U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

BUCKEYE LAKE

FAIRFIELD, LICKING, AND PERRY COUNTIES

OHIO

EPA REGION V

WORKING PAPER No. 396

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

BUCKEYE LAKE

FAIRFIELD, LICKING, AND PERRY COUNTIES

OHIO

EPA REGION V

WORKING PAPER No. 396

WITH THE COOPERATION OF THE

OHIO ENVIRONMENTAL PROTECTION AGENCY

AND THE

OHIO NATIONAL GUARD

JUNE, 1975

CONTENTS

FOREWORD

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 Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

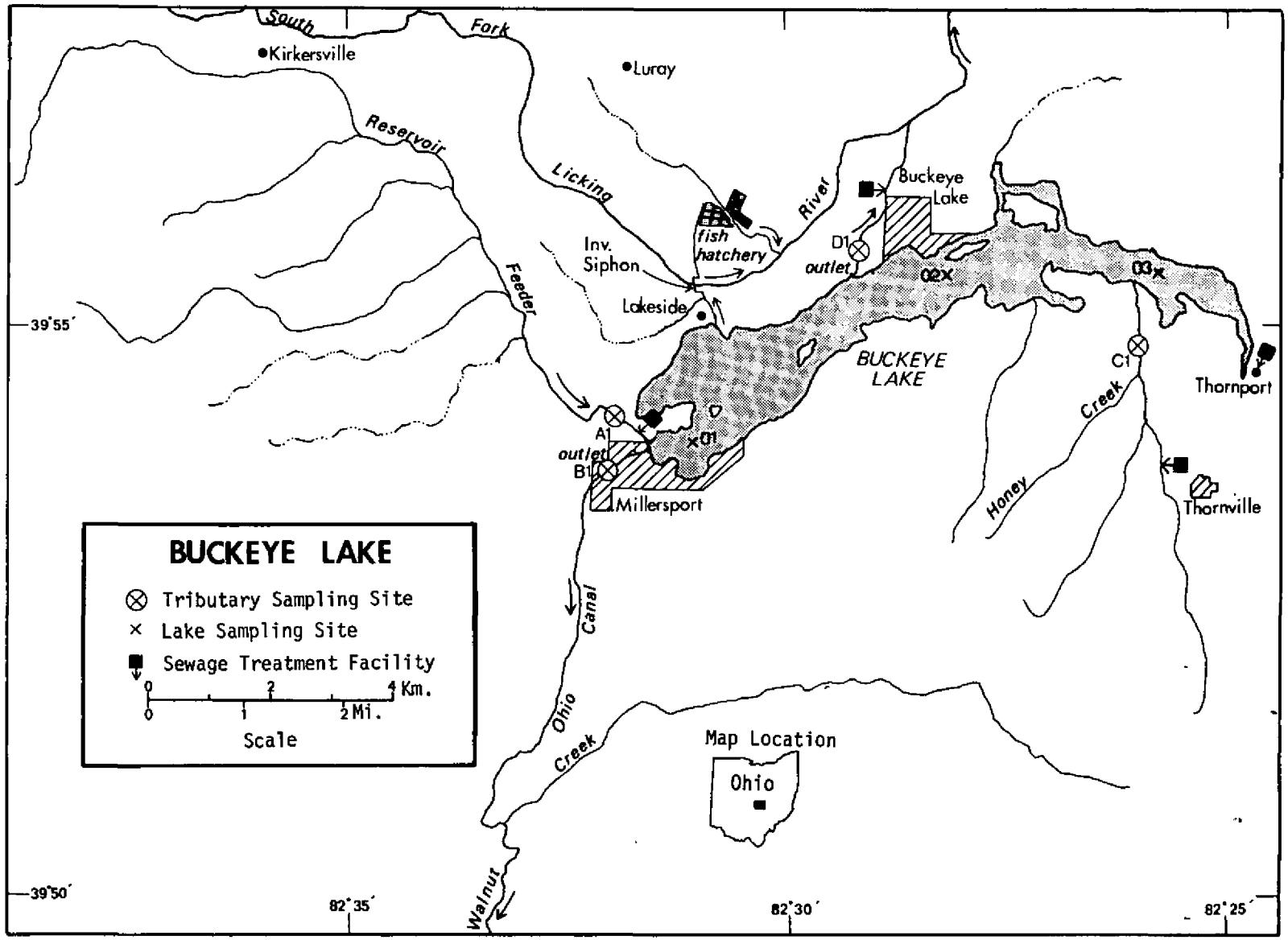
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


