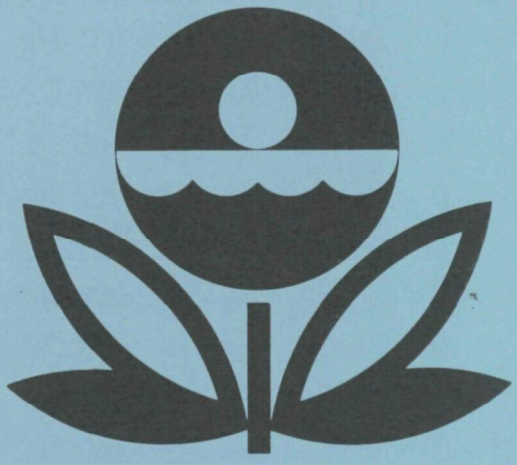
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT
ON
HIGGINS LAKE
ROSCOMMON COUNTY
MICHIGAN
EPA REGION V
WORKING PAPER No. 195

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
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EPA REGION V
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WITH THE COOPERATION OF THE
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
AND THE
MICHIGAN NATIONAL GUARD

FEBRUARY, 1975

CONTENTS

F O R E W O R D

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 Michigan Department of Natural Resources for professional involvement and to the Michigan National Guard for conducting the tributary sampling phase of the Survey.

A. Gene Gazlay, former Director, and David H. Jenkins, Acting Director, Michigan Department of Natural Resources; and Carlos Fetterolf, Chief Environmental Scientist, and Dennis Tierney, Aquatic Biologist, Bureau of Water Management, Department of Natural Resources, provided invaluable lake documentation and counsel during the course of the Survey. John Vogt, Chief of the Bureau of Environmental Health, Michigan Department of Public Health, and his staff were most helpful in identfying point sources and soliciting municipal participation in the Survey.

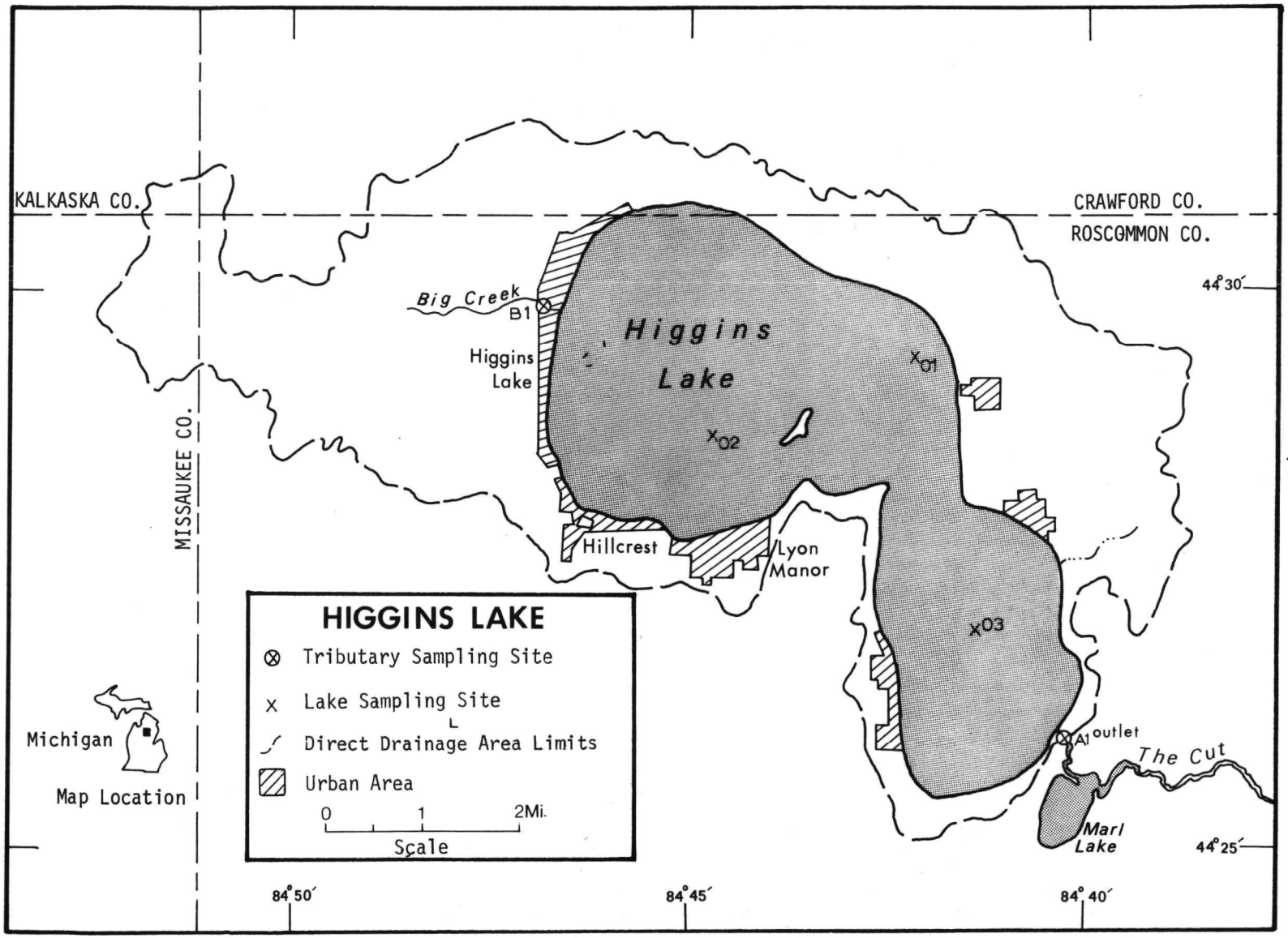
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MICHIGAN

