U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

GRAND LAKE

GREEN LAKE COUNTY

WISCONSIN

EPA REGION V

WORKING PAPER No. 38

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

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EPA REGION V

WORKING PAPER No. 38

WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

OCTOBER, 1974

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

Francis H. Schraufnagel, Acting Assistant Director, and Joseph R. Ball of the Bureau of Water Quality, and Donald R. Winter, Lake Rehabilitation Program, provided invaluable lake documentation and counsel during the Survey. Central Office and District Office personnel of the Department of Natural Resources reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

Major General James J. Lison, Jr., the Adjutant General of Wisconsin, and Project Officer CW-4 Donald D. Erickson, who directed the volunteer efforts of the Wisconsin National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

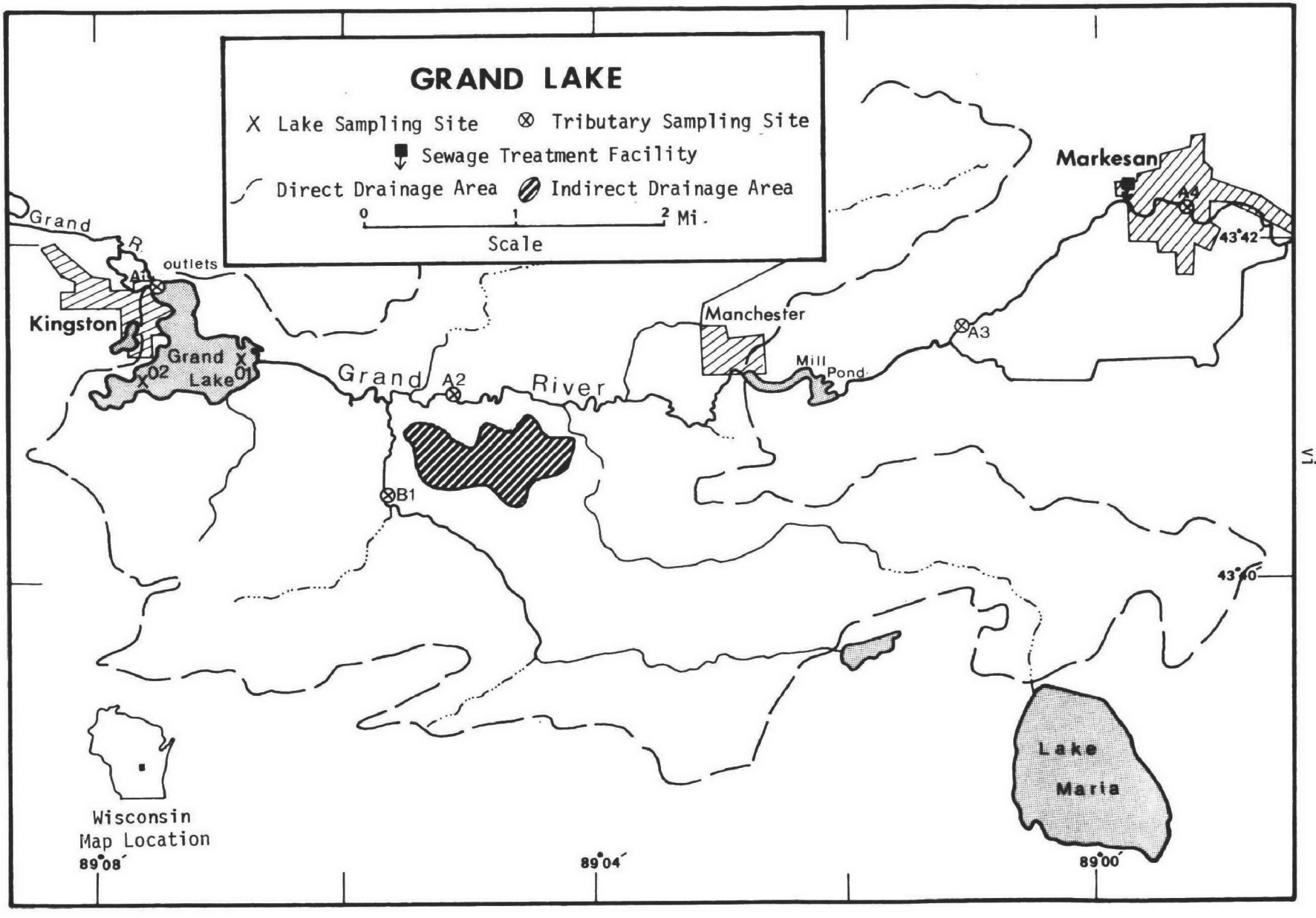
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WISCONSIN

