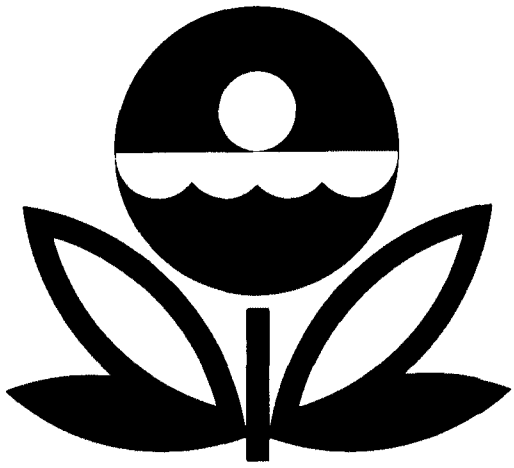
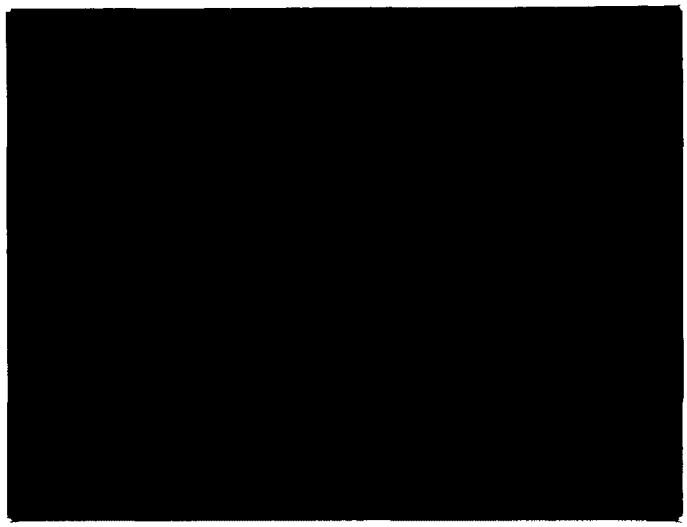
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES





PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

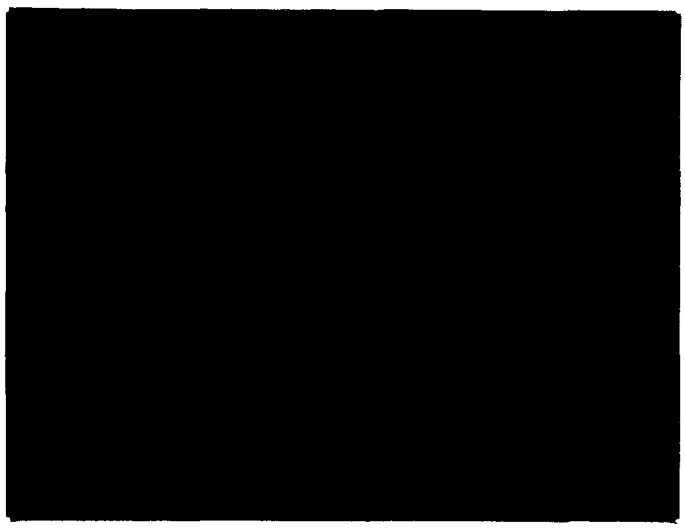
An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

☆GPO—697-032



REPORT
ON
DEER LAKE
MARQUETTE COUNTY
MICHIGAN
EPA REGION V
WORKING PAPER No. 192

WITH THE COOPERATION OF THE
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
AND THE
MICHIGAN NATIONAL GUARD

FEBRUARY, 1975

CONTENTS

	Page
Foreword	ii
List of Michigan Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	8
V. Literature Reviewed	13
VI. Appendices	14

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.