LAKE NAME	COUNTY
Allegan Res.	Allegan
Barton	Kalamazoo
Belleville	Wayne
Betsie	Benzie
Brighton	Livingston
Caro Res.	Tuscola
Charlevoix	Charlevoix
Chemung	Livingston
Constantine Res.	St. Joseph
Crystal	Montcalm
Deer	Marquette
Ford	Washtenaw
Fremont	Newago
Higgins	Roscommon
Holloway Res.	Genesee, Lapeer
Houghton	Roscommon
Jordon	Ionia, Barry
Kent	Oakland
Long	St. Joseph
Macatawa	Ottawa
Manistee	Manistee
Mona	Muskegon
Muskegon	Muskegon
Pentwater	Oceana
Pere Marquette	Mason
Portage	Houghton
Randall	Branch
Rogers Pond	Mecosta
Ross	Gladwin
St. Louis Res.	Gratiot
Sanford	Midland
Strawberry	Livingston
Thompson	Livingston
Thornapple	Barry
Union	Branch
White	Muskegon


KALKASKA CO.
CRAWFORD CO.
ROSCOMMON CO.
MISSAUKEE CO.
44°30′
44°25′
84°50′
84°45′
84°40′
Big Creek
B1
Higgins Lake
Higgins Lake
X01
X02
X03
Hillcrest
Lyon Manor
A1 outlet
The Cut
Marl Lake
HIGGINS LAKE
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Limits
Urban Area
0 1 2Mi.
Scale
Michigan
Map Location

HIGGINS LAKE

STORET NO. 2695

I. CONCLUSIONS

A. Trophic Condition:

On the basis of Survey data, it is concluded that Higgins Lake is oligotrophic. Of the 35 Michigan lakes sampled in November when essentially all were well-mixed, only one had less mean dissolved and total phosphorus, and none had less mean inorganic nitrogen*. Of all of the 41 Michigan lakes sampled, none had greater mean Secchi disc transparency, and none had less mean chlorophyll a.

B. Rate-Limiting Nutrient:

A significant loss of nutrients occurred in the algal assay sample, and the results are not indicative of conditions in the lake at the time the sample was collected.

The lake data indicate phosphorus limitation in September but narrow nitrogen limitation in June and November of 1972.