LAKE NAME	COUNTY
Altoona	Eau Claire
Beaver Dam	Barron
Beaver Dam	Dodge
Big Eau Pleine	Marathon
Browns	Racine
Butte des Morts	Winnebago
Butternut	Price, Ashland
Castle Rock Flowage	Juneau
Como	Walworth
Crystal	Vilas
Delavan	Walworth
Eau Claire	Eau Claire
Elk	Price
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
Long	Price
Middle	Walworth
Nagawicka	Waukesha
Oconomowoc	Waukesha
Okauchee	Waukesha
Petenwell Flowage	Juneau
Pewaukee	Waukesha
Pigeon	Waupaca
Pine	Waukesha
Poygan	Winnebago, Waushara
Rock	Jefferson
Rome Pond	Jefferson, Waukesha
Round	Waupaca
Shawano	Shawano

LAKE NAME	COUNTY
Sinnissippi	Dodge
Swan	Columbia
Tainter	Dunn
Tichigan	Racine
Townline	Oneida
Trout	Vilas
Wapogassett	Polk
Wausau	Marathon
Willow	Oneida
Winnebago	Winnebago, Fond Du Lac, Calumet
Wisconsin	Columbia
Wissota	Chippewa
Yellow	Burnett


GRAND LAKE
X Lake Sampling Site
⊗ Tributary Sampling Site
Sewage Treatment Facility
Direct Drainage Area
Indirect Drainage Area
0 1 2 Mi.
Scale
Grand R.
outlets
A1
Kingston
Grand Lake
O2
O1
Grand River
A2
Manchester
A3
Mill Pond
Markesan
A4
43°42
43°40
B1
Lake Maria
Wisconsin
Map Location
89°08
89°04
89°00

vi

GRAND LAKE

STORET NO. 5570

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Grand Lake is eutrophic.

B. Rate-Limiting Nutrient:

The algal assay results indicate the rate-limiting nutrient in Grand Lake is phosphorus. Nitrogen to phosphorus ratios observed during lake sampling support this conclusion.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Grand Lake received a total phosphorus load at a rate about seven times greater than the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 13). It is estimated that only about 20% of this load is attributable to point sources, and it is considered unlikely that point-source control would improve the trophic condition of Grand Lake to any significant degree.

2. Non-point sources (see page 13)--The phosphorus export of the unnamed creek (B-1) was somewhat higher than unimpacted Wisconsin streams studied elsewhere. However, there are no known point sources impacting the stream, and the load probably results from agricultural practices in the drainage.

The estimated nutrient exports of the Grand River are about the same as the unnamed creek which indicates the point-source estimates are about right.

II. INTRODUCTION

Grand Lake is a small impoundment in the Upper Fox River Basin. The drainage is in a glaciated area of Wisconsin and is completely covered with glacial drift. The drainage is used primarily for agricultural purposes--mostly dairy farming and the growing of canning crops.

Recreational uses of the lake include boating and fishing. Game fish present include northern pike, largemouth bass, walleyes, and panfish.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry:

1. Surface area: 234 acres.
2. Mean depth: 4 feet.
3. Maximum depth: 7 feet.
4. Volume: 936 acre/feet.
5. Mean hydraulic retention time: 11 days.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
Grand River	73.7 mi^2	32.8 cfs
Unnamed Creek (B-1)	18.7 mi^2	6.7 cfs
Minor tributaries & immediate drainage -	5.0 mi^2	1.6 cfs
Totals	97.4 mi^2	41.1 cfs

2. Outlet -

Grand River	97.8 mi^2**	41.1 cfs

C. Precipitation†:

1. Year of sampling: 44.6 inches.
2. Mean annual: 26.5 inches.

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* Drainage areas are accurate within ±0.5%; mean daily flows are accurate within ±40%; mean monthly flows are accurate within ±35%; and normalized monthly flows are accurate within ±35%.

** Includes area of lake.

† See Working Paper No. 1, "Survey Methods".

