

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES**



REPORT
ON
MUSKEGON LAKE
MUSKEGON COUNTY
MICHIGAN
EPA REGION V
Working Paper No. 203

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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WITH THE COOPERATION OF THE
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
AND THE
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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 identifying point sources and soliciting municipal participation in the Survey.

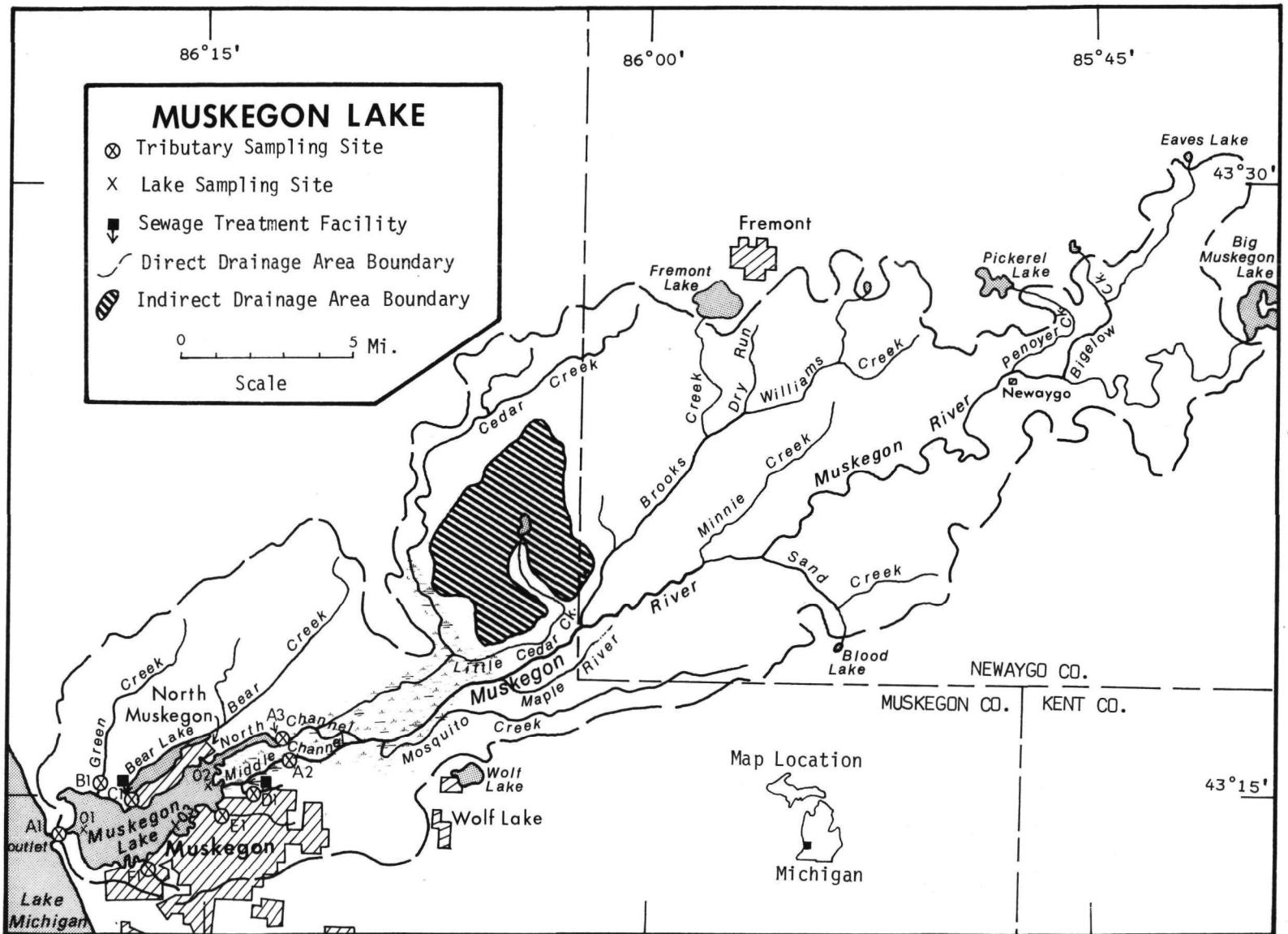
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MICHIGAN

<u>LAKE NAME</u>	<u>COUNTY</u>
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



MUSKEGON LAKE

STORET NO. 2659

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Muskegon Lake is eutrophic. Of the 35 Michigan lakes sampled in November when essentially all were well-mixed, 21 had less mean total phosphorus, 19 had less mean dissolved phosphorus, and 14 had less mean inorganic nitrogen; of the 41 Michigan lakes sampled, ten had less mean chlorophyll a, but 16 had greater Secchi disc transparency*. Ketelle and Uttormark (1971) report that excessive weed growths and algal blooms are problems at this lake.

B. Rate-Limiting Nutrient:

The results of the algal assay show that Muskegon Lake was nitrogen limited at the time the sample was collected (09/19/72). The lake data indicate nitrogen limitation at the other sampling times as well (N/P ratios were 11/1 or less, and nitrogen limitation would be expected).