C. Nutrient Controllability:

1. Point sources--During the sampling year, it is calculated that Higgins Lake received a total phosphorus load at a rate about one-third of that proposed by Vollenweider (in press) as "permissible"; i.e., at a rate less than an oligotrophic rate (see page 10).

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* See Appendix A.

There are no known municipal or industrial point sources impacting Higgins Lake; and, although septic tanks were estimated to have contributed 28% of the total phosphorus load, a shoreline survey would be needed to determine the actual contribution from these sources.

While the present phosphorus loading rate is quite low, every effort should be made to reduce all phosphorus inputs to the lowest practicable level to ensure that the existing high quality of Higgins Lake is maintained.

2. Non-point sources (see page 10)--It is estimated that non-point sources, including precipitation, contributed nearly 72% of the total phosphorus load to Higgins Lake during the sampling year. However, the phosphorus export of the only stream sampled, Big Creek, was the lowest of any of the Michigan streams sampled in 1972.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 9,600 acres.
2. Mean depth: 49 feet.
3. Maximum depth: 135 feet.
4. Volume: 470,400 acre-feet.
5. Mean hydraulic retention time: 15.6 years.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
Big Creek	10.5 mi^2	1.7 cfs
Minor tributaries & immediate drainage -	23.7 mi^2	40.0 cfs
Totals	34.2 mi^2	41.7 cfs

2. Outlet -

"The Cut"	49.2 mi^2**	41.7 cfs

C. Precipitation***:

1. Year of sampling: 32.4 inches.
2. Mean annual: 30.7 inches.

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† MI Dept. Cons. lake inventory map (1939).
* Drainage areas are accurate within ±5%; mean daily flows for 74% of the sampling sites are accurate within ±25% and the remaining sites up to ±40%; and mean monthly flows, normalized mean monthly flows, and mean annual flows are slightly more accurate than mean daily flows.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods, 1972".

III. LAKE WATER QUALITY SUMMARY

Higgins Lake was sampled three times during the open-water season of 1972 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 a number of depths at each station (see map, page v). During each visit, a single depth-integrated (15 feet to surface) sample was composited from the three stations for phytoplankton identification and enumeration; and during the second visit, a single five-gallon 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 analyses. The maximum depths sampled were 100 feet at station 1, 35 feet at station 2, and 89 feet at station 3.

The results obtained are presented in full in Appendix C, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix C.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/14/72)		
Temperature (Cent.)	5.8	6.5	6.5	6.7
Dissolved oxygen (mg/l)	10.2	10.8	10.7	11.6
Conductivity (μmhos)	216	228	230	240
pH (units)	8.1	8.2	8.2	8.2
Alkalinity (mg/l)	107	110	109	116
Total P (mg/l)	0.006	0.007	0.007	0.008
Dissolved P (mg/l)	0.004	0.005	0.005	0.007
NO_2 + NO_3 (mg/l)	0.020	0.024	0.020	0.040
Ammonia (mg/l)	0.030	0.034	0.030	0.050
		ALL VALUES		
Secchi disc (inches)	144	232	228	348

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
09/16/72	1. Lyngbya	196
	2. Melosira	129
	3. Polycystis	126
	4. Dinobryon	87
	5. Flagellates	54
	Other genera	252
	Total	844
11/14/72	1. Flagellates	1,583
	2. Chroococcus	1,030
	3. Fragilaria	904
	4. Kirchneriella	352
	5. Dinobryon	327
	Other genera	2,839
	Total	7,035

* The June sample was lost in shipment.

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/15/72	01	1.1
	02	-
	03	-
09/16/72	01	0.6
	02	0.6
	03	0.6
11/14/72	01	1.1
	02	2.0
	03	1.3

C. Limiting Nutrient Study:

There was a loss of about 56% of dissolved phosphorus and inorganic nitrogen in the algal assay sample from the time of collection until the assay was begun. Consequently, the algal assay results are not indicative of conditions in the lake at the time the sample was collected.