IV. LAKE WATER QUALITY SUMMARY

By means of a Huey helicopter, Grand Lake was sampled three times at station 1 and twice at station 2 during the open-water season of 1972 (see map, page vi). Each time, surface samples for physical and chemical parameters were collected. During each visit, a single sample was composited from the two sites for phytoplankton identification and enumeration; and, during the last visit, a single five-gallon sample was collected for algal assays. Also each time, a sample was collected from each station for chlorophyll a analysis. Lack of depth at the sampling sites permitted only surface samples.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially 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 B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/08/72)		
Temperature (Cent.)		(not determined)		
Dissolved oxygen (mg/l)		(not determined)		
Conductivity (μmhos)	650	700	700	750
pH (units)	8.0	8.1	8.1	8.2
Alkalinity (mg/l)	270	285	285	300
Total P (mg/l)	0.044	0.092	0.092	0.140
Dissolved P (mg/l)	0.024	0.043	0.043	0.063
NO_2 + NO_3 (mg/l)	2.840	3.770	3.770	4.700
Ammonia (mg/l)	0.050	0.050	0.050	0.050
		ALL VALUES		
Secchi disc (inches)	16	22	24	24

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/22/72	1. Dinobryon	1,719
	2. Cyclotella	1,358
	3. Anabaena	1,312
	4. Melosira	860
	5. Oocystis	814
	Other genera	3,485
	Total	9,548
08/21/72	1. Cryptomonas	561
	2. Cyclotella	470
	3. Scenedesmus	266
	4. Flagellates	190
	5. Chroococcus	154
	Other genera	800
	Total	2,441
11/08/72	1. Stephanodiscus	5,542
	2. Fragilaria	1,386
	3. Cylindrocystis	783
	4. Flagellates	693
	5. Dinobryon	663
	Other genera	2,469
	Total	11,536

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)
06/22/72	01	13.4
	02	11.1
08/21/72	01	8.1
	02	-
11/08/72	01	270.0
	02	24.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.031	3.700	13.8
0.006 P	0.037	3.700	17.4
0.012 P	0.043	3.700	21.3
0.024 P	0.055	3.700	27.8
0.060 P	0.091	3.700	51.3
0.060 P + 10.0 N	0.091	13.700	52.1
10.0 N	0.031	13.700	14.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates the potential primary productivity of Grand Lake was high at the time the sample was taken. Also, the increased yields with increased levels of orthophosphorus (to about 0.090 mg/l) indicate that the lake was phosphorus

limited. Note that the addition of only nitrogen resulted in a yield not significantly different than that of the control.

D. Trophic Condition:

Grand Lake is eutrophic as indicated by high nutrient and chlorophyll a levels and low secchi disc transparencies. Algal assay results indicate the potential primary productivity in Grand Lake was high, and algal blooms were present during late summer and fall sampling periods. Also, heavy growths of aquatic vegetation were noted by Survey limnologists.

The lake morphometry is also indicative of a eutrophic water body.

V. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Wisconsin National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1972, and was completed in August, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Wisconsin 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 the unnamed creek at station B-1 and mulitplying the means by the ZZ area in mi^2.

The operator of the Markesan wastewater treatment plant provided too few samples to permit direct calculation of nutrient loadings from that source. Therefore, nutrient loads were estimated on the basis of 2.5 lbs of phosphorus and 7.5 lbs of nitrogen per capita per year.

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* See Working Paper No. 1.

The community of Manchester is served by individual septic tanks, and nutrient loads there were estimated using 0.25 lbs of phosphorus and 9.4 lbs of nitrogen per capita per year.

In the nutrient loading tables which follow, the loads attributed to the Grand River are those measured at station A-2 minus the loads attributed to Markesan and Manchester.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served*	Treatment	Mean Flow (mgd)	Receiving Water
Markesan	1,378	secondary	0.138*	Grand River
Manchester	777	septic tanks	?	Grand River drainage

2. Known industrial** -

Name	Treatment	Mean Flow (mgd)	Receiving Water
Markesan Dairy	(Markesan STP)	?	Grand River
Precision Metalsmiths Inc.	(Markesan STP)	?	Grand River

