

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



REPORT
ON
MARION RESERVOIR
MARION COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 517

**CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA**

REPORT
ON
MARION RESERVOIR
MARION COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 517

WITH THE COOPERATION OF THE
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
AND THE
KANSAS NATIONAL GUARD
APRIL, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater 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 freshwater 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 Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health 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.

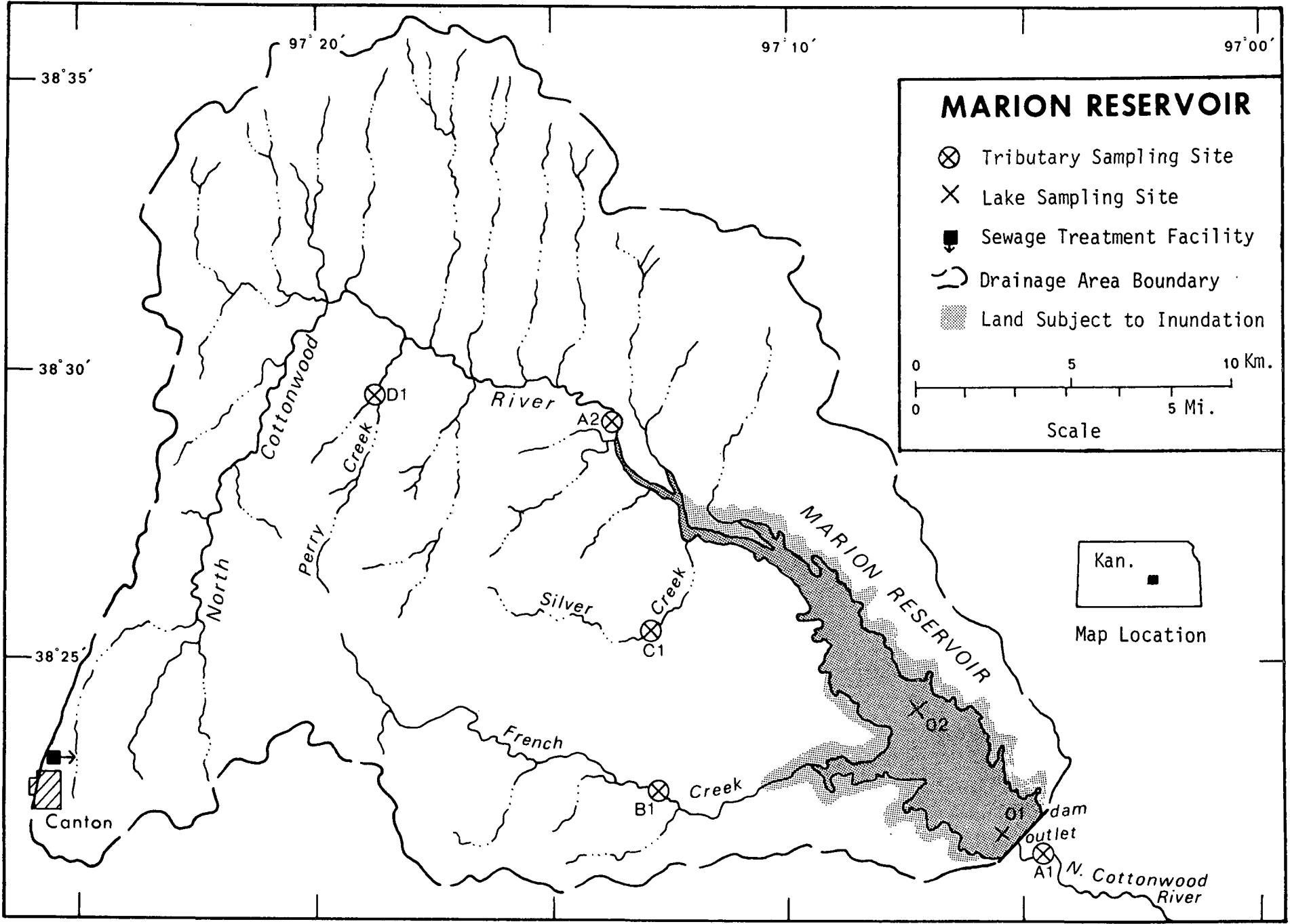
Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

<u>NAME</u>	<u>COUNTY</u>
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell



MARION RESERVOIR

STORET NO. 2007

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Marion Reservoir is eutrophic. It ranked third in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*. Five of the reservoirs had less median total phosphorus, four had less median dissolved orthophosphorus, five had less median inorganic nitrogen, ten had less mean chlorophyll a, and eight had greater mean Secchi disc transparency.

Survey limnologists did not observe macrophytes or surface concentrations of algae.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Marion Reservoir was phosphorus limited at the time the sample was taken (04/12/74). The reservoir data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--The only known point source contributing phosphorus to Marion Reservoir was the municipal wastewater treatment facility at Canton. It is estimated that this plant contributed about 9.5% of the load during the sampling year. However, the phosphorus export rate of North Cottonwood River at station A-2

* See Appendix A.