C. Nutrient Controllability:

1. Point sources--During the sampling year, Muskegon Lake received a total phosphorus load at a rate more than three times the rate proposed by Vollenweider as "dangerous"; i.e., a eutrophic rate (see page 13). However, the hydraulic retention time

* See Appendix A.

of Muskegon Lake is a relatively short 23 days, and Vollenweider's model may not be applicable.

Sewage effluents from the cities of Muskegon and Roosevelt Park as well as industrial wastes (not measured or estimated in this study) were diverted to a cropland spray-irrigation management system that became operational in May, 1973 (Bastian, 1974).

The phosphorus loads from the municipal point sources noted above amounted to about 7% of the total load during the sampling year. After diversion, it is calculated that the loading rate was reduced to $4.4 \text{ g/m}^2/\text{yr}$ or about twice the eutrophic rate. However, since the applicability of Vollenweider's model is questionable, and since unmeasured industrial nutrient loads were also diverted, it is believed the trophic condition of Muskegon Lake will improve significantly once a new phosphorus equilibrium is attained.

2. Non-point sources--During the sampling year, it is estimated that non-point sources, including precipitation, contributed about 65% of the total phosphorus load to Muskegon Lake.

Except for the Muskegon River and Green Creek, the phosphorus exports of the Muskegon Lake tributaries were unusually high, especially the smaller Four Mile, Ryerson, and Ruddiman creeks

drainages (see page 13). It is probable that the high exports of the latter streams are due to urban drainage.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry[†]:

1. Surface area: 4,150 acres.
2. Mean depth: 23.5 feet.
3. Maximum depth: 69 feet.
4. Volume: 97,525 acre-feet.
5. Mean hydraulic retention time: 23 days.

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

1. Tributaries -

<u>Name</u>	<u>Drainage area*</u>	<u>Mean flow*</u>
Muskegon River	2,567.0 mi ²	2,078.7 cfs
Green Creek	11.7 mi ²	11.8 cfs
Bear Lake outlet	28.6 mi ²	29.5 cfs
Four Mile Creek	3.4 mi ²	3.1 cfs
Ryerson Creek	7.6 mi ²	7.1 cfs
Ruddiman Creek	3.4 mi ²	3.1 cfs
Minor tributaries & immediate drainage -	<u>5.8 mi²</u>	<u>9.7 cfs</u>
Totals	2,627.5 mi ²	2,143.0 cfs

2. Outlet -

Muskegon River	2,634.0 mi ² **	2,143.0 cfs
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C. Precipitation***:

1. Year of sampling: 31.8 inches.
2. Mean annual: 30.2 inches.

[†] Fetterolf, 1973.

* Drainage areas are accurate within $\pm 5\%$; mean daily flows for 74% of the sampling sites are accurate within $\pm 25\%$ and the remaining sites up to $\pm 40\%$; 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

Muskegon 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 44 feet at station 1, 31 feet at station 2, and 59 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:

<u>Parameter</u>		<u>FALL VALUES</u> <u>(11/14/72)</u>		
	<u>Minimum</u>	<u>Mean</u>	<u>Median</u>	<u>Maximum</u>
Temperature (Cent.)	7.1	7.4	7.5	7.5
Dissolved oxygen (mg/l)	9.4	9.7	9.6	10.1
Conductivity (μmhos)	330	365	370	380
pH (units)	7.7	7.7	7.7	7.8
Alkalinity (mg/l)	142	148	147	164
Total P (mg/l)	0.046	0.087	0.059	0.530
Dissolved P (mg/l)	0.035	0.043	0.039	0.059
$\text{NO}_2 + \text{NO}_3$ (mg/l)	0.150	0.186	0.160	0.600
Ammonia (mg/l)	0.210	0.283	0.220	1.210
<u>ALL VALUES</u>				
Secchi disc (inches)	60	64	62	72

B. Biological characteristics:

1. Phytoplankton* -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Number per ml</u>
09/19/72	1. Melosira 2. Anabaena 3. Flagellates 4. Stephanodiscus 5. Marssionella Other genera	1,525 506 145 145 126 <u>597</u>
	Total	3,044
11/14/72	1. Lyngbya 2. Oscillatoria 3. Dinobryon 4. Microcystis 5. Anabaena Other genera	2,132 675 229 193 157 <u>613</u>
	Total	3,999

2. Chlorophyll a -

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

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll a ($\mu\text{g/l}$)</u>
06/13/72	01	13.0
	02	17.9
	03	28.1
09/19/72	01	8.8
	02	3.7
	03	10.0
11/14/72	01	2.5
	02	0.5
	03	1.1

* The June sample was lost in shipment.

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

<u>Spike (mg/l)</u>	<u>Ortho P Conc. (mg/l)</u>	<u>Inorganic N Conc. (mg/l)</u>	<u>Maximum yield (mg/l-dry wt.)</u>
Control	0.055	0.238	7.3
0.010 P	0.065	0.238	7.4
0.020 P	0.075	0.238	7.4
0.050 P	0.105	0.238	7.2
0.050 P + 5.0 N	0.105	5.238	35.8
0.050 P + 10.0 N	0.105	10.238	37.9
10.0 N	0.105	10.238	14.0

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Muskegon Lake was high at the time the assay sample was collected. Also, the lack of significant increase in yields with increasing increments of orthophosphorus, until nitrogen was also added, indicates that the lake was limited by nitrogen at sampling time (09/19/72). Note that the addition of only nitrogen resulted in a yield much greater than the control yield.

