U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

OCONOMOWOC LAKE

WAUKESHA COUNTY

WISCONSIN

EPA REGION V

WORKING PAPER No. 63

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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WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

JUNE, 1975

CONTENTS

F O R E W O R D

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

OBJECTIVES

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

ANALYTIC APPROACH

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

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

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

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

LAKE ANALYSIS*

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

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* The lake discussed in this report was included in the National Eutrophication Survey as a water body of interest to the Wisconsin Department of Natural Resources. Nutrient sources were not sampled, and this report relates only to the data obtained from lake sampling.

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 conducting 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.

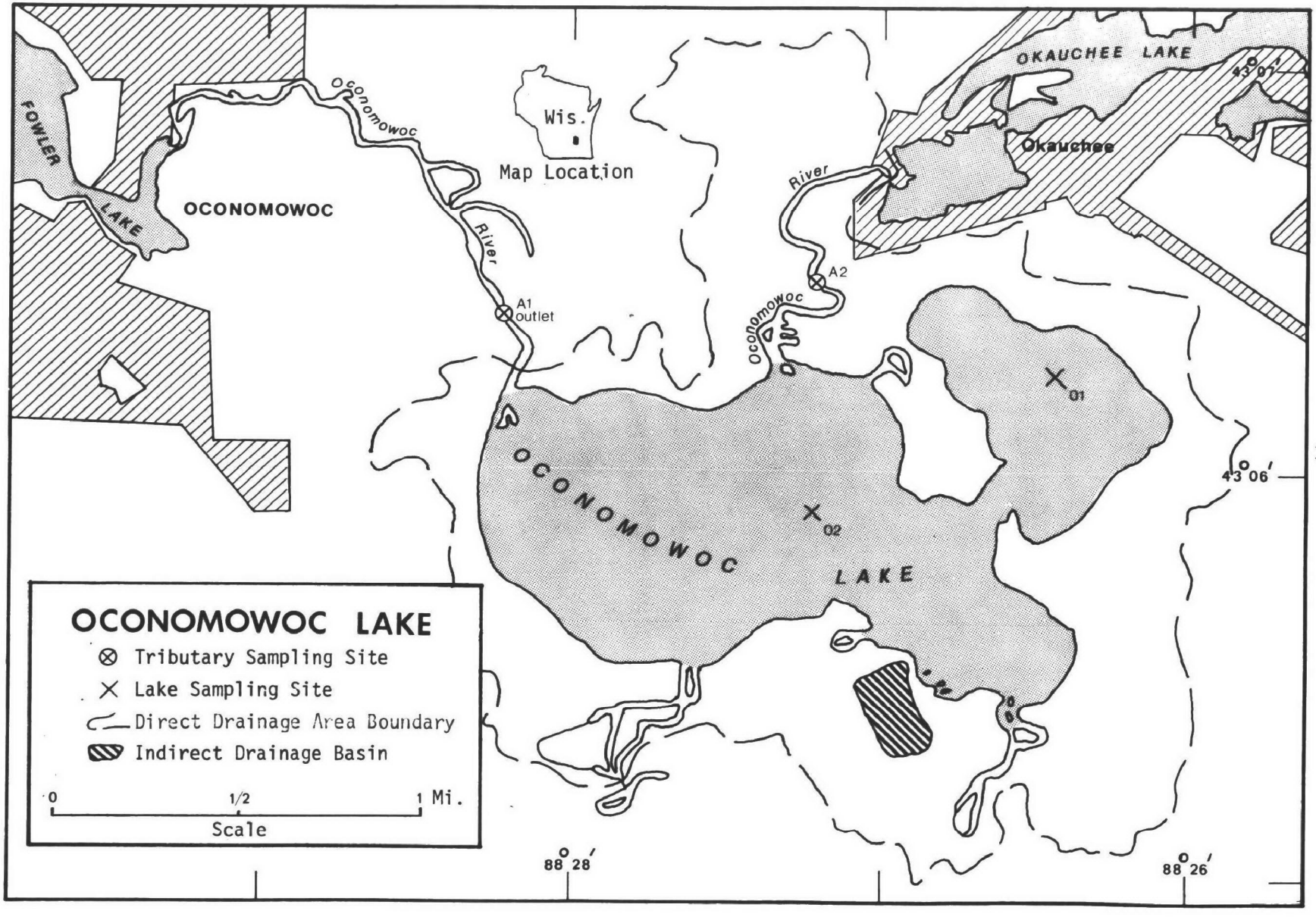
NATIONAL EUTROPHICATION SURVEY

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
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
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
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