The lake data indicate phosphorus limitation in September (N/P ratio = 16/1) but narrow nitrogen limitation the other sampling times (N/P ratios = 12/1). Phosphorus limitation would be expected at about 14/1 and higher.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Michigan 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 months of April and May, when two samples were collected, and the colder months when flows were too low in Big Creek. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Michigan 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 loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in $lbs/mi^2/year$, in Big Creek at station B-1 and multiplying the means by the ZZ area in mi^2.

There are no known municipal or industrial point sources impacting Higgins Lake.

* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/yr	% of total
a. Tributaries (non-point loads) -		
Big Creek	40	1.8
b. Minor tributaries & immediate drainage (non-point load) -	90	3.9
c. Known municipal STP's - None	-	-
d. Septic tanks* -	640	28.2
e. Known industrial - None	-	-
f. Direct precipitation** -	1,500	66.1
Total	2,270	100.0

2. Outputs -

Lake outlet - Higgins/Marl Lake connection	680

3. Net annual P accumulation - 1,590 pounds

* Estimated 1,000 seasonal dwellings and 4 parks on shoreline; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
Big Creek	2,610	2.1
b. Minor tributaries & immediate drainage (non-point load) -	5,900	4.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	23,810	19.1
e. Known industrial - None	-	-
f. Direct precipitation** -	92,490	74.1
Total	124,810	100.0

2. Outputs -

Lake outlet - Higgins/Marl Lake connection	58,130

3. Net annual N accumulation - 66,680 pounds

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

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Big Creek	4	249

* Estimated 1,000 seasonal dwellings and 4 parks on shoreline; see Working Paper No. 1.
** See Working Paper No. 1.

E. Yearly Loading Rates:

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

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	0.24	0.17	13.0	6.9
grams/m^2/yr	0.03	0.02	1.5	0.8

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Higgins Lake:

"Dangerous" (eutrophic rate)	0.20
"Permissible" (oligotrophic rate)	0.10

V. LITERATURE REVIEWED

Vollenweider, Richard A. (in press). Input-output models. Schweiz. Z. Hydrol.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500- MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15- MIN DO
26A0	HOLLOWAY RESERVOIR	0.062	0.043	1.461	439.375	10.678	9.200
26A1	CARO RESERVOIR	0.117	0.022	3.835	473.000	11.967	9.500
26A2	BOARDMAN HYDRO POND	0.006	0.005	0.358	363.500	1.267	6.600
2603	ALLEGAN LAKE	0.123	0.057	1.168	470.222	20.311	12.600
2606	BARTON LAKE	0.121	0.086	1.489	456.167	27.800	14.850
2609	BELLEVILLE LAKE	0.118	0.048	1.420	465.250	28.262	8.200
2610	BETSIE LAKE	0.025	0.008	0.273	461.667	4.567	7.400
2613	BRIGHTON LAKE	0.109	0.073	1.015	456.000	44.233	7.500
2617	LAKE CHARLEVOIX	0.007	0.006	0.230	351.250	3.008	9.240
2618	LAKE CHEMUNG	0.044	0.014	0.132	404.333	13.483	14.800
2621	CONSTANTINE RESERVOIR	0.027	0.008	0.910	456.167	39.317	7.500
2629	FORD LAKE	0.105	0.058	1.536	456.167	14.733	14.000
2631	FREMONT LAKE	0.372	0.342	1.406	441.667	28.500	14.800
2640	JORDAN LAKE	0.180	0.144	1.998	427.667	20.517	14.900
2643	KENT LAKE	0.040	0.015	0.417	455.000	33.944	13.000
2648	LAKE MACATAWA	0.197	0.120	2.358	477.600	25.600	12.200
2649	MANISTEE LAKE	0.018	0.010	0.304	451.333	6.317	11.380
2659	MUSKEGON LAKE	0.087	0.043	0.469	436.444	9.511	14.800
2665	PENTWATER LAKE	0.027	0.017	0.496	430.667	16.083	14.800
2671	RANDALL LAKE	0.246	0.183	0.818	457.333	27.217	8.020
2672	ROGERS POND	0.026	0.015	0.183	435.500	8.133	9.600
2673	ROSS RESERVOIR	0.034	0.021	0.460	465.333	10.383	8.200
2674	SANFORD LAKE	0.016	0.008	0.307	458.750	13.791	8.300
2683	THORNAPPLE LAKE	0.042	0.032	1.737	442.833	14.650	10.800
2685	UNION LAKE	0.083	0.064	1.252	455.500	15.667	8.200
2688	WHITE LAKE	0.027	0.019	0.367	417.778	9.211	13.400
2691	MONA LAKE	0.307	0.241	0.963	451.667	27.783	14.100
2692	LONG LAKE	0.163	0.148	0.749	418.400	10.067	13.600

