U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT
ON
INDIAN LAKE
LOGAN COUNTY
OHIO
EPA REGION V
WORKING PAPER No. 404

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

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REPORT
ON
INDIAN LAKE
LOGAN COUNTY
OHIO
EPA REGION V
WORKING PAPER NO. 404

WITH THE COOPERATION OF THE
OHIO ENVIRONMENTAL PROTECTION AGENCY
AND THE
OHIO NATIONAL GUARD
JUNE, 1975

CONTENTS

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

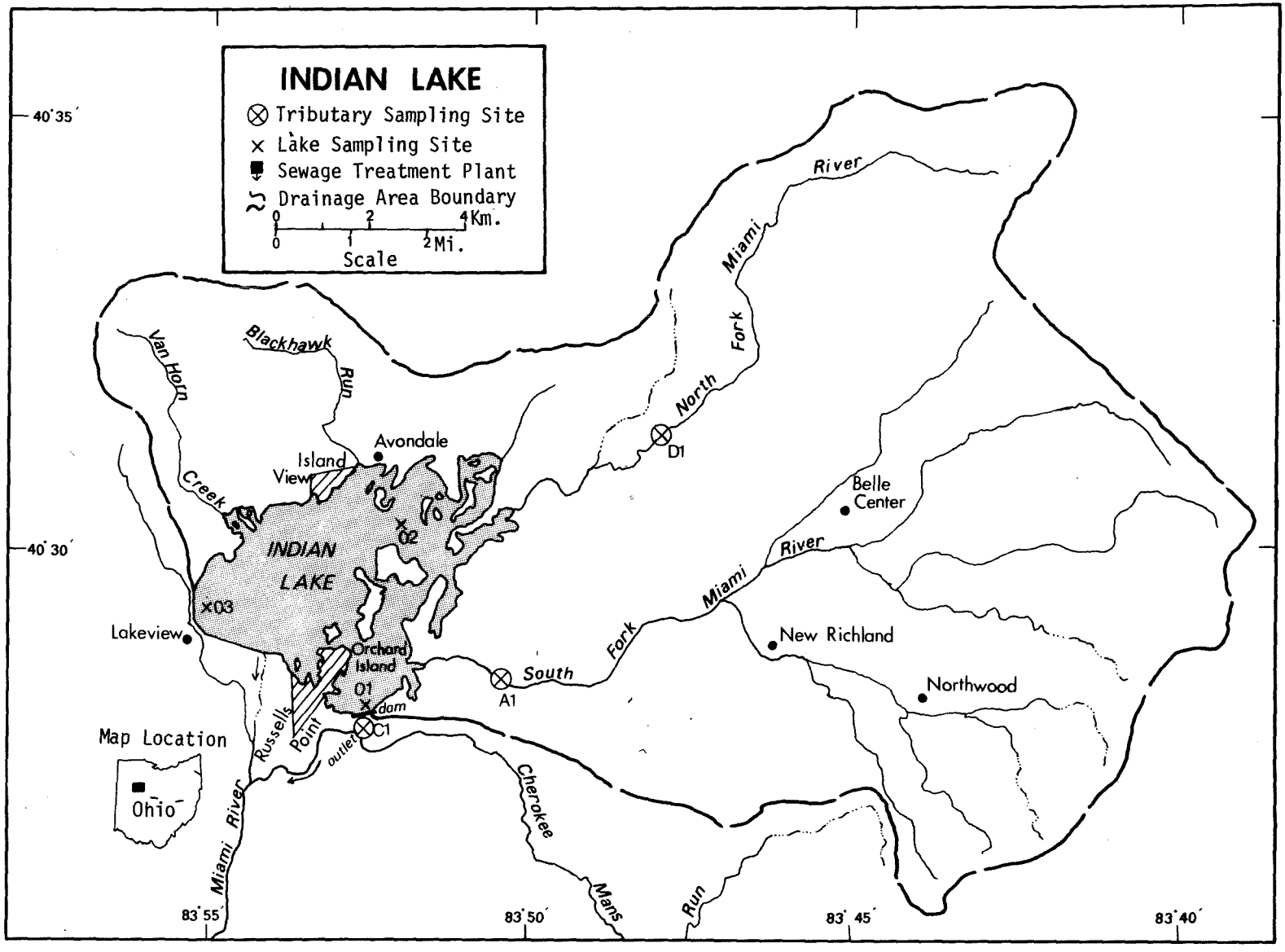
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