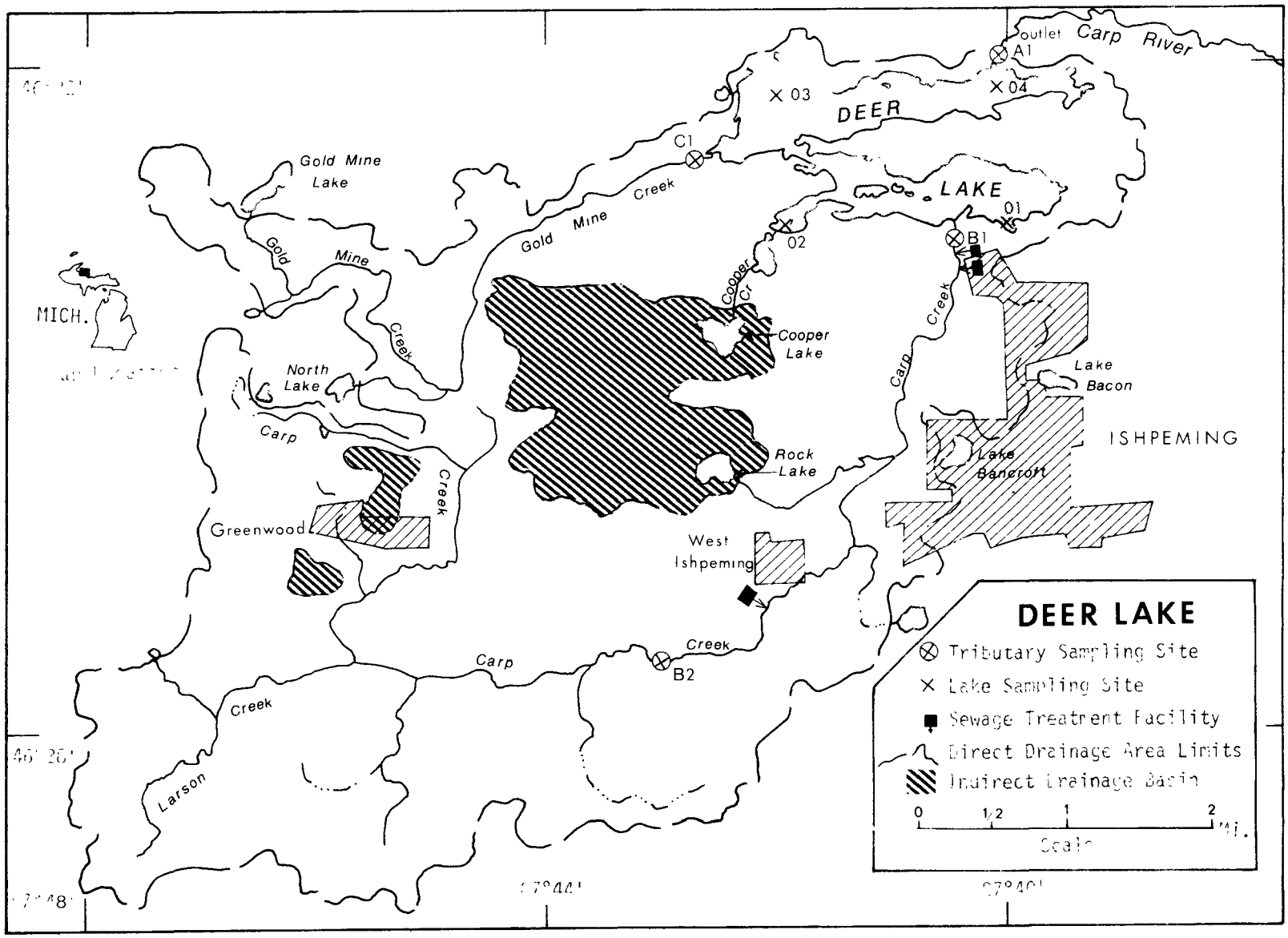
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

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


outlet
Carp River
A1
X 03
X 04
DEER
LAKE
C1
01
02
B1
Gold Mine Lake
Gold Mine Creek
Gold Mine Creek
MICH.
Cooper Cr
Cooper Lake
Carp Creek
Lake Bacon
North Lake
Carp Creek
Rock Lake
Lake Bancroft
ISHPEMING
Greenwood
West Ishpeming
Carp Creek
B2
Carp Creek
Larson
DEER LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Direct Drainage Area Limits
Indirect Drainage Basin
0 1/2 1 2 Mi.
Scale

DEER LAKE

STORET NO. 2624

I. CONCLUSIONS

A. Trophic Condition:

Deer Lake was sampled only two times. On the basis of these somewhat limited data, it appears that the lake is eutrophic. Of the 35 Michigan lakes on which sampling was completed, 31 had less mean total and dissolved phosphorus, 16 had greater Secchi disc transparency, and 25 had less mean chlorophyll a*.