South Fork
Kirkersville
Luray
Reservoir
Licking River
Buckeye Lake
fish hatchery
Inv. Siphon
D1 outlet
Feeder
Lakeside
39°55'
BUCKEYE LAKE
C1
Thornport
A1 outlet
B1
Millersport
Creek
Honey
Thornville
Canal
Ohio Creek
Map Location
Ohio
Walnut
39°50'
82°35'
82°30'
82°25'
BUCKEYE LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 2 4 Km.
0 1 2 Mi.
Scale

BUCKEYE LAKE

STORET NO. 3902

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Buckeye Lake is eutrophic. It ranked seventeenth in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Seventeen lakes had less median total phosphorus, 14 had less median dissolved phosphorus, four had less and one had the same median inorganic nitrogen, 19 had less mean chlorophyll a, and 18 had greater mean Secchi disc transparency.

Survey limnologists noted floating and emergent vegetation along much of the shoreline. High numbers of the blue-green algae (see page 7) further indicate the over-enriched condition of this water body.

Almost continuous dredging of the lake is required to maintain satisfactory depths (Ketelle and Uttormark, 1971).

B. Rate-Limiting Nutrient:

The algal assay results are not considered indicative of conditions in the lake at the time the sample was collected (04/26/73). The lake data show nitrogen limitation in April at stations 2 and 3 and phosphorus limitation at station 1; phosphorus limitation in July at all stations; and phosphorus limitation in October at stations 1 and 2 and nitrogen limitation at station 3.

---

* See Appendix A.

C. Nutrient Controllability:

1. Point Sources--During the sampling year, the phosphorus contribution of the listed point sources amounted to about 28% of the total phosphorus load to Buckeye Lake. The major portion of this load came from the wastewater treatment plants at Millersport (13.5%) and Thornville (10.8%).

The present loading of 0.51 g/m^2/year is 1.5 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). Because the lake is phosphorus limited much of the time, all phosphorus inputs should be minimized to the greatest practicable extent. An 85% reduction in the phosphorus loads from the listed point sources would lower the loading to 0.40 g/m^2/year and should at least slow the present rate of eutrophication. Further water quality improvement would be expected if a significant portion of the phosphorus export in Reservoir Feeder is controllable (see discussion below).

2. Non-point sources--Over 72% of the total phosphorus input to Buckeye Lake during the sampling year is attributed to non-point sources. Ungaged tributaries contributed an estimated 7.2%, Honey Creek contributed 8.3%, and the Reservoir Feeder contributed 53.2% of the total phosphorus load.

The phosphorus export rate of Reservoir Feeder, 79 kg/km^2/year, is very high as compared to the rate of Honey Creek, 31 kg/km^2/year, and the rates of tributaries of nearby Dillon Reservoir*; e.g., Big

* Working Paper No. 400.

Run, 10 kg/km^2/yr; Rocky Fork, 7 kg/km^2/yr; and Bowling Green Run, 15 kg/km^2/yr. The high export rate may be due to unknown and unsampled point sources (e.g., Kirkersville) or to land-use practices in that drainage. Additional investigation is needed to determine the controllability of nutrient sources in the Reservoir Feeder drainage.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 12.71 kilometers^2.
2. Mean depth: 1.9 meters.
3. Maximum depth: 4.0 meters.
4. Volume: 24.149 x 10^6 m^3.
5. Mean hydraulic retention time: 233 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Reservoir Feeder	43.5	0.4
Honey Creek	17.5	0.2
Minor tributaries & immediate drainage -	40.8	0.6
Totals	101.8	1.2

2. Outlet -

Unnamed Stream (D-1)	114.5**	1.2
Fish Hatchery Diversion	-	<0.1***

C. Precipitation****:

1. Year of sampling: 102.7 centimeters.
2. Mean annual: 98.0 centimeters.

---

† Table of metric equivalents--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** Flow based on use of 378,500 m^3/year (Mehlhop, 1975).
**** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Buckeye Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter 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 1.8 meters at station 1, 3.4 meters at station 2, and 1.5 meters at station 3.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR BUCKEYE LAKE
STORET CODE 3902