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500- MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15- MIN DO
2693	ST LOUIS RESERVOIR	0.134	0.093	1.227	462.667	5.583	8.420
2694	CRYSTAL LAKE	0.009	0.006	0.164	380.000	2.986	13.000
2695	HIGGINS LAKE	0.007	0.005	0.058	268.500	1.043	9.400
2696	HOUGHTON LAKE	0.018	0.008	0.136	420.833	9.217	8.200
2697	THOMPSON LAKE	0.043	0.029	0.436	407.889	11.967	14.800
2698	PERE MARQUETTE LAKE	0.032	0.024	0.346	448.667	11.833	8.600
2699	STRAWBERRY LAKE	0.069	0.050	0.567	419.800	11.117	13.600

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

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500-MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15-MIN DO	INDEX NO
26A0	HOLLOWAY RESERVOIR	46 (16)	43 (15)	17 (6)	57 (20)	60 (21)	63 (22)	286
26A1	CARO RESERVOIR	29 (10)	54 (19)	0 (0)	3 (1)	49 (17)	54 (19)	189
26A2	BOARDMAN HYDRO POND	97 (34)	97 (34)	69 (24)	91 (32)	94 (33)	97 (34)	545
2603	ALLEGAN LAKE	20 (7)	31 (11)	31 (11)	6 (2)	29 (10)	40 (14)	157
2606	BARTON LAKE	23 (8)	20 (7)	14 (5)	29 (9)	14 (5)	3 (1)	103
2609	BELLEVILLE LAKE	26 (9)	37 (13)	20 (7)	11 (4)	11 (4)	79 (26)	184
2610	BETSIE LAKE	77 (27)	77 (27)	80 (28)	17 (6)	86 (30)	94 (33)	431
2613	BRIGHTON LAKE	31 (11)	23 (8)	34 (12)	34 (12)	0 (0)	90 (31)	212
2617	LAKE CHARLEVOIX	91 (32)	91 (32)	83 (29)	94 (33)	89 (31)	60 (21)	508
2618	LAKE CHEMUNG	49 (17)	71 (25)	94 (33)	86 (30)	46 (16)	11 (2)	357
2621	CONSTANTINE RESERVOIR	71 (25)	83 (29)	40 (14)	29 (9)	3 (1)	90 (31)	316
2629	FORD LAKE	34 (12)	29 (10)	11 (4)	29 (9)	37 (13)	23 (8)	163
2631	FREMONT LAKE	0 (0)	0 (0)	23 (8)	54 (19)	9 (3)	11 (2)	97
2640	JORDAN LAKE	11 (4)	11 (4)	6 (2)	69 (24)	26 (9)	0 (0)	123
2643	KENT LAKE	57 (20)	69 (24)	63 (22)	40 (14)	6 (2)	36 (12)	271
2648	LAKE MACATAWA	9 (3)	14 (5)	3 (1)	0 (0)	23 (8)	43 (15)	92
2649	MANISTEE LAKE	80 (28)	74 (26)	77 (27)	46 (16)	80 (28)	46 (16)	403
2659	MUSKEGON LAKE	37 (13)	40 (14)	54 (19)	60 (21)	69 (24)	11 (2)	271
2665	PENTWATER LAKE	69 (24)	63 (22)	51 (18)	66 (23)	31 (11)	11 (2)	291
2671	RANDALL LAKE	6 (2)	6 (2)	43 (15)	23 (8)	20 (7)	86 (30)	184
2672	ROGERS POND	74 (26)	66 (23)	86 (30)	63 (22)	77 (27)	51 (18)	417
2673	ROSS RESERVOIR	60 (21)	57 (20)	57 (20)	9 (3)	63 (22)	79 (26)	325
2674	SANFORD LAKE	86 (30)	80 (28)	74 (26)	20 (7)	43 (15)	71 (25)	374
2683	THORNAPPLE LAKE	54 (19)	46 (16)	9 (3)	51 (18)	40 (14)	49 (17)	249
2685	UNION LAKE	40 (14)	26 (9)	26 (9)	37 (13)	34 (12)	79 (26)	242
2688	WHITE LAKE	66 (23)	60 (21)	66 (23)	80 (28)	74 (26)	31 (11)	377
2691	MONA LAKE	3 (1)	3 (1)	37 (13)	43 (15)	17 (6)	20 (7)	123
2692	LONG LAKE	14 (5)	9 (3)	46 (16)	77 (27)	66 (23)	27 (9)	239