Survey limnologists noted heavy algal growths in many portions of the lake.

B. Rate-Limiting Nutrient:

An algal assay sample was not taken at Deer Lake. However, the lake data indicate nitrogen limitation in June and September (i.e., N/P ratios were 3/1 or less).

C. Nutrient Controllability:

1. Point sources--During the sampling year, Deer Lake received a total phosphorus load at a rate nearly four times that proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 12). Now, Vollenweider's model may not apply to water bodies with short hydraulic retention times,

* See Appendix A.

and the hydraulic retention time of Deer Lake is not known. However, the maximum depth sounded by Survey limnologists was 24 feet; and, if it is assumed that the mean depth is about one-third of that (i.e., eight feet), the mean hydraulic retention time would be about 90 days. If the assumed mean depth is reasonable, Vollenweider's model may be applicable to Deer Lake, although it is noted that less than 9% of the total phosphorus load was retained in the lake which indicates a rather short retention time.

It is calculated that the wastewater treatment plants serving Ishpeming and Ishpeming Township contributed nearly 85% of the total phosphorus load to Deer Lake during the sampling year. Removal of 80% of the phosphorus at these sources would reduce the loading rate to 0.76 $g/m^2/yr$ or about 1.2 times the eutrophic rate. In view of the questionable applicability of Vollenweider's model, it is likely that the reduced loading would improve the trophic condition of the lake and, in particular, reduce the incidence and severity of nuisance algal blooms as well as provide additional protection for downstream Lake Superior.

2. Non-point sources (see page 12)--During the sampling year, the phosphorus export of Gold Mine Creek was a rather

high 100 lbs/mi^2/yr. The relatively high Carp Creek export may have been due to underestimation of the phosphorus load from the Ishpeming Township B plant.

In all, it is estimated that non-point sources, including precipitation, contributed only about 15% of the total phosphorus load to Deer Lake during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 897 acres.
2. Mean depth: unknown.
3. Maximum depth: >20 feet.
4. Volume: unknown.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
Carp Creek	24.0 mi^2	28.2 cfs
Gold Mine Creek	4.9 mi^2	6.0 cfs
Minor tributaries & immediate drainage -	6.0 mi^2	6.2 cfs
Totals	34.9 mi^2	40.4 cfs

2. Outlet -

Carp River	36.3 mi^2**	40.4 cfs

C. Precipitation***:

1. Year of sampling: 37.9 inches.
2. Mean annual: 32.0 inches.

---

† Miller and Thompson, 1970.
* 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

Deer Lake was sampled twice 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 four stations on the lake and from a number of 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 a similar sample was collected for chlorophyll a analysis. The maximum depths sampled were 13 feet at station 1, 16 feet at station 2, 16 feet at station 3, and 20 feet at station 4.

The results obtained are presented in full in Appendix C, and the data for the September 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 in June, refer to Appendix C.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (09/10/72)		
Temperature (Cent.)	16.9	17.3	17.4	17.6
Dissolved oxygen (mg/l)	6.4	8.0	7.8	9.4
Conductivity (μmhos)	220	228	225	240
pH (units)	8.2	8.4	8.4	8.6
Alkalinity (mg/l)	52	56	54	63
Total P (mg/l)	0.231	0.255	0.249	0.282
Dissolved P (mg/l)	0.203	0.219	0.218	0.243
NO_2 + NO_3 (mg/l)	0.030	0.038	0.040	0.050
Ammonia (mg/l)	0.060	0.082	0.070	0.170
		ALL VALUES		
Secchi disc (inches)	36	58	72	72

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/24/72	1. Fragilaria	4,955
	2. Polycystis	362
	3. Cyclotella	344
	4. Cryptomonas	127
	5. Anabaena	90
	Other genera	270
	Total	6,148
09/10/72	1. Microcystis	226
	2. Melosira	206
	3. Dinobryon	186
	4. Cyclotella	116
	5. Flagellates	105
	Other genera	467
	Total	1,306

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)
06/24/72	01	66.1
	02	42.8
	03	44.8
	04	18.3
09/10/72	01	4.0
	02	1.8
	03	2.3
	04	1.1

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 months of May and September 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 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 Gold Mine Creek at station C-1 and multiplying the means by the ZZ area in mi^2.

