U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

BARTLETT LAKE

KOOCHICHING COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 83

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON

and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

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REPORT
ON
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WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

DECEMBER, 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 nation-wide 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 Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

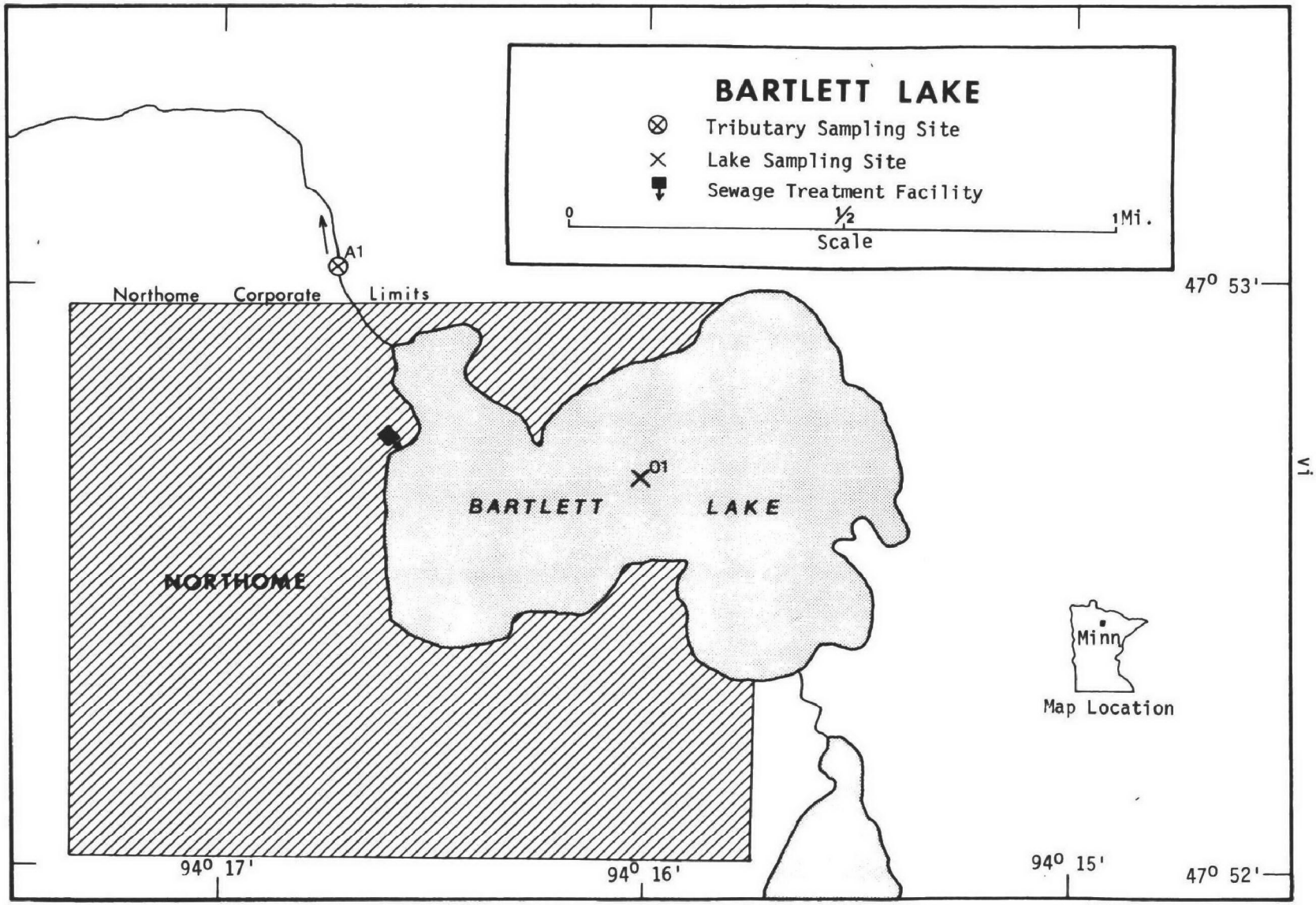
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


BARTLETT LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0
½
1 Mi.
Scale
A1
Northome Corporate Limits
47° 53'
01
BARTLETT LAKE
NORTHOME
Minn
Map Location
94° 17'
94° 16'
94° 15'
47° 52'

BARTLETT LAKE

STORET NO. 2705

I. CONCLUSIONS

A. Trophic Condition:

Survey data and the data of others show that Bartlett Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 38 had less mean total phosphorus and mean inorganic nitrogen, and 24 had less mean dissolved phosphorus. Of the 80 Minnesota lakes sampled, 57 had less mean chlorophyll a, and 60 had greater Secchi disc transparency.