OKAUCHEE LAKE
43° 07′
Okauchee
FOWLER LAKE
OCONOMOWOC
Oconomowoc River
Wis.
Map Location
A1 outlet
A2
Oconomowoc River
X01
OCONOMOWOC LAKE
X02
43° 06′
88° 28′
88° 26′
OCONOMOWOC LAKE
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Boundary
Indirect Drainage Basin
0
1/2
1 Mi.
Scale

VI

OCONOMOWOC LAKE

STORET NO. 5532

I. INTRODUCTION

Oconomowoc Lake was included in the National Eutrophication Survey as a water body of interest to the Wisconsin Department of Natural Resources. The inlet and outlet of the lake were sampled (Appendix C), but no wastewater treatment plants impact the lake. Therefore, this report relates only to the lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:

Survey data and a report by others (Lueschow, et al., 1970) indicate Oconomowoc Lake is meso-eutrophic. Of the 46 Wisconsin lakes sampled, four had less and one the same mean total phosphorus, six had less and one the same mean dissolved phosphorus, 27 had less mean inorganic nitrogen, six had greater Secchi disc transparency, but only three lakes had less mean chlorophyll a. In August, dissolved oxygen was depleted at station 1 (at 45 feet) and was essentially depleted at station 2 (at 55 feet).

Survey limnologists did not observe any aquatic nuisances during sampling visits; however, the lake has had extensive aquatic weed and Chara sp. control programs (Lueschow, et al., 1970; Lueschow, 1972).

B. Rate-Limiting Nutrient:

The algal assay results indicate the lake was phosphorus limited at the time the sample was taken (11/11/72). The lake data indicate phosphorus limitation at the other sampling times as well.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 785 acres.
2. Mean depth: 31.5 feet.
3. Maximum depth: 60 feet.
4. Volume: 24,723 acre-feet.
5. Mean hydraulic retention time: 209 days.

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

1. Tributaries -

Name	Drainage area (mi^2)*	Mean flow (cfs)*
Oconomowoc River	83.9	56.4
Minor tributaries & immediate drainage -	3.7	3.3
Totals	87.6	59.7

2. Outlet -

Oconomowoc River	88.8**	59.7**

C. Precipitation***:

1. Year of sampling: 38.7 inches.
2. Mean annual: 30.7 inches.

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† Ball, 1973.
* 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; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 1, "Survey Methods, 1972".

IV. LAKE WATER QUALITY SUMMARY

Oconomowoc 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 two stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last 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 analysis. The maximum depths sampled were 45 feet at station 1 and 55 feet at station 2.

The results obtained are presented in full in Appendix B, 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 B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/11/72)		
Temperature (Cent.)	7.9	7.9	7.9	8.0
Dissolved oxygen (mg/l)	9.0	9.5	9.4	9.9
Conductivity (μmhos)	450	459	460	480
pH (units)	7.7	7.8	7.7	7.9
Alkalinity (mg/l)	192	198	194	218
Total P (mg/l)	0.011	0.014	0.014	0.019
Dissolved P (mg/l)	0.007	0.009	0.009	0.014
NO_2 + NO_3 (mg/l)	0.090	0.110	0.090	0.120
Ammonia (mg/l)	0.130	0.233	0.310	0.320
		ALL VALUES		
Secchi disc (inches)	18	115	116	187

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
06/21/72	1. Dinobryon	488
	2. Cyclotella	126
	3. Microcystis	77
	4. Anabaena	68
	5. Chroococcus	63
	Other genera	371
	Total	1,193
08/19/72	1. Microcystis	380
	2. Fragilaria	181
	3. Dinobryon	175
	4. Chroococcus	127
	5. Flagellates	114
	Other genera	307
	Total	1,284

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)
06/21/72	01	4.8
	02	2.1
08/19/72	01	1.3
	02	1.6
11/11/72	01	2.5
	02	6.1

* The November sample was lost in shipment.

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	0.005	0.268	0.2
0.006 P	0.011	0.268	0.6
0.012 P	0.017	0.368	2.3
0.024 P	0.029	0.268	4.9
0.060 P	0.064	0.268	5.9
0.060 P + 10.0 N	0.064	10.268	24.0
10.0 N	0.005	10.268	0.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates the potential primary productivity of Oconomowoc Lake was relatively low at the time the sample was taken (11/11/72). Also, the increased yields with increased levels of orthophosphorus indicate the lake was phosphorus limited at that time (note the lack of yield response when only nitrogen was added).

The lake data indicate phosphorus limitation at the other sampling times as well; i.e., mean N/P ratios were 29/1 in June and 20/1 in August, and phosphorus limitation would be expected.