The operators of the Ishpeming and the Ishpeming Township A wastewater treatment plants provided monthly effluent samples and corresponding flow data. However, the Ishpeming Township B plant was not sampled, and nutrient loads were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

---

* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Ishpeming	8,000	Prim. clarifier	1.848	Carp River
Ishpeming Township A	1,550	Imhoff tank	0.129	Carp River
Ishpeming Township B	400	Imhoff tank	0.040**	Carp River

2. Known industrial - None

* Erickson, 1973.
** Estimated at 100 gal/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Carp Creek	2,410	12.8
Gold Mine Creek	160	0.8
b. Minor tributaries & immediate drainage (non-point load) -	200	1.1
c. Known municipal STP's -		
Ishpeming	11,300	59.9
Ishpeming Township A	3,660	19.4
Ishpeming Township B	1,000	5.3
d. Septic tanks - unknown	-	-
e. Known industrial - none	-	-
f. Direct precipitation* -	140	0.7
Total	18,870	100.0

2. Outputs -

Lake outlet - Carp River 17,240

3. Net annual P accumulation - 1,630 pounds

* 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) -		
Carp Creek	84,640	43.6
Gold Mine Creek	14,180	7.3
b. Minor tributaries & immediate drainage (non-point load) -	17,360	9.0
c. Known municipal STP's -		
Ishpeming	51,670	26.6
Ishpeming Township A	14,420	7.4
Ishpeming Township B	3,000	1.6
d. Septic tanks - unknown	-	-
e. Known industrial - none	-	-
f. Direct precipitation* -	8,640	4.5
Total	193,910	100.0

2. Outputs -

Lake outlet - Carp River 146,930

3. Net annual N accumulation - 46,980 pounds

* See Working Paper No. 1.

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

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Carp Creek	100	3,527
Gold Mine Creek	33	2,894

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 water 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.

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	21.0	1.8	216.2	52.4
grams/m^2/yr	2.36	0.20	24.2	5.9

Vollenweider loading rates for phosphorus (g/m^2/yr) based on surface area and mean outflow of Deer Lake:

"Dangerous" (eutrophic rate)	0.62
"Permissible" (oligotrophic rate)	0.31

V. LITERATURE REVIEWED

Erickson, John, 1973. Treatment plant questionnaire (Ishpeming and Ishpeming Township treatment plants). MI Dept. of Publ. Health, Escanaba.

Miller, J. B., and T. Thompson, 1970. Compilation of data for Michigan lakes. U.S. Geol. Survey, Dept. Interior, and MI Dept. of Nat. Resources, Lansing.

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	RUSS 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 2624 DEER LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 36.30

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2624A1	36.30	45.71	64.10	58.98	18.49	23.51	46.42	36.04	33.16	43.50	37.98	35.47	43.71	40.45
2624B1	24.00	18.00	16.10	19.30	65.20	50.50	30.20	23.10	19.30	21.60	25.50	26.80	22.00	28.15
2624C1	4.89	4.30	3.80	4.60	11.50	9.70	6.60	5.30	4.60	5.00	5.80	6.00	5.20	6.04
2624ZZ	7.40	2.60	2.00	3.00	21.40	14.50	6.60	4.10	3.00	3.70	4.80	5.40	3.80	6.24

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 36.30
SUM OF SUB-DRAINAGE AREAS = 36.29
TOTAL FLOW IN = 484.90
TOTAL FLOW OUT = 487.07

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2624A1	10	72	45.00						
	11	72	74.00	4	117.00				
	12	72	102.00	2	96.00				
	1	73	104.00						
	2	73	94.00						
	3	73	16.00						
	4	73	5.00						
	5	73	38.00						
	6	73	88.00						
	7	73	84.00	15	82.00				
	8	73	53.00						
	9	73	49.00						
2624B1	10	72	40.00	28	30.00				
	11	72	40.00						
	12	72	20.00	2	22.00				
	1	73	19.00	6	20.00				
	2	73	15.00	3	17.00				
	3	73	54.00	3	17.00				
	4	73	64.00	7	57.00				
	5	73	73.00	2	104.00	10	138.00	20	41.00
	6	73	28.00	2	27.00				
	7	73	21.00	15	16.00				
	8	73	21.00	17	14.00				
	9	73	18.00	9	13.00	25	20.00		