Survey limnologists noted generally poor water quality on all sampling visits with high turbidity and intensive algal blooms.

B. Rate-Limiting Nutrient:

There was a significant loss of nutrients in the assay sample between the time the sample was collected and the algal assay was begun. The lake data indicate nitrogen limitation in July and September but phosphorus limitation in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Bartlett Lake received a total phosphorus load at a rate about 1.5 times the rate proposed by Vollenweider (in press) as "dangerous"; i.e.,

a eutrophic rate (see page 12). It is estimated that the Village of Northome contributed 87% of that load.

It is calculated that 70% removal of phosphorus at the Northome wastewater treatment plant would reduce the loading rate to 1.3 lbs/acre/yr or 0.15 $g/m^2/yr$ (a mesotrophic rate); 80% phosphorus removal would reduce the loading rate to 1.0 lbs/acre/yr or 0.11 $g/m^2/yr$ (an oligotrophic rate). Either level of phosphorus removal should improve the trophic condition of Bartlett Lake.

2. Non-point sources--It is estimated that non-point sources contributed about 13% of the total phosphorus load during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 303 acres.
2. Mean depth: 8.5 feet.
3. Maximum depth: >15 feet.
4. Volume: 2,575 acre/feet.
5. Mean hydraulic retention time: 1.9 years.

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

1. Tributaries -

Name	Drainage area*	Mean flow*
None gaged	-	-
Minor tributaries & immediate drainage -	2.9 mi^2	1.9 cfs
Totals	2.9 mi^2	1.9 cfs

2. Outlet -

Unnamed Creek (A-1)	3.4 mi^2**	1.9 cfs

C. Precipitation***:

1. Year of sampling: 27.2 inches.
2. Mean annual: 26.0 inches.

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† DNR lake survey map (1948); mean depth by random-dot method.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Bartlett 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 one or more depths at one station on the lake (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was composited 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 for chlorophyll a analysis. The maximum depth sampled was 4 feet.

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 (10/21/72)		
Temperature (Cent.)*	-	-	-	-
Dissolved oxygen (mg/l)*	-	-	-	-
Conductivity (μmhos)	241	241	241	241
pH (units)	8.5	8.5	8.5	8.5
Alkalinity (mg/l)	107	107	107	107
Total P (mg/l)	0.117	0.117	0.117	0.117
Dissolved P (mg/l)	0.024	0.024	0.024	0.024
NO_2 + NO_3 (mg/l)	0.170	0.170	0.170	0.170
Ammonia (mg/l)	0.210	0.210	0.210	0.210
		ALL VALUES		
Secchi disc (inches)	12	20	18	30

* Only a surface sample was collected in the fall, and temperature and dissolved oxygen were not determined.

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
07/12/72	1. Anabaena	6,920
	2. Dinobryon	1,123
	3. Microcystis	616
	4. Ankistrodesmus	326
	5. Synedra	290
	Other genera	508
	Total	9,783
09/08/72	1. Microcystis	17,970
	2. Chroococcus	7,668
	3. Anabaena	4,586
	4. Lyngbya	1,955
	5. Oscillatoria	1,729
	Other genera	2,791
	Total	36,699

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)
07/12/72	01	58.7
09/08/72	01	63.9
10/21/72	01	25.8

* The October sample was lost in shipment.

C. Limiting Nutrient Study:

There was a significant loss of nutrients between the time the sample was collected and the assay was begun. Therefore, the assay results are not indicative of lake conditions at the time of sampling.

The lake data indicate nitrogen limitation in July (N/P = 8/1) and September (N/P = 12/1) but phosphorus limitation in October (N/P = 16/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from the outlet site indicated on the map (page vi), except for the high runoff month of April when two samples were collected. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, outlet flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey.

In this report, nutrient loads for the sampled outlet 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 Leech Lake tributaries at stations C-1, D-1, G-1, H-1, and J-1 and multiplying the means by the ZZ area in mi^2.

The Village of Northome did not participate in the Survey, and nutrient loads were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

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* See Working Paper No. 1.