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

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500- MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15- MIN DO	INDEX NO
2693	ST LOUIS RESERVOIR	17 (6)	17 (6)	29 (10)	14 (5)	83 (29)	69 (24)	229
2694	CRYSTAL LAKE	89 (31)	89 (31)	89 (31)	89 (31)	91 (32)	36 (12)	483
2695	HIGGINS LAKE	94 (33)	94 (33)	97 (34)	97 (34)	97 (34)	57 (20)	536
2696	HOUGHTON LAKE	83 (29)	86 (30)	91 (32)	71 (25)	71 (25)	79 (26)	481
2697	THOMPSON LAKE	51 (18)	49 (17)	60 (21)	83 (29)	51 (18)	11 (2)	305
2698	PERE MARQUETTE LAKE	63 (22)	51 (18)	71 (25)	49 (17)	54 (19)	66 (23)	354
2699	STRAWBERRY LAKE	43 (15)	34 (12)	49 (17)	74 (26)	57 (20)	27 (9)	284

APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MICHIGAN 2/3/75

LAKE CODE 2695 HIGGINS LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 49.20

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2695A1	49.20	31.20	36.60	39.30	55.90	53.60	60.60	59.10	42.90	31.50	32.90	27.80	28.60	41.68
2695B1	10.50	1.50	1.40	1.90	2.80	2.10	1.70	1.40	1.20	1.40	1.40	1.60	1.50	1.66
2695ZZ	38.70	29.70	35.20	37.40	53.10	51.50	58.90	57.70	41.70	30.10	31.50	26.20	27.10	40.03

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 49.20
SUM OF SUB-DRAINAGE AREAS = 49.20
TOTAL FLOW IN = 500.00
TOTAL FLOW OUT = 500.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2695A1	10	72	41.00	28	45.00				
	11	72	29.00	22	28.00				
	12	72	30.00	19	30.00				
	1	73	44.00	20	60.00				
	2	73	48.00	24	46.00				
	3	73	55.00	24	49.00				
	4	73	50.00	7	54.00	21	48.00		
	5	73	55.00	5	54.00	19	51.00		
	6	73	66.00	23	57.00				
	7	73	62.00	21	53.00				
	8	73	45.00	23	43.00				
	9	73	31.00	28	32.00				
2695B1	10	72	1.80	28	1.90				
	11	72	1.70	22	1.60				
	12	72	1.50	19	1.60				
	1	73	2.10	20	2.80				
	2	73	1.90	24	1.80				
	3	73	2.70	24	2.40				
	4	73	2.40	7	2.60	21	2.30		
	5	73	2.20	5	2.20	19	2.00		
	6	73	1.90	23	1.60				
	7	73	1.50	21	1.30				
	8	73	1.30	23	1.20				
	9	73	1.40	28	1.50				
2695ZZ	10	72	39.00						
	11	72	28.00						
	12	72	29.00						
	1	73	42.00						
	2	73	46.00						
	3	73	52.00						
	4	73	48.00						
	5	73	53.00						
	6	73	64.00						
	7	73	60.00						
	8	73	44.00						
	9	73	30.00						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