The lake data further substantiate nitrogen limitation. On all occasions, the nitrogen to phosphorus ratios were less than 11 to 1.

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, June, and July when two samples were collected. 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 loadings 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 $\text{lbs}/\text{mi}^2/\text{year}$, at stations B-1, C-1, D-1, E-1, and F-1 and multiplying the means by the ZZ area in mi^2 .

Nutrient loads for the cities of Muskegon and Roosevelt Park were estimated at 2.5 lbs P and 7.5 lbs N/capita/year. The diversion of the municipal and industrial wastes of Muskegon and Roosevelt Park was instituted in May, 1973, when a cropland spray-irrigation wastewater management system began pumping wastewater to aeration and storage lagoons (Bastian, 1974). The estimated nutrient loads from the above

* See Working Paper No. 1.

communities were adjusted for this diversion and represent the loads for eight months of the sampling year.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Muskegon	51,081	(land disp.)	8.700	Muskegon Lake
Roosevelt Park	2,578	(land disp.)	0.600	Muskegon Lake

2. Industrial - Unknown

* Bastian, 1973.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>lbs P/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Muskegon River	152,680	60.1
Green Creek	640	0.3
Bear Lake outlet	3,370	1.3
Four Mile Creek	1,680	0.7
Ryerson Creek	2,410	0.9
Ruddiman Creek	1,350	0.5
b. Minor tributaries & immediate drainage (non-point load) -		1,590
c. Known municipal STP's -		0.6
Muskegon	85,140	33.5
Roosevelt Park	4,300	1.7
d. Septic tanks* -		100
e. Known industrial - Unknown		-
f. Direct precipitation** -		<u>650</u>
Total	253,910.	100.0

2. Outputs -

Lake outlet - Muskegon River 250,690

3. Net annual P accumulation - 3,220 pounds

* Estimate based on 151 shoreline dwellings and one State park; see Working Paper No. 1.

** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>lbs N/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Muskegon River	3,613,530	88.0
Green Creek	24,630	0.6
Bear Lake outlet	73,530	1.8
Four Mile Creek	9,100	0.2
Ryerson Creek	37,410	0.9
Ruddiman Creek	15,420	0.4
b. Minor tributaries & immediate drainage (non-point load) -	19,500	0.5
c. Known municipal STP's -		
Muskegon	255,400	6.2
Roosevelt Park	12,890	0.3
d. Septic tanks* -	3,630	0.1
e. Known industrial - Unknown	-	-
f. Direct precipitation** -	<u>39,980</u>	<u>1.0</u>
Total	4,105,020	100.0

2. Outputs -

Lake outlet - Muskegon River 3,942,810

3. Net annual accumulation - 162,210 pounds

* Estimate based on 151 shoreline dwellings and one State park; see Working Paper No. 1.

** See Working Paper No. 1.

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

<u>Tributary</u>	<u>1bs P/mi²/yr</u>	<u>1bs N/mi²/yr</u>
Muskegon River	59	1,408
Green Creek	55	2,105
Bear Lake outlet	118	2,571
Four Mile Creek	494	2,676
Ryerson Creek	317	4,922
Ruddiman Creek	397	4,535

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".

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

<u>Units</u>	<u>Total Phosphorus</u>		<u>Total Nitrogen</u>	
	<u>Total</u>	<u>Accumulated</u>	<u>Total</u>	<u>Accumulated</u>
1bs/acre/yr	61.2	0.8	989.2	39.1
grams/m ² /yr	6.86	0.09	110.9	4.4

Vollenweider loading rates for phosphorus (g/m²/yr) based on mean depth and mean hydraulic retention time of Muskegon Lake:

"Dangerous" (eutrophic rate) 2.00
 "Permissible" (oligotrophic rate) 1.00

V. LITERATURE REVIEWED

Bastian, Robert K., 1973. Project status and research at Muskegon, Michigan. Symp. on Land Treatment of Secondary Effluent, Boulder, CO, November 8-9.

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Fetterolf, Carlos, 1973. Personal communication (lake morphometry). MI Dept. Nat. Resources, Lansing.