A. Waste Sources:

1. Known muncipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Northome	351	Imhoff tank	0.035**	Bartlett Lake

2. Known industrial - None

* Anonymous, 1974.
** 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) -		
None gaged	-	-
b. Minor tributaries & immediate drainage (non-point load) -	80	7.9
c. Known municipal -		
Northome	880	87.1
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	50	5.0
Total	1,010	100.0

2. Outputs -

Lake outlet - Unnamed Creek (A-1) 430

3. Net annual P accumulation - 580 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) -		
None gaged	-	-
b. Minor tributaries & immediate drainage (non-point load) -	3,630	39.6
c. Known municipal -		
Northome	2,630	28.6
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	2,920	31.8
Total	9,180	100.0

2. Outputs -

Lake outlet - Unnamed Creek (A-1) 7,460

3. Net annual N accumulation - 1,720 pounds

* See Working Paper No. 1.

D. Yearly Loading Rates:

In the following table, the exisiting 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".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	3.3	1.9	30.3	5.7
grams/m^2/yr	0.37	0.21	3.4	0.6

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

"Dangerous" (eutrophic rate) 0.24
"Permissible" (oligotrophic rate) 0.12

V. LITERATURE REVIEWED

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

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

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2705 BARTLETT LAKE

TOTAL DRAINAGE AREA OF LAKE 3.36

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2705A1	3.36	0.46	0.22	0.65	4.10	5.17	3.98	2.03	0.92	2.36	1.10	0.66	0.74	1.87
2705ZZ	3.36	0.45	0.29	0.85	4.02	4.93	3.99	1.95	0.84	2.23	1.02	0.61	0.87	1.86

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 3.36
SUM OF SUB-DRAINAGE AREAS = 3.36
TOTAL FLOW IN = 22.25
TOTAL FLOW OUT = 22.39

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2705A1	10	72	1.01	14	1.30				
	11	72	0.63	5	0.60				
	12	72	1.12	3	1.30				
	1	73	0.51	20	0.40				
	2	73	0.24						
	3	73	1.77	17	5.30				
	4	73	0.57	1	1.60	14	0.20		
	5	73	0.67	19	1.30				
	6	73	0.49	3	0.70				
	7	73	0.39	8	0.45				
	8	73	1.89	11	3.50				
	9	73	16.20	16	10.00				
2705ZZ	10	72	0.93	14	1.20				
	11	72	0.57	5	0.60				
	12	72	1.30	3	1.50				
	1	73	0.71	20	1.50				
	2	73	0.31						
	3	73	2.32	17	7.00				
	4	73	0.56	1	1.60	14	0.20		
	5	73	0.64	19	1.30				
	6	73	0.48	3	0.70				
	7	73	0.37	8	0.43				
	8	73	1.72	11	3.20				
	9	73	15.30	16	9.50				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

270501
47 52 45.0 094 16 00.0
BARTLETT LAKE
27 MINNESOTA

11EPALES 2111202
4 0004 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
72/07/12	14 25	0000			30							
	14 25	0004	22.4	7.2		220	8.30	93	0.080	0.100	0.105	0.022
72/09/09	14 40	0000	15.7		18	258	8.85	121	0.150	0.180	0.157	0.032
	14 40	0004	15.2	10.3		255	8.90	118	0.200	0.270	0.156	0.034
72/10/21	15 45	0000			12	241	8.50	107	0.170	0.210	0.117	0.024

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/12	14 25	0000	58.7J
72/09/09	14 40	0000	63.3J
72/10/21	15 45	0000	25.8J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/30

2705A1 LS2705A1
47 53 00.0 094 17 00.0
UNNAMED STREAM DRNG BARTLET LAKE
27 CO #36. SHEET #1
0/BARTLETT LAKE
US 71 BRDG N OF NORTHOME
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
72/10/14	10 30		0.110	1.470	0.150	0.014	0.115
72/11/05	13 30		0.143	1.900	0.260	0.028	0.115
73/03/17	11 55		0.220	1.700	0.040	0.054	0.160
73/04/01	16 20		0.035	1.980	0.220	0.009	0.080
73/04/14	12 15		0.044	1.800	0.168	0.024	0.155
73/05/19	12 53		0.028	1.400	0.028	0.016	0.120
73/06/03	13 10		0.042	1.610	0.036	0.021	0.125
73/07/08	12 55		0.024	3.400	0.530	0.033	0.135
73/08/11	11 40		0.054	2.000	0.440	0.022	0.095
73/09/16	12 20		0.010K	3.500	0.054	0.036	0.185

K VALUE KNOWN TO BE LESS THAN INDICATED