LAKE CODE 2624 DEER LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2624C1	10	72	8.20	28	7.20				
	11	72	8.30						
	12	72	5.50	2	6.00				
	1	73	5.30	6	5.50				
	2	73	4.60	3	4.40				
	3	73	10.00	3	4.70				
	4	73	11.00	7	9.50				
	5	73	12.00	2	19.00	10	23.00	20	8.20
	6	73	6.70	2	6.50				
	7	73	5.60	15	4.60				
	8	73	5.60	17	4.20				
	9	73	5.10	9	4.10	25	5.40		
2624Z2	10	72	14.00						
	11	72	14.00						
	12	72	5.00						
	1	73	4.70						
	2	73	3.20						
	3	73	22.00						
	4	73	24.00						
	5	73	31.00						
	6	73	8.10						
	7	73	5.40						
	8	73	5.30						
	9	73	4.20						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

262401
46 31 00.0 087 40 00.0
DEER LAKE
26 MICHIGAN

11EPALES 2111202
5 0016 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
72/06/24	13 25	0000	16.0	12.0	72	185	8.50	60	0.080	0.110	0.099	0.076
	13 25	0012	15.8	10.4		180	8.61	60	0.070	0.090	0.099	0.076
72/09/10	16 55	0000			42		8.60	63	0.040	0.090	0.249	0.228
	16 55	0004	17.1	9.2		236	8.60	63	0.050	0.100	0.266	0.222
	16 55	0013	16.9	8.0		240	8.50	63	0.050	0.170	0.282	0.243

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/24	13 25	0000	56.1J
72/09/10	16 55	0000	4.0J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

262402
46 31 00.0 087 42 00.0
DEER LAKE
26 MICHIGAN

11EPALES 2111202
5 0020 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
72/06/24	14 00	0000	16.2	11.6	72	180	8.69	59	0.040	0.070	0.084	0.064
	14 00	0015	15.0	10.9		175	8.62	63	0.080	0.300	0.172	0.115
72/09/10	17 10	0000					8.50	54	0.030	0.060	0.231	0.215
	17 10	0004	17.2	6.4		225	8.50	54	0.030	0.060	0.249	0.212
	17 10	0016	17.0	7.6		230	8.40	58	0.040	0.070	0.246	0.203

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/24	14 00	0000	42.8J
72/09/10	17 10	0000	1.8J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

262403
46 32 00.0 087 42 00.0
DEER LAKE
26 MICHIGAN

11EPALES 2111202
5 0017 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
72/06/24	14 20	0000	16.0	11.7	72	160	8.58	55	0.050	0.100	0.088	0.062
	14 20	0015	15.2	7.9		165	7.61	58	0.050	0.160	0.147	0.088
72/09/10	17 25	0000			39		8.30	54	0.040	0.070	0.241	0.210
	17 25	0004	17.4	7.8		225	8.20	53	0.030	0.070	0.247	0.218
	17 25	0016	17.4	7.9		225	8.30	53	0.030	0.070	0.264	0.211

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/24	14 20	0000	44.8J
72/09/10	17 25	0000	2.3J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 75/02/04

262404
46 32 00.0 087 40 00.0
DEER LAKE
26 MICHIGAN

11EPALES 2111202
5 0024 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
72/06/24	14 45	0000	16.0	11.6	72	155	8.63	55	0.040	0.060	0.067	0.054
	14 45	0020	12.0	5.4		180	6.96	65	0.040	0.680	0.359	0.288
72/09/10	17 40	0000			36		8.30	54	0.040	0.080	0.244	0.220
	17 40	0004	17.5	7.7		220	8.30	52	0.040	0.070	0.279	0.217
	17 40	0015	17.6	7.8		225	8.40	57	0.040	0.090	0.244	0.224
	17 40	0019	17.6	9.4		225	8.30	54	0.040	0.070	0.268	0.225

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/24	14 45	0000	18.3J
72/09/10	17 40	0000	1.1J