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES			ALL VALUES		
		MEAN TOTAL P	MEAN DISS P	MEAN INORG N	500- MEAN SEC	MEAN CHLORA	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-----			-----ALL VALUES-----		
		MEAN TOTAL P	MEAN DISS P	MEAN INORG N	500- MEAN SEC	MEAN CHLORA	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-----			-----ALL VALUES-----			INDEX NO
		MEAN TOTAL P	MEAN DISS P	MEAN INORG N	500+ MEAN SEC	MEAN CHLORA	15- MIN DO	
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-----			-----ALL VALUES-----			INDEX NO
		MEAN TOTAL P	MEAN DISS P	MEAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	
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 2659 MUSKEGON LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 2634.00

TRIBUTARY	SUB-DRAINAGE AREA (SQ MI)		NORMALIZED FLOWS (CFS)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	
2659A1	2634.00	2019.40	2182.30	3244.40	3740.10	2715.90	2091.40	1515.80	1284.00	1354.90	1608.70	1984.40	1998.40	2143.05
2659A2	1283.00	878.00	948.00	1416.00	1626.00	1192.00	917.00	666.00	564.00	595.00	702.00	864.00	866.00	935.36
2659A3	1284.00	1074.00	1159.00	1730.00	1987.00	1456.00	1121.00	813.00	690.00	728.00	858.00	1057.00	1058.00	1143.26
2659B1	11.70	12.60	13.80	18.40	20.60	12.80	9.40	6.60	5.80	6.80	9.20	12.20	14.20	11.85
2659C1	28.60	34.20	39.20	46.70	48.00	29.70	24.00	16.10	12.20	12.50	23.50	31.00	37.70	29.50
2659D1	3.44	3.10	3.50	4.90	5.70	3.60	2.70	1.80	1.60	1.60	2.30	3.10	3.60	3.12
2659E1	7.59	6.90	7.60	10.70	12.60	8.20	6.20	4.30	4.00	4.20	5.40	7.00	8.00	7.08
2659F1	3.37	3.00	3.40	4.80	5.60	3.60	2.70	1.90	1.80	1.80	2.40	3.10	3.60	3.14
2659ZZ	12.00	9.00	10.00	15.00	17.00	12.00	10.00	7.00	6.00	6.00	7.00	9.00	9.00	9.74

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2634.00
SUM OF SUB-DRAINAGE AREAS = 2633.70

TOTAL FLOW IN = 25739.41
TOTAL FLOW OUT = 25739.68

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2659A1	10	72	1750.00	29	1820.00				
	11	72	2240.00						
	12	72	2030.00	3	2350.00				
	1	73	3910.00	7	2200.00				
	2	73	2910.00	4	3740.00				
	3	73	4990.00	4	3360.00				
	4	73	3410.00	6	3970.00	27	2610.00		
	5	73	2460.00	15	3060.00				
	6	73	2490.00	3	3340.00	23	1490.00		
	7	73	1650.00	10	1520.00	11	1500.00	28	1450.00
2659A2	8	73	1480.00	27	1250.00				
	9	73	1280.00	29	1300.00				
	10	72	917.00	29	941.00				
	11	72	1192.00						
	12	72	1070.00	3	1260.00				
	1	73	2080.00	7	1170.00				
	2	73	1560.00	4	2000.00				
	3	73	2680.00	4	1730.00				
	4	73	1820.00	6	2130.00	27	1400.00		
	5	73	1290.00	15	1640.00				
	6	73	1330.00	3	1770.00	23	792.00		
	7	73	886.00	10	808.00	11	803.00	28	776.00
	8	73	792.00	27	671.00				
	9	73	688.00	29	732.00				

TRIBUTARY FLOW INFORMATION FOR MICHIGAN

2/3/75

LAKE CODE 2659 MUSKEGON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2659A3	10	72	751.00	29	770.00				
	11	72	976.00						
	12	72	879.00	3	1030.00				
	1	73	1700.00	7	958.00				
	2	73	1280.00	4	1630.00				
	3	73	2190.00	4	1420.00				
	4	73	1480.00	6	1740.00	27	1140.00		
	5	73	1050.00	15	1340.00				
	6	73	1090.00	3	1450.00	23	648.00		
	7	73	724.00	10	662.00	11	657.00	28	634.00
	8	73	648.00	27	549.00				
	9	73	562.00	29	598.00				
2659B1	10	72	1.60	29	2.40				
	11	72	1.80						
	12	72	1.60	3	1.50				
	1	73	4.30	7	2.90				
	2	73	2.60	4	3.90				
	3	73	4.50	4	7.80				
	4	73	4.00	6	3.70	27	2.90		
	5	73	4.30	15	3.00				
	6	73	2.30	3	3.90	23	1.60		
	7	73	1.10	10	1.10	11	1.00	28	1.10
	8	73	1.10	27	1.10				
	9	73	1.00	29	1.10				
2659C1	10	72	40.00	29	51.00				
	11	72	34.00						
	12	72	40.00	3	23.00				
	1	73	51.00	7	30.00				
	2	73	27.00	4	42.00				
	3	73	46.00	4	107.00				
	4	73	44.00	6	36.00	27	27.00		
	5	73	55.00	15	33.00				
	6	73	27.00	3	53.00	23	16.00		
	7	73	17.00	10	18.00	11	14.00	28	13.00
	8	73	12.00	27	10.00				
	9	73	9.40	29	11.00				
2659D1	10	72	1.40	29	1.90				
	11	72	1.50						
	12	72	1.30	3	1.20				
	1	73	3.80	7	2.40				
	2	73	2.20	4	3.40				
	3	73	4.00	4	7.30				
	4	73	3.60	6	3.20	27	2.40		
	5	73	3.80	15	2.60				
	6	73	1.30	3	1.80	23	0.90		
	7	73	0.80	10	0.80	11	0.80	28	0.80
	8	73	0.90	27	0.90				
	9	73	0.70	29	0.70				