INDIAN LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
Drainage Area Boundary
0 2 4 Km.
0 1 2 Mi.
Scale
40°35'
40°30'
83°55'
83°50'
83°45'
83°40'
Van Horn Creek
Blackhawk Run
Avondale
Island View
INDIAN LAKE
X02
X03
Lakeview
Orchard Island
Russells Point
O1
dam
outlet
C1
Map Location
Ohio
Miami River
North Fork Miami River
D1
Belle Center
South Fork Miami River
A1
New Richland
Northwood
Cherokee Mans Run

INDIAN LAKE

STORET NO. 3915

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Indian Lake is eutrophic. It ranked eleventh in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Eleven lakes had less median total phosphorus, nine had less median dissolved phosphorus, four had less and one had the same median inorganic nitrogen, 16 had less mean chlorophyll a, and 15 had greater Secchi disc transparency. Depression of dissolved oxygen with depth occurred at station 3 in October.

Survey limnologists reported an algal bloom in October and noted that macrophytes were common in the shallow areas near shore.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Indian Lake was phosphorus limited at the time the sample was collected (05/04/73). The lake data indicate phosphorus limitation in May and August as well, but nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--No municipal or industrial wastewater

* See Appendix A.

treatment plants impacted Indian Lake during the sampling year, and the mean estimated phosphorus contribution of shoreline septic tanks amounted to only 4.2% of the total load reaching Indian Lake during the sampling year. However, recent Ohio Environmental Protection Agency investigations indicate major pollution problems at the lake are over-development and by-passing of sewage during wet periods when the capacity of sewer lines is exceeded (Youger, 1975). Therefore, it is likely that the estimation of septic tank phosphorus contributions is much too low.

The calculated phosphorus loading of 0.28 $g/m^2/yr$ is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). However, in view of the trophic condition of the lake and the problems associated with over-development noted above, it is probable that the actual loading is much higher than that indicated, and a need for a more-detailed study of the lake is indicated.

It is noted that an apparent phosphorus loss from the lake occurred during the sampling year (see page 10). It is likely that the "loss" resulted from underestimation of the shoreline septic tank loads and solubilization of previously sedimented phosphorus during the almost continuous dredging required to maintain satisfactory depths in the lake (Youger, op. cit.)

2. Non-point sources--About 94% of the total phosphorus input to Indian Lake is attributed to non-point sources. The North Fork Miami River contributed 25.5% of the total, and the

South Fork Miami River contributed 38.0%. Ungaged tributaries and immediate drainage were estimated to have contributed 26.1% of the total load.

The phosphorus export rates of the Indian Lake tributaries were relatively low. The North Fork rate was 34 kg/km^2/yr, and the South Fork rate was 20 kg/km^2/yr (see page 11). These rates compare well with the 49 kg/km^2/yr rate of Loramie Creek, a tributary of nearby Lake Loramie*.

* Working Paper No. 405.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 24.82 kilometers^2.
2. Mean depth: 2.3 meters.
3. Maximum depth: 3.6 meters.
4. Volume: 57.086 x 10^6 m^3.
5. Mean hydraulic retention time: 275 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
S. Fk., Miami River	129.5	1.2
N. Fk., Miami River	51.5	0.5
Minor tributaries & immediate drainage -	52.7	0.7
Totals	233.7	2.4

2. Outlet -

Miami River	258.5**	2.4

C. Precipitation***:

1. Year of sampling: 105.6 centimeters.
2. Mean annual: 92.2 centimeters.

† Table of metric conversions--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Indian Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from one or more depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1, 0.9 meters at station 2, and 3.0 meters at station 3.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR INDIAN LAKE
STORET CODE 3915