* 1970 Census; flow estimated at 100 gal/capita/day.
** Schraufnagel, et al., 1967.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Grand River	10,440	58.3
Unnamed Creek (B-1)	2,960	16.5
b. Minor tributaries & immediate drainage (non-point load) -	790	4.4
c. Known municipal -		
Markesan STP	3,450	19.3
Manchester (septic tanks)	190	1.1
d. Septic tanks* -	30	0.2
e. Known industrial - None known	-	-
f. Direct precipitation** -	40	0.2
Total	17,900	100.0

2. Outputs -

Lake outlet - Grand River 15,080

3. Net annual P accumulation - 2,820 pounds

* Two resorts and 35 dwellings on lakeshore (Fassvender and Weber, 1971); 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) -		
Grand River	271,360	73.6
Unnamed Creek (B-1)	60,060	16.3
b. Minor tributaries & immediate drainage (non-point load) -	16,060	4.4
c. Known municipal -		
Markesan STP	10,340	2.8
Manchester (septic tanks)	7,300	2.0
d. Septic tanks* -	1,180	0.3
e. Industrial - None known	-	-
f. Direct precipitation** -	2,250	0.6
Total	368,550	100.0

2. Outputs -

Lake outlet - Grand River 371,400

3. Net annual N loss - 2,850 pounds

* Two resorts and 35 dwellings on lakeshore (Fassvender and Weber, 1971); see Working Paper No. 1.
** 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
Grand River	142	3,682
Unnamed Creek (B-1)	158	3,212

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	76.5	12.1	1,575.0	loss*
grams/m^2/yr	8.57	1.35	176.5	-

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

"Dangerous" (eutrophic rate)	1.20
"Permissible" (oligotrophic rate)	0.60

* The apparent loss of nitrogen during the sampling year may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, or (probably) insufficient sampling. Whatever the cause, a similar loss of nitrogen has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication Research and Lake Restoration Branch.

VI. LITERATURE REVIEWED

Anonymous, 1972. Wisconsin lakes. Publ. 218-72, Dept. of Natural Resources, Madison.

Fassvender, Ronald L., and John J. Weber, 1971. Surface water resources of Green Lake County. Dept. of Natural Resources, Madison.

Schraufnagel, F. H., L. A. Montie, J. R. McKersie, and Donald Winter, 1967. Report on an investigation of the pollution in the Upper Fox River basin made during 1966 and early 1967. Dept. of Natural Resources, Madison.

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

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5570 GRAND LAKE

TOTAL DRAINAGE AREA OF LAKE 97.80

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5570A1	97.80	18.10	19.90	90.50	99.60	57.00	57.90	29.00	21.70	23.50	24.40	34.40	17.20	41.13
5570A2	73.70	14.00	15.00	76.00	77.00	46.00	48.00	23.00	17.00	18.00	19.00	27.00	13.00	32.79
5570B1	18.70	2.30	2.60	18.00	17.00	9.40	11.00	4.30	2.90	3.10	3.10	5.10	1.90	6.73
5570ZZ	5.40	0.50	0.50	4.90	4.20	2.30	3.00	0.90	0.60	0.60	0.60	1.10	0.30	1.63

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 97.80
SUM OF SUB-DRAINAGE AREAS = 97.80

TOTAL FLOW IN = 493.20
TOTAL FLOW OUT = 493.20

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5570A1	9	72	120.00	24	140.00				
	10	72	140.00	22	160.00				
	11	72	110.00						
	12	72	82.00	23	74.00				
	1	73	170.00						
	2	73	120.00	4	270.00				
	3	73	350.00	3	430.00				
	4	73	230.00	1	150.00	15	230.00		
	5	73	270.00	6	250.00	15	190.00		
	6	73	130.00	16	140.00				
	7	73	56.00	8	58.00				
	8	73	50.00	4	43.00				
5570A2	9	72	86.00	24	100.00				
	10	72	95.00	22	110.00				
	11	72	78.00						
	12	72	55.00	7	54.00	23	50.00		
	1	73	130.00						
	2	73	92.00	4	200.00				
	3	73	260.00	3	320.00				
	4	73	168.00	1	108.00	15	170.00		
	5	73	194.00	6	183.00	15	139.00		
	6	73	93.00	16	107.00				
	7	73	40.00	8	42.00				
	8	73	35.00	4	30.00				