TRIBUTARY FLOW INFORMATION FOR MICHIGAN

2/3/75

LAKE CODE 2659 MUSKEGON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2659E1	10	72	13.00	29	17.00				
	11	72	13.00						
	12	72	14.00	3	9.90				
	1	73	19.00	7	13.00				
	2	73	12.00	4	18.00				
	3	73	20.00	4	35.00				
	4	73	18.00	6	17.00	27	13.00		
	5	73	19.00	15	14.00				
	6	73	11.00	3	18.00	23	7.00		
	7	73	6.50	10	6.60	11	5.70	28	5.50
2659F1	8	73	5.40	27	4.90				
	9	73	4.60	29	5.00				
	10	72	18.00	29	24.00				
	11	72	18.00						
	12	72	19.00	3	13.00				
	1	73	27.00	7	18.00				
	2	73	16.00	4	24.00				
	3	73	28.00	4	49.00				
	4	73	25.00	6	23.00	27	18.00		
	5	73	27.00	15	19.00				
2659ZZ	6	73	15.00	3	24.00	23	9.80		
	7	73	8.80	10	9.00	11	7.80	28	7.60
	8	73	7.40	27	6.80				
	9	73	6.30	29	6.90				
	10	72	10.00						
	11	72	10.00						
	12	72	10.00						
	1	73	20.00						
	2	73	10.00						
	3	73	20.00						
	4	73	20.00						
	5	73	10.00						
	6	73	10.00						
	7	73	10.00						
	8	73	10.00						
	9	73	10.00						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

265901
43 14 00.0 086 19 00.0
MUSKEGON LAKE
26 MICHIGAN

11EPALES
S 2111202
0030 FEET DEPTH

DATE	TIME	DEPTH	00010 WATER OF TO CENT	00300 DU	00077 TRANSP SECCHI	00094 CNDUCTVY FIELD	00400 PH	00410 TALK CACO3	00630 NU2&N03 N-TOTAL	00610 NH3-N TOTAL	00665 PHOS-TOT	00666 PHOS-DIS
			MG/L	MG/L	INCHES	MICROMHO	SU	MG/L	MG/L	MG/L	MG/L P	MG/L P
72/06/13	01	35 0000	18.2	7.8	62	360	8.30	127	0.040	0.060	0.058	0.044
	01	35 0015	17.5	7.1		360	8.20	126	0.040	0.090	0.053	0.044
	01	35 0030	15.5	6.6		360	8.15	124	0.070	0.130	0.058	0.045
72/09/19	11	50 0000			60	328	8.48	130	0.020	0.050	0.048	0.037
	11	50 0004	20.4	9.0		340	8.50	131	0.030	0.060	0.058	0.040
	11	50 0015	20.4	8.8		340	8.45	129	0.030	0.050	0.068	0.047
	11	50 0022	20.3	8.6		330	8.45	129	0.030	0.060	0.066	0.051
	11	50 0030	20.0	8.2		340	8.35	129	0.030	0.060	0.068	0.049
	11	50 0037	20.0	3.8		330	7.80	125	0.030	0.360	0.142	0.080
	11	50 0044	17.7	4.0		330	7.85	127	0.030	0.360	0.100	0.063
72/11/14	11	25 0000			72	380	7.80	144	0.150	0.220	0.530	0.036
	11	25 0004	7.5	9.4		370	7.80	142	0.150	0.220	0.048	0.037
	11	25 0015	7.5	9.5		370	7.80	147	0.150	0.220	0.046	0.037
	11	25 0022	7.5	9.6		380	7.70	144	0.150	0.210	0.053	0.036
	11	25 0030	7.5	9.5		380	7.70	144	0.160	0.220	0.058	0.039
	11	25 0044	7.5	9.6		370	7.70	144	0.160	0.220	0.059	0.037