PARAMETER	1ST SAMPLING (5/ 4/73) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 2/73) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/11/73) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	11.9 - 12.5	12.1	12.0	23.4 - 24.1	23.8	23.8	18.6 - 20.3	19.4	19.5
DISS OXY (MG/L)	10.6 - 11.2	10.9	10.9	7.8 - 9.1	8.5	8.5	0.8 - 8.4	4.8	4.2
CNDCTVY (MCROMO)	400. - 480.	435.	420.	355. - 390.	368.	359.	295. - 337.	312.	310.
PH (STAND UNITS)	8.6 - 8.8	8.6	8.6	8.6 - 8.9	8.7	8.7	7.7 - 9.0	8.4	8.2
TOT ALK (MG/L)	142. - 168.	154.	151.	123. - 137.	128.	124.	101. - 126.	113.	113.
TOT P (MG/L)	0.046 - 0.063	0.056	0.057	0.075 - 0.164	0.128	0.131	0.124 - 0.157	0.136	0.133
ORTHO P (MG/L)	0.003 - 0.008	0.005	0.005	0.009 - 0.025	0.015	0.012	0.028 - 0.051	0.038	0.036
NO2+NO3 (MG/L)	0.660 - 0.990	0.793	0.725	0.140 - 0.380	0.245	0.225	0.060 - 0.080	0.068	0.070
AMMONIA (MG/L)	0.060 - 0.110	0.075	0.065	0.120 - 0.150	0.137	0.140	0.090 - 0.180	0.120	0.100
KJEL N (MG/L)	0.800 - 1.100	0.983	1.000	2.300 - 2.900	2.617	2.650	1.600 - 2.600	1.940	1.800
INORG N (MG/L)	0.750 - 1.050	0.868	0.795	0.260 - 0.530	0.382	0.370	0.150 - 0.250	0.188	0.180
TOTAL N (MG/L)	1.470 - 2.090	1.777	1.775	2.490 - 3.140	2.862	2.875	1.660 - 2.680	2.008	1.870
CHLRPYL A (UG/L)	48.7 - 59.3	53.8	53.5	94.8 - 114.2	105.3	107.0	64.7 - 76.2	71.4	73.3
SECCHI (METERS)	0.2 - 0.5	0.4	0.5	0.4 - 0.5	0.4	0.4	0.3 - 0.3	0.3	0.3

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/04/73	1. Oscillatoria sp.	10,187
	2. Ankistrodesmus (?) sp.	3,374
	3. Nitzschia sp.	1,933
	4. Microcystis sp.	1,212
	5. Raphidiopsis sp.	1,146
	Other genera	4,782
	Total	22,634
08/02/73	1. Raphidiopsis sp.	26,980
	2. Oscillatoria sp.	25,699
	3. Nitzschia sp.	9,713
	4. Synedra sp.	4,722
	5. Lyngbya sp.	3,102
	Other genera	8,836
	Total	79,052
10/11/73	1. Lyngbya sp.	41,319
	2. Oscillatoria sp.	18,403
	3. Nitzschia sp.	11,632
	4. Merismopedia sp.	11,458
	5. Microcystis sp.	7,465
	Other genera	18,404
	Total	108,681

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/04/73	01	48.7
	02	59.3
	03	53.5
08/02/73	01	107.0
	02	114.2
	03	94.8
10/11/73	01	73.3
	02	76.2
	03	64.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.024	0.428	4.5
0.050 P	0.074	0.428	22.2
0.050 P + 1.0 N	0.074	1.428	26.3
1.0 N	0.024	1.428	5.4

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Indian Lake was moderately high at the time the sample was collected (05/04/73). The addition of phosphorus alone produced a significant increase in yield over that of the control which indicates phosphorus limitation (note that addition of nitrogen alone produced a yield which was not significantly greater than that of the control).

The lake data also indicate limitation by phosphorus in May and August (the mean inorganic nitrogen/orthophosphorus ratios were 17/1 or greater at all stations). However, nitrogen limitation is indicated in October; i.e., the mean N/P ratios were 5/1 or less at all stations, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when three samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station D-1 and multiplying by the ZZ area in km^2.

No municipal or industrial wastewater treatment plants impacted Indian Lake during the sampling year.

A. Waste Sources**:

1. Known municipal - None
2. Known industrial - None

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* See Working Paper No. 175.
** Youger, 1975.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
S. Fk., Miami River	2,645	38.0
N. Fk., Miami River	1,775	25.5
b. Minor tributaries & immediate drainage (non-point load) -	1,820	26.1
c. Known municipal STP's - None	-	-
d. Septic tanks* -	290	4.2
e. Known industrial - None	-	-
f. Direct precipitation** -	435	6.2
Total	6,965	100.0

2. Outputs -

Lake outlet - Miami River 9,500

3. Net annual P loss - 2,535 kg.

* Estimate based on 1,009 shoreline dwellings and two parks; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
S. Fk., Miami River	92,485	35.4
N. Fk., Miami River	64,715	24.8
b. Minor tributaries & immediate drainage (non-point load) -	66,225	25.4
c. Known municipal STP's - None	-	-
d. Septic tanks* -	10,825	4.1
e. Known industrial - None	-	-
f. Direct precipitation** -	26,795	10.3
Total	261,045	100.0

2. Outputs -

Lake outlet - Miami River 195,610

3. Net annual N accumulation - 65,435 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
S. Fk., Miami River	20	714
N. Fk., Miami River	34	1,257

* Estimate based on 1,009 shoreline dwellings and two parks; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.28	loss*	10.5	2.6

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Indian Lake:

"Dangerous" (eutrophic loading)	0.34
"Permissible" (oligotrophic loading)	0.17

* There was an apparent loss of phosphorus during the sampling year. This may have been due to underestimation of the phosphorus loads from shoreline septic tanks, phosphorus release from the sediments during dredging, or both.

