to reach a low nutrient level in sediment. Although satisfactory disposal of the spoils may be very expensive, however, high quality dredge material can be used for beneficial purposes and may offset the initial high cost of dredging. In nearly all cases, permits from the U.S. Army Corps of Engineers are required (USEPA, 1990b).

Peterson's (1981) report on the restoration of Wisconsin Spring Ponds through dredging is one of the most thoroughly documented studies concerning the ecological effects of dredging small lakes. The purpose of the dredging was to deepen the ponds to improve fish production. Incidental to the deepening was the control of aquatic macrophytes. It is reported that even though there was a temporary decrease in the benthic organisms soon after dredging, four to five years after lake restoration the average density and biomass of fishable-size fish were substantially greater than during the predredging period. During the dredging process, there will be an increase in turbidity in the immediate surrounding area and a possible decrease in the ambient DO concentrations. However these problems are short-lived and many of these problems can be minimized with proper planning.

Peterson (1981) also reports on the successful restoration of Lilly Lake (southeastern Wisconsin) by dredging. The main problems in the lake were severe shoaling, abundant aquatic plant growths, and winter fish kills. In addition to dredging the whole basin, ten percent of the 97-acre lake was dredged to a depth of approximately 6.0 meters (20 feet). Dredging was completed in September 1979, and as of 1981, water quality had remained good, macrophytes had virtually been eliminated, and local sponsors were generally pleased with the outcome.

The city of Springfield, IL, successfully employed hydraulic dredging to dredge Lake Springfield to meet multiple objectives: namely, to deepen the shallow end of the lake in order to increase sediment retention capacity, control emergent aquatic vegetation, and enhance aesthetic and recreational opportunities. This project is considered the largest inland lake dredging project completed in the early 1990s (Cochran & Wilkin, Inc., personal communication, 1994).

Sediment removal can be accomplished either by hydraulic dredging or by exposing lake sediments for removal by conventional earth-moving equipment. Pierce (1970) describes various types of hydraulic dredging equipment and provides guidance on the engineering aspects of dredge selection. Peterson (1981) describes various grab, bucket, and clam-shell dredges; hydraulic cutterhead dredges; and specialized dredges to minimize secondary water quality impacts. Sediment removal using earth-moving equipment after lake-level drawdown was successfully used in Crystal Lake, Urbana, IL, during 1990-1991.

The advantages and disadvantages of mechanical dredging or excavation and hydraulic dredging have been discussed by Berrini (1992). There are several methods of mechanical dredging or excavation presently available. The lake can either be dredged at normal pool with a dragline, or the water level can be lowered enough to allow low ground pressure excavation equipment into the dry lakebed. There are several advantages to dry lakebed excavation as compared to hydraulic or dragline dredging, such as the elimination of excessive turbidity or resuspended solids, and a smaller quantity of material to remove due to consolidation and compaction. However, there are many disadvantages and problems that would be encountered. Although initial water level drawdown could be accomplished quickly with high capacity pumps, the length of time required for the sediment to dewater and consolidate sufficiently enough to support excavation equipment would be a year or more.

Another method of mechanical dredging would be accomplished with a dragline while the lake water level is at normal pool. This is accomplished by extending excavating equipment from shore, or by mounting the equipment on a barge. This method is more practical for smaller lakes or when a large quantity of rocks or debris is anticipated. Removal of accumulated lake sediment is inefficient and can leave high percentages of material behind. Disposal of the sediment is also very inefficient and labor intensive since it must be handled several times. Once the sediment is removed from the lake, it must be placed on a barge or a truck and transported to the retention site. This repeated handling is generally not cost effective, and can result in sediment losses during transfer. Equipment access for the removal and placement of dredged sediment would also have a negative impact on the lake shoreline. Therefore mechanical dredging would not be considered as a feasible restoration method.

Hydraulic dredging involves a centrifugal pump mounted on a pontoon or hull which uses suction to pull the loose sediment off the bottom and pump it through a polyethylene pipeline to a sediment retention area. Generally, a cutterhead is added to the intake of the suction line in order to loosen the accumulated or native sediment for easy transport and discharge. A slurry of sediment and water, generally between 10 percent and 30 percent solids, can be pumped for distances as much as 5,000 feet or as much as 10,000 feet with the use of a booster pump. The efficiently pumped sediment slurry must reach a suitable constructed earthern dike-walled containment area with adequate storage capacity. The sediment contaminant or retention area must be properly designed to allow sufficient retention time for the sediment particles to settle throughout the project, and allow the clear decant or effluent water to flow through the outlet structure back to the lake.

One of the advantages of hydraulic dredging is the efficiency of sediment handling. The removal, transport, and deposition are performed in one operation, which minimizes expenses and potential sediment losses during transport. Another advantage is that the lake does not have to be drained, and most areas can remain open for public use. Most hydraulic dredges are considered portable and area easily moved from one site to another. They are extremely versatile and capable of covering large areas of the lake by maneuvering with their spud anchorages system and moving the discharge pipeline when necessary.

Dredging as a restoration technique for Wolf Lake Channel, and Pools 6 and 7, if accepted, pool drawdown and excavation cannot be considered because no flow control devices exist for the pools. Mechanical dragline dredging at these pools would also be of very limited applicability due to inadequate access and is also uneconomical for large-scale dredging operations. Equipment access for the removal and placement of dredged sediment would also have a negative impact on the shorelines. Hydraulic dredging is the recommended method of sediment removal for Wolf Lake Channel and Pools 6 and 7 because of its efficiency, versatility, and capability of removing large quantities of sediment without dewatering the pools.

Hydraulic dredging will require a Section 404 permit from the U.S. Army Corps of Engineers. A 401 Water Quality Certification permit will be required by Illinois EPA for the clarified return water from the sediment retention site. Coordination and consultation with IDEM, City of Hammond, Indiana Department of Transportation, IEPA, and U.S. Fish and Wildlife Service will also be necessary. The permit application process will have to be initiated during the design phase of the dredging project.

Dredging costs are difficult to determine accurately and even more difficult to compare because they vary a great deal depending on a number of factors (Peterson, 1981): 1) types and quantity of sediment removed, 2) type of dredges used, 3) nature of the operational environment, 4) geographic location, and 5) mode of disposal of the dredged material. The USEPA (1980) indicated that costs of sediment removal vary widely from $0.76 to $12.00 per cubic yard.

Table 63 supplies details of dredging costs for those lakes in Illinois where dredging has either been completed in recent years or is being contemplated for the near future. These data were obtained from Cochran & Wilken, Inc., Springfield, IL (personal communication, 1994). It should be noted that the unit cost of dredging decreases with increased volume of dredging. It is also influenced by the location of the dredging project; namely, the cost is relatively high in urban centers.

Macrophyte Control

Macrophytes are generally grouped into classes: emergents (such as cattails), floating leaves (water lilies), and submergents (Eurasian water milfoil and pondweeds), plus the mats of filamentous algae that develop in weed beds. They reproduce by the production of flowers and seeds, by asexual propagation from fragments and shoots extending from roots, or by both mechanisms. It is obvious that overabundant rooted and floating plants are a major nuisance to lake users, interfere with recreation, and detract from the aesthetic values of lakes.

Available light is a significant factor in how profusely and where the plants will grow. Submergent plants will grow profusely only where underwater illumination (sunlight penetration) is sufficient. The growth rate of macrophytes, especially exotic species like Eurasian water milfoil and water hyacinth, can be very high. Turbid lakes and reservoirs are unlikely to have dense beds of submerged plants. Direct in-lake controls of macrophytes include sediment removal and tilling; sediment exposure and desiccation; sediment covers; herbicide treatment; harvesting by machine, hand, and other manual removal methods; and biological control. The most commonly considered techniques for controlling and managing excessive weeds are discussed below.

Sediment Removal and Sediment Tilling

Sediment removal can limit submerged weed growth through deepening, thereby limiting light, and/or by removing favorable substrate for weed growth. These techniques can also eliminate or limit plant growth through removal of roots.

Sediment removal was discussed in detail in the previous section. The amount of sediments removed, and hence the new depth and associated light penetration, is critical to successful long-term control of rooted submerged plants. USEPA (1988) provided a criterion for determining the maximum depth of colonization (MDC) by macrophytes based on Secchi disc (SD) values. For Wisconsin, the suggested relationship is:

$$\log MDC = 0.79 \log SD + 0.25$$

in which MDC and SD are expressed in meters.

Adapting this empirical relationship developed for Wisconsin to Indiana and Illinois and assuming the SD values in the range of 6 to 10 feet, the corresponding depths to which rooted vegetation could colonize are between 9.4 and 14.1 feet. This implies that in order to prevent colonization of aquatic weeds in the lake, the lake has to be dredged to a depth of more than 9 to 14 feet, depending on the likely SD readings (i.e., 6 to 10 feet). Data obtained during the Wolf Lake investigation indicate that this range of SD values is within the realm of possibility, depending on the depths of the measurement sites.

Rototilling and the use of cultivation equipment are newer procedures, which are under development and testing by the British Columbia Ministry of Environment (Newroth and Soar, 1986). A rototiller is a bargelike machine with a hydraulically operated tillage device that can be lowered to depths of 10 to 12 feet for the purpose of tearing out roots. The purpose of this

Table 63. Costs of Dredging in Illinois

Item	*Paris Twin Lake, Edgar County*	*Skokie Lagoons. Cook County*	*Lake Decatur, Macon County*	*Lake Springfield, Sangamon County*
Retention basin, dollars	290,000	1,030,000	941,400	1,153,000
Dredging, dollars	690,500	1,260,000	3,352,500	4,400,000
Engineering, dollars	134,000	200,000	463,000	360,000
Total cost, dollars	1,114,500	2,550,000	4,756,900	5,913,000
Volume, cubic yards	410,000	470,000	2,100,000	3,200,000
Unit cost, dollars/cubic yard	2.72	5.42	2.26	1.85

method is to stress rooted aquatic plants and to prevent the development of surfacing colonies that could cause rapid fragment dispersal or nuisance conditions. Rototilling or tillage using agricultural plows is best applied during the nongrowing season, when shoot material is minimal. Root masses may be buried, stressed, or dislodged. Containment using floating boom systems may be required or root masses may be washed into shoreline areas and raked manually or gathered by shore-based equipment. A detailed discussion of this method, including capital and operating costs, can be found elsewhere (Province of British Columbia, 1978).

The use of sediment removal for long-term control of macrophytes is effective when the source of sediments is controlled. Dredging below the lake's photic zone will prevent macrophyte growth. However, the cost of dredging often makes the use of this technique unfeasible. It is reported that rototilling to remove water milfoil is as effective as three to four harvesting operations. Costs of rototiller operations were found to be similar to herbicides and harvesting methods, but speed of operation is slower.

Sediment Exposure and Desiccation

Water-level manipulation has been employed as a mechanism for enhancing the quality of certain lakes and reservoirs. The exposure of lake-bottom mud to prolonged freezing and drying reduces sediment oxygen demand and increases the oxidation state of the mud surface. This procedure may retard the movement of nutrients from the sediments to the overlying water when flooded once again. Sediment exposure can also curb sediment nutrient release by physically stabilizing the upper flocculant zone of the sediments. Lake drawdown has been investigated as a control measure for submerged rooted aquatic vegetation and as a mechanism for lake deepening through sediment consolidation. Lake drawdown also allows repair to dams and docks, fish management, sediment removal, and installation of sediment covers to control plant growth.

Some rooted plant species are permanently damaged by freezing conditions over two to four weeks of lake water-level drawdown. Species such as Eurasian water milfoil, coontail, elodea, and water lily may be decreased. However, other species are either enhanced (bushy pondweed, and hydrilla) or unaffected (cattail and common elodea). The most significant problems with drawdown are the loss of use of the lake and the sharp reduction in the abundance of benthic macroinvertebrates essential to fish diets, which can even lead to a fish kill.

Since there is no water-flow control system for Wolf Lake, drawdown is not a technically feasible alternative. Moreover, since the lake bottom is mostly composed of fine gritty sand, the method does not hold promise.

Lake-Bottom Sealing

Sediment covering to control macrophytes and sediment nutrient release has been widely used as an in-lake treatment technique. Covering of bottom sediments with sheeting material (plastic, rubber, fiberglass, nylon, etc.) or particulate material (sand, clay, fly ash, etc.) can prevent the exchange of nutrients from the sediments to the overlying waters either by forming a physical barrier or by increasing the capacity of surface sediments to hold nutrients.

The problem encountered when covering sediments with sheeting is the ballooning of the sheeting in the underlying sediments. Sand and other large materials tend to sink below flocculent sediments. Cooke *et al*. (1986) report that polyethylene sheeting has not had long-term effectiveness due to macrophyte regrowth on its surface. Bottom covering in small areas, such as dock space or a swimming beach, can terminate plant growth. However, covering large areas is not cost effective and is difficult to apply and to relocate (USEPA, 1990b).

Cooke *et al*. (1986) also discussed PVC-coated fiberglass screen, which they note is expensive but nontoxic and appears to give long-term macrophyte control. They report that PVC fiberglass screening (aqua screen) of size 62 apertures per square centimeter (cm^2) was very effective in controlling macrophytes. Screenings with 9.9 and 39 apertures/cm^2 were either ineffective or less effective than the screens with 52 apertures/cm^2. Seed germination and regrowth occurred on screens after significant sedimentation (two to three years after deployment) had taken place, but autumnal removal of the screens followed by repositioning in spring seemed to correct the sedimentation problem. Cost of the screen with 62 apertures/cm^2 was $140 (1979 prices), for a roll 7 feet wide and 100 feet long. Unless the lake is drawn down, screening must be placed directly over vegetative growth by scuba divers and anchored with metal T-bars.

In view of the extensive macrophyte growth in Pools 6 and 7 of Wolf Lake, the high initial cost of $8,640 per acre for materials alone (1979 prices), and the need for skilled labor to remove and reposition the screens almost annually, covering sediment with screens to control macrophytes is not economically justifiable at Wolf Lake.

Shading

Use of dyes to suppress plant growth was first suggested in 1947 (Cooke *et al.,* 1986). Commercial products are designed specifically to shade hydrologically closed systems such as ponds. The dye is added as a concentrate, and winds disperse it throughout the pond giving a blue or aqua-green color to the lake water. The manufacturers claim that the materials are effective against several species of macrophytes, including *Myriophyllum spicatum* (Eurasian water milfoil), without toxicity to aquatic life. The mode of action is light limitation rather than direct toxicity to the plants. There is insufficient published information at this time to evaluate commercial dyes.

Chemical Controls

USEPA (1988) considers herbicide treatment as an effective, short-term management procedure to produce a rapid reduction in vegetation for periods of weeks to months. Plants are left to die and decompose, resulting in high demand on the lake's oxygen resources. Subsequently, new plants regrow, sometimes to densities greater than before. The use of herbicides to control rooted vegetation and algae remains a controversial and emotionally charged issue, and the pros and cons of herbicides have not been well understood by proponents and opponents alike.

Chemical control of nuisance weed growths involves less labor and generally costs less. Years of testing chemical effectiveness, toxicity, and residues have weeded out questionable, hazardous materials. Now only a limited number of highly effective, approved products are available for weed control. Certain chemicals and application rates selectively control only target weed species, so the applicator has the option of treating only specific nuisance weeds. Applications can be made to areas that cannot be reached by mechanical harvesters, and waters under piers and docks can be treated easily. A detailed list of various chemicals and dosage rates, and the macrophytes' responses to chemical treatments, can be found in Fishery Bulletin No. 4 (IDOC, 1990) and the *Lake and Reservoir Restoration Guidance Manual* (USEPA, 1988).

Application of copper sulfate for algae control may improve water clarity for macrophyte growth. However, the treatment of Eurasian water milfoil in North Carolina with the herbicide 2,4-D (2,4-dichlorophenoxyacetic acid) stimulated a blue-green bloom (Getsinger *et al.,* 1982). Diquot is more effective against native pondweeds than against Eurasian water milfoil (Nichols, 1986). However, chara is resistant to most herbicides (Hurlbert, 1975; Newbold, 1976).

Herbicides disappear from lake water within a few days or weeks, but Diquat is absorbed by sediment for more than two years (Berry *et al.,* 1975).

Table 64 lists the types of herbicides, recommended by the IDOC, that can be used to control water milfoil. Hudson *etal.* (1992) recommended using 2,4-D (2,4-dichlorphenoxy acetic acid), in granular form (trade name Aqua-Kleen), for Eurasian water milfoil control in McCullom Lake, McHenry County, IL. It is reported that 2,4-D has the advantage of killing the entire plant, including the root. 2,4-D is selective for water milfoil and does not affect narrow-leaved pondweeds (monocots). The proper dosage of 2,4-D can kill dicots such as lilies and broad-leaved pondweeds. Under favorable conditions, a 95 to 100 percent decrease in Eurasian water milfoil biomass can be seen within two to three weeks of 2,4-D treatment; and full-season control is possible with successive annual treatments. A minimum of 24 to 36 hours contact time at 1 mg/L is recommended. No long-term adverse impacts are expected from the proper application of 2,4-D. In dosages below labeled rates, the herbicide is not toxic to fish nor does it bioaccumulate at significant levels nor does it persist for more than a few days after 2,4-D exposure. Risks to human health from low levels of carcinogenic impurities found in some 2,4-D samples are considered negligible.

The U.S. Army Corps of Engineers (Westerdahl and Getsinger, 1988) lists ten registered herbicides for aquatic plant control. It also clearly states chemical formulations, made of action, application formulations, time of application, application rates, maximum water concentration, use restrictions, waiting period, toxicological data, precautions, field instructions, adjuvant use, application techniques, and antidote information for each herbicides. For Eurasian water milfoil control, 2,4-D (both butoxyethyl ester and dimethylamine, DMA), Diquat plus complexed copper, and endothall (dipotassium salt, K_2, K_2 plus complexed copper, and dimethylalkylamine salts) are reported to be excellent. The use of Diquat, fluridone, and simazine each gives only good results of water milfoil control.

The use of fluridone (trade name Sonar) to control water milfoil is relatively new. The manufacturer claims that Sonar does not eliminate desirable vegetation; low concentrations of fluridone (0.015 to 0.025 mg/L) are selective for Eurasian water milfoil and hydrilla. After treatment, desirable native species can become more abundant, creating a more diverse habitat. Sonar does not harm fish or waterfowl. Its application can be less frequent than that of other aquatic herbicides. However, results from evaluation of the use of fluridone in northern U.S. lakes are not available.

Following are some of the drawbacks to chemical control of macrophytes.

- Different chemicals are required to control different plant species.
- Chemical application permits and monitoring programs are required.
- Restrictions are often placed on water usage after chemical applications.
- Success or failure of the treatment depends on various factors, such as chemical dosage, water temperature, pH, weather conditions, wind, and water velocity.
- Toxicity and residue problems may make chemical control controversial and less acceptable environmentally.
- Decaying vegetation creates unsightly conditions in the lake. Released nutrients become readily available for recycling. Algal blooms occur subsequent to chemical treatments.

The cost of chemical control of macrophytes is estimated to vary between $200 and $300 per acre. Herbicide treatments are reportedly expensive for what they accomplish. They produce no restorative benefit, show no carry-over of effectiveness to the following season, and may require several applications per year. The short-term benefit-cost ratio can be desirably high, but the long-term benefit-cost ratio is likely to be very low (USEPA, 1988). Additionally, the

Table 64. Recommended Herbicide Dosages for Controlling Water Milfoil

Chemical	*Concentration, parts per million*	*Dosage*
Liquid silvex	2.0	1.4 gallons per acre foot
Granular endothail	3.0	81 pounds per acre foot
Granular 2,4-D ester	2.0	27 pounds per acre foot
Diquat	0.5	0.7 gallon per acre foot
Liquid potassium endothail	2.0 - 3.0	1.3 to 1.9 gallons per acre foot
Dichlobenil acquatic granules	-	100 to 150 pounds per surface acre
Liquid fenac	-	10 to 13 gallons per acre of exposed bottom soil
Liquid endothail and silvex	2.0 • 3.0	1 to 1.6 gallons per acre foot
Granular endothail and silvex	2.0-3.0	51 to 77 pounds per acre foot
Aquazine*	1.0- 2.0	3.4-6.8 pounds per acre foot

* Treat whole body of water.

Note: Dosages recommended by the Illinois Department of Conservation

USEPA considers chemical control of macrophytes and algae to be a palliative approach to lake restoration. Therefore, these measures are rarely eligible for financial assistance.

Harvesting

The harvesting of nuisance organisms by mechanical harvesters or scuba hand removal is limited to macrophytes and some undesirable fish. The technique has been advocated as a practical means of accelerating the nutrient outflow from lake systems; however, this technique alone is deemed inadequate for lowering nutrient input to lakes receiving enrichment from anthropogenic activities. Conyers and Cooke (1983) reported that stumps of Eurasian water milfoil plants about 0.5 to 3 inches in height were left after cutting, and complete regrowth occurred in 21 days. The removal of roots is essential.

Harvesting is as effective as herbicide treatment; it is no more expensive than chemical control in the long run (USEPA, 1988); and it has several distinct advantages over herbicide treatments. Following are some of the advantages.

- The procedure is target-specific, and the time and place of harvesting are decided by lake managers.
- The nuisance vegetation is immediately removed along with a certain quantity of plant nutrients.
- No toxicants are introduced, hence no toxic residues remain.
- The lake can remain open during harvesting.
- The plants do not remain in the lake to decompose, utilize oxygen, and release nutrients that may stimulate algal growth.
- Harvested weeds may be used for compost, mulch, methane production, etc.
- Harvesting can be easily regulated to preserve fish habitats and recreational access, and at the same time avoid any major upset in the ecological balance.
- Regrowth after harvesting is usually delayed, and reharvesting in one year tends to inhibit regrowth in subsequent years.
- The adverse impact on fish abundance is slight.
- Fish growth rates may increase, and fish may increasingly turn to grazing on algae instead of snails and insects.

The following are potential negative impacts of harvesting.

- The procedure requires high capital outlay for equipment.
- The technique is energy and labor intensive.
- Only relatively small areas can be treated per unit time, which may create lake-user dissatisfaction.
- Plants may fragment and spread the infestation.
- Harvesting constitutes habitat removal, and with it will come a reduction in species of the shallow area of the lake, particularly animals such as snails, insects, and worms.
- Machine breakdown can be frequent, especially if an undersized piece of equipment is employed.

The cost of harvesting depends on several factors, including equipment cost, labor, fuel, insurance, disposal, and the amount of downtime. Harvesting costs in the Midwest have ranged from $135 to $300 per acre (USEPA, 1988).

It should be noted that the Clean Lakes Program considers harvesting to be a palliative approach to lake restoration in most cases, and it is therefore rarely eligible for financial assistance.

Biological Controls

Using plant-eating or plant pathogenic biocontrol organisms is a long-term control approach to reduce nuisance aquatic vegetation without introducing expensive machinery or toxic chemicals. This approach encompasses the introduction or promotion of organisms that are inimical to the target organisms. White amur, or grass carp, has been widely recognized as a plant-control agent. Grass carp have been used in Illinois for small ponds. Even though it is permitted in Indiana to use sterile grass carp for aquatic plant control, this biological control technique is considered experimental and has not been successfully employed in large water bodies. Also Eurasian water milfoil is not a preferred plant food for grass carp. Hence its utility in controlling aquatic plants in Wolf Lake is questionable.

The USEPA has awarded a $448,000 grant to the state of Vermont for a four-year study of the success of weevil *(Eurhychiopsis lecontei)* against Eurasian water milfoil. So far, the results of placing weevils in Lake Bomoseen near Castleton are encouraging. The weevil is a prolific breeder with a seemingly insatiable appetite for Eurasian water milfoil. Additionally, the weevil does not have to devour the whole plant to destroy it. The effectiveness of weevils varies with locations of the lake (U.S. Water News, 1994).

Declines in Eurasian water milfoil populations in other parts of the nation have been correlated with weevils. In Illinois, milfoil decline due to weevil attack was first discovered in McCullom Lake, McHenry County on June 3, 1995 (Northeastern Illinois Planning Commission, 1995). The weevil feeds exclusively on Eurasian water milfoil, and it has the potential to be an effective "biological control": in research experiments, weevils have not damaged any other non-milfoil plant species. This is very important, because the goal of lake management programs is to maintain a balanced community of native plants.

A research and demonstrtion study of milfoil control by weevil in Pools 6 and 7 may be made with possible funding from the USEPA.

OBJECTIVES OF WOLF LAKE MANAGEMENT PLAN

The objectives of the Wolf Lake management plan are to correct existing lake problems and to restore and protect beneficial uses, including cultural uses such as fishing, water sports, swimming, and aesthetics, as well as environmental quality concerns such as lake water and sediment quality and fish and wildlife habitat. Some portions of Wolf Lake are shallow and eutrophic, and some are covered with dense non-native macrophytes, which impair lake aesthetics and beneficial lake uses. It is essential to eliminate the problem sources that impair beneficial uses in Wolf Lake. The major goals and objectives of the lake management plan should include:

- Selective deepening of the lake for macrophyte control.
- Eradicating the invasive exotic plant, Eurasian water milfoil (*Myriophyltum spicatum),* and preventing its reestablishment by promoting diversity of native macrophytes.
- Reducing bacterial contamination of Wolf Lake Channel and improving water quality at the swimming beach.
- Managing discharges from storm sewer pumping stations in the Hammond Sanitary District.
- Enhancing aesthetic and recreational opportunities in and around the lake by cleaning up debris and improving fish management.

A basic eligibility requirement for Clean Lakes Program funding is that the lake be open and publicly accessible and that such access be across publicly owned land. Public access must be provided independent of a Clean Lakes Program project, and Section 314 funds may not be used to purchase or lease property solely to provide access. The intent of this regulation is to ensure that the benefits of a lake restoration or protection project are in fact enjoyed by the public (USEPA, 1980). All pools of Wolf Lake have public accesses.

PROPOSED RESTORATION ALTERNATIVES

Under the Wolf Lake restoration plan, three alternative pollution control and restoration measures are proposed, as shown in table 65.

Alternative I

Under Alternative I (table 65) no action needs to be taken for Pools 1, 2, 4, 6, 7, and 8. Pools 1, 2, and 4 have good water quality. Pools 6 and 7 can be left alone despite excessive macrophyte growths because there are adequate open waters elsewhere in the system to meet the demands of recreational uses. Although there is macrophyte growth in small parts of Pool 8, the major portion of the pool is in good condition.

Although Pools 3 and 5 have good water quality, discarded urban debris such as tires and shopping carts exist in the south end of both pools. These debris need to be removed for aesthetic enhancement. In addition, as mentioned earlier, the dumping site at the roadside of 129th Street (south of Pool 6) needs to be cleaned up to eliminate potential pollution. The road surface of this access road also needs to be improved.

Major attention should be focused on Wolf Lake Channel (Pool 9). Dredging the channel with or without sediment treatment is definitely required to improve its water and sediment quality, aesthetic conditions, and other uses. Improving the water quality of discharges from the Hammond Sanitary District (the Forsythe Park, Roby, and Sheffield pumping stations) is essential to restore Wolf Lake Channel and to reduce bacterial contamination. Diversion of the Pump Station discharges out of the Wolf Lake System could be considered but is beyond the scope of this project. Suitable management schemes need to be developed and implemented to improve the water quality of these discharges. Also, the stormwater discharges from the Sheffield Avenue pumping station to Pool 8 need to be managed for possible water quality enhancement.

Alternative II

In addition to the actions proposed under Alternative I, this alternative includes dredging in Pools 6 and 7 to increase lake volume and to control the non-native aquatic vegetation dominant in these pools. Use of herbicides or harvesting of macrophytes to control Eurasion water milfoil may also be an option.

Alternative III

Alternative III includes all the approaches of Alternative II and adds some selective dredging in Pool 3. The additional dredging is primarily to improve boating opportunities.

Proposed Restoration Scheme

The restoration scheme comprises cleanup of debris in and around the lake, lake dredging, macrophyte control, and lake ecosystem management such as replanting of desirable native aquatic plants, addition of physical structures for fish cover, and fish community manipulation.

Table 65. Proposed Alternatives for Achieving Wolf Lake Management Plan Objectives

	Alternative		
Area	*I*	*II*	*III*
Pool 1	No action	No action	No action
Pool 2	No action	No action	No action
Pool 3	Cleanup debris	Cleanup	Cleanup, dredging
Pool 4	No action	No action	No action
Pool 5	Cleanup debris	Cleanup	Cleanup
Pool 6	No action	Dredging or chemical control	Dredging or chemical control
Pool 7	No action	Dredging, or chemical control	Dredging, or chemical control
Pool 8	No action	No action	No action
Pool 9*	Dredging	Dredging	Dredging
Discharges to Pools 8 & 9	Management	Management	Management
Road to Pool 5	Cleanup area	Cleanup	Cleanup

Note:
* Wolf Lake Channel

Cleanup Campaign

Historically, cleanup activities near shorelines have been conducted in both Illinois and Indiana by nonprofit organizations or volunteers. Unfortunately, regular illegal dumping persists in and around the lake.

Urban debris at the south ends of Pools 3 and 5 should be removed. Signs stating "No littering" and the penalty for violation should be posted in those areas and at the dumping areas on 129th Street from Sheffield Avenue to Pools 4 and 5 (south of Pool 6), after all the trash and debris are cleared.

Labor costs for cleanup may be minimal or nothing if a volunteer force can be mobilized. Costs of signs and enforcement will be minimal and can probably be handled by the Illinois Department of Natural Resources and the Hammond Park District. The cleanup campaign and the enforcement scheme should be developed by these two agencies.

Paving of the wide unpaved bumpy approach road for Pool 5 (western portion of 129th Street) is recommended. The road is approximately 1,800 feet long with a good foundation. The pavement can be two-lanes with a total width of 20 feet. The estimated cost for 4-inch thickness of asphalt with sub-base is over $60,000. The use of gravel with rock sub-base will cost about $18,000. The latter is recommended since this segment is not heavily traveled, terminates on the east side of Pool 5, and is not a thoroughfare.

Lake Deepening and Macrophyte Control

Dredging the lake accomplishes the multiple objectives of increasing the lake volume, removing the undesirable rooted vegetation, and providing additional space for winter fish survival. Harvesting and removal of macrophytes are not viable options for controlling the dominant and dense growths of Eurasian water milfoil. Hence, for the reasons discussed earlier, dredging and herbicide application are the most technically and economically feasible methods for eliminating the predominance of this non-native aquatic vegetation in the lake. Because the lake's sediment characteristics were found to be nonhazardous, no special handling or precautions are needed for disposing the dredged materials.

Hydraulic dredging would be conducted with the lake at its normal water level. Using this method, sediment is loosened and pumped as slurry to a retention pond where the sediment settles out and the clarified effluent water is returned to the lake. Selection of a retention pond site for permanent deposition of the sediment is a major factor in implementing this approach. The dredged spoil could be disposed of in a suitable containment facility created on the nearby Bairstow property, which is currently owned by Lake County, IN.

The IDOC (1986) recommends that for fish stocking and survival in small lakes and ponds in northern Illinois, the water depth must be about 10 feet in one-quarter of the water area. The maximum depth of macrophyte colonization is estimated to range from 9 to 14 feet. These two criteria, in addition to the resources available for dredging, will determine the area, depth, and volume of lake to be dredged.

Wolf Lake Channel. *Dredging.* The main purpose of dredging of Wolf Lake Channel (Pool 9) is to remove lake bottom materials and near-bank macrophytes. The sediment is greasy and malodorous; it also contains leaves, tree stems, etc. Preventing leaves from blowing into the lake is another important task. Installation of snow fencing may serve this purpose.

The upper one-third of Wolf Lake Channel (Pool 9) varies in width from 140 to 190 feet. The width increases to about 300 feet in the southern part of the channel. The proposed length of channel to be dredged is approximately 3,500 feet. The final cut will be a trapezoidal shape with 1:2 slope on both sides of the banks. The average depth of dredging will be between 8 and 9 feet, and the estimated volume of bottom material dredged is about 7,100,000 cubic feet or 263,000 cubic yards. The estimated total cost of dredging Wolf Lake Channel is $1,052,000, using a unit cost of $4.00 per cubic yard. The total cost includes $90,000 for engineering design and construction inspection services, surveying, mapping, testing, and geotechnical investigation; $220,000 for retention site preparation and construction; and $742,000 for sediment dredging and transportation.

Thermo-Plasma Destruction. This process includes dredging and sediment treatment. Wangtec's WPS-2000 technology is recommended for an on-site treatment of the contaminated PCBs, hydrocarbons, and heavy-metals. However, the whole process requires three steps; namely, sediment removal (dredging), contaminant treatment, and soil restoration (or disposal elsewhere or sale to beneficial reuser). The following tasks are proposed in order to achieve the goal of the project:

Task 1. Removal (dredging) of the sediment from the lake
Task 2. Treatment of the contaminated sediment
Task 3. Disposal, return to lake, or sales to beneficial reuser of the treated sediment soils

Note that the dredged sediment can be directly sent to a special landfill without treatment (Task 1); however, the cost would be higher than treatment-and-return-to-the-lake due to the massive amount contaminated with PCBs. Either return-to-the-lake or sale-to-beneficial-reuser, requires sediment pre-treatment to remove its toxic chemicals.

The main purpose of dredging the Wolf Lake Channel (Pool #9) is to remove lake bottom materials and near-bank macrophytes. The sediment is greasy and malodorous; it also contains leaves, tree stems, and other debris. The hydraulic cutter head dredges will be used to remove contaminated sediment and deposit the material into settling impoundments at the lake edge. Upon sufficient dewatering, the sediment will be pre-conditioned to remove debris and optimized particle size and moisture content. Then the processable sediment shall be delivered to WPS-2000 system for removal of toxic metals and destruction of hazardous chemicals including PCBs. It is estimated that the dredging operation will take about six months (based on 900 cubic yards per day); and the treatment processing will occur concurrently.

The WPS-2000 system is a high-temperature, nonincineration, thermo-plasma destruction process. No air is required in the high-temperature destruction process; therefore, no combustion-derived toxic emission is produced. The current Wangtec Plasma System (WPS) uses thermo-plasma reaction in a high-temperature environment to perform the destruction/ dissociation of the waste stream.

The "volume" plasma is generated within the entire reactor volume. It produces highly energetic free radicals which possess a special affinity for the waste compounds such as chlorinated hydrocarbons. Once the collisions occur between these free radicals and the waste molecules, new unstable chemical compounds are formed and the chemical bonds are broken into short-chain nontoxic materials. This results in a high degree of chemical bond destruction and dissociation.

The WPS-2000 is an integrated multistage, closed-ioop treatment system for hazardous wastes, such as PCBs, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), low-level mixed wastes, heavy metals, acidic gases, etc. This closed-loop process eliminates the potential for any uncontrolled emissions often found with incinerators. It is a mobile, transportable unit that is excellent for emergency responses and on-site treatment needs. This integrated, mobile system also contains innovative safety concepts that significantly reduce the risk to the public and the environment. The WPS-2000's mobility and unique features result in safe, clean, and reliable treatment of the high-strength hazardous and acute wastes, and make it ideal for effectively treating the chemical compounds.

A fluidized-bed reactor located in the closed-loop system is used to remove the toxic heavy-metals and to neutralize the acidic gases. The sub-micron-sized particles of the heavy metals are nucleated and condensed from their vapor state onto existing particles in the bed. Since the bed material is made of absorbing agents, the acidic gases passing through the bubbling bed will be scrubbed and neutralized by the bed materials. Therefore, if the input waste stream contains halogenated organic compounds, the process also removes the halogen acids, products of their destruction.

This closed-loop system uses several off-gas treatment components and on-line computer-controlled diagnostic sensors and monitors for complete and safe treatment of the contaminated wastes. Finally, a catalytic oxidizer, located after the exit of the closed-loop system, converts the trace light-hydrocarbons and carbon monoxide to the final, and only emission products: water and carbon dioxide.

The advantages of thermo-plasma technology (WPS-2000) are:

- An on-site generator supplies system power, and utility power is not necessary.
- The system is small [6 feet × 7 feet × 8 feet], and can be moved around the lakeshore.
- Only small working area near the shoreline is needed.
- The system has high treatment efficiency and is cost effective.
- A closed-loop system provides safe, clean, and reliable treatment to the public and operators.
- The 4 mg/kg PCB-contaminated sediment is not a hazardous waste, so no stringent Toxic Substances Control Act (TSCA) permit is required.

Pool #9 of the Wolf Lake Channel varies in width from 140 to 190 feet. The width increases to about 300 feet in the southern part of the channel. The proposed length of channel to be dredged is approximately 3,500 feet. An average water depth is about 4 feet. The average depth of dredging the contaminated sediment for treatment is about 3 feet. For an estimate, a dimension of 250-feet (wide) × 3 500-feet (long) × 3-feet (deep) is being used. Therefore, an estimated volume of bottom material dredged is about 2,625,000 cubic feet or 97,236 cubic yards.

An estimated breakdown of cost includes:

Dredging/Sediment Removal	$5.00/yd^3,
Chemicals/Metal Treatment	$2.50/yd^3,
Treated Soils/Sediment Return to Lake	$3.50/yd^3,
(Option of Selling Soils to Beneficial Reuser)	($Income).

The estimated overall cost is about $1,069,600 (or $11.00 per cubic yard). This cost estimate for thermo-plasma destruction of pollution in sediment is close to that of dredging without the sediment treatment (larger volume removed). Only the cost of dredging is presented in the budget table.

Pools 6 and 7. The dredging proposed in Pools 6 and 7 (Alternative II) is for macrophyte control, fishery management, and boaters. As shown in figure 16f, a dense growth of Eurasian water milfoil occurred in the center portion of the east bay of Pool 6. Diverse species of aquatic plants were found near shorelines and in the west (narrow) bay at the Illinois-Indiana state border line. No action needs to be taken in these areas. Most of Pool 6 has a water depth of 2 to 4 feet except one area where the water depth is 6 feet. Assuming that the average depth of sediment to be dredged is 10 feet and the area to be dredged in the central portion of the pool is 740 feet x

1,000 feet, then the total volume of lake bottom material removed will be 274,000 cubic yards. Using the unit cost of $4.00 per cubic yard, the estimated total cost of dredging part of Pool 6 is $1,096,000.

As in Pool 6, the central area of Pool 7 (600 feet × 700 feet) is proposed for dredging. The area covers approximately 9.6 acres, or 20 percent of the the total lake surface area. The water depths in this area are about 4 feet, an the depth of sediment removal will be 10 feet, for a total volume of 156,000 cubic yards. On the basis of $4.00 per cubic yard, the total cost of dredging in this pool is estimated at $604,000.

Pool 3. The dredging in Pool 3 is for the purpose of enhancing fisheries and boating. The major portion of Pool 3 has a water depth of 4 to 6 feet. Only a few small areas (less than 10 percent) have depths of 6 to 12 feet. It is proposed (Alternative III) that the central part of the lake (1,300 feet × 1,100 feet, or 32.8 acres; approximately 40 percent of the lake bottom) be dredged to remove an average of 9 feet of sediment. The volume of bottom material removed from the lake (477,000 cubic yards) will leave the lake with a water depth of at least 14 feet. According to Raman *et al*. (1995) the unit cost of sediment removal from Lake George is $4.00 per cubic yard, which includes geotechnical and engineering services and sediment retention site construction. Using the same unit cost, the total cost of sediment removal from Pool 3 by hydraulic dredging will be $1,908,000. It should be pointed out that the dredged spoils could be a potential sand-and-gravel resource. However, the State of Indiana opposes any lake dredging for sand mining purposes.

The estimated cost for dredging includes costs of disposal site acquisition, surveying, mapping, geotechnical investigation, engineering design and construction inspection services, retention site preparation and construction, and sediment removal. The unit rate for dredging used provides for the special handling required for dealing with the hazardous sediments from the Wolf Lake Channel and utilizes the economy of scale in dredging costs. Dredged spoil disposal site selection, size of the retention basin which is dependent on the sediment settling rate, security requirements to exclude public access etc., will be dealt with under Phase II of the project once the dredging program is approved and funded.

Macrophyte Control by Herbicides

2,4-D Treatment in **Pools** 6 **and** 7. In a Phase I Clean Lakes Program diagnostic-feasibility study of McCullom Lake, McHenry County, IL, Hudson *et al*. (1992) proposed application of 2,4-D (2,4-dichlorophenoxy) acetic acid to eradicate Eurasian water milfoil. This approach has been accepted by the IEPA and USEPA. 2,4-D is selective for water milfoil and has the advantage of killing the entire plant, including the root, within two to three weeks of application; and full-season control is possible with successive annual treatments. A minimum of 24 to 36 hours contact time at 1 mg/L is recommended by Hudson *et al*. (1992).

For Pools 6 and 7, instead of expensive dredging, treatment with 2,4-D seems to be an option worth considering. The treatment scheme and cost estimates are adopted from Hudson *et al*. (1992). 2,4-D should be applied in the spring when plants are young and vigorously growing. Recently, it has been suggested that Eurasian water milfoil may be more vulnerable to fall application of 2,4-D due to active storing of carbonates in the roots in preparation for winter.

Chemical application must be carried out by a licensed aquatic herbicide applicator. The cost is relatively high for the initial treated acre, but additional acres are treated at a reduced rate. On the basis of an average contractor rate of $250 per acre, the initial spring application to 17 and 9.6 acres in Pools 6 and 7 would cost $4,250 and $2,400, respectively. It is necessary to run an application program for two to three years, even four years. Assuming half the cost for one fall application and two spring treatments, the three-year treatment cost would be $10,600 and $6,000 for Pools 6 and 7, respectively.

Two to three weeks following 2,4-D application, the treated areas should be inspected along with the remainder of the lake. Hand-harvesting of isolated plants and removal of milfoil fragments must also be carried out. Scanning of the lake by boat should then be performed at least monthly throughout the growing season to remove isolated plants. A fragment barrier, such as a small-mesh fishnet supported by buoys, can be placed around the area being harvested to collect drifted fragments.

Hudson *et al*. (1992) assumed that five acres of lake inspection and hand-pulling of Eurasian water milfoil would require 68 person-hours during the first year. It is estimated that 850 (50 per acre) and 580 (60 per acre) person-hours, respectively, for Pools 6 and 7 would be needed for lake inspection and hand-pulling of plants during the first year of treatment. A team of four persons (two divers and two technicians) is recommended. On average, professional divers cost $35 per hour and technicians cost $15 per hour (i.e., $25 for an average person-hour). Therefore, the first year follow-up job will cost $21,250 and $14,500 for Pools 6 and 7, respectively. The second and third years will require approximately 75 and 50 percent of the person-hours estimated for year one, for a cost of $16,000 and $10,900, respectively, for Pool 6, and $10,900 and $7,250, respectively, for Pool 7. Thus, the costs of manual removal in a three-year Eurasian water milfoil control program are estimated to be $48,000 and $32,600 for Pools 6 and 7, respectively.

Total costs of three years of 2,4-D applications to eradicate Eurasian water milfoil in the overgrown areas of Pools 6 and 7 are $58,600 and $38,600, respectively, including costs of chemical application and follow-up manual removal.

Application of Sonar. The use of fluridon (tradename Sonar) to control Eurasian water milfoil is promoted by its manufacturer, Dow Chemical Company. There are no published reports in technical journals about the efficacy of Sonar in controlling Eurasian water milfoil. The manufacturer claims that a low concentration of fluridon (0.015-0.020 mg/L) is selective for milfoil control and does not seriously affect native plant species. Sonar could be tried in Pool 7 on an experimental basis.

Any chemical application needs licensed operator and permit. Use of any federally approved herbicide, following the manufacturer's guidelines, should impact the lake system minimally.

Mechanical Harvesting. Mechanical harvesting is applicable to Pools 6 and 7 for macrophyte control. However, as stated previously, mechanical harvesting does not completely collect the cut plant at all. The plant (Eurasian water milfoil) fragments can easily drift and regrow to previously uninfested areas. Special care should be taken to eliminate or minimize plant fragment drift in the lake during harvesting. Special care should be exercised to prevent drifting of plant fragments to Pool 4. The large quantities of biomass removed have to be dewatered and disposed of to a landfill or composted.

As mentioned earlier, USEPA (1988) estimated harvest costs at $135 to $300 per acre. The ranges of per-acre costs for harvesting and herbicide treatment are similar in northern climates (USEPA, 1990). For the purpose of this report, cost of harvesting is assumed to be the same as herbicide treatment costs for Pools 6 and 7.

Mitigation Bacterial Contamination

To address the high indicator bacterial densities problem, detailed monitoring of the stormwater discharges and engineering studies needs to be carried out to determine the course of action to mitigate this problem. The city of Hammond has been directed by the IDEM to investigate this aspect and take appropriate action.

Lake Ecosystem Management

Replanting of Desirable Native Aquatic Plants. To help prevent reinfestation of Eurasian water milfoil in areas where it has been controlled, it is desirable to reintroduce and reestablish native aquatic plants. The goal of aquatic plant management is to provide the appropriate number of aquatic plants, taking into account the effects of macrophytes on fish communities and other lake uses such as boating and aesthetics. Macrophytes can help stabilize the lakebed and shoreline, reducing problems with lake shore erosion and high turbidity. Fisheries are enhanced by moderate growth of aquatic plants; the complete elimination of macrophyte beds may be as harmful as excessive plant growth.

Some desirable rooted aquatic submerged vegetation suited for Midwestern lakes are: certain broad-leaved pondweeds, *Potamogeton ampljfolius* (largeleaf pondweed), *P. illinoensis* (Illinois pondweed), *P. natans* (floating leaf pondweed), and *P. richardsonii* (Richardson pondweed); some narrow-leaved pondweeds, *Potamogeton berchtoldii* (Berchtold pondweed), *P. foliosus* (leafy pondweed), and *P. pectinatus* (sago pondweed); and wild celery *(Vallisneria americana)* (Wisconsin Department of Natural Resources, personal communication, November 21, 1994). *P. pectinatus* tubers as well as those of *P. richardsonii* and *P. americanus* (American pondweed) can be purchased commercially at a cost of approximately $150 per 1,000 tubers. Sago pondweed should be planted in April or May, two to three weeks following 2,4-D application. Broad-leaved pondweeds and naiads are best planted in June as cuttings, six to eight per bunch spaced 12 to 15 inches apart (Hudson *et al.,* 1992).

Cost of materials and labor to plant aquatic plants has been reported to be approximately $3,250 per acre (Chicago Park District, 1994) for small park lagoons. Hudson *et al.* (1992) estimated the cost for planting a five-acre area to be $8,250 for McCullom Lake in McHenry County, a collar county in the Chicago region. For Lake George, considering the economy of scale, the unit cost for replanting aquatic vegetation in the lake was estimated at about $1,500 per acre (Raman *et al.,* 1995).

No planting of native aquatic plants is recommended for Pools 3, 6, and 7 due to the abundance of mixed species near shorelines. Pool 9 needs to be replanted on both sloping banks. Planting in an area of 4.82 acres (30 feet × 7,000 feet) will cost $7,200.

Addition of Physical Structures for Fish Cover. Some lakes and reservoirs lack sufficient structural features and areas for fish to hide, particulary areas where younger, smaller fish can find cover to escape from larger fish and other predators. Without adequate cover, survival rates of young fish are often low. Structural features provide safety from predators, substrate for food organisms, and in some cases spawning habitat. Additionally, predators, which include most game species, tend to concentrate around structural features in search of prey. By concentrating fish in specific areas, the addition offish cover, such as artificial reefs, can increase fishing success and angler satisfaction (USEPA, 1993).

Common types of physical structural habitat include docks and piers, brush piles, and rock reefs, as well as constructed artificial reefs such as cribs, piping, and plastic structures. In addition to replanting native aquatic vegetation in Wolf Lake Channel, other artificial reef structures in adequate number and size should be considered for fisheries enhancement. The cost of installation offish cribs or artificial reefs in Pool 9 is $2,000.

Other Related Programs

Wolf Lake and its watershed are within the areas of concern (AOC) identified by the International Joint Commission (UC). The Remedial Action Plan (RAP) of the IJC is an ongoing effort to control and mitigate the effects of past waste disposal practices in the AOC. The management scheme for Wolf Lake could be integrated into the RAP of the IJC. The city of Hammond has the management authority for Wolf Lake.

Benefits Expected from Restoration Project

Once implemented, the proposed restoration plan (Alternative I) will improve the aesthetic appeal of Pools 3 and 5 and Wolf Lake Channel, and enhance water quality, habitat, and recreational uses in Wolf Lake. In addition to yielding water quality benefits, dredging and fisheries management in Wolf Lake Channel will also improve bank fishing at Forsythe Park.

In addition to providing the benefits of Alternative I, Alternative II will control Eurasian water milfoil, particularly in Pools 6 and 7, which interferes with boating activities and creates an extensive canopy formation that detracts from the aesthetic enjoyment of the water body. Control of this non-native aquatic vegetation and re-establishment of native aquatic plants will provide and sustain conditions for an ecological balance and desirable aquatic food chain in the ecosystem. Conditions will be vastly improved by the addition of strategically placed fish cribs and other fish structures. Selective deepening will increase fish survival over harsh winters, and the sports fisheries in the lake can be improved through the proposed fisheries management activities. Overall, the aesthetics and recreational opportunities provided by the lake environment will be increased significantly under Alternative II.

Alternative III includes the dredging of Pool 3 in addition to all the activities proposed in Alternative II. If Alternative III is implemented, the area for boating and fishing will be increased in the Illinois side of Wolf Lake. Resource (sand) recovery is a possible extra benefit of dredging Pool 3.

A report prepared by J AC A Corporation (1980) for the USEPA, assessing the economic benefits derived from 28 projects in the Section 314 Clean Lakes Program, shows a return in benefits of $8.30 per federal dollar expended, or $4.15 per total project dollar. The projects produced benefits in 12 categories: recreation, aesthetics, flood control, economic development, fish and wildlife, agriculture, property value, public health, public water supply, education, and research and development, resource recovery and reduced management cost, and pollution reduction. The report also indicates that while many benefits could not be measured in monetary terms, the success of many Clean Lakes Program projects appears to have been a catalyst for other community activities.

PHASE II LAKE MONITORING SCHEDULE AND BUDGET

Monitoring Program

In order to evaluate the response of Wolf Lake and Wolf Lake Channel to Phase II restoration activities, a monitoring program will be implemented once the restoration project is in place to document the changes in the lake's water quality. The following monitoring schedule will be used in evaluating the effectiveness of the in-lake management technique adopted for the lake.

The lake water will be monitored for dissolved oxygen, temperature, and Secchi disc readings at the deepest locations, one in each of Pools 8 and 9 (Alternative I), and Pools 6 and 7 (Alternative II), and Pool 3 and Indian Creek (Alternative III). Observations for dissolved oxygen and temperature will be made at 1-foot intervals commencing from the surface.

Water samples for chemical analyses will be taken at these deep stations from two different points: 1 foot below the water surface and 2 feet above the bottom. Analyses will be made for pH, alkalinity (phenolphthalein and total), conductivity, total suspended and dissolved solids, volatile suspended solids, turbidity, total phosphorus, dissolved phosphorus, nitrate plus nitrite nitrogen, ammonia nitrogen, total kjeldahl nitrogen, turbidity, and chemical oxygen demand.

Integrated water samples (integrated to a depth of twice the Secchi disc depth) will be collected at each deep station for determining chlorophyll-a, *b*, *c*, and pheophytin. Integrated water samples will also be collected for algae and zooplankton identification and enumeration.

Physical and chemical water quality characteristics will be monitored at biweekly intervals (May - September) and at monthly intervals (October - April). Algae and zooplankton samples will be collected at monthly interval (May - September), and benthos will be examined once in late spring and again in midsummer.

A macrophyte survey and a fish survey using an electroshocking technique will be made once, approximately 12 to 18 months after the implementation of the management techniques. A fish-flesh contamination assessment is desirable.

Sediment samples taken with an Ekman/Petite Ponar dredge will be examined for macroinvertebrate identification and enumeration. Surficial sediment will be collected once at each water sample location for metals and organics analyses. Sediment samples will be collected at the same locations as in the Phase I study.

Implementation Schedule

The proposed implementation schedule is listed in table 66, which outlines planning, design, in-lake management, and report phases. The proposed duration of Phase II is 27 months. The schedule has not yet been assigned specific target dates, due to the uncertainty of funding availability.

Budget

The estimated costs for various alternatives are as follows: Alternative I ($1,269,000); Alternative II with dredging in Pools 9, 6, and 7 ($2,969,000); Alternative II using 2-4-D to control macrophytes or harvesting in Pools 6 and 7 ($1,366,000); Alternative III with dredging in Pools 3,6,7, and 9 ($4,877,000); and Alternative III using chemical control in Pools 6 and 7 and dredging in Pool 3 ($3,279,000).

The lake will be monitored during the implementation of Phase I recommendations and for a period of one year after the implementation of all the recommendations. The initial monitoring of the lake will be much less frequent (once a month), and the subsequent monitoring will be at the same schedule as for the Phase I diagnostic study. The estimated costs for these two monitoring phases are $50,000 and $140,000 for a total of $190,000.

Table 66. Proposed Implementation Schedule for Wolf Lake Restoration

Activity	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*
Final Design and Construction Document Development	X	X	X	X																							
Obtain Necessary Permits			X	X																							
Cleanup Campaign					X																						
Advertise and Award Construction Contracts					X	X																					
Hydraulic Dredging							X	X	X	X																	
Removal of Rough Fish and Restocking											X																
Replanting of Native Vegetation										X	X																
Installation of Fish Cribs and Artificial Reefs											X	X															
Post Restoration Monitoring													X	X	X	X	X	X	X	X	X	X	X	X			
Phase II Report																								X	X	X	X

Month spans columns 1–27.

A breakdown of project costs is as follows:

Activity	*Alternative I*	*Alternative II* Dredging or treatment	*Alternative II* Chemical or harvesting	*Alternative III* Dredging or treatment	*Alternative III* Chemical or harvesting
1. Sediment removal					
Pool 9	1,052,000	1,052,000	1,052,000	1,052,000	1,052,000
Pool 6	N/A	1,096,000	N/A	1,096,000	N/A
Pool 7	N/A	604,000	N/A	604,000	N/A
Pool 3	N/A	N/A	N/A	1,908,000	1,908,000
2. Macrophyte control					
a. Chemical					
Pool 6			10,600		10,600
Pool 7			6,000		6,000
b. Three-year manual removal					
Pool 6			48,000		48,000
Pool 7			32,600		32,600
3. Replanting native plants					
Pool 9	7,200	7,200	7,200	7,200	7,200
4. Installation of fish cribs or artificial reefs	2,000	2,000	2,000	2,000	2,000
5. Improvement of 129th Street	18,000	18,000	18,000	18,000	18,000
6. Post-implementation study	190.000	190.000	190.000	190.000	190.000
Project total	1,269,200	2,969,200	1,366,400	4,877,200	3,274,400

Cost, $

EVALUATION OF ENVIRONMENTAL IMPACTS

This section covers some of the environmental impacts of the proposed Phase II restoration project. The Clean Lakes Program requires that the following questions be addressed.

Will the project displace people?

The project will not displace people, since all project-related activities occur in park areas.

Will the project deface residential areas?

The project will not deface residences located near the project areas. In any case, hydraulic dredging, if chosen as a mitigation technique, is considerably less noisy than drag-line equipment and earth-moving machinery. The dredged spoils from Wolf Lake Channel have to be disposed of in a sealed containment area and monitored for contamination of ground water. The PCB levels of the Channel were found to be of "high concern". Some noise associated with cutterhead operation and pumping is unavoidable. Nonetheless, no defacement of residences is anticipated.

Will the project entail changes in land-use patterns or increases in development pressure?

No land-use pattern will be affected. However, improved aesthetics and recreational opportunities will positively impact the surrounding educational, commercial, and residential entities. There will be no increase in development pressure.

Will the project impact prime agricultural land or activities?

No agricultural land is affected by the project.

Will the project adversely affect parkland, public, or scenic land?

There will be some visual and noise impacts during the transitory period of restoration activities. However, lake restoration will provide long-term enhancement of the environmental, aesthetic, and recreational values in the general area.

Will there be adverse impacts to historical, architectural, archaeological, or cultural resources?

There are no known lands or structures of historical, architectural, archaeological, or cultural significance in the project area.

Will the project entail long-range increases in energy demand?

Once the major components of the restoration scheme are implemented, there will be no activity requiring excessive energy use in the operation and maintenance of the lake system.

Are changes in ambient air quality expected?

Because the project area is in a highly industrialized region of Indiana and Illinois, changes in air quality due to the operation of the diesel-powered dredge may not be perceptible.

Are there any adverse effects due to chemical treatment?

No long-term adverse impacts are expected from the proper application of 2,4-D to eradicate Eurasian water milfoil. Laboratory tests suggest that 2,4-D application at approved dosages is not toxic to tested fish and does not bioaccumulate at significant levels in the bodies of those fish. However, certain macroinvertebrates, such as *Daphnia* and midges, may be affected by some formulations, especially liquid esters at label application rates (Wisconsin Department of Natural Resources, 1990). Adverse impacts to aquatic life from 2,4-DCP (a breakdown product of 2,4-D) have not been documented in the field. Because 2,4-D is selective for water milfoil when applied at the proper rate and time, nontargeted plants will not be adversely affected, and low levels of carcinogenic impurities detected in some 2,4-D sample are of negligible risk to human health. Furthermore, it is believed that no significant risk will occur to recreational users from exposure to water treated with 2,4-D (Wisconsin Department of Natural Resources, 1990).

Does the management plan comply with Executive Order (E.O.) 11988 on floodplain management?

The restoration of Wolf Lake does not involve any activities in floodplains and consequently does not infringe on E.O. 11988.

Will the dredged material be discharged into the waters of the United States?

The dredged materials will not be discharged into any waterway.

Are any adverse effects on wetlands and related resources anticipated?

The small parcels of wetland on the south side of the lake and south of Wolf Lake Channel will not be affected by the lake improvement activities.

Have all the feasible alternatives been considered?

All the relevant and applicable management options were considered and discussed, and appropriate suggestions and recommendations have been made.

Are there other mitigative measures required?

The pros and cons of various alternatives have been considered, and the need for no other mitigative measure should arise. Proper management of stormwater outfalls from the Hammond Sanitary District is required.