	1ST SAMPLING (4/26/73) 3 SITES			2ND SAMPLING (7/30/73) 3 SITES			3RD SAMPLING (10/ 8/73) 3 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	14.5 - 15.6	15.1	15.3	25.3 - 25.9	25.6	25.6	20.4 - 20.9	20.6	20.6
DISS OXY (MG/L)	9.0 - 10.4	9.8	10.1	5.6 - 8.6	7.3	7.4	5.4 - 8.4	6.7	6.2
CNDCTVY (MCROMO)	300. - 339.	323.	328.	268. - 296.	284.	286.	257. - 269.	262.	261.
PH (STAND UNITS)	8.8 - 9.2	9.0	9.0	7.8 - 9.2	8.6	8.6	8.1 - 9.2	8.8	8.9
TOT ALK (MG/L)	74. - 96.	83.	79.	67. - 87.	76.	76.	73. - 87.	78.	76.
TOT P (MG/L)	0.151 - 0.194	0.173	0.179	0.142 - 0.202	0.165	0.166	0.252 - 0.305	0.273	0.267
ORTHO P (MG/L)	0.016 - 0.040	0.026	0.025	0.012 - 0.020	0.015	0.015	0.031 - 0.036	0.034	0.034
NO2+NO3 (MG/L)	0.070 - 0.560	0.223	0.075	0.100 - 1.390	0.483	0.180	0.150 - 0.270	0.202	0.195
AMMONIA (MG/L)	0.060 - 0.060	0.060	0.060	0.100 - 0.270	0.187	0.190	0.160 - 0.400	0.287	0.295
KJEL N (MG/L)	2.400 - 2.800	2.550	2.550	2.000 - 2.500	2.286	2.300	2.900 - 3.900	3.550	3.700
INORG N (MG/L)	0.130 - 0.620	0.283	0.135	0.200 - 1.660	0.670	0.380	0.310 - 0.600	0.490	0.525
TOTAL N (MG/L)	2.470 - 3.290	2.773	2.625	2.130 - 3.660	2.769	2.630	3.170 - 4.090	3.752	3.875
CHLRPYL A (UG/L)	240.6 - 258.6	247.1	242.0	111.3 - 161.9	141.2	150.3	167.6 - 176.3	171.5	170.5
SECCHI (METERS)	0.2 - 0.2	0.2	0.2	0.3 - 0.3	0.3	0.3	0.2 - 0.4	0.3	0.3

B. Biological characteristics:

1. Phytoplankton

Sampling Date	Dominant Genera	Algal Units per ml
04/26/73	1. Oscillatoria sp.	137,630
	2. Synedra sp.	16,192
	3. Raphidiopsis sp.	4,453
	4. Microcystis sp.	3,482
	5. Cryptomonas sp.	1,619
	Other genera	10,442
	Total	173,818
07/30/73	1. Chroococcus sp.	7,430
	2. Microcystis sp.	7,281
	3. Stephanodiscus sp.	6,910
	4. Oscillatoria sp.	6,613
	5. Lyngbya sp.	6,613
	Other genera	32,087
	Total	66,934
10/08/73	1. Oscillatoria sp.	13,821
	2. Lyngbya sp.	8,153
	3. Cryptomonas sp.	7,256
	4. Chroococcus sp.	6,047
	5. Dactylococcopsis sp.	5,874
	Other genera	37,979
	Total	79,130

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/26/73	01	240.6
	02	258.6
	03	242.0
07/30/73	01	111.3
	02	161.9
	03	150.3
10/08/73	01	170.5
	02	167.6
	03	176.3

C. Limiting Nutrient Study:

The algal assay results are not considered indicative of conditions in the lake at the time of sampling (04/26/73) because of significant changes in nutrient concentrations between the field and the laboratory. The lake data indicate a combination of limiting nutrients. Following is a tabulation of the mean inorganic nitrogen/orthophosphorus ratios for each of the stations and sampling times with the indicated limiting nutrient in parenthesis.

Station	04/26/73	07/30/73	10/08/73
01	16/1 (P)	131/1 (P)	17/1 (P)
02	8/1 (N)	21/1 (P)	15/1 (P)
03	6/1 (N)	16/1 (P)	10/1 (N)

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio 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 loads shown are those measured minus point-source loads, if any.