V. LITERATURE REVIEWED

Ketelle, Martha J., and Paul D. Uttormark, 1971. Problem lakes in the United States, EPA Water Poll. Contr. Res. Ser., Proj. #16010 EHR, Washington, DC.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Youger, John, 1975. Personal communication (lake morphometry; review of preliminary report). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.990	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3926	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3915 INDIAN LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 258.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3915A1	129.5	1.76	2.04	3.11	2.52	1.47	0.88	0.54	0.24	0.18	0.25	0.48	0.99	1.20
3915C1	258.5	3.51	4.13	6.29	5.07	2.97	1.73	1.08	0.48	0.37	0.48	0.96	2.01	2.41
3915D1	51.5	0.68	0.82	1.27	1.02	0.59	0.34	0.21	0.09	0.07	0.09	0.18	0.40	0.48
3915Z2	77.4	1.08	1.27	1.90	1.53	0.91	0.51	0.31	0.15	0.11	0.14	0.28	0.62	0.73

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 258.5
SUM OF SUB-DRAINAGE AREAS = 258.5
TOTAL FLOW IN = 29.06
TOTAL FLOW OUT = 29.08

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3915A1	5	73	2.12	5	2.44				
	6	73	1.47	9	1.50				
	7	73	1.53	14	0.62				
	8	73	2.29	28	0.96				
	9	73	0.24	15	0.24				
	10	73	0.62	20	0.51				
	11	73	1.19	10	0.51				
	12	73	1.59	16	0.85				
	1	74	3.82	12	0.91				
	2	74	2.15	9	1.81				
	3	74	1.93	2	2.24	9	1.73	15	1.42
	4	74	2.46	6	3.74				
3915C1	5	73	3.48	5	6.54				
	6	73	1.73	9	6.26				
	7	73	2.07	14	0.48				
	8	73	4.70	28	0.20				
	9	73	0.01	15	0.0				
	10	73	0.62	20	0.02				
	11	73	2.15	10	2.55				
	12	73	2.61	16	0.0				
	1	74	7.39	12	0.01				
	2	74	5.80	9	0.0				
	3	74	2.75	2	0.01	9	4.25	15	4.25
	4	74	5.13	6	19.82				

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3915 INDIAN LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3915D1	5	73	0.85	5	0.96				
	6	73	0.57	9	0.57				
	7	73	0.59	14	0.24				
	8	73	0.88	28	0.37				
	9	73	0.01	15	0.0				
	10	73	0.23	20	0.0				
	11	73	0.45	10	0.19				
	12	73	0.62	16	0.0				
	1	74	1.47	12	0.34				
	2	74	0.88	9	0.74				
	3	74	0.79	2	0.91	9	0.71	15	0.59
	4	74	0.99	6	1.50				
3915ZZ	5	73	1.30						
	6	73	0.85						
	7	73	0.91						
	8	73	1.05						
	9	73	0.03						
	10	73	0.34						
	11	73	0.71						
	12	73	0.99						
	1	74	1.67						
	2	74	0.99						
	3	74	0.85						
	4	74	1.08						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

391501
40 28 14.0 083 52 35.0
INDIAN LAKE
39091 OHIO

11EPALES 2111202
3 0006 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	14 00	0000	11.9		18	480	8.60	165	0.060	0.900	0.990	0.008
	14 00	0004	11.9	11.2		480	8.60	168	0.060	1.100	0.990	0.006
73/08/02	13 20	0000	23.8		18	386	8.90	136	0.120	2.600	0.310	0.012
	13 20	0005	23.4	9.1		390	8.70	137	0.150	2.400	0.380	0.012
73/10/11	10 50	0000	18.6	2.4	12	337	8.20	126	0.100	2.600	0.080	0.036

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	14 00	0000	0.057	48.7
	14 00	0004	0.061	
73/08/02	13 20	0000	0.142	107.0
	13 20	0005	0.120	
73/10/11	10 50	0000	0.157	73.3

STORET RETRIEVAL DATE 75/01/27

391502
40 30 28.0 083 52 05.0
INDIAN LAKE
39091 OHIO

11EPALES 2111202
3 0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	14 25	0000	12.0		9	420	8.60	142	0.060	1.100	0.710	0.006
	14 25	0003	12.0	10.9		420	8.60	152	0.070	1.000	0.740	0.004
73/08/02	12 45	0000	23.8		17	359	8.70	124	0.140	2.900	0.240	0.019
	12 45	0003	23.8	8.5		357	8.60	123	0.150	2.800	0.210	0.025
73/10/11	11 10	0000	19.8	8.4	12	310	8.90	113	0.100	2.000	0.070	0.040

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	14 25	0000	0.046	59.3
	14 25	0003	0.063	
73/08/02	12 45	0000	0.146	114.2
	12 45	0003	0.164	
73/10/11	11 10	0000	0.133	76.2

STORET RETRIEVAL DATE 75/01/27

391503
40 29 17.0 083 55 08.0
INDIAN LAKE
39091 OHIO

11EPALES 2111202
3 0007 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	14 50	0000	12.5		19	410	8.70	150	0.110	0.800	0.670	0.003
	14 50	0004	12.5	10.6		400	8.80	149	0.090	1.000	0.660	0.004
73/08/02	13 00	0000	24.1		16	359	8.70	123	0.120	2.700	0.140	0.009
	13 00	0004	23.9	7.8		355	8.70	123	0.140	2.300	0.190	0.012
73/10/11	11 30	0000	20.3	8.4	12	295	9.00	101	0.180	1.800	0.070	0.051
	11 30	0005	19.5	4.2		304	8.10	109	0.090	1.600	0.060	0.028
	11 30	0010	18.6	0.8		313	7.70	116	0.130	1.700	0.060	0.033

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	14 50	0000	0.049	53.5
	14 50	0004	0.058	
73/08/02	13 00	0000	0.075	94.8
	13 00	0004	0.119	
73/10/11	11 30	0000	0.129	64.7
	11 30	0005	0.124	
	11 30	0010	0.138	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/03

3915A1
40 28 28.0 083 50 25.0
S FORK MIAMI RIVER
39041 7.5 HUNTSVILLE
1/INDIAN LAKE
2NDRY RD BRDG 1 MI UPSTREAM OF LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 20		1.660	1.100	0.029	0.011	0.030
73/06/09	13 05		2.500	1.500	0.126	0.046	0.105
73/07/14	11 00		1.140	0.540	0.090	0.022	0.040
73/08/28	17 33		0.860	0.560	0.042	0.026	0.045
73/09/15	09 25		0.740	1.000	0.088	0.026	0.045
73/10/20	14 35		0.170	0.800	0.066	0.020	0.030
73/11/10	10 00		0.440	0.650	0.048	0.016	0.030
73/12/16	09 40		2.100	0.700	0.042	0.018	0.050
74/02/09	14 35		1.920	0.300	0.050	0.020	0.025
74/03/02	12 30		2.940	0.700	0.020	0.015	0.080
74/03/09	15 30		0.610	0.800	0.025	0.015	0.070
74/03/15	13 40		2.375	1.700	0.125	0.060	0.235
74/04/06	11 20		2.200	0.900	0.067	0.037	0.120

STORET RETRIEVAL DATE 75/02/03

391581
40 27 50.0 083 51 28.0
CHEROKEE MANS RUN
39 7.5 HUNTSVILLE
T/INDIAN LAKE
2NDRY RD BRDG BTWN US HWY 33 & ST HWY366
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 40		1.900	1.260	0.040	0.007	0.030

STORET RETRIEVAL DATE 75/02/10

3915D1
40 31 25.0 083 48 00.0
N FORK MIAMI RIVER
39 7.5 ROUND HEAD
I/INDIAN LAKE
DUNN RD BRDG 0.8 MI NNW OF ST HWY 273JCT
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	08 50		3.800	1.600	0.054	0.017	0.030
73/06/09	12 42		5.500	2.900	0.092	0.080	0.170
73/07/14	10 47		2.400	0.930	0.140	0.032	0.070
73/08/28	17 17		0.410	1.100	0.032	0.031	0.055
74/02/09	14 20		3.300	1.000	0.065	0.035	0.035
74/03/02	12 15		1.760	1.000	0.025	0.040	0.130
74/03/09	15 15		0.500	0.200	0.030	0.025	0.105
74/03/15	13 25		5.500	1.400	0.110	0.125	0.290
74/04/06	11 05		4.100	1.600	0.060	0.090	0.160