32217
DATE TIME DEPTH CHLORPHYL
FROM OF A
TO DAY FEET UG/L

72/06/13	01	35 0000	13.0
72/09/19	11	50 0000	8.8
72/11/14	11	25 0000	2.5

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

265902
43 14 00.0 086 15 00.0
MUSKEGON LAKE
26 MICHIGAN

DATE FROM TO	TIME OF DAY	DEPTH FEET	WATER TEMP CENT	00010	00300	00077	00094	00400	00410	00630	00610	00665	00666
				DO MG/L	TRANSP SECCHI INCHES	CNDCTVY FIELD MICROMHO	PH SU	TALK CACO3 MG/L	NU2&N03 N-TOTAL MG/L	NH3-N TOTAL MG/L	PHOS-TOT MG/L P	PHOS-DIS MG/L P	
72/06/13	02 20	0000	21.2	8.0	60	340	8.10	129	0.110	0.160	0.079	0.066	
	02 20	0015	18.5	7.4		350	8.10	127	0.100	0.150	0.080	0.066	
	02 20	0025	15.6	3.6		350	7.85	128	0.110	0.380	0.089	0.083	
72/09/19	09 25	0000			60	345	8.00	132	0.070	0.180	0.079	0.067	
	09 25	0004	20.0	6.4		340	8.00	132	0.080	0.180	0.090	0.068	
	09 25	0015	20.0	5.9		340	8.00	131	0.060	0.170	0.087	0.065	
	09 25	0020	19.9	6.0		345	8.00	131	0.070	0.180	0.104	0.063	
	09 25	0025	19.5	4.2		330	7.80	134	0.040	0.270	0.096	0.058	
	09 25	0031	19.1	4.3		333	7.80	133	0.040	0.280	0.071	0.055	
72/11/14	12 25	0000			66	380	7.80	164	0.600	1.210	0.065	0.049	
	12 25	0004	7.4	9.9		380	7.80	149	0.170	0.230	0.065	0.051	
	12 25	0015	7.3	9.8		380	7.80	150	0.170	0.230	0.070	0.055	
	12 25	0021	7.2	9.9		380	7.80	153	0.170	0.240	0.071	0.057	
	12 25	0028	7.1	10.1		380	7.80	151	0.190	0.240	0.077	0.059	

32217			
DATE FROM TO	TIME OF DAY	DEPTH FEET	CHLRPHYL UG/L
72/06/13	02 20	0000	17.9J
72/09/19	09 25	0000	3.7J
72/11/14	12 25	0000	0.5J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

265903
43 14 00.0 086 16 00.0
MUSKEGON LAKE
26 MICHIGAN

DATE FROM TO	TIME OF DAY	DEPTH FEET	WATER TEMP CENT	00010 DO MG/L	00300 TRANSP SECCHI INCHES	00077 FIELD MICROMHO	00094 CNDUCTVY	11EPALES		2111202 0050 FEET DEPTH		00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
								00400 PH SU	00410 ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L		
72/06/13	15 00	0000	19.6	9.0	66	355	6.30	128	0.140	0.140	0.064	0.054	
	15 00	0015	18.1	7.0		360	8.20	127	0.090	0.130	0.059	0.050	
	15 00	0030	16.1			300	7.95	125	0.060	0.150	0.052	0.027	
72/09/19	10 05	0000			60	340	8.25	128	0.030	0.060	0.051	0.040	
	10 05	0004	20.2	8.0		335	8.25	128	0.020	0.050	0.060	0.040	
	10 05	0015	20.0	7.4		340	8.15	127	0.030	0.060	0.062	0.042	
	10 05	0021	20.0	7.2		340	8.15	126	0.030	0.070	0.065	0.044	
	10 05	0028	19.9	6.9		340	8.10	127	0.030	0.090	0.057	0.042	
	10 05	0035	19.4	1.8		320	7.63	125	0.040	0.490	0.089	0.073	
	10 05	0042	17.0	1.0		325	7.60	124	0.020	0.810	0.131	0.110	
	10 05	0050	14.9	0.2		308	7.45	123	0.030	0.890	0.156	0.111	
	10 05	0059	14.2	0.4		300	7.50	123	0.030	0.900	0.149	0.111	
72/11/14	11 55	0000			66	360	7.70	149	0.150	0.220	0.063	0.044	
	11 55	0004	7.5	9.6		360	7.70	150	0.150	0.220	0.058	0.043	
	11 55	0015	7.5	9.6		340	7.70	152	0.160	0.230	0.066	0.043	
	11 55	0025	7.5	9.6		330	7.70	145	0.160	0.220	0.048	0.035	
	11 55	0040	7.5	9.5		330	7.70	145	0.160	0.220	0.048	0.036	
	11 55	0054	7.4	9.6		330	7.70	147	0.170	0.240	0.047	0.036	

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217	
			CHLRPHYL A UG/L	
72/06/13	15 00	0000	28.10	
72/09/19	10 05	0000	10.00	
72/11/14	11 55	0000	1.10	

J VALUE KNOWN TO BE IN ERROR

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/04

2659A1 LS2659A1
 43 14 00.0 086 20 00.0
 MUSKEGON RIVER
 26 15 LAKE HARBOR
 U/MUSKEGON LAKE
 SAMPLE OUTLET CHANNEL BEACHST IN MUSKEGN
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE	TIME	DEPTH	00630 NO ₂ &NO ₃ N-TOTAL	00625 TOT KJEL N	00610 NH ₃ -N TOTAL	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
FROM	OF		MG/L	MG/L	MG/L	MG/L P	MG/L P
TO	DAY	FEET					
72/10/29	11	40	0.156	0.600	0.147	0.034	0.075
72/12/03	10	40	0.197	0.880	0.132	0.042	0.072
73/01/07	10	50	0.300	0.690	0.120	0.040	0.072
73/02/04	09	35	0.370	0.580	0.051	0.029	0.060
73/03/04	10	00	0.350	0.700	0.105	0.033	0.070
73/04/06	16	25	0.260	0.630	0.050	0.023	0.060
73/04/27	10	50	0.062	0.760	0.026	0.017	0.057
73/05/15	09	00	0.048	0.660	0.011	0.006	0.060
73/06/03	11	00	0.010K	1.000	0.037	0.014	0.060
73/06/23	16	10	0.011	0.960	0.008	0.011	0.050
73/07/10	10	50	0.022	1.680	0.038	0.007	0.055
73/07/28	08	30	0.080	0.750	0.018	0.012	0.037
		15 00	0.072	0.630	0.054	0.020	0.045
73/09/29	09	30	0.058	0.460	0.056	0.010	0.050