V. LITERATURE REVIEWED

Ball, Joseph R., 1973. Personal communication (lake morphometry). WI Dept. Nat. Resources, Madison.

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_____, James M. Helm, Donald R. Winter, and Gary W. Karl; 1970. Trophic nature of selected Wisconsin lakes. Trans. Wisc. Acad. Sci., Arts & Ltrs., vol. 58, pp. 237-264.

McKersie, Jerome, George Hansel, Floyd Stautz, and Dick Narf; 1969. Report on an investigation of the pollution in the upper Rock River drainage basin made during 1967-1968. WI Dept. Nat. Resources, Madison.

Poff, Ronald J., and C. W. Threinen, 1963. Surface water resources of Waukesha County. WI Cons. Dept., Madison.

VI. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5532 OCONOMOWOC LAKE

TOTAL DRAINAGE AREA OF LAKE 88.80

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5532A1	88.80	34.00	38.00	100.00	140.00	79.00	94.00	42.00	30.00	38.00	39.00	54.00	33.00	60.03
5532A2	83.90	32.00	36.00	94.00	130.00	74.00	88.00	40.00	28.00	36.00	37.00	51.00	31.00	56.37
5532ZZ	4.90	1.90	2.10	5.50	7.40	4.40	5.20	2.30	1.60	2.10	2.10	3.00	1.80	3.28

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 88.80
SUM OF SUB-DRAINAGE AREAS = 88.80
TOTAL FLOW IN = 716.40
TOTAL FLOW OUT = 721.00

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5532A1	9	72	140.00	23	220.00				
	10	72	160.00						
	11	72	120.00						
	12	72	45.00	9	37.00				
	1	73	96.00						
	2	73	73.00	11	73.00				
	3	73	170.00	18	230.00				
	4	73	390.00	14	260.00	29	250.00		
	5	73	270.00	12	270.00	28	340.00		
	6	73	100.00	16	94.00				
	7	73	29.00	1	43.00				
	8	73	19.00	26	20.00				
5532A2	9	72	130.00	23	200.00				
	10	72	150.00						
	11	72	110.00						
	12	72	43.00	9	35.00				
	1	73	90.00						
	2	73	68.00	11	68.00				
	3	73	160.00	18	210.00				
	4	73	380.00	14	250.00	29	230.00		
	5	73	250.00	12	260.00	28	320.00		
	6	73	98.00	16	90.00				
	7	73	27.00	1	40.00				
	8	73	18.00	26	19.00				
5532ZZ	9	72	10.00	23	15.00				
	10	72	11.00						
	11	72	8.00						
	12	72	3.10	9	2.60				
	1	73	2.70						
	2	73	1.30	11	1.30				
	3	73	4.70	18	6.60				
	4	73	48.00	14	31.00	29	19.00		
	5	73	20.00	12	21.00	28	25.00		
	6	73	4.70	16	44.00				
	7	73	2.50	1	3.60				
	8	73	1.70	26	1.70				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

553201
43 06 00.0 088 26 30.0
OCONOMOWOC LAKE
55 WISCONSIN

11EPALES 2111202
5 0048 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
72/06/21	08 20	0000	14.6	9.3	108	400	8.20	192	0.090	0.070	0.012	0.011
	08 20	0015	18.9	10.8		380	8.40					
	08 20	0023	10.1	15.4		400	8.40	198	0.090	0.040	0.014	0.006
	08 20	0045	5.9			420	7.40	212	0.070	0.920	0.076	0.028
72/08/19	08 15	0000			125	410	8.40	180	0.070	0.070	0.008	0.005
	08 15	0004	25.4	8.8		400	8.40	183	0.070	0.070	0.008	0.006
	08 15	0015	21.2	12.8		435	8.10	192	0.150	0.140	0.009	0.007
	08 15	0025	13.8	14.1		440	7.95	204	0.120	0.100	0.008	0.005
	08 15	0035	7.5	6.1		450	7.60	224	0.160	0.280	0.009	0.006
	08 15	0045	6.6	0.0		500	7.30	244	0.120	2.380	0.020	0.011
72/11/11	11 25	0000			187	480	7.70	218	0.090	0.310	0.012	0.007
	11 25	0004	7.9	9.4		460	7.70	192	0.090	0.320	0.013	0.008
	11 25	0015	7.9	9.3		460	7.70	200	0.090	0.320	0.015	0.010
	11 25	0022	7.9	9.0		465	7.70	192	0.090	0.320	0.014	0.009
	11 25	0030	7.9	9.3		465	7.70	208	0.090	0.310	0.012	0.007
	11 25	0043	7.9	9.2		470	7.70	200	0.090	0.310	0.011	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	08 20	0000	4.8J
72/08/19	08 15	0000	1.3J
72/11/11	11 25	0000	2.5J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