Assuming that phosphorus and nitrogen concentrations were similar to those in the lake outlet stream, nutrient loads in the water directed to the Hebron National Fish Hatchery were estimated using the mean nitrogen and phosphorus concentrations at station D-1 and the amount of water diverted annually as reported by the Ohio Environmental Protection Agency (Mehlhop, 1975).

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1, C-1, E-1, and F-1 of nearby Dillon Reservoir and multiplying the means by the ZZ area in km^2.

* See Working Paper No. 175.

The operator of the Thornville wastewater treatment plant provided monthly effluent samples and corresponding flow data. The community of Millersport did not participate and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year.

Also, the effluent of the Crown Wehrle Estates wastewater treatment plant is discharged to an abandoned gravel pit near Thornport (see map, page v). It is not known whether ground water in that area moves toward the lake; if it does, the treatment plant could be another source of nutrients.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Thornville†	750	act. sludge	280.1	Honey Creek
Millersport*	777**	ext. aer.	294.1***	Reservoir Feeder

2. Known industrial - None

† Thompson, 1974.
* Anonymous, 1971.
** 1970 Census.
*** Flow estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Reservoir Feeder	3,450	53.2
Honey Creek	540	8.3
b. Minor tributaries & immediate drainage (non-point load) -	465	7.2
c. Known municipal STP's -		
Thornville	700	10.8
Millersport	880	13.5
d. Septic tanks* -	235	3.6
e. Known industrial - None	-	-
f. Direct precipitation** -	220	3.4
Total	6,490	100.0

2. Outputs -

Lake outlet - Unnamed Stream (D-1)	5,855
Fish Hatchery Diversion	60
Total	5,915

3. Net annual P accumulation - 575 kg.

* Estimate based on 826 shoreline dwellings and one state park; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Reservoir Feeder	54,515	48.8
Honey Creek	10,375	9.3
b. Minor tributaries & immediate drainage (non-point load) -	20,500	18.3
c. Known municipal STP's -		
Thornville	1,160	1.0
Millersport	2,645	2.4
d. Septic tanks* -	8,840	7.9
e. Known industrial - None	-	-
f. Direct precipitation** -	13,720	12.3
Total	111,755	100.0

2. Outputs -

Lake outlet - Unnamed Stream (D-1)	85,745
Fish Hatchery Diversion	720
Total	86,465

3. Net annual N accumulation - 25,290 kg.

* Estimate based on 826 shoreline dwellings and one state park; see Working Paper No. 175.
** See Working Paper No. 175.

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

Tributary	kg P/km^2/yr	kg N/km^2/yr
Reservoir Feeder	79	1,253
Honey Creek	31	593

E. Yearly Loading Rates:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1975). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

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

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.51	0.05	8.8	2.0

Vollenweider phosphorus loadings (g/m^2/yr) based on mean depth and mean hydraulic retention time of Buckeye Lake:

"Dangerous" (eutrophic loading)	0.34
"Permissible" (oligotrophic loading)	0.17

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 5, Washington, DC.

Ketelle, Martha J. and Paul D. Uttormark, 1971. Problem lakes in the United States. EPA Water Poll. Contr. Res. Ser., Proj. #16010 EHR, Wash. DC.

Mehlhop, Rod, 1975. Personal communication (Hebron National Fish Hatchery). OH. Env. Prot. Agency, Columbus.

Thompson, Richard, 1974. Treatment plant questionnaire (Thornville STP). Thornville.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Youger, John, 1975. Personal communication (lake morphometry). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.990	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3926	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3402 BUCKEYE LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 114.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3902A1	43.5	0.74	0.91	1.08	0.88	0.51	0.28	0.18	0.12	0.08	0.08	0.20	0.42	0.45
3902B1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3902C1	17.5	0.28	0.37	0.45	0.37	0.21	0.11	0.07	0.05	0.03	0.03	0.07	0.17	0.18
3902D1	114.5	1.93	2.38	2.86	2.32	1.33	0.74	0.48	0.31	0.22	0.21	0.51	1.10	1.19
3902ZZ	53.6	0.91	1.10	1.33	1.08	0.62	0.34	0.22	0.15	0.11	0.10	0.25	0.51	0.56