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5570 GRAND LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5570B1	9	72	14.00	24	17.00				
	10	72	16.00	22	18.00				
	11	72	15.00						
	12	72	8.30	7	8.10	23	7.50		
	1	73	30.00						
	2	73	22.00	4	48.00				
	3	73	62.00	3	76.00				
	4	73	31.00	1	24.00	15	37.00		
	5	73	34.00	6	38.00	15	28.00		
	6	73	23.00	16	25.00				
	7	73	6.30	8	7.90				
	8	73	4.30	4	4.30				
5570ZZ	9	72	2.80	24	3.30				
	10	72	3.00	22	3.70				
	11	72	3.30						
	12	72	1.50	7	1.40	23	1.30		
	1	73	8.20						
	2	73	5.90	4	13.00				
	3	73	17.00	3	21.00				
	4	73	7.80	1	5.80	15	9.20		
	5	73	8.10	6	9.00	15	6.80		
	6	73	6.20	16	6.60				
	7	73	1.40	8	1.70				
	8	73	0.90	4	0.90				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

557001
43 41 18.0 089 06 54.0
GRAND LAKE
55 WISCONSIN

11EPALES
3

2111202
0003 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
72/06/22	10 00	0000	18.8	11.6	24	510	8.70	265	0.450	0.220	0.218	0.180
72/08/21	11 45	0000	25.6	5.8	24	500	8.00	196	0.070	0.130	0.264	0.227
72/11/08	15 40	0000			16	750	8.00	270	2.840	0.050	0.140	0.063

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/22	10 00	0000	13.4J
72/08/21	11 45	0000	8.1J
72/11/08	15 40	0000	270.0J

J= VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

557002
43 41 12.0 089 07 36.0
GRAND LAKE
55 WISCONSIN

11EPALES 2111202
3 0003 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
72/06/22	10 40	0000	19.3	9.4	24	430	8.90	210	0.050	0.140	0.190	0.150
72/11/08	15 50	0000			24	650	8.20	300	4.700	0.050	0.044	0.024

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/22	10 40	0000	11.1J
72/11/08	15 50	0000	24.0J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/02

5570A1 LS5570A1
43 42 00.0 089 07 30.0
GRAND RIVER
55 15 RANDOLPH
0/GRAND LAKE
ST HWY 44 BRDG NE OF KINGSTON
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
72/09/24	09	25	0.430	2.000	0.150	0.195	0.252
72/10/22	13	50	3.700	1.750	0.390	0.015	0.030
72/11/07	15	50	3.500	0.120	0.066	0.015	0.048
72/12/23	10	10	4.200	0.120	0.120	0.031	0.054
73/01/14	10	35	6.200	0.100K	0.052	0.037	0.050
73/02/04	14	30	3.000	3.360	0.690	0.280	0.410
73/03/03	14	15	3.200	4.690	1.890	0.330	0.460
73/04/01	11	09	3.200	0.910	0.017	0.039	0.090
73/04/15	13	20	2.600	1.050	0.026	0.044	0.085
73/05/06	13	25	0.350	1.600	0.037	0.062	0.095
73/05/15	14	30	4.600	0.960	0.021	0.028	0.065
73/06/16	11	00	0.960	2.000	0.210	0.140	0.195
73/07/08	08	00	0.033	1.380	0.189	0.273	0.370
73/08/04	14	45	1.880	2.200	0.113	0.032	0.105

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/02

5570A2 LS5570A2
43 41 00.0 089 05 00.0
GRAND RIVER
55 15 RANDOLPH
I/GRAND LAKE
CO RD XING 2 MI W .25 MI S OF MANCHESTER
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
72/09/24	09 40		0.460	1.250	0.139	0.225	0.280
72/10/22	14 05		3.600	1.450	0.056	0.092	0.160
72/12/07	16 05		4.800	0.105	0.105	0.044	0.083
72/12/23	10 17		4.300	0.190	0.138	0.050	0.100
73/02/04	14 40		3.400	3.500	0.680	0.300	0.430
73/03/03	14 20		3.000	5.000	2.100	0.430	0.610
73/04/01	11 14		3.900	1.100	0.078	0.050	0.100
73/04/15	13 40		3.100	1.400	0.073	0.042	0.085
73/05/06	13 40		0.063	0.740	0.016	0.042	0.070
73/05/15	14 00		3.300	0.880	0.016	0.015	0.045
73/06/16	11 15		1.640	1.500	0.082	0.176	0.275
73/07/09	08 30		1.040	0.800	0.054	0.189	0.250
73/08/04	14 30		1.920	2.520	0.078	0.010	0.070