K VALUE KNOWN TO BE
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2659A2 LS2659A2
 43 16 00.0 086 12 30.0
 MUSKEGON RIVER
 26 15 TWIN LAKE
 I/MUSKEGON LAKE
 MIDDLE CHANNEL N EDGE OF MUSKEGON
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS URTHO MG/L P	00665 PHOS-TUT MG/L P
72/10/29	10	15	0.169	0.575	0.050	0.012	0.047
72/12/03	10	05	0.210	0.440	0.031	0.014	0.028
73/01/07	13	35	0.510	0.630	0.038	0.016	0.028
73/02/04	09	00	0.430	0.460	0.040	0.018	0.035
73/03/04	09	15	0.430	0.630	0.066	0.020	0.055
73/04/06	14	00	0.138	0.460	0.024	0.008	0.020
73/04/27	09	50	0.066	0.540	0.008	0.008	0.030
73/05/15	09	40	0.110	0.560	0.008	0.005K	0.035
73/06/03	09	30	0.150	1.100	0.037	0.014	0.035
73/06/23	15	15	0.176	0.560	0.015	0.014	0.040
73/07/10	11	30	0.130	0.660	0.040	0.005K	0.037
73/07/28	09	25	0.098	0.480	0.026	0.022	0.045
73/07/30	14	50	0.063	0.700	0.017	0.015	0.035
73/09/29	11	30	0.082	0.400	0.026	0.026	0.050

K VALUE KNOWN TO BE
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2659A3 LS2659A3
 43 16 30.0 086 12 30.0
 MUSKEGON RIVER
 26 15 TWIN LAKE
 17 MUSKEGON LAKE
 NORTH CHANNEL 1.5 MI E NORTH MUSKEGON
 11 EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 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
72/10/29	10 55		0.084	0.450	0.046	0.009	0.031
72/12/03	10 09		0.200	2.400	0.095	0.011	0.022
73/01/07	13 50		0.399	0.500	0.025	0.014	0.028
73/02/04	08 45		0.378	0.500	0.040	0.014	0.030
73/03/04	09 20		0.440	0.900	0.076	0.018	0.050
73/04/06	14 07		0.147	0.500	0.019	0.007	0.020
73/04/27	10 05		0.079	0.580	0.008	0.008	0.030
73/05/15	09 50		0.052	0.660	0.007	0.009	0.030
73/06/03	09 40		0.140	1.150	0.048	0.024	0.045
73/06/23	15 25		0.180	1.260	0.046	0.026	0.050
73/07/10	11 40		0.130	0.450	0.017	0.007	0.040
73/07/28	09 15		0.013	0.500	0.023	0.011	0.055
73/07/30	14 30		0.065	0.820	0.039	0.011	0.035
73/09/29	12 25		0.084	0.340	0.023	0.025	0.050

STORET RETRIEVAL DATE 75/02/04

265981 LS265981
 43 15 00.0 086 19 00.0
 GREEN CREEK
 26 15 LAKE HARBOR
 T/MUSKEGON LAKE
 BRDG 1.5 MI W N MUSKEGON STP DISC TO LK
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 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
72/10/29	11 25		0.156	1.050	0.115	0.006	0.022
72/12/03	10 35		0.300	2.730	0.144	0.008	0.018
73/02/04	09 30		0.300	0.360	0.052	0.006	0.015
73/03/04	09 50		0.340	0.585	0.064	0.007	0.025
73/04/06	15 20		0.220	1.650	0.060	0.006	0.015
73/04/27	10 45		0.126	0.610	0.029	0.011	0.055
73/05/15	09 15		0.140	0.840	0.069	0.007	0.025
73/06/03	10 50		0.086	0.740	0.084	0.025	0.055
73/06/23	15 50		0.022	2.800	0.060	0.022	0.080
73/07/10	11 00		0.029	0.580	0.032	0.008	0.030
73/07/28	08 45		0.010K	0.520	0.027	0.016	0.030
73/07/30	08 45		0.013	0.540	0.022	0.017	0.030
73/09/29	09 45		0.072	0.500	0.105	0.013	0.035

K VALUE KNOWN TO BE
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2659C1 LS2659C1
 43 14 30.0 086 18 00.0
 REAR LAKE OUTLET
 26 15 LAKE HARBOR
 T/MUSKEGON LAKE
 ST HWY 213 BRDG SW NORTH MUSKEGON
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 N-TOTAL	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS TOTAL MG/L P	00665 PHOS-TOT MG/L P
			00630 N02&N03 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS TOTAL MG/L P	00665 PHOS-TOT MG/L P
72/10/29	11 15		0.104	1.350	0.080	0.006	0.048
72/12/03	10 28		0.273	10.000	0.410	0.014	0.050
73/02/04	09 15		0.430	0.630	0.130	0.010	0.030
73/03/04	09 45		0.450	0.660	0.147	0.006	0.030
73/04/06	15 00		0.270	0.630	0.042	0.010	0.040
73/04/27	10 25		0.017	0.740	0.009	0.006	0.045
73/05/15	09 25		0.010K	0.600	0.005K	0.006	0.050
73/06/03	10 40		0.012	1.700	0.037	0.007	0.040
73/06/23	15 45		0.011	2.400	0.035	0.010	0.070
73/07/10	11 10		0.015	1.320	0.023	0.008	0.090
73/07/28	09 00		0.294	1.500	0.035	0.023	0.107
73/07/30	08 00		0.010K	1.320	0.105	0.026	0.095
73/09/29	09 55		0.013	0.780	0.032	0.010	0.065

K VALUE KNOWN TO BE
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

265901 LS265901
 43 15 00.0 086 13 30.0
 FOURMILE CREEK
 26 15 MUSKEGON
 T/MUSKEGON LAKE
 CITY BRDG W US31 BRDG N EDGE MOSKEGON
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03	00625 TOT KJEL	00610 NH3-N	00671 PHOS-DIS	00665 PHOS-TOT	
			MG/L	MG/L	MG/L	MG/L P	MG/L P	
72/10/29	10	40		1.070	0.700	0.147	0.210	0.260
72/12/03	09	58		0.300	1.470	0.140	0.132	0.160
73/01/07	13	28		1.780	1.600	0.220	0.147	0.170
73/02/04	09	00		1.640	1.000	0.160	0.084	0.150
73/03/04	09	05		1.420	0.660	0.120	0.130	0.165
73/04/06	14	41		1.220	0.540	0.037	0.140	0.175
73/04/27	09	50		0.850	0.635	0.072	0.240	0.280
73/05/15	10	05		0.730	0.710	0.087	0.200	0.230
73/06/03	10	30		0.115	1.150	0.132	0.280	0.380
73/06/23	15	00		0.072	0.600	0.140	0.354	0.410
73/07/11	08	30		0.014	0.750	0.168	0.420	0.560
73/07/29	09	45		0.013	1.100	0.150	0.330	0.385
73/08/27	06	55		0.010K	0.585	0.180	0.378	0.470
73/09/29	11	45		0.580	0.230	0.078	0.280	0.315

K VALUE KNOWN TO BE
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2659E1 LS2659E1
 43 14 30.0 086 14 30.0
 BYERSON CREEK
 26 15 MUSKEGON
 T/MUSKEGON LAKE
 AT US 16 BRDG IN MUSKEGON
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 N-TOTAL	00625 TOT KJEL MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
			00630 N02&N03 N-TOTAL	00625 TOT KJEL MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/29	10 30		1.400	1.750	0.420	0.072	0.176
72/12/03	11 05		0.420	2.600	0.540	0.087	0.140
73/01/07	11 32		2.100	1.200	0.530	0.073	0.100
73/02/04	10 15		1.620	1.380	0.054	0.020	0.110
73/03/04	10 30		1.520	1.200	0.320	0.060	0.110
73/04/06	15 40		1.520	1.750	0.315	0.058	0.110
73/04/27	11 25		1.360	0.880	0.231	0.065	0.130
73/05/15	12 00		1.440	1.100	0.290	0.088	0.160
73/06/03	13 15		0.890	0.980	0.200	0.154	0.270
73/06/23	16 45		1.220	1.800	0.378	0.100	0.200
73/07/11	08 45		0.730	0.960	0.270	0.147	0.260
73/07/29	10 00		1.200	0.900	0.265	0.087	0.185
73/08/27	07 05		1.200	0.880	0.345	0.105	0.170
73/09/29	12 00		1.480	0.940	0.410	0.068	0.175

STORET RETRIEVAL DATE 75/02/04

2659F1 LS2659F1
 43 13 00.0 086 17 00.0
 RODDIMAN CREEK
 26 15 LAKE HARBOR
 T/MUSKEGON LAKE
 LAKESHORE DRIVE BRDG W EDGEMUSKEGON
 11EPALES 2111204
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL	00625 KJEL N	00610 NH3-N TOTAL	00671 PHOS-DIS ORTHO	00665 PHOS-TOT MG/L P
			MG/L	MG/L	MG/L	MG/L P	MG/L P
72/10/29	10 00		0.420	0.900	0.370	0.105	0.160
72/12/03	09 40		0.260	1.320	0.290	0.115	0.180
73/01/07	14 40		1.440	1.260	0.410	0.126	0.250
73/02/04	08 00		1.620	2.940	0.460	0.150	0.270
73/03/04	08 45		1.680	2.200	0.430	0.230	0.360
73/04/06	13 00		0.890	1.000	0.210	0.048	0.130
73/04/27	14 05		0.780	1.050	0.115	0.021	0.140
73/05/15	11 30		1.020	1.000	0.160	0.014	0.080
73/06/03	11 30		0.720	1.890	0.016	0.019	0.150
73/06/23	14 35		0.550	1.470	0.190	0.081	0.225
73/07/10	16 40		0.240	1.700	0.061	0.029	0.140
73/07/29	09 25		0.410	1.000	0.100	0.048	0.145
73/09/29	12 30		0.590	0.840	0.060	0.032	0.135