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 114.5
SUM OF SUB-DRAINAGE AREAS = 114.6
TOTAL FLOW IN = 14.40
TOTAL FLOW OUT = 14.39

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3902A1	5	73	0.45	5	0.45				
	6	73	0.68	10	0.26				
	7	73	0.37	14	0.05				
	8	73	0.34	12	0.15				
	9	73	0.05	9	0.0				
	10	73	0.19	16	0.10				
	11	73	0.82	4	0.31				
	12	73	0.85	9	0.48				
	1	74	1.05	13	0.85				
	2	74	0.96	10	0.88	24	0.91		
	3	74	0.85	10	0.71	24	0.85		
	4	74	1.10	27	0.37				
3902B1	1	74	0.0	13	0.0				
	2	74	0.0	10	0.0	24	0.0		
	3	74	0.0	10	0.0	24	0.0		
	4	74	0.0	27	0.0				
3902C1	5	73	0.18	5	0.18				
	6	73	0.27	10	0.10				
	7	73	0.15	14	0.02				
	8	73	0.13	12	0.06				
	9	73	0.02	9	0.04				
	10	73	0.07	16	0.04				
	11	73	0.31	4	0.11				
	12	73	0.34	9	0.19				
	1	74	0.40	13	0.34				
	2	74	0.40	10	0.37	24	0.37		
	3	74	0.37	10	0.31	24	0.37		
	4	74	0.45	27	0.15				

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3902 BUCKEYE LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3902D1	5	73	1.16	5	1.16				
	6	73	1.78	10	0.68				
	7	73	0.99	14	0.14				
	8	73	0.91	12	0.40				
	9	73	0.12	9	0.16				
	10	73	0.48	16	0.25				
	11	73	2.18	4	0.79				
	12	73	2.21	9	1.22				
	1	74	2.75	13	2.27				
	2	74	2.52	10	2.27	24	2.41		
	3	74	2.27	10	1.87	24	2.24		
	4	74	2.89	27	0.96				
3902ZZ	5	73	0.54						
	6	73	0.82						
	7	73	0.45						
	8	73	0.42						
	9	73	0.06						
	10	73	0.24						
	11	73	1.05						
	12	73	1.02						
	1	74	1.30						
	2	74	1.16						
	3	74	1.05						
	4	74	1.33						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

390201
39 54 13.0 082 31 10.0
BUCKEYE LAKE
39045 OHIO

11EPALES 2111202
3 0005 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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	10 15	0000	14.5		6	335	8.80	79	0.060	2.600	0.560	0.040
	10 15	0003	14.5	9.0		320	9.10	79	0.060	2.800	0.490	0.035
73/07/30	10 30	0000	25.5	7.2	12	285	8.50	73	0.230	2.400	1.260	0.012
	10 30	0006	25.3	5.6		296	7.80	75	0.270	2.100	1.390	0.012
73/10/08	16 00	0000	20.4	6.2	9	264	8.90	77	0.330	2.900	0.270	0.035

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	10 15	0000	0.181	240.6
	10 15	0003	0.194	
73/07/30	10 30	0000	0.146	111.3
	10 30	0006	0.202	
73/10/08	16 00	0000	0.305	170.5

STORET RETRIEVAL DATE 75/01/27

390202
39 55 42.0 082 28 13.0
BUCKEYE LAKE
39045 OHIO

11EPALES
3

2111202
0008 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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	10 45	0000	15.4		8	305	9.20	74	0.060	2.600	0.080	0.016
	10 45	0005	15.3	10.1		300	9.20	78	0.060	2.400	0.070	0.020
73/07/30	10 50	0000	25.7	8.6	12	286	9.20	76	0.190	2.500	0.190	0.015
	10 50	0005	25.7	7.8		287	8.90	77	0.100	2.200	0.100	0.015
	10 50	0011	25.6	7.4		287	8.60	77	0.200	2.300	0.180	0.016
73/10/08	15 45	0000	20.9		14	257	9.20	74	0.260	3.800	0.200	0.036
	15 45	0005	20.6	5.4		258	8.10	73	0.400	3.900	0.190	0.033

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	10 45	0000	0.151	258.6
	10 45	0005	0.154	
73/07/30	10 50	0000	0.142	161.9
	10 50	0005	0.153	
	10 50	0011	0.166	
73/10/08	15 45	0000	0.275	167.6
	15 45	0005	0.260	

STORET RETRIEVAL DATE 75/01/27

390203
39 55 36.0 082 25 41.0
BUCKEYE LAKE
39127 OHIO

11EPALES 2111202
3 0005 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	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/26	11 10	0000	15.6		6	337	9.00	94	0.060	2.400	0.070	0.030
	11 10	0003	15.6	10.4		339	9.00	96	0.060	2.500	0.070	0.017
73/07/30	11 15	0000	25.9	7.6	12	268	8.90	87	0.160	2.500	0.130	0.016
	11 15	0005	25.3	7.0		276	8.60	67	0.160	2.000	0.130	0.020
73/10/08	15 30	0000	20.7	8.4	11	269	8.90	87	0.160	3.600	0.150	0.031

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/26	11 10	0000	0.179	242.0
	11 10	0003	0.179	
73/07/30	11 15	0000	0.172	150.3
	11 15	0005	0.172	
73/10/08	15 30	0000	0.252	176.3

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/03

3902A1
39 54 28.0 082 32 00.0
RESERVOIR FEEDER
39157 7.5 MILLERSPORT
I/BUCKEYE LAKE
MILLERSPORT RD BRDG N OF MILLERSPORT
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
73/05/05	09 35			0.500			0.035
73/06/10	10 45		5.700	1.100	0.176	0.040	0.090
73/07/14	14 25		1.920	2.400	0.086	0.170	0.360
73/08/12	09 30		1.480	1.400	0.154	0.036	0.105
73/09/09	11 00		0.105	1.400	0.105	0.750	1.050
73/10/16	12 00		0.168	3.100	0.126	0.715	1.150
73/11/04	10 00		4.400	0.800	0.040	0.032	0.070
73/12/09	13 30		4.000	0.300	0.036	0.036	0.055
74/01/13	11 15		3.960	0.400	0.044	0.032	0.060
74/02/10	14 15		4.600	0.600	0.040	0.025	0.060
74/02/24	12 30		2.520	0.400	0.025	0.020	0.065
74/03/10	13 30		2.700	0.400	0.015	0.020	0.055
74/03/24	14 30		2.300	0.700	0.040	0.020	0.055
74/04/27	13 30		0.200	1.200	0.105	0.030	0.140

STORET RETRIEVAL DATE 75/02/03

3902B1
39 54 00.0 082 32 30.0
OHIO CANAL
39 7.5 MILLERSPORT
I/BUCKEYE LAKE
MILLERSPORT RD BRDG IN MILLERSPORT
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
73/05/05	10 00		1.900	2.100	0.210	0.016	0.130
73/06/10	10 30		1.600	1.000	0.082	0.014	0.085
73/07/14	14 10		0.024	2.900	0.061	0.038	0.200
73/08/12	09 35		0.038	2.500	0.060	0.033	0.200
73/09/09	11 15		0.022	1.100	0.033	0.031	0.280
73/10/16	12 15		0.018	2.200	0.032	0.072	0.415
73/11/04	09 45		5.000	1.150	0.088	0.020	0.065
73/12/09	13 15		2.200	0.450	0.160	0.032	0.070
74/02/24	13 00		1.500	0.800	0.035	0.020	0.110
74/03/10	13 45		1.100	0.500	0.020	0.015	0.045
74/03/24	14 45		1.120	0.600	0.030	0.015	0.035
74/04/27	13 45		1.920	0.500	0.025	0.015	0.020

STORET RETRIEVAL DATE 75/02/03

390201
39 55 01.0 082 26 00.0
HONEY CREEK
39 7.5 THORNVILLE
T/BUCKEYE LAKE
HONEY CREEK RD BRDG 1 MI N OF THORNPORT
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
73/05/05	10 35		2.020	0.280	0.010	0.089	0.108
73/06/10	10 00		1.900	0.300	0.060	0.147	0.185
73/07/14	13 50		0.910	1.260	0.063	0.340	0.420
73/08/12	10 00		0.880	0.820	0.054	0.160	0.240
73/09/09	11 30		0.550	0.300	0.056	0.210	0.270
73/10/16	12 45		0.630	0.500	0.032	0.390	0.460
73/11/04	09 30		1.430	0.700	0.032	0.192	0.250
73/12/09	13 00		1.850	0.200	0.020	0.120	0.145
74/01/13	11 45		2.200	0.350	0.024	0.100	0.150
74/02/10	13 45		2.600	0.400	0.035	0.080	0.125
74/02/24	13 30		1.840	0.300	0.015	0.115	0.180
74/03/10	14 30		1.680	0.200	0.010	0.110	0.160
74/03/24	15 00		1.440	0.400	0.015	0.115	0.140
74/04/27	13 10		0.890	0.200	0.010	0.147	0.165

STORET RETRIEVAL DATE 75/02/03

390201
39 55 45.0 082 29 14.0
UNNAMED STREAM
39 7.5 THORNVILLE
O/BUCKEYE LAKE
ST RT 79 BRDG SW EDGE OF BUCKEYE 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
73/05/05	08 35		0.010K	3.100	0.021	0.019	0.155
73/06/10	11 00		0.079	2.500	0.060	0.020	0.125
73/07/14	14 50		0.013	2.400	0.029	0.037	0.180
73/08/12	09 10		0.037	2.600	0.044	0.029	0.180
73/09/09	10 50		0.050	1.600	0.120	0.042	0.260
73/10/16	11 45		0.300	1.650	0.028	0.120	0.185
73/11/04	10 00		0.300	2.000	0.288	0.020	0.170
73/12/09	13 45		0.924	1.200	0.440	0.052	0.130
74/01/13	10 50		0.720	1.300	0.020	0.020	0.105
74/02/10	14 35		1.180	1.700	0.020	0.035	0.140
74/02/24	12 00		0.980	1.500	0.015	0.015	0.150
74/03/10	13 00		0.610	1.300	0.080	0.040	0.155
74/03/24	14 15		0.390	1.400	0.100	0.020	0.100
74/04/27	14 10		0.088	1.100	0.065	0.035	0.135

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

390221 AS390221 P000750
39 54 39.0 082 24 50.0
THORNEVILLE WASTEWATER
39127 7.5 THORNVILLE
D/BUCKEYE LAKE
BUCKEYE LAKE
11EPALES 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
73/08/16	08 00								
CP(T)-			3.200	0.100K	0.040	1.600	4.600	0.093	0.080
73/08/16	16 00								
73/09/26	08 00								
CP(T)-			2.940	0.680	0.430	9.100	12.000	0.062	0.059
73/09/26	16 00								
73/10/24	08 00								
CP(T)-			3.100	0.700	0.005K	5.500	15.000	0.048	0.058
73/10/24	16 00								
73/11/19	08 00								
CP(T)-			8.900	1.200	0.076	5.300	6.100	0.076	0.068
73/11/19	16 00								
73/12/17	08 00								
CP(T)-			13.600	0.500K	0.078	7.100	7.700	0.065	0.073
73/12/17	16 00								
74/01/15	08 00								
CP(T)-			6.300	14.000	0.040K	3.600	7.350	0.095	0.089
74/01/15	16 00								
74/02/20	08 00								
CP(T)-			10.600	1.300	0.061	5.000	5.100	0.090	0.088
74/02/20	16 00								
74/03/25	08 00								
CP(T)-			9.800	1.000K	0.050K	4.000	4.500	0.080	0.087
74/03/25	16 00								
74/04/23	08 00								
CP(T)-			8.900	1.900	0.095	5.300	5.575	0.087	0.087
74/04/23	16 00								
74/05/23	08 00								
CP(T)-			3.840	2.200	0.100	4.900	5.600	0.086	0.085
74/05/23	16 00								
74/06/24	08 00								
CP(T)-			6.240	1.500	0.050K	2.800	2.900	0.068	0.072
74/06/24	16 00								
74/07/22	08 00								
CP(T)-			10.000	1.000K	0.050K	8.700	9.450	0.045	0.055
74/07/22	16 00								

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

390221 AS390221 C P000750
39 54 39.0 082 24 50.0
THORNEVILLE WASTEWATER
39127 7.5 THORNVILLE
D/BUCKEYE LAKE
BUCKEYE LAKE
11EPALES 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
74/08/23	08 00								
CP(T)-			11.800	25.000	0.150	6.700	9.500	0.055	0.061
74/08/23	16 00								