STORET RETRIEVAL DATE 74/10/02

5570A3 LS5570A3
43 42 00.0 089 01 30.0
GRAND RIVER
55 15 RANDOLPH
I/GRAND LAKE
CO RD E OF MANCHESTER BELO MARKESAN 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
72/09/24	10 00		0.510	1.150	0.124	0.225	0.290
72/10/22	14 15		4.400	2.730	0.780	0.170	0.290
72/12/23	10 30		5.600		0.115	0.050	0.088
73/02/04	14 50		3.900	2.950	0.630	0.315	0.440
73/03/03	14 40		3.400	5.000	1.900	0.400	0.630
73/04/01	11 26		4.900	1.050	0.100	0.052	0.090
73/04/15	13 47		3.700	1.380	0.066	0.046	0.080
73/05/06	13 49		0.110	1.050	0.027	0.046	0.075
73/05/15	14 50		6.100	0.840	0.060	0.054	0.095
73/06/16	11 50		2.100	1.900	0.220	0.200	0.440
73/07/08	09 00		1.800	0.880	0.075	0.220	0.270
73/08/04	15 00		0.011	1.800	0.050	0.016	0.070

STORET RETRIEVAL DATE 74/10/02

5570A4 LS5570A4
43 42 30.0 088 59 15.0
GRAND RIVER
55 15 FOX LAKE
1/GRAND LAKE
2ND BRDG ABV HWY44 BRDG ABVMARKESAN 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
72/09/24	10 00		0.472	1.250	0.093	0.215	0.273
72/10/22	14 20		4.200	1.800	0.198	0.176	
72/12/07	16 40		7.100	0.123	0.123	0.033	0.061
72/12/23	10 36		5.700	0.115	0.115	0.035	0.068
73/01/14	10 10		8.500	0.175	0.100	0.031	0.050
73/02/04	15 00		4.100	2.900	0.640	0.310	0.430
73/03/03	14 50		3.400	5.300	1.900	0.440	0.650
73/04/01	11 31		5.100	1.150	0.096	0.044	0.185
73/04/15	13 55		3.800	0.930	0.033	0.038	0.080
73/05/06	14 05		0.630	1.400	0.168	0.040	0.070
73/05/15	15 00		6.200	1.050	0.024	0.031	0.070
73/06/16	12 00		2.000	2.520	0.130	0.240	0.420
73/07/08	09 30		1.520	0.820	0.063	0.200	0.250
73/08/04	15 30		0.015	2.700	0.052	0.006	0.190

STORET RETRIEVAL DATE 74/10/02

557081 LS557081
43 40 30.0 089 05 30.0
UNNAMED CREEK
55 15 RANDOLPH
T/GRAND LAKE
RD XING 2 MI W 1 MI S .5 MIW MANCHESTER
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
72/09/24	09	45	0.844	3.200	0.132	0.174	0.231
72/10/22	14	08	2.000	2.590	0.310	0.220	0.400
72/12/23	10	20	2.900	1.400	0.092	0.021	0.046
73/01/14	10	20	4.300	1.050	0.094	0.020	0.040
73/02/04	14	45	3.100	2.310	0.357	0.170	0.260
73/04/01	11	17	2.100	1.990	0.082	0.078	0.198
73/04/15	13	45	2.600	1.700	0.031	0.094	0.155
73/05/06	13	55	2.600	1.540	0.040	0.126	0.185
73/05/15	14	40	2.600	1.320	0.014	0.046	0.090
73/06/16	11	40	2.120	2.200	0.220	0.273	0.650
73/07/08	08	45	3.100	1.760	0.100	0.147	0.180
73/08/04	14	50	1.300	1.400	0.044	0.018	0.045

STORET RETRIEVAL DATE 74/04/30

557050 TF557050 P001378
43 42 00.0 JRR 59 30.0
CITY OF MARKESAN
55 15 FOX RIVER
T/GRAND LAKE
GRAND RIVER
LIFEALES 2141204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 I-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
73/08/29	09 30								
CP(T)-				15.400	1.220	3.400	5.100	0.245	0.198
73/09/29	15 30								