269501
44 29 30.0 084 42 30.0
HIGGINS LAKE
26 MICHIGAN

11EPALES
4

2111202
0120 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	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/15	11	05 0000	17.0	8.4	348	235	8.29	120	0.020	0.030	0.005	0.002
	11	05 0040	8.0	11.2								
	11	05 0045	6.5	12.4		235	7.70	120	0.020	0.010K	0.009	0.002K
	11	05 0100	5.0	11.2		240	7.53	120	0.020	0.010	0.010	0.002
72/09/16	15	15 0000			148	240	7.80	95	0.040	0.060	0.005	0.005
	15	15 0004	18.2	9.3		228	7.90	94	0.040	0.060	0.005	0.004
	15	15 0015	18.2	9.4		225	7.90	102	0.040	0.050	0.005	0.005
	15	15 0022	18.2	9.2		225	7.95	102	0.040	0.050	0.005	0.005
	15	15 0030	18.2	9.2		225	7.95	102	0.030	0.040	0.008	0.004
	15	15 0038	18.1	9.4		225	8.00	101	0.030	0.040	0.006	0.005
	15	15 0046	13.3	10.6		235	7.90	109	0.040	0.040	0.002	0.002K
	15	15 0054	8.8	9.8		240	7.73	115	0.030	0.040	0.004	0.002K
	15	15 0064	7.9	9.1		250	7.70	112	0.030	0.050	0.005	0.002K
	15	15 0074	7.7	9.0		240	7.70	114	0.030	0.040	0.007	0.002K
	15	15 0084	7.5	8.8		245	7.60	114	0.030	0.050	0.007	0.002K
72/11/14	13	45 0000			228	240	8.10	110	0.020	0.030	0.007	0.006
	13	45 0004	6.5	11.1		235	8.10	109	0.030	0.040	0.007	0.006
	13	45 0015	6.5	10.7		235	8.10	109	0.020	0.030	0.006	0.005
	13	45 0025	6.4									
	13	45 0035	6.4									
	13	45 0045	6.5	10.7		235	8.10	110	0.030	0.040	0.008	0.005
	13	45 0055	6.5									
	13	45 0065	6.4									
	13	45 0075	6.3	11.4		216	8.10	109	0.020	0.030	0.007	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/15	11	05 0000	1.1J
72/09/16	15	15 0000	0.6J
72/11/14	13	45 0000	1.1J

K VALUE KNOWN TO BE LESS THAN INDICATED

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

269502
44 28 30.0 084 44 30.0
HIGGINS LAKE
26 MICHIGAN

11EPALES 2111202
4 0035 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	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/15	12 00	0000	16.0	8.4	348							
	12 00	0035	10.0	5.6		235	7.72	122	0.020	0.020	0.010	0.006
72/09/16	14 45	0000			144	223	8.15	101	0.040	0.050	0.002K	0.002K
	14 45	0004		9.1		225	8.23	100	0.040	0.030	0.002K	0.002K
	14 45	0015	18.0	9.3		223	8.20	103	0.040	0.050	0.005	0.003
	14 45	0022	17.9	9.5		223	8.25	102	0.030	0.040	0.004	0.003
	14 45	0030	17.4	9.5		230	8.20	103	0.030	0.040	0.004	0.003
72/11/14	14 15	0000			228	220	8.20	111	0.020	0.030	0.007	0.004
	14 15	0004	5.8	11.2		220	8.20	109	0.020	0.030	0.007	0.004
	14 15	0016	5.8	10.6		220	8.20	116	0.020	0.030	0.008	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/09/16	14 45	0000	0.6J
72/11/14	14 15	0000	2.0J