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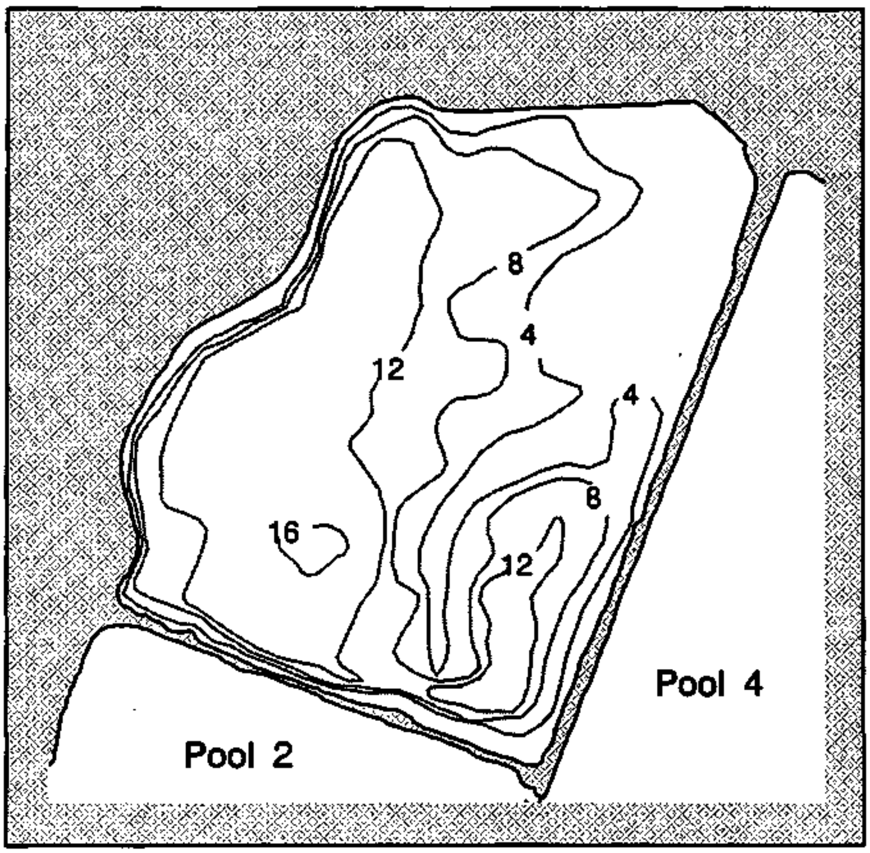
Appendix A. Bathymetric Maps of Wolf Lake

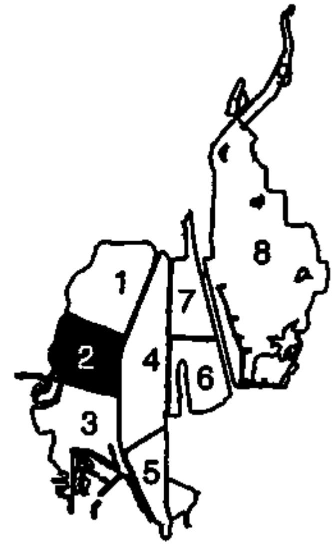
Pool 1 of Wolf Lake
Cook County, Illinois

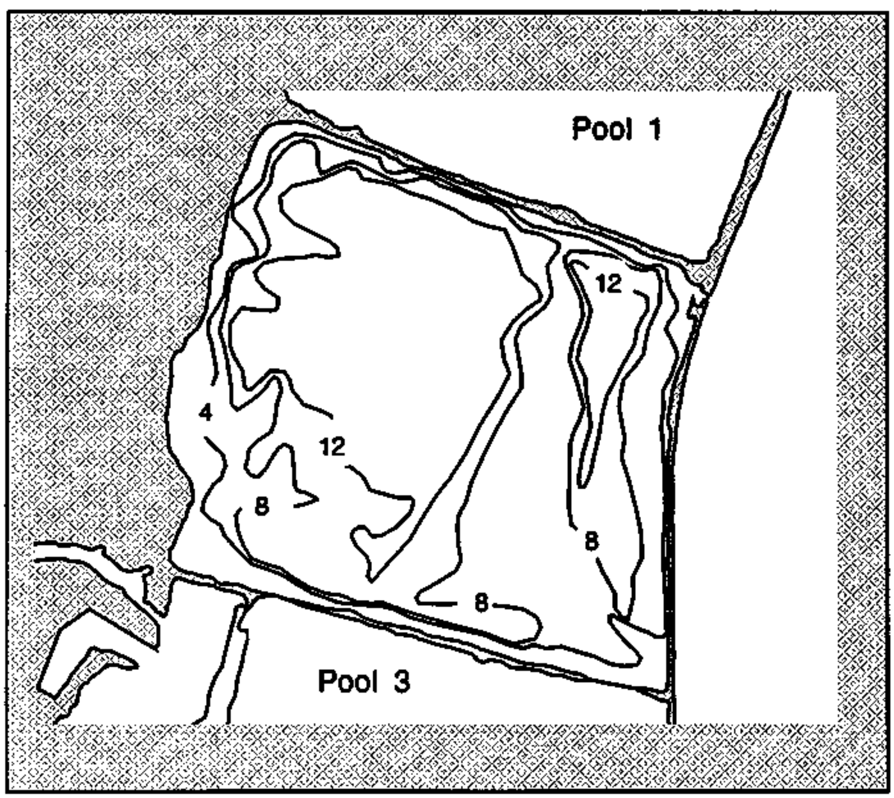


Contour interval = 4 feet

Pool 2 of Wolf Lake

Cook County, Illinois





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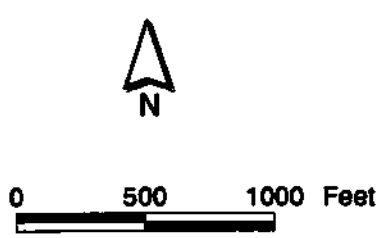
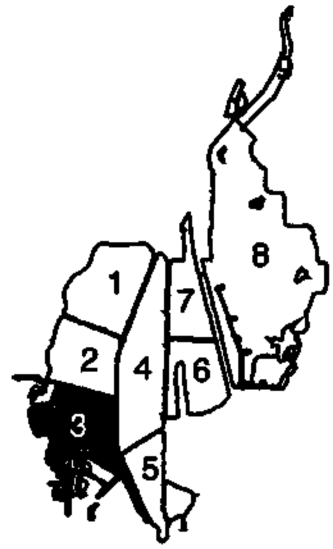
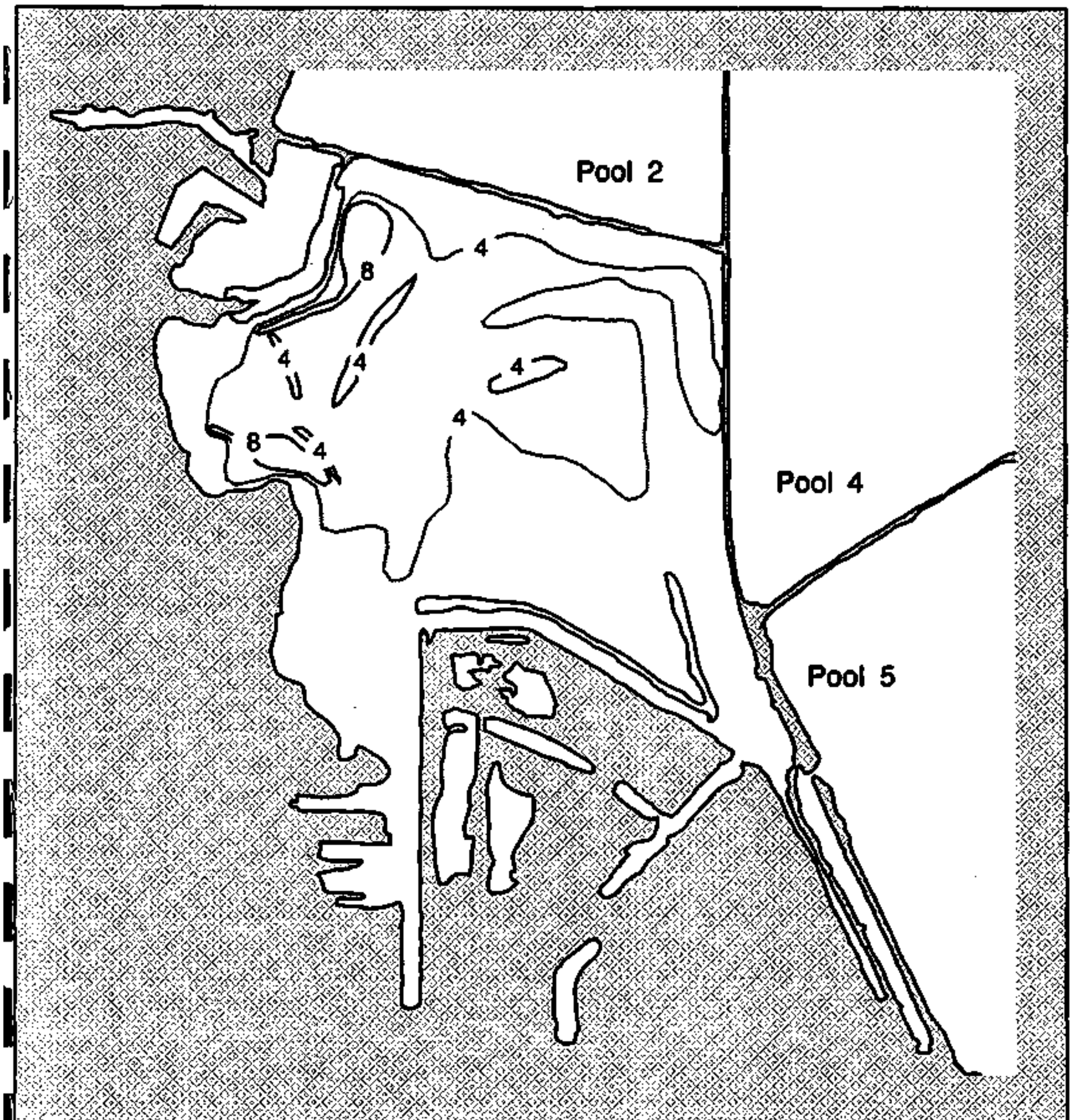


Pool 3 of Wolf Lake
Cook County, Illinois





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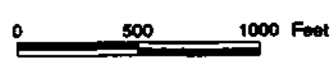
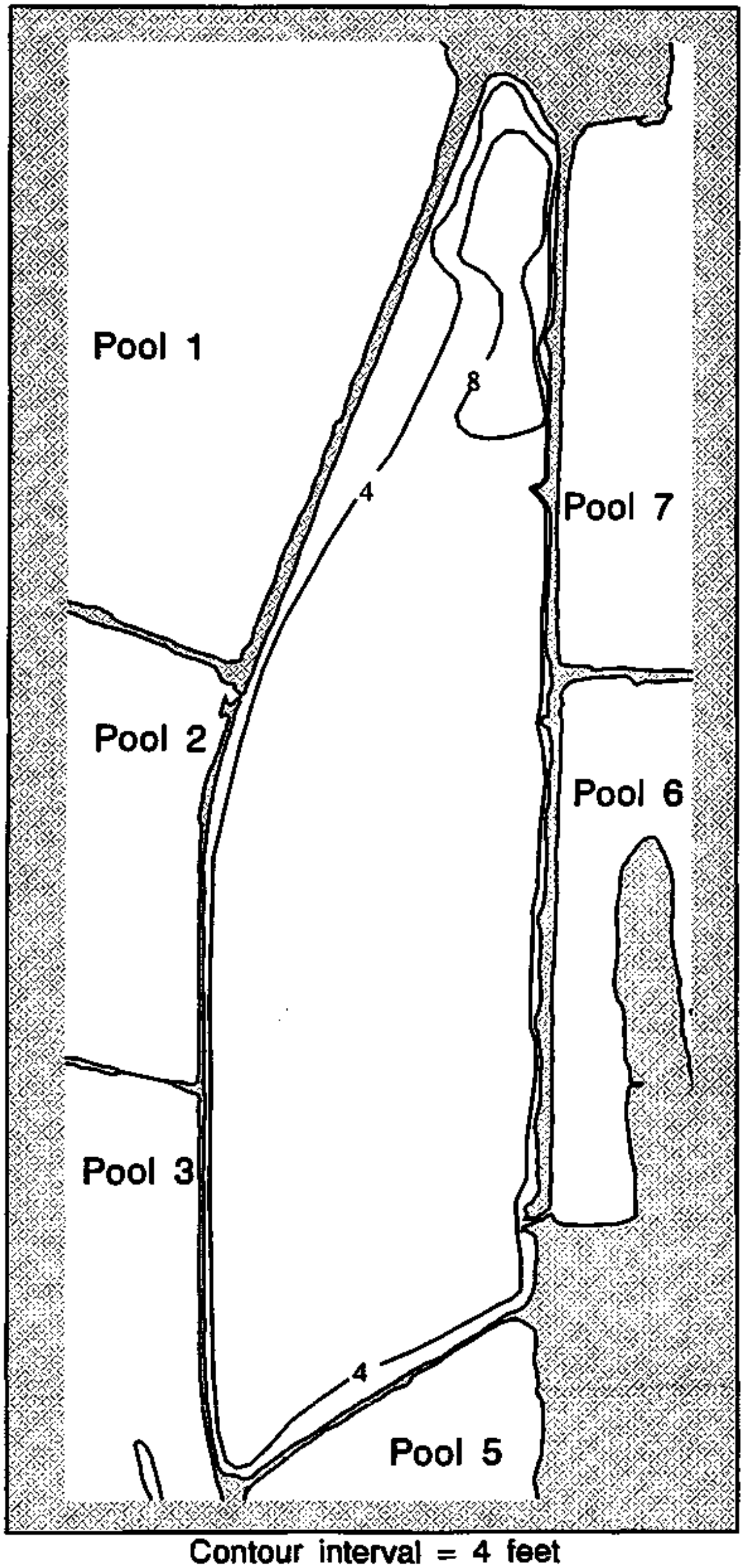


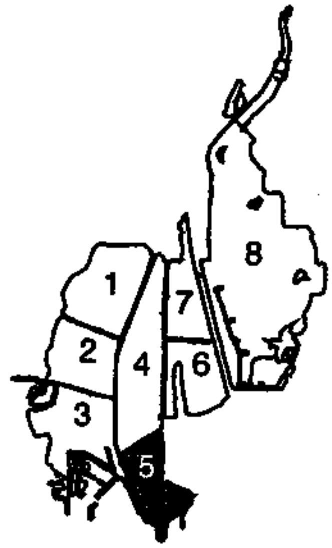
Pool 4 of Wolf Lake
Cook County, Illinois

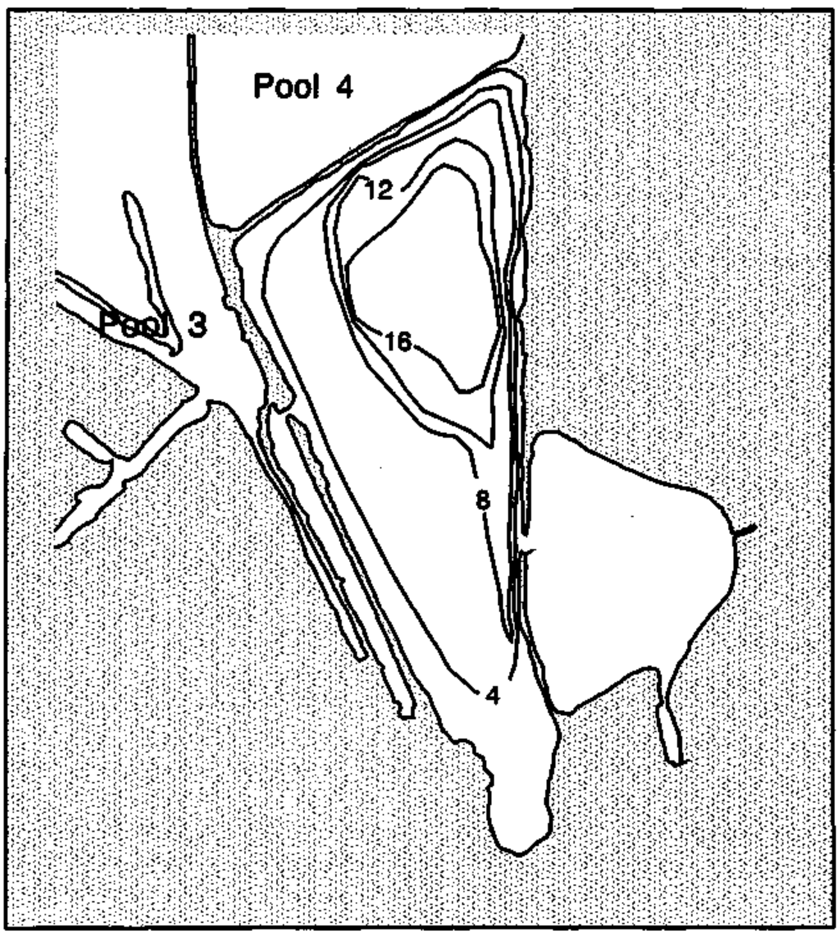


Contour interval = 4 feet

Pool 5 of Wolf Lake

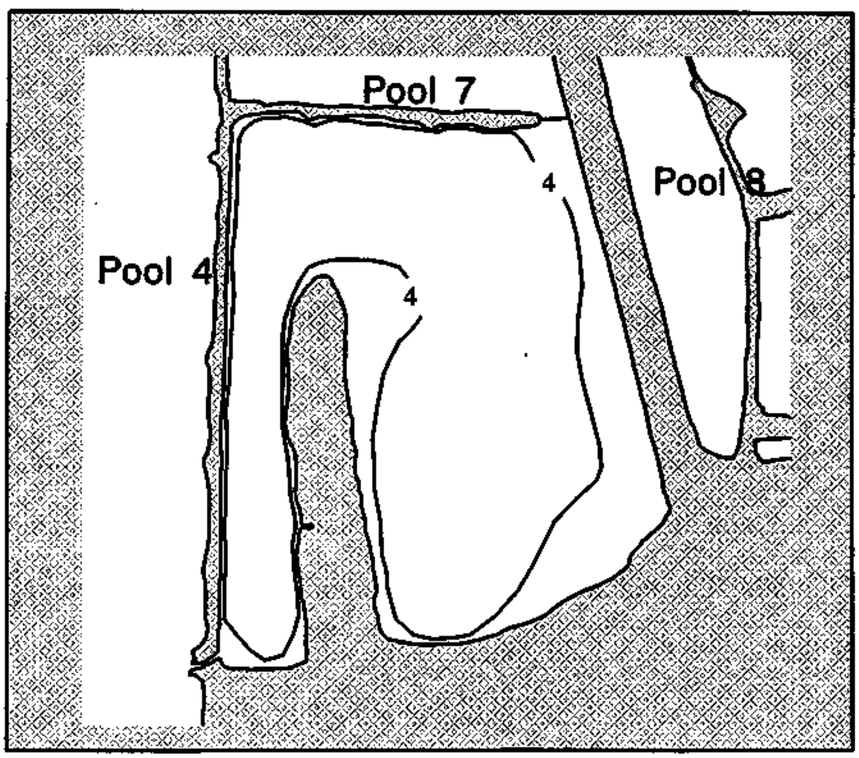
Cook County, Illinois



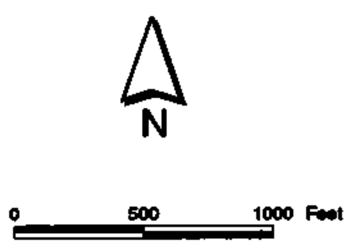


Contour interval = 4 feet

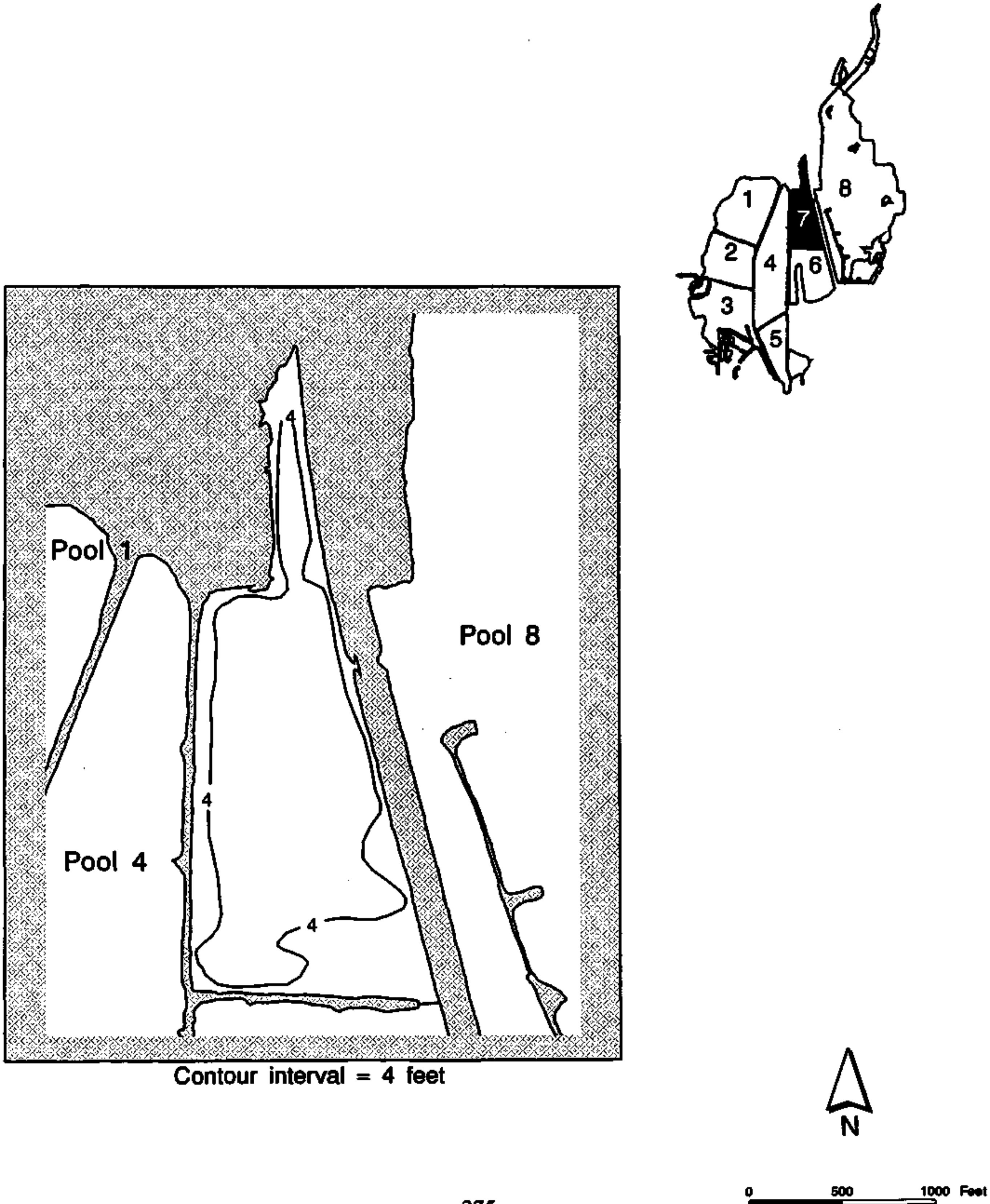
Pool 6 of Wolf Lake
Lake County, Indiana



Contour interval = 4 feet

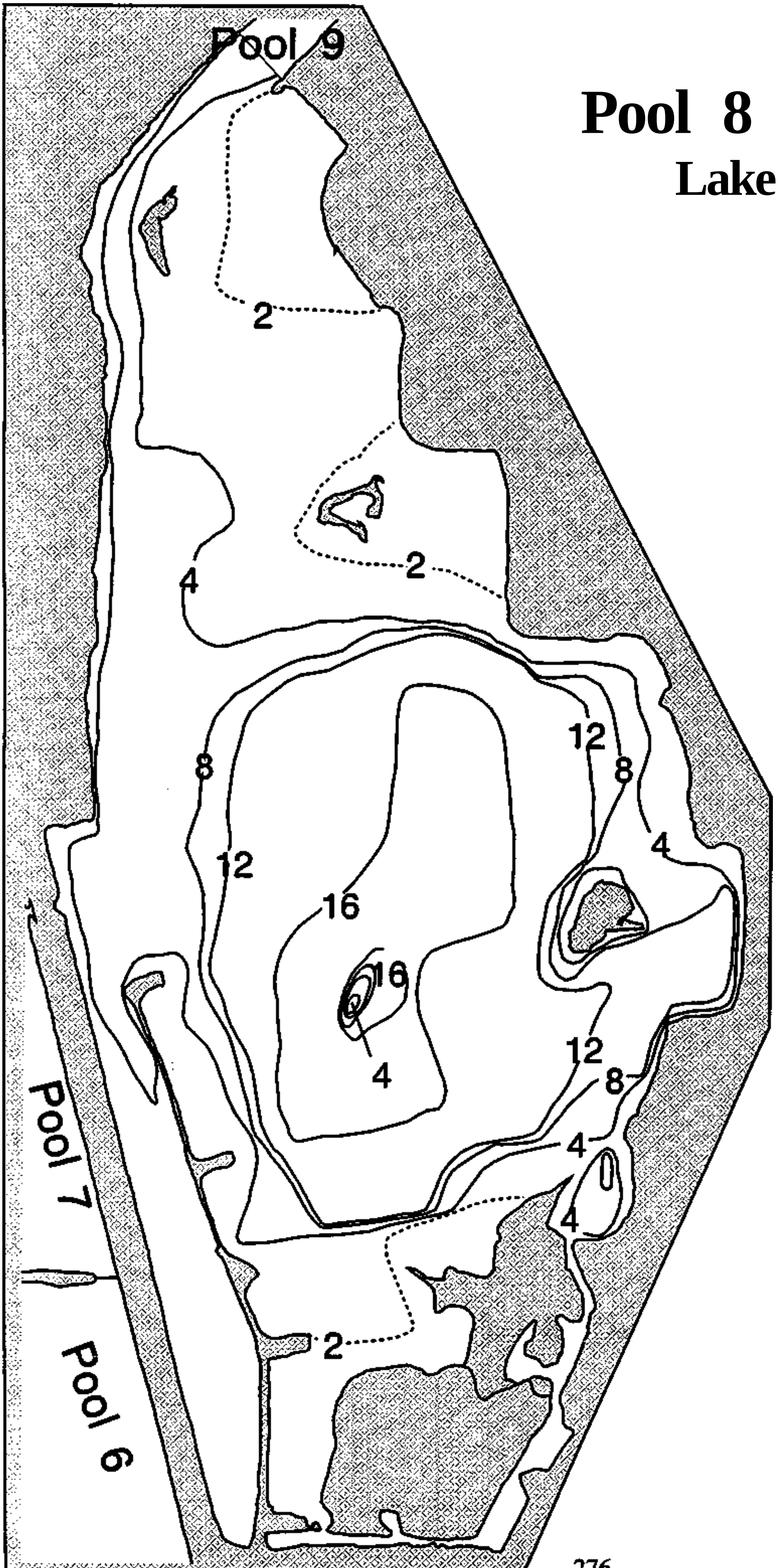


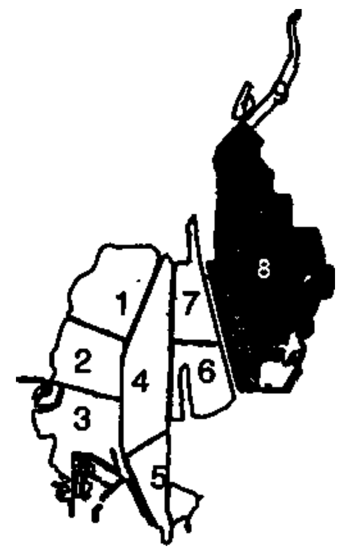
Pool 7 of Wolf Lake
Lake County, Indiana

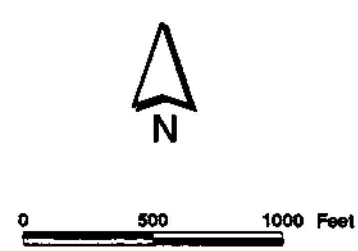


Pool 8 of Wolf Lake

Lake County, Indiana



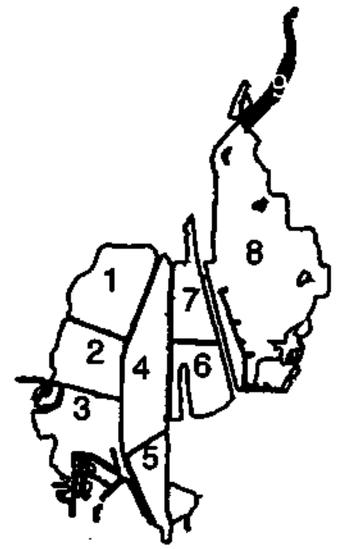


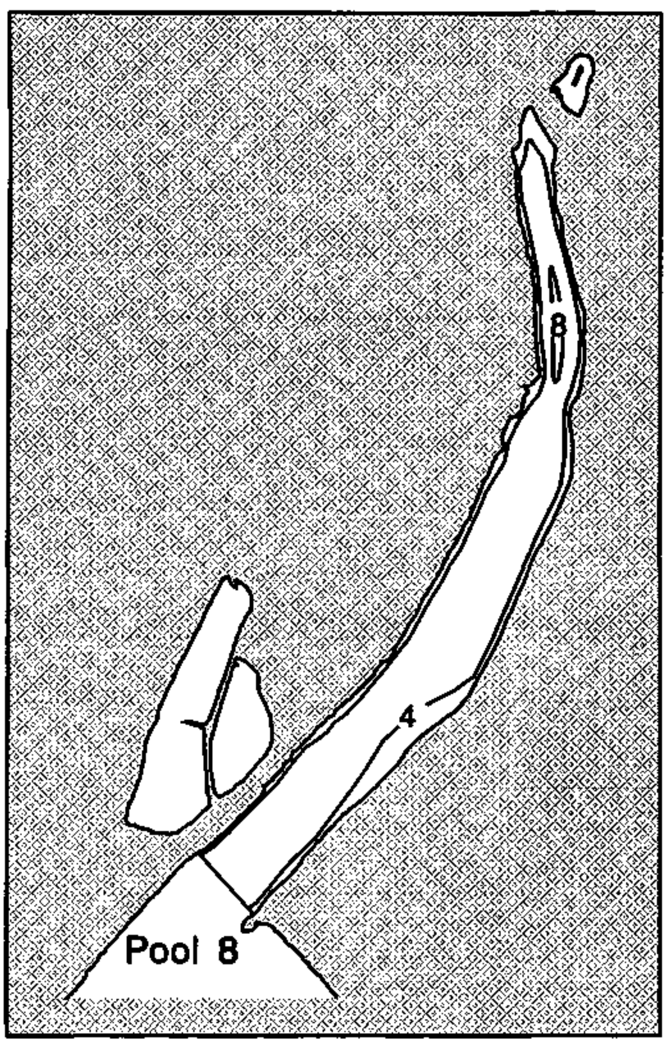


Contour interval = 4 feet

Pool 9 of Wolf Lake

Lake County, Indiana





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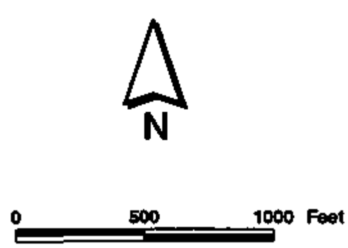


Appendix B. Ambient Lake Monitoring Data for Wolf Lake

Appendix B. Ambient Lake Monitoring Data for Wolf Lake

Station Code	Sample Date	Sample Time	Sample Depth (It.)	Turbidity (NTU)	Secchl Trans. (In.)	Cond- udMty (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (mg/L CaC03)	Phenoph. Alkalinity (moA CeC03)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total KlekJahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos- phorus (mg/L)	DIaiolved Phos- phorus (mg/L)	Total Depth (ft.)
RH-A06-A-1	08/04/77	1200	0		104	670		8.60	92		9		0.02		0.0	0.040		
RH-A06-A-1	05/09/91	1125	1	1	159	573	23.00	7.60	108	0	3	3	0.13	0.70	0.3	0.006	0.002	15.0
RH-A06-A-1	06/11/91	1340	1	1	158	563	16.00	8.30	120	2	3	1	0.09	0.50	0.2	0.006	0.006	15.5
RH-A06-A-1	07/16/91	1250	1	2	96	560	17.00	8.29	122	2	5	5	0.05	0.60	0.1 K	0.009		14.0
RH-A06-A-1	08/13/91	1215	1	1	108	566	19.00	8.34	140	3	5	5	0.04	0.60	0.1 K	0.007	0.007	14.0
RH-A06-A-1	10/08/91	820	1	1	144	570	19.00	8.19	110	0	2	2	0.12	0.50	0.1 K	0.013	0.007	12.0
RH-A06-A-1	10/13/92	1535	1	3	105	577	17.00	8.30	102	0	4	2	0.38	0.50	0.0 K	0.010	0.003	15.0
RH-A06-A-1	11/12/92	930	1	11	188	553	15.00	7.90	102	0	3	1	0.06	0.50	0.0	0.003	0.001 K	16.0
RH-A06-A-1	12/21/92	1140	1	3	131	568	14.00	7.70	180	0	1	1K	0.06	0.50	0.1	0.006	0.004	15.0
RH-A06-A-1	02/10/93	1040	1	0	168	540	14.00	7.38	100	0	1	1K	0.02	0.32	0.1	0.004	0.001 K	16.0
RH-A06-A-1	03/16/93	935	1	0	126	570	14.00	8.41	107	4	2	1K	0.05	0.58	0.2	0.008	0.001 K	16.0
RH-A06-A-1	04/13/93	935	1	0	91	600	17.00	8.44	106	2	4	2	0.01 K	0.10 K	0.2	0.006	0.001 K	16.0
RH-A06-A-1	05/10/93	930	1	13	132	530	16.00	8.30	112	0	3	1	0.03	0.76	0.1	0.005	0.001 K	16.5
RH-A06-A-1	05/26/93	925	1	4	95	550	14.00	8.39	114	0	2	1	0.01 K	0.73	0.1	0.001 K	0.001 K	16.0
RH-A06-A-1	06/09/93	1010	1		91	520	16.00	8.33	106	0	23	6	0.05	0.78	0.0	0.009	0.001 K	17.0
RH-A06-A-1	06/22/93	1030	1	4	151	530	16.00	8.58	107	4	3	2	0.07	0.74	0.0	0.003	0.003	17.0
RH-A06-A-1	07/07/93	1605	1	0	132		14.00	8.39	101	0	4	2	0.01 K	0.33	0.0	0.003	0.001 K	15.0
RH-A06-A-1	07/20/93	1945	1	0	118	560	14.00	8.68	105	2	2	1	0.02	0.31	0.0 K	0.004	0.001 K	16.0
RH-A06-A-1	08/04/93	1410	1	0	108	540	15.00	8.62	108	4	2	1	0.03	0.77	0.0 K	0.003	0.001 K	16.0
RH-A06-A-1	08/18/93	1640		10	163	520	17.00	8.75	102	3	1 K	1 K	0.01 K	0.47	0.0 K	0.001 K	0.001 K	16.0
RH-A06-A-1	09/08/93	900	1	1	144	520	16.00	8.40	100	1	2	1K	0.03	0.36	0.0 K	0.006	0.001	16.0
RH-A06-A-1	09/28/93	930	1	0	116	490	15.00	8.44	98	2	3	1	0.02	0.47	0.1	0.008	0.001	16.0
RH-A06-A-1	04/27/94	1220	1	2	126	565		8.24	120	0	1	1	0.10	0.50	0.2	0.016	0.015	14.0
RH-A06-A-1	08/21/94	1225	1	1	168	552		8.34	144	0	1 K	1 K	0.08	0.40	0.1	0.003	0.001	14.0
RH-A06-A-1	08/23/94	1400	1	1	81	536		8.55	116	4	2	2	0.02	0.50	0.1 K	0.006	0.002	15.0
RH-A06-A-1	10/04/94	1407	1	2	120	524		8.57	100	0	2	1K	0.01	0.90	0.1 K	0.016	0.010	14.0
RH-A06-A-1	05/09/91	1125	13	1		576	14.00	7.70	116	0	6	5	0.15	0.60	0.3	0.008	0.003	15.0
RH-A06-A-1	10/13/92	1535	13	3		579	16.00	8.30	101	0	3	2	0.37	0.40	0.0 K	0.009	0.002	15.0
RH-A06-A-1	11/12/92	930	14	4		559	18.00	8.00	101	0	2	1	0.03	0.50	0.0	0.005	0.001 K	16.0
RH-A06-A-1	12/21/92	1140	13	3		569	13.00	7.80	180	0	1	1 K	0.05	0.60	0.1	0.007	0.002	15.0
RH-A06-A-1	02/10/93	1040	14	0		540	15.00	7.35	103	0	1 K	1 K	0.03	0.29	0.2	0.018	0.001 K	16.0
RH-A06-A-1	03/16/93	935	14	0		570	17.00	8.53	110	4	3	1	0.04	0.56	0.2	0.010	0.002	16.0
RH-A06-A-1	04/13/93	935	14	0		570	17.00	8.47	106	1	3	2	0.01 K	0.59	0.2	0.006	0.001 K	16.0
RH-A06-A-1	05/10/93	930	14	2		640	17.00	8.24	90	0	4	2	0.02	0.67	0.2	0.004	0.001 K	16.5
RH-A06-A-1	05/26793	925	14	3		550	16.00	8.31	114	0	3	2	0.01 K	0.66	0.1	0.007	0.001 K	16.0
RH-A06-A-1	06/09/93	1010	15			520	17.00	8.38	106	1	7	2	0.11	0.86	0.0	0.011	0.007	17.0
RH-A06-A-1	06/22/93	1030	15	2		520	15.00	8.33	103	0	3	2	0.01 K	0.94	0.0	0.007	0.001 K	17.0
RH-A06-A-1	07/07/93	1650	15	0			16.00	8.23	105		5	3	0.01 K	0.32	0.0 K	0.005	0.001 K	17.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (fl.)	Turbidity (NTU)	Secchl Trans. (In.)	Cond- uctlvlty (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total AkalMy (mg/L CaC03)	Phenoph. AfcaMty (mg/L CaC03)	Total Susp. Solids (mg/L)	Volatile Suap. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total KjekJahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos- phorus (mg/L)	Dissolved Phos- phorus (mg/L)	Total Depth (ft.)
RH-A06-A-1	07/20/93	1945	14	0		400	17.00	6.73	106	4	11	10	0.02	0.26	0.0 K	0.020	0.001 K	16.0
RH-A06-A-1	08/04/93	1410	14	1		530	15.00	6.60	102	4	10	3	0.15	0.75	0.0 K	0.001	0.001 K	16.0
RH-A06-A-1	08/18/93	1640	14	0		510	16.00	8.74	102	4	6	2	0.01 K	0.48	0.0	0.001	0.001 K	16.0
RH-A06-A-1	09/08/93	900	14	0		500	17.00	8.40	100	1	2	1	0.02	0.66	0.0	0.010	0.003	16.0
RH-A06-A-1	09/28/93	930	14	2		370	25.00	8.40	101	1	23	17	0.01 K	0.71	0.0	0.039	0.001 K	16.0
RH-A06-A-1	04/27/94	1220	12	2		563		8.28	120	0	3	3	0.10	0.50	0.3	0.026	0.009	14.0
RH-A06-A-1	06/21/94	1225	12	2		553		8.35	128	0	1	1 K	0.08	0.30	0.1	0.006	0.001	14.0
RH-A06-A-1	08/23/94	1400	13	1		541		6.61	128	8	1	1	0.02	0.50	0.1 K	0.006	0.003	15.0
RH-A06-A-1	10/04/94	1407	12	2		526		8.57	108	0	2	1K	0.01	0.50	0.1 K	0.012	0.012	14.0
RH-A06-A-2	08/04/77	1200	0		35	400		8.60	82		12	10	0.01		0.0	0.040		
RH-A06-A-2	06/12/79	1430	1	14							43	28	0.02	1.50	0.0	0.080	0.000	
RH-A06-A-2	08/17/79	1000	1	15	12	860		8.70	70	10	26	25	0.00	1.00	0.0	0.100	0.000	13.0
RH-A06-A-2	05/02/89	1250	1	4	72	383	12.00	8.10	126	0	4	4	0.05	0.50	0.4	0.011	0.007	14.0
RH-A06-A-2	06/12/89	1205	1	4	48	280	15.00	9.10	82	14	2	2	0.11	0.50	0.1 K	0.015	0.007	14.5
RH-A06-A-2	07/20/89	1100	1	5	26	298	24.00	9.20	66	10	12	11	0.03	0.60	0.1 K	0.029	0.009	14.5
RH-A06-A-2	08/24/89	1030	16		34	284	25.00	9.00	70	10	6	6	0.02	0.60	0.1 K	0.028	0.005	13.0
RH-A06-A-2	10/04/89	1615	1	3	38	290	19.00	8.80	69	8	4	4	0.04	0.60	0.1 K	0.016	0.006	14.0
RH-A06-A-2	05/09/91	1215		12	99	407	12.00	8.30	100	2	4	4	0.04	0.50	0.2	0.010	0.005	12.0
RH-A06-A-2	06/11/91	1420	1	3	72	370	19.00	8.50	94	4	7	3	0.14	0.70	0.1 K	0.015	0.008	13.0
RH-A06-A-2	07/16/91	1330	1	5	39	366	22.00	8.78	86	8	12	10	0.02	0.60	0.1 K	0.019	0.006	13.5
RH-A06-A-2	08/13/91	1240	1	7	26	352	27.00	8.86	140	30	16	8	0.03	0.80	0.1 K	0.024	0.005	13.0
RH-A06-A-2	10/08/91	850	1	12	18	345	32.00	8.35	92	0	17	16	0.08	0.80	0.1 K	0.046	0.011	12.0
RH-A06-A-2	10/13/92	1630		13	35	336	18.00	8.10	102	1 K	B	6	0.36	0.70	0.0 K	0.027	0.005	14.0
RH-A06-A-2	11/12/92	1055		12	84	344	15.00	7.90	107	0	4	2	0.08	0.50	0.1	0.010	0.001 K	16.0
RH-A06-A-2	12/21/92	1030	1	3	131	364	11.00	7.90	116	0	1	1 K	0.13	0.50	0.2	0.011	0.003	15.0
RH-A06-A-2	01/19/93	1120	1	0	82	400	9.00	8.08	117	0	2	1	0.18	0.65	0.3	0.007	0.001	15.5
RH-A06-A-2	02/10/93	840		10	91	410	12.00	7.75	113	0	2	2	0.11	0.43	0.3	0.015	0.001 K	15.0
RH-A06-A-2	03/16/93	1105	1	1	85	420	14.00	8.34	117	1	5	3	0.05	0.51	0.4	0.011	0.001 K	15.0
RH-A06-A-2	04/13/93	1040	1	0	66	430	12.00	8.22	110	0	4	2	0.02	0.43	0.4	0.010	0.001 K	16.0
RH-A06-A-2	05/10/93	1000	1	4	51	470	15.00	8.28	120	0	6	3	0.04	0.81	0.2	0.023	0.001 K	14.0
RH-A06-A-2	05/26/93	1040	1	5	62	460	14.00	8.58	112	1	8	4	0.01 K	0.89	0.1	0.020	0.001	14.0
RH-A06-A-2	06/09/93	1225	1	5	46	390	17.00	8.55	89	1	10	6	0.04	0.93	0.0	0.026	0.001 K	15.0
RH-A06-A-2	06/22/93	1140	1	2	56	370	15.00	9.13	74	8	16	11	0.09	0.86	0.0 K	0.021	0.001 K	16.0
RH-A06-A-2	07/07/93	1650	1	3	42		16.00	9.04	67	2	6	6	0.01 K	0.43	0.0 K	0.014	0.001 K	16.0
RH-A06-A-2	07/20/93	1815	1	0	36	410	18.00	9.30	7	8	15	13	0.01	0.32	0.0 K	0.019	0.001 K	16.0
RH-A06-A-2	07/23/93	1815	1						70									
RH-A06-A-2	08/04/93	1455	1	8	36	390	18.00	9.00	76	8	11	8	0.01 K	0.72	0.0 K	0.022	0.001 K	14.0
RH-A06-A-2	00/18/93	1720	1	0	37	380	20.00	9.38	70	10	8	2	0.03	0.45	0.0 K	0.010	0.001 K	15.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Secchl Trans. (In.)	Cond-uctlvily (umho/em)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (mg/L CaCO3)	Phenoph. Alkalinity (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total Kjektahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos-phorus (mg/L)	Dissolved Phos-phorus (mg/l)	Total Depth (ft.)
RH-A06-A-2	09/08/93	950	1	14	27	370	25.00	8.85	80	5	23	16	0.01 K	0.62	0.0 K	0.036	0.005	15.0
RH-A06-A-2	09/28/93	1020	1	1	25	380	25.00	8.67	88	2	20	10	0.01 K	0.91	0.0	0.029	0.001 K	15.0
Rh-A06-A-2	04/27/94	1145		19	36	465		8.11	132	0	9	6	0.08	1.00	0.1	0.035	0.009	13.0
RH-A06-A-2	06/21/94	1200	1	6	51	425		8.54	124	8	5	3	0.01	0.60	0.1 K	0.015	0.003	14.0
RH-A06-A-2	08/23/94	1313	1	16	18	367		8.81	120	12	17	14	0.02	1.10	0.1 K	0.029	0.002	12.5
RH-A06-A-2	10/04/94	1334	1	12	24	343		8.77	108	8	13	8	0.01	0.70	0.1 K	0.031	0.012	11.5
RH-A06-A-2	08/17/79	1000	11	16		830		8.80	65	5	26	23	0.00	0.90	0.1	0.090	0.000	
RH-A06-A-2	05/02/89	1250	99	5		382	14.00	8.20	126	0	4	4	0.04	0.50	0.3	0.015	0.007	14.0
RH-A06-A-2	08/24/89	1030	11	6		284	28.00	8.50	74	8	6	6	0.02	0.60	0.1 K	0.021	0.007	13.0
RH-A06-A-2	10/04/89	1615	12	4		291	22.00	8.90	80	12	6	6	0.06	0.60	0.1 K	0.020	0.006	14.0
RH-A06-A-2	06/11/91	1420	11	5		371	19.00	8.30	86	2	6	3	0.13	0.70	0.1 K	0.026	0.005	13.0
RH-A06-A-2	07/16/91	1330	12	4		374	24.00	8.10	88	0	12	10	0.03	0.80	0.1 K	0.024	0.007	13.5
RH-A06-A-2	08/13/91	1240	11	8		368	28.00	8.12	140	0	17	10	0.02	0.70	0.1 K	0.029	0.007	13.0
RH-A06-A-2	10/08/91	850	10	8		350	33.00	8.38	96	0	16	14	0.11	0.90	0.1 K	0.045	0.009	12.0
RH-A08-A-2	10/13/92	1630	12	4		337	18.00	8.10	100	0	7	6	0.34	0.60	0.0 K	0.027	0.002	14.0
RH-A06-A-2	11/12/92	1055	14	1		338	12.00	7.90	105	0	4	2	0.11	0.50	0.1	0.011	0.001 K	16.0
RH-A06-A-2	12/21/92	1030	13	3		362	11.00	7.90	115	0	1	1 K	0.14	0.60	0.2	0.011	0.003	15.0
RH-A06-A-2	01/19/93	1120	14	0		390	10.00	8.02	115	0	3	2	0.20	0.62	0.3	0.009	0.005	15.5
RH-A06-A-2	02/10/93	840	13	0		400	13.00	7.70	112	0	2	2	0.07	0.38	0.3	0.008	0.001 K	15.0
RH-A06-A-2	03/16/93	1105	13	0		420	13.00	8.52	115	4	3	1K	0.03	0.49	0.4	0.011	0.001	15.0
RH-A06-A-2	04/13/93	1040	14	0		430	12.00	8.18	110	0	2	1 K	0.09	0.66	0.3	0.013	0.001 K	16.0
RH-A06-A-2	05/10/93	1000	12	5		500	15.00	8.17	118	0	12	6	0.03	0.89	0.3	0.036	0.001	14.0
RH-A06-A-2	05/26/93	1040	12	2		450	16.00	8.52	113	1	8	5	0.01 K	1.08	0.1	0.024	0.001	14.0
RH-A06-A-2	06/09/93	1225	13	4		400	16.00	8.50	88	1	12	6	0.03	1.06	0.0	0.024	0.004	15.0
RH-A06-A-2	06/22/93	1140	14	2		380	17.00	8.56	82	1	7	5	0.01 K	0.97	0.0 K	0.023	0.001 K	16.0
RH-A06A-2	07/07/93	1650	14	5			18.00	7.88	72		14	8	0.01 K	0.35	0.0 K	0.027	0.001 K	16.0
RH-A06-A-2	07/20/93	1815	14	0		380	14.00	8.74	72	2	21	17	0.02	0.45	0.0 K	0.023	0.002	16.0
RH-A06-A-2	08/04/93	1455	12	7		380	20.00	8.95	75	6	20	13	0.03	0.67	0.0 K	0.026	0.001 K	14.0
RH-A06-A-2	08/18/93	1720	13	0		390	23.00	7.90	88	0	6	1	0.01 K	0.55	0.0 K	0.030	0.001	15.0
RH-A06-A-2	09/08/93	950	13	9		370	27.00	8.80	79	4	15	12	0.03	0.58	0.0 K	0.034	0.002	15.0
RH-A06-A-2	09/28/93	1020	13	0		500	14.00	8.65	87	2	1	1 K	0.01 K	0.42	0.1	0.005	0.001 K	15.0
RH-A06-A-3	08/04/77	1200	0		34	420		9.00	76		2		0.02		0.0	0.000		
RH-A06-A-3	06/12/79	1130	1	18							40	24	0.02	1.50	0.0	0.090	0.000	
RH-A06-A-3	05/02/89	1340	1	2	120	369	11.00	8.30	100	6	2	2	0.04	0.50	0.2	0.013	0.007	13.0
RH-A06-A-3	06/12/89	1315	1	1	100	337	12.00	9.00	76	10	1 K	1 K	0.08	0.50	0.1 K	0.011	0.005	13.0
RH-A06-A-3	07/20/89	1130	1	3	41	310	22.00	8.40	66	7	11	11	0.03	0.60	0.1 K	0.022	0.008	15.5
RH-A06-A-3	08/24/89	1115	1	5	30	316	28.00	8.60	84	6	6	5	0.02	0.60	0.1 K	0.017	0.009	13.0
RH-A06-A-3	10/04/89	1700	1	3	48	295	24.00	8.90	86	6	4	4	0.04	0.60	0.1 K	0.022	0.006	13.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Secchl Trans. (in.)	Cond- uctMty (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total AlkalInlty (mg/L CaCO3)	Phanoph. AlkalInlty (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos- phorus (mg/L)	Dissolved Pros- phorus (mg/L)	Total Depth (lt.)
RH-A06-A-3	05/09/91	1245	1	2	105	440	13.00	8.30	106	2	6	6	0.04	0.50	0.2	0.012	0.005	13.0
RH-A06-A-3	06/11/91	1445	1	2	66	395	18.00	8.60	89	4	7	2	0.08	0.70	0.1 K	0.017	0.011	13.0
RH-A06-A-3	07/16/91	1410	1	5	40	386	23.00	8.81	90	10	5	2	0.05	0.80	0.1 K	0.022	0.007	13.5
RH-A06-A-3	08/13/91	1315	1	13	26	369	27.00	8.88	150	30	13	5	0.12	0.80	0.1 K	0.026	0.016	13.0
RH-A06-A-3	10/08/91	930	1	7	24	358	29.00	8.45	102	0	10	9	0.12	0.70	0.1 K	0.031	0.010	4.5
RH-A06-A-3	10/13/92	1715	1	4	51	346	19.00	8.10	99	0	5	2	0.32	0.60	0.0 K	0.026	0.004	11.0
RH-A06-A-3	11/12/92	1130	1	1	91	353	17.00	7.70	106	0	3	2	0.10	0.50	0.1	0.008	0.001 K	14.0
RH-A06-A-3	12/21/92	825	1	3	129	393	11.00	7.80	121	0	2	1 K	0.17	0.70	0.2	0.007	0.002	13.0
RH-A06-A-3	01/19/93	1005	1	1	97	410	12.00	8.03	117	0	2	1K	0.17	0.66	0.3	0.006	0.001	13.5
RH-A06-A-3	02/10/93	950	1	1	130	400	12.00	7.77	110	0	4	3	0.06	0.31	0.3	0.008	0.001 K	13.0
RH-A06-A-3	03/16/93	1230	10		113	420	12.00	8.43	111	2	4	2	0.04	0.48	0.4	0.005	0.001	13.0
RH-A06-A-3	04/13/93	1155	10		84	440	12.00	8.14	110	0	4	2	0.03	0.61	0.3	0.010	0.001	13.0
RH-A06-A-3	05/10/93	1040	1	3	74	450	14.00	8.28	112	0	3	1	0.03	0.70	0.3	0.012	0.001 K	12.0
RH-A06-A-3	05/26/93	1200	1	1	102	430	13.00	8.66	104	4	3	2	0.01 K	0.83	0.1	0.015	0.002	13.0
RH-A06-A-3	06/09/93	1307	1	1	62	370	11.00	8.57	83	1	8	4	0.03	0.96	0.0	0.017	0.003	14.0
RH-A06-A-3	06/22/93	1225	1	2	81	380	14.00	9.17	114	5	6	5	0.01 K	0.68	0.0 K	0.010	0.001 K	14.0
RH-A06-A-3	07/07/93	1730	1	3	60		16.00	9.16	74	5	6	4	0.01 K	0.29	0.0 K	0.013	0.001 K	14.0
RH-A06-A-3	07/20/93	1900	1	0	49	540	18.00	9.17	72	6	2	2	0.01	0.53	0.0 K	0.008	0.001	13.0
RH-A06-A-3	08/04/93	1550	1	6	42	390	19.00	8.92	75	4	29	14	0.02	0.68	0.0 K	0.021	0.001 K	13.0
RH-A06-A-3	08/16/93	1805	10		36	370	23.00	9.30	77	11	16	8	0.01 K	0.60	0.0 K	0.020	0.001 K	13.0
RH-A06-A-3	09/08/93	1040	17		36	390	23.00	8.52	85	2	18	10	0.01 K	0.59	0.0 K	0.030	0.003	13.0
RH-A06-A-3	09/28/93	1055	1	2	31	370	25.00	8.44	87	1	24	18	0.01 K	0.78	0.0	0.036	0.001 K	14.0
RH-A06-A-3	04/27/94	1125	1	5	66	468		7.97	140	0	5	3	0.10	0.70	0.1	0.025	0.011	6.0
RH-A06-A-3	06/21/94	1135	16		45	442		8.25	136	0	3	2	0.12	0.60	0.1 K	0.022	0.004	6.0
RH-A06-A-3	08/23/94	1226	1	16	14	379		8.80	128	4	13	13	0.02	0.80	0.1 K	0.032	0.002	14.0
RH-A06-A-3	10/04/94	1305	1	10	30	351		8.68	100	4	13	10	0.01	0.90	0.1 K	0.027	0.012	5.0
RH-A06-A-3	08/17/79	1100	4	20		800		8.80	75	5	35	27	0.00	1.20	0.0	0.100	0.010	9.0
RH-A06-A-3	10/13/92	1715	9	4		346	17.00	8.10	99	0	6	4	0.26	0.50	0.0 K	0.020	0.002	11.0
RH-A06-A-3	11/12/92	1130	12	1		358	15.00	7.90	106	0	2	2	0.08	0.50	0.0	0.009	0.001 K	14.0
RH-A06-A-3	12/21/92	825	11	2		397	12.00	7.70	118	0	1	1 K	0.19	0.70	0.1	0.012	0.004	13.0
RH-A06-A-3	01/19/93	1005	12	1		430	10.00	7.80	110	0	1	1K	0.17	0.68	0.2	0.007	0.001	13.5
RH-A06-A-3	02/10/93	950	11	0		390	12.00	7.65	109	0	2	1K	0.12	0.20	0.3	0.009	0.001 K	13.0
RH-A06-A-3	03/16/93	1230	11	0		420	14.00	8.55	112	4	4	1	0.04	0.54	0.4	0.011	0.001 K	13.0
RH-A06-A-3	04/13/93	1155	11	0		460	12.00	8.14	110	0	2	2	0.04	0.66	0.3	0.010	0.001 K	13.0
RH-A06-A-3	05/10/93	1040	10	4		470	14.00	8.25	114	0	2	1	0.02	0.75	0.2	0.020	0.001	12.0
RH-A06-A-3	05/26/93	1200	11	1		430	14.00	8.57	103	2	5	2	0.01 K	0.90	0.1	0.015	0.004	13.0
RH-A06-A-3	06/09/93	1307	12	2		370	15.00	8.58	83	1	9	4	0.04	0.87	0.0	0.018	0.003	14.0
RKNA06-A-3	06/22/93	1225	12	2		350	14.00	8.97	79	8	2	2	0.01 K	0.67	0.0 K	0.023	0.001	14.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Secchl Trans. (in.)	Cond-uctlvity (umho/cm)	Chemical Oxygen Demand (mg/L.)	pH	Total Alkalinity (mg/L CaCO3)	Phenoph. Alkalinity (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mgA)	Total kjeldahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mgA)	Total Phos-phorus (mg/L)	Dissolved Phos-phorus (mg/L)	Total Depth (ft.)
RH-A06-A-3	07/07/93	1730	12	4			17.00	8.83	75	3	8	5	0.01 K	0.40	0.0 K	0.014	0.001 K	14.0
RH-A06-A-3	07/20/93	1900	11	0		400	20.00	8.95	75	0	10	8	0.01 K	0.66	0.0 K	0.025	0.001	13.0
RH-A06-A-3	08/04/93	1550	11	7		390	19.00	8.70	77	4	30	13	0.04	0.73	0.0 K	0.026	0.001 K	13.0
RH-A06-A-3	08/18/93	1805	11	1		380	21.00	7.98	81	0	11	4	0.01 K	0.46	0.0 K	0.026	0.001 K	13.0
RH-A06-A-3	09/08/93	1040	11	6		390	24.00	8.50	83	1	16	9	0.02	0.44	0.0 K	0.030	0.003	13.0
RH-A06-A-3	09/28/93	1055	12	2		380	23.00	8.44	90	1	20	15	0.01 K	0.76	0.0	0.033	0.001 K	14.0
RH-A06-A-4	10/13/92	1500	14		34		17.00	8.30	104	0	9	6	0.33	0.60	0.0 K	0.028	0.002	11.0
RH-A06-A-4	11/12/92	1340	11		64	336	15.00	7.80	110	0	9	5	0.14	0.40	0.1	0.016	0.002	11.0
RH-A06-A-4	12/21/92	1435	12		134	363	9.00	7.80	118	0	1 K	1 K	0.18	0.67	0.2	0.009	0.002	11.0
RH-A06-A-4	01/19/93	1340	1	0	75	380	9.00	8.03	118	0	2	1	0.18	0.58	0.3	0.006	0.001 K	12.0
RH-A06^A-4	02/10/93	1225	1	1	123	380	10.00	7.75	114	0	2	1	0.07	0.42	0.3	0.007	0.001 K	11.0
RH-A06-A-4	03/16/93	1415	10		84	420	14.00	6.48	114	2	4	1	0.06	0.46	0.4	0.011	0.001 K	11.0
RH-A06-A-4	04/13/93	1310	10		61	440	12.00	8.24	112	0	4	2	0.03	0.95	0.3	0.011	0.001 K	11.0
RH-A06-A-4	05/10/93	1155	1	5	42	470	17.00	8.24	81	0	9	4	0.06	0.82	0.2	0.021	0.001 K	11.5
RH-A06-A-4	05/26/93	1310	1	2	62	450	17.00	8.52	109	1	7	4	0.01 K	0.99	0.1	0.022	0.004	11.0
RH-A06-A-4	06/09/93	1450	1	4	40	380	18.00	8.38	88	1	17	10	0.02	0.93	0.0	0.031	0.002	12.0
RH-A06-A-4	06/22/93	1330	1	2	67	320	15.00	9.28	68	8	8	6	0.01 K	0.90	0.0 K	0.020	0.001 K	12.0
RH-A06-A-4	07/07/93	1505		15	35		18.00	9.07	66	4	9	7	0.20	0.37	0.0 K	0.021	0.001 K	12.0
RH-A06-A-4	07/20/93	1730	1	1	30	400	17.00	9.33	70	8	6	6	0.04	0.35	0.0 K	0.019	0.003	12.0
RH-A06-A-4	08/04/93	1310	1	9	29	4	21.00	8.97	76	6	27	16	0.01 K	0.84	0.0 K	0.028	0.001 K	10.0
RH-A06-A-4	08/18/93	1540	1	0	30	350	22.00	9.50	67	11	5	2	0.01 K	0.62	0.0 K	0.019	0.001 K	11.0
RH-A06-A-4	09/08/93	1150	1	14	21	360	30.00	8.95	78	4	25	21	0.01 K	0.38	0.0 K	0.041	0.003	11.0
RH-A06-A-4	09/28/93	1200		14	22	360	25.00	8.68	88	3	30	20	0.01 K	0.74	0.0	0.039	0.001 K	11.0
RH-A06-A-4	10/13/92	1500	9	4		338	18.00	8.30	103	0	9	6	0.41	0.80	0.0 K	0.030	0.001	11.0
RH-A06-A-4	11/12/92	1340	9	1		336	13.00	7.90	109	0	4	2	0.14	0.52	0.1	0.023	0.003	11.0
RH-A06-A-4	12/21/92	1435	9	3		370	11.00	8.00	120	0	1	1 K	0.18	0.70	0.2	0.010	0.003	11.0
RH-A06-A-4	01/19/93	1340	10	0		380	10.00	8.00	116	0	1	1 K	0.19	0.88	0.3	0.010	0.001 K	12.0
RH-A06-A-4	02/10/93	1225	9	0		390	10.00	7.68	116	0	3	1	0.08	0.41	0.3	0.009	0.001 K	11.0
RH-A06-A-4	03/16/93	1415	9	0		420	16.00	8.50	115	2	3	2	0.04	0.56	0.4	0.012	0.001	11.0
RH-A06-A-4	04/13/93	1310	9	0		440	11.00	8.25	113	0	6	4	0.06	0.74	0.3	0.011	0.001 K	11.0
RH-A06-A-4	05/10/93	1155	10	6		480	15.00	7.98	120	0	9	5	0.11	0.79	0.2	0.036	0.001 K	11.5
RH-A0&A-4	05/26/93	1310	9	3		450	17.00	8.50	110	0	8	5	0.04	1.19	0.1	0.024	0.003	11.0
RH-A08-A-4	06/09/93	1450	10	4		380	19.00	8.43	88	1	20	13	0.04	1.24	0.0	0.033	0.005	12.0
RH-A06-A-4	06/22/93	1330	10	2		330	20.00	8.99	71	5	9	6	0.01 K	1.13	0.0 K	0.031	0.002	12.0
RH-A06-A-4	07/07/93	1505	10	5			1900	8.92	67	1	15	9	0.22	0.45	0.0 K	0.024	0.001	12.0
RH-A06-A-4	07/20/93	1730	10	0		380	15.00	9.10	72	5	17	15	0.02	0.46	0.0 K	0.026	0.001	12.0
RH-A06-A-4	08/04/93	1310	8	9		380	22.00	8.95	71	4	27	19	0.02	0.78	0.0 K	0.030	0.001 K	10.0
RH-A06-A-4	08/18/93	1540	9	0		360	25.00	8.73	81	1	10	4	0.03	0.56	0.0 K	0.033	0.001	11.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft)	Turbidity (NTU)	Secchl Trans. (in.)	Cond-uctivlty (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (moA CaCO3)	Phenoph. Alkeinlty (mot CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total Kjektahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mgrL)	Total Phos-phorus (mg/L)	Dissolved Phos-phorus (mg/L)	Total Depth (ft.)
RH-A06-A-4	09/08/93	1150	9	13		350	31.00	8.80	77	3	32	23	0.06	0.67	0.0 K	0.044	0.001	11.0
RH-A06-A-4	09/28/93	1200	9	3		510	22.00	8.67	87	3	26	17	0.01 K	0.83	0.0	0.036	0.003	11.0
RH-A06-A-5	10/13/92	1315		14	42	467	20.00	8.30	87	1	7	5	0.34	0.60	0.0 K	0.025	0.002	16.0
RH-A06-A-5	11/12/92	1530	1	1	86	479	16.00	7.80	92	0	3	2	0.09	0.50	0.1	0.014	0.003	17.0
RH-A06-A-5	12/21/92	1630	1	3	132	493	12.00	7.80	98	0	1 K	1 K	0.16	0.70	0.2	0.011	0.003	17.0
RH-A06-A-5	01/19/93	1650		10	94	500	12.00	7.80	98	0	1	K	0.24	0.63	0.3	0.010	0.003	18.0
RH-A06-A-5	02/10/93	1615	1	0	131	490	13.00	7.77	94	0	2	2	0.16	0.34	0.4	0.010	0.002	17.0
RH-A06-A-5	03/16/93	1645	1	0	114	530	13.00	8.33	98	1	2	1	0.15	0.51	0.5	0.011	0.002	17.0
RH-A06-A-5	04/13/93	1745	1	0	80	510	13.00	8.10	84	0	4	2	0.09	0.56	0.4	0.009	0.001	17.0
RH-A06-A-5	05/10/93	1400	1	3	105	510	13.00	8.10	87	0	2	1	0.07	0.78	0.3	0.012	0.001 K	17.0
RH-A06-A-5	05/26/93	1810	1	1	120	520	15.00	8.63	84	0	3	2	0.11	0.85	0.3	0.014	0.004	16.0
RH-A06-A-5	06/09/93	1640	1	1	58	470	13.00	8.15	73	0	4	2	0.08	0.94	0.2	0.017	0.004	18.0
RH-A06-A-5	06/22/93	1945	1	2	76	460	16.00	8.48	73	1	9	6	0.09	0.88	0.2	0.012	0.001 K	18.0
RH-A06-A-5	07/07/93	1340	1	2	84		15.00	8.30	79		5	4	0.29	0.45	0.2	0.015	0.001 K	18.0
RH-A06-A-5	07/20/93	1530	1	0	52	400	15.00	8.80	79	2	16	14	0.03	0.37	0.1	0.013	0.001 K	17.0
RH-A06-A-5	08/04/93	1205	1	6	32	520	16.00	8.55	63	2	16	8	0.11	0.77	0.0 K	0.019	0.001 K	16.0
RH-A06-A-5	08/18/93	1410	1	0	50		12.00	8.84	80	4	2	1	0.01 K	0.57	0.0 K		0.001 K	17.0
RH-A06-A-5	09/08/93	1325	1	16	47	500	20.00	8.60	78	6	9	2	0.01 K	0.28	0.0 K	0.024	0.003	17.0
RH-A06-A-5	09/28/93	1400	1	1	33	390	28.00	8.52	83	2	30	22	0.01	1.06	0.0	0.058	0.002	17.0
RH-A06-A-5	10/13/92	1315	14	5		469	20.00	8.20	86	0	11	7	0.30	0.70	0.0 K	0.024	0.002	16.0
RH-A06-A-5	11/12/92	1530	15	1		480	19.00	7.80	93	0	2	1 K	0.12	0.50	0.1	0.019	0.004	17.0
RH-A06.A-5	12/21/92	1630	15	3		494	14.00	7.80	100	0	1	1 K	0.15	0.80	0.2	0.011	0.002	17.0
RH-A06-A-5	01/19/93	1650	16	0		530	10.00	7.88	91	0	1	1 K	0.25	0.66	0.4	0.010	0.003	18.0
RH-A06-A-5	02/10/93	1615	14	0		490	13.00	7.68	94	0	2	1	0.17	0.42	0.4	0.012	0.003	17.0
RH-A06-A-5	03/16/93	1645	15	0		530	13.00	8.35	117	0	2	1K	0.16	0.40	0.5	0.012	0.003	17.0
RH-A06-A-5	04/13/93	1745	15	0		520	12.00	8.25	85	0	4	2	0.14	0.61	0.4	0.012	0.001 K	17.0
RH-A06-A-5	05/10/93	1400	15	4		530	12.00	7.93	87	0	4	2	0.09	0.71	0.3	0.018	0.003	17.0
RH-A06-A-5	05/26/93	1810	14	2		520	14.00	8.42	87	0	4	2	0.07	1.08	0.3	0.016	0.004	16.0
RH-A06-A-5	06/09/93	1640	16	1		480	13.00	8.06	75	0	4	2	0.10	0.89	0.2	0.020	0.004	18.0
RH-A06-A-5	06/22/93	1945	16	2		480	21.00	7.85	80	0	5	3	0.22	0.99	0.2	0.014	0.001 K	18.0
RH-A06-A-5	07/07/93	1340	16	2			14.00	7.86	79		4	2	0.35	0.26	0.2	0.010	0.001	18.0
RH-A06-A-5	07/20/93	1530	15	0		520	14.00	8.57	81	2	12	9	0.02	0.28	0.1	0.013	0.001 K	17.0
RH-A06-A-5	08/04/93	1205	14	5		530	17.00	8.51	83	2	16	11	0.01 K	0.68	0.0 K	0.023	0.001 K	16.0
RH-A06-A-5	08/18/93	1410	15	0		520	17.00	7.67	91	0	7	5	0.01 K	0.51	0.0 K	0.016	0.001 K	17.0
RH-A06-A-5	09/08/93	1325	15	9		510	20.00	8.20	79	0	10		0.03	0.57	0.0 K	0.027	0.003	17.0
RH-A06-A-5	09/28/93	1400	15	0		370	24.00	8.55	82	2	31	22	0.01 K	0.83	0.0	0.055	0.002	17.0
RH-A06-A-6	10/13/92	1130	1	4	36	337	15.00	8.00	103	0	8	2	0.31	0.60	0.0 K	0.021	0.001	4.0
RH-A06-A-6	11/13/92	1050		12	44	341	14.00	8.20	110	0	4	1	0.18	0.60	0.1	0.016	0.004	5.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Ssechl Trans. (In.)	Cond- activity (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (mg/L CaCO3)	Phenoph. Alkalinity (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos- phorus (mg/L)	Dissolved Phos- phorus (mg/L)	Total Depth (ft)
RH-A06-A-6	12/21/92	1530	1	3	66	383	10.00	7.60	122	0	4	2	0.38	1.20	0.2	0.012	0.001	6.0
RH-A06-A-6	01/19/93	1540	1	1	57	420	8.00	8.20	119	0	2	1 K	0.31	0.80	0.3	0.025	0.001	5.0
RH-A06-A-6	02/10/93	1355	10		54	410	12.00	7.80	111	0	3	1	0.07		0.3	0.015	0.004	4.5
RH-A06-A-6	03/16/93	1530	1	0	53	440	15.00	8.56	111	2	3	2	0.09	0.61	0.4	0.017	0.003	4.0
RH-A06-A-6	04/13/93	1550	1	0	52	590	12.00	8.35	118	0	5	3	0.13	0.77	0.4	0.013	0.002	5.0
RH-A06-A-6	05/10/93	1600	1	7	35	460	19.00	8.64	120	3	13	8	0.05	0.87	0.2	0.035	0.001 K	4.5
RH-A06-A-6	05/26/93	1545	1	4	51	430	17.00	8.89	97	4	6	4	0.01 K	0.10 K	0.0	0.026	0.001	4.5
RH-A06-A-6	06/09/93	1855	1	8	40	360	17.00	8.77	83	3	23	10	0.02	0.94	0.0	0.035	0.001 K	5.0
RH-A06-A-6	06/22/93	1715	1	2	40	370	22.00	6.98	87	8	10	8	0.01 K	0.74	0.0 K	0.023	0.004	5.0
RH-A06-A-6	07/07/93	1125	- 1	6	27		22.00	8.60	2		13	8	0.24	0.59	0.0 K	0.025	0.001 K	5.0
RH-A06-A-6	07/20/93	1320	1	0	26	530	22.00	9.04	63	5	23	19	0.02	0.19	0.0 K	0.029	0.001 K	5.0
RH-A06-A-6	08/04/93	1030	1	17	26	380	27.00	8.91	79	4	30	25	0.01 K	0.84	0.0 K	0.049	0.001 K	5.0
RH-A06-A-6	08/18/93	1135	1	1	23	350	27.00	9.14	80	7	29	22	0.01 K	0.67	0.0 K	0.039	0.001 K	4.0
RH-A06-A-6	09/08/93	1530	1	9	26	360	12.00	8.82	87	4	35	23	0.01 K	0.83	0.0 K	0.049	0.002	5.0
RH-A06-A-6	09/28/93	1550	1	2	20	360	25.00	8.41	80	1	29	23	0.01 K	0.84	0.0	0.068	0.007	5.0
RH-A06-A-7	10/13/92	1200	14		34	331	20.00	6.10	101	0	18	11	0.39	0.70	0.0 K	0.040	0.001	8.0
RH-A06-A-7	11/13/92	1115	1	2	53	336	13.00	7.90	109	0	6	4	0.25	0.70	0.1	0.020	0.001	5.0
RH-A06-A-7	12/22/92	1230	1	3	61	378	11.00	7.90	121	0	1 K	1 K	0.39	1.00	0.3	0.012	0.002	5.0
RH-A06-A-7	01/19/93	1440	1	0	62	400	10.00	8.07	122	0	2	1K	0.32	0.69	0.3	0.008	0.002	5.0
RH-A06-A-7	02/10/93	1320	1	0	60	410	11.00	7.82	116	0	4	2	0.15	0.49	0.4	0.014	0.003	5.0
RH-A06-A-7	03/16/93	1500	10		54	440	14.00	8.43	120	1	8	5	0.22	0.59	0.4	0.026	0.005	5.0
RH-A06-A-7	04/13/93	1615	1	0	40	490	13.00	8.38	123	1	8	5	0.14	0.92	0.4	0.025	0.001	5.0
RH-A06-A-7	05/10/93	1625	1	14	29	470	21.00	8.48	122	1	16	11	0.03	0.88	0.2	0.047	0.001 K	5.0
RH-A06-A-7	05/26/93	1630	1	3	45	430	20.00	8.79	114	4	21	12	0.01	1.04	0.1	0.028	0.004	6.0
RH-A06-A-7	06/09/93	1916	1	10	31	390	20.00	8.44	96	1	23	15	0.04	1.17	0.0	0.058	0.040	7.0
RH-A06-A-7	06/22/93	1750	1	2	33	380	15.00	8.97	102	8	11	8	0.01 K	0.75	0.0 K	0.029	0.001 K	7.0
RH-A06-A-7	07/07/93	1150	1	12	26		22.00	8.73	101	2	18	12	0.23	1.10	0.0 K	0.048	0.001 K	7.0
RH-A06^A-7	07/20/93	1355	1	0	23	400	24.00	8.97	90	4	37	28	0.02	0.71	0.0 K	0.052	0.001 K	6.0
RH-A06-A-7	08/04/93	1055	1	16	27	380	23.00	8.87	8		34	25	0.08	0.86	0.0 K	0.061	0.002	6.0
RH-A06-A-7	08/18/93	1225	1	2	25	350	26.00	9.10	85	7	25	20	0.08	0.65	0.0 K	0.044	0.001 K	6.0
RH-A06-A-7	09/08/93	1600	1	12	27	370	26.00	8.90	93	4	8	8	0.02	0.68	0.0 K	0.054	0.003	6.0
RH-A06-A-7	09/28/93	1620	1	0	24	350	28.00	8.65	98	2	10	6	0.01 K	0.58	0.1	0.024	0.001	6.0
RH-A06-A-8	10/13/92	1000	1	4	23	324	21.00	8.20	100	0	23	16	0.33	0.80	0.0 K	0.053	0.002	16.0
RH-A06-A-8	11/13/92	1210	12		44	331	18.00	7.80	110	0	8	4	0.27	0.80	0.1	0.025	0.001 K	17.0
RH-A06-A-8	12/22/92	1130	1	3			9.00	8.00	119	0	2	1K	0.40	1.10	0.3	0.014	0.002	17.0
RH-A06-A-8	01/20/93	930	1	0	63	400	8.00	7.96	119	0	3	.1	0.30	0.77	0.3	0.013	0.002	17.0
RH-A06-A-8	02/10/93	1500	1	0	62	400	9.00	7.90	118	0	4	1	0.18		0.4	0.015	0.003	17.0
RH-A06-A-8	03/17/93	1000	10		70	440	15.00	8.49	122	3	4	3	0.21	0.62	0.4	0.020	0.003	17.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Secchi Trans. (In.)	Cond-uctivity (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (mg/L CaCO3)	Phenoph. Alkalinity (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total kjekdahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Phos-phorus (mg/L)	Dissolved Phos-phorus (mg/L)	Total Depth (ft.)
RH-A06-A-8	04/13/93	1450	1	0	40	450	19.00	8.43	116	2	10	6	0.11	0.89	0.4	0.017	0.001	17.0
RH-A06-A-8	05/10/93	1530	1	6	45	450	17.00	8.40	123	2	9	5	0.05	0.78	0.2	0.026	0.001 K	16.5
RH-A06-A-8	05/26/93	1455	1	5	38	430	21.00	8.63	114	0	14	9	0.01 K	1.0A	0.1	0.034	0.004	16.0
RH-A06-A-8	06/09/93	1828	1	7	25	360	21.00	8.38	95	0	25	16	0.03	1.09	0.0	0.044	0.006	17.0
RH-A06-A-8	06/22/93	1630	12		35	350	22.00	9.00	95	7	10	8	0.06	0.87	0.0 K	0.027	0.001 K	17.0
RH-A06-A-8	07/07/93	1050	1	8	30		22.00	8.29	97		13	10	0.01 K	0.68	0.0 K	0.040	0.001 K	17.0
RH-A06-A-8	07/20/93	1245	1	0	48	400	23.00	9.03	51	4	25	20	0.02	0.73	0.0 K	0.044	0.001 K	17.0
RH-A06-A-8	08/04/93	930	1	12	28	380	20.00	8.57	94	2	32	22	0.01 K	0.80	0.0 K	0.059	0.001 K	17.0
RH-A06-A-8	08/18/93	1100		11	34	340	19.00	9.10	83	7	13	10	0.01 K	0.71	0.0 K	0.029	0.001 K	16.0
RH-A06-A-8	09/08/93	1450	1	13	29	340	27.00	9.00	90	6	21	14	0.03	1.40	0.0 K	0.068	0.001	16.0
RH-A06-A-8	09/28/93	1510	1	2	24	360	28.00	8.45	98	1	31	20	0.01 K	1.20	0.0	0.041	0.018	17.0
RH-A06-A-8	10/13/92	1000	14	4		326	21.00	8.20	100	0	24	16	0.37	0.80	0.0 K	0.060	0.001	16.0
RH-A06-A-8	11/13/92	1210	15	3		333	16.00	7.90	110	0	8	5	0.89	0.80	0.1	0.028	0.001 K	17.0
RH-A06-A-8	12/22/92	1130	15	3		8	9.00	7.90	121	0	1	1K	0.40	1.20	0.3	0.018	0.002	17.0
RH-A06-A-8	01/20/93	930	15	0		420	8.00	7.73	118	0	2	1	0.36	0.82	0.3	0.020	0.001	17.0
RH-A06-A-8	02/10/93	1500	15	0		400	12.00	7.83	117	0	4	2	0.17	0.56	0.4	0.010	0.001	17.0
RH-A06-A-8	03/17/93	1000	15	0		440	12.00	8.53	122	3	4	2	0.21	0.59	0.4	0.022	0.002	17.0
RH-A06-A-8	04/13/93	1450	15	0		450	12.00	8.27	117	0	10	6	0.12	0.82	0.4	0.022	0.001	17.0
RH-A06-A-8	05/10/93	1530	15	6		460	15.00	8.38	122	1	5	3	0.11	0.91	0.3	0.029	0.002	16.5
RH-A06-A-8	05/26/93	1455	14	4		430	17.00	8.45	122	0	13	8	0.08	1.28	0.1	0.036	0.006	16.0
RH-A06-A-8	06/09/93	1828	15	9		370	21.00	8.40	96	1	30	18	0.02	1.10	0.0	0.054	0.002	17.0
RH-A06-A-8	06/22/93	1630	15	2		360	22.00	7.98	96	0	12	8	0.03	0.85	0.0 K	0.048	0.001 K	17.0
RH-A06-A-8	07/07/93	1050	15	5			21.00	7.90	105		14	9	0.01 K	0.47	0.0 K	0.041	0.001	17.0
RH-A06-A-8	07/20/93	1245	15	0		380	24.00	8.83	90	3	25	10	0.01 K	0.76	0.0 K	0.046	0.001 K	17.0
RH-A06-A-8	08/04/93	930	15	12		380	23.00	8.57	94	2	30	20	0.06	0.98	0.0 K	0.057	0.001 K	17.0
RH-A06-A-8	08/18/93	1100	14	0		370	22.00	7.68	105	0	17	10	0.01 K	0.64	0.0 K	0.045	0.001 K	16.0
RH-A06-A-8	09/08/93	1450	14	12		350	29.00	8.95	89	5	37	26	0.04	0.69	0.0 K	0.068	0.002	16.0
RH-A06-A-8	09/28/93	1510	15	3		510	22.00	8.57	99	2	23	16	0.01 K	0.91	0.0	0.035	0.001	17.0
RH^A06-A-9	10/13/92	1100	1	4	76	322	9.00	8.00	107	0	4	1	0.35	0.30	0.3	0.018	0.001	7.0
RH-A06-A-9	11/13/92	1145		11	43	342	12.00	7.70	109	0	5	2	0.74	0.40	0.4	0.026	0.002	8.0
RH-A06-A-9	12/22/92	940		13	86	357	8.00	7.70	114	0	1K	1 K	0.20	1.10	0.3	0.016	0.002	7.0
RH-A06-A-9	01/20/93	1310		11	54	380	6.00	7.60	114	0	2	1 K	0.05	0.29	0.3	0.011	0.001 K	4.5
RH-A06-A-9	02/10/93	1725	1	0	47	360	6.00	7.55	118	0	4	2	0.18	0.36	0.3	0.017	0.001 K	8.0
RH-A06-A-9	03/17/93	1325	1	3	26	480	10.00	8.25	120	0	10	2	0.19	0.60	0.4	0.036	0.005	8.0
RH-A06-A-9	04/13/93	1640	1	0	37	450	10.00	8.30	120	0	10	4	0.28	0.84	0.4	0.022	0.001	8.0
RH-A06-A-9	05/10/93	1700	1	3	52	380	8.00	8.45	118	1	3	2	0.05	0.68	0.2	0.024	0.002	7.5
RH-A06-A-9	05/26/93	1700	1	3	47	380	13.00	8.01	114	0	6	4	0.01 K	0.81	0.1	0.026	0.004	7.0
RH-A06-A-9	06/09/93	1940		14	24	340	25.00	7.39	94	0	19	10	0.04	1.10	0.0	0.064	0.011	8.0

Appendix B. Continued

Station Code	Sample Date	Sample Time	Sample Depth (ft.)	Turbidity (NTU)	Secohl Trans. (In.)	Cond-uctlvilty (umho/cm)	Chemical Oxygen Demand (mg/L)	pH	Total Alkalinity (mg/L CaCO3)	Phanoph. Alkalinity (mg/L CaCO3)	Total Susp. Solids (mg/L)	Volatile Susp. Solids (mg/L)	Ammonia Nitrogen (mg/L)	Total kjeldahl Nitrogen (mg/L)	Nitrate Nitrite Nitrogen (mg/L)	Total Pros-phorus (mg/L)	Dissolved Pnos-phoros (mg/L)	Total Depth (ft.)
RH-A06-A-9	06/22/93	1825	1	2	35	360	28.00	7.98	107	0	7	3	0.04	1.05	0.0	0.052	0.003	8.0
RH-A06-A-9	07/07/93	1215	1	5	29		27.00	7.93	106		12	8	0.01 K	0.60	0.0 K	0.060	0.003	8.0
RH-A06-A-9	07/20/93	1425	1	0	35	380	36.00	7.66	111	0	11	11	0.02	0.38	0.0 K	0.031	0.001 K	7.0
RH-A06-A-9	08/04/93	830	1	5	32	370	46.00	7.38	114	0	6	4	0.03	0.80	0.0 K	0.061	0.001	3.0
RH-A06-A-9	08/18/93	1900	1	0	31	330	13.00	7.77	112	0	6	2	0.01 K	0.46	0.0 K	0.030	0.001	3.0
RH-A06-A-9	09/08/93	1645	1	2	42	370	26.00	7.60	114	0	2	1 K	0.02	0.54	0.0	0.033	0.001	7.0
RH-A06-A-9	09/28/93	1645	1	1	43	370	28.00	7.59	105	0	36	23	0.01 K	0.78	0.0	0.061	0.007	7.0

Appendix B. Continued

Station Cods	Sampl* sts	Sample Time	Sampl Depth	Chlorophyll a (µg/L)	Chlorophyll a Corrected (µg/L)	Chlorophyll b (µg/L)	Chlorophyll c <µg/L)	Phaeophytll (µg/L)
RH-A06HA-1	05/09/91	1125	15	3.37	2.67	0.74	0.06	1.07
RH-A06-A-1	06/11/91	1340	16	2.26	3.56	0.23	0.00 '	0.00
RH-A06-A-1	07/16/91	1250	14	3.40	3.12	0.34	0.00	0.31
RH-A06-A-1	08/13/91	1215	14	2.69	3.12	0.00	0.05	0.00
RH-A06-A-1	10/08/91	830	12	1.08	0.89	0.77	0.14	0.36
RH-A0&*-1	10/13/92	1535	13	2.38	2.51	0.49	0.00	0.00
RH-A06-A-1	11/12/92	930	19	2.24	2.14	0.49	0.04	0.10
RH-A0&A-1	12/21/92	1140	13	1.22	1.60	0.35	0.42	0.00
RH-A0&A-1	01/19/93	1240	14	2.21	3.20	0.75	1.36	0.00
RH-A06W-1	02/10/93	1040	14	4.72	5.34	0.82	0.53	0.00
RH-A06HA-1	03/16/93	935	14	8.06	8.01	1.92	0.93	0.00
RH-A06-A-1	05/10/93	930	14	2.28	2.67	0.12	0.00	0.00
RH-A06-A-1	05/26/93	925	14	6.53	6.94	1.21	0.00	0.00
RH-A06-A-1	06/09/93	1010	15	4.45	4.27	1.29	0.91	0.21
RH-A06-A-1	06/22/93	1030	15	2.55	3.20	0.00	0.00	0.00
RH^A06-A-1	07/07/93	1605	15	2.75	2.14	0.00	0.12	0.85
RH-A06-A-1	07/20/93	1945	14	3.39	3.20	0.26	0.70	0.16
RH-A06-A-1	08/03/93	1410	14	2.99	3.74	0.00	0.00	0.00
RH-A06-A-1	08/18/93	1640	14	2.75	2.67	0.00	0.12	0.00
RH-A0&A-1	04/27/94	1220	12	2.09	1.99	0.41	0.49	0.10
RH-A06-A-1	07/19/94	1350	12	4.28	4.27	0.56	1.24	0.00
RH-A06-A-1	08/23/94	1400	13	6.74	5.34	4.96	8.47	2.76
RH-A06-A-1	10/04/94	1407	1	4.25	4.81	3.13	6.37	0.00
RH-A06-A-2	06/12/79	1430	2	51.00	43.60	0.00 K	5.75	10.40
RH-A0&A-2	08/17/79	1000	2	38.40	36.30	0.00	0.00	2.30
RH-A06-A-2	05/02/89	1250	12	5.53	4.58	0.06	0.91	1.30
RH-A06-A-2	06/12/89	1205	8	11.70	11.87	1.37	2.72	0.00
RH-A06-A-2	07/20/89	1100	4	14.77	15.13	0.73	0.51	0.00
RH-A06-A-2	08/24/89	1030	6	13.93	13.35	1.71	1.19	0.36
R»+A06-A-2	10/04/89	1615	7	8.60	8.01	1.53	2.16	0.71
RH-A06-A-2	05/09/91	1215	12	4.69	4.27	1.19	0.87	0.59
RH-A0&A-2	06/11/91	1420	12	9.35	8.90	1.95	0.98	0.45
RH-A06-A-2	07/16/91	1330	7	12.16	12.46	0.00	0.84	0.00
RH-A06-A-2	08/13/91	1240	5	18.56	20.47	0.76	1.65	0.00
RH-A06-A-2	10/08/91	850	3	20.09	20.47	0.91	0.00	0.00
RHA06nA-2	10/13/92	1630	6	10.93	10.68	1.32	0.00	0.00
RH-A06-A-2	11/12/92	1055	14	6.79	6.94	0.58	0.91	0.00
RH-A06-A-2	12/21/92	1030	13	6.11	6.94	0.48	1.16	0.00
Rr+A06nA-2	01/19/93	1120	14	7.41	7.48	1.46	0.85	0.00
RH-A06-A-2	02/10/93	840	13	7.00	7.48	0.99	0.00	0.00
RH-A06-A-2	03/16/93	1105	13	7.17	7.48	1.57	0.88	0.00
RH-A06-A-2	05/10/93	1000	9	9.13	10.15	0.00	0.00	0.00
RHA06-A-2	05/26/93	1040	10	11.55	13.35	1.13	0.13	0.00
RH-A06-A-2	06/09/93	1225	8	20.38	22.43	1.94	0.77	0.00
RH-A06-A-2	06/22/93	1140	9	8.21	9.08	0.00	0.22	0.00
RH-A06nA-2	07/07/93	1650	8	9.34	9.61	0.22	0.24	0.00
RH-A06-A-2	07/20/33	1815	6	12.02	12.82	0.86	0.55	0.00
RH-A06-A-2	08/03/93	1455	6	20.24	22.03	0.08	0.59	0.00
RH-A06-A-2	08/18/93	1720	6	14.83	15.49	0.00	0.49	0.00
RH-A06-A-2	04/27/94	1145	6	12.91	14.05	2.65	1.84	0.00
RH-A06-A-2	07/19/94	1315	7	32.04	32.93	3.26	3.45	0.00
RH-A06-A-2	08/23/94	1313	3	10.92	10.68	1.14	1.57	0.00
RH-A06-A-2	10/04/94	1334	1	14.03	3.18	1.49	10.35	17.96

Appendix B. Continued

Station Code	Sample ate	Time	Sample Sampl Dapth	Chlorophyll a (µg/L)	Chlorophyll a Corrected <µg/L)	Chlarophyl b (µg/L)	Chlorophyll e (µg/L)		Phaeophytin (µg/L)
RH-A06-A-3	06/12/79	1130	2	46.90	40.90	0.46	0.00	K	8.83
RH-A06-A-3	08/17/79	1100	2	20.70	19.10	0.70	0.20		2.50
RH-A06-A-3	05/02/89	1340	11	3.54	3.05	0.39	1.41		0.69
RH-A06-A-3	06/12/89	1315	11	4.86	4.88	0.00	0.60		0.00
RH-A06-A-3	07/20/89	1130	7	9.85	7.12	0.46	0.61		4.09
RH-A06-A-3	08/24/89	1115	6	12.03	12.21	0.34	0.75		0.00
RH-A06-A-3	10/04/89	1700	8	10.19	9.79	0.89	1.12		0.18
RH-A06-A-3	05/09/91	1245	13	4.31	3.74	0.25	0.42		0.75
RH-A06-A-3	06/11/91	1445	13	5.27	6.23	0.79	0.00		0.00
RH-A06-A-3	07/16/91	14i0	7	11.66	13.35	1.39	2.03		0.00
RH-A06-A-3	08/13/91	1315	5	15.27	17.80	0.00	0.14		0.00
RH-A06-A-3	10/08/91	930	4	16.64	18.69	1.05	1.36		0.00
RH-A0&A-3	10/13/92	1715	9	6.08	6.41	1.06	0.00		0.00
RH-A06-A-3	11/12/92	1130	12	4.08	3.74	0.41	0.00		0.37
RH-A06-A-3	12/21/92	825	11	7.00	7.48	0.83	1.22		0.00
RH-A06-A-3	01/19/93	1005	12	6.29	6.41	1.21	0.83		0.00
RH-A06-A-3	02/10/93	950	11	6.08	6.41	1.01	0.03		0.00
RH-A0&A-3	03/16/93	1230	11	5.64	5.87	0.80	0.25		0.00
RH-A0&A-3	05/10/93	1040	10	5.50	6.41	0.00	0.25		0.00
RH-A0&A-3	05/26/93	1200	11	6.52	6.94	1.05	1.28		0.00
RRA0&A-3	06/09/93	1307	10	8.12	8.01	1.19	0.25		0.00
RH-A06-A-3	06/22/93	1225	12	6.59	6.94	0.42	0.00		0.00
RH-A0&A-3	07/07/93	1750	10	8.39	9.61	0.71	0.00		0.00
RH-A06-A-3	07/20/93	1900	8	8.62	10.15	0.49	0.83		0.00
RH-A06-A-3	08/03/93	1550	7	18.67	19.76	0.44	0.48		0.00
RH-A06-A-3	08/18/93	1805	6	17.76	18.69	0.51	0.27		0.00
RH-A06-A-3	04/27/94	1125	5	9.17	9.63	2.14	2.69		0.66
RH-A06-A-3	07/19/94	1250	3	14.32	14.24	1.44	1.94		0.00
RH-A06-A-3	08/23/94	1226	3	24.22	24.92	1.37	1.18		0.00
RH-A06-A-3	10/04/94	1305	3	17.11	20.66	6.60	3.21		0.00
RH-A06-A-4	10/13/92	1500	6	8.57	9.61	1.44	0.00		0.00
RH-A06-A-4	11/12/92	1340	9	4.99	5.34	0.34	0.16		0.00
RH-A06-A-4	12/21/92	1435	9	5.64	5.87	0.70	1.23		0.00
RH-A06-A-4	01/19/93	1340	10	8.02	8.01	2.23	1.76		0.00
RH-A06-A-4	02/10/93	1225	9	6.52	7.48	1.10	0.79		0.00
RH-A06-A-4	03/16/93	1415	7	6.46	5.87	1.95	0.49		0.85
RH-A06-A-4	05/10/93	1155	7	3.22	4.27	0.00	0.00		0.00
RH-A06-A-4	05/26/93	1310	9	11.96	13.35	1.60	1.23		0.00
RH-A06-A-4	06709/93	1450	7	20.35	21.36	2.31	1.11		0.00
RH-A06-A-4	06/22/93	1330	10	11.17	12.82	0.14	0.16		0.00
RH-A06-A-4	07/07/93	1505	6	14.33	14.95	0.62	0.00		0.00
RH-A06-A-4	07/20/93	1730	5	13.62	13.35	0.84	0.99		0.00
RH-A06-A-4	08/03/93	1310	5	26.41	27.23	0.64	0.77		0.00
RH-A06-A-4	08/18/93	1540	5	17.99	18.69	0.40	0.24		0.00
RH-A06-A-5	10/13/92	1315	7	9.86	10.68	2.37	0.00		0.00
RH-A06-A-5	11/12/92	1530	15	5.88	5.87	0.70	0.22		0.00
RKA06-A-5	12/21/92	1630	15	4.28	4.27	0.56	1.24		0.00
RH-A06-A-5	01/19/93	1650	16	4.28	4.27	0.61	0.75		0.00
RH-A06-A-5	02/10/93	1615	12	5.20	5.87	0.60	0.47		0.00
RH-A06-A-5	03/16/93	1645	10	2.90	3.20	0.53	0.28		0.00
RH-A06-A-5	05/10/93	1400	15	3.39	4.27	0.26	0.70		0.00
RH-A06-A-5	05/26/93	1810	14	7.68	6.94	1.04	0.00		0.91
RH-A06-A-5	06/09/93	1640	10	7.74	9.61	0.19	0.29		0.00

Appendix B. Continued

Station Coda	Sample ate	Sample Time	Sampl Dapth	Chorophyll a (µg/L)	Chlorophyll a Corrected (µg/L)	Chlorophyll b (µg/L)	Chlorophyll c (µg/L)	Phasophytin (uo/L)
RH-A06-A-5	06/22/93	1945	13	6.82	7.48	0.26	0.08	0.00
RH-A06-A-5	07/07/93	1340	14	8.62	8.S4	0.49	0.83	0.00
RH-A06-A-5	07/20/93	1530	9	12.43	12.28	1.49	0.18	0.00
RH-A06-A-5	08/03/93	1205	5	17.93	19.22	1.19	0.43	0.00
RH-A06-A-5	08/18/93	1410	8	17.69	18.69	1.30	0.46	0.00
RH-A06-A-6	10/13/92	1130	6	7.81	6.41	0.98	0.00	2.00
RH-A06-A-6	11/13/92	1050	4	12.88	13.35	1.64	0.45	0.00
RH-A06-A-6	12/21/92	1530	4	8.56	8.54	1.23	1.51	0.00
RH-A06-A-6	01/19/93	1540	3	13.45	13.88	2.62	3.18	0.00
RH-A06-A-6	02/10/93	1355	3	10.57	10.15	1.88	1.09	0.32
RH-A06-A-6	03/16/93	1530	3	8.32	9.08	1.39	1.05	0.00
RH-A06-A-6	05/10/93	1600	2	17.49	19.76	0.93	1.14	0.00
RH-A06-A-6	05/26/93	1545	3	5.84	5.87	1.06	0.55	0.00
RH-A06-A-6	06/09/93	1855	3	15.45	18.16	0.81	0.42	0.00
RH-A06-A-6	06/22/93	1715	2	10.25	11.75	0.16	0.44	0.00
RH-A06-A-6	07/07/93	1125	2	22.92	24.03	1.59	0.10	0.00
RH-A06-A-6	07/20/93	1320	2	26.08	26.70	1.90	1.32	0.00
RH-A06-A-6	08/03/93	1030	3	36.12	39.31	0.17	0.22	0.00
RH-A06-A-6	08/18/93	1135	2	30.46	33.11	1.42	1.06	0.00
RH-A06-A-7	10/13/92	1200	4	18.55	19.22	2.13	0.00	0.00
RH-A06-A-7	11/13/92	1115	3	11.31	11.21	1.24	0.16	0.00
RH-A06-A-7	12/22/92	1230	3	5.40	5.87	0.81	1.26	0.00
RH-A06-A-7	01/19/93	1440	3	0.65	0.53	0.46	0.09	0.21
RH-A06-A-7	02/10/93	1320	3	15.53	16.02	2.64	1.10	0.00
RH-A06-A-7	03/16/93	1500	3	14.88	14.95	2.18	1.01	0.00
RH-A06-A-7	05/10/93	1625	2	31.82	35.78	1.55	1.05	0.00
RH-A06-A-7	05/26/93	1630	4	19.49	20.83	1.53	1.21	0.00
RH-A06nA-7	06/09/93	1916	5	27.50	30.97	1.25	1.12	0.00
RH-A06-A-7	06/22/93	1750	3	18.88	21.89	0.76	0.29	0.00
RH-A06-A-7	07/07/93	1150	2	39.97	41.65	2.32	1.45	0.00
RH-A06-A-7	07/20/93	1355	3	47.88	51.26	3.24	1.40	0.00
RH-A06-A-7	08/03/93	1055	4	42.84	45.39	1.70	0.63	0.00
RH-A06-A-7	08/18/93	1225	3	25.26	27.23	0.87	0.10	0.00
RH-A06-A-8	10/13/92	1000	4	29.87	30.66	1.77	0.00	0.00
RH-A06-A-8	11/13/92	1210	7	15.59	16.02	1.86	0.91	0.00
RH-A06-A-8	12/22/92	1130	15	8.53	8.54	1.60	1.85	0.00
RH-A06-A-8	01/20/93	930	11	17.11	17.09	2.35	3.99	0.00
RH-A06-A-8	02/10/93	1500	10	18.68	19.76	2.91	2.81	0.00
RH-A06-A-8	03/17/93	1000	6	12.16	12.28	1.86	1.53	0.00
RH-A06-A-8	05/10/93	1530	8	16.13	18.16	0.85	0.66	0.00
RH-A06-A-8	05/26/93	1455	6	19.49	21.89	1.53	1.21	0.00
RH-A06-A-8	06/09/93	1828	4	31.14	35.78	1.56	0.32	0.00
RH-A06-A-8	06/22/93	1630	6	21.90	24.56	0.08	0.54	0.00
RH,A06-A-8	07/07/93	1050	5	42.21	44.86	2.86	1.00	0.00
RH-A06-A-8	07/20/93	1245	8	58.11	63.55	3.87	1.21	0.00
RH-A06-A-8	08/03/93	930	5	45.29	46.46	1.40	1.06	0.00
RH-A06-A-8	08/18/93	1100	6	30.93	32.57	1.20	1.00	0.00
RH-A06-A-9	10/13/92	1100	5	4.53	4.45	0.45	0.00	0.00
RH-A06-A-9	11/13/92	1145	6	2.72	2.14	0.27	0.00	0.85
RH-A06-A-9	12/22/92	940	5	1.77	1.07	0.65	0.60	1.17
RH-A06-A-9	01/20/93	1310	3	0.41	0.00	0.52	0.61	0.75
RH-A06-A-9	02/10/93	1725	6	2.24	3.20	0.44	0.53	0.00
RH-A06-A-9	03/17/93	1325	4	5.64	5.87	0.86	0.00	0.00

Appendix B. Concluded

Station Code	Sample ate	Sample Time	Sampl Depth	Chtorophyll a (µg/L)	Chtarophyfl a Corrected (µg/L)	Chlorophyll b (µg/L)	Chlorophyll c (µg/L)	Phaeophytin (µg/L)
RH-A06-A-9	05/10/93	1700	6	9.30	10.68	0.59	0.58	0.00
RH-A06-A-9	05/26/93	1700	5	13.55	13.88	1.68	0.69	0.00
RH-A06-A-9	06/09/93	1940	4	10.90	12.28	0.67	0.04	0.00
RH-A06-A-9	06/22/93	1825	6	23.98	25.10	2.57	0.80	0.00
RH-A06-A-9	07/07/93	1215	5	34.68	37.38	2.87	1.51	0.00
RH-A06-A-9	07/20/93	1425	5	16.89	17.09	2.83	0.60	0.00
RH-A06-A-9	08/03/93	830	4	19.86	18.69	1.13	1.48	0.93
RH-A06-A-9	08/18/93	1015	5	23.35	23.50	4.78	1.08	0.00

Appendix C. Summary of Water Quality Characteristics in Wolf Lake

Appendix C1. Summary of Water Quality Characteristics in Wolf Lake at RHA-1, October 1992 - September 1993

Parameters	*Surface* *Mean*	*Surface* *Range*	*Standard deviation*	*Bottom* *Mean*	*Bottom* *Range*	*Standard deviation*
Turbidity, NTU	3	0-13	4	1	0-4	1
Secchi readings, in	129	91-188	29			
Conductivity, μmho/cm	545	490-600	28	528	370-640	68
COD	15	14-17	1	17	13-25	3
pH, units	-	7.38-8.75	-	-	7.35-8.74	
Total alkalinity	109	98-180	19	108	90-180	20
Phenolphthalein alkalinity	1	0-4	2	1	0-4	2
Total suspended solids	6	1-53	13	5	1-23	6
Volatile suspended solids	2	1-6		13	1-17	4
Ammonia-N	0.05	0.01-0.38	0.09	0.06	0.01-0.37	0.09
Total kjeldahl nitrogen-N	0.51	0.10-0.78	0.20	0.58	0.28-0.94	0.19
Nitrate/nitrite-N	0.1	0.0-0.2	0.1	0.1	0.0-0.2	0.1
Total phosphate-P	0.005	0.001-0.01	0.003	0.01	0.001-0.039	0.009
Dissolved phosphate-P	0.001	0.001-0.004	0.001	0.002	0.001-0.007	0.002
Chlorophyll-*a*, μg/L	3.69	1.60-8.01	1.87			
Chlorophyll-*b*, μg/L	0.55	0.00-1.92	0.59			
Chlorophyll-*c*, μg/L	0.37	0.00-1.36	0.45			
Pheophytin-*a*, μg/L	0.09	0.00-0.85	0.23			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C2. Summary of Water Quality Characteristics in Wolf Lake at RHA-2, October 1992 - September 1993

Parameters	*Surface* Mean	*Surface* Range	*Standard deviation*	*Bottom* Mean	*Bottom* Range	*Standard deviation*
Turbidity, NTU	3	0-14	4	2	0-9	3
Secchi readings, in	58	25-131	28			
Conductivity, μmho/cm	395	336-470	37	402	337-500	49
COD	16	9-25	4	16	10-27	4
pH, units	-	7.75-9.38	-	-	7.70-8.95	
Total alkalinity	%	67-120	20	97	72-118	17
Phenolphthalein alkalinity	3	0-10	4	1	0-6	2
Total suspended solids	9	1-23	7	8	1-21	6
Volatile suspended solids	6	1-16	5	5	1-17	5
Ammonia-N	0.07	0.01-0.36	0.09	0.07	0.01-0.34	0.09
Total kjeldahl nitrogen-N	0.63	0.32-0.93	0.20	0.64	0.35-1.08	0.23
Nitrate/nitrite-N	0.1	0.0-0.4	0.2	0.1	0.0-0.4	0.1
Total phosphate-P	0.018	0.007-0.036	0.008	0.020	0.005-0.036	0.010
Dissolved phosphate-P	0.002	0.001-0.005	0.001	0.002	0.001-0.005	0.001
Chlorophyll-*a*, μg/L	11.57	6.94-22.43	5.21			
Chlorophyll-*b*, μg/L	0.76	0.00-1.94	0.66			
Chlorophyll-*c*, μg/L	0.49	0.00-1.16	0.39			
Pheophytin-*a*, μg/L	0.00	0.00-0.00	0.00			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C3. Summary of Water Quality Characteristics in Wolf Lake at RHA-3, October 1992 - September 1993

Parameters	*Surface* *Mean*	*Range*	*Standard deviation*	*Bottom* *Mean*	*Range*	*Standard deviation*
Turbidity, NTU	2	0-7	2	2	0-7	2
Secchi readings, in	75	31-130	32			
Conductivity, μmho/cm	403	346-540	47	398	346-470	36
COD	16	11-25	5	16	10-24	4
pH, units	-	7.70-9.30	-	-	7.65-8.97	
Total alkalinity	97	72-121	17	96	75-118	16
Phenolphthalein alkalinity	2	0-11	3	1	0-8	2
Total suspended solids	8	2-29	8	8	1-30	8
Volatile suspended solids	5	1-18	5	4	1-15	4
Ammonia-N	0.06	0.01-0.32	0.08	0.06	0.01-0.26	0.08
Total kjeldahl nitrogen-N	0.62	0.29-0.%	0.17	0.61	0.20-0.90	0.18
Nitrate/nitrite-N	0.10	0.0-0.4	0.1	0.1	0.0-0.4	0.1
Total phosphate-P	0.015	0.005-0.036	0.009	0.018	0.007-0.033	0.008
Dissolved phosphate-P	0.002	0.001-0.004	0.001	0.002	0.001-0.004	0.001
Chlorophyll-*a*, μg/L	8.77	3.74-19.76	4.70			
Chlorophyll-*b*, μg/L	0.72	0.00-1.21	0.36			
Chlorophyll-*c*, μg/L	0.41	0.00-1.28	0.45			
Pheophytin-*a*, μg/L	0.03	0.00-0.37	0.10			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C4. Summary of Water Quality Characteristics in Wolf Lake at RHA-4, October 1992 - September 1993

Parameters	*Surface* *Mean*	*Range*	*Standard deviation*	*Bottom* *Mean*	*Range*	*Standard deviation*
Turbidity, NTU	3	0-14	4	3	0-13	4
Secchi readings, in	56	21-134	33			
Conductivity, umho/cm	386	320-470	44	393	330-510	53
COD	17	9-30	6	17	10-31	6
pH, units	-	7.75-9.50	-	-	7.68-9.10	
Total alkalinity	93	66-118	20	96	67-120	20
Phenolphthalein alkalinity	3	0-11	4	1	0-5	2
Total suspended solids	10	1-30	9	12	1-32	10
Volatile suspended solids	7	1-21	6	8	1-23	7
Ammonia-N	0.08	0.35-0.99	0.09	0.10	0.01-0.41	0.10
Total kjeldahl nitrogen-N	0.65	0.35-0.99	0.23	0.75	0.41-1.24	0.25
Nitrate/nitrite-N	0.1	0.0-0.4	0.1	0.1	0.0-0.4	0.1
Total phosphate-P	0.021	0.006-0.041	0.010	0.025	0.009-0.044	0.011
Dissolved phosphate-P	0.002	0.001-0.004	0.001	0.002	0.001-0.005	0.001
Chlorophyll-*a*, µg/L	12.01	4.27-27.23	6.79			
Chlorophyll-*b*, µg/L	1.02	0.00-2.31	0.77			
Chlorophyll-*c*, µg/L	0.64	0.00-1.76	0.57			
Pheophytin-*a*, µg/L	0.006	0.00-0.85	0.23			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix CS. Summary of Water Quality Characteristics in Wolf Lake at RHA-5, October 1992 - September 1993

Parameters		*Surface* *Mean*	*Range*	*Standard deviation*	*Bottom* *Mean*	*Range*	*Standard deviation*
Turbidity, NTU		2	0-16	4	2	0-9	3
Secchi readings, in		79	32-132	34			
Conductivity, umho/cm		483	390-530	41	498	370-530	40
COD		15	12-28	4	16	10-24	4
pH, units		-	7.77-8.84	-	-	7.67-8.57	
Total alkalinity		85	73-98	8	88	75-117	10
Phenolphthalein alkalinity		1	0 - 6	2	0	0-2	1
Total suspended solids		7	1-30	8	7	1-31	8
Volatile suspended solids		4	1-22	6	5	1-22	6
Ammonia-N		0.12	0.01-0.34	0.10	0.13	0.01-0.35	0.10
Total kjeldahl nitrogen-N		0.63	0.28-1.06	0.22	0.64	0.26-1.08	0.23
Nitrate/nitrite-N		0.2	0.0-0.5	0.2	0.2	0.0-0.5	0.2
Total phosphate-P		0.017	0.09-0.058	0.012	0.018	0.100-0.055	0.011
Dissolved phosphate-P		0.002	0.001-0.004	0.001	0.002	0.001-0.004	0.001
Chlorophyll-*a*,	μg/L	8.66	3.20-19.22	5.10			
Chlorophyll-*b*,	μg/L	0.83	0.19-2.37	0.60			
Chlorophyll-*c*,	μg/L	0.42	0.00-1.24	0.35			
Pheophytin-*a*,	μg/L	0.07	0.00-0.91	0.24			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C6. Summary of Water Quality Characteristics in Wolf Lake at RHA-6 and RHA-7, October 1992 - September 1993

Parameters		*RHA-6. Surface*			*RHA-7. Surface*	
	Mean	*Range*	*Standard deviation*	*Mean*	*Range*	*Standard deviation*
Turbidity, NTU	4	0-17	4	5	0-16	6
Secchi readings, in	40	20-66	14	38	23-62	14
Conductivity, µmho/cm	408	337-590	71	394	331-490	46
COD	17	8-27	6	19	10-28	6
pH, units	-	7.80-9.14	-	-	7.82-9.10	
Total alkalinity	100	79-122	16	106	85-123	13
Phenolphthalein alkalinity	3	0-8	3	3	0-8	3
Total suspended solids	14	2-35	11	15	1-37	11
Volatile suspended solids	10	1-25	9	10	1-26	8
Anunonia-N	0.11	0.01-0.38	0.13	0.14	0.01-0.39	0.14
Total kjeldahl nitrogen-N	0.70	0.10-1.20	0.27	0.79	0.49-1.17	0.20
Nitrate/nitrite-N	0.1	0.0-0.4	0.2	0.1	0.0-0.4	0.2
Total phosphate-P	0.029	0.012-0.068	0.015	0.035	0.008-0.061	0.017
Dissolved phosphate-P	0.002	0.001-0.007	0.002	0.004	0.001-0.040	0.009
Chlorophyll-*a*, µg/L	17.15	5.87-39.31	10.29	24.9	0.53-51.26	15.02
Chlorophyll-*b*, µg/L	1.27	0.16-2.62	0.67	1.62	0.46-3.24	0.80
Chlorophyll-*c*, µg/L	0.90	0.00-3.18	0.81	0.78	0.00-1.45	0.54
Pheophytin-*a*, µg/L	0.17	0.00-2.00	0.53	0.02	0.00-0.21	0.06

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C7. Summary of Water Quality Characteristics in Wolf Lake at RHA-8, October 1992 - September 1993

Parameters	*Surface* *Mean*	*Range*	*Standard deviation*	*Bottom* *Mean*	*Range*	*Standard deviation*
Turbidity, NTU	4	0-13	4	4	0-12	4
Secchi readings, in	40	23-70	15			
Conductivity, μmho/cm	384	324-450	44	399	326-510	52
COD	19	8-28	6	18	8-29	6
pH, units	-	7.80-9.10	-	-	7.68-8.95	
Total alkalinity	103	51-123	18	107	89-122	12
Phenolphthalein alkalinity	2	0-7	3	1	0-5	2
Total suspended solids	15	2-32	10	15	1-37	11
Volatile suspended solids	10	1-22	7	9	1-26	7
Ammonia-N	0.12	0.01-0.40	0.13	0.17	0.01-0.89	0.23
Total kjeldahl nitrogen-N	0.89	0.62-1.40	0.21	0.83	0.47-1.28	0.22
Nitiate/nitrite-N	0.1	0.0-0.4	0.2	0.1	0.0-0.4	0.2
Total phosphate-P	0.033	0.013-0.068	0.016	0.038	0.100-0.068	0.017
Dissolved phosphate-P	0.003	0.001-0.018	0.004	0.002	0.001-0.006	0.001
Chlorophyll-*a*, μg/L	28.01	8.54-63.55	15.39			
Chlorophyll-*b*, μg/L	1.84	0.08-3.87	0.94			
Chlorophyll-*c*, μg/L	1.29	0.00-3.99	1.03			
Pheophytin-*a*, μg/L	0.00	0.00-0.00	0.00			

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix C8. Summary of Water Quality Characteristics in Wolf Lake at RHA-9, October 1992 - September 1993

		Surface	
Parameters	*Mean*	*Range*	*Standard deviation*
Tuibidity, NTU	2	0-5	2
Secchi readings, in	43	24-86	17
Conductivity, μmho/cm	373	322-480	41
COD	18	6-46	12
pH, units	-	7.38-8.45	
Total alkalinity	112	94-120	7
Phenolphthalein alkalinity	0	0-1	0
Total suspended solids	8	1-36	8
Volatile suspended solids	5	1-23	6
Ammonia-N	0.13	0.01-0.74	0.19
Total kjeldahl nitrogen-N	0.65	0.29-1.10	0.27
Nitrate/nitrite-N	0.2	0.0-0.4	0.2
Total phosphate-P	0.035	0.011-0.064	0.018
Dissolved phosphate-P	0.003	0.001-0.011	0.003
Chlorophyll-*a*, μg/L	12.52	0.00-37.38	10.93
Chlorophyll-*b*, μg/L	1.45	0.27-4.78	1.33
Chlorophyll-*c*, μg/L	0.61	0.00-1.51	0.50
Pheophytin-*a*, μg/L	0.26	0.00-1.17	0.44

Notes: Concentrations are in mg/L except where noted.
Surface samples were collected 1 foot from surface and bottom samples were collected 2 feet from lake bottom.

Appendix D. Dissolved Oxygen and Temperature Observations in Wolf Lake

Appendix D1. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-1

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	11.5	8.39	4.6	13.1	P	14.4	1.4	14.5	2.4	13.2	1.4	13.7	8.8	11.9	20.8	8.4	18.2	9.9
1	11.5	8.38	4.6	13.2	r	14.4	1.5	14.5	2.4	13.4	1.5	13.7	8.7	11.9	20.6	8.4	18.3	9.9
2	11.5	8.38	4.6	13.3	o	14.4	1.7	14.5	2.4	13.5	1.6	13.8	8.8	11.9	20.4	8.4	18.2	9.9
3	11.5	8.38	4.6	13.3	b	14.4	1.7	14.5	2.4	13.5	1.6	13.8	8.7	11.9	20.3	8.4	18.1	9.9
4	11.4	8.38	4.6	13.3	e	14.4	1.7	14.6	2.4	13.5	1.7	13.7	8.7	11.9	20.2	8.4	17.9	9.9
5	11.4	8.37	4.6	13.2		14.5	1.7	14.6	2.4	13.5	1.8	13.7	8.7	12.0	20.1	8.4	17.9	9.8
6	11.4	8.37	4.6	13.2	m	14.5	1.7	14.6	2.4	13.5	1.8	13.6	8.7	12.0	20.0	8.4	17.8	9.8
7	11.3	8.36	4.6	13.2	a	14.5	1.7	14.6	2.4	13.5	1.9	13.6	8.7	12.0	20.0	8.4	17.8	9.8
8	11.3	8.37	4.6	13.2	l	14.5	1.8	14.6	2.4	13.5	1.9	12.7	8.7	12.0	19.9	8.4	17.7	9.8
9	11.2	8.37	4.6	13.2	f	14.5	1.9	14.6	2.4	13.5	1.9	13.2	8.7	12.0	19.7	8.4	17.7	9.7
10	11.2	8.38	4.6	13.2	u	14.5	2.0	14.5	2.4	13.5	1.9	13.3	8.7	12.0	19.7	8.4	17.7	9.7
11	11.2	8.38	4.5	13.1	n	14.5	2.1	14.4	2.4	13.5	1.9	13.3	8.7	12.0	19.3	8.4	17.6	9.7
12	11.1	8.39	4.5	13.1	c	14.5	2.3	14.3	2.4	13.5	1.9	13.3	8.7	12.0	18.9	8.3	17.6	9.6
13	11.1	8.40	4.5	13.1	t	14.5	2.5	14.2	2.4	13.5	1.9	13.3	8.7	12.0	17.8	8.1	17.5	9.6
14	11.0	8.40	4.5	13.1	i	14.5	2.6	14.0	2.4	13.5	1.9	12.4	8.7	12.0	16.8	7.6	17.5	9.4
15	11.0	8.40	4.6	13.1	o	14.4	2.7	13.8	2.4	13.5	2.0	13.0	8.7	12.0	15.1	6.3	17.5	9.0
16			4.6	13.1	n		3.0	13.5	2.4	13.5	2.0	12.9	8.7	12.0	14.9	4.3	17.3	8.0
17					e								8.7	12.0				
					d													

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	18.7	9.5	24.8	8.1	26.1	8.0	26.6	8.3	24.8	8.0	27.1	8.4	22.2	8.7	16.0	8.7
1	18.7	9.5	24.8	8.1	26.1	8.0	26.6	8.3	24.8	8.0	27.1	8.4	22.0	8.7	16.0	8.7
2	18.7	9.5	24.8	8.1	26.1	8.0	26.6	8.3	24.8	8.0	27.1	8.4	22.0	8.1	16.0	8.7
3	18.8	9.5	24.8	8.1	26.1	8.0	26.6	8.3	24.8	8.0	27.1	8.4	22.0	8.1	16.0	8.7
4	18.8	9.5	24.8	8.1	26.1	8.0	26.6	8.3	24.8	8.0	26.7	8.5	22.1	8.1	16.0	8.7
5	18.8	9.5	24.8	8.2	25.9	8.0	26.6	8.3	24.8	8.4	26.6	8.5	22.1	8.1	16.0	8.7
6	18.5	9.5	24.8	8.1	25.9	8.0	26.6	8.3	24.8	8.0	26.6	8.5	22.0	8.1	16.0	8.7
7	18.2	9.4	24.4	8.2	25.8	8.0	26.7	8.3	24.8	8.1	26.6	8.5	21.9	8.1	16.0	8.7
8	18.1	9.4	24.4	8.2	25.7	7.9	26.7	8.3	24.8	8.1	26.5	8.5	22.0	8.1	16.0	8.7
9	18.0	9.4	24.2	8.2	25.7	7.9	26.6	8.3	24.8	8.1	26.1	8.5	21.9	8.1	16.0	8.7
10	17.8	9.3	24.2	8.1	25.6	7.8	26.6	8.3	24.8	8.1	25.8	8.5	21.9	8.1	15.9	8.7
11	17.4	9.3	24.0	8.0	25.6	7.8	26.7	8.3	24.8	8.1	25.5	8.5	21.9	8.1	16.0	8.7
12	17.3	9.2	23.8	7.9	25.6	7.8	26.7	8.3	24.6	8.1	25.4	8.3	21.9	8.1	15.9	8.7
13	17.0	9.2	23.3	7.7	25.5	7.8	26.6	8.3	24.6	8.1	25.3	8.1	21.8	8.0	15.9	8.8
14	16.6	8.7	22.6	6.9	25.5	7.7	26.6	8.3	24.5	8.1	25.0	6.2	21.8	8.0	15.8	8.9
15	16.4	8.5	20.0	4.2	24.2	6.6	26.3	7.7	24.5	8.0	24.5	4.6	21.8	8.0	15.8	8.9
16	16.2	8.2	19.3	3.1	23.2	5.3	26.0	7.0	24.5	8.0	24.3	3.8	21.9	7.9		
17					22.3	4.0										

Appendix D2. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-2

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	11.5	10.3	4.4	13.1		14.2	0.5	15.3	1.5	15.3	1.2	14.0	9.1	11.3	21.9	8.3	18.7	10.3
1	11.5	10.3	4.3	13.1		14.2	0.7	15.3	2.2	15.3	1.2	13.9	9.1	11.3	21.9	8.3	18.7	10.3
2	11.5	10.3	4.3	13.1		14.2	1.1	15.2	2.2	15.4	1.3	13.8	9.1	11.3	21.6	8.3	18.5	10.3
3	11.5	10.3	4.3	13.1		14.5	1.0	15.3	2.4	15.4	1.3	13.8	9.0	11.2	21.3	8.3	18.3	10.3
4	11.5	10.3	4.3	13.1		14.5	1.0	15.3	2.4	15.4	1.3	13.8	9.0	11.2	21.2	8.4	18.2	10.4
5	11.4	10.3	4.3	13.1		14.5	1.0	15.3	2.4	15.4	1.3	13.8	9.0	11.2	21.0	8.5	18.2	10.4
6	11.4	10.3	4.2	13.1		14.5	1.0	15.3	2.5	15.4	1.3	13.8	9.0	11.2	20.9	8.6	18.0	10.5
7	11.4	10.3	4.3	13.1		14.5	1.0	15.3	2.5	15.4	1.3	13.8	8.9	11.2	20.8	8.3	17.9	10.6
8	11.3	10.3	4.3	12.8		14.5	1.0	15.3	2.5	15.4	1.3	13.8	8.9	11.1	20.7	8.2	17.9	10.6
9	11.2	10.3	4.2	12.8		14.5	1.0	15.4	2.5	15.4	1.3	13.8	8.0	11.1	20.6	8.2	17.8	10.6
10	11.1	10.2	4.2	12.8		14.6	1.0	15.3	2.5	15.4	1.3	13.8	8.9	11.1	20.4	7.9	17.7	10.5
11	11.1	10.2	4.2	12.7		14.5	1.1	15.4	2.6	15.4	1.3	13.8	8.9	11.1	19.3	6.6	17.7	10.4
12	11.0	10.1	4.3	12.8		14.5	1.2	14.8	2.6	15.5	1.3	13.8	8.9	11.1	18.3	5.9	16.5	10.2
13	10.9	9.7	4.3	12.8		14.4	1.3	14.8	2.6	15.4	1.3	13.8	8.9	11.1	17.1	3.2	16.7	5.9
14	10.8	9.5	4.3	12.8		14.4	1.5	14.3	2.5	15.2	1.3	13.8	8.9	11.1	16.2	1.6		
15			4.3	12.8		14.3	2.1	12.1	2.5	15.1	1.3	13.8	8.9	11.2				
16			4.3	12.8									8.9	10.9				

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	19.6	9.8	24.4	9.0	26.7	8.8	26.5	9.2	24.2	8.4	26.4	10.1	21.7	8.6	15.5	8.7
1	19.6	9.7	24.4	9.0	26.7	8.8	26.6	9.2	24.3	8.4	26.4	10.1	21.6	8.8	15.5	8.7
2	19.6	9.7	24.4	9.1	26.7	8.8	26.6	9.2	24.3	8.4	25.9	10.5	21.4	9.0	15.5	8.7
3	19.6	9.6	24.3	9.1	26.7	8.8	26.6	9.2	24.2	8.3	25.6	10.3	21.2	9.0	15.5	8.7
4	19.5	9.7	24.0	9.0	26.7	8.8	26.6	9.1	24.1	8.1	25.5	10.1	21.3	9.0	15.5	8.7
5	19.5	9.6	24.0	8.9	26.7	8.8	26.5	9.1	24.1	8.0	25.3	9.8	21.2	8.8	15.5	8.7
6	19.5	9.6	23.9	8.9	26.7	8.8	26.4	9.0	24.1	8.0	25.2	8.9	21.1	8.7	15.5	8.7
7	19.5	9.8	23.9	8.8	26.7	8.8	26.1	8.5	23.9	7.7	25.0	8.6	21.2	8.7	15.4	8.7
8	19.5	9.7	23.8	8.6	26.7	8.8	25.9	8.3	23.9	7.7	23.9	7.0	21.1	8.7	15.3	8.7
9	19.5	9.8	23.7	8.4	26.7	8.8	25.8	8.1	23.8	7.7	23.3	4.7	21.1	8.6	15.3	8.7
10	19.5	9.7	23.6	8.3	26.7	8.8	25.6	6.9	23.8	7.7	22.9	2.9	21.3	8.7	15.2	8.7
11	19.5	9.6	23.4	7.5	26.7	8.8	25.5	6.4	23.8	7.7	22.4	0.9	21.3	8.7	15.2	8.7
12	19.5	9.7	22.8	5.6	24.8	8.0	25.1	4.2	23.7	7.6	22.2	0.1	21.1	8.7	15.1	8.7
13	19.5	9.7	22.1	4.6	24.2	2.5	24.7	2.0	23.7	7.4	21.8	0.1	21.1	8.5	15.0	8.7
14	19.5	9.6	21.3	2.3	24.0	2.0	24.5	0.1	23.7	7.3	21.8	0.1	21.0	8.3	14.9	8.8
15	19.4	9.4	19.8	0.1	23.6	0.7	24.1	0.1			21.5	0.1			14.8	8.9
16			19.0	0.1	23.5	0.6									14.8	8.9

Appendix D3. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-3

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	11.2	10.7	4.5	13.3		15.4	0.9	15.2	2.2	15.2	1.6	13.9	9.3	11.1	22.2	8.8	19.8	11.2
1	11.1	10.7	4.5	13.1		15.8	0.8	15.3	2.2	15.2	1.5	13.9	9.3	11.1	22.1	8.8	19.4	11.2
2	11.1	10.8	4.5	13.0		15.7	1.0	15.2	2.2	15.2	1.5	13.9	9.3	11.1	22.1	8.8	19.4	11.3
3	11.1	10.8	4.5	13.0		15.7	1.2	15.1	2.2	15.2	1.5	13.9	9.3	11.1	21.9	8.8	19.2	11.3
4	11.1	10.8	4.5	13.0		15.8	1.5	15.1	2.2	15.2	1.5	14.0	9.3	11.1	21.7	9.1	18.6	11.7
5	11.1	10.7	4.5	13.0		14.4	1.6	15.2	2.2	15.2	1.5	13.9	9.3	11.1	21.4	9.1	18.4	11.6
6	11.1	10.7	4.5	13.0		13.5	1.9	14.9	2.2	15.2	1.5	14.0	9.3	11.1	21.3	9.1	18.4	11.4
7	11.1	10.7	4.5	13.0		12.8	2.2	14.1	2.2	15.2	1.5	13.9	9.2	11.1	21.2	9.1	18.2	11.2
8	11.0	10.7	4.5	13.0		11.9	2.4	13.2	2.3	15.2	1.5	13.9	9.2	11.1	21.1	8.9	18.1	10.6
9	11.0	10.6	4.5	13.0		11.3	2.5	13.0	2.3	15.2	1.5	13.9	9.1	11.0	20.5	8.1	17.8	10.1
10	11.0	10.6	4.5	13.0		11.2	2.6	12.7	2.3	15.2	1.5	14.0	9.1	11.0	19.9	7.3	17.8	9.5
11	11.0	10.6	4.5	13.0		11.0	2.7	12.3	2.3	15.3	1.5	13.9	8.9	11.0	19.1	7.0	18.0	10.2
12			4.5	13.0		10.4	2.8	12.3	2.4	15.4	1.5	13.9	8.9	11.0	18.5	5.5	17.8	10.3
13			4.5	12.9		10.3	2.8	12.3	2.4	15.4	1.5	13.9	8.9	11.0			17.7	10.3
14							3.0	11.5										

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	20.5	10.0	25.1	9.2	27.0	9.7	26.9	9.3	24.3	8.2	27.7	9.9	21.6	8.1	14.9	9.2
1	20.5	10.0	25.0	9.3	27.0	9.7	26.9	9.3	24.3	8.2	27.7	10.0	21.4	8.1	14.9	9.2
2	20.5	10.1	25.0	9.1	27.0	9.7	26.9	9.4	24.4	8.2	27.7	10.0	20.9	8.6	14.9	9.2
3	20.5	10.1	25.0	9.1	27.1	9.7	26.9	9.4	24.3	8.2	27.5	10.1	20.9	8.5	14.8	9.2
4	20.5	10.1	25.0	9.0	27.1	9.7	27.0	9.4	24.4	8.2	25.7	8.2	20.8	8.5	14.8	9.2
5	20.5	10.1	24.9	9.0	27.0	9.7	27.0	9.4	24.4	8.2	25.5	7.9	21.1	8.3	14.5	9.0
6	20.5	10.2	24.8	8.8	27.0	9.5	26.7	9.0	24.2	7.5	25.3	7.0	20.8	8.2	14.5	9.0
7	20.4	10.2	24.3	8.5	26.6	9.0	26.5	8.6	24.0	7.2	25.0	5.8	20.8	8.1	14.5	9.0
8	20.4	10.2	23.6	7.7	25.9	6.9	26.2	8.1	23.9	7.0	24.6	3.8	20.8	7.9	14.4	9.0
9	20.2	10.5	23.3	7.0	25.7	6.8	25.9	8.0	23.7	6.6	23.4	1.7	2.08	7.6	14.4	9.0
10	20.2	10.5	22.4	6.4	25.3	7.1	25.2	6.8	23.6	6.4	22.9	1.4	20.7	7.6	14.4	9.0
11	20.2	10.3	21.9	5.8	25.1	6.9	25.5	5.9	23.5	6.3	22.5	0.1	20.7	7.6	14.3	8.8
12	20.0	10.0	21.7	5.2	24.2	5.5	25.3	4.5	23.4	6.4	22.1	0.1	20.6	7.8	14.3	8.8
13	17.5	8.3	20.7	3.6	22.6	2.5	24.9	3.4	23.3	6.3			20.6	7.6	14.3	8.8
14	15.5	7.6	20.7	3.6	21.7	1.1									14.2	8.8

Appendix D4. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-4

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	10.6	8.5	4.2	12.8		13.8	0.9	15.9	3.0	13.3	1.2	13.8	9.8	11.0	22.9	8.2	19.8	10.6
1	10.6	8.5	4.2	12.7		13.8	1.2	15.9	3.0	13.2	1.3	13.8	9.8	11.0	22.8	8.3	19.6	10.5
2	10.6	8.5	4.2	12.7		13.9	1.4	15.9	3.0	13.3	1.3	13.9	9.8	11.0	22.8	8.3	19.2	10.3
3	10.5	8.5	4.2	12.7		13.7	1.5	15.9	3.0	13.3	1.3	13.9	9.8	11.0	22.7	8.3	19.0	10.4
4	10.5	8.5	4.2	12.7		13.7	1.6	16.0	2.9	13.2	1.3	13.9	9.8	11.0	22.4	7.9	19.0	10.4
5	10.6	8.5	4.3	12.7		13.7	1.5	16.0	2.9	13.0	1.4	13.9	9.8	11.0	21.8	7.7	18.8	10.3
6	10.6	8.5	4.3	12.7		13.7	1.6	16.0	2.9	13.0	1.4	13.9	9.8	11.0	21.2	7.9	18.6	10.2
7	10.5	8.5	4.3	12.7		13.7	1.7	16.0	3.0	13.0	1.4	13.9	9.7	11.0	21.1	7.7	17.5	9.9
8	10.5	8.5	4.3	12.8		13.6	1.8	15.1	3.0	13.0	1.4	14.0	9.7	11.1	21.0	7.4	17.2	9.6
9	10.4	8.5	4.3	12.8		13.7	2.5	13.3	3.0	12.9	1.4	14.0	9.7	11.1	19.4	5.3	16.9	8.9
10	10.4	8.4	4.3	12.9		13.7	2.6	11.2	3.0	12.9	1.4	13.9	9.6	11.1	18.0	2.8	16.8	8.1
11	10.4	8.2	4.3	12.9		13.5	3.3	9.2	3.0	12.9	1.4	13.9	9.6	11.1	17.2	1.4	16.7	7.9
12							3.3	9.1										

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	20.4	9.8	25.3	9.3	26.6	9.0	26.8	9.7	24.1	8.9	26.9	10.5	21.8	9.5	14.8	9.6
1	20.4	9.8	25.3	9.3	26.6	9.0	26.9	9.6	24.1	8.9	26.9	10.5	21.9	9.6	14.9	9.7
2	20.4	9.8	25.1	9.4	26.6	9.0	27.0	9.6	24.1	8.9	26.7	10.7	21.9	9.6	14.9	9.7
3	20.4	9.8	24.8	9.4	26.6	9.0	26.9	9.6	24.0	8.9	26.2	11.0	21.5	9.6	14.9	9.7
4	20.3	9.8	24.6	9.5	26.6	9.0	26.7	9.7	23.9	8.9	25.4	10.5	20.6	8.6	14.9	9.7
5	20.4	9.8	24.2	9.3	26.5	9.0	26.2	9.8	23.6	8.8	25.1	9.9	20.5	8.7	14.9	9.6
6	20.4	9.8	24.0	8.8	26.5	9.0	25.8	9.0	23.6	8.6	24.8	9.2	20.5	8.8	14.9	9.6
7	20.4	9.8	23.8	8.4	26.5	9.0	25.6	8.7	23.4	8.0	24.2	6.6	20.5	8.8	14.9	9.6
8	20.4	9.8	23.7	7.8	26.3	8.7	25.4	7.0	23.3	7.7	22.3	0.1	20.4	8.4	14.9	9.6
9	20.4	9.8	23.6	7.7	25.0	6.4	25.4	4.9	23.2	7.1	22.1	0.1	20.5	8.1	14.9	9.6
10	20.4	9.8	23.6	7.4	25.0	3.5	24.8	0.4	23.2	7.1	21.8	0.1			14.9	5.6
11	20.3	9.8	23.1	5.7	24.7	2.2	24.4	0.1			21.7	0.1			14.9	5.6
12	20.3	9.7	23.3	5.6												

Appendix DS. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-5

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	11.6	8.0	4.2	12.9		13.2	1.3	14.4	2.9	13.8	2.8	13.5	9.7	11.9	21.9	8.9	20.6	11.3
1	11.6	8.1	4.3	12.7		13.2	1.4	14.4	2.9	13.8	2.8	13.5	9.6	12.0	21.9	8.9	20.5	11.3
2	11.6	8.1	4.2	12.7		13.2	1.4	14.4	2.9	13.8	2.8	13.5	9.7	12.0	21.8	8.9	20.5	11.2
3	11.6	8.2	4.2	12.7		13.2	1.4	14.4	2.9	13.8	2.8	13.5	9.7	12.0	21.7	8.9	19.7	10.6
4	11.6	8.3	4.2	12.7		13.2	1.3	14.5	2.9	13.8	2.8	13.5	9.7	12.0	21.7	9.0	19.7	10.5
5	11.6	8.3	4.3	12.7		13.2	1.3	14.5	2.9	13.8	2.8	13.5	9.6	11.9	21.6	9.0	19.6	10.5
6	11.6	8.3	4.3	12.8		13.1	1.4	14.6	2.9	13.8	2.8	13.5	9.5	11.9	21.6	9.0	19.4	10.5
7	11.6	8.3	4.3	12.8		13.2	1.4	14.6	2.9	13.8	2.8	13.5	9.5	11.8	21.2	9.0	18.7	10.5
8	11.6	8.3	4.3	12.8		13.2	1.3	14.6	2.9	13.8	2.9	13.5	9.4	11.8	20.5	8.8	18.3	10.8
9	11.6	8.3	4.3	12.8		13.2	1.3	14.6	2.9	13.8	2.9	13.5	9.5	11.8	20.4	9.0	18.6	10.8
10	11.6	8.3	4.3	12.8		13.1	1.3	14.5	2.9	13.8	2.8	13.5	9.4	11.8	20.1	8.6	18.4	10.9
11	11.6	8.3	4.3	12.8		13.1	1.4	14.5	2.9	13.8	2.8	13.5	9.4	11.8	19.7	8.4	17.9	10.8
12	11.7	8.3	4.3	12.9		13.1	1.4	13.8	2.9	13.8	2.8	13.5	9.4	11.8	19.2	8.2	17.9	10.5
13	11.6	8.3	4.3	13.0		13.1	1.6	14.0	2.9	13.8	2.8	13.5	9.4	11.8	18.2	7.5	18.0	9.9
14	11.7	8.3	4.3	13.0		13.0	1.7	13.6	3.0	13.8	2.8	13.5	9.3	11.8	17.1	6.3	17.7	9.4
15	11.7	8.3	4.3	13.0		13.0	1.8	13.5	3.0	13.8	2.8	13.5	9.3	11.8	16.1	4.9	17.2	7.9
16			4.3	13.0		13.0	1.8	11.5	3.0	13.8	2.8	13.5	9.3	11.7	15.4	3.4	17.1	6.4
17			4.3	13.0		12.9	2.2	10.6	3.0	13.8	2.8	13.5	9.3	11.7	14.8	1.7	17.1	6.0

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	20.0	9.3	25.5	8.5	26.5	8.2	26.7	8.6	24.5	7.8	26.6	9.0	22.5	9.3	15.6	9.4
1	20.0	9.3	25.5	8.5	26.5	8.2	26.7	8.6	24.5	7.8	26.6	9.0	22.4	9.4	15.6	9.4
2	20.0	9.3	25.5	8.5	26.5	8.2	26.7	8.6	24.5	7.8	26.5	9.0	22.3	9.4	15.6	9.4
3	20.0	9.3	25.5	8.5	26.5	8.2	26.7	8.6	24.5	7.8	26.1	9.4	21.6	9.3	15.6	9.4
4	20.0	9.3	25.5	8.5	26.5	8.2	26.6	8.6	24.6	7.8	25.8	9.5	21.6	9.2	15.6	9.4
5	20.1	9.3	25.5	8.5	26.5	8.2	26.5	8.5	24.5	7.8	25.8	9.5	21.6	8.8	15.6	9.4
6	20.1	9.3	25.3	8.4	26.5	8.2	26.4	8.4	24.5	7.8	25.6	9.2	21.4	8.5	15.6	9.4
7	20.0	9.3	25.3	8.4	26.5	8.2	26.3	8.3	24.4	7.8	25.4	8.8	21.3	8.4	15.6	9.4
8	20.0	9.3	24.9	7.9	26.5	8.2	26.1	8.1	24.4	7.7	25.3	8.5	21.4	8.0	15.6	9.4
9	20.0	9.3	24.5	8.1	26.4	8.1	26.1	8.1	24.3	7.7	25.2	7.9	21.3	8.0	15.6	9.4
10	20.0	9.3	24.3	8.3	25.8	7.7	26.1	8.1	24.4	7.7	24.4	5.8	21.3	8.1	15.7	9.4
11	20.0	9.3	24.0	7.6	25.7	7.5	26.0	8.0	24.4	7.7	23.9	4.8	21.2	7.9	15.7	9.4
12	20.0	9.3	23.6	6.8	25.5	7.2	25.9	7.8	24.3	7.7	23.6	4.1	21.2	7.2	15.7	9.4
13	20.0	9.3	23.0	6.2	25.3	7.0	25.5	6.3	24.4	7.6	23.1	2.3	21.2	7.2	15.7	9.4
14	20.0	9.3	21.0	4.0	25.1	6.4	25.0	4.9	24.4	7.6	22.9	1.0	21.2	7.0	15.6	9.4
15	17.5	8.7	19.7	2.2	24.3	5.7	24.8	4.2	24.5	7.7	22.6	0.1	21.2	6.8	15.6	9.4
16	16.5	7.3	18.6	1.1	23.0	3.4	24.3	1.5	24.2	7.7	22.3	0.1	21.2	6.4	15.6	9.4
17	15.6	5.1	17.8	0.2	20.2	0.1	22.8	0.1					21.1	5.7	15.5	9.3
18			17.6	0.2	20.0	0.1										

Appendix D6. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-6

	10/13/92		11/12		12/21		1/19/93		2/10		3/16		4/13		5/10		5/26	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	9.3	9.5	2.2	13.7		13.6	0.9	15.7	2.3	14.4	2.1	14.5	10.0	11.6	23.9	10.1	20.7	12.6
1	9.3	9.8	2.2	13.6		13.5	1.1	15.8	2.3	14.4	2.0	14.5	10.1	11.7	24.0	10.2	20.7	12.7
2	9.3	9.8	2.3	13.6		13.4	1.5	15.0	2.3	14.5	2.0	14.6	10.1	11.7	24.0	10.2	20.9	12.8
3	9.3	9.8	2.3	13.6		13.4	1.6	16.0	2.3	14.6	2.0	14.6	10.1	11.7	23.8	10.4	19.7	12.7
4	9.3	9.4	2.3	13.6		13.3	2.8	15.8	2.3	14.6	2.0	14.5	10.1	11.7	22.2	9.1	18.7	12.1
5			2.3	13.3		12.4	3.0	13.7	2.4	14.6	2.0	14.3	10.1	11.7				

	6/9		6/22		7/7		7/20		8/4		8/18		9/8		9/28	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	21.1	10.6	26.0	10.5	26.2	9.0	26.5	9.2	22.3	8.9	26.0	9.4	21.8	11.1	13.9	10.3
1	21.2	10.6	26.0	10.6	26.1	9.1	26.5	9.3	22.4	8.9	26.0	9.4	21.9	11.1	13.9	10.3
2	21.2	10.6	26.0	10.6	26.0	9.1	26.5	9.3	22.4	8.9	25.9	9.5	21.9	11.1	13.9	10.3
3	21.2	10.5	25.5	11.0	25.6	9.0	26.2	9.4	22.3	8.9	25.2	8.7	20.6	11.1	13.9	10.3
4	21.2	10.4	24.3	10.0	25.4	8.3	25.7	6.9	22.3	8.5	25.0	5.3	20.2	10.5	14.0	10.3
5	21.2	10.2	24.0	7.6	25.3	7.5										

Appendix D7. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-7

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	10.0	9.7	2.4	13.5		14.5	0.7	15.7	2.6	14.1	2.3	13.6	10.4	11.5	24.4	10.7	20.3	12.3
1	10.0	9.6	2.4	13.4		14.4	0.9	15.7	2.6	14.1	2.3	13.6	10.4	11.5	24.5	10.8	20.4	12.3
2	10.0	9.6	2.5	13.3		14.5	1.1	15.7	2.6	13.9	2.3	13.6	10.4	11.5	25.5	10.8	20.3	12.4
3	10.0	9.6	2.5	13.3		14.4	1.2	15.7	2.5	14.0	2.3	13.7	10.4	11.5	24.1	10.5	20.2	12.4
4	10.0	9 6	2.6	13.3		14.5	1.3	15.8	2.5	13.8	2.4	13.8	10.5	11.5	22.2	9.4	20.0	12.5
5	10.0	9.7	2.5	13.2		14.5	1.5	15.9	2.5	14.0	2.3	13.8	10.5	11.5	21.9	8.8	18.5	12.9
6	10.0	9.5																
7																		

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	20.8	10.3	26.2	10.4	26.3	10.2	26.9	10.5	24.1	9.6	26.6	10.1	22.2	11.6	14.8	10.4
1	20.9	10.3	26.2	10.4	26.3	10.2	26.9	10.5	24.2	9.6	26.4	10.1	22.2	11.6	14.8	10.4
2	20.9	10.3	25.9	10.6	26.3	10.3	26.9	10.5	23.8	9.7	25.8	9.3	22.2	11.6	14.8	10.4
3	20.9	10.3	25.6	10.6	26.3	10.3	26.9	10.4	23.2	9.0	25.5	8.9	22.0	11.5	14.7	10.4
4	20.9	10.3	25.5	10.6	26.2	9.7	26.8	10.4	22.9	8.6	25.4	8.7	21.4	11.1	14.6	10.4
5	20.6	10.1	24.7	9.8	25.7	8.4	26.5	10.0	23.0	8.5	25.3	7.5	21.4	11.0	14.6	10.4
6	20.4	10.0	24.5	9.1	25.3	6.3	26.4	9.5	22.9	8.3	25.0	4.8	21.2	10.6	14.5	10.4
7	20.4	9.8			25.3	6.1										

Appendix D8. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-8

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	11.0	10.4	3.3	12.9		14.6	1.0	15.6	2.5	14.7	2.3	13.3	9.4	11.7	20.8	9.0	18.7	11.8
1	11.0	10.4	3.3	12.8		14.6	1.0	15.6	2.5	14.7	2.4	13.3	9.4	11.7	21.2	9.0	18.7	11.8
2	11.0	10.4	3.3	12.8		14.5	1.1	15.7	2.5	14.7	2.4	13.3	9.4	11.7	21.2	9.0	18.7	11.7
3	11.0	10.4	3.3	12.8		14.5	1.0	16.1	2.5	14.8	2.4	13.3	9.4	11.7	21.1	9.0	18.7	11.6
4	11.0	10.4	3.3	12.8		14.5	1.1	16.5	2.5	14.8	2.4	13.3	9.4	11.7	20.9	9.0	18.4	11.5
5	11.0	10.4	3.3	12.8		14.5	1.0	16.6	2.5	14.8	2.4	13.3	9.4	11.7	20.9	9.0	18.3	11.4
6	11.0	10.4	3.3	12.8		14.5	1.0	16.0	2.5	14.8	2.4	13.3	9.4	11.7	20.9	9.0	18.3	11.4
7	11.0	10.4	3.3	12.8		14.5	1.0	16.1	2.5	14.8	2.4	13.3	9.4	11.7	20.9	9.0	18.2	11.4
8	11.0	10.3	3.3	12.8		14.5	1.0	16.1	2.5	14.8	2.4	13.3	9.4	11.7	20.8	9.0	17.9	10.7
9	11.0	10.4	3.3	12.7		14.5	1.0	16.0	2.5	14.8	2.4	13.2	9.4	11.7	20.8	9.0	17.5	10.4
10	11.0	10.3	3.3	12.8		14.5	1.0	16.0	2.5	14.8	2.4	13.2	9.4	11.7	20.8	9.1	17.3	10.4
11	11.0	10.3	3.3	12.8		14.5	1.1	15.1	2.5	14.8	2.4	13.2	9.4	11.7	20.8	9.1	17.1	9.5
12	11.0	10.3	3.3	12.7		14.5	1.6	12.7	2.5	14.7	2.4	13.2	9.4	11.7	20.6	8.9	16.9	8.8
13	11.0	10.3	3.3	12.8		14.5	1.8	12.6	2.5	14.7	2.4	13.2	9.4	11.7	20.6	8.9	16.8	8.5
14	10.9	10.3	3.3	12.8		14.4	2.2	13.0	2.5	14.7	2.4	13.2	9.4	11.7	20.6	8.9	16.7	8.2
15	10.7	10.3	3.3	12.7		14.4	2.4	12.7	2.5	14.7	2.4	13.2	9.4	11.7	20.6	8.6	16.6	7.7
16	10.6	10.2	3.3	12.6		14.4	2.5	10.9	2.6	14.7	2.4	13.2	9.4	11.7	20.3	8.6	16.5	6.6
17			3.4	12.3		14.1			2.6	14.6	2.4	13.1	9.4	11.6	20.1	8.5	16.4	5.8

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	19.2	10.0	25.8	9.8	25.6	8.5	26.1	10.0	23.8	7.7	26.0	10.0	22.4	12.2	15.3	9.5
1	19.2	10.0	25.8	9.8	25.5	8.5	26.1	10.0	23.8	7.7	26.1	10.1	22.4	12.2	15.3	9.5
2	19.2	10.0	25.8	9.8	25.5	8.6	26.1	10.1	23.8	7.6	26.1	10.1	22.4	12.2	15.4	9.5
3	19.2	10.0	25.8	9.8	25.3	8.0	26.1	10.0	23.8	7.7	26.0	10.1	22.4	12.2	15.4	9.5
4	19.2	10.0	25.8	9.8	25.3	7.9	26.0	10.0	23.8	7.6	26.0	10.1	22.4	12.2	15.4	9.5
5	19.1	9.9	25.8	9.8	25.2	7.6	26.0	9.9	23.8	7.6	25.8	9.9	22.3	12.1	15.4	9.5
6	19.1	9.9	25.6	9.8	25.2	7.4	26.0	10.0	23.8	7.5	25.7	9.7	22.2	11.9	15.4	9.5
7	19.1	9.9	25.5	9.9	25.2	7.3	26.0	10.0	23.8	7.5	25.6	9.6	22.2	11.7	15.4	9.5
8	19.1	9.9	25.3	9.7	25.1	7.2	25.9	9.7	23.7	7.4	25.5	9.3	22.2	11.6	15.4	9.5
9	19.1	9.9	25.2	9.7	25.1	7.0	25.9	9.7	23.7	7.4	25.3	8.8	22.2	11.6	15.4	9.5
10	19.1	9.9	24.6	8.8	25.1	6.8	25.9	9.7	23.7	7.4	25.1	7.5	22.2	11.6	15.4	9.5
11	19.1	9.9	24.2	8.0	25.0	6.8	25.9	9.7	23.7	7.4	23.9	2.3	22.2	11.5	15.4	9.5
12	19.1	9.9	23.8	7.1	25.0	6.9	25.9	9.6	23.6	7.4	23.4	0.3	21.9	11.5	15.4	9.5
13	19.1	9.9	23.3	5.9	25.0	7.0	25.9	9.6	23.6	7.5	23.1	0.1	21.4	9.7	15.4	9.5
14	19.1	9.9	23.3	4.9	24.9	5.6	25.9	9.6	23.6	7.4	22.9	0.1	21.2	9.4	15.4	9.5
15	19.1	9.9	22.0	1.2	24.8	3.8	25.9	9.6	23.5	7.0	22.3	0.1	21.1	8.9	15.4	9.5
16	19.1	9.8	21.6	0.2	24.6	3.6	25.9	9.6	23.4	6.9	22.1	0.1	21.1	8.6	15.4	9.5
17	19.1	9.8	20.6	0.1	24.3	2.2	25.9	9.4	23.4	7.0						

Appendix D9. Dissolved Oxygen and Temperature Observations in Wolf Lake at RHA-9

	10/13/92		*11/12*		*12/21*		*1/19/93*		*2/10*		*3/16*		*4/13*		*5/10*		*5/26*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	13.4	7.1	5.9	12		14.3	3.0	17.1	5.0	11.3	3.7	11.0	10.4	11.8	22.6	10.0	20.7	8.4
1	13.5	6.9	5.9	10.2		14.3	3.3	17.1	5.0	11.3	3.8	11.0	10.5	11.8	22.5	10.0	20.7	8.4
2	13.4	7.0	5.9	10.2		14.2	3.4	16.8	5.0	11.3	3.8	11.0	10.5	11.8	22.4	9.9	20.6	8.7
3	13.1	7.1	5.9	10.2		14.2	3.6	16.9	5.0	11.3	3.8	11.0	10.5	11.8	21.1	9.8	20.5	8.9
4	12.9	7.6	5.9	10.1		14.2	3.7	17.1	5.0	11.3	3.8	11.0	10.5	11.9	19.2	9.4	20.5	9.0
5	12.9	7.6	5.9	10.1		14.0			5.0	11.3	3.8	11.0	10.5	11.9	18.3	9.2	20.3	8.9
6	12.9	7.6	5.9	10.1		14.0			5.0	11.3	3.8	11.0	10.5	11.9	17.6	8.9	18.3	8.8
7	12.8	7.6	5.9	10.1		13.4			4.9	11.4	3.8	11.0	10.5	12.0	16.2	8.7		
8			5.9	10.1					5.0	11.4	3.8	11.0	10.5	11.9				

	6/9		*6/22*		*7/7*		*7/20*		*8/4*		*8/18*		*9/8*		*9/28*	
Depth	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*	*Temp*	*DO*
0	21.4	3.6	24.5	7.9	26.0	7.9	26.8	5.5	23.7	3.0	25.3	6.1	23.1	3.7	19.1	4.2
1	21.4	3.6	24.5	7.8	25.9	7.9	26.8	5.5	23.7	3.0	25.4	6.1	23.2	3.7	19.2	4.2
2	21.4	3.5	24.5	7.8	25.9	7.9	26.7	5.6	23.8	3.0	25.3	5.9	23.1	3.6	19.2	4.1
3	21.4	3.5	24.3	7.9	25.9	7.9	26.7	5.6	23.8	2.9	25.1	5.7	23.1	3.5	19.1	4.0
4	21.4	3.4	24.1	7.9	25.9	7.9	26.7	5.6	23.8	2.8	25.0	5.6	22.9	3.3	19.0	3.9
5	21.4	3.3	22.9	5.9	24.2	7.2	26.6	5.8	23.8	2.9	24.8	5.0	22.6	2.7	18.2	2.6
6	21.4	3.2	21.5	4.1	21.8	5.7	26.2	5.6	23.8	2.9	24.5	2.6	22.3	2.0	17.2	1.3
7	21.1	2.4	21.0	4.3	21.2	5.9	26.1	5.3	23.7	2.7	24.0	1.8	22.2	1.8	16.6	1.2
8	20.1	4.1	19.7	5.4	21.2	5.9			23.7	2.8						

Appendix E. Percent Dissolved Oxygen Saturation in Wolf Lake

Appendix E1. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-1

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	77	101		103	%	97	103	95	106	103	99	100	105	97	107	94	89
1	77	101		103	98	97	102	94	106	103	99	100	105	97	107	93	89
2	77	101		104	98	98	103	94	106	103	99	100	105	97	107	93	89
3	77	101		104	98	98	102	94	106	103	99	100	105	97	107	93	89
4	77	101		104	98	98	102	93	105	103	99	100	105	97	107	94	89
5	77	102		104	98	98	103	93	104	103	99	100	105	99	107	94	89
6	77	102		104	98	98	103	93	104	103	99	100	105	97	107	93	89
7	77	102		104	98	98	103	93	104	100	99	100	105	99	107	93	89
8	77	102		105	98	91	103	93	104	100	99	100	105	99	107	93	89
9	76	102		105	98	95	103	93	103	100	99	98	105	99	106	93	89
10	77	102		105	98	96	103	93	103	98	98	97	105	99	106	93	89
11	77	101		104	98	96	103	92	102	98	96	97	105	99	105	93	89
12	77	101		104	98	96	103	90	101	96	94	97	105	99	102	93	88
13	77	101		104	98	96	103	86	101	96	91	96	105	98	76	92	90
14	76	101		103	98	89	103	79	99	90	81	95	105	98	76	92	90
15	76	101		101	98	94	103	63	95	87	47	79	97	97	56	92	90
16		101		100	98	93	103	43	84	84	34	63	87	97	46	91	
17							103					47					

Appendix E2. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-2

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	95	101		106	109	99	98	96	111	108	109	111	116	101	127	99	88
1	95	101		106	111	98	98	96	111	107	109	111	116	101	127	101	88
2	95	101		107	112	98	98	95	111	107	110	111	116	101	131	103	88
3	95	101		107	112	98	97	94	110	106	110	111	116	100	127	102	88
4	95	101		107	112	98	97	95	111	107	108	111	115	97	125	102	88
5	95	101		107	112	98	97	96	111	105	107	111	115	96	121	100	88
6	95	101		107	113	98	97	97	112	105	107	111	113	96	109	99	88
7	94	101		107	113	98	97	94	112	108	105	111	106	92	105	99	87
8	94	98		107	113	98	97	92	112	106	103	111	103	92	84	99	87
9	93	98		108	113	98	97	92	112	106	103	111	103	92	84	99	87
10	93	98		107	113	98	97	88	111	106	99	111	85	92	34	97	87
11	92	97		108	113	98	97	72	110	105	89	111	79	92	10	99	87
12	92	98		104	113	98	97	63	108	106	66	97	51	91	1	97	87
13	88	98		105	113	98	97	33	61	106	53	30	24	88	1	%	87
14	86	98		102	111	98	97	16		105	26	24	1	87	1	94	88
15		98		88	110	98	94			103	1	8	1		1		88
16		98									1	7			1		88

Appendix E3. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-3

Depth	10/13/92	11/12	12/21	1/19/93	2/10	3/16	4/13	5/10	5/26	6/9	6/22	7/7	7/20	8/4	8/18	9/8	9/28
0	98	103		106	110	99	97	102	124	112	113	123	118	99	127	93	91
1	98	101		107	110	99	97	102	123	112	114	123	118	99	129	92	91
2	98	100		107	110	99	97	102	124	113	111	123	119	99	129	97	91
3	98	100		107	110	99	97	101	123	113	111	123	119	99	130	96	91
4	98	100		107	110	100	97	104	126	113	110	123	119	99	102	96	91
5	97	100		108	110	99	97	104	124	113	110	123	119	99	98	94	89
6	97	100		107	110	100	97	104	122	114	107	121	114	90	86	92	89
7	97	100		102	110	99	97	103	120	114	103	113	108	86	71	91	89
8	97	100		96	111	99	97	101	113	114	92	86	101	84	46	89	88
9	96	100		95	111	99	95	91	107	117	83	84	100	79	20	86	88
10	96	100		93	111	100	95	81	101	117	74	87	83	76	16	85	88
11	%	100		90	111	99	95	76	108	115	67	85	73	75	1	85	86
12		100		91	112	99	95	59	109	111	60	66	55	76	1	88	86
13		100		91	112	99	95		109	87	40	29	42	75		85	86
14				85						77	40	13					86

Appendix E4. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-4

Depth	10/13/92	11/12	12/21	1/19/93	2/10	3/16	4/13	5/10	5/26	6/9	6/22	7/7	7/20	8/4	8/18	9/8	9/28
0	77	98		111	99	97	97	96	117	110	114	113	123	107	133	109	95
1	77	98		112	98	98	97	97	115	110	114	113	122	107	133	111	96
2	77	98		113	99	98	97	97	112	110	115	113	122	107	135	111	96
3	76	98		113	99	98	97	97	113	110	115	113	122	107	138	110	96
4	76	98		114	98	98	97	92	113	109	115	113	123	107	129	96	96
5	77	98		114	98	99	97	88	111	110	112	113	123	105	121	97	96
6	77	98		114	96	99	97	90	110	110	106	113	112	102	112	99	95
7	76	97		114	96	99	97	87	104	110	100	113	108	95	79	99	95
8	76	98		108	96	99	97	84	100	110	93	109	86	91	1	94	95
9	76	98		97	96	99	97	58	92	110	92	78	60	84	1	91	95
10	75	99		82	96	99	98	30	84	110	88	43	5	84	1		95
11	73	99		69	96	99	98	15	82	109	67	27	1		1		95
12				68						108	66						

Appendix E5. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-5

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	74	98		102	102	100	105	102	127	103	105	103	109	94	113	108	95
1	75	97		102	102	100	105	102	127	103	105	103	109	94	113	109	95
2	75	97		102	102	100	106	102	125	103	105	103	109	94	113	109	95
3	76	97		102	102	100	106	102	117	103	105	103	109	94	117	106	95
4	77	97		103	102	100	106	103	116	103	105	103	108	95	118	105	95
5	77	97		103	102	100	105	103	115	103	105	103	107	94	118	101	95
6	77	98		104	102	100	104	103	115	103	103	103	106	94	114	97	95
7	77	98		104	102	100	103	102	113	103	103	103	104	94	108	96	95
8	77	98		103	102	100	103	99	116	103	96	103	101	93	105	91	95
9	77	98		103	102	100	103	101	116	103	98	102	101	93	97	91	95
10	77	98		103	102	100	103	96	117	103	100	96	101	93	70	92	95
11	77	98		103	102	100	103	93	115	103	91	93	100	93	57	90	95
12	77	99		98	102	100	103	89	111	103	81	89	97	93	49	82	95
13	77	100		100	102	100	103	80	105	103	73	86	78	92	27	82	95
14	77	100		97	102	100	103	66	99	103	45	78	60	92	12	79	95
15	77	100		97	102	100	103	50	83	92	24	69	51	93	1	77	95
16		100		83	102	100	102	34	67	75	12	40	18	93	1	73	95
17		100		77	102	100	102	17	63	52	2	1	1			65	94
18											2	1					

Appendix E6. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-6

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	83	99		110	105	105	103	121	142	120	131	113	116	103	117	128	100
1	85	99		111	105	105	104	122	143	120	132	114	117	104	117	128	100
2	85	99		114	105	105	104	122	144	120	132	113	117	104	118	128	100
3	85	99		114	106	105	104	124	140	119	136	111	118	103	107	125	100
4	82	99		116	106	105	104	105	131	118	121	102	86	99	65	117	100
5		97		102	106	103	104			116	91	92					

Appendix E7. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-7

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	86	98		109	103	99	103	129	137	116	130	128	133	115	127	134	103
1	86	98		110	103	99	103	131	137	116	130	128	133	116	127	134	103
2	86	97		110	102	99	103	131	137	116	132	128	133	116	116	134	103
4	86	97		111	102	100	103	126	138	116	131	128	133	106	110	133	103
5	86	97		113	102	100	103	101	139	113	119	104	126	100	92	125	103
6	84								135	112	110	78	119	97	59	120	102
7										110		75					

Appendix E8. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-8

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	95	96		109	107	97	102	101	127	109	122	105	125	92	125	142	95
1	95	%		109	107	97	102	102	127	109	122	105	125	92	125	142	95
2	95	96		110	107	97	102	102	127	109	122	105	125	92	125	142	96
3	95	%		113	108	97	102	102	125	109	122	98	125	92	125	142	96
4	95	%		116	108	97	102	102	123	108	122	97	125	92	125	142	96
5	95	96		116	108	97	102	102	123	108	122	93	123	92	123	140	96
6	95	96		112	108	97	102	102	122	108	121	91	125	90	120	138	96
7	94	96		113	108	97	102	102	122	108	122	90	125	90	119	136	96
8	95	96		113	108	97	102	101	114	108	119	88	121	88	115	134	96
9	94	95		113	108	96	102	101	109	108	119	86	121	88	108	134	96
10	94	96		113	108	96	102	103	109	108	107	83	121	88	92	134	96
11	94	%		106	108	96	102	103	99	108	96	83	121	88	28	133	96
12	94	95		91	107	96	102	100	91	108	85	84	119	88	4	132	96
13	94	%		90	107	96	102	100	85	108	70	86	119	89	1	110	96
14	93	96		94	107	96	102	100	85	108	58	68	119	88	1	107	96
15	93	95		93	107	96	102	96	79	108	14	46	119	83	1	101	96
16	92	94		80	108	96	102	96	68	107	2	44	119	82	1	97	96
17		92			107	96	102	94	60	107	1	27	117	83			
18																	

Appendix E9. Percent Dissolved Oxygen Saturation in Wolf Lake at RHA-9

Depth	*10/13/92*	*11/12*	*12/21*	*1/19/93*	*2/10*	*3/16*	*4/13*	*5/10*	*5/26*	*6/9*	*6/22*	*7/7*	*7/20*	*8/4*	*8/18*	*9/8*	*9/28*
0	68	82		127	88	83	106	117	94	41	96	98	70	36	75	44	46
1	66	82		128	88	83	106	117	94	41	94	98	70	36	75	44	46
2	67	82		126	88	83	106	115	98	40	94	98	71	36	73	42	45
3	68	82		127	88	83	106	111	100	40	95	98	71	35	70	41	44
4	72	81		129	88	83	107	102	101	39	95	98	71	33	68	39	42
5	72	81			88	83	107	98	99	38	69	87	73	35	61	32	28
6	72	81			88	83	107	94	94	36	47	66	70	35	31	23	14
7	72	81			89	83	108	89		27	49	67	66	32	22	21	12
8		81			89	83	107			46	59	67		33			

Appendix F. Salt Usage on the Indiana Toll Road

STATE of INDIANA

INDIANA DEPARTMENT OF TRANSPORTATION

Governor Evan Bayh

TOLL ROAD DIVISION
John A. Piraccini
General Manager
Post Office Box 1
Granger, Indiana 46530-0001
(219) 674-8836

September 14, 1994

Illinois State Water Survey
P. O. Box 697
Peoria, Illinois 61652

Attn: Ramon K. Ramon

Re: Wolf Lake - Winter Salt

Dear Mr. Ramon:

The information on salt used on the Indiana Toll Road for snow and ice removal in the area of Wolf Lake and Lake George is as follows:

Winter Period	Harbor Belt Railroad to 129th Street Salt spread adjacent to Wolf Lake
1991-92	86.8 Tons
1992-93	150.0 Tons
1993-94	167.5 Tons

A copy of our "Policy For Straight Salt Usage" Indiana Toll Road is enclosed for your information.

Very truly yours,

Samuel E Wolfe

Samuel E. Wolfe, P.E., L.S.
Road Operations Engineers

SEW:BAB

Enclosures

INDIANA TOLL ROAD

POLICY FOR STRAIGHT SALT USAGE

I. EQUIPMENT
  A. All spreading equipment will be calibrated and posted in trucks.
    1. 350 lbs/Miles - Mainline
    2. 250 lbs/Miles - Plaza Ramps
    3. 200 lbs/Miles - Service Areas
  B. All spreader trucks will be equipped with spreader lights for nighttime spreading.

II. SPREADING PROCEDURES - MAINLINE
  A. Spreader rate will be determined by projected and/or type of accumulation when possible.
  B. Priority areas and spot spreading will be determined by supervisors only. In the event of a supervisors absence, crew leaders will assume responsibility.
  C. Spreading in both lanes will only be done during peak traffic hours. During low volume traffic hours, spreading may be done from only the driving lane if conditions allow passing lane to be kept safe using this procedure.
  D. No spreading will be allowed on roadway shoulders with the exception of extreme drifting resulting in hazardous conditions being created in roadway and/or unplowable ice conditions. (Drifting is to be controlled by plowing as needed).
  E. Crossovers will only be spread on approach and acceleration area.
  F. At no time will any "Pre-Spreading" be done.

III. SPREADING PROCEDURES - PLAZAS
  A. Plaza ramps will only be spread so as to accommodate curves, deceleration areas, and grades. Straight-away sections on ramp areas will not be spread.
  B. Ramp bridges will be spread - deck only.
  C. Closed lanes at toll booths will only be treated prior to usage (upon request of Toll Collection).

IV. SPREADING PROCEDURES - SERVICE AREAS
  A. Ramps
    1. Off-ramps only, except if curves, bridge decks, or grades exist at on-ramp.
  B. Truck parking areas will only be spread when non-plowable ice exists.
  C. Fuel pump and car parking areas will be spread as needed. Only the parking areas that are lined for parking will be treated.
  D. Back dock area will only be spread to ramp, i.e. only sloped delivery/walkway area behind each building.
  E. Employee parking area to be treated same as truck parking area.

NOTE: NON-PLOWABLE ICE CONDITIONS WILL BE TREATED AS NEEDED TO MAINTAIN SAFETY IN ALL AREAS. THIS SITUATION MAY IMPLEMENT THE USE OF ABRASIVES AND/OR ALTERNATIVES.

11-06-91
Revised 07-05-94

11-06-91

INDIANA TOLL ROAD

POST STORM CLEAN-DP

I. Pavement sensors and/or ambient temperature will determine the cut-off of salt spreading unless packing conditions exist.

II. As soon as mainline lanes and plaza ramps are cleared, clean-up of salt handling areas will begin. All unused salt will be returned to the building.

III. Salt trucks will be unloaded as post storm clean-up progresses. NO salt will be used during post storm operations unless packing conditions are present and as needed around walkways. Trucks may remain loaded only if weight is needed to remove snow.

IV. Trucks will be unloaded inside salt storage facilities as room allows.

V. All salt handling equipment will be rinsed only in designated areas.

VI. All facilities will be inspected for compliance following each storm.

INDIANA DEPARTMENT OF TRANSPORTATION
Toll Road Division

INTER-OFFICE CORRESPONDENCE

orm SR-6
tem 7-146
ev. 07-81

o: Samuel E. Wolfe From; Patrick W. Baird
Road Operations Engineer Roadway Maintenance Superintendent

ubiect: Toll Road Snow Policy Date: December 22. 1992

Our current policy, which will remain in effect, for snow removal on the Toll Road is as follows:

1. Mainline Roadway
2. Toll Road Interchanges
3. Service Areas

(

NOTE: Ramps at Plazas and Service Areas may be included in Mainline Priority when needed to keep traffic flowing.

/PWB

cc: Joseph Agostino
W. J. Steely

Appendix G. A Sampling of Historical Data for Wolf Lake from Old IDEM Files

1929-1968

(from Hammond Park & Rec. Dept. 1979)

WOLF LAKE POLLUTION DATA

ch 16 1929 - Ordinance No. 2123 authorizing the sale of property to Lever Brothers Company. (Land under control of Board of Public Parks)

6 1929 - Motion at Park Board meeting calling attention to waste material being deposited in the lake by American Maize company.

ch 25 1936 - Articles of Agreement between Lever Brothers and the Health Department of the City of Hammond regarding composition of materials proposed to be emptied into Wolf Lake.

il 27 1944 - Letters between United States Senate committee on naval affairs and Board of Park Commissioners regarding reopening of the Wolf Lake River Channel to Lake Michigan.

y 13 1945 - Letter from Board of Park Commissioners to Hammond Council stating that swimming is closed due to high bacteria count. Lever Bros. and Amaizo contacted to reduce bacteria count. Impossible to get chlorine since it is on war-time priority.

y 13 1945 - Letter from Park Board to American Maize requesting assistance in lowering bacteria count in waste condenser water being disposed into Wolf River.

y 19 1945 - Letter from American Maize stating that Park Board is misinformed as they have completely stopped such practice over a year and a half previously. Statement that there can be no contamination of water from their procedure.

30 1945 - Letter from Lever Bros. stating that they are chlorinating water going into Wolf Lake from their plant. Preparing to install permanent chlorination equipment.

h 9 1946 - Letter to American Maize stating water is unsuitable for swimming at Wolf Lake due to sewage organisms.

ch 12 1946 - Excerpt from Park Board minutes stating that water is unfit for swimming after being tested by city chemist. Motion to send letters to Amaizo and Lever Bros. asking for representatives to attend next park board meeting to discuss the plant waste being dumped into Wolf Lake making it unsafe for swimming.

h 22 1946 - Letter from Amaizo stating they are not discharging waste materials either industrial or sanitary into Wolf Lake. The only materials they discharge is overflow of Lake Michigan water which is delivered from their pumping station on the lake front to the Plant Process Well. Statement that they are positive all sanitary wastes are being diverted to the Hammond Sanitary System. They stated they do not feel they are in any way responsible for the polluted condition found in Wolf Lake.

h 14 1946 - Robertsdale Civic League r to Lever Bros. stating they are not convinced that al sible steps are being taken by Lever Bros. to prevent po on of Wolf Lake. Asking for representative to come to park board meeting.

19 1946 - Letter from [illegible] stating [illegible] chlorination equipment ordered which will [illegible] reduce bacterial count to safe limits on water discharged into Wolf Lake.

5 1946 - Letter requesting Mr. Carpenter, Sewage Disposal Plant, to attend next park board meeting.

9 1946 - Excerpt from Park Board minutes - Mr. Carpenter stated that the Sanitary District has been in contact with Lever Bros. and Amaizo relative to contamination of water. Assurance from Park Board that they will cooperate with the Sanitary District in efforts to clear up bacteria in Wolf River and Wolf Lake.

3 1946 - Letter from Sanitary District stating they have assurance from Lever Bros. that efforts will be continued to improve bacteria count of material discharged from the plant into upper Wolf Lake River. Discussion with Amaizo still unsatisfactory, but work will be continued toward elimination of contamination.

t 27 1946 - Mr. Cunningham instructed to get all information from Sanitary District and State Board of Health relative to water conditions and progress being made to clear up contamination in Wolf Lake.

ber 12 1946- Excerpt from Park Board minutes - Motion that Park Dept. draft a letter to the Sanitary District stating that progress has not been satisfactory during 1946 on the correction of pollution of Wolf River, and that unless something is done immediately the Board will ask the State Board of Health to investigate the situation so Wolf River will be available for swimming during 1947.

ber 20 1946- Letter from Park Board to Sanitary Board as above.

ry 11 1947 -Letter from Sanitary District stating where water comes from that enters Wolf Lake (Lever Bros., Amaizo, surface run-off, and some of sub-surface origin.) Statement that their investigations began in 1942 and show that discharge from Amaizo and Lever Bros. have resulted in a thorough innoculation of the bed or floor of the channel with sedimentary deposits containing excessive amounts of sewage bacteria. It will be a considerable time before such contamination can be eliminated. Little progress made due to war shortages in getting responsible industries to improve quality of effluents from their plants. For the past few months all discharges from Lever Bros. and Amaizo have been chlorinated continuously. Sanitary Board will continue sampling of industrial plant effluents. Statement that the Sanitary Board has worked with the Indiana State Board of Health representatives on Wolf Lake problem and will continue such work.

ry 24 1947- Excerpt from Park Board minutes - The Board took no action due to the fact that Hammond Beach is one of the main sources of pollution and cannot be cleared up at this time.

9 1947 - Board requests Mr. McClau 324 to write Mr. Stilley, City attorney inquiring what c the Park Board should take regarding pollution. Fish are being destroyed at this time.

ay 26 1955 - Request from Dr. [illegible] of the City Health Dep to take samples of Wolf Lake channel. Copy of letter to Northwest Branch of State Dept. of Public Health.

une 15 1955 - Letter from Dr. Muscachio stating that samples will be taken regularly from Wolf Lake Channel and from 121st Street beach.

une 23 1955 - Letter from State Board of Health stating they plan to do further investigation throughout the summer.

ugust 24 1955 - Letter from Robert McKinnon to Dr. Muscachio requesting water tests and recommendation as to whether water is suitable for swimming at 121st Street beach.

ept. 21 1955 - Letter from James Adams, Park Board, to Stream Pollution control board requesting information relative to pollution of streams and lakes. Statement that Wolf Lake State property was transferred for control and supervision to the City of Hammond. Asking if the Stream Pollution Control Board has ar jurisdiction in the matter and asking for advice.

ctober 5 1955 - Letter from Stream Pollution Control Board stating that in accordance with Administrative Adjudication Act of 1947, a public hearing must be held to determine if a stream or lake is polluted. Statement that members of the Division of Sanitary Engineering of the Indiana State Board of Health have been working with Lever Bros. and Amaizo. Statement that bot companies maintain a chlorine residual so the water should be of a good bacteriological quality. However sludge deposits i the upper end of Wolf Lake indicate the need for better waste treatment to remove organic material from Wolf Lake. Assuranc that engineers will continue their work.

ctober [illegible] 1955 - Resolution by Park Board requesting continued action of the State Boards which have jurisdiction in stream pollution unti such time as the water pollution is eliminated and the water in Wolf Lake is made safe for swimming purposes.

ctober 11 1955 - Letter to Lever Bros. with copy of resolution and request for a representative to attend next Park Board meeting.

ctober [illegible] 1955 - Letter from Amaizo stating their chief chemist and their bacteriologist will attend the park board meeting.

ctober 18 1955 - Letter from Lever Bros. stating they will have representative at the Park Board meeting.

ctober 24 1955 - Letter to Mr. Perry Miller, State Board of Health, suggesting they have an engineer [illegible] with the Park Board to discuss pollution.

ctober 26 1955 - Letter stating that inspection trip was made along shore of Wolf Lake by Stream Pollution Control Board. Black sludge was observed, indicating [illegible] presence of putrescible organic soli Statement that Stream 325 ution Control Board does not have a engineer, but they [illegible] contact industries in the area advisi them of their findings and recommendations.

October 31,1955- Excerpt from Park Board minutes - Representative from Lever Bros., Amaizo and the State Board of Health were present. Plans shown for proposed swimming at Wolf Lake and representatives of companies asked if they were depositing waste material into Wolf Lake that would cause impurities. Amaizo stated their company is doing nothing to contaminate the water going into Wolf Lake because it is chlorinated. They stated they are working on plans to have their outlet run into Lake Michigan instead of Wolf Lake and will have this work comple within 3 months if desired. Lever Bros. said they put 10 million gallons of water per day into Wolf Lake and it is li[illegible] wise chlorinated. Mr. Miller of State Board of Health state[illegible] he noticed 3 storm sewers leading into Wolf Lake from Indiana[illegible] polis Blvd. This permanent easement was given to the State [illegible] Indiana by American Maize for drainage. Lever Bros. invited all concerned to visit their plant to see their facilites fo[illegible] chlorination of discharge water.

Nov. 22 1955 - Letter to Lever Bros. from Stream Pollution Control Board stating that water samples will be analyzed and that every effort must be made by the company to determine the source of wastes as well as providing treatment or elimination of such undesirable wastes. Same letter to Amaizo.

Jan. 23 1956 - Excerpt from Park Board minutes - Mr. Adams reported that Mr. Miller of the State Board of Health informed him that Lever Bros. have considered suggestions for installation or redevis ing the present engineering to improve quality of waste material being discharged into Wolf Lake.

Jan. 26 1956 - Letter from Mr. Higgins to Stream Pollution Control Board asking findings of State Board of Health regarding kind of pollution found and what steps recommended to solve the problem. Answer requested in order to determine whether a beach will be placed at Wolf Lake.

Feb. 10 1956 - Letter from Stream Pollution Control Board stating their engineers had met with representatives of Lever Bros. and Amaiz[illegible] Amaizo proposed to change sewer system so that no wastes, cool ing water or Lake Michigan water pumped by the company could enter Wolf Lake. Arrangements made with Mr. Johnson, Supt. o[illegible] Sanitary District to visit Lever Bros. Lever Bros. contacted the manufacturer of Colloidairo units used to treat wastes discharged to Wolf Lake to determine if the operation of the units could be improved. Manufacturer recommended that the scrapers be changed to further reduce amount of solid material being lost to Wolf Lake. New scrapers ordered. Pollution Board unable at this time to answer question whether Lever Bros. will correct pollution upon suggestions from them or whether it will be necessary to take court action against the company.

March 20 1956 - Letter from State Board of Health to Lever Bros. with report of survey of pollution of Wolf Lake (also Amaizo). Survey attached to the letter

April 20 1956 - Report of Mr. Higgins on conversation with State Board of Health at Indianapolis as submitted to Park Board meeting

May 24 1956 - Letter from Mr. Adams to Stream Pollution Control Board stati[illegible] they feel no progress has been made in reducing pollution of Wolf Lake to date. Correction of statement made previously that Lever Bros. was installing new scrapers. Mr. Cyler of Lever Bros. advised that his company had no plans to alter present installations to reduce sludge flow into Wolf Lake. Board of Park Commissioners requests Stream Pollution Control Board to schedule and proceed with a public hearing in accordance with administrative adjudication act of 1947. Board regrets attitude of Lever Bros.

May 25 1956 - Letter from Dr. Mucacchio to Mr. Higgins stating water at Hammond Beach is unsatisfactory for swimming.

May 28 1956 - Excerpt from Park Board minutes - Statement that Mr. Herring reported that after meeting with Lever Bros. representatives the company took the position that they were unable to dispos[illegible] of their industrial waste water in any other manner than what they were doing. Letter to Stream Pollution Control Board stating request for hearing in connection with Lever Bros. di[s]charge into Wolf Lake.

May 31 1956 - Copies of letter with diagram of areas where water tests were taken and copies of report of bacteriological tests.

June 6 1956 - Letter from Mr. Higgins to Director of Illinois Conservation Dept. stating that Lever Bros. is polluting Wolf Lake and soliciting their aid in helping the City of Hammond and State of Indiana correct pollution that is ruining swimming and fis[h]ing in Wolf Lake.

June 12 1956 - Letter from Amaiko to Southeast Sportsmen's Club (Illinois) in reply to their inquiry regarding pollution. Map of Amaiko plant included showing outlets etc.

June 22 1956 - Letter to Mr. Adams from Stream Pollution Control Board stati[ng] that officials of Lever Bros. and the Hammond Park Board are invited to be present at a meeting regarding the proposed hearing to determine if Lever Bros. is polluting Wolf Lake.

June 25 1956 - Letter from Illinois Department of Conservation to Mr. Higgin[s] stating they are asking the State Sanitary Water Board to investigate conditions of pollution of Wolf Lake as far as Illinois is concerned.

June 27 1956 - Letter from Mr. Higgins to Dr. Ranker asking him to accompany a group to Indianapolis to the Stream Pollution Control Board investigation of Lever Bros. pollution of Wolf Lake. Also a similar letter to Ray Dowling stating that the Park Board attorney and Mr. Gauthier of the Hammond Health Dept. have be[en] asked to attend the meeting.

July 25 1956 - Letter from Stream Po[illegible]ion Control Board changing date of original meeting to [illegible] 15th.

August 16 1956 - Letter to Dr. Ranker from Mr. Higgins requesting cooperation [illegible]

[illegible] 30 1956 - Brief on Pollution of [illegible] calling [illegible] of Stream Pollution Control Board of the State of Indiana and the provisions for composition of the board etc.

gust 3 1956 - Letter to Mayor Dowling from Mr. Higgins inviting him to accompany group to attend Stream Pollution hearing. Same letter sent to Dr. Fanker.

pt. 21 1956 - Letter from Mr. Higgins to Mr. Potesta of the Hammond Board of Health requesting that sampling of Wolf Lake water be continue

ept. 24 1956 - Letter of reply from Mr. Potesta stating that weekly tests can not be handled because of limited facilities, but offered to instruct a park man on the procedure of picking up water sampl to be run by Health Department laboratories.

tober 3 1956 - Letter to Lever Bros. from Stream Pollution Control Board requesting report of steps planned to abate pollution of Wolf La

ril 4 1957 - Long letter to Mayor Dowling from Mr. Oyler, plant manager of Lever Bros. stating method of treatment of water discharged in Wolf Lake. States that some city authorities agree with position of Lever Bros. that even though they might remove all effluent, Wolf Lake could probably not be made a suitable plac for swimming. Statement that depending upon the attitude of Lever Bros. toward the problem, the city may be willing to wit draw the complaint made against the company and recommend to the Stream Pollution Control Board that the hearing be dismiss ed. If the hearing is dismissed, he advised that the company stands ready to cooperate with the City, the State and all pro per authorities to the end that they will be on the alert to improve the operation of their treatment equipment. State that residents of an industrial community must tolerate inconvenien such as impurities in air and water. Will continue to coopera

ay 21 1957 - Letter from Mr. Weidor of the Stream Pollution Control Board t Mr. Starba stating that the Board is aware of conditions of pollution of Wolf Lake and are working to improve the conditions there.

c. 6 1957 - Letter to Mr. Higgins from Mr. Potesta stating that the temporary structure of Smarthart Motor Company at Sheffield and Calumet Avenues does not have toilet facilities.

rch 21 1958 - Letter from Stream Pollution Control Board to Mr. Potesta stat ing that work is being done by Lever Bros. to correct waste disposal methods. Repairs to Colloidair units underway and investigation of possibility of certain devices to reduce entrainment from barometric condensers and deodorizers. Says the company is pursuing a more active program to determine the nature of its wastes and possible means of reduction.

pril 22 195[illegible] - Letter from Mr. Higg[illegible] Stream Pollution Control Board thanking them for [illegible] Lever Bros. in progress of correct ive measures on puri[illegible] on of waste waters.

May 7 1958 - Letter from Stream Pollution Control Board to Mr. Higgins sta ing that Mr. Biels, chief chemist of Lever Bros. has been a- ppointed by the company to be responsible for the waste reduc ion and treatment program within the company. Repairs have b made to the Colloidair units and the manufacturer's represent ative has been contacted to assist in improving operation of t units. No recent tests have been conducted by representatives of the State Board of Health on Wolf Lake Channel.

May 20 1958 - Letter to Mr. Poole of Stream Pollution Control Board from Mr Higgins stating the Park Board is not satisfied with progress made by Lever Bros. in correcting pollution. States that ove a period of years there is scarcely any change and that much undesirable material is being discharged into the lake daily.

May 20 1958 - Letter from Mr. Higgins to Mr. Potesta inviting him to attend park board meeting and requesting routine water tests be con- tinued with findings reported to park board twice a month.

May 28 1958 - Letter from Stream Pollution Control Board to Mr. Higgins sta ing that a stipulation was signed by the Stream Pollution Con trol Board and Lever Bros. whereby the company agreed to assi a staff member to the responsibility of waste reduction and treatment. States it will take time to evaluate the effect of the improvements and changes made, and assuring that continue checks will be made to insure compliance with the stipulation

Sept. 19 1958 - Letter from Stream Pollution Control Board to Board of Sani- tary Commissioners re: approval of plans and specifications of Robertsdale relief sewers and northeast sanitary sewer. Approval given with the understanding that the work as well a any other work necessary to eliminate the discharge of raw or inadequately treated sewage from the Hammond Sanitary Distri be completed without delay.

Nov. 10 1958 - Letter from Stream Pollution Control Board to Mr. Higgins sta ing that Lever Bros. has dredged out an area on the east side of Indianapolis Blvd. and used mill slag to cover the banks around this basin. Improvements have been made in the operati and maintenance of the Colloidair units. Automatic water temp erature control valves have been installed on part of the equipment to keep the volume of water used at a minimum, pro- viding a longer detention time in the treatment units. Compan studying the problem and has several proposals under conside ation to further improve effluent discharges into Wolf Lake. Investigation will be made to determine if filling operations on Shedd Estate are causing pollution. Copy of letter approv ing plans and specifications for Robertsdale sewers attached.

Nov. 21 1958 - Letter from Dr. Hunker to Dr. Offutt, State Health Commissio stating proposed pumping station at 115th Street is about to built. Asking if the State Board of Health has considered th pumping of storm [illegible] to Wolf Lake would stir up the bott of the lake and cau 329 "gung" at the bottom to rise, flow down the channel an[illegible] ute the beach at 121st Street. Wond- ing if it would be wiser to dredge the channel and clean it this sediment before storm water is pumped into the lake.

c. 4 1958 - Letter to Dr. R[illegible] [illegible] about [illegible] States th[illegible] [illegible] observations [illegible] the natural flow from the channel follows the [illegible] of Wolf Lake through the openin in the Toll road and railroad into the Illinois portion of Wol Lake. Stated that no sanitary wastes are to be discharged to the pumping station therefore, only storm water will be discharged into Wolf Lake.

c. 13 1958 - Letter to Dr. Rarker from Mr. Higgins pointing out that Dr. Offutt's letter did not answer all questions raised. Said that attention should be called to the fact that in estimating the capacity of Wolf Lake the engineering firm that drew up the plans for the sewer department used a 1937 map to make their estimates of the lake capacity and potential to drain the area Pointed out that much of Wolf Lake has been filled since 1937 creating reduced capacity to absorb a sudden abundance of wate Asking further investigation be made before acceptance is permitted.

rch 2 1959 - Letter to Dr. Remker from Stream Pollution Control Board stating that in considering plans and specifications for pumping station it was their opinion that the discharge of storm water will not have an appreciable effect on the swimming beach. Statement that although information supplied in 1958 indicates that water was acceptable for swimming, it is the feeling of the Stream Pollution Control Board that the beach by its very nature can never make a really desirable swimming area. Control of the quality of water in such a lake is exceedingly dif cult. If a beach of this quality fills a need in the recreati program, it should receive constant vigilance and regulation of swimming days.

ne 14 1961 - Letter to Mr. Poole of the Stream Pollution Control Board requesting prompt consideration [illegible] necessary to terminate pollution and contamination [illegible] in Wolf Lake. This letter was from members of the Outdoor Recreation Resources Study Commission because their attention has been called to pollution and consequent fish kills and loss of use because of contamination of Wolf Lake.

ne 16 1961 - Letter to members of Outdoor Recreation Study Commission stati that a survey of Wolf Lake will be conducted during the week o. June 19-24, 1961.

REPORT OF
BIOLOGICAL SURVEY
WOLF LAKE
LAKE CO., INDIANA
August 28, 1961

Forward

Because aquatic plants and animals are exposed to any pollution in the waters of the lake or stream in which they live, they are of necessity affected by it. Therefore, the biological communities of a lake or stream can be studied to evaluate the reaction of the aquatic organisms to pollutants.

There is no organism or group of organisms which can be referred to as "the" specific indicator of pollution. However, the presence or absence of certain plant and animal forms reflects the quality of water which has existed in a certain area of a lake or stream.

If an organism cannot live or propagate in polluted waters, it may be said that it is intolerant of pollution. Conversely, those able to exist and propagate readily in polluted waters are called pollution tolerant.

Between the tolerant and intolerant types is a group of organisms considered moderately tolerant. Members of this group vary in their ability to withstand unfavorable or polluted conditions.

A grossly polluted stream or lake contains a few pollution-tolerant kinds. As the stream or lake progresses toward recovery, it yields fewer of the tolerant organisms and more of the moderate types. In a clean stream or lake area, all three types of organisms may be expected, but the pollution-tolerant individuals form a small part of the total.

Bottom samples collected on the west side of the south end of the large island below Wolf Lake Channel contained eight types of aquatic animals. Seven of the eight types present were tolerant to some degree of pollution.

Algal forms present at this station were of three types, all of which are moderately tolerant of pollution, but indicative of better water quality than those observed in Wolf Lake Channel.

Seven types of aquatic animals were found in the lake at a point approximately 200 yards south of the island mentioned above. (See map) Four of the seven forms present were intolerant of pollution, one form moderately tolerant, and two tolerant.

II. CONCLUSIONS

1. That Lever Brothers Company in Hammond discharges large quantities of waste to Wolf Lake Channel.
2. That this discharge is responsible for a polluted condition in Wolf Lake Channel and is detrimental to aquatic life.
   a. The bottom of the channel is covered with black putrid sludge
   b. Water in the channel contains large quantities of suspended organic material that increases turbidity
   c. Decomposing organic material exhausts the supply of dissolved oxygen for the length of the channel
3. That the conditions mentioned above are responsible for the biological depression noted in Wolf Lake Channel and Wolf Lake.
   a. Only pollution tolerant plant and animal forms were noted in Wolf Lake Channel
   b. Only one pollution intolerant form and ten tolerant forms to some degree of pollution were noted at a Wolf Lake station near the mouth of the channel
4. That the conditions noted during [this su]rvey are in violation of the Stream Pollution Control Law and Regulation SPC-1.

III. FINDINGS

A. Location and Description of Sampling Stations

1 Pool on the north side of the Indianapolis Blvd. bridge

2 Wolf Lake Channel near the south side of the Indianapolis Blvd. bridge

3 Wolf Lake Channel near the old Amaize outfall

4 Wolf Lake Channel at 115th Street

5 Wolf Lake Channel at 117th Street

6 Wolf Lake Channel at mouth

7 Wolf Lake Channel on the west side of the south end of the island near the mouth of Wolf Lake Channel

8 Wolf Lake approximately 200 yards west of 121st Street and approximately 200 yards south of the island mentioned above

TABLE II

Occurrence of Aquatic Organisms (Animals)

Intolerant organisms	Station						
	2	3	4	5	6	7	8
Amphipoda (scuds, sideswimmers)							
Hyalella	no	no	no	no	no	no	yes
Gammarus	no	no	no	no	no	no	yes
Ephemeroptera (mayflies)							
Centroptilum	no	no	no	no	no	no	yes
Caenis	no	no	no	no	no	yes	yes
Moderately tolerant organisms							
Zygoptera (damsel flies)							
Chromagrion	no	no	no	no	no	yes	no
Lestes	no	no	no	no	no	yes	no
Decapoda (crayfish)							
Orconectes propinquis	no	no	no	no	no	yes	yes
Tolerant organisms							
Planaria (flat worms)	no	no	no	no	no	yes	yes
Hirudinea (leech)	no	no	no	no	no	yes	no
Nematoda (round worms)	yes	yes	yes	yes	yes	yes	no
Hemiptera (water bugs)							
Corixidae sigara	no	no	no	no	no	yes	no
Diptera (true flies)							
Chironomidae	no	no	no	no	no	no	yes

Table III

Occurence of Aquatic Organisms (Algae)

	Station					
	2	3	4	5	6	7
Moderately Tolerant						
Fragilaria	yes	yes	yes	yes	yes	no
Tabellaria	yes	yes	yes	yes	yes	no
Microspora	yes	yes	yes	yes	yes	no
Cladophora	no	no	no	no	no	yes
Anacystis	no	no	no	no	no	yes
Tolerant						
Oscillatoria	yes	yes	yes	yes	yes	no
Navicula	yes	yes	yes	yes	yes	no
Spirogyra	yes	yes	yes	yes	yes	no
Melosira	yes	yes	yes	yes	yes	no
Spirapira	no	no	no	no	no	yes

I. SUMMARY

Lever Brothers Company discharges a large quantity of industrial wastes from their manufacturing plant into Wolf Lake Channel in Hammond. A biological survey conducted June 20-22, 1961, by representatives of this office, disclosed that this discharge affects the aquatic plants and animals in these ways:

1. Organic material suspended in the waste increases turbidity to the point that light penetration is limited, thereby inhibiting the growth of aquatic organisms.
2. Organic material that settles to the bottom of Wolf Lake Channel forms a putrid sludge blanket which extends the full length of the channel. This sludge covers and smothers bottom organisms and destroys their habitat. Sludge deposits ranged from a depth of more than 18 inches at Indianapolis Boulevard to approximately 1/2 inch at the mouth of the channel.
3. Decomposing organic material exhausts the supply of available dissolved oxygen to the point that only a few types of organisms can exist.

Examination of bottom samples collected from Wolf Lake Channel disclosed that with the exception of two pollution tolerant types of organisms found near the shore, Ostracods (seed shrimp) and Tubificids (sludge worms), no aquatic animals were present along its entire length.

Large clumps of _Sphaerotilus natans_ (slime bacteria) were observed attached to the Indianapolis Boulevard bridge, spotting the substrate, and intermixed with the tolerant blue green algae _Oscillatoria_ in floating masses. Only a few strands of Sphaerotilus were observed at the lower end of the channel.

Examination of the plankton algae disclosed that there were seven forms present at channel stations. These were all types commonly found in polluted areas.

1965 - field

Wolf Lake Channel

35 yards south of Indianapolis Blvd 9:00 A.M. 5/5/65

Center of channel
Sludge depth 3 ft 9 in.
Water depth 4 ft 5 in

Surface
Temp. 23 D.O 5.0 Meter 3.0 D.O. 5.0
3 ft deep
Temp. 21 Meter 1.6 D.O. 2.95

East 1/4 of the channel
Sludge depth 4 ft 2 inches
Water depth 4 ft 9 inches

Surface
Temp. 21 Meter 2.1 D.O 3.90
3 ft 2 in. deep
Temp 20 Meter 0.0 D.O. .20

West 1/4 of the channel.
Sludge depth 3 ft 9 inches
Water depth 3 ft 3 inches

Surface
Temp. 20 Meter 3.5 7.0

3 ft Temp. 20 Meter 1.0 2.0

Sensitivity coefficient $\frac{3.0}{5.0}$ = .6 at a temperature of 23°

Wolf Lake Channel 400 yards [illegible]
Indianapolis Blvd. Ferris outlet from American Maize
9:15 AM - 6/9/[illegible]

Center of channel
Sludge depth 4 ft
Water depth 6 ft 6 inches

Surface
Temp 22 Meter 1.0 D.O. 1.75

3 ft 3 inches deep
Temp. 22 Meter 0.0 D.O 0.0

East 1/4 of the channel
Sludge depth 4 ft 3 inches
Water depth 6 ft 4 inches

Surface
Temp. 21 Meter 1.0 D.O 1.8

4 ft 2 inches deep
Temp. 20 Meter 2.0 D.O. 4.0

West 1/4 of the channel

Sludge depth 4 ft 3 inches
Water depth 5 ft 7 inches

Surface

Temp. 19 Meter 1.1 D.O. 2.3

3 ft 4 inches deep
Temp. 21 0.2 DO 0.4

[illegible] Channel [illegible] Blvd. bridge. Across from the lift station
9:30 AM – 6/9/65
Center of the channel

Sludge depth 4 ft 10 inches
Water depth 6 ft [illegible] inches

Surface
Temp. 26 Meter 1.4 D.O. 2.0

3 ft 4 inches deep
Temp. 22 Meter 0.6 D.O 1.0

East [illegible] of the channel
Sludge depth 11 inches
Water depth [illegible] ft [illegible] inches

Surface
Temp 22 Meter 1.8 D.O. 3.2
3 ft. deep 22 0.6 D.O. [illegible]

West [illegible] of channel

Sludge depth [illegible] ft [illegible] inches
Water depth 5 ft 11 inches

Surface
Temp 22 Meter 0.7 D.O 1.2

3 ft [illegible] inches deep 22 0.4 D.O 0.7

Wolf Lake Channel [illegible] yards downstream from the Indianapolis Blvd. bridge. At the start of the set-falls
7:45 AM – 6/7/65

Center of the channel
Sludge depth 2 ft 3 inches
Water depth 5 ft 3 inches

Surface
Temp. 21 Meter 1.0 D.O. 1.8

3 ft 4 inches deep
Temp 21 Meter 0.6 D.O. 1.1

East 1/4 of the channel
Sludge depth 2 ft 6 inches
Water depth 4 ft 3 inches

Surface
Temp. 22 Meter 1.0 D.O. 1.7

2 ft 3 inches deep
Temp 21 Meter 0.5 D.O 0.9

West 1/4 of the channel
Surface
Temp 21 Meter 1.0 D.O. 1.8

3 ft 2 inches deep
Temp 21 0.5 D.O 0.9

Wolf Walk Channel [illegible] end

Center

Sludge depth   5 ft 9 inches
Water depth   4 ft 9 inches

Surface
Temp. 22   Meter 1.2   D.O 2.1

3 ft 4 inches deep
Temp. 21   Meter 0.8   D.O. 1.5

Wolf Lake Channel
35 yd south of Indianapolis Blvd.
12:00 noon 6/9/65

Center

Surface

Temp	26	Meter 3.4	D.O. 4.7

3 ft deep

Temp.	23	Meter 1.2	D.O 2.0

East 1/4

Surface

Temp.	22	Meter 3.0	D.O 5.3

3 ft 2 in. deep

Temp	22	Meter 1.0	D.O. 1.7

West 1/4

Surface

Temp	23	Meter 2.8	D.O 4.2

3 ft 4 in. deep

Temp.	21	Meter 1.1	D.O. 2.0

Wolf Lake Channel
400 gallons 34
12:30 PM – 5/9/65

Center

Surface			
Temp	22	Meter 2.2	D.O 3.9
3 ft 4 inches deep			
Temp	22	Meter 0.7	D.O 1.2

East ¼

Surface			
Temp	23	Meter 2.0	D.O. 3.3
4 ft deep			
Temp	22	Meter 1.0	D.O 0.7

West ¼

Surface			
Temp.	2[illegible]	Meter 1.6	D.O. 2.7
3 ft 4 inches deep			
Temp.	22	Meter 0.5	D.O. 0.55

7 00 [illegible] South
12:30 P.M.

Center				
Surface Temp.	23	Meter	3.7	D.O. 6.2
3ft 4inches deep Temp	23	Meter	2.8	D.O. 1.3
East 1/2				
Surface Temp.	23	Meter	3.6	D.O 6.0
3ft deep	23	Meter	2.5	D.O. 2.8
West 1/4				
Surface Temp.	25	Meter	2.0	D.O. 2.9
3ft 4inches deep Temp.	23	Meter	1.0	D.O 1.7

Wolf Lake
1500 ft South
12:45 P.M. 5/9/65

Center

Surface

Temp 19 Meter 0.7 DO 1.5

3ft 4 inches deep

Temp 22 Meter 0.5 D.O 0.35

East 1/4

Surface

Temp 20 Meter 1.0 DO. 2.0

2ft 3 inches deep

Temp 20 Meter 1.0 D.O. 2.0

West 1/4

Surface

Temp. 23 Meter 0.4 D.O 0.7

3ft 2 inches deep

Temp. 23 Meter 0.4 D.O. 0.7

35 yd South
3:00 PM 6/5/65

Center

Surface

Temp.	25	Meter	3.2	D.O. 4.6

3 ft deep

Temp	22	Meter	1.2	D.O 2.1

East 1/4

Surface

Temp	24	Meter	2.6	D.O 3.8

3 ft 2 inches deep

Temp.	22	Meter	2.5	D.O 4.9

West 1/4

Surface

Temp	24	Meter	3.0	D.O 4.1

3 ft 4 inches deep

Temp.	23	Meter	1.5	D.O. 2.7

Wolf Lake Channel
400 yd South
3:20 PM 6/9/65

Center				
Surface				
Temp.	24	Meter	3.0	D.O 4.7
3 ft 3 inches deep				
Temp	24	Meter	2.0	D.O 3.1
East 1/4				
Surface				
Temp.	24	Meter	2.5	D.O 4.4
4 ft [illegible] deep				
Temp	24	Meter	2.4	D.O 3.7
West 1/4				
Surface				
Temp.	23	Meter	2.4	D.O. 4.0
3 ft. 4 in. deep				
Temp	24	Meter	2.2	D.O 3.4

900 yd South
3:45 PM June 3 1965

Center
Surface
Temp 24 Meter 2.2 D.O 3.4

3 1/4 inches deep
Temp 24 Meter 1.8 D.O. 2.8

East 1/4
Surface
Temp 23 Meter 2.9 D.O. 4.0

3 1/4 deep
Temp 24 Meter 2.1 D.O. 3.3

West 1/4
Surface
Temp. 23 Meter 1.7 D.O 2.8

3 1/4 inches deep
Temp. 24 Meter 1.6 D.O. 2.5

Wait side channel
1500 yd south
4:10 P.M. 6/9/65

Center
Surface
Temp 24 Meter 1.8 D.O 2.8

3 ft 1 inches deep 24 Meter 1.7 D.O 2.7

East 1/4
Surface
Temp 24 Meter 2.2 D.O 3.4
2 ft 8 inches deep
Temp 24 Meter 2.1 D.O 3.3

West 1/4
Surface
Temp 24 Meter 1.7 D.O 2.7

3 ft 2 inches deep
Temp 24 Meter 1.9 D.O 3.0

Rain at 8:00 P.M.

FIELD DATA					LABORATORY DATA	
Lever Brothers Outfall					LAB. NO. D 1717	
					Sample Opened By	
					Sample Opened On JUN 10 1965	
					Arrival Temperature	
					St. Poll. / Sew. / I.W. ✓	
	DISSOLVED OXYGEN				Send Extra Copy To Branch: NW / NE / SW / SE	
Place Hammond	Hour	P.P.M.	TEMP.	% Sat.	Analyses	Results
	12 N	7.6	25	91		
Industry Lever Brothers	1 P.M.				B.O.D.	43
	2				pH	7.4
Date(s) June 7 & 8 1965	3				Alk. (M.O.)	166
	4½	7.5	25	90	Chlorides	17
Station 4	5				Total Solids	266
Composite Started 8:00 AM	6				Vol. Total Solids	87
Time Sample Sent to Lab.	7				Susp. Solids	7
Sample Sent Via By	8	7.[illegible]	[illegible]	88	Vol. Susp. Solids	3
Delivered By To	9					
PHYSICAL OBSERVATIONS	10				~~[illegible]~~	52
Date, Last Rain	11					
Weather: Rain, Overcast, Sunny, Fair	12M	[illegible]	[illegible]	52	~~[illegible]~~ ABS	0.1
Ave. Water Width Ft.	1 A.M.					
Ave. Water Depth Ft.	2				[illegible]	6
Surface Velocity Ft./Sec.	3					
Black Putrid Sludge	4		[illegible]	87		
Red Worms	5					
White Fungi	6					
Bottom: Rock, Gravel, Sand, Silt	7				Hour	Coliforms/100 ml.
Oil	8	6.7	25	80	12 Noon	< 30
Grease	9				Entero	< 10
Algae	10				8:00 PM	< 30
Sewage Solids	11				Entero	< 10
Odor	TOTAL				9:00 AM	< 30
Color	AVE.	6.9		81.3	Entero	< 10

Supervisor(s)	Samples Collected By	Time		
Dean Hax				
J. Harrison JR				
			Total	< 90
			Ave.	< 30

FIELD DATA						LABORATORY DATA		
Wolf lake Channel at the bridge on Indianapolis Blvd.						LAB. NO. D 171		
						Sample Opened By		
						Sample Opened On JUN 10 1965		
						Arrival Temperature		
						St. Poll.	Sew.	I.W.
	DISSOLVED OXYGEN					Send Extra Copy To Branch		
Place Hammond	Hour	P.P.M.	TEMP.	% Sat.		NW / NE		SW / SE
	12 N	7.8	25	93		Analyses		Results
Industry	1 P.M.					B.O.D.	✓	6
	2					pH	✓	7.6
Date(s) June 8&9 1965	3					Alk. (M.O.)	✓	150
	4:20	7.2	26	87		Chlorides	✓	18
Station A-1	5					Total Solids	✓	225
Composite Started 8:00 AM	6					Vol. Total Solids	✓	115
Time Sample Sent to Lab.	7					Susp. Solids	✓	11
Sample Sent Via By	8		23	87		Vol. Susp. Solids	✓	10
Delivered By To	9							
PHYSICAL OBSERVATIONS	10					Detergent	✓	2.2
Date, Last Rain	11							
Weather: Rain, Overcast, Sunny, Fair	12M			55		0.1	✓	0.1
Ave. Water Width Ft.	1 A.M.							
Ave. Water Depth Ft.	2							
Surface Velocity Ft./Sec.	3							
Black Putrid Sludge	4			83				
Red Worms	5							
White Fungi	6							
Bottom: Rock, Gravel, Sand, Silt	7					Hour	Coliforms/100 ml.	
Oil	(8)	6.4		77		12 Noon	<30	
Grease	9					Entero	<10	
Algae	10					8 PM	<30	
Sewage Solids	11					Entero	<10	
Odor	TOTAL					4 AM	2300	
Color	AVE.	6.8		83		Entero	<20	
Supervisor(s)	Samples Collected By			Time				
Dalem, Mas. Pattison, DH.								
						Total	<300	
						Ave.	<766	

FIELD DATA	LABORATORY DATA
State Highway Lift Station	LAB. NO. D -5
wet-well – Indianapolis Blvd.	Sample Opened By [illegible]
	Sample Opened On JUN 10 1965
	Arrival Temperature [illegible]
	St. Poll. / Sew. / I.W.

Place Hammond

Industry

Date(s) June 2-3 1965

Station B

Composite Started

Time Sample Sent to Lab.

Sample Sent Via By

Delivered By To

DISSOLVED OXYGEN Hour	P.P.M.	TEMP.	% Sat.
12 N	—		
1 P.M.			
2			
3			
4	5.6	19	54
5			
6			
7			
8	6.2	15	62
9			
10			
11			
12M			53
1 A.M.			
2			
3			
4		13	57
5			
6			
7			
8	—		
9			
10			
11			
TOTAL			
AVE.	3.5		34

PHYSICAL OBSERVATIONS

- Date, Last Rain
- Weather: Rain, Overcast, Sunny, Fair
- Ave. Water Width Ft.
- Ave. Water Depth Ft.
- Surface Velocity Ft./Sec.
- Black Putrid Sludge
- Red Worms
- White Fungi
- Bottom: Rock, Gravel, Sand, Silt
- Oil
- Grease
- Algae
- Sewage Solids
- Odor
- Color

Send Extra Copy To Branch: NW / NE / SW / SE

Analyses		Results
B.O.D.	✓	110
pH	✓	7.4
Alk. (M.O.)	✓	274
Chlorides	✓	250
Total Solids	✓	1660
Vol. Total Solids	✓	359
Susp. Solids	✓	132
Vol. Susp. Solids	✓	52
Oil	✓	45

Hour	Coliforms/100 ml.
12:00 Noon	9300
Extra	6100
8:00 PM	23000
Extra	9400
4:00 AM	9300
Extra	3900
Total	209[illegible]
Ave.	16461

Supervisor(s)	Samples Collected By	Time
Drew, M.		
Patterson, D.H.		

FIELD DATA	LABORATORY DATA
Wolf Lake at the beach on 121st	LAB. NO. D [illegible]
	Sample Opened By [illegible]
	Sample Opened On JUN 10 '65
	Arrival Temperature 4°C
	St. Poll. | Sew. | I.W.

Place Hammond

Industry

Date(s) June 8+9 1965

Station # WL-002

Composite Started 8:00 AM

Time Sample Sent to Lab.

Sample Sent Via By

Delivered By To

DISSOLVED OXYGEN			
Hour	P.P.M.	TEMP.	% Sat.
12 N	11.2	23	129
1 P.M.			
2			
3			
4	10.3	22	116
5			
6			
7			
8	10.0	21	111
9			
10			
11			
12M	[illegible]	[illegible]	58
1 A.M.			
2			
3			
4	[illegible]	[illegible]	96
5			
6			
7			
8	10.3	[illegible]	116
9	[illegible]		
10			
11	[illegible]		
TOTAL	[illegible]		[illegible]
AVE.	9.3		104.3

Send Extra Copy To Branch: NW | NE | SW | SE

Analyses		Results
B.O.D.	✓	5.4
pH	✓	9.3
Alk. (M.O.)	✓	114
Chlorides	✓	22
Total Solids	✓	266
Vol. Total Solids	✓	99
Susp. Solids	✓	10
Vol. Susp. Solids	✓	9
Detergents	✓	[illegible]
0.1	✓	[illegible]

PHYSICAL OBSERVATIONS

Date, Last Rain

Weather: Rain, Overcast, Sunny, Fair

Ave. Water Width Ft.

Ave. Water Depth Ft.

Surface Velocity Ft./Sec.

Black Putrid Sludge None

Red Worms None

White Fungi None

Bottom: Rock, Gravel, Sand, Silt

Oil None

Grease None

Algae None

Sewage Solids None

Odor None

Color Clear

Hour	Coliforms/100 ml.
12 Noon	23,000
E. coli	< 10
8 PM	23,000
E. coli	110
4 AM	93,000
E. coli	< 10
Total	139,000
Ave.	46,333

Supervisor(s)	Samples Collected By	Time
Oren Max		
Patterson D. H.		

FIELD DATA	LABORATORY DATA
Wolf Lake at the discharge at the Illinois-Indiana State Line	LAB. NO. D
	Sample Opened By [illegible]
	Sample Opened On JUN 18 1965
	Arrival Temperature 4° C
	St. Poll. / Sew. / I.W.
	Send Extra Copy To Branch: NW / NE / SW / SE

Field		Hour	P.P.M.	TEMP.	% Sat.	Analyses		Results
Place	Hammond							
		12 N	8.9	24	104			
Industry		1 P.M.				B.O.D.	✓	3.1
		2				pH	✓	6.5
Date(s)	June 8 + 9, 1965	3				Alk. (M.O.)	✓	90
		4	9.1	23	105	Chlorides	✓	36
Station	#WL 003	5				Total Solids	✓	267
Composite Started	8:00 AM	6				Vol. Total Solids	✓	91
Time Sample Sent to Lab.		7				Susp. Solids	✓	11
Sample Sent Via / By		8	2.2	2[illegible]	160	Vol. Susp. Solids	✓	7
Delivered By / To		9						
PHYSICAL OBSERVATIONS		10				Detergents	✓	<0.1
Date, Last Rain		11						
Weather: Rain, Overcast, Sunny, Fair		12M	-		77	O.P.	✓	4.0
Ave. Water Width Ft.		1 A.M.				T		
Ave. Water Depth Ft.		2				[illegible]		[illegible]
Surface Velocity Ft./Sec.		3						
Black Putrid Sludge	None	4	[illegible]		92			
Red Worms	None	5						
White Fungi	None	6						
Bottom: Rock, Gravel, Sand, Silt		7				Hour		Coliforms/100 ml.
Oil	None	8	8.9	[illegible]	101	12 Noon		2300
Grease	None	9				E. tec		<10
Algae	None	10				9:00 PM		15,000
Sewage Solids	None	11				E. tec		10
Odor	None	TOTAL	[illegible]		[illegible]	4:00 AM		430
Color	Clear	AVE.	8.5		97	E. tec		30

Supervisor(s)	Samples Collected By	Time
Dren, Mia		
P. Harlan, J.H.		

Total 2160

Ave. 720

FIELD DATA					LABORATORY DATA		
Channel 35 yards					LAB. NO. D		727
Indianapolis Blvd					Sample Opened By		H. Beal
					Sample Opened On		JUN 10 1965
					Arrival Temperature		
bridge - About even with sign					St. Poll.	Sew.	I.W.
	DISSOLVED OXYGEN				Send Extra Copy To Branch		
Place Hammond	Hour	P.P.M.	TEMP.	% Sat.	NW NE		SW SE
	12 N	6.3	27	78	Analyses		Results
Industry	1 P.M.	3.0	26	37	B.O.D.	✓	7.9
	2				pH	✓	7.7
Date(s) June 8 & 9 1965	3				Alk. (M.O.)	✓	164
	4	6.6	25	79	Chlorides	✓	26
Station 1	5	3.0	24	35	Total Solids	✓	342
Composite Started 9:00 A.M.	6				Vol. Total Solids	✓	113
Time Sample Sent to Lab.	7				Susp. Solids	✓	50
Sample Sent Via By	8		24	82	Vol. Susp. Solids	✓	22
Delivered By To	9		24	77			
PHYSICAL OBSERVATIONS	10				Detergents	✓	0.1
Date, Last Rain	11						
Weather: Rain, Overcast, Sunny, Fair	12 M			49	~~Oil~~		
Ave. Water Width — Ft. —	1 A.M.			54			
Ave. Water Depth — Ft. —	2						
Surface Velocity — Ft./Sec. —	3				Oil		0.1
Black Putrid Sludge 10 in. sewer	4	7.			81		
Red Worms	5				78		
White Fungi	6						
Bottom: Rock, Gravel, Sand, Silt	7				Hour	Coliforms/100 ml.	
Oil	8	6.4	23	74	12 Noon	430	
Grease	9	6.0	22	68	Entero	20	
Algae	10				1 PM	9300	
Sewage Solids	11				Entero	200	
Odor				74	4 AM	430	
Color	AVE.			58	Entero	20	

Supervisor(s)	Samples Collected By	Time	
Orem, Max			
Patterson, D.H.			
			Total 10160
			Ave. 3386

FIELD DATA					LABORATORY DATA		
Wolf Lake Channel 900 yards down the channel from Indianapolis Blvd. bridge — As channel starts to widen					LAB. NO. D		
					Sample Opened By H. Beale		
					Sample Opened On JUN 10 1965		
					Arrival Temperature 10° C		
					St. Poll.	Sew. ✓	I.W.
	DISSOLVED OXYGEN				Send Extra Copy To Branch		
Place Hammond	Hour	P.P.M.	TEMP.	% Sat.	NW / NE		SW / SE
	12 N	4.3	25	50	Analyses		Results
Industry	1 P.M.	3.4	22	40	B.O.D.	✓	16
	2				pH	✓	7.6
Date(s) June 8+9 1965	3				Alk. (M.O.)	✓	116
	4	3.1	25	61	Chlorides	✓	20
Station 2	5	2.7	23	31	Total Solids	✓	302
Composite Started 8:00 AM	6				Vol. Total Solids	✓	130
Time Sample Sent to Lab.	7				Susp. Solids	✓	15
Sample Sent Via By	8	[illegible]	24	56	Vol. Susp. Solids	✓	14
Delivered By To	9	3.1	23	40			
PHYSICAL OBSERVATIONS	10				Detergents	✓	<0.1
Date, Last Rain	11						
Weather: Rain, Overcast, Sunny, Fair	12M			29	O:I	✓	[illegible]
Ave. Water Width — Ft. —	1 A.M.			38			
Ave. Water Depth — Ft. —	2				PO4		0.7
Surface Velocity Ft./Sec. -	3						
Black Putrid Sludge 1/2" Layer	4			42			
Red Worms	5			43			
White Fungi	6						
Bottom: Rock, Gravel, Sand, Silt	7				Hour	Coliforms/100 ml.	
Oil	8	3.5	22	40	12 Noon	150	
Grease	9	2.3	22	26	E. coli	10	
Algae	10				8 PM	93,000	
Sewage Solids	11				E. coli	770	
Odor	TOTAL	40		46	4 AM	730	
Color	AVE.	32		36	E. coli	420	

Supervisor(s)	Samples Collected By	Time
Oren Ass		
Patterson, D.H.		

Total	[illegible]
Ave.	31360

FIELD DATA	LABORATORY DATA
Salt Lake Channel 900 yards down the channel from Indianapolis Blvd. bridge. Even with lift station	LAB. NO. D Sample Opened By H. Bom Sample Opened On JUN 10 19 Arrival Temperature 40 St. Poll. / Sew. ✓ / I.W.

Place Hammond

Industry

Date(s) June 7 & 8, 1965

Station #3

Composite Started 8:00 AM

Time Sample Sent to Lab.

Sample Sent Via — By — To

Delivered By

PHYSICAL OBSERVATIONS

Date, Last Rain	
Weather: Rain, Overcast, Sunny, Fair	
Ave. Water Width Ft.	
Ave. Water Depth Ft.	
Surface Velocity Ft./Sec.	
Black Putrid Sludge	1/3 Bottom covered
Red Worms	
White Fungi	
Bottom: Rock, Gravel, Sand, Silt	
Oil	Few
Grease	[illegible]
Algae	
Sewage Solids	
Odor	
Color	

DISSOLVED OXYGEN

Hour	P.P.M.	TEMP.	% Sat.
12 N	3.1	23	36
1 P.M.	2.9	22	32
2			
3			
4	3.7	23	43
5	3.5	22	41
6			
7			
8	[illegible]	[illegible]	35
9	[illegible]	[illegible]	29
10			
11			
12M		—	26
1 A.M.	[illegible]	[illegible]	20
2			
3			
4	[illegible]		24
5			19
6			
7			
8	2.2	22	25
9	1.6	22	18
10			
11			
TOTAL	27		32
AVE.	23		26

Send Extra Copy To Branch: NW | NE | SW | SE

Analyses		Results
B.O.D.		47.
pH		7.6
Alk. (M.O.)		114
Chlorides		21
Total Solids		291
Vol. Total Solids		131
Susp. Solids		15
Vol. Susp. Solids		3
Detergents	✓	<0.1
7.1	✓	[illegible]
[illegible]		6.12

Hour	Coliforms/100 ml.
12 Noon	430
Even	10
8:00 PM	750
Even	220
4:00 AM	330
Even	360
Total	105
Ave.	56

Supervisor(s)	Samples Collected By	Time
Orem, Wm.		
Patterson, J.H.		

FIELD DATA	LABORATORY DATA
Wolf Lake Channel ... downstream from the Indianapolis Blvd. Bridge - At the outfall	LAB. NO. D
	Sample Opened By H. Beale
	Sample Opened On JUN 10 1965
	Arrival Temperature
	St. Poll. / Sew. / I.W.

Place: Hammond

Industry:

Date(s): June 8&9 1965

Station: #4

Composite Started: 8:00 AM

Time Sample Sent to Lab.

Sample Sent Via / By

Delivered By / To

DISSOLVED OXYGEN			
Hour	P.P.M.	TEMP.	% Sat.
12 N	3.6	23	42
1 P.M.	3.2	23	37
2			
3			
4	3.8	23	44
5	3.6	22	41
6			
7			
8	[illegible]	22	34
9	[illegible]	[illegible]	26
10			
11			
12M			31
1 A.M.			27
2			
3			
4	[illegible]	21	23
5			17
6			
7			
8	2.2	22	25
9	2.3	22	25
10			
11			
TOTAL	29		35
AVE.	25		29

PHYSICAL OBSERVATIONS	
Date, Last Rain	
Weather: Rain, Overcast, Sunny, Fair	
Ave. Water Width Ft.	
Ave. Water Depth Ft.	
Surface Velocity Ft./Sec.	
Black Putrid Sludge	
Red Worms	
White Fungi	
Bottom: Rock, Gravel, Sand, Silt	
Oil	[illegible]
Grease	[illegible]
Algae	
Sewage Solids	
Odor	
Color	

Send Extra Copy To Branch: NW NE SW SE

Analyses		Results
B.O.D.	✓	11
pH	✓	7.7
Alk. (M.O.)	✓	118
Chlorides	✓	26
Total Solids	✓	265
Vol. Total Solids	✓	164
Susp. Solids	✓	22
Vol. Susp. Solids	✓	17
Detergents	✓	<0.1
Oil	✓	[illegible]
[illegible]		0.7

Hour	Coliforms/100 ml.
12 Noon	230
Extra	30
8:00 PM	730
Extra	30
8:00 AM	23,[illegible]
Extra	340
Total	24160
Ave.	8053

Supervisor(s)	Samples Collected By	Time
Owen, Max		
Patterson, D.H.		
		[illegible]

400

Lake Gill County [illegible] Date 6 [illegible]

...rmination	Water Column Ave.	EPI.	Meta.	Hypo.
D.	3.9			
...l Phosphorus (Water)	0.09			
. Phosphorus	< 0.03			
...anic Nitrogen	0.7			
~~...al Nitrogen~~ Nitrate	< 0.1			
...onia	0.1			
...al Phosphorus (Core)	—			
...alinity	—			
.D.	36.			
...uration %				
...nt ...ration I%		3' = 20%		6'6" = 1%
...us...ded Solids	13.			

361

...pth of Tow	ft.	5'0 ft.	ft.	ft.
...tal Algae		25,500		
...inant ...gae		Aphanizomenon		
D.O. Dissolved Oxygen				

Macrophytes a problem throughout Especially [illegible] month.

Oxygen and Temperature Profiles

0 10 20 30 Temperature C

10ft. TEMP D.O

20ft.

30ft.

40ft.

50ft.

60ft.

0 5 10 15

Dissolved Oxygen PPM

Main body of lake South East of only Island. Deepest point found

8/20/74
I.U. Biological Center

Mr. Baily:

Here is the summary that you requested of the lake survey conducted on Wolf Lake on the date of 6/26/74.

Due to the fact that the lake was still in complete circulation there was little variation in Temp. and D.O. readings from top to bottom. This of course gives us no diagnostic profile of either parameter.

Because of the fact that Wolf Lake is shallow, (average 5 ft), it is doubtful that there are many periods of time when stagnation occurs because of thermal stratification... The winds are strong and fairly constant in the area and these winds stir the main body of the lake and provide for, ~~aeration~~ and recycling of nutrients from bottom sedimen

The lake guide lists an eight foot maximum for depth. I found eighteen feet, but it must have been an old barrow pit. After a spell of quiet, hot weather 0.0 determinations would possibly be found in this location

In all probability Wolf lake would be a eutrophic body of water even if Lever Brothers had never discharged to it. Lever's accelerates the process of eutrophication, bu it is difficult to state the extent. I have seen several shallow lakes with poorer conditions and they had no industrial or municipal discharges, only agricultural drainage or at times swamp drainage only.

(tot P)

There is definitely alot of phosphorus in the lake, more than I've found in other lakes since the determinations shown are a water column average. This contributes to the overabundance of algae and weeds.

Wish I could be of more help.

Sincerely,

H. Bonham

Wolf Lake Algae 6-26-74
Deepest Part of lake

Greens	
Tetraedron	300
Scenedesmus	300
Staurastrum	800
Oocystis	300
Coelastrum	400
Lagerheimia	300
Pediastrum	1300
	3,700
Blue Greens	
Aphanizomenon	15,000
Anacystis	1,000
Anabaena	400
Chroococcus	1,000
Coelosphaerium	900
	18,300
Flagellates	
Ceratium	1700
Dinobryon	100
	1800
Diatoms	
Cyclotella	1200
Fragilaria	300
Stephanodiscus	100
Navicula	100
	1,700

Total 25,500 per ml.

Volume of sample = 50 ml.

50 × 25,500 = 1,275,000 (sample total)

Approximate entrance of Lever Bros. Channel to Wolf Lake

B.O.D 3.4
PH 7.9

Suspended Sol 7

COD 28.
Total Phos. 0.06
Sol Phos. < 0.03

Nitrate < 0.1
Org. N.t. 0.7
Ammonia 0.1

Light % (as det by Envirocy.

3' = 35%
7' = 9% (bottom)

D.O. Surface = 9.8
D.O 7' = 8.7

Temp Surface = 18°
7' = 17°

Problem concentrations of macrophytes.

Lake Wolf Lake   County Lake   Date 6-26-74

...mination	Water Column Ave.	EPI.	Meta.	Hypo.
Phosphorus (Water)	0.09			
Phosphorus	<0.03			
...ic Nitrogen	<0.7			
Nitrogen	<0.1			
...ia	0.1			
Phosphorus (Core)				
...inity	NT			
...	NT			
...ation %	NT			
P...ation 1%		3' = 20%		
...chi 18'	Composited Sample			

... of Tow	5-0 ft	NT ft.	ft.	ft.
Algae	25,500			
...ant Algae	Aphanizomenon			
Dissolved Oxygen				

365

Oxygen and Temperature Profiles

0 10 20 30 Temperature C

10ft. 20ft. 30ft. 40ft. 50ft. 60ft.

Complete Circulation

18°C Surface to Bottom
D.O. = 9.4 Surface
8.4 17 ft. (Bottom)

0 5 10 5

Dissolved Oxygen PPM

Lake Wolf County Date 6

...rmination	Water Column Ave.	EPI.	Meta.	Hypo.
...D.	3.9			
...l Phosphorus (Water)	0.09			
Phosphorus	< 0.03			
...nic Nitrogen	0.7			
~~...l Nitrogen~~ Nitrate	< 0.1			
...nia	0.1			
...l Phosphorus (Core)	—			
...linity	—			
D.	36.			
...ration %				
...t ...tion 1%		3' = 20%		6'6" = 1%
...spended Solids	13.			

RECEIVED

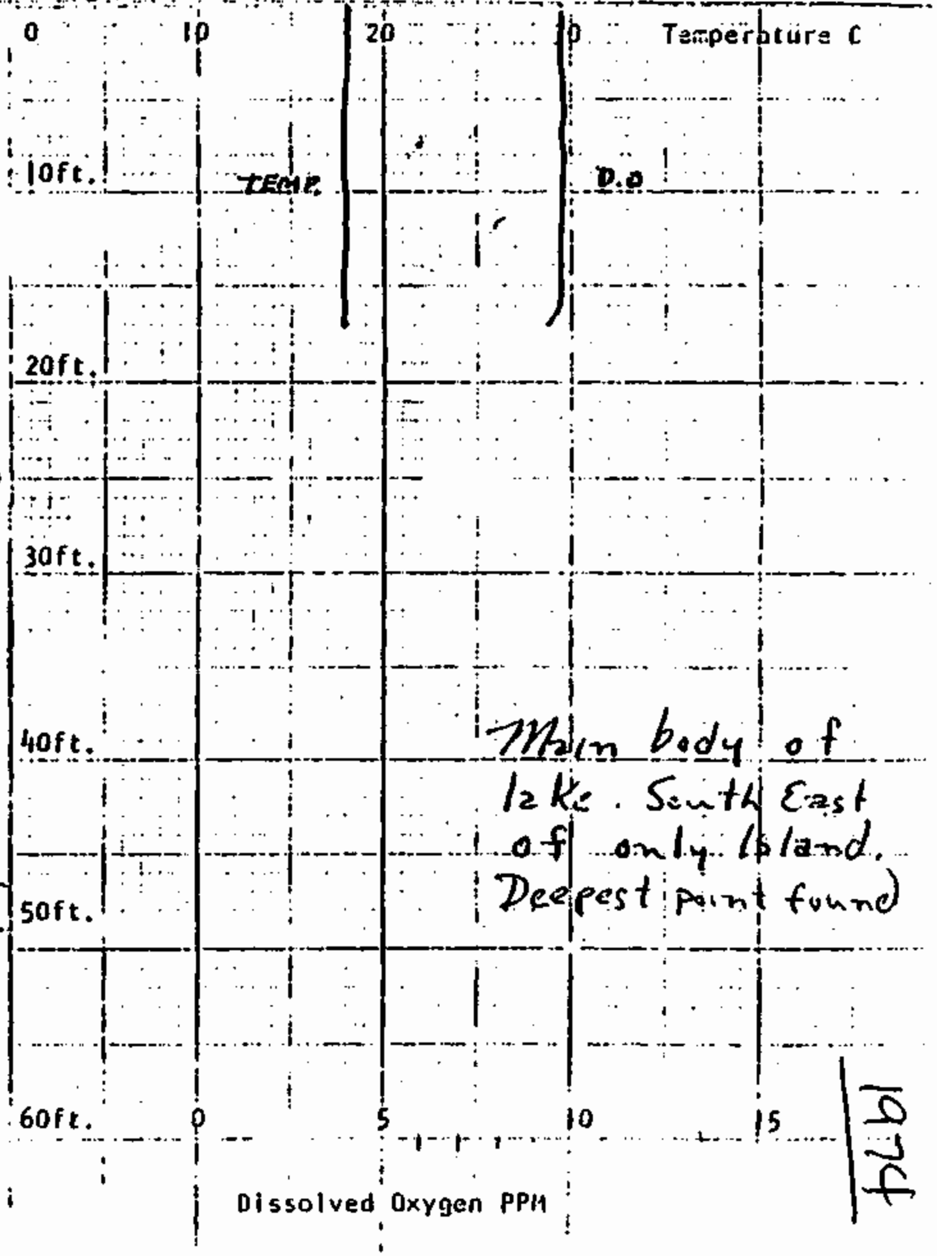
WATER POLLUTION CONTROL

...h of Tow	ft.	5-0 ft.	ft.	ft.
...al Algae		25,500		
...inant Algae		Aphanizomenon		
. Dissolved Oxygen				

...acrophytes a problem ...roughout. Especially ... month.

996

Oxygen and Temperature Profiles



Main body of lake. South East of only Island. Deepest point found

1974

1974-79 (1)

Dissolved O_2 data on Wolf Lake (Lake co.)

We have very little oxygen data on the lake. None earlier than 6/26/74.

June

6/26/74

On this date I did a profile in conjunction with Mr. Raymond Bailey's '24 hour' survey of Seven Brothers.

Middle of the lake station - Indiana side.

The weather had been cool and windy.

Max depth found = 17 ft.

Temperature 18°C from surface to bottom.

D.O. - Surface to 13 ft. constant 9.4 ppm

On the bottom (17') D.O = 8.9 ppm.

Wolf Lake channel coming into the lake had a max. depth of 6 ft. Surface D.O = 9.8

6 ft = 8.7

8/10/76

This survey was done for classification purposes. Site = The Indiana main basin.

Max. depth = 15 ft.

Temp = 22°C surface to 12 ft.

21°C bottom 15 FT

D.O. = Surface = 11.5 mg/l
10 ft = 10.5
15 ft = 6.0

<u>Water Quality monitoring station</u>
<u>State Line.</u>

2/3/76	D.O. Surface =	2.8 mg/l
2/15/77		5.3
Oct. 10/79		5.4.

All other recent water quality data show D.O. concentration approx. 5.0 mg/l or above.

Lake *Wolf Lake* County *Lake* Date *6-26-74*

mination	Water Column Ave.	EPI.	Meta.	Hypo.
Phosphorus (Water)	*0.09*			
Phosphorus	*<0.03*			
ic Nitrogen	*-0.7*			
Nitrogen	*<0.1*			
ia	*0.1*			
~~Phosphorus (Core)~~				
inity	*NT*			
).	*NT*			
ation %	*NT*			
Pe ... tion 1%		*3' = 20%*		
chi *18'*	*Composited Sample*			

n of Tow	*5-0* ft.	*NT* ft.	ft.	ft.
Algae	*25,500*			
nant Algae	*Aphanizomenon*			
Dissolved Oxygen				

369

Oxygen and Temperature Profiles

Temperature C: 0, 10, 20, 30

10ft., 20ft., 30ft., 40ft., 50ft., 60ft.

Complete Circulation

18°C Surface to Bottom

D.O. = 9.4 Surface

8.9 17 ft. (Bottom)

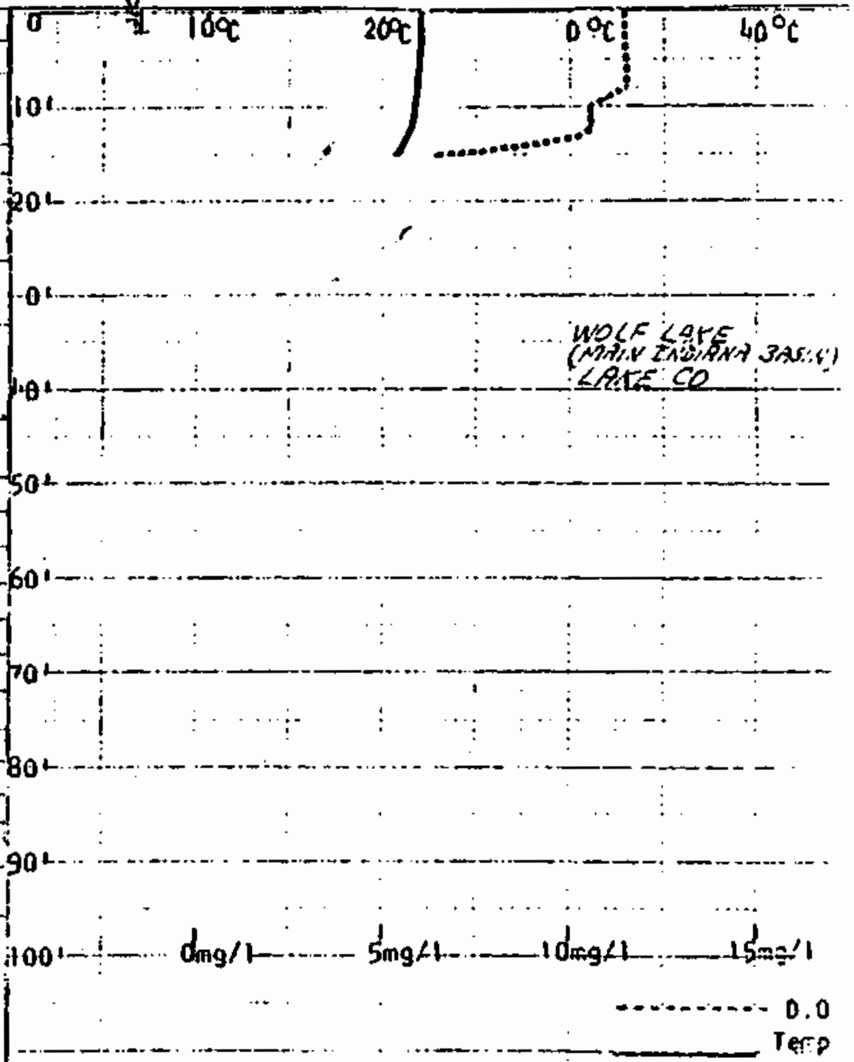
Dissolved Oxygen PPM: 0, 5, 10, 15

Avg. Depth: 5'
Lake: Wolf Lake (Main Indiana)
County: Lake Co.
Date: 10 August 1976

SUMMARY OF LAKE DATA 1976

ETERMINATION	WATER COLUMN AVERAGE	EPI. (mg/l)	META. (mg/l)	HYPO. (mg/l)
tal Phosphorus	0.09			
l. Phosphorus	<0.03			
rganic Nitrogen	1.1			
itrates & Nitrites	0.1			
mmonia				
D.O. Saturation (5')	129			
ight Penetration (3'; 1%)				
rcentage of water column th at least 0.1 ppm D.O	100			

OXYGEN AND TEMPERATURE PROFILES



RIB S AND OUTLETS	TOT. P	SOL. P	N-ORG	NO_2-N NO_3-N	NH_3-N	D.O.
Char 370 rom Lever Bros.	0.08	0.03	1.1	0.1	0.1	

ALGAL TOWS	Depth of Tow ft.	5'-0'	10'-5'	ft.
Total Algae		Max. Points		
Dominant Algae		Microcystics		

1976

STATE of INDIANA

STATE BOARD OF HEALTH

AN EQUAL OPPORTUNITY EMPLOYER

Sent: 3/27/80

1980

INDIANAPOLIS

Address Reply to:
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, IN 46206

March 26, 1980

Mr. Al Ackerman
U.S. Army Corps of Engineers
219 South Dearborn St.
Chicago, IL 60604

Dear Mr. Ackerman:

Re: Bottom Samples—Wolf Lake, Hammond, Indiana

On February 13, 1980, samples of bottom sediment were received in the Water and Sewage Laboratory. The samples were given the following laboratory identification numbers:

Field Identification (see attached sheet)	ISBH Water & Sew. Lab I.D. Numbers
#1	D 0301
#2	D 0302
#3	D 0303
#4	D 0304

The samples, as received, consisted of a sediment layer and a water layer. The water layer was decanted and a total residue analysis was done on each sample. The remaining sludge was air dried, homogenized, and stored in a dessicator.

Mr. John Leads of the Corp. of Engineers requested the following parameters be analyzed using the dry method:

Volatile Solids	PCB
Total Kjeldahl Nitrogen	Phosphorus
Oil and Grease	Mercury
Lead	C.O.D. (leachate on dry material)
Zinc	

The results of the tests are shown on the attached report forms.

Sincerely,

Craig T. Hinshaw

Craig f. Hinshaw, Chemist Supervisor
Water and Sewage Laboratory Division
Bureau of Laboratories

Enclosure

cc: Mr. Mike Bicanic
Hammond Parks & Recreation Dep
5823 Sohl
Hammond, IN 46320

371 Mr. Dick Tillotson, Distric Manager
Mud Division
15670 West Ten Mile, Suite 107
Southfield, MI 48075

	D0301 (mg/kg)	D0302 (mg/kg)	D0303 (mg/kg)	D0304 (mg/kg)
COD				
*1. Leachate	<5.0 (mg/1)	180. (mg/1)	140. (mg/1]	120. (mg/1)
2. Total	4,000.	630,000.	300,000.	350,000.
Lead	19.	860.	200.	260.
Mercury	0.21	1.40	0.43	0.86
TKN	460.	8,900.	3,600.	6,900.
Oil & Grease	600.	23,300.	7,700.	6,000.
PCB: Aroclor 1248	<0.1	1.3	0.3	0.6
Aroclor 1260	<0.1	0.8	0.2	0.4
P	190.	2,700.	1,090.	1,560.
Zinc	52.	1,310.	430.	610.
	Z by weight of the dry residue			
Total Volatile Residue	4.5	13.4	5.8	10.0
	Z by weight of the sample is received in the lab			
Total Residue	75.5	15.5	35.9	23.6

* See attached procedure for leachate method.

EPA LEACIIATE PROCEDURE

1. Homogenize sample without chancing its physical nature.

2. Weigh 100 gms. of samplc and place into a 2 liter beaker.

3. Add 1600 ml of deionized - distilled water to the 2 liter beaker
   * and begin agitation (16 x weight of sample = ml volume).

A. Adjust pH to' 5.0 ± 0.2 using 0.5 N. Acetic acid.

5. Mix for 24 hours. Check pH initially, 15 min; 30 min; and then hourly. Adjust pH to 5.0 ± 0.2 if necessary.

6. After 24 hours, check pH and record.

7. Filter the mixture, using a 0.45 micron membrane filter (millipore type HAW/142 or equivalent) and a prefilter (millipore AP25124 or a equivalent).

8. Adjust volume of the filtrate to 2000 ml using deionized - distilled water. (20 × weight of sample) = ml volume

9. Run analysis on the filtrate.

Reference: Federal Register, Vol. 43, No. 243 - Monday, December 18, 1978.

Note: 5 gms of sample used
total adjusted volume of filtrate 100m
H_2SO_4 used in place of acetic acid

Sample Site City of Hammond - Wolf Lake Sediment #1

Station Number

Sample Date ______ ______ ______ ______
Mo. 11-12 | Day 13-14 | Yr. 15-16 | AM/PM

Supervisor per Steve Kin

Collector(s)

Delivered to lab 2 (Mo.) 7 (Day) 80 (Yr.) 1 (AM/PM)

By Mail

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		2
Total		2

Standard Procedure Followed All Some None

NPDES Number ______ (1-7) Outfall ______ (8-10)

17 ______
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18 ______
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 ______ Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 ______ Sample Interval

21 ______
0 - at outfall
1 - above outfall
2 - below outfall

22-26 ______ Stream miles from outfall

LAB INFORMATION

Lab No. 0301 Date FEB 7 1980 (Mo. Day Yr. AM/PM)

Rec'd by JTS

Temp of samples when received ______

Comments:
1 bottle - glass, metal cap with wax paper liner
1 bottle - glass, metal cap with aluminum foil liner

CODE	PARAMETERS	UNIT		LAB DATA 34-41 Sediment	Supernatant
28-32 00410	Alkalinity Total $CaCO_3$	mg/l			
00610	Ammonia-N	mg/l			
01002	Arsenic REPORTED	ug/l			
00310	BOD_5 MAR 24 1980	mg/l			
01027	Cadmium	ug/l			
00940	Chloride WATER LABORATORY	mg/l			
01032	Chromium-Hex IND. STATE BD. OF HEALTH	ug/l			
01034	~~Chromium-Tr~~ COD (Supernatant)	mg/l			<5.0
00335	COD	mg/l	✓	4000. mg/kg	
01042	Copper	ug/l			
00720	Cyanide-CN	mg/l			
00951	Fluoride	mg/l			
01045	Iron	ug/l			
01051	Lead	~~ug/l~~	✓	19,000 µg/kg	650
01055	Manganese	ug/l			
71900	Mercury	~~ug/l~~	✓	210. µg/kg	5.6 µg
01067	Nickel	ug/l			
00630	NO_2+NO_3-N	mg/l			
00550	Oil & Grease	~~mg/l~~	✓	600. mg/kg	
00403	pH (lab)	S.U.			
32730	Phenol	ug/l			
00665	Phosphorus-P	~~mg/l~~	✓	190. mg/kg	1.52 mg/l
00530	Solids - Susp	mg/l			
00500	Solids (total) by wt.	~~mg/l~~	✓	75.5%	0.2 %
00945	Sulfate	mg/l			
00625	TKN	~~mg/l~~	✓	460. mg/kg	12. mg/l
00680	TOC	mg/l			
01092	Zinc	~~ug/l~~	✓	52,000 µg/kg	1,100. µg/l
31616	Fecal coliform	100 ml			
	Vol Total Solids	by wt.	✓	4.5%	—
	PCB ppm		✓	<0.1 as Aroclor	
				<0.1 as Aroclor	

374

SBH65-030
State Form 1490

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake Sediment (City of Hammond)

Station Number #2

Sample Date ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor per Steve Kir

Collector(s) ____

Delivered to lab 2 Mo. 7 Day 80 Yr. 1 AM/PM

By Mil.