J VALUE KNOWN TO BE I... FROM

APPENDIX D

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/04

202441 202483
46 32 00.0 087 40 00.0
CARP RIVER
26 15 VEGAUNEE
U/DEER LK MARQUETTE CO
RD EASTERLY FROM CO RD N END 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
72/11/04	13 45		0.018	1.600	0.084	0.030	0.200
72/12/02	13 45		[illegible]	1.000	0.192	0.069	0.120
73/01/07	14 00		0.120	1.000	0.350	0.105	0.160
73/02/03	12 35		0.210	3.780	0.700	0.154	0.240
73/05/26	11 00		[illegible]	1.000	0.037	0.009	0.050
73/06/02	13 30		0.020	2.200	0.090	0.069	0.050
73/07/15	15 00		0.014	1.700	0.490	0.240	0.330
73/08/17	10 30		0.040	1.640	0.370	0.350	0.430
73/09/25	10 25		0.020	1.000	0.072	0.154	0.240

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

262431 L5262461
46 30 00.0 087 46 30.0
CARP CREEK
26 15 MENOMINEE
1/DEER LAKE MARQUETTE CO
CO RD BRDG N ISHPEMING NEARLK BELO STP'S
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	15	14	0.300	2.730	0.780	0.215	0.660
72/12/02	09	40	0.420	2.600	0.600	0.131	0.235
73/01/06	11	15	0.420	1.540	0.655	0.176	0.300
73/02/03	14	00	0.430	5.700	1.100	0.300	0.720
73/03/03	10	30	0.460	1.600	0.670	0.154	0.315
73/04/07	09	15	0.400	0.880	0.190	0.052	0.115
73/05/02	20	30	0.330	1.650	0.091	0.037	0.115
73/05/10	11	30	0.088	2.200	0.061	0.006	0.020
73/05/20	09	00	0.920	1.500	0.180	0.052	0.100
73/06/02	11	25	0.860	1.540	0.378	0.105	0.210
73/07/15	10	45	0.570	2.700	0.460	0.090	0.270
73/08/17	11	15	0.610	2.400	0.700	0.138	0.390
73/09/09	15	30	0.054	2.730	0.052	0.026	0.680
73/09/25	11	00	0.490	3.150	1.020	0.200	0.480

STORET RETRIEVAL DATE 75/02/04

262482 L5262482
46 28 00.0 087 43 00.0
CARP CREEK
26 15 ISHPEMING
T/DEER LAKE-MARQUETTE CO
CO RD BRDG 1 MI SW W ISHPEMING ABOVE STP
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
72/12/09	09 45		0.231	0.520	0.024	0.005K	0.009
73/01/06	10 35		0.273	2.940	0.168	0.007	0.011
73/02/03	11 25		0.260	0.390	0.092	0.006	0.006
73/03/03	10 00		0.280	0.320	0.077	0.011	0.015
73/04/07	09 30		0.220	1.750	0.083	0.006	0.015
73/05/02	19 45		0.100	0.440	0.014	0.006	0.020
73/05/10	12 30		1.020	2.300	0.168		
73/05/20	08 30		0.200	2.200	0.082	0.008	0.015
73/06/02	10 30		0.180	0.440	0.054	0.006	0.015
73/07/15	10 15		0.180	0.890	0.092	0.012	0.015
73/08/17	11 30		0.154	1.050	0.049	0.007	0.015
73/09/09	14 00		0.110	0.750	0.078	0.010	0.015
73/09/25	11 10		0.115	0.340	0.048	0.007	0.015

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2524C1 LS2624C1
45 31 00.0 087 42 30.0
GOLD MINE CREEK
26 15 NEGAUNEE
T/DEER LAKE-MARQUETTE CO
XING CO RD W END LK 2.5 MI NNW ISHPEMING
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	14 55		0.170	0.610	0.044	0.005K	0.009
72/12/02	09 20		0.200	0.400	0.026	0.005K	0.006
73/01/06	10 50		0.260	0.245	0.033	0.005K	0.006
73/03/03	11 00		0.240	0.225	0.044	0.005K	0.010
73/04/07	09 00		0.190	0.500	0.063	0.005K	0.015
73/05/02	20 00		0.170	0.500	0.025	0.005K	0.025
73/05/10	12 00		0.188	3.100	0.064	0.007	0.025
73/05/20	09 30		0.184	2.200	0.065	0.006	0.010
73/06/02	11 38		0.220	0.720	0.038	0.008	0.010
73/07/15	10 55		0.260	1.100	0.075	0.005K	0.010
73/08/17	11 00		0.220	0.780	0.052	0.014	0.020
73/09/04	15 00		0.025	1.300	0.033	0.005K	0.015
73/09/25	10 50		0.180	0.900	0.063	0.008	0.010