553202
43 06 00.0 088 27 30.0
OCONOMOWOC LAKE
55 WISCONSIN

11EPALES 2111202
5 0050 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
72/06/21	14	30 0000	16.8	9.0	18			188	0.060	0.060	0.011	0.010
	14	30 0030	8.5	10.2		385	8.00	182	0.160	0.040	0.010	0.006
	14	30 0045	6.3	6.8		400	7.60	186	0.270	0.060	0.012	0.010
72/08/19	07	40 0000			151	410	8.40	174	0.050	0.060	0.009	0.006
	07	40 0004	25.5	8.7		405	8.43	175	0.050	0.050	0.008	0.005
	07	40 0015	21.9	8.9		425	8.10	176	0.050	0.050	0.008	0.007
	07	40 0025	18.5			430	7.90	184	0.090	0.080	0.009	0.006
	07	40 0035	9.4	5.6		450	7.60	195	0.310	0.060	0.011	0.007
	07	40 0045	7.3	4.3		455	7.55	194	0.380	0.050	0.011	0.007
	07	40 0055	6.5	0.02		460	7.40	210	0.050	0.410	0.042	0.028
72/11/11	11	50 0000			99	450	7.90	192	0.110	0.140	0.014	0.009
	11	50 0004	8.0	9.8		450	7.90	194	0.110	0.130	0.015	0.010
	11	50 0015	7.9	9.8		450	7.90	192	0.120	0.130	0.019	0.012
	11	50 0022	7.9	9.9		450	7.90	194	0.110	0.140	0.017	0.014
	11	50 0035	7.9	9.8		455	7.90	195	0.110	0.130	0.015	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	14	30 0000	2.1J
72/08/19	07	40 0000	1.6J
72/11/11	11	50 0000	6.1J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/02

5532A1 LS5532A1
43 05 30.0 088 28 30.0
OCONOMOWOC RIVER
55 15 HARTLAND
O/OCONOMOWOC LAKE
US 16 BRDG E OF OCONOMOWOC
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
72/09/23	15 10		0.379	0.550	0.166	0.021	0.105
72/11/05	13 30		0.168	0.780	0.033	0.005K	0.017
72/12/09	14 10		0.138	0.680	0.080	0.009	0.016
73/01/06	15 30		0.189	0.560	0.063	0.006	0.020
73/02/11	14 16		0.270	0.600	0.024	0.009	0.020
73/03/18	10 30		0.378	2.200	0.105	0.011	
73/04/14	13 30		0.320	1.760	0.052	0.008	0.030
73/04/29	14 00		0.250	1.000	0.026	0.005K	0.015
73/05/12	14 15		0.270	1.300	0.067	0.010	0.015
73/05/28	14 44		0.240	1.300	0.071	0.014	0.025
73/06/15	13 15		0.168	1.050	0.074	0.007	0.020
73/07/01	13 00		0.130	0.580	0.042	0.011	0.025
73/08/26	13 30		0.026	0.530	0.050	0.011	0.015

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/02

5532A2 LS5532A2
43 05 30.0 088 27 30.0
OCONOMOWOC RIVER
55 15 HARTLAND
I/OCONOMOWOC LAKE
US 16 BRDG W OF OKAUCHEE
11FPALES 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
72/09/23	15 00		0.297	1.100	0.340	0.004	0.024
72/11/05	13 40		0.099	0.580	0.050	0.005K	0.016
72/12/09	14 00		0.250	0.610	0.022	0.005K	0.019
73/01/06	15 45		0.290	0.730	0.026	0.005K	0.020
73/02/11	14 12		0.340	0.720	0.007	0.005K	0.025
73/03/18	10 45		0.430	1.000	0.026	0.007	0.155
73/04/14	13 45		0.350	0.940	0.014	0.004	0.035
73/04/29	14 15		0.176	1.100	0.016	0.006	0.025
73/05/12	14 30		0.220	0.970	0.026	0.010	0.030
73/05/28	14 50		0.160	1.260	0.052	0.008	0.035
73/06/16	13 25		0.022	1.200	0.048	0.005K	0.030
73/07/01	13 10		0.010K	1.000	0.060	0.005K	0.030
73/08/26			0.013	0.780	0.046	0.008	0.020

K VALUE KNOWN TO BE LESS THAN INDICATED