Preservatives Added: Kind ____ Lot No. ____ Amount ____

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		1
Total		1

Standard Procedure Followed All Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

17 — 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

18 — 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

19 — Sample Type 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

20 — Sample interval

21 — 0 - at outfall 1 - above outfall 2 - below outfall

22-26 — Stream miles from outfall

LAB INFORMATION

Lab No. 0302 Date FEB 7 1980 Mo. Day Yr. AM/PM

Rec'd by JJS

Temp of samples when received ____

Comments: bottle - glass, cap (metal) with wax paper liner

CODE	PARAMETERS	UNIT		LAB DATA 34-41	
25-32 00410	Alkalinity Total $CaCO_3$	mg/l		Sediment	Supernate
00610	Ammonia-N	mg/l			
01002	Arsenic				
00310	BOD_5	mg/l			
01027	Cadmium	ug/l			
00940	Chloride	mg/l			
01032					
01034	~~Chromium-Tot~~ COD on Supernate	~~ug/l~~		180 mg/l	
00335	COD	~~mg/l~~	✓	630,000	mg/kg
01042	Copper	ug/l			
00720	Cyanide-CN	mg/l			
00951	Fluoride	mg/l			
01045	Iron	ug/l			
01051	Lead	~~ug/l~~	✓	860,000 µg/kg	2,400 µg/l
01055	Manganese	ug/l			
71900	Mercury	~~ug/l~~	✓	1,400 µg/kg	6.2 µg/l
01067	Nickel	ug/l			
00630	NO_2+NO_3-N	mg/l			
00550	Oil & Grease	mg/l	✓	25,300 mg/kg	
00403	pH (lab)	S.U.			
32730	Phenol	ug/l			
00665	Phosphorus-P	~~mg/l~~	✓	2,700 mg/kg	1.02 mg/l
00530	Solids - Susp	mg/l			
00500	Solids (total) by wt.	~~mg/l~~	✓	15.5%	0.3%
00945	Sulfate	mg/l			
00625	TKN	~~mg/l~~	✓	8900 mg/kg	45. mg/l
00680	TOC	mg/l			
01092	Zinc	~~ug/l~~	✓	1,310,000 µg/kg	3,600 µg/l
31616	Fecal coliform	100 ml			
Vol.	Total Solids	by wt.	✓	13.4%	
	PCB	ppm	✓	1.3 as	Aroclor 1[illegible]
				0.8 as	" 12[illegible]

REPORTED

MAR 24 1980

WATER LABORATORY IND. STATE BD. OF HEALTH

SBH65-030 State Form 1100

Sample Site *City of Hammond*
Wolf Lake Sediment
#3

Station Number ~~*—*~~

Sample Date ____ ____ ____ AM/PM
Mo. 11-12 Day 13-14 Yr. 15-16

Supervisor *per Steve Kin*

Collector(s) ______

Delivered to lab *2* (Mo.) *7* (Day) *80* (Yr.) *1* AM/PM (PM circled)

By *mail*

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		*2*
Total		*2*

Standard Procedure Followed · All Some None

NPDES Number ____ (1-7) Outfall ____ (8-10)

17: 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

18: 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

19: Sample Type 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

20: Sample Interval

21: 0 - at outfall 1 - above outfall 2 - below outfall

22-26: Stream miles from outfall

LAB INFORMATION

Lab No. *0303* Date FEB 7 1980
Mo. Day Yr. AM/PM

Rec'd by *JS*

Temp of samples when received ______

CODE	PARAMETERS	UNIT		LAB DATA 34-41	
28-32 00410	Alkalinity Total $CaCO_3$	mg/l		*Sediment*	*Supernat.*
00610	Ammonia-N	mg/l			
01002	Arsenic	ug/l			
00310	BOD_5	mg/l			
01027	Cadmium	ug/l			
00940	Chloride	mg/l			
01032	Chromium-Hex	ug/l			
01034	~~Chromium~~ *COD on leachate*	~~ug/l~~		*140. mg/l*	
00335	COD	~~mg/l~~	✓	*300,000 mg/kg*	
01042	Copper	ug/l			
00720	Cyanide-CN	mg/l			
00951	Fluoride	mg/l			
01045	Iron	ug/l			
01051	Lead	ug/l	✓	*300,000. µg/kg*	*720. µg/l*
01055	Manganese	ug/l			
71900	Mercury	ug/l	✓	*430. µg/kg*	*1.9 µg/l*
01067	Nickel	ug/l			
00630	NO_2+NO_3-N	mg/l			
00550	Oil & Grease	~~mg/l~~	✓	*1,700. mg/kg*	
00403	pH (lab)	S.U.			
32730	Phenol	ug/l			
00665	Phosphorus-P	mg/l	✓	*1,090. mg/kg*	*0.36 mg/l*
00530	Solids - Susp	mg/l			
00500	Solids (total) *by wt.*	~~mg/l~~	✓	*35.9%*	*0.1%*
00945	Sulfate	mg/l			
00625	TKN	mg/l	✓	*3600. mg/kg*	*3.6 mg/l*
00680	TOC	mg/l			
01092	Zinc	ug/l	✓	*430,000 µg/kg*	*1,100. µg/l*
31616	Fecal coliform	100 ml			
Vol. Total Solids		*by wt.*	✓	*5.8%*	
	PCB	*ppm*	✓	*0.3 as Aroclor*	
				0.2 "	*"*

REPORTED
MAR 24 1980
WATER LABORATORY
IND. STATE BD. OF HEALTH

Comments:
1 bottle - glass, metal cap with wax paper liner
1 bottle - glass, metal cap with aluminum foil liner

SBH65-030
State Form 1490

WATER SAMPLE IDENTIFICATION SHEET

Sample Site City of Hammond Wolf Lake Sediment #4

Station Number

Sample Date ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor per Steve Kim

Collector(s)

Delivered to lab 2 (Mo.) 7 (Day) 80 (Yr.) 1 (AM/PM)

By Mail

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		2
Total		2

Standard Procedure Followed All Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 Sample Interval

21
0 - at outfall
1 - above outfall
2 - below outfall

22-26 Stream miles from outfall

LAB INFORMATION

Lab No. 0304 Date FEB 7 1980 (Mo. Day Yr. AM/PM)

Rec'd by JES

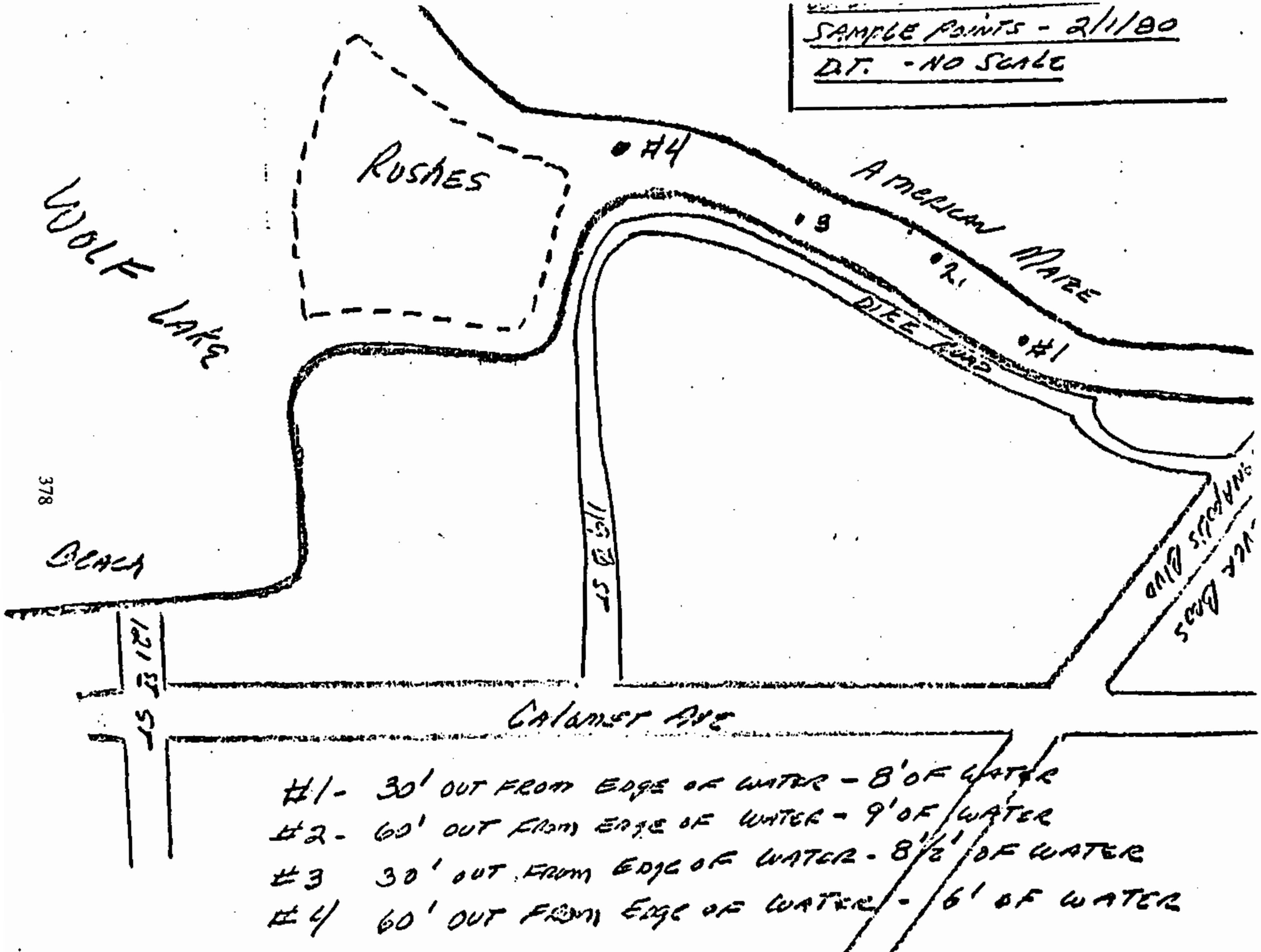
Temp of samples when received

Comments:
1 bottle - glass, metal cap with wax paper liner
1 bottle - glass, metal cap & aluminum foil liner

CODE	PARAMETERS	UNIT		LAB DATA 34-41	
28-32 . 00410	Alkalinity Total $CaCO_3$	mg/l		Sediment	Supernate
00610	Ammonia-N	mg/l			
01002	Arsenic	ug/l			
00310	BOD_5	mg/l			
01027	Cadmium	ug/l			
00940	Chloride	mg/l			
01033	Chromium-Hex	ug/l			
01034	~~Chromium-Tot~~ on leachate COD	~~ug/l~~		120 mg/l	
00335	COD	mg/l	✓	350,000 mg/kg	
01042	Copper	ug/l			
00720	Cyanide-CN	mg/l			
00951	Flouride	mg/l			
01045	Iron	ug/l			
01051	Lead	ug/l	✓	260,000. ug/kg	3,000. ug/l
01055	Manganese	ug/l			
71900	Mercury	ug/l	✓	860. ug/kg	7.0 ug/l
01067	Nickel	ug/l			
00630	NO_2+NO_3-N	mg/l			
00550	Oil & Grease	mg/l	✓	6,000. mg/kg	
00403	pH (lab)	S.U.			
32730	Phenol	ug/l			
00665	Phosphorus-P	mg/l	✓	1,560. mg/kg	0.53 mg/l
00530	Solids - Susp	mg/l			
00500	Solids (total) Dry wt.	~~mg/l~~	✓	23.6%	0.7%
00945	Sulfate	mg/l			
00625	TKN	mg/l	✓	6900. mg/kg	31. mg/l
00680	TOC	mg/l			
01092	Zinc	ug/l	✓	610,000. ug/kg	5,600. ug/l
31616	Fecal coliform	100 ml			
Vol	Total Solids	% wt	✓	10.0%	
	PCB	ppm	✓	0.6 as Aroclor	
				0.4 "	"

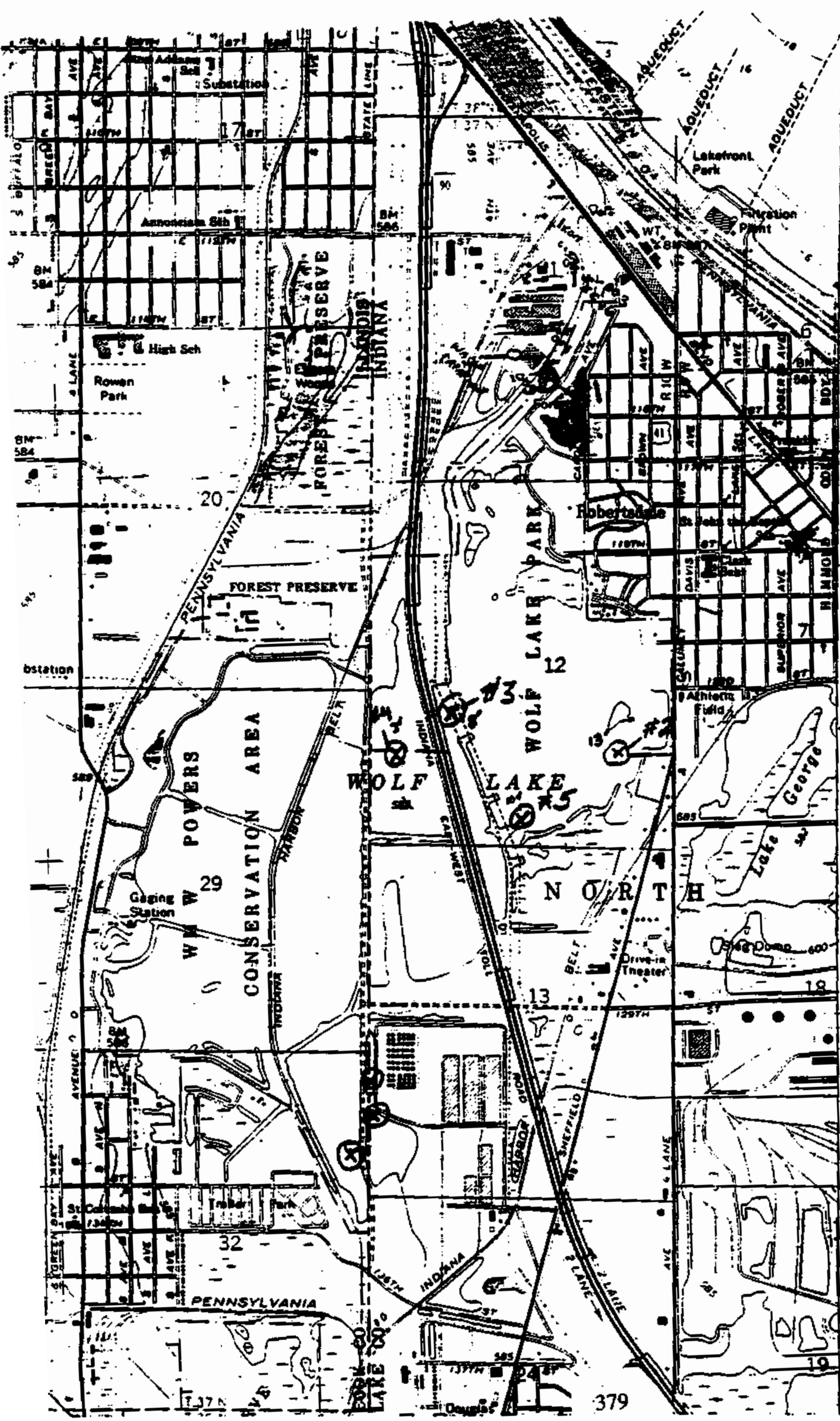
REPORTED MAR 24 1980 [initials]
WATER LABORATORY
IND. STATE BD. OF HEALTH

SH165-030



SAMPLE POINTS - 2/1/80
D.T. - NO SCALE
RUSHES
WOLF LAKE
#4
3
2
#1
AMERICAN MAIZE
DIKE ROAD
BEACH
121 ST
CALUMET AVE
INDIANAPOLIS BLVD
#1- 30' OUT FROM EDGE OF WATER - 8' OF WATER
#2- 60' OUT FROM EDGE OF WATER - 9' OF WATER
#3 30' OUT FROM EDGE OF WATER - 8½' OF WATER
#4 60' OUT FROM EDGE OF WATER - 6' OF WATER

378



1981
Sample Sites

American Maize

Lever Bros

these sites first appear on a map ~1981; couldn't they be the ones used throughout the next decade?

they are described in the following report

Summary of Limnological Survey
Wolf Lake, Lake County
July 22, 1981

In past years, many limnologlcal and chemical surveys have been conducted at Wolf Lake. These have all provided data that indicated the advanced eutrophic condition of the lake. Excessive concentrations of nitrogen and phosphorus have consistently been found throughout the water column and nuisance blue-green algal blooms are common. Fish kills have occurred and complaints concerning poor water quality conditions are regularly received by this office. The Indiana Lake Classification System and Management Plan lists Wolf Lake in Group IV, Subgroup A.

Group IV contains most of the problom lakes of the state. The majority of these lakes have water quality problems that often impair recreational uses. The choice of specific restoration techniques for an individual lake depends in part on the area and depth of the lake. Group IV, Subgroup A lakes have shallow mean depths. Some of the more feasible restoration techniques are dredging, bottom sealing, or sediment consolidation. Restoration projects must be accompanied by curbing future nutrient and sediment inputs in order to achieve long-term improvements.

Wolf Lake is a high use problem lake and, as such, it is a likely candidate for restoration. This agency reviews and comments on lake restoration feasibility plans and restoration project proposals; therefore, up-to-date background limnological data on Wolf Lake is necessary.

Aquatic Vegetation

There are significant wetlands around the mouth of Wolf Lake Channel and the north end of the lake basin. The south end of the lake contains smaller areas of wetland. These wetlands closely resemble a Type 4 Deep Marsh. The wetland soils are covered with one-half to three feet of water and the dominant macrophytes are cattails, yellow and white pond lily, and various aquatic grasses. This vegetation provides the only fish habitat available for spawning and protection of fry, as the lake is shallow and contains little bottom structure. Many shore birds and migratory waterfowl were observed in the wetland areas.

Tows were made with a plankton net from bottom to surface. Examination of these samples revealed that, at the time of survey, the plankton population was almost entirely composed of the blue-green algae, Microcystis sp. There were also trichomes of Anabaena sp. present. These are two of the most common genera in nuisance algae blooms. In quiet waters, they will often form dense floating scums and produce odors that are often Che source of complaints. The sediments of midlake also contained masses of pea-sized gelatinous bodics. Examination under the microscope indicated that these were probably the blue-green algae, Aphanothece sp. Large numbers of pennate diatoms were found adhering to the copious mucilage of the blue-green colonies.

The constant turbidity and low secchi-disk measurements are a result of the presence of large populations of blue-green algae and algal remains that are wind and current circulated from bottom sediments. The high turbidities of the epilimnion waters are light-limiting and, therefore, prevent even higher populations of plankton from developing. Turbidity also restricts the area of maerophyte growth.

Sediments

Sediment samples were collected with a dredge at five lake stations. Most of the sediments were jet black in color and of very fine composition. When the sediments were washed, they all passed quickly through a #30 sieve. The sediments were at least several inches deep throughout the lake. There was practically no odor to the sediments and this indicates aerobic decomposition had taken place. The sediments resembled completely stable plankton remains.

Most highly eutrophic lakes deep enough to completely stratify thermally will have organic sediments that have undergone anaerobic decomposition. The sediments may not be completely stable and will usually have a characteristic hydrogen sulfide odor. Hypolimnetic water may also smell of hydrogen sulfide. This is prevented in Wolf Lake, for dissolved oxygen is readily circulated throughout the water column by wind-induced currents.

There are also partially decomposed algal remains and macrophyte detritus that forms most of the flocculent suspended sediments of Wolf Lake. This lies just above the bottom during quiet weather, but is often dispersed throughout the water column by wind and motor boat activity. Nutrients are also recycled to the trophic zone along with sediments.

Benthic Aquatic Life and Zooplankton

The sediments were examined at five stations for benthic macroinvertebrates. None were found except in Wolf Lake Channel. In the channel only a few Oligochaets were found. This absence of benthic organisms is partially due to the poor habitat provided by the soft shifting sediments of the substrate. Laboratory analysis of the sediments revealed very high concentrations of metals (Table II). These high concentrations may also inhibit colonization by benthic life. The littoral regions of the lake were not examined. It is possible that some macroinvertebrate may exist there, especially midge larvae.

No zooplankton was found in samples obtained by towing a plankton net through the water column. This is also unusual for most eutrophic lakes containing large populations of certain zooplankton. These organisms may also be limited by excessive metals concentrations. The zooplankton food supply may not be suitable. The phytoplankton of Wolf Lake, upon which much zooplankton feeds, is composed of blue-green genera which are not a preferred food source.

Lake Uses

Wolf Lake is a heavily used resource. During weekdays, many fishermen were observed in boats and along the banks. Fishing activity must be heavy on the weekend. The *Northeastern Sportsman* magazine states that Wolf Lake supports significant populations of largemouth bass and northern pike. We observed a fisherman bringing in a fifteen-inch bass. Personnel of this office have observed fishermen on Wolf Lake on many occasions throughout the year.

There is a public boat ramp and parking lot on the south side of the lake and a marina on the west side. Water skiing and pleasure boating are popular although Wolf Lake is shallow and boats must keep to the lake center.

Forsyth Park is located along the Wolf Lake Channel and the north end of the lake. This area offers extensive bank fishing, three ball fields, and picnic areas. There is also a large swimming beach along the northeast quadrant of the lake.

The wetland areas attract numerous birds and animals and nature study may be enjoyed at Wolf Lake.

General Statements

The July 22, 1981, survey of Wolf Lake confirms the lake's position in the Lake Classification and Management Plan. The lake contains excessive amounts of nitrogen and phosphorus (Table III) and periodically supports blue-green algal blooms. Fish kills have been recorded. Recreational uses have been impaired by industrial discharges, storm water overflow, bacterial contamination, and algal blooms. Pollution complaints have been received from the Lake County Health Department, private citizens, and conservation organizations.

Wolf Lake is heavily used by Lake County residents and provides the only water-oriented recreation available to a large number of people.

The sediments of Wolf Lake contain excessive concentrations of several metals. Care should taken with the disposal of any dredged bottom sediments.

Dissolved Oxygen Table I

Wolf Lake is noc protected by natural features such as hills or stands of forest. It is open to the strong winds of Lake Michigan which frequently move and stir the water column. Wolf Lake averages only about five feet in depth. A maximum depth of fourteen feet was found. The strong winds and shallow depth result in the mixing of the waters and the prevention of strong thermal stratification. The lack of dissolved oxygen is not a common problem with Wolf Lake; however, it is probable that nighttime low dissolved oxygen concentrations are a factor in fish kills during extended, quiet, hot weather periods, as well as during winter ice cover.

Station #1 Wolf Lake Channel. Mid-channel near the last building in the American Maize complex.

Depth (Feet)	Temperature (C)	Dissolved Oxygen (mg/l)
0	23.0	7.0
1	23.0	6.9
2	23.0	6.9
3	23.0	7.1
4	22.0	6.7
5 (Bottom)	22.0	5.6

Secchi-Disk - 30 in. Wind = N 15 mph Hazy Sun 12 noon

Station #2. 100 yards south of the island on the east side of Wolf Lake

Depth (Feet)	Temperature (C)	Dissolved Oxygen (mg/1)
0	23.0	8.8
1	23.0	8.6
2	23.0	8.4
3	23.0	8.3
4	23.0	8.1
5	23.0	8.1
6	23.0	7.9
7	23.0	7.8
8	23.0	7.5
9	23.0	7.5
10	22.5	7.3
11	22.5	7.1
12	22.0	6.5
13 (Bottom)	22.0	5.3

Secchi-Disk - 18 in. Wind = N 10 mph Hazy Sun 1:45 p.m.

Station #3. 50 yards east of the culvert which leads under Toll Road #90. In the main Wolf Lake basin.

Depth (Feet)	Temperature (C)	Dissolved Oxygen (mg/1)
0	23.0	9.8
1	23.0	9.5
2	23.0	9.3
3	23.0	9.3
4	23.0	9.0
5	23.0	9.0
6	23.0	8.9
7	23.0	8.9
8	23.0	7.2

Secchi-Disk = 18 in. Wind = N 15 mph Hazy Sun 1:15 p.m.

sration #4. Center of the West Basin. West of Toll Road culvert.

Depth (Feet)	Temperature (C)	Dissolved Oxygen (mg/l)
0	22.0	10.1
1	22.0	10.1
2	22.0	10.0
3	22.0	9.6

Secchi-Disk = 12 in.   Wind = N 15 mph   Hazy Sun 12:45 p.m.

Station #5. South end of Wolf Lake.

Depth (Feet)	Temperature (C)	Dissolved Oxygen (mg/1)
0	24.0	9.9
1	24.0	9.7
2	24.0	9.5
3	23.5	9.5
4	23.5	9.2
5	23.5	9.0
6	23.5	8.8
7	23.0	8.8
8	23.0	8.6
9	23.0	8.5
10	23.0	8.5

Secchi-Disk = 18 in.   Wind - N 10 mph   Direct Sun 2:15 p.m.

Table II
Wolf Lake, Lake County
Results of Analysis, Sediment Metals, Analysis on Dry Weight
July 22, 1981

Station	PCB ug/kg	Arsenic ug/kg	Cadmium ug/kg	Total Chromium ug/kg	Copper ug/kg	Iron ug/kg	Lead ug/kg	Manganese ug/kg	Nickel ug/kg	Zinc ug/kg
#1	(see below)	17,000	7,000	160,000	340,000	37,000,000	1,000,000	740,000	46,000	1,300,000
#2		11,000	2,000	42,000	81,000	19,000,000	240,000	690,000	18,000	430,000
#3		15,000	3,000	54,000	110,000	25,000,000	290,000	690,000	22,000	600,000
#4		17,000	1,000	29,000	160,000	10,000,000	110,000	440,000	8,800	240,000
#5		2,300	800	9,700	8,000	5,700,000	25,000	330,000	3,700	60,000

#1 Wolf Lake Channel. Mid channel near the last building in the American Maize complex.
#2 100 yards south of the island on the east side of Wolf Lake.
#3 The main Wolf Lake basin, 50 yards east of the culvert which leads under Toll Road 90.
387 #4 Center of the west basin, west of the Toll Road 90 culvert.
#5 South end of Wolf Lake.

	PCB ug/kg			
Station #1	AROCLOR	1242		0.67
	AROCLOR	1260		0.94
Station #2	AROCLOR	1242	<	0.10
	AROCLOR	1260	<	0.10
Station #3	AROCLOR	1242	<	0.10
	AROCLOR	1260	<	0.10
Station #4	AROCLOR	1242	<	0.10
	AROCLOR	1260	<	0.10
Station #5	AROCLOR	1242	<	0.10
	AROCLOR	1260	<	0.10

Table III
Wolf Lake, Lake County
Results of Analysis, Water Samples, Surface and Bottom
July 22, 1981

Parameter	Station #1 Surface	Station #1 5 Feet	Station #2 Surface	Station #2 13 Feet	Station #3 Surface	Station #3 8 Feet	Station #4 Surface	Station #4 3 Feet	Station #5 Surface	Station #5 10 Feet
Alkalinity Total $CaCo_3$ mg/1		100.0		60.0		68.0	----	60.0	----	66.0
Ammonia-N mg/1	0.1	0.5	0.1	0.1	0.1	0.9	0.1	0.1	0.1	0.1
Arsenic ug/1	2.9	3.1	2.4	2.5	2.4	4.9	5.6	6.5	2.4	2.6
Cadmium ug/1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Chronium-Total ug/1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Copper ug/1	22.0	27.0	A.O	4.0	4.0	24.0	6.0	6.0	4.0	4.0
Cvmiide mg/1		0.005		0.005		0.005	----	0.005	----	0.005
Iron ug/1	1,500.0	2,000.0	A30.0	.480.0	430.0	2,800.	520.0	680.0	A60.0	560.0
Lead ug/1	50.0	60.0	10.0	10.0	10.0	50.0	10.0	10.0	10.0	10.0
Manganese ug/1	100.0	110.0	100.0	100.0	90.0	260.0	100.0	110.0	90.0	100.0
Nickel ug/1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
No_2+No_3-N mg/1	0.2	0.2	0.6	0.5	0.1	0.1	0.1	0.1	0.1	2.4
Phosphorus-P mg/1	0.08	0.32	0.12	0.12	0.13	0.35	0.17	0.19	0.13	0.15
TKN mg/l	0.1	2.4	0.1	0.1	0.1	1.1	0.1	2.2	1.6	2.3
Zinc ug/1	100.0	120.0	10.0	10.0	10.0	90.0	10.0	30.0	10.0	10.0
Hardness mg/l $CaCo_3$		156.0		100.0	.	1A8.0	----	128.0	----	108.0
PCB ug/kg										

TABLE II B

Wolf Lake, Lake County
Results of Analysis, Laboratory Leachate of Sediment Samples
July 22, 1981

Station	Arsenic ug/1	Cadmium ug/1	Chromium -Total ug/1	Lead ug/1	Mercury ug/1	Barium ug/1	Selenium ug/1	Silver ug/1
#1	2.3	<2.0	<10.0	<10.0	0.3	<30.0	<0.2	<10.0
#2	2.5	<2.0	<10.0	<10.0	0.1	<30.0	0.2	<10.0
#3	2.2	<2.0	<10.0	<10.0	0.2	50.0	0.6	<10.0
#4	3.1	<.2.0	<10.0	<10.0	<0.1	50.0	0.3	<10.0
#5	1.9	<2.0	<10.0	<10.0	0.1	60.0	0.2	<10.0
Ccnposlte of Samples #1,#2, #3, #4, and #5	3.8	<2.0	< 10.0	<10.0	0.1	80.0	0.3	<10.0

August 7, 1981

C. Lee Bridges, Chief
Biological Studies & Standards Section

Harold L. BonHomme, Supervisor of Lake Studies
Biological Studies & Standards Section

Wolf Lake Limnological Survey

Biologists of this section conducted a limnological survey of Wolf Lake in Lake County on July 22, 1981.

The survey was done under about as stable weather conditions as is possible that near to Lake Michigan. A cool front had moved in the day before the survey and temperatures had fallen from daytime highs of 90 to 65 ; however, the winds had subsided to a relatively moderate 10-15 mph for the duration of the survey. There was constant sunlight--sometimes direct and sometimes hazy.

Only the Indiana waters of Wolf Lake were surveyed because no boat inlet to the Illinois waters was found.

The shoreline of the lake was observed and no flowing outfalls or drainage was noticed at the time of the survey.

There are significant wetlands around the mouth of the Wolf Lake Channel and the north end of the lake basin. The south end of the lake also contains smaller wetlands. These wetlands closely resembled a Type 4 Deep Marsh. The wetland soils were covered with one-half to three feet of water; and the dominant macrophytes were cattail, yellow and white pond lily, and various aquatic grasses. Much of this vegetation provides the only available fish cover for spawning and fry survival, as the lake averages about five feet deep and bottom structure is scarce. Many shore birds and ducks were observed using the wetland areas.

Sediment samples were collected with a dredge at the five lake stations. These were for PCB and metals analysis. Samples were taken from the Wolf Lake Channel and midlake for benthic life.

The bottom sediments were jet black and were of very fine composition. When washed, it all passed quickly through a #30 sieve. There were numerous bits of grass-like vegetative detritus in the sediments. The sediments were at least several inches deep throughout the lake basin. There was practically no odor to the sediments and they closely resembled decomposed stable plankton remains. Most lakes deep enough to stratify long enough for anaerobic conditions to develop will have bottom sediments and hypolimnetic waters with a hydrogen sulfide odor. The sediments will not be completely stable. This is prevented in Wolf

Lake, for the lake is open and very shallow so that the epilimnetic waters and dissolved oxygen are usually well circulated by the frequent winds of that area. Sediments of this type should be easier than most to dispose of if dredged. The sediment is light in weight (at least the interface sediments) and they are easily stirred by wind-induced currents so that nutrients are circulated and some suspended solids turbidity is practically always present. Motorboat activity contributes to sediment stirring.

Plankton tows were made with a net from top to bottom in several locations. Examination of these samples revealed that at the time of survey the plankton was almost entirely composed of the blue-green algae, Microcystis. There were also trichomes of Anabaena present. These are the most common genera in nuisance algae blooms. In quiet waters they will form dense floating scums and produce the odors that are often the source of complaints. The sediments in midlake also contained masses of pea-sized gelatinous bodies. Examination under the microscope indicated that these were probably the blue-green algae, Aphanothece or Gloeothece. Large populations of pennate diatoms of various species were found adhering to the firm copious mucilage of the blue-green colonies. No zooplankton was observed in any of the tows.

The bottom sediments were examined for macroinvertebrates. No macroinvertebrates were found except four oligochaetes in the Wolf Lake Channel station. No visible living organisms were found in the midlake sample except the aforementioned gelatinous blue-green algae colonies.

I would have expected great numbers of midge larvae in this shallow, organically-rich lake. Perhaps even midge larva are confined to more firm bottom shore areas because of the fine shifting sediments farther out in the lake basin.

The following are Wolf Lake sampling stations and temperature and DO profiles:

Station #1. Wolf Lake Channel. Mid-channel near the last building in the American Maize complex.

Depth (ft.)	Temperature (C°)	Dissolved Oxygen (mg/l)
0	23.0	7.0
1	23.0	6.9
2	23.0	6.9
3	23.0	7.1
4	22.0	6.7
5 (Bottom)	22.0	5.6

Secchi-disc = 30"   Wind = 15 mph Chop N   Hazy Sun

Station #2, 100 yards south of the island on the east side of the lake.

Depth (ft.)	Temperature (C)	Dissolved Oxygen (mg/1)
0	23.0	8.8
1	23.0	8.6
2	23.0	8.4
3	23.0	8.3
4	23.0	8.1
5	23.0	8.1
6	23.0	7.9
7	23.0	7.8
8	23.0	7.5
9	23.0	7.5
10	22.5	7.3
11	22.5	7.1
12	22.0	6.5
13 (Bottom)	22.0	5.3

Secchi = 18"   Wind = N 10 mph   Hazy Sun

Station #3. 50 yards east of the culvert which Leads under the Toll Road #90. In the main Wolf Lake Basin.

Depth (ft.)	Temperature (C°)	Dissolved Oxygen (mg/l)
0	23.0	9.8
1	23.0	9.5
2	23.0	9.3
3	23.0	9.3
4	23.0	9.0
5	23.0	9.0
6	23.0	8.9
7	23.0	8.9
8	23.0	7.2

Secchi = 18"   Wind = N 15 mph Chop   Hazy Sun

Station #4. Center of West Basin. West of Toll Road Culvert.

Depth (ft.)	Temperature (C°)	Dissolved Oxygen (mg/1)
0	22.0	10.1
1	22.0	10.1
2	22.0	10.0
3	22.0	9.6

Secchi = 12"   Wind = 15 mph-N   Hazy Sun

Station #5. South end of Wolf Lake.

Depth (ft.)	Temperatures (C)		Dissolved Oxygen (mg/1)
0	24.0	393	9.9
1	24.0		9.7
2	24.0		9.5

4	23.5	9.2
5	23.5	9.0
6	23.5	8.8
7	23.5	8.8
8	23.0	8.6
9	23.0	8.5
10	23.0	8.7

Secchi = 18"　　Wind = N 10 mph　　Sunny

Wolf Lake is a heavily used lake. During a weekday, many fishermen were observed in boats and along the bank. Fishing pressure must be heavy on weekends. The Northeastern Sportsman magazine states that Wolf Lake supports a significant population of Largemouth Bass and Northern Pike. We observed a fisherman bringing in a fifteen-inch bass.

There is a public boat ramp and parking lot on the south side of the lake and a marina on the west side. Water skiing and pleasure boating are popular. Fishing and boating are more compatible on Wolf Lake, for the large boats must keep more to the center of the lake because of the extensive shallows near shore.

Forsyth Park is located along the Wolf Lake Channel and the north end of the lake. This has extensive bank fishing, three ball fields, and picnic areas. There is also a large swimming beach on the northeast side of the lake.

Wolf Lake is an important resource for the Calumet area. It provides a game and rough fish fishery, wildlife habitat and observation opportunities, boating, swimming, and a park area for sports and relaxation. These are available for people who cannot reach or afford Lake Michigan activities.

The water quality of Wolf Lake is not good; however, the rather constant wind-induced circulation of its waters permits the biological and physical processes to keep lake conditions at something more than a tolerable level. The lake cannot adequately assimilate more organic wastes without the risk of the more constant and intense nuisance lake conditions that will inhibit lake uses and the fishery.

Surface and bottom water samples for nutrients, metals, cyanide, and alkalinity were taken at the five stations and will be added to this report when results of analyses are received.

ATER SAMPLE IDENTIFICATION SHEET

1982

Sample Site: WOLF LAKE SEDIMENT

Station Number: #1 - DISCHARGE

Sample Date: 6 (Mo. 11-12) 16 (Day 13-14) 82 (Yr. 15-16) AM/PM

Supervisor: C.L. BRIDGES

Collector(s): G. BRIGHT - J. RAY

Delivered to lab: 6 (Mo.) 29 (Day) 82 (Yr.) AM/PM

By: J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed: All Some None

NPDES Number ____ (1-7) Outfall ____ (8-10)

4 (17)
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7 (18)
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1 (19) Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ Sample Interval (20)

____ (21)
0 - at outfall
1 - above outfall
2 - below outfall

____ Stream miles from outfall (22-26)

JB

LAB INFORMATION

Lab No. D1791 Date JUN 29 1982 (Mo. Day Yr.) 10:00 AM/PM

Rec'd by: JB

Temp of samples when received ____

Comments:
* This group of analyses was made on dried sample after water had been poured off.

SH065-030

SUBSTANCE ~~(mg/kg)~~ µg/kg *	
PCB, TOTAL	
BHC, ALPHA	<10.
BHC, BETA	<10.
BHC, DELTA	<10.
BHC, GAMMA	<10.
HEXACHLOROBENZENE	<2.0
PENTACHLOROANISOLE	<10.
HEPTACHLOR	<2.0
HEPTACHLOR EPOXIDE	<10.
TRANS - NONACHLOR	<2.0
CIS - NONACHLOR	<10.
TRANS - CHLORDANE	<10.
CIS - CHLORDANE	<10.
OXYCHLORDANE	<10.
ALDRIN	<2.0
DDE, P, P' -	<2.0
DDE, O, P' -	<20.
DDD, P, P' -	<20.
DDD, O, P' -	<20.
DDT, P, P' -	<30.
DDT O, P' -	<10.
METHOXYCHLOR, P, P' -	<50.
METHOXYCHLOR O, P' -	<50.
DIELDRIN	<70.
ENDRIN	<30.
MERCURY	<20.
CHROMIUM	34,000. ✓
CADMIUM	700.
COPPER	10,000.
LEAD	340,000. ✓
ARSENIC	2100.
TOTAL SOLIDS	66.3%

Please analyze these on a wet weight basis

	mg/kg
di-N-butyl phthalate	<30.
aliphatic hydrocarbons	**
toluene	0.64
methylene chloride	<0.01
chloroform	<0.01
carbon tetrachloride	<0.01
1-1-1 trichloroethane	<0.01
trichloroethylene	<0.01
tetrachloroethylene	<0.01
fluorotrichloromethane	<0.01

** Not detected by GCMS

ATER SAMPLE IDENTIFICATION SHEET

Sample Site: WOLF LAKE SEDIMENT

Station Number: #2 - INDIANA POND

Sample Date: 6 (Mo. 11-12) 16 (Day 13-14) 82 (Yr. 15-16) AM/PM

Supervisor: C.L. BRIDGES

Collector(s): G. BRIGHT - J. RAY

Delivered to lab: 6 (Mo.) 29 (Day) 82 (Yr.) AM/PM

By: J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed: All Some None

NPDES Number ____ (1-7) Outfall ____ (8-10)

4 (17)
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7 (18)
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1 (19) Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ (20) Sample Interval

____ (21)
0 - at outfall
1 - above outfall
2 - below outfall

____ (22-26) Stream miles from outfall

JB

STATE DEPT. OF HEALTH

LAB INFORMATION

Lab No. D1742 Date JUN 29 1982 (Mo. Day Yr.) 10:00 AM/PM

Rec'd by JB

Temp of samples when received ____

SUBSTANCE ~~mg/kg~~ µg/kg *	
PCB, TOTAL	
BHC, ALPHA	<10.
BHC, BETA	<10.
BHC, DELTA	<10.
BHC, GAMMA	<10.
HEXACHLOROBENZENE	<2.0
PENTACHLOROANISOLE	<10.
HEPTACHLOR	<2.0
HEPTACHLOR EPOXIDE	<10.
TRANS - NONACHLOR	<2.0
CIS - NONACHLOR	<10.
TRANS - CHLORDANE	<10.
CIS - CHLORDANE	<10.
OXYCHLORDANE	<10.
ALDRIN	<2.0
DDE, P, P' -	3.6
DDE, O, P' -	<20.
DDD, P, P' -	<20.
DDD, O, P' -	<20.
DDT, P, P' -	<30.
DDT O, P' -	<2.0
METHOXYCHLOR, P, P' -	<50.
METHOXYCHLOR O, P' -	<50.
DIELDRIN	<70.
ENDRIN	<30.
MERCURY	<20.
CHROMIUM	110,000.
CADMIUM	<1,400.
COPPER	24,000.
LEAD	43,000
ARSENIC	3,200.
TOTAL SOLIDS	84.8%

Please analyze these on a wet weight basis mg/kg

di-N-butyl phthalate	<30.
aliphatic hydrocarbons	**
toluene	<0.01
methylene chloride	0.06
chloroform	<0.01
carbon tetrachloride	<0.01
1-1-1 trichloroethane	<0.01
trichloroethylene	<0.01
tetrachloroethylene	<0.01
fluorotrichloromethane	<0.01

Comments:
* Analyses made on dried sample & water was poured off. Before metal analyses were made 28% rocks were discarded from dried sample

** Not detected by GC/MS

396

SBH63030

WATER SAMPLE IDENTIFICATION SHEET

Sample Site: WOLF LAKE SEDIMENT

Station Number: #3 - ILLINOIS POND

Sample Date: 6 (Mo. 11-12) 16 (Day 13-14) 82 (Yr. 15-16) AM/PM

Supervisor: C. L. BRIDGES

Collector(s): G. BRIGHT - J. RAY

Delivered to lab: 6 (Mo.) 29 (Day) 82 (Yr.) AM/PM

By: J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ______ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed: All (circled) Some None

NPDES Number ______ (1-7) Outfall ______ (8-10)

4 (17)
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7 (18)
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1 (19) Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

______ (20) Sample Interval

______ (21)
0 - at outfall
1 - above outfall
2 - below outfall

______ (22-26) Stream miles from outfall

SUBSTANCE ~~(mg/kg)~~ ug/kg	
PCB, TOTAL	
BHC, ALPHA	< 10.
BHC, BETA	< 10.
BHC, DELTA	< 10.
BHC, GAMMA	< 10.
HEXACHLOROBENZENE	< 2.0
PENTACHLOROANISOLE	< 10.
HEPTACHLOR	< 2.0
HEPTACHLOR EPOXIDE	< 10.
TRANS - NONACHLOR	< 2.0
CIS - NONACHLOR	< 10.
TRANS - CHLORDANE	< 10.
CIS - CHLORDANE	< 10.
OXYCHLORDANE	< 10.
ALDRIN	< 2.0
DDE, P, P' -	2.2 ✓
DDE, O, P' -	< 20.
DDD, P, P' -	< 20.
DDD, O, P' -	< 20.
DDT, P, P' -	< 30.
DDT O, P' -	< 2.0
METHOXYCHLOR, P, P' -	< 50.
METHOXYCHLOR O, P' -	< 50.
DIELDRIN	< 70.
ENDRIN	< 30.
MERCURY	< 20.
CHROMIUM	1,200,000. ✓
CADMIUM	< 1 100.
COPPER	29,000.
LEAD	30,000.
ARSENIC	2,400.
TOTAL SOLIDS	84.6%

Please analyze these on a wet weight basis

	mg/kg
di-N-butyl phthalate	< 3.0
aliphatic hydrocarbons	**
toluene	< 0.01
methylene chloride	0.03
chloroform	< 0.01
carbon tetrachloride	< 0.01
1-1-1 trichloroethane	< 0.01
trichloroethylene	< 0.01
fluorotrichloromethane	< 0.01
tetrachloroethylene	< 0.01

** Not detected by GC/MS

LAB INFORMATION

Lab No. D1793 Date JUN 29 1982 (Mo. Day Yr.) 10:00 AM/PM

Rec'd by GB

Temp of samples when received ______

Comments: Analyses made on dried sample after water was poured off. Before metal analyses were made 77% rocks were discarded from dried sample.

SH165 070

397

WATER SAMPLE IDENTIFICATION SHEET

Sample Site WOLF LAKE
SEDIMENT

Station Number #3A-ILLINOIS POND (DUPLICATE)

Sample Date 6 16 82 ____
Mo. 11-12 Day 13-14 Yr. 15-16 AM/PM

Supervisor C.L. BRIDGES

Collector(s) G. BRIGHT - J. RAY

Delivered to lab 6 29 82 ____
Mo. Day Yr. AM/PM

By J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ______ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed All Some None

NPDES Number ______ (1-7) Outfall ______ (8-10)

4 (17): 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

7 (18): 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

1 (19): Sample Type 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

GB

______ Sample Interval

______ (21): 0 - at outfall 1 - above outfall 2 - below outfall

______ (22-26) Stream miles from outfall

SUBSTANCE µg/kg *	
PCB, TOTAL	
BHC, ALPHA	< 10.
BHC, BETA	< 10.
BHC, DELTA	< 10.
BHC, GAMMA	< 10.
HEXACHLOROBENZENE	< 2.0
PENTACHLOROANISOLE	< 10.
HEPTACHLOR	< 2.0
HEPTACHLOR EPOXIDE	< 10.
TRANS - NONACHLOR	< 2.0
CIS - NONACHLOR	< 10.
TRANS - CHLORDANE	< 10.
CIS - CHLORDANE	< 10.
OXYCHLORDANE	< 10.
ALDRIN	< 2.0
DDE, P, P' -	< 2.0
DDE, O, P' -	< 20.
DDD, P, P' -	< 20.
DDD, O, P' -	< 20.
DDT, P, P' -	< 30.
DDT O, P' -	< 2.0
METHOXYCHLOR, P, P' -	< 50.
METHOXYCHLOR O, P' -	< 50.
DIELDRIN	< 70.
ENDRIN	< 30.
MERCURY	< 30.
CHROMIUM	1,200,000
CADMIUM	< 1800.
COPPER	53,000.
LEAD	20,000.
ARSENIC	3700.
TOTAL SOLIDS	87.17.

Please analyze these on a wet weight basis

	mg/l
di-N-butyl phthalate	< 3.0
aliphatic hydrocarbons	**
toluene	< 0.0
methylene chloride	(0.0)
chloroform	< 0.0
carbon tetrachloride	< 0.0
1-1-1 trichloroethane	< 0.01
trichloroethylene	< 0.0
tetrachloroethylene	< 0.01
fluorotrichloromethane	< 0.0

LAB INFORMATION
Lab No. D1794 Date JUN 29 1982 10:00
Mo. Day Yr. AM/PM
Rec'd by GB
Temp of samples when received ______

*Comments: Analyses were made on dried sample after water was poured off. Before metal analyses were made 40% rocks were discarded from dried sample.

** Not detected by GC/MS

398

SB-105-030
State Form 1390

WATER SAMPLE IDENTIFICATION SHEET

Sample Site WOLF LAKE

SEDIMENT

Station Number WOLF LAKE #1

Sample Date 6 16 82 ____ (Mo. 11-12, Day 13-14, Yr. 15-16, AM/PM)

Supervisor C. L. BRIDGES

Collector(s) G. BRIGHT - J. RAY

Delivered to lab 6 29 82 ____ (Mo., Day, Yr., AM/PM)

By J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles (PINT)	1	1
Total	1	1

Standard Procedure Followed (All) Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

4 (17): 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

7 (18): 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

1 (19) Sample Type: 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

____ (20) Sample Interval

____ (21): 0 - at outfall 1 - above outfall 2 - below outfall

____ (22-26) Stream miles from outfall

LAB INFORMATION

Lab No. D1786 Date JUN 29 1982 10:00 AM/PM

Rec'd by JB

Temp of samples when received ____

Comments:

SUBSTANCE (µg/Kg)	
PCB, TOTAL	
BHC, ALPHA	≤10.
BHC, BETA	≤10.
BHC, DELTA	<10.
BHC, GAMMA	≤10.
HEXACHLOROBENZENE	<10.
PENTACHLOROANISOLE	<20.
HEPTACHLOR	≤10.
HEPTACHLOR EPOXIDE	18.
TRANS - NONACHLOR	<10.
CIS - NONACHLOR	<10.
TRANS - CHLORDANE	38.
CIS - CHLORDANE	34.
OXYCHLORDANE	<10.
ALDRIN	<10.
DDE, P, P' -	<10.
DDE, O, P' -	43.
DDD, P, P' -	87.
DDD, O, P' -	43.
DDT, P, P' -	<30.
DDT O, P' -	<10.
METHOXYCHLOR, P, P' -	<50.
METHOXYCHLOR O, P' -	<50.
DIELDRIN	<350.
ENDRIN	<150.
MERCURY	730.
CHROMIUM	160,000.
CADMIUM	7,200.
COPPER	330,000
LEAD	870,000.
ARSENIC	17,000.
TOTAL SOLIDS	19.17

Analyses made on dried sample after water was poured off.

Toluene <0.01 µg/g

REPORTED ... WATER LABORATORY IND. STATE BD. OF HEALTH

SBH 65.030 State Form 1590

WATER SAMPLE IDENTIFICATION SHEET

Sample Site WOLF LAKE SEDIMENT

Station Number WOLF LAKE #12 (DUPLICATE)

Sample Date 6 16 82 ___
Mo. 11-12 Day 13-14 Yr. 15-16 AM/PM

Supervisor C.L. BRIDGES

Collector(s) G. BRIGHT - J. RAY

Delivered to lab 6 29 82 ___
Mo. Day Yr. AM/PM

By J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ___ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of PINT Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed All Some None

NPDES Number ___ (1-7) Outfall ___ (8-10)

4 (17)
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7 (18)
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1 (19) Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

___ (20) Sample Interval

___ (21)
0 - at outfall
1 - above outfall
2 - below outfall

___ (22-26) Stream miles from outfall

SUBSTANCE µg/Kg	
PCB, TOTAL	
BHC, ALPHA	< 10.
BHC, BETA	< 10.
BHC, DELTA	< 10.
BHC, GAMMA	< 10
HEXACHLOROBENZENE	< 10.
PENTACHLOROANISOLE	< 20.
HEPTACHLOR	< 10.
HEPTACHLOR EPOXIDE	19.
TRANS - NONACHLOR	< 10.
CIS - NONACHLOR	< 10.
TRANS - CHLORDANE	39.
CIS - CHLORDANE	42.
OXYCHLORDANE	< 10.
ALDRIN	< 10.
DDE, P, P' -	< 10.
DDE, O, P' -	44.
DDD, P, P' -	110.
DDD, O, P' -	44.
DDT, P, P' -	< 30.
DDT O, P' -	< 10.
METHOXYCHLOR, P, P' -	< 50
METHOXYCHLOR O, P' -	< 50.
DIELDRIN	< 350.
ENDRIN	< 150.
MERCURY	1,300.
CHROMIUM	150,000.
CADMIUM	6,200.
COPPER	320,000.
LEAD	840,000.
ARSENIC	17,000.
TOTAL SOLIDS	17.7%

Analyses made on dried sample after water was poured off.

Toluene - 0.03 µg/g

LAB INFORMATION

Lab No. D1787 Date JUN 29 1982 10:00 AM
Mo. Day Yr. AM/PM

Rec'd by JB

Temp of samples when received ___

Comments:

REPORTED

JB

WATER LABORATORY
IND. STATE BD. OF HEALTH

SB1165-030
State Form 1190

WATER SAMPLE IDENTIFICATION SHEET

Sample Site WOLF LAKE
SEDIMENT

Station Number WOLF LAKE #3

Sample Date 6 16 82 AM/PM
Mo. 11-12 Day 13-14 Yr. 15-16

Supervisor C.L. BRIDGES

Collector(s) G.BRIGHT-J.RAY

Delivered to lab 6 29 82 AM/PM
Mo. Day Yr.

By J.RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of PINT Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed All Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

4
17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7
18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1
19
Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ 20 Sample Interval

21
0 - at outfall
1 - above outfall
2 - below outfall

____ 22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1788 Date JUN 29 1982 10:00
Mo. Day Yr. AM/PM

Rec'd by JB

Temp of samples when received ____

Comments:

SUBSTANCE ~~(mg/kg)~~ µg/kg	
PCB, TOTAL	
BHC, ALPHA	<10.
BHC, BETA	<10.
BHC, DELTA	<10.
BHC, GAMMA	<10.
HEXACHLOROBENZENE	<2.0
PENTACHLOROANISOLE	<10.
HEPTACHLOR	<2.0
HEPTACHLOR EPOXIDE	<10.
TRANS - NONACHLOR	<2.0
CIS - NONACHLOR	<10.
TRANS - CHLORDANE	<10.
CIS - CHLORDANE	<10.
OXYCHLORDANE	<10.
ALDRIN	<2.0
DDE, P, P' -	3.4
DDE, O, P' -	<20.
DDD, P, P' -	<20.
DDD, O, P' -	<20.
DDT, P, P' -	<30.
DDT O, P' -	<2.0
METHOXYCHLOR, P, P' -	<50.
METHOXYCHLOR O, P' -	<50.
DIELDRIN	<70.
ENDRIN	<30.
MERCURY	23.
CHROMIUM	6,500.
CADMIUM	<500.
COPPER	6,400.
LEAD	18,000.
ARSENIC	2,700.
Total Solids	70.67

Analyses made on dried sample after water was poured off.

Toluene – <0.01 µg/g

JB

SB165-030

.ATER SAMPLE IDENTIFICATION SHEET (-2)

Sample Site WOLF LAKE
SEDIMENT

Station Number WOLF LAKE #4

Sample Date 6 16 82 ____ (Mo. 11-12, Day 13-14, Yr. 15-16, AM/PM)

Supervisor C.L. BRIDGES

Collector(s) G. BRIGHT - J. RAY

Delivered to lab 6 29 82 ____ (Mo., Day, Yr., AM/PM)

By J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed All Some None

NPDES Number ____ (1-7) Outfall ____ (8-10)

4 (17): 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

7 (18): 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

1 (19): Sample Type 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

____ (20) Sample Interval

____ (21): 0 - at outfall 1 - above outfall 2 - below outfall

____ (22-26) Stream miles from outfall

LAB INFORMATION

Lab No. D1789 Date JUN 29 1982 10:00 (Mo., Day, Yr., AM/PM)

Rec'd by JB

Temp of samples when received ____

Comments:

SUBSTANCE ~~mg/kg~~ ug/kg	
PCB, TOTAL	
BHC, ALPHA	≤ 10.
BHC, BETA	≤ 10.
BHC, DELTA	≤ 10.
BHC, GAMMA	≤ 10.
HEXACHLOROBENZENE	≤ 2.0
PENTACHLOROANISOLE	≤ 10.
HEPTACHLOR	≤ 2.0
HEPTACHLOR EPOXIDE	≤ 10.
TRANS - NONACHLOR	≤ 2.0
CIS - NONACHLOR	≤ 10.
TRANS - CHLORDANE	≤ 10.
CIS - CHLORDANE	≤ 10.
OXYCHLORDANE	≤ 10.
ALDRIN	≤ 2.0
DDE, P, P' -	8.8
DDE, O, P' -	≤ 20.
DDD, P, P' -	≤ 20.
DDD, O, P' -	≤ 20.
DDT, P, P' -	≤ 30.
DDT O, P' -	≤ 2.0
METHOXYCHLOR, P, P' -	≤ 50.
METHOXYCHLOR O, P' -	≤ 50.
DIELDRIN	≤ 70.
ENDRIN	≤ 30.
MERCURY	100.
CHROMIUM	17,000.
CADMIUM	780.
COPPER	48,000
LEAD	66,000
ARSENIC	11,000.
TOTAL SOLIDS	49.8%

Analyses made on dried sample after water was poured off.

Toluene — < 0.01 μg/g

REPORTED

JB

WATER LABORATORY
ILLINOIS DEPT. OF HEALTH

SHH65.030
State Form 1190

WATER SAMPLE IDENTIFICATION SHEET

Sample Site: WOLF LAKE SEDIMENT

Station Number: WOLF LAKE #5

Sample Date: 6 (Mo. 11-12) 16 (Day 13-14) 82 (Yr. 15-16) ____ AM/PM

Supervisor: C.L. BRIDGES

Collector(s): G. BRIGHT - J. RAY

Delivered to lab: 6 (Mo.) 29 (Day) 82 (Yr.) ____ AM/PM

By: J. RAY

	Kind	Lot No.	Amount
Preservatives Added:	NONE		

Sample Chlorinated ____ Not Chlorinated ✓

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
Glass Jars or Bottles	1	1
Total	1	1

Standard Procedure Followed: All Some None

NPDES Number ____ (1-7) Outfall ____ (8-10)

4 (17)
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

7 (18)
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

1 (19) Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ (20) Sample Interval

____ (21)
0 - at outfall
1 - above outfall
2 - below outfall

____ (22-26) Stream miles from outfall

LAB INFORMATION

Lab No. D1790 Date JUN 29 1982 (Mo. Day Yr.) 10:00 AM/PM

Rec'd by JB

Temp of samples when received ____

Comments:

SUBSTANCE ng/kg	
PCB, TOTAL	
BHC, ALPHA	<10.
BHC, BETA	<10.
BHC, DELTA	<10.
BHC, GAMMA	<10.
HEXACHLOROBENZENE	<2.0
PENTACHLOROANISOLE	<10.
HEPTACHLOR	<2.0
HEPTACHLOR EPOXIDE	<10.
TRANS - NONACHLOR	<2.0
CIS - NONACHLOR	<10.
TRANS - CHLORDANE	<10.
CIS - CHLORDANE	<10.
OXYCHLORDANE	<10.
ALDRIN	<2.0
DDE, P, P' -	<2.0
DDE, O, P' -	<20.
DDD, P, P' -	<20.
DDD, O, P' -	<20.
DDT, P, P' -	<30.
DDT O, P' -	<2.0
METHOXYCHLOR, P, P' -	<50.
METHOXYCHLOR O, P' -	<50.
DIELDRIN	<70.
ENDRIN	<30.
MERCURY	13.
CHROMIUM	5000.
CADMIUM	<400.
COPPER	3500.
LEAD	8,800.
ARSENIC	1400.
TOTAL SOLIDS	76.4%

Analyses were made on dried sample after water was poured off.

Toluene — <0.01 µg/g

JB

SH165.030
File Form 1190

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake
SEDIMENT #1

Station Number

Sample Date ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor

Collector(s)

Delivered to lab ____ Mo. ____ Day ____ Yr. ____ AM/PM

By

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ________ Not Chlorinated ________

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number ________ 1-7 Outfall ________ 8-10

____ 17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

____ 18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

____ 19
Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ 20 Sample Interval

____ 21
0 - at outfall
1 - above outfall
2 - below outfall

____ 22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1786 Date 6-29-82 10:00 (Mo. Day Yr. AM/PM)

Rec'd by QB

Temp of samples when received

Comments:

* Lab does not analyze for this compound.

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	µg/kg		<30.
	bis(2-Ethylhexyl)phthalate			<100.
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	µg/kg		<10.
	Aldrin			<10.
	Dieldrin			<350
	Endrin aldehyde			*
	Endrin			<150.
	Heptachlor			<10.
	Heptachlor-epoxide			13.
	p,p-DDT			<30.
	p,p-DDE			<10.
	p,p-DDD			77.
	~~a~~-Endosulfan I			<100.
	~~b~~-Endosulfan II			<500.
	a-BHC			<10.
	b-BHC			<10.
	g-BHC			<10.
	δ-BHC			<10
	Endosulfan sulfate			<500.
	Arochlor 1016	µg/kg		<0.5
	Arochlor 1232			<0.5
	Arochlor 1248			<0.5
	Arochlor 1260			1.3
	Arochlor 1221			<0.5
	Arochlor 1242			2.3
	Arochlor 1254			<0.5
	Chlordane & Toxaphene			
	TRANS-NONACLOR	µg/kg		<10.
	op" DDT	µg/kg		<10.
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			
	4-Nitrophenol			QB
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

WATER SAMPLE IDENTIFICATION SHEET

Sample Site *Wolf Lake*

SEDIMENT # 1a

Station Number

Sample Date ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor

Collector(s)

Delivered to lab ____ Mo. ____ Day ____ Yr. ____ AM/PM

By

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

17: 1. NPDES 2. SPC-15 3. WQ Study 4. Pollution complaint 5. Fish kill investigation

18: 1. Industry 2. Semi-Public 3. Municipal 4. Federal 5. Public Water Supply 6. State operation 7. Other

19: Sample Type 1. Grab 2. 24-hour comp. 3. 8-hour comp. 4. 24-hour flow comp. 5. 8-hour flow comp.