K VALUE KNOWN TO BE LESS THAN INDICATED

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

269503
44 27 00.0 084 41 30.0
HIGGINS LAKE
26143 MICHIGAN

11EPALES 2111202
6 0000 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	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/09/16	11 30	0000			180	225	8.20	102	0.030	0.050	0.005	0.004
	11 30	0004	18.1	10.4		225	8.25	110	0.030	0.040	0.005	0.003
	11 30	0015	18.1	11.2		221	8.25	108	0.030	0.040	0.008	0.004
	11 30	0022	18.1	9.2		222	8.30	109	0.030	0.040	0.005	0.003
	11 30	0030	18.1	9.9		222	8.30	108	0.040	0.050	0.004	0.003
	11 30	0040	16.3	10.7		222	8.30	116	0.040	0.050	0.005	0.005
	11 30	0050	9.1	9.7		240	8.10	118	0.040	0.060	0.010	0.006
	11 30	0059	8.3	8.2		240	8.00	119	0.040	0.050	0.013	0.009
	11 30	0069	8.0	8.3		240	7.90	118	0.040	0.040	0.006	0.003
	11 30	0079	7.7	8.5		245	7.85	118	0.030	0.040	0.007	0.005
	11 30	0089	7.7	10.0		248	7.85	117	0.030	0.040	0.006	0.003
72/11/14	14 40	0000			228	230	8.10	107	0.040	0.050	0.006	0.004
	14 40	0004	6.7	11.6		225	8.20	110	0.020	0.030		0.004
	14 40	0015	6.7	10.3		230	8.20	109	0.030	0.040	0.007	0.006
	14 40	0025	6.7									
	14 40	0035	6.7									
	14 40	0045	6.7	10.2		230	8.20	108	0.020	0.030	0.006	0.005
	14 40	0055	6.7									
	14 40	0065	6.7	10.6		230	8.20	109	0.020	0.030	0.006	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/09/16	11 30	0000	0.6J
72/11/14	14 40	0000	1.3J

J VALUE KNOWN TO BE IN ERROR

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/04

2695A1 LS2695A1
44 26 00.0 084 40 30.0
UNNAMED OUTLET HIGGINS/MARL LK
26 7.5 LYON MANOR
O/HIGGINS LAKE
BRDG SE CORNER HIGGINS 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
72/10/28	11	10	0.017	0.350	0.015	0.005K	0.005
72/11/22	11	20	0.022	2.400	0.078	0.010	0.010
72/12/19	11	30	0.015	0.440	0.023	0.005K	0.005
73/01/20	14	00		0.190			0.005K
73/02/24	10	15	0.010K	0.300	0.010	0.005K	0.005K
73/03/24	10	35	0.042	0.100K	0.005K	0.005K	0.005K
73/04/07	11	30	0.013	2.600	0.062	0.005K	0.010
73/04/21	11	20	0.023	0.850	0.048	0.013	0.020
73/05/05	12	00	0.033	0.295	0.021	0.005K	0.010
73/05/19	11	00	0.010K	0.370	0.027	0.005K	0.005K
73/06/23	11	45	0.025	0.420	0.055	0.005K	0.010
73/07/21	10	40	0.010K	0.270	0.017	0.005K	0.005K
73/08/23	15	30	0.010K	0.220	0.015	0.007	0.010
73/09/28	13	30	0.055	0.370	0.027		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

269581 LS269581
44 30 00.0 084 47 00.0
BIG CREEK
26 15 HOUGHTON LAKE
T/HIGGINS LAKE
US 27 BRDG IN TOWN OF HIGGINS 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
72/10/28	10 05		0.031	0.950	0.056	0.006	0.016
72/11/22	09 00		0.029	0.400	0.015	0.005K	0.009
72/12/19	09 05		0.039	0.990	0.039	0.005K	0.008
73/02/24	08 20		0.035	0.520	0.029	0.005K	0.010
73/03/24	08 20		0.025	0.350	0.005K	0.005K	0.010
73/04/07	09 00		0.028	1.540	0.075	0.005K	0.015
73/04/21	08 30		0.035	1.890	0.132	0.008	0.025
73/05/05	09 00		0.052	1.500	0.052	0.005K	0.010
73/05/19	08 20		0.023	0.460	0.048	0.005K	0.010
73/06/23			0.023	0.260	0.033	0.005K	0.010
73/07/21	09 25		0.011	0.100K	0.008	0.005K	0.005K
73/09/28	13 30		0.036	0.160	0.035	0.008	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED