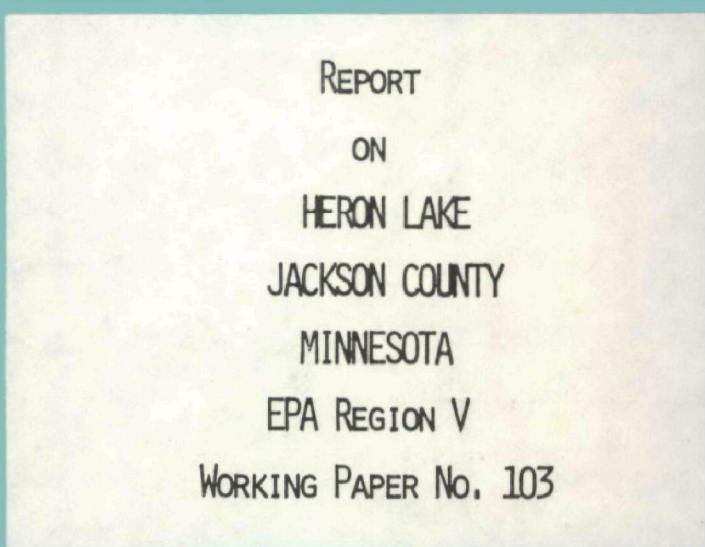


U.S. ENVIRONMENTAL PROTECTION AGENCY  
NATIONAL EUTROPHICATION SURVEY  
WORKING PAPER SERIES



PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON  
and

NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA

REPORT  
ON  
HERON LAKE  
JACKSON COUNTY  
MINNESOTA  
EPA REGION V  
WORKING PAPER No. 103

WITH THE COOPERATION OF THE  
MINNESOTA POLLUTION CONTROL AGENCY  
AND THE  
MINNESOTA NATIONAL GUARD  
DECEMBER, 1974

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## 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 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.

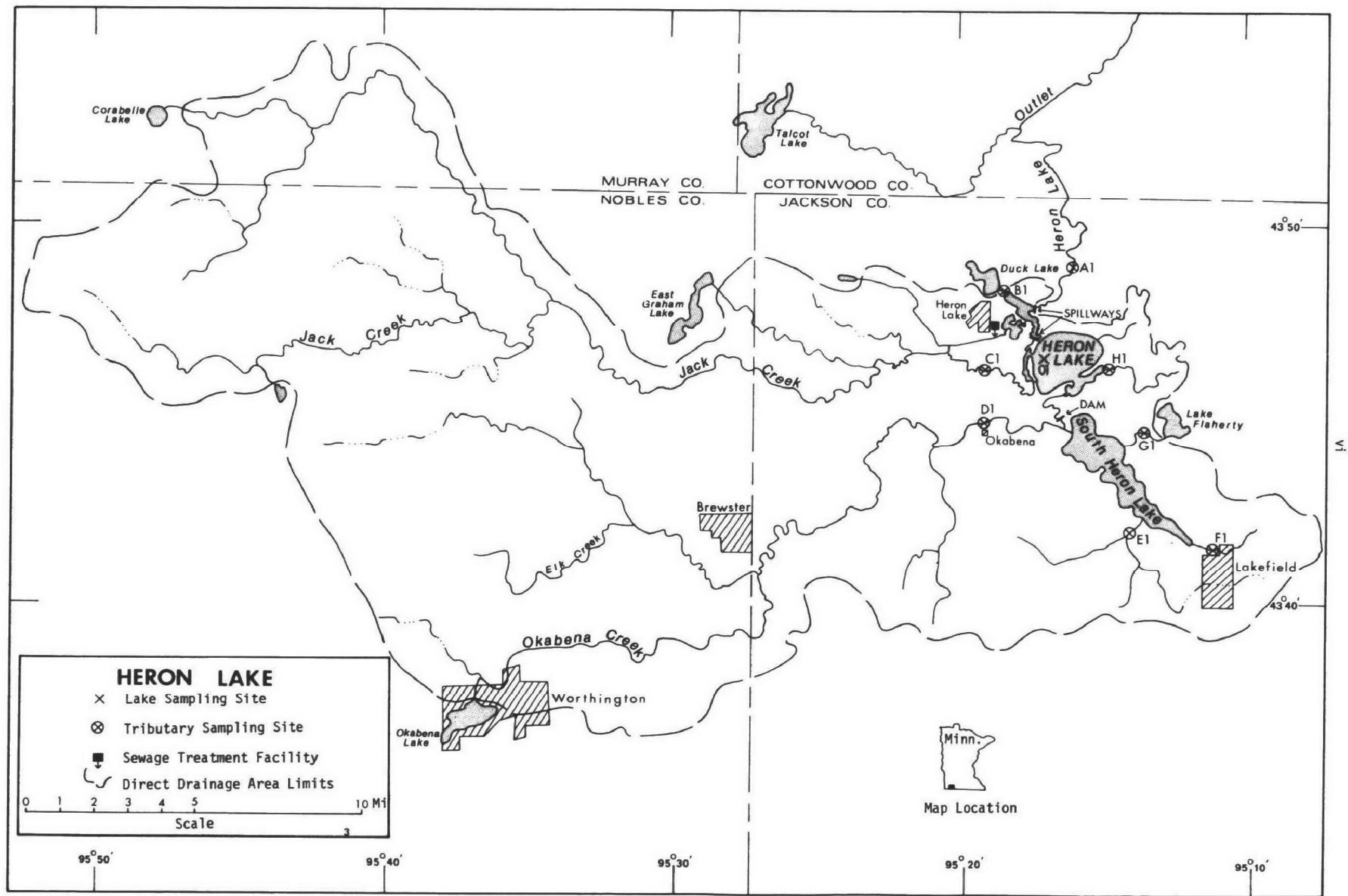
## NATIONAL EUTROPHICATION SURVEY

## STUDY LAKES

STATE OF MINNESOTA

<u>LAKE NAME</u>	<u>COUNTY</u>
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

<u>LAKE NAME</u>	<u>COUNTY</u>
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



HERON LAKE

STORET NO. 2739

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Heron Lake is eutrophic. Of the 80 Minnesota lakes sampled, 58 had less mean total phosphorus, 54 had less mean dissolved phosphorus, 68 had greater Secchi disc transparency, 71 had less mean chlorophyll a, but only five had less mean inorganic nitrogen.

B. Rate-Limiting Nutrient:

The lake data indicate nitrogen limitation during July and August when N/P ratios were about 1/1 at the time of sampling.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Heron Lake received a total phosphorus load at a rate more than three times the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 11). It is calculated that three point sources--Heron Lake, Lakefield, and Worthington--contributed nearly 41% of the total phosphorus load. However, even with a 100% reduction in phosphorus from the point sources, the loading rate would still be more than twice the eutrophic loading rate. With the rich agricultural land in the drainage area, it is not likely that phosphorus reduction at the point sources would result

in a significant improvement in the trophic condition of the lake unless non-point sources can be controlled as well.

2. Non-point sources--The phosphorus exports of the Heron Lake tributaries were somewhat high as compared to unimpacted Minnesota streams studied elsewhere (e.g., the mean phosphorus export of four Big Stone Lake\* tributaries was 19 lbs/mi<sup>2</sup>/yr).

In all, it is estimated that non-point sources contributed about 60% of the total phosphorus load to Heron Lake during the sampling year.

---

\* Working Paper No. 85.

## II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

### A. Lake Morphometry<sup>†</sup>:

1. Surface area: 8,251 acres.
2. Mean depth: 3 feet.
3. Maximum depth: 5 feet.
4. Volume: 24,753 acre/feet.
5. Mean hydraulic retention time: 135 days.

### B. Tributary and Outlet:

(See Appendix A for flow data)

#### 1. Tributaries -

<u>Name</u>	<u>Drainage area*</u>	<u>Mean flow*</u>
Duck Lake outlet	7.6 mi <sup>2</sup>	1.3 cfs
Jack Creek	215.0 mi <sup>2</sup>	41.3 cfs
Okabena Creek	160.0 mi <sup>2</sup>	32.0 cfs
Ditch J-3 (E-1)	28.5 mi <sup>2</sup>	5.6 cfs
Unnamed Stream (F-1)	3.6 mi <sup>2</sup>	0.7 cfs
Lake Flaherty outlet	7.5 mi <sup>2</sup>	1.4 cfs
Teal Lake outlet (H-1)	3.8 mi <sup>2</sup>	0.7 cfs
Minor tributaries & immediate drainage -	<u>33.1 mi<sup>2</sup></u>	<u>9.2 cfs</u>
Totals	459.1 mi <sup>2</sup>	92.2 cfs

#### 2. Outlet -

Heron Lake outlet	472.0 mi <sup>2</sup> **	92.2 cfs
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### C. Precipitation\*\*\*:

1. Year of sampling: 25.4 inches.
2. Mean annual: 21.7 inches.

<sup>†</sup> Schilling, 1973; DNR lake survey map (1964).

<sup>\*</sup> Drainage areas are accurate within  $\pm 5\%$ ; mean daily flows are accurate within  $\pm 10\%$ ; and ungaged flows are accurate within  $\pm 10$  to  $25\%$  for drainage areas greater than  $10 \text{ mi}^2$ .

<sup>\*\*</sup> Includes area of lake.

<sup>\*\*\*</sup> See Working Paper No. 1, "Survey Methods".

### III. LAKE WATER QUALITY SUMMARY

Heron Lake was sampled twice during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, near-surface samples for physical and chemical parameters were collected at the single station on the lake (see map, page vi). During each visit, a depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration, and a similar sample was collected for chlorophyll a analysis.

The results obtained are presented in full in Appendix B, and the data are summarized below.

#### A. Physical and chemical characteristics:

<u>Parameter</u>	<u>Mean Values</u>	
	<u>1st Sample (07/01/72)</u>	<u>2nd Sample (08/30/72)</u>
Temperature (Cent.)	25.0	22.0
Dissolved oxygen (mg/l)	10.8	8.4
Conductivity ( $\mu\text{mhos}$ )	940	875
pH (units)	8.9	9.2
Alkalinity (mg/l)	152	104
Total P (mg/l)	0.366	0.239
Dissolved P (mg/l)	0.204	0.105
$\text{NO}_2 + \text{NO}_3$ (mg/l)	0.050	0.060
Ammonia (mg/l)	0.060	0.100
Chlorophyll a ( $\mu\text{g/l}$ )	41	181
Secchi disc (inches)	18	6

<u>Parameter</u>	<u>Min. for all samples</u>	<u>Max. for all samples</u>	<u>Mean for all samples</u>
Temperature	22.0	25.0	23.5
Dissolved oxygen	8.4	10.8	9.6
Conductivity	875	940	908
pH	8.9	9.2	9.0
Alkalinity	104	152	128
Total P	0.239	0.366	0.302
Dissolved P	0.105	0.204	0.154
NO <sub>2</sub> + NO <sub>3</sub>	0.050	0.060	0.055
Ammonia	0.060	0.100	0.080
Chlorophyll a	41	181	111
Secchi disc	6	18	12

B. Biological characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Number per ml</u>
07/01/72	1. Oscillatoria 2. Fragilaria 3. Synedra 4. Navicula 5. Cryptomonas Other genera	13,575 815 317 226 226 <u>452</u>
	Total	15,611
08/30/72	1. Oscillatoria 2. Merismopedia 3. Cryptomonas 4. Cyclotella 5. Flagellates Other genera	7,602 996 362 362 272 <u>768</u>
	Total	10,362

## 2. Chlorophyll a -

(Because of instrumentation problems during the 1972 sampling,  
the following values may be in error by plus or minus 20 percent.)

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll a (<math>\mu</math>g/l)</u>
07/01/72	01	40.9
08/30/72	01	181.2

## C. Limiting Nutrient Study:

Heron Lake was not sampled in the fall of 1972 when ordinarily an algal assay sample would have been collected. However, the lake data indicate nitrogen limitation on both sampling visits (N/P ratios were near 2/1).

The potential primary productivity would likely have been high based on the level of nutrients in the lake.

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 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 October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota 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  $\text{lbs}/\text{mi}^2/\text{year}$ , at stations C-1, G-1, and H-1 and multiplying the means by the ZZ area in  $\text{mi}^2$ . Except for Ditch J-3, the tributary nutrient loads given are those measured minus point sources, if any. The estimated nutrient loads for Lakeland exceeded those measured in Ditch J-3, and the non-point loads for the Ditch were estimated in the same way as the ZZ loads.

The operators of the Heron Lake, Lakefield, and Worthington wastewater treatment plants declined to 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 municipal<sup>†</sup> -

<u>Name</u>	<u>Pop. Served</u>	<u>Treatment</u>	<u>Mean Flow (mgd)</u>	<u>Receiving Water</u>
Heron Lake	777	stab. ponds	0.078*	Heron Lake
Lakefield	1,820	trickling filter	0.182*	Ditch J-3
Worthington	9,825	trickling filter	0.982*	Ditch J-12 to Okabena Creek

2. Known industrial - None

<sup>†</sup> Anonymous, 1974.

\* Estimated at 100 gal/capita/day.

## B. Annual Total Phosphorus Loading - Average Year:

## 1. Inputs -

<u>Source</u>	<u>lbs P/ yr</u>	<u>% of total</u>
<b>a. Tributaries (non-point load) -</b>		
Duck Lake outlet	1,010	1.3
Jack Creek	16,210	21.2
Okabena Creek	21,970	28.8
Ditch J-3 (E-1)	1,790	2.3
Unnamed Stream (F-1)	200	0.3
Lake Flaherty outlet	610	0.8
Teal Lake outlet	120	0.2
<b>b. Minor tributaries &amp; immediate drainage (non-point load) -</b>		2.7
<b>c. Known municipal STP's -</b>		
Heron Lake	1,940	2.5
Lakefield	4,550	6.0
Worthington	24,560	32.2
<b>d. Septic tanks - Unknown</b>		-
<b>e. Known industrial - None</b>		-
<b>f. Direct precipitation* -</b>		<u>1.7</u>
Total	76,330	100.0

## 2. Outputs -

Lake outlet - Heron Lake outlet 49,450

3. Net annual P accumulation - 26,880 pounds

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\* See Working Paper No. 1.

## C. Annual Total Nitrogen Loading - Average Year:

## 1. Inputs -

<u>Source</u>	<u>lbs N/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Duck Lake outlet	13,810	1.1
Jack Creek	443,450	36.3
Okabena Creek	438,260	35.9
Ditch J-3 (E-1)	55,000	4.5
Unnamed Stream (F-1)	13,050	1.1
Lake Flaherty outlet	16,190	1.3
Teal Lake outlet	5,960	0.5
b. Minor tributaries & immediate drainage (non-point load) -	63,870	5.2
c. Known municipal STP's -		
Heron Lake	5,830	0.5
Lakefield	13,650	1.1
Worthington	73,690	6.0
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>79,490</u>	<u>6.5</u>
Total	1,222,250	100.0

## 2. Outputs -

Lake outlet - Heron Lake outlet 753,640

## 3. Net annual N accumulation - 468,610 pounds

\* See Working Paper No. 1.

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

<u>Tributary</u>	<u>lbs P/mi<sup>2</sup>/yr</u>	<u>lbs N/mi<sup>2</sup>/yr</u>
Duck Lake outlet	133	1,817
Jack Creek	75	2,062
Okabena Creek	137	2,739
Unnamed Stream (F-1)	56	3,625
Lake Flaherty outlet	81	812,159
Teal Lake outlet	32	1,568

## 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 morphology permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

<u>Units</u>	<u>Total Phosphorus</u>		<u>Total Nitrogen</u>	
	<u>Total</u>	<u>Accumulated</u>	<u>Total</u>	<u>Accumulated</u>
lbs/acre/yr	9.3	3.3	148.1	56.8
grams/m <sup>2</sup> /yr	1.04	0.37	16.6	6.4

Vollenweider loading rates for phosphorus (g/m<sup>2</sup>/yr) based on mean depth and mean hydraulic retention time of Heron Lake:

"Dangerous" (eutrophic rate) 0.30  
 "Permissible" (oligotrophic rate) 0.15

**V. LITERATURE REVIEWED**

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

Schilling, Joel, 1973. Personal communication (lake morphometry). 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 2739 HERON LAKE

TOTAL DRAINAGE AREA OF LAKE 472.00

TRIBUTARY	SUR-DRAINAGE AREA	NORMALIZED FLOWS												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
2739A1	472.00	9.81	18.10	162.00	239.50	170.00	245.50	106.30	46.40	35.00	34.50	22.60	15.40	92.22
2739B1	7.65	0.07	0.10	1.56	3.17	2.67	4.08	1.81	0.57	0.81	0.50	0.27	0.19	1.33
2739C1	215.00	4.24	7.69	76.00	105.00	76.40	109.00	47.50	20.50	16.00	15.40	9.70	7.11	41.28
2739D1	160.00	3.41	6.34	67.00	77.30	56.70	81.10	36.90	16.30	13.80	11.40	7.05	6.17	32.06
2739E1	28.50	0.52	0.90	11.70	12.60	9.98	14.70	6.87	2.92	3.08	1.96	1.11	1.15	5.65
2739F1	3.57	0.05	0.07	0.98	1.43	1.29	1.92	0.92	0.37	0.48	0.26	0.13	0.13	0.67
2739G1	7.53	0.04	0.12	1.71	3.12	2.67	4.02	1.89	0.75	0.93	0.52	0.28	0.22	1.36
2739H1	3.79	0.05	0.06	1.01	1.52	1.32	2.04	0.90	0.32	0.42	0.24	0.13	0.11	0.68
2739Z2	46.00	0.93	1.70	16.30	24.10	17.00	24.20	10.70	4.67	3.50	3.40	2.21	1.45	9.20

## SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 472.00      TOTAL FLOW IN = 1104.56  
 SUM OF SUR-DRAINAGE AREAS = 472.04      TOTAL FLOW OUT = 1105.10

## MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739A1	10	72	15.30	14	15.00				
	11	72	52.00	4	60.00				
	12	72	30.20	3	39.00				
	1	73	41.90						
	2	73	48.40	4	65.00				
	3	73	432.00	11	389.00				
	4	73	195.00	8	203.00	20	203.00		
	5	73	90.67	4	132.00	14	63.00		
	6	73	76.80	19	40.00				
	7	73	18.20	15	14.00				
2739H1	8	73	6.54	19	5.00				
	9	73	5.28	8	3.30				
	10	72	0.22	14	0.20				
	11	72	0.62	4	0.70				
	12	72	0.17	3	0.50				
	1	73	0.30						
	2	73	0.27	4	0.40				
	3	73	4.13	11	3.70				
	4	73	2.57	8	2.70	20	2.70		
	5	73	1.42	4	2.10	19	1.00		

## TRIBUTARY FLOW INFORMATION FOR MINNESOTA

10/30/74

LAKE CODE 2739 HERON LAKE

## MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739C1	10	72	6.78	14	6.60				
	11	72	22.20	4	26.00				
	12	72	13.90	3	18.00	12	16.00		
	1	73	18.00						
	2	73	20.50	4	28.00				
	3	73	201.00	11	181.00				
	4	73	85.00	8	88.00	20	88.00		
	5	73	40.50	4	59.00	19	28.00		
	6	73	34.50	19	35.00				
	7	73	8.08	15	7.70				
	8	73	2.87	19	3.50				
	9	73	2.40	8	1.70				
2739D1	10	72	5.02	14	4.90				
	11	72	16.10	4	19.00				
	12	72	12.00	3	16.00				
	1	73	16.20						
	2	73	16.90	4	23.00				
	3	73	178.00	11	160.00				
	4	73	62.60	8	65.00	20	65.00		
	5	73	30.00	4	44.00	19	21.00		
	6	73	25.80	19	26.00				
	7	73	6.27	15	6.00				
	8	73	2.28	19	2.80				
	9	73	2.07	8	1.50				
2739E1	10	72	0.86	14	0.80				
	11	72	2.54	4	2.90				
	12	72	2.24	3	2.90				
	1	73	2.64						
	2	73	2.39	4	3.20				
	3	73	31.00	11	28.00				
	4	73	10.20	4	11.00	20	11.00		
	5	73	5.29	4	7.70	19	3.70		
	6	73	4.67	19	4.90				
	7	73	1.17	15	1.10				
	8	73	0.41	19	0.50				
	9	73	0.46	8	0.33				
2739F1	10	72	0.11	14	0.10				
	11	72	0.30	4	0.30				
	12	72	0.25	3	0.30	8	0.30		
	1	73	0.21						
	2	73	0.19	4	0.20				
	3	73	2.60	11	2.30				
	4	73	1.16	8	1.20	20	1.20		
	5	73	0.59	4	1.00	19	0.50		
	6	73	0.61	19	0.60				
	7	73	0.16	15	0.15				
	8	73	0.05	19	0.06				
	9	73	0.07	8	0.05				

## TRIBUTARY FLOW INFORMATION FOR MINNESOTA

10/30/74

LAKE CODE 2739 HERON LAKE

## MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2739G1	10	72	0.23	14	0.20				
	11	72	0.64	4	0.70				
	12	72	0.43	3	0.60				
	1	73	0.34						
	2	73	0.32	4	0.40				
	3	73	4.53	11	4.10				
	4	73	2.53	8	2.60	20	2.60		
	5	73	1.42	4	2.10	19	1.00		
	6	73	1.28	19	1.30				
	7	73	0.32	15	0.31				
	8	73	0.11	19	0.13				
	9	73	0.14	8	0.10				
2739H1	10	72	0.11	14	0.10				
	11	72	0.30	4	0.30				
	12	72	0.21	3	0.30				
	1	73	0.21						
	2	73	0.16	4	0.20				
	3	73	2.68	11	2.40				
	4	73	1.23	8	1.30	20	1.30		
	5	73	0.70	4	1.00	19	0.50		
	6	73	0.65	19	0.70				
	7	73	0.15	15	0.14				
	8	73	0.04	19	0.05				
	9	73	0.06	8	0.04				
2739ZZ	10	72	1.50	14	1.50				
	11	72	5.06	4	5.80				
	12	72	2.83	3	3.60	8	3.60		
	1	73	4.17						
	2	73	4.52	4	6.10				
	3	73	43.20	11	34.00				
	4	73	19.50	8	20.00	20	20.00		
	5	73	9.01	4	13.00	19	6.30		
	6	73	7.68	19	8.00				
	7	73	1.82	15	1.90				
	8	73	0.65	19	0.74				
	9	73	0.53	8	0.34				

## **APPENDIX B**

### **PHYSICAL and CHEMICAL DATA**

STORED RETRIEVAL DATE 74/10/30

273901  
43 47 00.0 095 17 00.0  
HERON LAKE  
27053 MINNFSOTA

11EPALES  
5 2111202  
0005 FEET DEPTH

DATE	TIME	DEPTH	WATER	00010	00300	00077	00094	00400	00410	00630	00610	00665	00666
FROM	OF		TEMP	DO		TRANSP	CONDUTVY	PH	T ALK	NO2&NO3	NH3-N	PHOS-TOT	PHOS-DIS
TO	DAY	FEET	CENT	MG/L		SECCHI	FIELD	CACO3	N-TOTAL	TOTAL		MG/L P	MG/L P
72/07/01	17	30	0000	25.0		10.8	18	940	8.90	152	0.050	0.060	0.366
72/08/30	18	40	0000	22.0		8.4	6	875	9.19	104	0.060	0.100	0.234

32217  
DATE TIME DEPTH CHLOROPHYL  
FROM OF A  
TO DAY FEET UG/L

72/07/01	17	30	0000	40.9J
72/08/30	18	40	0000	181.2J

J VALUE KNOWN TO BE IN ERROR

## APPENDIX C

TRIBUTARY and WASTEWATER  
TREATMENT PLANT DATA

STOPLIT RETRIEVAL DATE 74/12/27

2751A1 152761A1  
 45 36 30.0 045 32 00.0  
 OUTLET CREEK  
 27 7.5 STARRICK  
 U/LAKE MINNEWASKA  
 ST HWY 29 RDG S OF STARHUCK  
 11EPALFS 2111204  
 + 0000 FEET DEPTH

DATE	TIME	DEPTH	N026403	TOT KJEL	NH3-N	PHOS-PIC	PHOS-TOT
FROM	OF		N-TOTAL	N	TOTAL	OPTHO	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
72/10/15	09	30	0.104	0.850	0.126	0.009	0.037
72/11/10	10	50	1.042	0.950	0.005K	0.005K	0.032
72/12/04	12	30	0.012	0.670	0.011	0.005K	0.016
73/01/27	12	23	0.115	0.960	0.169	0.025	
73/02/04	11	20	0.021	0.840	0.029	0.005K	0.015
73/02/10	10	45	1.056	1.500	0.154	0.023	0.023
73/04/15	10	45	0.013	0.990	0.056	0.005K	0.030
73/04/20	12	10	0.010K	1.700	0.026	0.008	0.040
73/05/20	12	10	0.011	1.200	0.054	0.005K	0.030
73/06/11	12	51	0.010K	0.840	0.060	0.011	0.040
73/07/17	11	41	0.011	1.050	0.019	0.008	0.035
73/08/07	13	30	0.010K	0.960	0.120	0.010	0.040
73/09/10	14	45	0.010K	1.000	0.638	0.012	0.050

K VALUE KNOWN TO IF  
 LESS THAN INDICATED

STATION : T-1 TAL 003 74/12/27

2761H1 LS2761H1  
 45 39 30.0 095 24 00.0  
 UNNAMED DITCH TO LK MINNEWASKA  
 27 7.5 GLENWOOD  
 T/LAKE MINNEWASKA  
 HWYS 28/29 W GLENWOOD BELOWSTP  
 11EPALES 2111204  
 4 0000 FEET DEPTH

DATE	TIME	TEMP °C	TOT NUTL	NH3-N	PHOS-DIS	PHOS-TOT
FROM	OF		TOTAL	TOTAL	ORTHO	
T)	DAY	FEET	M.G/L	MG/L	MG/L P	MG/L P
72/11/15	09 00		3.000	0.200	0.154	1.100
72/11/17	10 32		1.700	5.000	0.054	0.255
73/02/04	11 05		4.700	0.960	0.470	0.960
73/03/10	10 30		3.100	0.830	0.135	0.805
73/04/15	10 35		2.200	2.520	0.710	1.000
73/04/30	11 40		2.300	3.500	1.890	1.570
73/05/20	11 40		2.300	3.230	1.680	1.435
73/05/30	11 40		2.300	3.600	1.750	1.300
73/05/31	12 20		2.300	3.500	1.600	1.600
73/07/17	11 30		2.300	2.700	1.500	1.740
73/09/17	12 40		2.100	3.100	1.370	2.000
73/10/17	14 25		2.400	4.100	1.000	2.100
						3.150

STOPEL RETRIEVAL DATE 74/12/27

2741C1 LS2761C1  
 45 39 00.0 045 25 00.0  
 HELICAN LAKE /LAKE MINNEWASKA CN  
 ?7 7.5 GLENWOOD  
 T/LAKE MINNEWASKA  
 2ND ROAD XING SW OF LONG BEACH  
 11EPALES 2111204  
 4 0000 FEET DEPTH

DATE	TIME	DR PT + NO2N103	00630	00625	00610	00671	00665
FROM	Dr	N-TOTAL	TOT KJEL	N	NH3-N	PHOS-DIS	PHOS-TOT
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
72/10/11	13	10	3.156	1.300	0.198	0.019	0.048
72/11/11	10	45	0.177	1.540	0.008	0.017	0.040
72/12/12	12	15	0.134	1.540	0.231	0.002	0.042
73/02/01	11	50	0.120	1.700	0.490	0.005K	0.035
73/03/10	10	40	0.473	3.490	1.790	0.110	0.155
73/04/10	10	40	0.016K	1.470	0.046	0.011	0.065
73/04/30	11	50	0.012	1.320	0.060		0.050
73/05/20	11	50	0.013	1.470	0.058	0.005K	0.065
73/05/30	11	50	0.016	1.300	0.060	0.011	0.055
73/06/11	12	45	0.023	1.380	0.075	0.015	0.040
73/07/17	11	05	0.039	1.540	0.056	0.015	0.065
73/08/07	12	50	0.015	1.610	0.189	0.018	0.060
73/09/10	1+	35	0.018	2.700	0.028	0.013	0.050

K VALUE KNOWN TO BE  
 LESS THAN INDICATED

## APPENDIX C

TRIBUTARY and WASTEWATER  
TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/03/03

2739A1 LS2739A1  
 43 49 00.0 095 15 30.0  
 HERON LAKE OUTLET  
 27 7.5 HERON LAKE  
 0/HERON LAKE  
 ST HWY 60 BRDG BETW HERON LK AND WILDER  
 11EPAL5 2111204  
 4 0000 FEET DEPTH

DATE FROM TU	TIME OF DAY	DEPTH FEET	00630 N02&N03 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-TUT MG/L P
72/10/14	09 00		0.020	2.015	0.160	0.210	0.330
72/11/04	10 40		0.580	1.800	0.280	0.147	0.220
73/03/11	08 45		1.060	2.940	0.720	0.270	0.430
73/03/23	16 45		2.900	1.980	0.950	0.115	0.250
73/04/08	09 45		3.700	2.600	0.160	0.063	0.230
73/04/20	15 30		3.400	2.300	0.063	0.060	0.210
73/05/04	17 15		2.400	4.300	0.066	0.033	0.221
73/05/19	10 00		1.300	3.100	0.019	0.032	0.210
73/06/19	08 00		0.147	4.100	0.056	0.066	0.410
73/07/15	09 00		0.019	4.200	0.042	0.094	0.400
73/08/19	10 15		0.039	3.300	0.420	0.147	0.195
73/09/06	09 20		0.250	3.990	0.470	0.168	0.470

STORET RETRIEVAL DATE 75/03/03

273981 LS273981  
43 48 30.0 095 16 00.0  
DUCK LK OUTLET TO HERON LK  
27 7.5 HERON LAKE  
T/HERON LAKE  
ST HWY 60 BRDG .75 MI NE OF HERON LAKE  
11EPALES 2111204  
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NU26N03	00625 TOT KJEL	00610 NH3-N N	00671 PHOS-DIS TOTAL	00665 PHOS-TOT MG/L P
72/10/14	09 30		0.087	7.875	0.410	0.060	0.151
72/11/04	10 50		0.360	2.900	0.770	0.075	0.147
73/03/11	08 30		0.910	2.600	0.435	0.655	0.810
73/03/23	15 30		0.110	2.100	0.093	0.020	0.165
73/04/08	10 00		0.024	3.150	0.147	0.022	0.170
73/04/20	15 45		0.048	2.600	0.027	0.028	0.165
73/05/04	17 25		0.126	2.400	0.024	0.031	0.160
73/05/19	09 30		0.012	2.200	0.044	0.026	0.160
73/06/19	08 15		0.028	6.400	0.126	0.115	0.490
73/07/15	09 15		0.010K	20.500	7.800	0.420	1.650

K VALUE KNOWN TO BE  
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2734C1 LS2739C1  
 43 46 00.0 095 14 00.0  
 JACK CREEK  
 27 7.5 HERON LAKE  
 T/HERON LAKE  
 CO HWY 9 BRDG 1.5 MI S OF HERON LAKE  
 11EPALES 2111204  
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 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	09 40		0.030	1.675	0.075	0.011	0.190
72/11/04	10 50		5.500	3.200	0.270	0.240	0.610
72/12/12	08 15		7.500	0.330	0.066	0.052	0.043
73/03/11	09 20		1.400	2.300	0.560	0.230	0.375
73/03/23	16 15		3.700	1.890	0.138	0.079	0.230
73/04/08	09 30		5.000	2.000	0.069	0.042	0.170
73/05/04	17 40		6.200	1.500	0.006	0.015	0.070
73/05/14	09 15		5.800	2.300	0.075	0.015	0.110
73/06/19	08 30		5.800	1.400	0.047	0.057	0.240
73/07/15	09 30		0.550	1.800	0.092	0.027	0.220
73/08/19	09 45		0.030	3.100	0.067	0.066	0.080

STJRET RETRIEVAL DATE 75/03/03

2739D1 LS2739D1  
 43 45 00.0 095 19 00.0  
 OKABENA CREEK  
 27 CO # 32  
 T/HERON LAKE  
 CO HWY 9 BRDG N EUGE OF OKABENA  
 11EPALES 2111204  
 4 0000 FEET DEPTH

DATE FROM TU	TIME OF DAY	DEPTH FEET	00630 N02&N03	00625 TOT KJEL	00610 NH3-N	00671 PHOS-DIS	00665 PHOS-TOT
			MG/L	MG/L	TOTAL MG/L	ORTHO MG/L P	MG/L P
72/10/14	10 00		0.220	5.075	0.336	0.360	0.630
72/11/04	11 00		4.200	4.200	0.780	0.610	1.040
73/03/11	09 10		2.500	2.520	1.260	0.470	0.575
73/03/23	16 00		7.700	1.380	0.590	0.350	0.430
73/04/08	09 20		8.900	4.100	3.400	0.650	0.760
73/04/20	16 15		10.000	2.310	0.730	0.300	0.440
73/05/04	17 50		10.300	2.800	0.590	0.320	0.450
73/05/19	10 15		7.300	3.780	0.022	0.198	0.490
73/06/19	08 45		7.500	1.950	0.176	0.430	0.680
73/07/15	09 45		2.400	4.600	0.050	0.310	0.795
73/08/19	09 30		0.240	1.200	0.390	0.750	1.500
73/09/08	08 40		0.380	6.900	0.760	0.992	1.880

STORET RETRIEVAL DATE 75/03/03

2739E1 LS2739E1  
43 41 30.0 095 13 30.0  
UNNAMED TRIB TO S PART S HERON L  
27 CO #32  
T/HERON LAKE  
CO HWY 20 BRDG 2.5 MI WNW OF LAKEFIELD  
11PALES 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	00685 PHOS-TOT MG/L P
72/10/14	10 05		0.450	2.475	0.320	0.126	0.294
72/11/04	11 10		8.300	0.980	0.132	0.200	0.390
73/03/11	08 55		4.200	3.700	0.660	0.357	0.510
73/03/23	15 45		10.200	2.200	0.005K	0.096	0.130
73/04/08	09 05		12.400	1.100	0.105	0.037	0.090
73/04/20	16 30		12.000		0.008	0.031	0.040
73/05/04	18 00		13.000	0.500	0.026	0.034	0.070
73/05/19	10 30		14.400	1.000	0.088	0.031	0.113
73/06/19	09 00		14.700	1.380	0.154	0.160	0.290
73/07/15	10 00		8.300	1.260	0.115	0.095	0.155
73/08/19	09 15		4.900	1.130	0.180	0.200	0.280

K VALUE KNOWN TO BE  
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739F1 LS2739F1  
 43 41 00.0 095 10 30.0  
 UNNAMED TRIB TO SE END S HERON L  
 27 CO # 32  
 T/HERON LAKE  
 ST HWY 86 XING N EUGE OF LAKEFIELD  
 11EPALES 2111204  
 4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03	00625 TOT KJEL	00610 NH3-N	00671 PHOS-DIS	00665 PHOS-TOT
			N-TOTAL MG/L	N MG/L	TOTAL MG/L	ORTHO MG/L P	MG/L P
72/10/14	10 15		2.000	0.580	0.049	0.082	0.105
72/11/04	11 15		8.900	0.100K	0.007	0.092	0.115
72/12/08	08 10		10.400	0.700	0.017	0.096	0.210
73/03/11	08 10		5.900	3.500	0.650	0.400	0.590
73/03/23	17 30		10.200	0.420	0.005K	0.115	0.130
73/04/08	09 00		12.000	0.310	0.018	0.057	0.065
73/04/20	16 45		12.000	0.760	0.018	0.052	0.055
73/05/04	16 40		12.600	0.240	0.005K	0.050	0.065
73/05/19	09 45		11.200	0.300	0.020	0.050	0.065
73/06/19	09 15		17.000	1.470	0.054	0.105	0.175
73/07/15	10 15		12.000	0.150	0.021	0.115	0.135
73/08/19	09 00		7.400	2.000	0.178	0.105	0.125
73/09/08	08 00		2.200	1.340	0.138	0.280	0.320

K VALUE KNOWN TO BE  
 LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739G1 LS2739G1  
43 44 30.0 095 13 00.0  
LK FLAHERTY/S HERON LK CONNECTIO  
27 CO #32  
T/HERON LAKE  
CO HWY 24 XING .5 M W OF LNFLAHERTY  
11EPALES 2111204  
4 0000 FEET DEPTH

DATE	TIME	DEPTH	NO26N03	00630	00625	00610	00671	00665
FROM	OF		N-TOTAL	TOT KJEL	N	NH3-N	PHOS-DIS	PHOS-TUT
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L	MG/L P	MG/L P
72/10/14	10	30		0.070	2.800	0.170	0.016	0.240
72/11/04	11	25		1.400	1.600	0.394	0.138	0.260
73/02/04	08	20		0.294	4.000	1.300	0.005K	0.075
73/03/11	08	30		0.480	1.980	0.520	0.037	0.150
73/03/23	17	00		0.740	8.700	0.138	0.019	0.160
73/04/08	09	15		0.950	3.800	0.050	0.031	0.160
73/04/20	17	00		1.000	3.650	0.105	0.050	0.190
73/05/04	16	55		6.730		0.150	0.044	0.190
73/05/19	08	45		2.600	3.100	0.710	0.048	0.330
73/06/19	09	30		7.000	2.800	0.370	0.036	0.142
73/07/15	10	30		0.019	11.000	4.500	0.160	0.760
73/08/19	10	30		0.078	13.000	4.625	0.105	0.185
73/09/08	09	40		2.000	3.900	1.000	0.260	0.490

K VALUE KNOWN TO BE  
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/03

2739H1 LS2739H1  
43 46 00.0 095 14 30.0  
TEAL LAKE/HERON LAKE CONNECTION  
27 CU #32  
T/HERON LAKE  
CO HWY 24 XING .5 MI E OF HERON LAKE  
11EPALES 2111204  
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N026N03 MG/L	00625 TOT KJEL MG/L	00610 NH3-N N MG/L	00671 PHOS-DIS TOTAL MG/L	00665 PHOS-TOT MG/L P
72/10/14	10 45		0.104	1.325	0.100	0.015	0.170
72/12/03	08 00		0.273	2.000	0.480	0.005K	0.033
73/03/11	08 50		2.200	2.500	0.450	0.210	0.345
73/03/23	17 15		3.800	3.300	0.005K	0.030	0.060
73/04/08	09 30		5.900	1.750	0.115	0.014	0.030
73/04/20	17 15		5.800	0.920	0.042	0.014	0.025
73/05/04	17 00		5.800	0.950	0.022	0.014	0.040
73/05/19	09 00		2.600	3.100	0.130	0.015	0.050
73/06/19	09 45		5.400	0.585	0.048	0.030	0.065
73/07/15	10 45		0.080	1.380	0.113	0.025	0.145
73/08/19	10 30		0.066	1.600	- 0.120	0.120	0.125

K VALUE KNOWN TO BE  
LESS THAN INDICATED

STORED RETRIEVAL DATE 74/10/30

273951 P0273951 P000777  
43 47 00.0 095 18 30.0  
HERON LAKE  
27063 7.5 LAKE HERON  
T/HERON LAKE  
UNNAMED CREEK  
11EPALES 2141204  
4 0000 FEET DEPTH

DATE	TIME	DEPTH	NO <sub>2</sub> &NO <sub>3</sub>	00630	00625	00610	00671	00665	50051	50053
FROM	OF		N-TOTAL	TOT	KJEL	NH <sub>3</sub> -N	PHOS-DIS	PHOS-TOT	FLOW	CONDUIT
TO	DAY	FEET	MG/L		MG/L	TOTAL	ORTHO		RATE	FLOW-MGD
			MG/L		MG/L	MG/L	MG/L P	MG/L P	INST	MGD
										MONTHLY
73/04/03	09 00			0.670	11.000	0.176	0.680	1.725		0.085