20: Sample Interval

21: 0 - at outfall 1 - above outfall 2 - below outfall

22-26: Stream miles from outfall

LAB INFORMATION

Lab No. *D1787* Date *6-29-82* *10:00* Mo. Day Yr. AM/PM

Rec'd by *QB*

Temp of samples when received

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	*μg/g*		*< 30.*
	bis(2-Ethylhexyl)phthalate	*μg/g*		*<100.*
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	*μg/g*		*<10.*
	Aldrin			*<10.*
	Dieldrin			*<350.*
	Endrin aldehyde			*
	Endrin			*<150.*
	Heptachlor			*<10.*
	Heptachlor-epoxide			*17.*
	p,p-DDT			*<30.*
	p,p-DDE			*<10.*
	p,p-DDD			*110.*
	~~a-~~Endosulfan *I*			*<100.*
	~~b-~~Endosulfan *II*			*<500.*
	a-BHC			*<10.*
	b-BHC			*<10.*
	γ-BHC			*<10.*
	δ-BHC			*<10.*
	Endosulfan sulfate			*<500.*
	Arochlor 1016	*μg/g*		*<0.5*
	Arochlor 1232			*<0.5*
	Arochlor 1248			*<0.5*
	Arochlor 1260			*0.8*
	Arochlor 1221			*<0.5*
	Arochlor 1242			*1.1*
	Arochlor 1254			*<0.5*
	Chlordane & Toxaphene			
	TRANS-NONACHLOR	*μg/g*		*<10.*
	OP' DDT			*<10.*
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			*QB*
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

Comments:

** lab does not analyze for this compound*

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake
SEDIMENT #2

Station Number

Sample Date: Mo. 11-12 | Day 13-14 | Yr. 15-16 | AM/PM

Supervisor

Collector(s)

Delivered to lab: Mo. | Day | Yr. | AM/PM

By

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed: All Some None

NPDES Number ______ 1-7 Outfall ______ 8-10

17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 Sample Interval

21
0 - at outfall
1 - above outfall
2 - below outfall

22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1788 Date 6-29-82 10:00 AM (Mo. Day Yr. AM/PM)

Rec'd by OB

Temp of samples when received

Comments:

* Lab does not analyze for this compound.

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	µg/g		≤ 30.
	bis(2-Ethylhexyl)phthalate	µg/g		≤ 100.
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	µg/kg		< 2.0
	Aldrin			< 2.0
	Dieldrin			< 70.
	Endrin aldehyde			*
	Endrin			< 30.
	Heptachlor			< 2.0
	Heptachlor-epoxide			< 10.
	p,p-DDT			< 30.
	p,p-DDE			3.4
	p,p-DDD			< 20.
	Endosulfan I			< 20.
	Endosulfan II			< 100.
	a-BHC			< 10
	b-BHC			< 10.
	g-BHC			< 10.
	d-BHC			< 10.
	Endosulfan sulfate			< 100.
	Arochlor 1016	µg/g		< 0.5
	Arochlor 1232			< 0.5
	Arochlor 1248			< 0.5
	Arochlor 1260			< 0.5
	Arochlor 1221			< 0.5
	Arochlor 1242			< 0.5
	Arochlor 1254			< 0.5
	Chlordane & Toxaphene			
	TRANS-NONACLOR	µg/kg		< 2.0
	OP'DDT			< 2.0
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			OB
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake
SEDIMENT #4

Station Number

Sample Date (Mo. 11-12) (Day 13-14) (Yr. 15-16) AM/PM

Supervisor

Collector(s)

Delivered to lab Mo. Day Yr. AM/PM

By

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number (1-7) Outfall (8-10)

17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 Sample Interval

21
0 - at outfall
1 - above outfall
2 - below outfall

22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1789 Date 6-29-82 10:00 (Mo. Day Yr. AM/PM)

Rec'd by DB

Temp of samples when received

Comments:

* Lab does not analyze for this ...

CODE	PARAMETERS	UNIT	LAB DATA
	2,6-Dinitrotoluene		
	4-Bromophenyl-phenyl ether		
	Dimethylphthalate		
	Di-N-Butylphthalate	µg/g	<3.0
	bis(2-Ethylhexyl)phthalate		<10.0
	3,3-Dichlorobenzidene		
	Benzo(b)fluoranthene		
	Benzidene		
	Benzo(a)pyrene		
	4-Chlorophenylphenyl ether		
	bis(Chloromethyl)ether		
	Benzo(ghi)perylene		
	Benzo(k)fluoranthene		
	Indeno(1,2,3-cd)pyrene		
	n-Nitrosodimethylamine		
	Di-n-octylphthalate		
	2-Chloroethyl Vinyl ether		
	Acrolein-Acrylonitrile		
	HEXACHLOROBENZENE	µg/kg	<2.0
	Aldrin		<2.0
	Dieldrin		<70.
	Endrin aldehyde		*
	Endrin		<30.
	Heptachlor		<2.0
	Heptachlor-epoxide		<10.
	p,p-DDT		<30.
	p,p-DDE		5.8
	p,p-DDD		<20.
	~~a~~-Endosulfan I		<20.
	~~b~~-Endosulfan II		<100.
	a-BHC		<10
	b-BHC		<10.
	g-BHC		<10.
	δ-BHC		<10.
	Endosulfan sulfate		<100.
	Arochlor 1016	µg/g	<0.5
	Arochlor 1232		<0.5
	Arochlor 1248		<0.5
	Arochlor 1260		<0.5
	Arochlor 1221		<0.5
	Arochlor 1242		<0.5
	Arochlor 1254		<0.5
	Chlordane & Toxaphene		
	TRANS-NONACLOR	µg/kg	<2.0
	OP' DDT		<3.0
	Phenol		
	2-Chlorophenol		
	2,4-Dichlorophenol		
	2,4,6-Trichlorophenol		
	Pentachlorophenol		
	p-Chloro-m-cresol		
	2-Nitrophenol		
	4-Nitrophenol		
	2,4-Dinitrophenol		
	4,6-Dinitro-o-cresol		
	2,4-Dimethylphenol		
407			

DB

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake
SEDIMENT #5

Station Number

Sample Date Mo. 11-12 Day 13-14 Yr. 15-16 AM/PM

Supervisor

Collector(s)

Delivered to lab Mo. Day Yr. AM/PM

By

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number 1-7 Outfall 8-10

17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 Sample Interval

21
0 - at outfall
1 - above outfall
2 - below outfall

22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1790 Date 6-29-82 10:00 (Mo. Day Yr. AM/PM)

Rec'd by [initials]

Temp of samples when received

Comments:
* Lab does not analyze

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	mg/kg		<3.0
	bis(2-Ethylhexyl)phthalate	mg/kg		<10.0
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	mg/kg		<2.0
	Aldrin			<2.0
	Dieldrin			<70.
	Endrin aldehyde			*
	Endrin			<30.
	Heptachlor			<2.0
	Heptachlor-epoxide			<10.
	p,p-DDT			<30.
	p,p-DDE			<2.0
	p,p-DDD			<20.
	~~a~~-Endosulfan I			<20.
	~~b~~-Endosulfan II			<100.
	a-BHC			<10.
	b-BHC			<10.
	g-BHC			<10.
	d-BHC			<10.
	Endosulfan sulfate			<100.
	Arochlor 1016	mg/kg		<0.5
	Arochlor 1232			<0.5
	Arochlor 1248			<0.5
	Arochlor 1260			<0.5
	Arochlor 1221			<0.5
	Arochlor 1242			<0.5
	Arochlor 1254			<0.5
	Chlordane & Toxaphene			
	TRANSNONACLOR	mg/kg		<2.0
	OP' DDT			<2.0
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

WATER SAMPLE IDENTIFICATION SHEET

Sample Site Wolf Lake
SEDIMENT #1-DISCHARGE

Station Number ____________

Sample Date ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor ____________

Collector(s) ____________

Delivered to lab ____ Mo. ____ Day ____ Yr. ____ AM/PM

By ____________

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number ______ 1-7 Outfall ______ 8-10

______ 17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

______ 18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

______ 19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

______ 20 Sample Interval

______ 21
0 - at outfall
1 - above outfall
2 - below outfall

______ 22-25 Stream miles from outfall

LAB INFORMATION

Lab No. D1791 Date 6-29-82 10:00 Mo. Day Yr. AM/PM

Rec'd by JB

Temp of samples when received ____________

Comments:

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	ug/g		≤30.
	bis(2-Ethylhexyl)phthalate			560. ✓
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	ug/kg		≤2.0
	Aldrin			<2.0
	Dieldrin			<70.
	Endrin aldehyde			*
	Endrin			<30.
	Heptachlor			<2.0
	Heptachlor-epoxide			<10.
	p,p-DDT			<30.
	p,p-DDE			2.0
	p,p-DDD			<20.
	-Endosulfan I			<20.
	-Endosulfan II			<100.
	a-BHC			<10
	b-BHC			<10.
	g-BHC			<10.
	S-BHC			<10.
	Endosulfan sulfate	✓		<100.
	Arochlor 1016	Mg/kg		<0.5
	Arochlor 1232			<0.5
	Arochlor 1248			<0.5
	Arochlor 1260			<0.5
	Arochlor 1221			<0.5
	Arochlor 1242			<0.5
	Arochlor 1254			<0.5
	Chlordane & Toxaphene			
	TRANSNONACHLOR	Mg/kg		<2.0
	OP' DDT			<2.0
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			JB
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

* Lab does not analyze for this compound.

WATER SAMPLE IDENTIFICATION SHEET

Sample Site: Wolf Lake
SEDIMENT #2 - INDIANA POND

Station Number: ____

Sample Date: ____ Mo. 11-12 ____ Day 13-14 ____ Yr. 15-16 ____ AM/PM

Supervisor: ____

Collector(s): ____

Delivered to lab: ____ Mo. ____ Day ____ Yr. ____ AM/PM

By: ____

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ____ Not Chlorinated ____

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed: All Some None

NPDES Number ____ 1-7 Outfall ____ 8-10

____ 17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

____ 18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

____ 19 Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

____ 20 Sample Interval

____ 21
0 - at outfall
1 - above outfall
2 - below outfall

____ 22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1792 Date 6-29-82 10:00 (Mo. Day Yr. AM/PM)

Rec'd by JB

Temp of samples when received ____

Comments:

* Lab does not analyze for this compound

CODE	PARAMETERS	UNIT	LAB DATA
	2,6-Dinitrotoluene		
	4-Bromophenyl-phenyl ether		
	Dimethylphthalate		
	Di-N-Butylphthalate	µg/kg	<30.
	bis(2-Ethylhexyl)phthalate		120.
	3,3-Dichlorobenzidene		
	Benzo(b)fluoranthene		
	Benzidene		
	Benzo(a)pyrene		
	4-Chlorophenylphenyl ether		
	bis(Chloromethyl)ether		
	Benzo(ghi)perylene		
	Benzo(k)fluoranthene		
	Indeno(1,2,3-cd)pyrene		
	n-Nitrosodimethylamine		
	Di-n-octylphthalate		
	2-Chloroethyl Vinyl ether		
	Acrolein-Acrylonitrile		
	HEXACHLOROBENZENE	µg/kg	<2.0
	Aldrin		<2.0
	Dieldrin		<70.
	Endrin aldehyde		*
	Endrin		<30.
	Heptachlor		<2.0
	Heptachlor-epoxide		<10.
	p,p-DDT		<30.
	p,p-DDE		3.6
	p,p-DDD		<20.
	α-Endosulfan I		<20.
	β-Endosulfan II		<100.
	a-BHC		<10
	b-BHC		<10.
	g-BHC		<10.
	δ-BHC		<10.
	Endosulfan sulfate		<100.
	Arochlor 1016	µg/g	<0.5
	Arochlor 1232		<0.5
	Arochlor 1248		<0.5
	Arochlor 1260		<0.5
	Arochlor 1221		<0.5
	Arochlor 1242		<0.5
	Arochlor 1254		<0.5
	Chlordane & Toxaphene		
	TRANS-NONACHLOR	µg/kg	<2.0
	OP' DDT		<2.0
	Phenol		
	2-Chlorophenol		
	2,4-Dichlorophenol		
	2,4,6-Trichlorophenol		
	Pentachlorophenol		
	p-Chloro-m-cresol		
	2-Nitrophenol		
	4-Nitrophenol		JB
	2,4-Dinitrophenol		
	4,6-Dinitro-o-cresol		
	2,4-Dimethylphenol		

410

WATER SAMPLE IDENTIFICATION SHEET

Sample Site *Wolf Lake*
SEDIMENT #3 - ILLINOIS POND

Station Number ______

Sample Date ______ Mo. 11-12 ______ Day 13-14 ______ Yr. 15-16 ______ AM/PM

Supervisor ______

Collector(s) ______

Delivered to lab ______ Mo. ______ Day ______ Yr. ______ AM/PM

By ______

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed All Some None

NPDES Number ______ 1-7 Outfall ______ 8-10

17 ______
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

18 ______
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

19 ______ Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

20 ______ Sample Interval

21 ______
0 - at outfall
1 - above outfall
2 - below outfall

22-26 ______ Stream miles from outfall

LAB INFORMATION

Lab No. *D1793* Date *6-29-82* *10:00* Mo. Day Yr. AM/PM

Rec'd by *[signature]*

Temp of samples when received ______

Comments:
** Lab does not analyze for it.*

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	*Mg/Kg*		*< 3.0*
	bis(2-Ethylhexyl)phthalate	*↓*		*< 10.*
	3,3-Dichlorobenzidene			
	Benzo(b)fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLORO BENZENE	*Mg/Kg*		*< 2.0*
	Aldrin			*< 2.0*
	Dieldrin			*< 20.*
	Endrin aldehyde			***
	Endrin			*< 30.*
	Heptachlor			*< 2.0*
	Heptachlor-epoxide			*< 10.*
	p,p-DDT			*< 30.*
	p,p-DDE			*2.2*
	p,p-DDD			*< 20.*
	a-Endosulfan			*< 20.*
	b-Endosulfan			*< 100.*
	a-BHC			*< 10.*
	b-BHC			*< 10.*
	g-BHC			*< 10*
	d-BHC			*< 10*
	Endosulfan sulfate	*✓*		*< 100*
	Arochlor 1016	*Mg/g*		*< 0.5*
	Arochlor 1232			*< 0.5*
	Arochlor 1248			*< 0.5*
	Arochlor 1260			*< 0.5*
	Arochlor 1221			*< 0.5*
	Arochlor 1242			*< 0.5*
	Arochlor 1254	*✓*		*< 0.5*
	Chlordane & Toxaphene			
	TRANS-NONACLOR	*Mg/Kg*		*< 2.0*
	OP' DDT	*✓*		*< 2.0*
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

WATER SAMPLE IDENTIFICATION SHEET

Sample Site: Wolf Lake
SEDIMENT # 3A - ILLINOIS POND (DUP)

Station Number: ______

Sample Date: ______ Mo. 11-12 ______ Day 13-14 ______ Yr. 15-16 ______ AM/PM

Supervisor: ______

Collector(s): ______

Delivered to lab: ______ Mo. ______ Day ______ Yr. ______ AM/PM

By: ______

	Kind	Lot No.	Amount
Preservatives Added:			

Sample Chlorinated ______ Not Chlorinated ______

	Field	Lab
No. of 1 Liter Plastic Bottles		
No. of 2 Liter Plastic Bottles		
No. of Bacteriological Bottles		
No. of Glass Jars or Bottles		
Total		

Standard Procedure Followed: All Some None

NPDES Number ______ 1-7 Outfall ______ 8-10

______ 17
1. NPDES
2. SPC-15
3. WQ Study
4. Pollution complaint
5. Fish kill investigation

______ 18
1. Industry
2. Semi-Public
3. Municipal
4. Federal
5. Public Water Supply
6. State operation
7. Other

______ 19
Sample Type
1. Grab
2. 24-hour comp.
3. 8-hour comp.
4. 24-hour flow comp.
5. 8-hour flow comp.

______ 20 Sample Interval

______ 21
0 - at outfall
1 - above outfall
2 - below outfall

______ 22-26 Stream miles from outfall

LAB INFORMATION

Lab No. D1794 Date 6-29-82 (Mo. Day Yr.) 10:00 AM/PM

Rec'd by JB

Temp of samples when received ______

Comments:
* Lab does not analyze for this compound.

CODE	PARAMETERS	UNIT		LAB DATA
	2,6-Dinitrotoluene			
	4-Bromophenyl-phenyl ether			
	Dimethylphthalate			
	Di-N-Butylphthalate	µg/kg		<3.0
	bis(2-Ethylhexyl)phthalate	µg/kg		<10.
	3,3-Dichlorobenzidene			
	Benzo(b)Fluoranthene			
	Benzidene			
	Benzo(a)pyrene			
	4-Chlorophenylphenyl ether			
	bis(Chloromethyl)ether			
	Benzo(ghi)perylene			
	Benzo(k)fluoranthene			
	Indeno(1,2,3-cd)pyrene			
	n-Nitrosodimethylamine			
	Di-n-octylphthalate			
	2-Chloroethyl Vinyl ether			
	Acrolein-Acrylonitrile			
	HEXACHLOROBENZENE	µg/kg		3.4
	Aldrin			<2.0
	Dieldrin			<70.
	Endrin aldehyde			—*
	Endrin			<30.
	Heptachlor			<2.0
	Heptachlor-epoxide			<10.
	p,p-DDT			<30.
	p,p-DDE			<2.0
	p,p-DDD			<20.
	Endosulfan I			<20.
	Endosulfan II			<100.
	a-BHC			<10.
	b-BHC			<10.
	g-BHC			<10.
	d-BHC			<10.
	Endosulfan sulfate			[illegible]
	Arochlor 1016	µg/kg		<0.5
	Arochlor 1232			<0.5
	Arochlor 1248			<0.5
	Arochlor 1260			<0.5
	Arochlor 1221			<0.5
	Arochlor 1242			<0.5
	Arochlor 1254			<0.5
	Chlordane & Toxaphene			
	TRANSNONACLOR	µg/kg		<2.0
	op' DDT			<2.0
	Phenol			
	2-Chlorophenol			
	2,4-Dichlorophenol			
	2,4,6-Trichlorophenol			
	Pentachlorophenol			
	p-Chloro-m-cresol			
	2-Nitrophenol			
	4-Nitrophenol			
	2,4-Dinitrophenol			
	4,6-Dinitro-o-cresol			
	2,4-Dimethylphenol			

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
NANCY A. MALOLEY. Commissioner

105 South Meridian Street
P.O. Box 6015
Indianapolis 46206-6015
Telephone 317-232-8603

August 5, 1987

Marvin W. Acklin, Ph.D.
Assistant Professor of Psychology
Department of Psychology
Loyola University of Chicago
6525 North Sheridan Road
Chicago, Illinois 60626

Dear Dr. Acklin:

This is in response to your letter of July 20, 1987, requesting information regarding Wolf Lake monitoring activities.

Since 1966, representatives of the Indiana water pollution control agency have monitored Wolf Lake at the state line culvert as part of the state's fixed station water quality monitoring program. For a time, samples were also collected from Wolf Lake channel and from the beach area on a regular basis.

Data from the fixed station water quality monitoring program are normally published each year. However, publication of the 1985 and 1986 data has been delayed. Copies of the 1983 and 1984 data are enclosed.

Lever Brothers and American Maize Products have discharges to Wolf Lake channel. Compliance sampling inspections of Lever Brothers conducted in 1982, 1985, and 1986 disclosed that the plant effluent was of good quality and met all NPDES permit limits and conditions. American Maize discharges only excess intake waters from Lake Michigan and/or noncontact cooling water. Wolf Lake Terminal has no valid NPDES permit to discharge to Wolf Lake.

We understand the lawsuit against Wolf "Lake Terminal was dismissed late last winter. We suggest that you contact Mr. Mathew Scherschel of the Indiana Attorney General's Office if you want specific information regarding this case.

In June of 1982, representatives of this office collected a carp fillet sample from the sound end of Wolf Lake. Analysis for PCBs, pesticides, and certain heavy metals disclosed that none of these materials was present in concentrations approaching FDA action levels.

Six additional fish samples were collected from the east and west basins and the channel in July of 1986. These are split evenly between whole fish and fillet samples. Results of priority pollutant analyses are expected by mid-winter.

LimnologjLcal surveys were conducted at Wolf Lake in July of 1981 and in July of 1986. To date, no formal reports have been prepared for distribution. Survey results are contained in our files in a form intended for administrative use only, but they may be reviewed at our office located at 5500 West Bradbury in Indianapolis during normal working hours.

Sincerely,

Jane Magee

Jane Magee
Assistant Commissioner
Office of Water Management

JLW/vs
Enclosure

DENDUM TO SAMPLE NO. 472 AUGUST 8, 1983

FAT = 5.206

SUBSTANCE	FAT BASIS	WHOLE SAMPLE BASIS
CB	33.687 PPM	1.754 PPM
IC,ALPHA	0.072 PPM	0.004 PPM
IC, BETA	0.091 PPM	0.005 PPM
IC, DELTA	NONE DETECTED	
IC, GAMMA	NONE DETECTED	
EXACHLOROBENZENE	0.040 PPM	0.002 PPM
ENTACHLOROANISOLE	0.024 PPM	0.001 PPM
EPTACHLOR	NONE DETECTED	
EPTACHLOR EPOXIDE	NONE DETECTED	
RANS-NONACHLOR	0.280 PPM	0.015 PPM
IS-NONACHLOR	NONE DETECTED	
RANS-CHLORDANE	1.059 PPM	0.055 PPM
IS-CHLORDANE	0.292 PPM	0.015 PPM
XYCHLORDANE	0.049 PPM	0.003 PPM
LDRIN	NONE DETECTED	
DE,P,P'-	21.564 PPM	1.123 PPM
DE,O,P'-	NONE DETECTED	
DD,P,P'-	3.829 PPM	0.199 PPM
DD,O,P'-	NONE DETECTED	
DT,P,P'-	NONE DETECTED	
DT,O,P'-	NONE DETECTED	
ETHOXYCHLOR,P,P'-	NONE DETECTED	
ETHOXYCHLOR,O,P'-	NONE DETECTED	
IELDRIN	NOT DETERMINED	
NDRIN	NONE DETECTED	

INDIANA STATE BOARD OF HEALTH

NOTE: PLEASE USE BLACK INK, No. 2 PENCIL OR TYPEWRITER.

Division of Food and Drugs
COLLECTION REPORT

BUREAU OF LABORATORIES
Sample Record

Date Collected JUNE 16, 1982 Station No. —
Identification 1 WHOLE CARP COLLECTED FROM WOLF LAKE - WRAPPED IN SOLVENT-RINSED ALUMINUM FOIL

Embargo: Yes ___ No ___

Type of Sample: 1. Obj. ✓ 2. Inves. ___ 3. Offic. ___

Lab. No. 472
Date Rec'd 10/19/82
Cond. of Cont. Intact
State Seal None Present
Identification As Noted

Sign. of Lab. Identifier TCC
Date Seal Broken ___
Sign. of Seal Breaker ___
Ana. Started ___
Ana. Finished ___
Samp. Resealed ___
Sign. of Resealer ___

Sample Storage
1—Pre-Analysis ___
2—Post Analysis ___
3—Date Discarded ___

Analysis Requested Pesticides, PCBs, Acid Extractable Organic Compounds, Mercury, Chromium, Cadmium, Copper, Lead, and Arsenic

Collected by BRIGHT & RAY

Sample No. ___
Lab. No. ___
Product ___

Report of Laboratory Analysis

Date Reported ___

SEE ADDENDUM REPORT FOR PCB, PESTICIDE, %FAT ANALYSIS:

	DETECTED		DETECTION LIMIT
LEAD	0.63	PPM	.11 PPM
CADMIUM	<0.03	PPM	0.03 PPM
COPPER	1.35	PPM	0.14 ug/gm (sample)
CHROMIUM	0.37	PPM	0.1 ug/gm
ARSENIC	.090	Ng/gm	.004 Ng/gm
ZINC	75	PPM	0.05 PPM

Analyst KEN HILL Date 7-28-83 ~~8-06-83~~

LABORATORY CONCLUSION

Sign. L. E. Sullivan Date 8/5/83

FOOD AND DRUG DIVISION CONCLUSION

417

Sign. ___ Date ___

ODENDUM TO SAMPLE NO. 471 AUGUST 8, 1983

FAT = .733

SUBSTANCE	FAT BASIS	WHOLE SAMPLE BASIS
CB	13.378 PPM	0.100 PPM
HC,ALPHA	0.077 PPM	0.001 PPM
HC, BETA	0.052 PPM	LESS THAN .001 PPM
HC, DELTA	NONE DETECTED	
HC, GAMMA	NONE DETECTED	
EXACHLOROBENZENE	0.026 PPM	LESS THAN .001 PPM
ENTACHLOROANISOLE	0.031 PPM	LESS THAN .001 PPM
EPTACHLOR	NONE DETECTED	
EPTACHLOR EPOXIDE	NONE DETECTED	
RANS-NONACHLOR	0.075 PPM	0.001 PPM
IS-NONACHLOR	NONE DETECTED	
RANS-CHLORDANE	NONE DETECTED	
IS-CHLORDANE	0.112 PPM	0.001 PPM
XYCHLORDANE	0.031 PPM	LESS THAN .001 PPM
LDRIN	NONE DETECTED	
DE,P,P'-	3.544 PPM	0.026 PPM
DE,O,P'-	NONE DETECTED	
DD,P,P'-	1.189 PPM	0.009 PPM
DD,O,P'-	NONE DETECTED	
DT,P,P'-	NONE DETECTED	
DT,O,P'-	NONE DETECTED	
ETHOXYCHLOR,P,P'-	NONE DETECTED	
ETHOXYCHLOR,O,P'-	NONE DETECTED	
IELDRIN	NOT DETERMINED	
NDRIN	NONE DETECTED	

INDIANA STATE BOARD OF HEALTH

NOTE: PLEASE USE BLACK INK, No. 2 PENCIL, OR TYPEWRITER.

Division of Food and Drugs
COLLECTION REPORT

BUREAU OF LABORATORIES
Sample Record

Date Collected JUNE 16, 1982 Station No. —

Identification 2 CARP FILLETS - NO SKIN - COLLECTED FROM WOLF LAKE - WRAPPED IN SOLVENT-RINSED ALUMINUM FOIL

Embargo: Yes ___ No ___

Type of Sample: 1. Obj. ✓ 2. Inves. ___ 3. Offic. ___

Lab. No. 471
Date Rec'd. 10-14-82
Cond. of Cont. Intact
State Seal None present
Identification As noted

Sign. of Lab. Identifier Am
Date Seal Broken ___
Sign. of Seal Breaker ___
Ana. Started ___
Ana. Finished ___
Samp. Resealed ___
Sign. of Resealer ___

Sample Storage
1—Pre-Analysis ___
2—Post Analysis ___
3—Date Discarded ___

Analysis Requested Pesticides, PCBs, Acid Extractable Organic Compounds, Mercury, Chromium, Cadmium, Copper, Lead, and Arsenic

Collected by BRIGHT & RAY

Sample No. ___
Lab. No. ___
Product ___

Report of Laboratory Analysis

Date Reported ___

SEE ADDENDUM REPORT FOR PCB, PESTICIDE, %FAT ANALYSIS:

	DETECTED	DETECTION LIMIT
LEAD	<0.11 PPM	.11 PPM
CADMIUM	<0.03 PPM	0.03 PPM
COPPER	.36 PPM	0.14 ug/gm (sample)
CHROMIUM	0.32 PPM	0.1 ug/gm
ARSENIC	.030 Ng/gm	.004 Ng/gm
ZINC	11 PPM	0.05 PPM

Analyst KEN HILL [illegible] Date 7-28-83 8-08-83

LABORATORY CONCLUSION	FOOD AND DRUG DIVISION CONCLUSION
	419
Sign. L. E. Sullivan Date 8/9/83	Sign. ___ Date ___

p50 → I didn't copy the sediment results & they may contain better site descriptions?!

BIOLOGICAL STUDIES AND STANDARDS
Summary Of Fish Collection Data

Fish 1982

Stream: Wolf Lake   Location: Most Southern Ind. portion

Date: 6/16/82   Station Number: Sampling Time: 20 min

Method of Sampling: DC   Distance Sampled:

Purpose of Survey: Flesh analysis   Collectors: GB, JKR

Station Description:

Fish Collected	Number	Length	Weight	Scale
Sample No. 1				
Cyprinus carpio	1	55 cm	4 lb 12 oz	
" "	2	57 cm	5 lb 8 oz	
	3			
	4			
	5			
Sample No. 2				
	6			
	7			
	8			
	9			
	10			
Sample No. 3				
	11			
	12			
	13			
	14			
	15			

HLA
GCR
Metals
Sed. Traps + Grabs

Fish Observed:

Family and Species	Number
CATOSTOMIDAE	
Blue Sucker	
Northern Hog Sucker	
White Sucker	
Buffalo	
River Carpsucker	
Quillback Carpsucker	
Highfin Carpsucker	
Silver Redhorse	
Golden Redhorse	

Family and Species	Number
Black Redhorse	
Shorthead Redhorse	
River Redhorse	
Spotted Sucker	
Chubsuckers	
Other	
CLUPEIDAE	Alewife
Gizzard Shad	
Threadfin Shad	
Skipjack Herring	

State Form 40133

diana State Board of Health
Division of Water Pollution Control

INDIANA STATE BOARD OF HEALTH
DIVISION OF WATER POLLUTION CONTROL
1984 WATER QUALITY ANNUAL REPORT

STATION WL 31

WOLF LAKE AT HAMMOND
CULVERTS EDGE OF DIKE W OF CALUMET AV

SAMPLING DATE	ALKALINITY (MG/L)	AMMONIA (MG/L)	ARSENIC (UG/L)	BOD (MG/L)	COD (MG/L)	CADMIUM (UG/L)	CHLORIDES (MG/L)	CHROME HEX (UG/L)	CHROME TOTAL (UG/L)	COLIFORM FECAL (NUMBER/100ML)	COLIFORM TOTAL (NUMBER/100ML)	COPPER (UG/L)	CYANIDE (MG/L)	DO (MG/L)
01/17/84		.04		1.2	21		39			10	2100		.005-	10.1
02/22/84		1.00		4.2	18		32			20	390		.005-	9.1
03/27/84		.04		2.2	16		41			10-	45		.005-	13.8
04/24/84		.60		2.3	30		37			10	230		.005-	10.1
05/15/84	120	.20		3.3	28		44			10-	240		.005-	10.0
06/19/84		.10-		1.0-	30		43			10-	140		.005-	10.1
07/19/84		.10-		2.7	41		49			10-	100-		.005-	9.0
08/16/84		.10-		2.3	33		75			10-	700		.005-	9.9
09/27/84		.30		1.7	20		40			10	20		.005-	10.0
10/16/84		.40		1.3	21		32			10-	10-		.005-	9.0
11/19/84		.40		1.4	24		76			10-	90		.005-	12.0
12/20/84		.10		2.0	19		29			100-	15000		.005-	12.7
MINIMUM	120	.10		1.0	18		29			10	10		.005 -	9.0
MAXIMUM	120	1.00		3.3	41		76			100	15000		.005 -	13.8
AVERAGE	120	.33		2.0	26		45			18	1589		.005 -	10.6
GEO.MEAN	120	.24		1.9	25		43			13	205		.005 -	10.5
MEDIAN	120	.25		2.1	24		40			10	105		.005 -	10.1

SAMPLING DATE	FLUORIDE (MG/L)	HARDNESS (MG/L)	IRON (UG/L)	LEAD (UG/L)	MANGANESE (UG/L)	MERCURY (UG/L)	NICKEL (UG/L)	NITRATE (MG/L)	NITROGEN (MG/L)	OIL & GREASE (MG/L)	PCB AROCLOR1254 (UG/L)	PH FIELD	PH LAB	PHENOLS (UG/L)	PHOSPHORUS (MG/L)	POTASSIUM (MG/L)	SODIUM (MG/L)
01/17/84								.3	1.2	1.9		8.0	6.8		.04		
02/22/84								.3	1.6	3.3		7.8	7.1		.06		
03/27/84								.3	1.2	4.4		7.9	7.8		.03-		
04/24/84								.4	.9	3.6		8.0	7.5		.06		
05/15/84		180						.4	.8	4.3		8.0	7.6		.06		
06/19/84								.4	.8	3.1		8.9	7.9		.07		
07/19/84								.1-	1.1	4.0			7.9		.06		
08/16/84								.1-	1.3	6.6		8.8	7.8		.03		
09/27/84								.1-	.8	5.9		8.8	7.9		.03		
10/16/84								.1-	1.6	6.0		8.4	7.8		.04		
11/19/84								.2	1.3	6.6			7.3		.03-		
12/20/84								.4	.4	1.3		8.3	7.5		.06		
MINIMUM		180						.1 -	.4	1.3		7.8	6.8		.03		
MAXIMUM		180						.4	1.6	5.9		8.9	7.9		.07		
AVERAGE		180						.2 -	1.1	3.8		8.3	7.6		.04		
GEO.MEAN		180						.2 -	1.0	3.3		8.3	7.6		.04		
MEDIAN		180						.3	1.0	3.7		8.2	7.7		.04		

SAMPLING DATE	SOLIDS SUSP. (MG/L)	SOLIDS VOL. (MG/L)	SOLIDS TOTAL (MG/L)	SPEC. COND. (U MHOS/CM)	SULFATE (MG/L)	TEMP. DEG C	TOC	TURBIDITY AS NTU	ZINC (UG/L)	SILICA (MG/L)	FECAL STREP. /100ML	CA AS CACO3 (MG/L)	MG AS MGCO3 (MG/L)	DISS. SOLIDS (MG/L)	MILITARY TIME
01/17/84	4			416	39.0	3	6.8	10							800
02/22/84	8			396	49.0	8	5.8	46							1000
03/27/84	8			446	39.0	8	6.2	5							930
04/24/84	3			450	32.0	8	9.1	14							815
05/15/84	25			480	49.0	15	3.3	18							1050
06/19/84	17			440	42.0	20	6.8	15							1120
07/19/84	23			370	45.0	25	6.8	17							1120
08/16/84	18			310	66.0	31	6.6	14							1035
09/27/84	9			376	46.0	15	16.1	11							1230
10/11/84	13			370	38.0	10	7.3	9							1115
11/19/84	23			370	86.0	4	9.3	11							1145
12/20/84	10			376	34.0		8.6	8							1200
MINIMUM	4			370	29.6	4	4.4	5							800
MAXIMUM	25			510	66.0	31	16.1	46							1230
AVERAGE	13			428	40.3	14	6.9	14							1044
GEO.MEAN	11			424	43.3	11	6.4	14							1037
MEDIAN	12			416	46.3	13	6.7	13							1082

NOTE: PARAMETER VALUES WITH A (-) SIGN FOLLOWING THE NUMBER INDICATES THAT THE OBSERVED VALUE WAS LESS THAN THE NUMBER INDICATED
PARAMETER VALUES OF ALL NINES (9999.99) INDICATES THAT THE OBSERVED VALUE WAS MORE THAN THE NUMBER INDICATED

INDIANA STATE BOARD OF HEALTH
DIVISION OF WATER POLLUTION CONTROL
1983 WATER QUALITY ANNUAL REPORT

STATION WL 5L

WOLF LAKE AT HAMMOND
CULVERT AT EDGE OF DIKE W OF CALUMET AV

SAMPLING DATE	ALKALINITY (MG/L)	AMMONIA (MG/L)	ARSENIC (UG/L)	BOD (MG/L)	COD (MG/L)	CADMIUM (UG/L)	CHLORIDES (MG/L)	CHROME HEX (UG/L)	CHROME TOTAL (UG/L)	COLIFORM FECAL (NUMBER/100ML)	COLIFORM TOTAL (NUMBER/100ML)	COPPER (UG/L)	CYANIDE (MG/L)	DO (MG/L)
/29/83		.40		2.6	18		35			10-	110		.005-	11.
/26/83		.10		4.4	26		37			10-	60		.005-	11.
/17/83		.30		1.4	16		34			10	90		.005-	11.
/09/83		.20		2.5	24		32			10-	30		.005-	13.
/28/83		.10-		4.1	46		37			500	95000		.005-	11.
/25/83	74	.40		2.4	50		36			20	60		.005-	6.
/01/83		.30		1.7	23		31			10-	10-		.005-	9.
/29/83		.50			21		30						.005-	10.
MINIMUM	74	.10		1.4	16		30			10	10		.005	6.
MAXIMUM	74	.50		4.4	50		37			500	95000		.005	11.
AVERAGE	74	.29		2.3	28		34			81	13623		.005	10.
G.MEAN	74	.25		2.6	26		34			19	139		.005	10.7
MEDIAN	74	.30		2.6	23		34			10	60		.005	11.

SAMPLING DATE	FLUORIDE (MG/L)	HARDNESS (MG/L)	IRON (UG/L)	LEAD (UG/L)	MANGANESE (UG/L)	MERCURY (UG/L)	NICKEL (UG/L)	NO2+NO3 (MG/L)	NITROGEN (MG/L)	OIL & GREASE (MG/L)	PCB AROCLOR 1254 (UG/L)	PH FIELD	PH LAB	PHENOL (UG/L)	PHOSPHORUS (MG/L)	POTASSIUM (MG/L)	SODIUM (MG/L)
'29/83								.4	1.4	3.9		8.4	7.8		.08		
'26/83								.4	1.0	3.3		8.1	7.8		.10		
'17/83								.3	.7	5.9		8.0	7.6		.08		
'09/83								.3	.6	2.2		8.5	7.6		.04		
'28/83								.1-	1.4	5.8		8.6	7.7		.12		
'25/83		116						.1-	2.0	3.8		8.6	7.5		.11		
'01/83								.1-	1.2	3.1		7.9	7.5		.06		
'29/83								.3	1.0	4.6			7.6		.03-		
MINIMUM		116						.1	.6	2.2		7.9	7.5		.03		
MAXIMUM		116						.4	2.0	5.9		8.6	7.8		.12		
AVERAGE		116						.2	1.2	4.1		8.3	7.6		.07		
G.MEAN		116						.2	1.1	3.9		8.3	7.6		.07		
MEDIAN		116						.3	1.1	3.8		8.4	7.6		.08		

SAMPLING DATE	SOLIDS SUSP. (MG/L)	SOLIDS VOL. (MG/L)	SOLIDS TOTAL (MG/L)	SPEC. COND. (UMHO/CM)	SULFATE (MG/L)	TEMP. DEG C	TOC	TURBIDITY AS NTU	ZINC (UG/L)	SILICA (MG/L)	FECAL STREP. /100ML	CA AS CACO3 (MG/L)	MG AS MGCO3 (MG/L)	DIS. SOLIDS (MG/L)	MILITARY TIME
29/83	7			390	34.0	4	7.2	14							1003
26/83	15			360	42.0	16	6.7	18							1200
17/83	10			360	40.0	14	6.2	12-							930
09/83	10			390	39.0	18	7.1	12							745
28/83	44			350	34.0	27	12.0	50							1100
25/83	18			350	34.0	24	12.0	34							1740
01/83	9			400	34.0	10	13.7	16							1450
29/83	11			390	38.0	3	6.0	30							950
MINIMUM	7			350	34.0	3	6.0	12							745
MAXIMUM	44			400	42.0	27	12.0	50							1740
AVERAGE	16			377	36.9	14	11.4	23							1137
G.MEAN	13			377	36.8	11	9.5	20							1101
MEDIAN	10			360	36.0	14	7.1	16							1050

** PARAMETER VALUES WITH A (-) SIGN FOLLOWING THE NUMBER INDICATES THAT THE OBSERVED VALUE WAS LESS THAN THE NUMBER INDICATED
PARAMETER VALUES OF ALL NINES (999.99) INDICATES THAT THE OBSERVED VALUE WAS MORE THAN THE NUMBER INDICATED

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
SEDIMENT CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:002486 SITE:WOLF LAKE COUNTY:LAKE | SEDIMENT
COLLECTION DATE:07/16/86 LOCATION:CHANNEL LAB:ISBH | PREPARATION:COMPOSITE OF 3 GRABS

TOTAL SOLIDS(%):46.00 %MOISTURE: NA VOLATILE SOLIDS(%): 9.00 TOTAL ORGANIC CARBON: NA % wet weight

METALS(dry weight)		(MG/KG)
ALUMINUM		NA
ANTIMONY		1.200
ARSENIC		6.700
BARIUM		NA
BERYLLIUM	<	2.200
CADMIUM		3.200
CALCIUM		NA
CHROMIUM		46.000
COBALT		NA
COPPER		120.000
IRON		NA
LEAD		180.000
MAGNESIUM		NA
MANGANESE		NA
MERCURY		0.063
NICKEL		23.000
POTASSIUM		NA
SELENIUM		1.800
SILVER	<	2.600
SODIUM		NA
THALLIUM	<	22.000
VANADIUM		NA
ZINC		390.000
CYANIDE		1.150

* MG/KG wet weight)

PESTICIDES		(MG/KG)
ALDRIN	<	0.002
alpha-BHC	<	0.001
beta-BHC	<	0.003
delta-BHC	<	0.002
gamma-BHC	<	0.0001
alpha-CHLORDANE		NA
gamma-CHLORDANE		NA
cis-NONACHLOR		NA
trans-NONACHLOR		NA
OXYCHLORDANE		NA
TOTAL CHLORDANE	<	0.010
p,p'-DDD	<	0.002
o,p'-DDD		NA
p,p'-DDE	<	0.002
o,p'-DDE		NA
p,p'-DDT	<	0.002
o,p'-DDT		NA
DIELDRIN		0.005
ENDOSULFAN I	<	0.004
ENDOSULFAN II	<	0.010
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.008
ENDRIN ALDEHYDE		NA
ENDRIN KETONE		NA
HEPTACHLOR	<	0.002
HEPTACHLOR EPOXIDE	<	0.002
HEXACHLOROBENZENE		NA
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE		NA
TOXAPHENE	<	0.200

BASE/NEUTRAL EXTRACTABLE COMPOUNDS		(MG/KG)
ACENAPHTHYLENE	<	2.000
ACENAPHTHENE	<	2.000
ANILINE	<	3.000
4-CHLOROANILINE	<	3.000
2-NITROANILINE	<	10.000
3-NITROANILINE	<	5.000
4-NITROANILINE	<	5.000
ANTHRACENE	<	2.000
BENZO(a)ANTHRACENE	<	10.000
DIBENZO(a,h)ANTHRACENE	<	4.000
3,3'-DICHLOROBENZIDINE	<	5.000
1,2-DICHLOROBENZENE	<	1.000
1,3-DICHLOROBENZENE	<	1.000
1,4-DICHLOROBENZENE	<	1.000
1,2,4-TRICHLORBENZENE	<	1.000
HEXACHLOROBENZENE	<	29.000
NITROBENZENE	<	2.000
BENZYL ALCOHOL	<	3.000
CARBAZOLE		NA
CHRYSENE	<	10.000
n-NITROSODIPHENYLAMINE	<	2.000
n-NITROSO-di-n-PROPYLAMINE	<	1.000
HEXACHLOROETHANE	<	5.000
BIS(2-CHLOROETHYL)ETHER	<	1.000
BIS(2-CHLOROISOPROPYL)ETHER	<	2.500
4-BROMOPHENYL-PHENYLETHER	<	2.000
4-CHLOROPHENYL-PHENYLETHER	<	3.000
FLUORANTHENE	<	2.000
FLUORENE	<	2.000
BENZO(beta)FLUORANTHENE	<	49.000
BENZO(kappa)FLUORANTHENE	<	4.000
DIBENZOFURAN	<	3.000
BIS(2-CHLOROETHOXY)METHANE	<	4.000
ISOPHORONE	<	1.000
NAPHTHALENE	<	1.000
2-CHLORONAPHTHALENE	<	10.000
2-METHYLNAPHTHALENE	<	3.000
HEXACHLOROCYCLOPENTADIENE	<	3.000
BENZO(ghi)PERYLENE	<	9.000
PHENANTHRENE	<	2.000
di-n-BUTYLPHTHALATE	<	3.000
DIETHYLPHTHALATE	<	2.000
DIMETHYLPHTHALATE	<	2.000
di-n-OCTYLPHTHALATE	<	20.000
BIS(2-ETHYLHEXYL)PHTHALATE		1.800
BUTYLBENZYLPHTHALATE	<	5.000
PYRENE	<	3.000
BENZO(alpha)PYRENE	<	30.000
INDENO(1,2,3-c,d)PYRENE	<	4.000
2,4-DINITROTOLUENE	<	5.000
2,6-DINITROTOLUENE	<	10.000
HEXACHLOROBUTADIENE	<	2.000

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	24.000
PHENOL	<	1.000
2-CHLOROPHENOL	<	1.000
2,4-DICHLOROPHENOL	<	2.000
2,4,5-TRICHLOROPHENOL	<	2.500
2,4,6-TRICHLOROPHENOL	<	2.500
PENTACHLOROPHENOL	<	5.000
2-METHYLPHENOL	<	3.000
4-METHYLPHENOL	<	3.000
2,4-DIMETHYLPHENOL	<	1.000
4-CHLORO-3-METHYLPHENOL	<	2.000
4,6-DINITRO-2-METHYLPHENOL	<	4.000
2-NITROPHENOL	<	2.500
4-NITROPHENOL	<	4.000
2,4-DINITROPHENOL	<	10.000

PCBs		(MG/KG)
AROCLOR-1016	<	0.010
AROCLOR-1221	<	0.010
AROCLOR-1232	<	0.010
AROCLOR-1242	<	0.010
AROCLOR-1248		0.350
AROCLOR-1254		0.500
AROCLOR-1260	<	0.020
AROCLOR-1262		NA
TOTAL PCB		NA

VOLATILE ORGANIC COMPOUNDS		(MG/KG)
ACETONE		NA
BENZENE	<	3.000
CHLOROBENZENE	<	1.000
ETHYLBENZENE	<	3.000
2-BUTANONE	<	360.000
CARBON DISULFIDE		NA
CHLOROETHANE		NA
1,1-DICHLOROETHANE	<	1.000
1,2-DICHLOROETHANE	<	1.000
1,1,1-TRICHLOROETHANE	<	1.000
1,1,2-TRICHLOROETHANE	<	1.000
1,1,2,2-TETRACHLORETHANE	<	1.000
2-CHLOROETHYLVINYLETHER		NA
1,1-DICHLOROETHYLENE	<	1.000
1,2-DICHLOROETHYLENE	<	1.000
TRICHLOROETHYLENE(TOTAL)	<	1.000
TETRACHLOROETHYLENE	<	1.000
2-HEXANONE		NA
BROMOMETHANE		NA
TRIBROMOMETHANE (BROMOFORM)	<	1.000
BROMODICHLOROMETHANE	<	1.000
DIBROMOCHLOROMETHANE	<	1.000
CHLOROMETHANE		NA
DICHLOROMETHANE (METHYLENE CHLORIDE)	<	5.000
TRICHLOROMETHANE (CHLOROFORM)	<	1.000
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	1.000
4-METHYL-2-PENTANONE	<	30.000
1,2-DICHLOROPROPANE	<	1.000
c-1,3-DICHLOROPROPYLENE	<	1.000
t-1,3-DICHLOROPROPYLENE		NA
STYRENE		NA
TOLUENE	<	5.000
VINYL ACETATE		NA
VINYL CHLORIDE		NA
TOTAL XYLENE	<	60.000

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLIC PRINT DATE: 03/04/9
PESTICIDES, PCBs, BASE NEUTRAL, ACID EXTRACTABLE AN ORGANIC COMPOUNDS
ARE REPORTED ON A WET WEIGHT BASIS.
NA=NOT ANALYZED ND=NONE DETECTED ISBH= INDIANA STATE BOARD OF HEALTH

1986
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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
SEDIMENT CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:002485 SITE:WOLF LAKE COUNTY:LAKE SEDIMENT
COLLECTION DATE:07/16/86 LOCATION:WEST BASIN LAB:ISBH PREPARATION:COMPOSITE OF 3 GRABS

TOTAL SOLIDS(%):64.00 %MOISTURE: NA VOLATILE SOLIDS(%): 2.00 TOTAL ORGANIC CARBON: NA % wet weight

METALS(dry weight)		(MG/KG)
ALUMINUM		NA
ANTIMONY		0.360
ARSENIC		6.500
BARIUM		NA
BERYLLIUM	<	2.100
CADMIUM	<	2.100
CALCIUM		NA
CHROMIUM		10.000
COBALT		NA
COPPER		23.000
IRON		NA
LEAD		35.000
MAGNESIUM		NA
MANGANESE		NA
MERCURY		0.025
NICKEL	<	4.100
POTASSIUM		NA
SELENIUM		0.810
SILVER	<	1.600
SODIUM		NA
THALLIUM	<	21.000
VANADIUM		NA
ZINC		100.000
CYANIDE		0.875
MG/KG wet weight)		

PESTICIDES		(MG/KG)
ALDRIN	<	0.002
alpha-BHC	<	0.001
beta-BHC	<	0.003
delta-BHC	<	0.002
gamma-BHC	<	0.0001
alpha-CHLORDANE		NA
gamma-CHLORDANE		NA
cis-NONACHLOR		NA
trans-NONACHLOR		NA
OXYCHLORDANE		NA
TOTAL CHLORDANE	<	0.010
p,p'-DDD	<	0.002
o,p'-DDD		NA
p,p'-DDE	<	0.002
o,p'-DDE		NA
p,p'-DDT	<	0.002
o,p'-DDT		NA
DIELDRIN	<	0.001
ENDOSULFAN I	<	0.004
ENDOSULFAN II	<	0.010
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.008
ENDRIN ALDEHYDE		NA
ENDRIN KETONE		NA
HEPTACHLOR	<	0.002
HEPTACHLOR EPOXIDE	<	0.002
HEXACHLOROBENZENE		NA
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE		NA
TOXAPHENE	<	0.200

BASE/NEUTRAL EXTRACTABLE COMPOUNDS		(MG/KG)
ACENAPHTHYLENE	<	2.000
ACENAPHTHENE	<	2.000
ANILINE	<	3.000
4-CHLOROANILINE	<	3.000
2-NITROANILINE	<	3.000
3-NITROANILINE	<	5.000
4-NITROANILINE	<	5.000
ANTHRACENE	<	2.000
BENZO(a)ANTHRACENE	<	10.000
DIBENZO(a,h)ANTHRACENE	<	4.000
3,3'-DICHLOROBENZIDINE	<	5.000
1,2-DICHLOROBENZENE	<	1.000
1,3-DICHLOROBENZENE	<	1.000
1,4-DICHLOROBENZENE	<	1.000
1,2,4-TRICHLORBENZENE	<	1.000
HEXACHLOROBENZENE	<	5.000
NITROBENZENE	<	2.000
BENZYL ALCOHOL	<	3.000
CARBAZOLE		NA
CHRYSENE	<	10.000
n-NITROSODIPHENYLAMINE	<	2.000
n-NITROSO-di-n-PROPYLAMINE	<	1.000
HEXACHLOROETHANE	<	5.000
BIS(2-CHLOROETHYL)ETHER	<	1.000
BIS(2-CHLOROISOPROPYL)ETHER	<	2.500
4-BROMOPHENYL-PHENYLETHER	<	2.000
4-CHLOROPHENYL-PHENYLETHER	<	3.000
FLUORANTHENE	<	2.000
FLUORENE	<	2.000
BENZO(beta)FLUORANTHENE	<	38.000
BENZO(kappa)FLUORANTHENE	<	5.000
DIBENZOFURAN	<	3.000
BIS(2-CHLOROETHOXY)METHANE	<	4.000
ISOPHORONE	<	1.000
NAPHTHALENE	<	1.000
2-CHLORONAPHTHALENE	<	2.000
2-METHYLNAPHTHALENE	<	3.000
HEXACHLOROCYCLOPENTADIENE	<	3.000
BENZO(ghi)PERYLENE	<	9.000
PHENANTHRENE	<	2.000
di-n-BUTYLPHTHALATE	<	3.000
DIETHYLPHTHALATE	<	2.000
DIMETHYLPHTHALATE	<	2.000
di-n-OCTYLPHTHALATE	<	20.000
BIS(2-ETHYLHEXYL)PHTHALATE	<	1.000
BUTYLBENZYLPHTHALATE	<	5.000
PYRENE	<	2.000
BENZO(alpha)PYRENE	<	30.000
INDENO(1,2,3-c,d)PYRENE	<	14.000
2,4-DINITROTOLUENE	<	5.000
2,6-DINITROTOLUENE	<	3.000
HEXACHLOROBUTADIENE	<	2.000

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	24.000
PHENOL	<	1.000
2-CHLOROPHENOL	<	1.000
2,4-DICHLOROPHENOL	<	2.000
2,4,5-TRICHLOROPHENOL	<	2.500
2,4,6-TRICHLOROPHENOL	<	2.500
PENTACHLOROPHENOL	<	5.000
2-METHYLPHENOL	<	3.000
4-METHYLPHENOL	<	3.000
2,4-DIMETHYLPHENOL	<	1.000
4-CHLORO-3-METHYLPHENOL	<	2.000
4,6-DINITRO-2-METHYLPHENOL	<	4.000
2-NITROPHENOL	<	2.500
4-NITROPHENOL	<	4.000
2,4-DINITROPHENOL	<	4.000

PCBs		(MG/KG)
AROCLOR-1016	<	0.010
AROCLOR-1221	<	0.010
AROCLOR-1232	<	0.010
AROCLOR-1242	<	0.010
AROCLOR-1248	<	0.010
AROCLOR-1254	<	0.020
AROCLOR-1260	<	0.020
AROCLOR-1262		NA
TOTAL PCB		NA

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE		NA
BENZENE	<	36.000
CHLOROBENZENE	<	1.000
ETHYLBENZENE	<	3.000
2-BUTANONE	<	360.000
CARBON DISULFIDE		NA
CHLOROETHANE		NA
1,1-DICHLOROETHANE	<	1.000
1,2-DICHLOROETHANE	<	1.000
1,1,1-TRICHLOROETHANE	<	1.000
1,1,2-TRICHLOROETHANE	<	1.000
1,1,2,2-TETRACHLORETHANE	<	1.000
2-CHLOROETHYLVINYLETHER		NA
1,1-DICHLOROETHYLENE	<	1.000
1,2-DICHLOROETHYLENE	<	1.000
TRICHLOROETHYLENE(TOTAL)	<	1.000
TETRACHLOROETHYLENE	<	1.000
2-HEXANONE		NA
BROMOMETHANE		NA
TRIBROMOMETHANE (BROMOFORM)	<	1.000
BROMODICHLOROMETHANE	<	1.000
DIBROMOCHLOROMETHANE	<	1.000
CHLOROMETHANE		NA
DICHLOROMETHANE (METHYL IDE)	<	5.000
TRICHLOROMETHANE (CHLOROFORM)	<	1.000
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	1.000
4-METHYL-2-PENTANONE	<	30.000
1,2-DICHLOROPROPANE	<	1.000
c-1,3-DICHLOROPROPYLENE	<	1.000
t-1,3-DICHLOROPROPYLENE		NA
STYRENE		NA
TOLUENE	<	1.000
VINYL ACETATE		NA
VINYL CHLORIDE		NA
TOTAL XYLENE	<	50.000

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLI PRINT DATE: 03/04/93
PESTICIDES, PCBs, BASE NEUTRAL, ACID EXTRACTABLE AND VOLATILE ORGANIC COMPOUNDS
ARE REPORTED ON A WET WEIGHT BASIS.