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 73/02/04

262450 PR262450 P008000
46 30 00.0 087 41 00.0
ISHPEMING
26 15 ISHPEMING
T/DEER LAKE
CARP CREEK
TIEPALES 2141204
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	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/02	07 00								
CP(T)-			0.520	11.000	0.820	0.905	2.400	1.470	2.250
73/01/02	16 00								
73/02/05	07 00								
CP(T)-			0.580	8.900	0.840	0.880	2.600	1.400	1.500
73/02/05	16 00								
73/03/05	08 00								
CP(T)-			0.590	9.350	2.300	0.910	2.650	1.730	1.500
73/03/05	16 00								
73/04/02	07 00								
CP(T)-			0.920	5.800	1.100	0.370	1.550	2.100	2.500
73/04/02	16 00								
73/05/01	09 00		0.780	6.600	1.500	0.500	1.350	3.220	1.750
73/06/04	08 00								
CP(T)-			0.820	8.100	1.010	0.800	2.700	1.900	2.000
73/06/04	16 00								
73/07/06	07 00								
CP(T)-			0.780	8.500	0.850		2.100	1.810	1.900
73/07/06	16 00								
73/08/01	08 00								
CP(T)-								2.300	1.900
73/08/01	16 00								
73/09/04	08 00								
CP(T)-			0.600	8.200	0.510	0.750	2.500	2.140	1.980
73/09/04	16 00								
73/10/31	07 00								
CP(T)-			0.890	8.150	0.120	0.420	1.530	2.100	1.600
73/10/31	16 00								
73/12/04	07 00								
CP(T)-			0.720	7.500	0.140	0.350	1.700	2.130	1.700
73/12/04	16 00								
74/01/22	07 00								
CP(T)-			1.000	12.00	0.300	0.440	1.450	1.800	1.650
74/01/22	16 00								

STORET RETRIEVAL DATE 75/02/04

4262451 1M262451 M001950
46 28 30.0 087 42 00.0
ISHPEMING TOWNSHIP
26 15 ISHPEMING
1/DEER LAKE
CARP CREEK
HIAWATHA 2141204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	NITROGEN NO2&NO3 N-TOTAL MG/L	NITROGEN TOT KJEL N MG/L	PHOSPHORUS TOTAL MG/L	PHOSPHORUS ORTHO MG/L P	PHOSPHORUS PHOS-TOT MG/L P	STREAM FLOW RATE INST CFS	STREAM CONDUIT FLOW-MGD MONTHLY
73/01/03	09 00		0.460	35.000	5.250	5.025		0.155	0.158
73/02/06	08 00		0.450	23.100	10.700	5.330	8.100		0.180
73/03/05	09 00		0.490	28.000	12.400	5.600	8.200	0.125	0.125
73/04/03	08 30		0.720	39.000	9.700	4.100	8.400	0.140	0.150
73/05/01	09 00		1.610	32.000	7.100	5.100	8.500	0.150	0.137
73/06/05	08 00								
CP(T)-			0.500	35.100	12.050	4.900	7.600	0.129	0.122
73/06/05	16 00								
73/07/06	08 00		0.540	28.000	9.900	4.940	8.000	0.151	0.126
73/08/02	11 00		0.480	33.600	8.700	4.100	10.000	0.105	0.126
73/09/04	08 00								
CP(T)-			0.092	29.600		4.720		0.142	0.122
73/09/04	16 00								
73/10/02	09 00		0.090	33.000	14.700	5.450	9.300	0.122	0.122
73/12/07	11 00		0.450	55.000	17.000	6.760	10.500	0.117	0.123
74/02/26	08 00		0.800	26.000	10.500	5.200	5.250	0.119	0.115
74/03/04	11 00		0.840	34.000	7.350	6.300	13.500	0.129	0.124