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
SEDIMENT CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:DD2488 SITE:WOLF LAKE COUNTY:LAKE | SEDIMENT
COLLECTION DATE:07/16/86 LOCATION:VOLATILES FIELD BLANK LAB:ISBH | PREPARATION:DISTILLED WATER

TOTAL SOLIDS(%): NA %MOISTURE: NA VOLATILE SOLIDS(%): NA TOTAL ORGANIC CARBON: NA % wet weight

METALS(dry weight)	(MG/KG)
ALUMINUM	NA
ANTIMONY	NA
ARSENIC	NA
BARIUM	NA
BERYLLIUM	NA
CADMIUM	NA
CALCIUM	NA
CHROMIUM	NA
COBALT	NA
COPPER	NA
IRON	NA
LEAD	NA
MAGNESIUM	NA
MANGANESE	NA
MERCURY	NA
NICKEL	NA
POTASSIUM	NA
SELENIUM	NA
SILVER	NA
SODIUM	NA
THALLIUM	NA
VANADIUM	NA
ZINC	NA
CYANIDE	NA

MG/KG wet weight)

PESTICIDES	(MG/KG)
ALDRIN	NA
alpha-BHC	NA
beta-BHC	NA
delta-BHC	NA
gamma-BHC	NA
alpha-CHLORDANE	NA
gamma-CHLORDANE	NA
cis-NONACHLOR	NA
trans-NONACHLOR	NA
OXYCHLORDANE	NA
TOTAL CHLORDANE	NA
p,p'-DDD	NA
o,p'-DDD	NA
p,p'-DDE	NA
o,p'-DDE	NA
p,p'-DDT	NA
o,p'-DDT	NA
DIELDRIN	NA
ENDOSULFAN I	NA
ENDOSULFAN II	NA
ENDOSULFAN SULFATE	NA
ENDRIN	NA
ENDRIN ALDEHYDE	NA
ENDRIN KETONE	NA
HEPTACHLOR	NA
HEPTACHLOR EPOXIDE	NA
HEXACHLOROBENZENE	NA
METHOXYCHLOR	NA
PENTACHLOROANISOLE	NA
TOXAPHENE	NA

BASE/NEUTRAL EXTRACTABLE COMPOUNDS	(MG/KG)
ACENAPHTHYLENE	NA
ACENAPHTHENE	NA
ANILINE	NA
4-CHLOROANILINE	NA
2-NITROANILINE	NA
3-NITROANILINE	NA
4-NITROANILINE	NA
ANTHRACENE	NA
BENZO(a)ANTHRACENE	NA
DIBENZO(a,h)ANTHRACENE	NA
3,3'-DICHLOROBENZIDINE	NA
1,2-DICHLOROBENZENE	NA
1,3-DICHLOROBENZENE	NA
1,4-DICHLOROBENZENE	NA
1,2,4-TRICHLORBENZENE	NA
HEXACHLOROBENZENE	NA
NITROBENZENE	NA
BENZYL ALCOHOL	NA
CARBAZOLE	NA
CHRYSENE	NA
n-NITROSODIPHENYLAMINE	NA
n-NITROSO-di-n-PROPYLAMINE	NA
HEXACHLOROETHANE	NA
BIS(2-CHLOROETHYL)ETHER	NA
BIS(2-CHLOROISOPROPYL)ETHER	NA
4-BROMOPHENYL-PHENYLETHER	NA
4-CHLOROPHENYL-PHENYLETHER	NA
FLUORANTHENE	NA
FLUORENE	NA
BENZO(beta)FLUORANTHENE	NA
BENZO(kappa)FLUORANTHENE	NA
DIBENZOFURAN	NA
BIS(2-CHLOROETHOXY)METHANE	NA
ISOPHORONE	NA
NAPHTHALENE	NA
2-CHLORONAPHTHALENE	NA
2-METHYLNAPHTHALENE	NA
HEXACHLOROCYCLOPENTADIENE	NA
BENZO(ghi)PERYLENE	NA
PHENANTHRENE	NA
di-n-BUTYLPHTHALATE	NA
DIETHYLPHTHALATE	NA
DIMETHYLPHTHALATE	NA
di-n-OCTYLPHTHALATE	NA
BIS(2-ETHYLHEXYL)PHTHALATE	NA
BUTYLBENZYLPHTHALATE	NA
PYRENE	NA
BENZO(alpha)PYRENE	NA
INDENO(1,2,3-c,d)PYRENE	NA
2,4-DINITROTOLUENE	NA
2,6-DINITROTOLUENE	NA
HEXACHLOROBUTADIENE	NA

ACID EXTRACTABLE COMPOUNDS	(MG/KG)
BENZOIC ACID	NA
PHENOL	NA
2-CHLOROPHENOL	NA
2,4-DICHLOROPHENOL	NA
2,4,5-TRICHLOROPHENOL	NA
2,4,6-TRICHLOROPHENOL	NA
PENTACHLOROPHENOL	NA
2-METHYLPHENOL	NA
4-METHYLPHENOL	NA
2,4-DIMETHYLPHENOL	NA
4-CHLORO-3-METHYLPHENOL	NA
4,6-DINITRO-2-METHYLPHENOL	NA
2-NITROPHENOL	NA
4-NITROPHENOL	NA
2,4-DINITROPHENOL	NA

PCBs	(MG/KG)
AROCLOR-1016	NA
AROCLOR-1221	NA
AROCLOR-1232	NA
AROCLOR-1242	NA
AROCLOR-1248	NA
AROCLOR-1254	NA
AROCLOR-1260	NA
AROCLOR-1262	NA
TOTAL PCB	NA

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE		NA
BENZENE	<	3.000
CHLOROBENZENE	<	1.000
ETHYLBENZENE	<	3.000
2-BUTANONE	<	30.000
CARBON DISULFIDE		NA
CHLOROETHANE		NA
1,1-DICHLOROETHANE	<	1.000
1,2-DICHLOROETHANE	<	1.000
1,1,1-TRICHLOROETHANE	<	1.000
1,1,2-TRICHLOROETHANE	<	1.000
1,1,2,2-TETRACHLORETHANE	<	1.000
2-CHLOROETHYLVINYLETHER		NA
1,1-DICHLOROETHYLENE	<	1.000
1,2-DICHLOROETHYLENE	<	1.000
TRICHLOROETHYLENE(TOTAL)	<	1.000
TETRACHLOROETHYLENE	<	1.000
2-HEXANONE		NA
BROMOMETHANE		NA
TRIBROMOMETHANE (BROMOFORM)	<	1.000
BROMODICHLOROMETHANE	<	1.000
DIBROMOCHLOROMETHANE	<	1.000
CHLOROMETHANE		NA
DICHLOROMETHANE (METHYLENE CHLORIDE)	<	5.000
TRICHLOROMETHANE (CHLOROFORM)	<	1.000
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	1.000
4-METHYL-2-PENTANONE	<	30.000
1,2-DICHLOROPROPANE	<	1.000
c-1,3-DICHLOROPROPYLENE	<	1.000
t-1,3-DICHLOROPROPYLENE		NA
STYRENE		NA
TOLUENE	<	3.000
VINYL ACETATE		NA
VINYL CHLORIDE		NA
TOTAL XYLENE	<	60.000

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLIC PRINT DATE: 03/04/93
PESTICIDES, PCBs, BASE NEUTRAL, ACID EXTRACTABLE AN ORGANIC COMPOUNDS
ARE REPORTED ON A WET WEIGHT BASIS.
NA=NOT ANALYZED ND=NONE DETECTED ISBH= INDIANA STATE BOARD OF HEALTH

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
SEDIMENT CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:002487 SITE:WOLF LAKE COUNTY:LAKE | SEDIMENT
COLLECTION DATE:07/16/86 LOCATION:EAST BASIN LAB:ISBH | PREPARATION:COMPOSITE OF 3 GRABS

TOTAL SOLIDS(%):53.00 %MOISTURE: NA VOLATILE SOLIDS(%): 5.00 TOTAL ORGANIC CARBON: NA % wet weight

METALS(dry weight)		(MG/KG)
ALUMINUM		NA
ANTIMONY		0.710
ARSENIC		5.200
BARIUM		NA
BERYLLIUM	<	1.700
CADMIUM	<	1.700
CALCIUM		NA
CHROMIUM		12.000
COBALT		NA
COPPER		31.000
IRON		NA
LEAD		83.000
MAGNESIUM		NA
MANGANESE		NA
MERCURY		0.046
NICKEL		5.000
POTASSIUM		NA
SELENIUM		0.870
SILVER	<	2.200
SODIUM		NA
THALLIUM	<	17.000
VANADIUM		NA
ZINC		150.000
CYANIDE	<	0.125

MG/KG wet weight)

PESTICIDES		(MG/KG)
ALDRIN	<	0.002
alpha-BHC	<	0.007
beta-BHC	<	0.003
delta-BHC	<	0.002
gamma-BHC	<	0.0001
alpha-CHLORDANE		NA
gamma-CHLORDANE		NA
cis-NONACHLOR		NA
trans-NONACHLOR		NA
OXYCHLORDANE		NA
TOTAL CHLORDANE	<	0.010
p,p'-DDD	<	0.002
o,p'-DDD		NA
p,p'-DDE		0.005
o,p'-DDE		NA
p,p'-DDT	<	0.002
o,p'-DDT		NA
DIELDRIN	<	0.006
ENDOSULFAN I	<	0.004
ENDOSULFAN II	<	0.010
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.008
ENDRIN ALDEHYDE		NA
ENDRIN KETONE		NA
HEPTACHLOR	<	0.002
HEPTACHLOR EPOXIDE	<	0.002
HEXACHLOROBENZENE		NA
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE		NA
TOXAPHENE	<	0.200

BASE/NEUTRAL EXTRACTABLE COMPOUNDS(MG/KG)		
ACENAPHTHYLENE	<	2.000
ACENAPHTHENE	<	2.000
ANILINE	<	3.000
4-CHLOROANILINE	<	3.300
2-NITROANILINE	<	3.000
3-NITROANILINE	<	3.000
4-NITROANILINE	<	5.000
ANTHRACENE	<	2.000
BENZO(a)ANTHRACENE	<	10.000
DIBENZO(a,h)ANTHRACENE	<	4.000
3,3'-DICHLOROBENZIDINE	<	5.000
1,2-DICHLOROBENZENE	<	1.000
1,3-DICHLOROBENZENE	<	1.000
1,4-DICHLOROBENZENE	<	1.000
1,2,4-TRICHLORBENZENE	<	1.000
HEXACHLOROBENZENE	<	5.000
NITROBENZENE	<	2.000
BENZYL ALCOHOL	<	3.000
CARBAZOLE		NA
CHRYSENE	<	10.000
n-NITROSODIPHENYLAMINE	<	2.000
n-NITROSO-di-n-PROPYLAMINE	<	1.000
HEXACHLOROETHANE	<	5.000
BIS(2-CHLOROETHYL)ETHER	<	1.000
BIS(2-CHLOROISOPROPYL)ETHER	<	2.500
4-BROMOPHENYL-PHENYLETHER	<	2.000
4-CHLOROPHENYL-PHENYLETHER	<	3.000
FLUORANTHENE	<	2.000
FLUORENE	<	2.000
BENZO(beta)FLUORANTHENE	<	3.000
BENZO(kappa)FLUORANTHENE	<	10.000
DIBENZOFURAN	<	3.000
BIS(2-CHLOROETHOXY)METHANE	<	4.000
ISOPHORONE	<	1.000
NAPHTHALENE	<	1.000
2-CHLORONAPHTHALENE	<	2.000
2-METHYLNAPHTHALENE	<	5.000
HEXACHLOROCYCLOPENTADIENE	<	3.000
BENZO(ghi)PERYLENE	<	9.000
PHENANTHRENE	<	2.000
di-n-BUTYLPHTHALATE	<	3.000
DIETHYLPHTHALATE	<	2.000
DIMETHYLPHTHALATE	<	2.000
di-n-OCTYLPHTHALATE	<	20.000
BIS(2-ETHYLHEXYL)PHTHALATE	<	10.000
BUTYLBENZYLPHTHALATE	<	5.000
PYRENE	<	2.000
BENZO(alpha)PYRENE	<	30.000
INDENO(1,2,3-c,d)PYRENE	<	4.200
2,4-DINITROTOLUENE	<	5.000
2,6-DINITROTOLUENE	<	3.000
HEXACHLOROBUTADIENE	<	2.000

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	24.000
PHENOL	<	1.000
2-CHLOROPHENOL	<	1.000
2,4-DICHLOROPHENOL	<	2.000
2,4,5-TRICHLOROPHENOL	<	2.500
2,4,6-TRICHLOROPHENOL	<	2.500
PENTACHLOROPHENOL	<	5.000
2-METHYLPHENOL	<	3.000
4-METHYLPHENOL	<	3.000
2,4-DIMETHYLPHENOL	<	10.000
4-CHLORO-3-METHYLPHENOL	<	2.000
4,6-DINITRO-2-METHYLPHENOL	<	4.000
2-NITROPHENOL	<	2.500
4-NITROPHENOL	<	4.000
2,4-DINITROPHENOL	<	4.000

PCBs		(MG/KG)
AROCLOR-1016	<	0.010
AROCLOR-1221	<	0.010
AROCLOR-1232	<	0.010
AROCLOR-1242	<	0.010
AROCLOR-1248	<	0.010
AROCLOR-1254	<	0.020
AROCLOR-1260	<	0.020
AROCLOR-1262		NA
TOTAL PCB		NA

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE		NA
BENZENE	<	36.000
CHLOROBENZENE	<	1.000
ETHYLBENZENE	<	3.000
2-BUTANONE	<	360.000
CARBON DISULFIDE		NA
CHLOROETHANE		NA
1,1-DICHLOROETHANE	<	1.000
1,2-DICHLOROETHANE	<	1.000
1,1,1-TRICHLOROETHANE	<	1.000
1,1,2-TRICHLOROETHANE	<	1.000
1,1,2,2-TETRACHLORETHANE	<	1.000
2-CHLOROETHYLVINYLETHER		NA
1,1-DICHLOROETHYLENE	<	1.000
1,2-DICHLOROETHYLENE	<	1.000
TRICHLOROETHYLENE(TOTAL)	<	1.000
TETRACHLOROETHYLENE	<	1.000
2-HEXANONE		NA
BROMOMETHANE		NA
TRIBROMOMETHANE (BROMOFORM)	<	1.000
BROMODICHLOROMETHANE	<	1.000
DIBROMOCHLOROMETHANE	<	1.000
CHLOROMETHANE		NA
DICHLOROMETHANE (METHY RIDE)	<	5.000
TRICHLOROMETHANE (CHLOROFORM)	<	1.000
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	1.000
4-METHYL-2-PENTANONE	<	30.000
1,2-DICHLOROPROPANE	<	1.000
c-1,3-DICHLOROPROPYLENE	<	1.000
t-1,3-DICHLOROPROPYLENE		NA
STYRENE		NA
TOLUENE	<	3.000
VINYL ACETATE		NA
VINYL CHLORIDE		NA
TOTAL XYLENE	<	60.000

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPL PRINT DATE: 03/04/?
PESTICIDES, PCBs, BASE NEUTRAL, ACID EXTRACTABLE ... ILE ORGANIC COMPOUNDS
ARE REPORTED ON A WET WEIGHT BASIS.
... ISBH= INDIANA STATE BOARD OF HEALTH

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604532 SITE:WOLF LAKE COUNTY:LAKE | SPECIES:3 LARGEMOUTH BASS
COLLECTION DATE:07/16/86 LOCATION:WEST BASIN LAB:H | PREPARATION:SK-OFF FILLETS

MEAN LENGTH(CM):37.5 RANGE(CM):34.0-43.4 MEAN WEIGHT(GM):596 RANGE(GM):596-596 %LIPID:0.61

METALS		(MG/KG)
ALUMINUM	<	20.000
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		460.00
CHROMIUM	<	1.000
COBALT	<	5.000
COPPER	<	2.500
IRON	<	10.000
LEAD		1.200
MAGNESIUM		300.000
MANGANESE	<	1.500
MERCURY		0.134
NICKEL	<	4.000
POTASSIUM		4270.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM		340.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		6.100

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD	<	0.010
o,p'-DDD	<	0.010
p,p'-DDE	<	0.010
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE	<	0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 0.222 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS(MG/KG)		
ACENAPHTHYLENE	<	0.740
ACENAPHTHENE	<	0.740
4-CHLOROANILINE	<	0.740
2-NITROANILINE	<	3.700
3-NITROANILINE	<	3.700
4-NITROANILINE	<	3.700
ANTHRACENE	<	0.740
BENZO(a)ANTHRACENE	<	0.740
DIBENZO(a,h)ANTHRACENE	<	0.740
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.740
1,3-DICHLOROBENZENE	<	0.740
1,4-DICHLOROBENZENE	<	0.740
1,2,4-TRICHLORBENZENE	<	0.740
HEXACHLOROBENZENE	<	0.740
NITROBENZENE	<	0.740
BENZYL ALCOHOL	<	0.740
CHRYSENE	<	0.740
n-NITROSODIPHENYLAMINE	<	0.740
n-NITROSO-di-n-PROPYLAMINE	<	0.740
HEXACHLOROETHANE	<	0.740
BIS(2-CHLOROETHYL)ETHER	<	0.740
BIS(2-CHLOROISOPROPYL)ETHER	<	0.740
4-BROMOPHENYL-PHENYLETHER	<	0.740
4-CHLOROPHENYL-PHENYLETHER	<	0.740
FLUORANTHENE	<	0.740
FLUORENE	<	0.740
BENZO(beta)FLUORANTHENE	<	0.740
BENZO(kappa)FLUORANTHENE	<	0.740
DIBENZOFURAN	<	0.740
BIS(2-CHLOROETHOXY)METHANE	<	0.740
ISOPHORONE	<	0.740
NAPHTHALENE	<	0.740
2-CHLORONAPHTHALENE	<	0.740
2-METHYLNAPHTHALENE	<	0.740
HEXACHLOROCYCLOPENTADIENE	<	0.740
BENZO(ghi)PERYLENE	<	0.740
PHENANTHRENE	<	0.740
di-n-BUTYLPHTHALATE	<	0.740
DIETHYLPHTHALATE	<	0.740
DIMETHYLPHTHALATE	<	0.740
di-n-OCTYLPHTHALATE	<	0.740
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.740
BUTYLBENZYLPHTHALATE	<	0.740
PYRENE	<	0.740
BENZO(alpha)PYRENE	<	0.740
INDENO(1,2,3-c,d)PYRENE	<	0.740
2,4-DINITROTOLUENE	<	0.740
2,6-DINITROTOLUENE	<	0.740
HEXACHLOROBUTADIENE	<	0.740

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.700
PHENOL	<	0.740
2-CHLOROPHENOL	<	0.740
2,4-DICHLOROPHENOL	<	0.740
2,4,5-TRICHLOROPHENOL	<	3.700
2,4,6-TRICHLOROPHENOL	<	0.740
PENTACHLOROPHENOL	<	3.700
2-METHYLPHENOL	<	0.740
4-METHYLPHENOL	<	0.740
2,4-DIMETHYLPHENOL	<	0.740
4-CHLORO-3-METHYLPHENOL	<	0.740
4,6-DINITRO-2-METHYLPHENOL	<	3.700
2-NITROPHENOL	<	0.740
4-NITROPHENOL	<	3.700
2,4-DINITROPHENOL	<	3.700

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	1.300
BENZENE	<	0.005
CHLOROBENZENE	<	0.005
ETHYLBENZENE	<	0.005
2-BUTANONE		0.030
CARBON DISULFIDE	<	0.005
CHLOROETHANE	<	0.010
1,1-DICHLOROETHANE	<	0.005
1,2-DICHLOROETHANE	<	0.005
1,1,1-TRICHLOROETHANE	<	0.005
1,1,2-TRICHLOROETHANE	<	0.005
1,1,2,2-TETRACHLORETHANE	<	0.005
1,1-DICHLOROETHYLENE	<	0.005
1,2-DICHLOROETHYLENE	<	0.005
TRICHLOROETHYLENE(TOTAL)	<	0.005
TETRACHLOROETHYLENE	<	0.005
2-HEXANONE	<	0.010
BROMOMETHANE	<	0.010
TRIBROMOMETHANE (BROMOFORM)	<	0.005
BROMODICHLOROMETHANE	<	0.005
DIBROMOCHLOROMETHANE	<	0.005
CHLOROMETHANE	<	0.010
DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.055
TRICHLOROMETHANE (CHLOROFORM)	B	0.012
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
4-METHYL-2-PENTANONE	<	0.010
1,2-DICHLOROPROPANE	<	0.005
c-1,3-DICHLOROPROPYLENE	<	0.005
t-1,3-DICHLOROPROPYLENE	<	0.005
STYRENE	<	0.005
TOLUENE	B	0.010
VINYL ACETATE	<	0.010
VINYL CHLORIDE	<	0.010
TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLIC
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I= AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

PRINT DATE: 03/04/93

1986 Fish

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604531 SITE:WOLF LAKE COUNTY:LAKE LAB:H SPECIES:3 CARP
COLLECTION DATE:07/16/86 LOCATION:WEST BASIN PREPARATION:WHOLE

MEAN LENGTH(CM):52.1 RANGE(CM):47.0-55.0 MEAN WEIGHT(GM):1747 RANGE(GM):1390-2639 %LIPID:8.44

METALS		(MG/KG)
ALUMINUM		41.700
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		16900.00
CHROMIUM	<	1.000
COBALT	<	5.000
COPPER	<	2.500
IRON		55.000
LEAD		0.900
MAGNESIUM		370.000
MANGANESE		4.900
MERCURY		0.026
NICKEL	<	4.000
POTASSIUM		2600.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM		1180.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		78.900

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD		0.028
o,p'-DDD	<	0.010
p,p'-DDE		0.078
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE	<	0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 0.674 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS(MG/KG)		
ACENAPHTHYLENE	<	0.670
ACENAPHTHENE	<	0.670
4-CHLOROANILINE	<	0.670
2-NITROANILINE	<	3.400
3-NITROANILINE	<	3.400
4-NITROANILINE	<	3.400
ANTHRACENE	<	0.670
BENZO(a)ANTHRACENE	<	0.670
DIBENZO(a,h)ANTHRACENE	<	0.670
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.670
1,3-DICHLOROBENZENE	<	0.670
1,4-DICHLOROBENZENE	<	0.670
1,2,4-TRICHLORBENZENE	<	0.670
HEXACHLOROBENZENE	<	0.670
NITROBENZENE	<	0.670
BENZYL ALCOHOL	<	0.670
CHRYSENE	<	0.670
n-NITROSODIPHENYLAMINE	<	0.670
n-NITROSO-di-n-PROPYLAMINE	<	0.670
HEXACHLOROETHANE	<	0.670
BIS(2-CHLOROETHYL)ETHER	<	0.670
BIS(2-CHLOROISOPROPYL)ETHER	<	0.670
4-BROMOPHENYL-PHENYLETHER	<	0.670
4-CHLOROPHENYL-PHENYLETHER	<	0.670
FLUORANTHENE	<	0.670
FLUORENE	<	0.670
BENZO(beta)FLUORANTHENE	<	0.670
BENZO(kappa)FLUORANTHENE	<	0.670
DIBENZOFURAN	<	0.670
BIS(2-CHLOROETHOXY)METHANE	<	0.670
ISOPHORONE	<	0.670
NAPHTHALENE	<	0.670
2-CHLORONAPHTHALENE	<	0.670
2-METHYLNAPHTHALENE	<	0.670
HEXACHLOROCYCLOPENTADIENE	<	0.670
BENZO(ghi)PERYLENE	<	0.670
PHENANTHRENE	<	0.670
di-n-BUTYLPHTHALATE	<	0.670
DIETHYLPHTHALATE	<	0.670
DIMETHYLPHTHALATE	<	0.670
di-n-OCTYLPHTHALATE	<	0.670
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.670
BUTYLBENZYLPHTHALATE	<	0.670
PYRENE	<	0.670
BENZO(alpha)PYRENE	<	0.670
INDENO(1,2,3-c,d)PYRENE	<	0.670
2,4-DINITROTOLUENE	<	0.670
2,6-DINITROTOLUENE	<	0.670
HEXACHLOROBUTADIENE	<	0.670

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.400
PHENOL	<	0.670
2-CHLOROPHENOL	<	0.670
2,4-DICHLOROPHENOL	<	0.670
2,4,5-TRICHLOROPHENOL	<	3.400
2,4,6-TRICHLOROPHENOL	<	0.670
PENTACHLOROPHENOL	<	3.400
2-METHYLPHENOL	<	0.670
4-METHYLPHENOL	<	0.670
2,4-DIMETHYLPHENOL	<	0.670
4-CHLORO-3-METHYLPHENOL	<	0.670
4,6-DINITRO-2-METHYLPHENOL	<	3.400
2-NITROPHENOL	<	0.670
4-NITROPHENOL	<	3.400
2,4-DINITROPHENOL	<	3.400

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	2.200	1,1-DICHLOROETHYLENE	<	0.005	TRICHLOROMETHANE (CHLOROFORM)	B	0.019
BENZENE	<	0.005	1,2-DICHLOROETHYLENE	<	0.005			
CHLOROBENZENE	<	0.005	TRICHLOROETHYLENE(TOTAL)	<	0.005	TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
ETHYLBENZENE	<	0.005	TETRACHLOROETHYLENE	<	0.005			
2-BUTANONE		0.140	2-HEXANONE	<	0.010	4-METHYL-2-PENTANONE	<	0.010
CARBON DISULFIDE		0.026	BROMOMETHANE	<	0.010	1,2-DICHLOROPROPANE	<	0.005
CHLOROETHANE	<	0.010	TRIBROMOMETHANE (BROMOFORM)	<	0.005	c-1,3-DICHLOROPROPYLENE	<	0.005
1,1-DICHLOROETHANE		0.005				t-1,3-DICHLOROPROPYLENE	<	0.005
1,2-DICHLOROETHANE	<	0.005	BROMODICHLOROMETHANE	<	0.005	STYRENE	<	0.005
1,1,1-TRICHLOROETHANE		0.022	DIBROMOCHLOROMETHANE	<	0.005	TOLUENE	B	0.029
1,1,2-TRICHLOROETHANE	<	0.005	CHLOROMETHANE	<	0.010	VINYL ACETATE	<	0.010
1,1,2,2-TETRACHLORETHANE	<	0.005	DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.082	VINYL CHLORIDE	<	0.010
						TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPL
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

PRINT DATE: 03/04/93

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604533 SITE:WOLF LAKE COUNTY:LAKE SPECIES:2 WHITE BASS
COLLECTION DATE:07/16/86 LOCATION:WEST BASIN. LAB:H PREPARATION:WHOLE

MEAN LENGTH(CM):36.0 RANGE(CM):34.1-38.8 MEAN WEIGHT(GM):611 RANGE(GM):536-685 %LIPID:5.52

METALS		(MG/KG)
ALUMINUM	<	20.000
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		8040.00
CHROMIUM	<	1.000
COBALT	<	5.000
COPPER	<	2.500
IRON		46.400
LEAD	<	0.500
MAGNESIUM		300.000
MANGANESE	<	1.500
MERCURY		0.136
NICKEL	<	4.000
POTASSIUM		2950.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM		1210.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		19.600

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD		0.043
o,p'-DDD	<	0.010
p,p'-DDE		0.092
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE		0.009
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 1.315 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS		(MG/KG)
ACENAPHTHYLENE	<	0.670
ACENAPHTHENE	<	0.670
4-CHLOROANILINE	<	0.670
2-NITROANILINE	<	3.400
3-NITROANILINE	<	3.400
4-NITROANILINE	<	3.400
ANTHRACENE	<	0.670
BENZO(a)ANTHRACENE	<	0.670
DIBENZO(a,h)ANTHRACENE	<	0.670
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.670
1,3-DICHLOROBENZENE	<	0.670
1,4-DICHLOROBENZENE	<	0.670
1,2,4-TRICHLORBENZENE	<	0.670
HEXACHLOROBENZENE	<	0.670
NITROBENZENE	<	0.670
BENZYL ALCOHOL	<	0.670
CHRYSENE	<	0.670
n-NITROSODIPHENYLAMINE	<	0.670
n-NITROSO-di-n-PROPYLAMINE	<	0.670
HEXACHLOROETHANE	<	0.670
BIS(2-CHLOROETHYL)ETHER	<	0.670
BIS(2-CHLOROISOPROPYL)ETHER	<	0.670
4-BROMOPHENYL-PHENYLETHER	<	0.670
4-CHLOROPHENYL-PHENYLETHER	<	0.670
FLUORANTHENE	<	0.670
FLUORENE	<	0.670
BENZO(beta)FLUORANTHENE	<	0.670
BENZO(kappa)FLUORANTHENE	<	0.670
DIBENZOFURAN	<	0.670
BIS(2-CHLOROETHOXY)METHANE	<	0.670
ISOPHORONE	<	0.670
NAPHTHALENE	<	0.670
2-CHLORONAPHTHALENE	<	0.670
2-METHYLNAPHTHALENE	<	0.670
HEXACHLOROCYCLOPENTADIENE	<	0.670
BENZO(ghi)PERYLENE	<	0.670
PHENANTHRENE	<	0.670
di-n-BUTYLPHTHALATE	<	0.670
DIETHYLPHTHALATE	<	0.670
DIMETHYLPHTHALATE	<	0.670
di-n-OCTYLPHTHALATE	<	0.670
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.670
BUTYLBENZYLPHTHALATE	<	0.670
PYRENE	<	0.670
BENZO(alpha)PYRENE	<	0.670
INDENO(1,2,3-c,d)PYRENE	<	0.670
2,4-DINITROTOLUENE	<	0.670
2,6-DINITROTOLUENE	<	0.670
HEXACHLOROBUTADIENE	<	0.670

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.400
PHENOL	<	0.670
2-CHLOROPHENOL	<	0.670
2,4-DICHLOROPHENOL	<	0.670
2,4,5-TRICHLOROPHENOL	<	3.400
2,4,6-TRICHLOROPHENOL	<	0.670
PENTACHLOROPHENOL	<	3.400
2-METHYLPHENOL	<	0.670
4-METHYLPHENOL	<	0.670
2,4-DIMETHYLPHENOL	<	0.670
4-CHLORO-3-METHYLPHENOL	<	0.670
4,6-DINITRO-2-METHYLPHENOL	<	3.400
2-NITROPHENOL	<	0.670
4-NITROPHENOL	<	3.400
2,4-DINITROPHENOL	<	3.400

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	1.300
BENZENE	<	0.005
CHLOROBENZENE	<	0.005
ETHYLBENZENE	<	0.005
2-BUTANONE		0.061
CARBON DISULFIDE	<	0.005
CHLOROETHANE	<	0.010
1,1-DICHLOROETHANE	<	0.005
1,2-DICHLOROETHANE	<	0.005
1,1,1-TRICHLOROETHANE		0.015
1,1,2-TRICHLOROETHANE	<	0.005
1,1,2,2-TETRACHLORETHANE	<	0.005
1,1-DICHLOROETHYLENE	<	0.005
1,2-DICHLOROETHYLENE	<	0.005
TRICHLOROETHYLENE(TOTAL)	<	0.005
TETRACHLOROETHYLENE	<	0.005
2-HEXANONE	<	0.010
BROMOMETHANE	<	0.010
TRIBROMOMETHANE (BROMOFORM)	<	0.005
BROMODICHLOROMETHANE	<	0.005
DIBROMOCHLOROMETHANE	<	0.005
CHLOROMETHANE	<	0.010
DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.160
TRICHLOROMETHANE (CHLOROFORM)	B	0.016
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
4-METHYL-2-PENTANONE	<	0.010
1,2-DICHLOROPROPANE	<	0.005
c-1,3-DICHLOROPROPYLENE	<	0.005
t-1,3-DICHLOROPROPYLENE	<	0.005
STYRENE	<	0.005
TOLUENE	B	0.034
VINYL ACETATE	<	0.010
VINYL CHLORIDE	<	0.010
TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLI PRINT DATE: 03/04/93
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604534   SITE:WOLF LAKE   COUNTY:LAKE   SPECIES:3 CARP
COLLECTION DATE:07/16/86   LOCATION:EAST BASIN   LAB:H   PREPARATION:WHOLE

MEAN LENGTH(CM):42.7   RANGE(CM):40.0-46.0   MEAN WEIGHT(GM):1040   RANGE(GM):851-1305   %LIPID:8.02

METALS		(MG/KG)
ALUMINUM		27.900
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		10800.00
CHROMIUM	<	1.000
COBALT	<	5.000
COPPER	<	2.500
IRON		65.800
LEAD		1.000
MAGNESIUM		410.000
MANGANESE		3.400
MERCURY	<	0.025
NICKEL	<	4.000
POTASSIUM		2870.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM		1030.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		79.000

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD		0.023
o,p'-DDD	<	0.010
p,p'-DDE		0.075
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE		0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLORDANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB   1.774 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS		(MG/KG)
ACENAPHTHYLENE	<	0.670
ACENAPHTHENE	<	0.670
4-CHLOROANILINE	<	0.670
2-NITROANILINE	<	3.400
3-NITROANILINE	<	3.400
4-NITROANILINE	<	3.400
ANTHRACENE	<	0.670
BENZO(a)ANTHRACENE	<	0.670
DIBENZO(a,h)ANTHRACENE	<	0.670
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.670
1,3-DICHLOROBENZENE	<	0.670
1,4-DICHLOROBENZENE	<	0.670
1,2,4-TRICHLORBENZENE	<	0.670
HEXACHLOROBENZENE	<	0.670
NITROBENZENE	<	0.670
BENZYL ALCOHOL	<	0.670
CHRYSENE	<	0.670
n-NITROSODIPHENYLAMINE	<	0.670
n-NITROSO-di-n-PROPYLAMINE	<	0.670
HEXACHLOROETHANE	<	0.670
BIS(2-CHLOROETHYL)ETHER	<	0.670
BIS(2-CHLOROISOPROPYL)ETHER	<	0.670
4-BROMOPHENYL-PHENYLETHER	<	0.670
4-CHLOROPHENYL-PHENYLETHER	<	0.670
FLUORANTHENE	<	0.670
FLUORENE	<	0.670
BENZO(beta)FLUORANTHENE	<	0.670
BENZO(kappa)FLUORANTHENE	<	0.670
DIBENZOFURAN	<	0.670
BIS(2-CHLOROETHOXY)METHANE	<	0.670
ISOPHORONE	<	0.670
NAPHTHALENE	<	0.670
2-CHLORONAPHTHALENE	<	0.670
2-METHYLNAPHTHALENE	<	0.670
HEXACHLOROCYCLOPENTADIENE	<	0.670
BENZO(ghi)PERYLENE	<	0.670
PHENANTHRENE	<	0.670
di-n-BUTYLPHTHALATE	<	0.670
DIETHYLPHTHALATE	<	0.670
DIMETHYLPHTHALATE	<	0.670
di-n-OCTYLPHTHALATE	<	0.670
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.670
BUTYLBENZYLPHTHALATE	<	0.670
PYRENE	<	0.670
BENZO(alpha)PYRENE	<	0.670
INDENO(1,2,3-c,d)PYRENE	<	0.670
2,4-DINITROTOLUENE	<	0.670
2,6-DINITROTOLUENE	<	0.670
HEXACHLOROBUTADIENE	<	0.670

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.400
PHENOL	<	0.670
2-CHLOROPHENOL	<	0.670
2,4-DICHLOROPHENOL	<	0.670
2,4,5-TRICHLOROPHENOL	<	3.400
2,4,6-TRICHLOROPHENOL	<	0.670
PENTACHLOROPHENOL	<	3.400
2-METHYLPHENOL	<	0.670
4-METHYLPHENOL	<	0.670
2,4-DIMETHYLPHENOL	<	0.670
4-CHLORO-3-METHYLPHENOL	<	0.670
4,6-DINITRO-2-METHYLPHENOL	<	3.400
2-NITROPHENOL	<	0.670
4-NITROPHENOL	<	3.400
2,4-DINITROPHENOL	<	3.400

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	3.200
BENZENE	<	0.005
CHLOROBENZENE	<	0.005
ETHYLBENZENE	<	0.005
2-BUTANONE		0.110
CARBON DISULFIDE		0.068
CHLOROETHANE	<	0.010
1,1-DICHLOROETHANE	<	0.005
1,2-DICHLOROETHANE	<	0.005
1,1,1-TRICHLOROETHANE		0.012
1,1,2-TRICHLOROETHANE	<	0.005
1,1,2,2-TETRACHLORETHANE	<	0.005
1,1-DICHLOROETHYLENE	<	0.005
1,2-DICHLOROETHYLENE	<	0.005
TRICHLOROETHYLENE(TOTAL)	<	0.005
TETRACHLOROETHYLENE	<	0.005
2-HEXANONE	<	0.010
BROMOMETHANE	<	0.010
TRIBROMOMETHANE (BROMOFORM)	<	0.005
BROMODICHLOROMETHANE	<	0.005
DIBROMOCHLOROMETHANE	<	0.005
CHLOROMETHANE	<	0.010
DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.079
TRICHLOROMETHANE (CHLOROFORM)	B	0.053
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
4-METHYL-2-PENTANONE	<	0.010
1,2-DICHLOROPROPANE	<	0.005
c-1,3-DICHLOROPROPYLENE	<	0.005
t-1,3-DICHLOROPROPYLENE	<	0.005
STYRENE	<	0.005
TOLUENE	B	0.018
VINYL ACETATE	<	0.010
VINYL CHLORIDE	<	0.010
TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPL   PRINT DATE: 03/04/93
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I   AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604535 SITE:WOLF LAKE COUNTY:LAKE | SPECIES:2 CARP
COLLECTION DATE:07/16/86 LOCATION:EAST BASIN LAB:H | PREPARATION:SK-OFF FILLETS

MEAN LENGTH(CM):45.5 RANGE(CM):43.5-47.5 MEAN WEIGHT(GM):1220 RANGE(GM):1135-1305 %LIPID:1.75

METALS		(MG/KG)
ALUMINUM	<	20.000
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		410.00
CHROMIUM	<	1.000
COBALT	<	5.000
COPPER	<	2.500
IRON		12.000
LEAD		0.700
MAGNESIUM		250.000
MANGANESE	<	1.500
MERCURY		0.046
NICKEL	<	4.000
POTASSIUM		4070.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM	<	500.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		6.500

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD	<	0.010
o,p'-DDD	<	0.010
p,p'-DDE		0.012
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE	<	0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 0.267 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS(MG/KG)		
ACENAPHTHYLENE	<	0.740
ACENAPHTHENE	<	0.740
4-CHLOROANILINE	<	0.740
2-NITROANILINE	<	3.700
3-NITROANILINE	<	3.700
4-NITROANILINE	<	3.700
ANTHRACENE	<	0.740
BENZO(a)ANTHRACENE	<	0.740
DIBENZO(a,h)ANTHRACENE	<	0.740
3,3'-DICHLOROBENZIDINE	<	1.500
1,2-DICHLOROBENZENE	<	0.740
1,3-DICHLOROBENZENE	<	0.740
1,4-DICHLOROBENZENE	<	0.740
1,2,4-TRICHLOROBENZENE	<	0.740
HEXACHLOROBENZENE	<	0.740
NITROBENZENE	<	0.740
BENZYL ALCOHOL	<	0.740
CHRYSENE	<	0.740
n-NITROSODIPHENYLAMINE	<	0.740
n-NITROSO-di-n-PROPYLAMINE	<	0.740
HEXACHLOROETHANE	<	0.740
BIS(2-CHLOROETHYL)ETHER	<	0.740
BIS(2-CHLOROISOPROPYL)ETHER	<	0.740
4-BROMOPHENYL-PHENYLETHER	<	0.740
4-CHLOROPHENYL-PHENYLETHER	<	0.740
FLUORANTHENE	<	0.740
FLUORENE	<	0.740
BENZO(beta)FLUORANTHENE	<	0.740
BENZO(kappa)FLUORANTHENE	<	0.740
DIBENZOFURAN	<	0.740
BIS(2-CHLOROETHOXY)METHANE	<	0.740
ISOPHORONE	<	0.740
NAPHTHALENE	<	0.740
2-CHLORONAPHTHALENE	<	0.740
2-METHYLNAPHTHALENE	<	0.740
HEXACHLOROCYCLOPENTADIENE	<	0.740
BENZO(ghi)PERYLENE	<	0.740
PHENANTHRENE	<	0.740
di-n-BUTYLPHTHALATE	<	0.740
DIETHYLPHTHALATE	<	0.740
DIMETHYLPHTHALATE	<	0.740
di-n-OCTYLPHTHALATE	<	0.740
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.740
BUTYLBENZYLPHTHALATE	<	0.740
PYRENE	<	0.740
BENZO(alpha)PYRENE	<	0.740
INDENO(1,2,3-c,d)PYRENE	<	0.740
2,4-DINITROTOLUENE	<	0.740
2,6-DINITROTOLUENE	<	0.740
HEXACHLOROBUTADIENE	<	0.740

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.700
PHENOL	<	0.740
2-CHLOROPHENOL	<	0.740
2,4-DICHLOROPHENOL	<	0.740
2,4,5-TRICHLOROPHENOL	<	3.700
2,4,6-TRICHLOROPHENOL	<	0.740
PENTACHLOROPHENOL	<	3.700
2-METHYLPHENOL	<	0.740
4-METHYLPHENOL	<	0.740
2,4-DIMETHYLPHENOL	<	0.740
4-CHLORO-3-METHYLPHENOL	<	0.740
4,6-DINITRO-2-METHYLPHENOL	<	3.700
2-NITROPHENOL	<	0.740
4-NITROPHENOL	<	3.700
2,4-DINITROPHENOL	<	3.700

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	1.200	1,1-DICHLOROETHYLENE	<	0.005	TRICHLOROMETHANE (CHLOROFORM)	B	0.026
BENZENE	<	0.005	1,2-DICHLOROETHYLENE	<	0.005			
CHLOROBENZENE	<	0.005	TRICHLOROETHYLENE(TOTAL)	<	0.005	TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
ETHYLBENZENE	<	0.005	TETRACHLOROETHYLENE	<	0.005			
2-BUTANONE		0.044	2-HEXANONE	<	0.010	4-METHYL-2-PENTANONE	<	0.01
CARBON DISULFIDE	J	0.004	BROMOMETHANE	<	0.010	1,2-DICHLOROPROPANE	<	0.005
CHLOROETHANE	<	0.010	TRIBROMOMETHANE (BROMOFORM)	<	0.005	c-1,3-DICHLOROPROPYLENE	<	0.00
1,1-DICHLOROETHANE	<	0.005				t-1,3-DICHLOROPROPYLENE	<	0.00
1,2-DICHLOROETHANE	<	0.005	BROMODICHLOROMETHANE	<	0.005	STYRENE	<	0.00
1,1,1-TRICHLOROETHANE		0.018	DIBROMOCHLOROMETHANE	<	0.005	TOLUENE	B	0.01
1,1,2-TRICHLOROETHANE	<	0.005	CHLOROMETHANE	<	0.010	VINYL ACETATE	<	0.01
1,1,2,2-TETRACHLORETHANE	<	0.005	DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.037	VINYL CHLORIDE	<	0.01
						TOTAL XYLENE	<	0.00

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUF 431 OD AND DRUG LAB PRINT DATE: 03/04/9
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604536 SITE:WOLF LAKE COUNTY:LAKE | SPECIES:3 CARP
COLLECTION DATE:07/16/86 LOCATION:CHANNEL LAB:H | PREPARATION:WHOLE

MEAN LENGTH(CM):45.2 RANGE(CM):43.0-48.5 MEAN WEIGHT(GM):1296 RANGE(GM):1107-1532 %LIPID:7.48

METALS		(MG/KG)
ALUMINUM		75.400
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		7520.00
CHROMIUM	<	1.000
COBALT	<	0.500
COPPER	<	2.500
IRON		124.000
LEAD		0.700
MAGNESIUM		310.000
MANGANESE		15.300
MERCURY		0.032
NICKEL	<	4.000
POTASSIUM		2760.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM		990.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		86.200

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD	<	0.010
o,p'-DDD	<	0.010
p,p'-DDE		0.021
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE	<	0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 1.891 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS		(MG/KG)
ACENAPHTHYLENE	<	0.670
ACENAPHTHENE	<	0.670
4-CHLOROANILINE	<	0.670
2-NITROANILINE	<	3.400
3-NITROANILINE	<	3.400
4-NITROANILINE	<	3.400
ANTHRACENE	<	0.670
BENZO(a)ANTHRACENE	<	0.670
DIBENZO(a,h)ANTHRACENE	<	0.670
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.670
1,3-DICHLOROBENZENE	<	0.670
1,4-DICHLOROBENZENE	<	0.670
1,2,4-TRICHLORBENZENE	<	0.670
HEXACHLOROBENZENE	<	0.670
NITROBENZENE	<	0.670
BENZYL ALCOHOL	<	0.670
CHRYSENE	<	0.670
n-NITROSODIPHENYLAMINE	<	0.670
n-NITROSO-di-n-PROPYLAMINE	<	0.670
HEXACHLOROETHANE	<	0.670
BIS(2-CHLOROETHYL)ETHER	<	0.670
BIS(2-CHLOROISOPROPYL)ETHER	<	0.670
4-BROMOPHENYL-PHENYLETHER	<	0.670
4-CHLOROPHENYL-PHENYLETHER	<	0.670
FLUORANTHENE	<	0.670
FLUORENE	<	0.670
BENZO(beta)FLUORANTHENE	<	0.670
BENZO(kappa)FLUORANTHENE	<	0.670
DIBENZOFURAN	<	0.670
BIS(2-CHLOROETHOXY)METHANE	<	0.670
ISOPHORONE	<	0.670
NAPHTHALENE	<	0.670
2-CHLORONAPHTHALENE	<	0.670
2-METHYLNAPHTHALENE	<	0.670
HEXACHLOROCYCLOPENTADIENE	<	0.670
BENZO(ghi)PERYLENE	<	0.670
PHENANTHRENE	<	0.670
di-n-BUTYLPHTHALATE	<	0.670
DIETHYLPHTHALATE	<	0.670
DIMETHYLPHTHALATE	<	0.670
di-n-OCTYLPHTHALATE	<	0.670
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.670
BUTYLBENZYLPHTHALATE	<	0.670
PYRENE	<	0.670
BENZO(alpha)PYRENE	<	0.670
INDENO(1,2,3-c,d)PYRENE	<	0.670
2,4-DINITROTOLUENE	<	0.670
2,6-DINITROTOLUENE	<	0.670
HEXACHLOROBUTADIENE	<	0.670

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.400
PHENOL	<	0.670
2-CHLOROPHENOL	<	0.670
2,4-DICHLOROPHENOL	<	0.670
2,4,5-TRICHLOROPHENOL	<	3.400
2,4,6-TRICHLOROPHENOL	<	0.670
PENTACHLOROPHENOL	<	3.400
2-METHYLPHENOL	<	0.670
4-METHYLPHENOL	<	0.670
2,4-DIMETHYLPHENOL	<	0.670
4-CHLORO-3-METHYLPHENOL	<	0.670
4,6-DINITRO-2-METHYLPHENOL	<	3.400
2-NITROPHENOL	<	0.670
4-NITROPHENOL	<	3.400
2,4-DINITROPHENOL	<	3.400

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	1.100
BENZENE	<	0.005
CHLOROBENZENE	<	0.005
ETHYLBENZENE	<	0.005
2-BUTANONE		0.410
CARBON DISULFIDE		0.022
CHLOROETHANE	<	0.010
1,1-DICHLOROETHANE	<	0.005
1,2-DICHLOROETHANE	<	0.005
1,1,1-TRICHLOROETHANE	J	0.004
1,1,2-TRICHLOROETHANE	<	0.005
1,1,2,2-TETRACHLORETHANE	<	0.005
1,1-DICHLOROETHYLENE	<	0.005
1,2-DICHLOROETHYLENE	<	0.005
TRICHLOROETHYLENE(TOTAL)	<	0.005
TETRACHLOROETHYLENE	<	0.005
2-HEXANONE	<	0.010
BROMOMETHANE	<	0.010
TRIBROMOMETHANE (BROMOFORM)	<	0.005
BROMODICHLOROMETHANE	<	0.005
DIBROMOCHLOROMETHANE	<	0.005
CHLOROMETHANE	<	0.010
DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.037
TRICHLOROMETHANE (CHLOROFORM)	B	0.059
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
4-METHYL-2-PENTANONE	<	0.010
1,2-DICHLOROPROPANE	<	0.005
c-1,3-DICHLOROPROPYLENE	<	0.005
t-1,3-DICHLOROPROPYLENE	<	0.005
STYRENE	<	0.005
TOLUENE	B	0.011
VINYL ACETATE	<	0.010
VINYL CHLORIDE	<	0.010
TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPL PRINT DATE: [illegible]
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL STUDIES
FISH TISSUE CONTAMINATION RESULTS
IDEM SAMPLE NUMBER:

LAB NUMBER:70604537 SITE:WOLF LAKE COUNTY:LAKE | SPECIES:1 CARP
COLLECTION DATE:07/16/86 LOCATION:CHANNEL LAB:H | PREPARATION:SK-OFF FILLETS

MEAN LENGTH(CM):51.5 RANGE(CM):51.5-51.5 MEAN WEIGHT(GM):1759 RANGE(GM):1759-1759 %LIPID:2.38

METALS		(MG/KG)
ALUMINUM	<	20.000
ANTIMONY	<	2.000
ARSENIC	<	1.000
BARIUM	<	5.000
BERYLLIUM	<	0.500
CADMIUM	<	0.500
CALCIUM		980.00
CHROMIUM	<	1.000
COBALT	<	0.500
COPPER	<	2.500
IRON		19.400
LEAD		0.800
MAGNESIUM		280.000
MANGANESE	<	1.500
MERCURY		0.044
NICKEL	<	4.000
POTASSIUM		3800.000
SELENIUM	<	1.000
SILVER	<	0.500
SODIUM	<	500.000
THALLIUM	<	2.000
VANADIUM	<	5.000
ZINC		8.800

PESTICIDES		(MG/KG)
ALDRIN	<	0.008
alpha-BHC	<	0.008
beta-BHC	<	0.008
delta-BHC	<	0.008
gamma-BHC	<	0.008
alpha-CHLORDANE	<	0.008
gamma-CHLORDANE	<	0.008
cis-NONACHLOR	<	0.008
trans-NONACHLOR	<	0.008
OXYCHLORDANE	<	0.008
p,p'-DDD	<	0.010
o,p'-DDD	<	0.010
p,p'-DDE		0.021
o,p'-DDE	<	0.010
p,p'-DDT	<	0.010
o,p'-DDT	<	0.010
DIELDRIN	<	0.010
ENDOSULFAN I	<	0.020
ENDOSULFAN II	<	0.020
ENDOSULFAN SULFATE	<	0.020
ENDRIN	<	0.010
ENDRIN ALDEHYDE	<	0.010
ENDRIN KETONE	<	0.010
HEPTACHLOR	<	0.008
HEPTACHLOR EPOXIDE	<	0.008
HEXACHLOROBENZENE	<	0.010
METHOXYCHLOR	<	0.020
PENTACHLOROANISOLE	<	0.008
TOXAPHENE		NA

TOTAL PCB 0.478 MG/KG

BASE/NEUTRAL EXTRACTABLE COMPOUNDS(MG/KG)		
ACENAPHTHYLENE	<	0.670
ACENAPHTHENE	<	0.670
4-CHLOROANILINE	<	0.670
2-NITROANILINE	<	3.400
3-NITROANILINE	<	3.400
4-NITROANILINE	<	3.400
ANTHRACENE	<	0.670
BENZO(a)ANTHRACENE	<	0.670
DIBENZO(a,h)ANTHRACENE	<	0.670
3,3'-DICHLOROBENZIDINE	<	1.300
1,2-DICHLOROBENZENE	<	0.670
1,3-DICHLOROBENZENE	<	0.670
1,4-DICHLOROBENZENE	<	0.670
1,2,4-TRICHLORBENZENE	<	0.670
HEXACHLOROBENZENE	<	0.670
NITROBENZENE	<	0.670
BENZYL ALCOHOL	<	0.670
CHRYSENE	<	0.670
n-NITROSODIPHENYLAMINE	<	0.670
n-NITROSO-di-n-PROPYLAMINE	<	0.670
HEXACHLOROETHANE	<	0.670
BIS(2-CHLOROETHYL)ETHER	<	0.670
BIS(2-CHLOROISOPROPYL)ETHER	<	0.670
4-BROMOPHENYL-PHENYLETHER	<	0.670
4-CHLOROPHENYL-PHENYLETHER	<	0.670
FLUORANTHENE	<	0.670
FLUORENE	<	0.670
BENZO(beta)FLUORANTHENE	<	0.670
BENZO(kappa)FLUORANTHENE	<	0.670
DIBENZOFURAN	<	0.670
BIS(2-CHLOROETHOXY)METHANE	<	0.670
ISOPHORONE	<	0.670
NAPHTHALENE	<	0.670
2-CHLORONAPHTHALENE	<	0.670
2-METHYLNAPHTHALENE	<	0.670
HEXACHLOROCYCLOPENTADIENE	<	0.670
BENZO(ghi)PERYLENE	<	0.670
PHENANTHRENE	<	0.670
di-n-BUTYLPHTHALATE	<	0.670
DIETHYLPHTHALATE	<	0.670
DIMETHYLPHTHALATE	<	0.670
di-n-OCTYLPHTHALATE	<	0.670
BIS(2-ETHYLHEXYL)PHTHALATE	<	0.670
BUTYLBENZYLPHTHALATE	<	0.670
PYRENE	<	0.670
BENZO(alpha)PYRENE	<	0.670
INDENO(1,2,3-c,d)PYRENE	<	0.670
2,4-DINITROTOLUENE	<	0.670
2,6-DINITROTOLUENE	<	0.670
HEXACHLOROBUTADIENE	<	0.670

ACID EXTRACTABLE COMPOUNDS		(MG/KG)
BENZOIC ACID	<	3.400
PHENOL	<	0.670
2-CHLOROPHENOL	<	0.670
2,4-DICHLOROPHENOL	<	0.670
2,4,5-TRICHLOROPHENOL	<	3.400
2,4,6-TRICHLOROPHENOL	<	0.670
PENTACHLOROPHENOL	<	3.400
2-METHYLPHENOL	<	0.670
4-METHYLPHENOL	<	0.670
2,4-DIMETHYLPHENOL	<	0.670
4-CHLORO-3-METHYLPHENOL	<	0.670
4,6-DINITRO-2-METHYLPHENOL	<	3.400
2-NITROPHENOL	<	0.670
4-NITROPHENOL	<	3.400
2,4-DINITROPHENOL	<	3.400

VOLATILE ORGANIC COMPOUNDS (MG/KG)

ACETONE	B	0.570
BENZENE	<	0.005
CHLOROBENZENE	<	0.005
ETHYLBENZENE	<	0.005
2-BUTANONE		0.058
CARBON DISULFIDE		0.011
CHLOROETHANE	<	0.010
1,1-DICHLOROETHANE	<	0.005
1,2-DICHLOROETHANE	<	0.005
1,1,1-TRICHLOROETHANE		0.016
1,1,2-TRICHLOROETHANE	<	0.005
1,1,2,2-TETRACHLORETHANE	<	0.005
1,1-DICHLOROETHYLENE	<	0.005
1,2-DICHLOROETHYLENE	<	0.005
TRICHLOROETHYLENE(TOTAL)	<	0.005
TETRACHLOROETHYLENE	<	0.005
2-HEXANONE	<	0.010
BROMOMETHANE	<	0.010
TRIBROMOMETHANE (BROMOFORM)	<	0.005
BROMODICHLOROMETHANE	<	0.005
DIBROMOCHLOROMETHANE	<	0.005
CHLOROMETHANE	<	0.010
DICHLOROMETHANE (METHYLENE CHLORIDE)	B	0.037
TRICHLOROMETHANE (CHLOROFORM)	B	0.02[illegible]
TETRACHLOROMETHANE (CARBON TETRACHLORIDE)	<	0.005
4-METHYL-2-PENTANONE	<	0.010
1,2-DICHLOROPROPANE	<	0.005
c-1,3-DICHLOROPROPYLENE	<	0.005
t-1,3-DICHLOROPROPYLENE	<	0.005
STYRENE	<	0.005
TOLUENE	B	0.01[illegible]
VINYL ACETATE	<	0.010
VINYL CHLORIDE	<	0.010
TOTAL XYLENE	<	0.005

RESULTS REPORTED ON A WHOLE SAMPLE BASIS. D=DUPLICATE PRINT DATE: 03/04/9[illegible]
H=HAZLETON ENVIRONMENTAL SERVICES, MADISON, WI I=I AND DRUG LAB
NA=NOT ANALYZED ND=NONE DETECTED
OTHER FLAGS ARE EXPLAINED ON A SEPARATE SHEET

-SL

-St Line

	Jan '85	Jan '86	Feb '85	Feb '86	Mar (etc.) '85	Mar '86	Apr '85	Apr '86	May '85	May '86	June '85	June '86	July '85	July '86	Aug '85	Aug '86	Sept '85	Sept '86	Oct '85	Oct '86	Nov '85	Nov '86	Dec '85	Dec '86
monia (total)	.3	.2	.6	.5	<.1	.1	<.1	.2	<.1	<.1	<.1	.2	.5	<.1	<.1	<.1	<.1	.1	<.1	<.1	.1	.1	.3	.2
O.D.5	2.5	4	1.4	1.5	2.7	1.4	2.4	2.5	3.5	*	3.1	3.0	4.6	*	3.3	2.5	3.5	*	2.1	2.6	2.2	4	3.1	1.2
al Coliform	<10	<10	<10	<10	70	<10	<10	<10	<10	<10	30	270	<10	60	<10	20	<10	10	<10	60	10	<10	<10	<10
O.	13.0	12.3	8.3	7.5	11.6	10.5	10.0	11.0	9.7	10.5	11.7	7.4	10.0	8.2	9.5	7.8	8.3	9.3	10.2	9.9	11.5	12.7	10.5	[illegible]
$O_2 + NO_3$	.4	.3	.4	.3	.5	.2	.4	.3	.1	<.01	<.1	.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	.4	.1	.3	.5
lab	7.5	7.3	7.1	7.6	7.4	7.7	7.4	8.0	7.4	8.1	7.7	8.0	8.3	8.1	8.3	8.1	8.2	7.8	7.7	8.0	7.6	7.9	8.0	7.1
ios	<.03	.03	<.03	.03	<.03	.03	.05	<.03	.04	.03	.08	.07	.1	<.03	.10	.15	.07	.07	.03	.08	.04	.13	.03	.04
S.	2	5	3	12	17	9	24	2	25	16	30	23	40	9	28	13	23	26	14	24	9	5	6	3
??	3	0	3	5	5	7	12	7	20	19	32	23	27	30	24	25	23	20	11	13	4			3

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1985-1986

Appendix H. An Article Regarding Fishing in Wolf Lake

A Tale Of Two Lakes

Chicago, IL — Recent creel census data makes for some interesting comparisons between Wolf Lake and Lake Defiance, two state-owned lakes that are both popular fishing holes in the Chicago area.

The creel censuses or surveys of fishing success were conducted last summer by the Department of Conservation.

What may be surprising to many anglers is that Wolf Lake at William Powers Conservation Area on Chicago's south side provided far better fishing in terms of numbers of fish caught than did Lake Defiance, long regarded as a premier bass fishing lake in the area. Fishermen managed to catch .69 fish per hour last summer at Wolf Lake while they took only .16 fish per hour from Lake Defiance.

A catch rate of .5 fish per hour is regarded by fishery biologists as indicative of decent fishing when that catch rate is reflective of all fishermen at a lake over an entire summer, according to Illinois Department of Conservation staff management fishery biologist James Allen.

The differences in the success of fishermen on the two lakes can be explained by the different ways the two fisheries are managed and by the different fishermen who frequent them.

Wolf Lake's 419 acres have been popular with local anglers for many years. Fishing pressure is heavy there; over 600 man hours per acre. Similarly, park attendance has grown by leaps and bounds over the past 10 years to about 600,000 annually because of the area's popularity for picnicking as well as fishing. Although fishing has always been decent, it has not been a big draw for people outside the area. Over 98% of the fishermen there come from within a radius of 25 miles.

Lake Defiance, located at Moraine Hills State Park in McHenry County, is another matter. Though only 48 acres, it is a big draw for fishermen from a much wider geographic area, primarily because of its reputation as a good bass fishing spot.

While Lake Defiance is limited to fishing from rental rowboats, 90% of Wolf Lake's anglers fish from shore.

Before Moraine Hills opened in October, 1976, Lake Defiance had been fished on a very limited basis because it had been privately owned.

Lake Defiance is regarded as a rarity in Illinois because it is a glacial lake with a strong population of native game fish.

Since Defiance's opening as a public lake it has been managed by the Department of Conservation as a special case: a challenge for boat fishermen where the native fishery would be protected through stringent regulation but where the fishery would otherwise not be boosted through the usual fishery management practices of stocking and installation of fish attractors.

Chicago area fishermen have jumped at the chance to try their hands at landing the big bass that reside in Defiance, but without notable success. After an initial period of hot fishing during 1977 when fishermen were pulling .9 fish per hour out of the lake, things have quieted down. Fishery biologist Harvey Brown denies that the slower fishing has much to do with the fish population. Brown does allow that the hot fishing at Lake Defiance in 1977 was "when all the dumb fish were here," but he adds that his sampling of fish populations shows continued strong populations of all species.

The key difference between fishing at the two lakes is the number of fishermen who fish Lake Defiance who are unfamiliar with the lake. While over 98% of the anglers at Wolf Lake come from within 25 miles, only about a third of those at Lake Defiance come from within that range. At most state lakes, about 75% of the fishermen live within 25 miles of the lake.

Another limiting factor at Lake Defiance is the common expectation of catching bass, says Brown, who has observed many fishermen fishing areas that would not normally be productive because of the time of day and water temperature.

Currently, the catch limits for fishermen on Lake Defiance are three bass over 14 inches in length, one northern at least 24 inches in length, and a total of 25 fish of all species.

Smokey Says:

Appendix I. Fisheries Information

FISH STOCKING RECORD

COUNTY Cook

WATER (NAME) Wolf Lake

DATE	SPECIES	NO.	Size Range or Avr. Wgt.	CONDITION	SOURCE	REMARKS
'63	No. Pike	50,000	Fry		State	
10/73	LMB	9,000	Fing.		"	Station 1 (Sect. B)
"	BLG	63,000	"		"	" "
"	Redear	27,000	"		"	" "
10/30/75	Channel Cat	3,500	10		Purchased	" "
"	" "	1,000	"		"	Station 2 (Sect. C)
5/76	No. Pike	13,000	Fry		Federal	Station 1
11/16/76	Channel Cat	2.954	8		Purchased	Station 2
11/19/77	Walleye	200	15		"	"
11/25/77	Channel Cat	13,000	8		"	Stations 1 & 2
4/25/78	Lk. Chubsuck	120	Adult		State	Station 1
11/6/78	Channel Cat	13,000	8		Purchased	Stations 2 & 3
5/11/79	Walleye	525,000	Fry		Federal	" "
10/3/80	Channel Cat	10,000	7		Purchased	" "
5/81	Threadfin	450	Adult		State	Station 1
4/13/82	No. Pike	960,000	Fry		Federal	Stations 2 & 3
5/10/82	Threadfin	450	Adult		State	" "
10/26/82	Channel Cat	13,000	8		Purchased	" "
5/18/83	Threadfin	450	Adult		State	" "
7/6/83	Channel Cat	13,000	8		"	" "
10/21/84	" "	"	"		"	" "
4/29/85	Walleye	700,000	Fry		LaSalle/SIU	" "
3/29/85	Tiger Muskie	1,257	8		State (JW)	" "
10/85	Channel Cat	13,000	8		State (JW)	Stations 1, 2, and 3

.M. 2.0 Distribution: State and Public—District, Area, Central Offices (8/70)

26662--10M 1-70) 2.0

COUNTY Cook

FISH STOCKING RECORD

WATER (NAME) Wolf Lake (WPCA)

DATE	SPECIES	NO.	Size Range or Avr. Wgt.	CONDITION	SOURCE	REMARKS
6/6/86	CCF		400 lbs.	Good	PR	For Free Fishing Days Fountain Bluff Fish Farm
7/7/86	CCF	20,950	8	Good	ST (LG)	
8/19/86	TGM	419	8	Good	St (JW)	
6/3/87	WAE	20,950	2	Good	ST (JW)	Via LaSalle Hatchery/Com Ed
6/12/87	TGM	419	5	Good	ST (JW)	Left Pelvic Fin Clip
6/17/87	CCF	10,475	8	Good	ST (LG)	
8/27/87	TGM	419	8	Good	ST (JW)	
5/25/88	WAE	20,950	2	Good	ST (JW)	
6/21/88	CCF	16,760	8	Good	ST (LG)	
8/10/88	TGM	419	8	Good	ST (JW)	
5/25/89	WAE	20,950	1.7	Good	ST (JW)	
7/24/89	TGM	419	8	Good	ST (JW)	
7/31/89	CCF	12,570	8	Good	ST (LG)	
9/6/89	SMB	4,500	5	Good	ST (LG)	Stocked in station I.
5/25/90	WAE	20,960	1.6	Good	ST (JW)	
8/8/90	TGM	879	8	Good	ST (JW)	
8/28/90	CCF	12,570	8	Good	ST (LG)	
5/24/91	WAE	16,760	1.6	Good	ST (JW)	
6/14/91	SMB	4,500	2	Good	ST (JW)	
7/10/91	CCF	12,570	8	Good	ST (LG)	
8/21/91	TGM	692	8	Good	ST (JW)	
5/27/92	WAE	16,670	2	Good	ST (JW)	
7/21/92	CCF	10,475	8	Good	ST (LG)	
9/16/92	TGM	419	10	Good	ST (JW)	

F.M. 2.0 Distribution: State and Public—District, Area, Central Offices (8/70)

(26662—10M—12-70) 2-a

ILLINOIS
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