(22 kg/km²/yr) may be indicative of an underestimation of the phosphorus load from Canton or unknown phosphorus sources in that drainage basin.

The present phosphorus loading of 0.41 g/m²/year is about 1.6 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). Because the reservoir is phosphorus limited, minimization of phosphorus loads to the greatest practicable extent may slow the rate of eutrophication in the reservoir, particularly if a major portion of the North Cottonwood River phosphorus export proves to be controllable.

2. Non-point sources--Non-point sources contributed about 90.5% of the total phosphorus load during the sampling year. The North Cottonwood River contributed 46.1%, and ungaged minor tributaries and immediate drainage contributed an estimated 40.1%. As noted above, improvement in water quality of the reservoir would be possible if a substantial reduction in the North Cottonwood River phosphorus load can be accomplished.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry^{††}:

1. Surface area: 24.93 kilometers².
2. Mean depth: 4.1 meters.
3. Maximum depth: 10.1 meters.
4. Volume: 102.213×10^6 m³.
5. Mean hydraulic retention time: 2.4 years (based on outflow).

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

1. Tributaries -

Name	Drainage area (km ²)*	Mean flow (m ³ /sec)*
North Cottonwood River	246.6	0.85
Minor tributaries & immediate drainage -	<u>246.5</u>	<u>1.46</u>
Totals	493.1	2.31

2. Outlet -

North Cottonwood River	518.0**	1.33
------------------------	---------	------

C. Precipitation***:

1. Year of sampling: 80.8 centimeters.
2. Mean annual: 82.2 centimeters.

[†] Table of metric conversions--Appendix B.

^{††} Stoltzenberg, 1975.

* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".

** Includes area of reservoir.

*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Marion Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or 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 9.1 meters at station 1 and 3.0 meters at station 2.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR MARION RESERVOIR
STURET CODE 2007

PARAMETER	1ST SAMPLING (4/12/74)			2ND SAMPLING (6/27/74)			3RD SAMPLING (10/ 2/74)		
	2 SITES			2 SITES			2 SITES		
	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	11.0 - 12.0	11.4	11.0	22.4 - 23.3	22.8	22.5	15.1 - 15.5	15.3	15.4
DISS OXY (MG/L)	10.0 - 10.2	10.1	10.0	6.0 - 7.4	6.7	6.7	8.4 - 9.8	9.0	8.8
CNDCTVY (MCROMO)	397. - 421.	409.	405.	474. - 488.	480.	475.	428. - 440.	433.	432.
PH (STAND UNITS)	8.1 - 8.3	8.3	8.3	8.3 - 8.4	8.3	8.3	8.4 - 8.6	8.5	8.4
TOT ALK (MG/L)	140. - 191.	150.	143.	116. - 129.	123.	123.	124. - 129.	126.	126.
TOT P (MG/L)	0.063 - 0.137	0.090	0.086	0.046 - 0.088	0.063	0.052	0.020 - 0.050	0.029	0.021
ORTHO P (MG/L)	0.005 - 0.011	0.007	0.006	0.021 - 0.026	0.023	0.022	0.007 - 0.010	0.008	0.008
NO2+N03 (MG/L)	0.310 - 0.600	0.383	0.350	1.020 - 1.180	1.134	1.150	0.050 - 0.230	0.172	0.220
AMMONIA (MG/L)	0.030 - 0.080	0.053	0.050	0.050 - 0.110	0.080	0.085	0.020 - 0.080	0.053	0.050
KJEL N (MG/L)	0.700 - 1.000	0.786	0.800	0.400 - 0.700	0.537	0.550	0.300 - 0.500	0.367	0.300
INORG N (MG/L)	0.360 - 0.640	0.436	0.400	1.110 - 1.290	1.214	1.225	0.070 - 0.300	0.225	0.275
TOTAL N (MG/L)	1.030 - 1.400	1.169	1.110	1.520 - 1.850	1.671	1.645	0.520 - 0.580	0.538	0.530
CHLRPYL A (UG/L)	18.0 - 21.5	19.8	19.8	1.2 - 2.0	1.6	1.6	7.7 - 24.0	15.8	15.8
SECCHI (METERS)	0.3 - 0.3	0.3	0.3	0.3 - 0.5	0.4	0.4	0.5 - 0.8	0.6	0.6

B. Biological Characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml</u>
04/12/74	1. <u>Cyclotella</u> sp. 2. <u>Melosira</u> sp. 3. <u>Stephanodiscus</u> sp. 4. <u>Synedra</u> sp. 5. <u>Crucigenia</u> sp. Other genera	30,718 6,211 1,310 211 169 <u>297</u>
	Total	38,916
06/27/74	1. <u>Stephanodiscus</u> sp. 2. <u>Melosira</u> sp. 3. <u>Chroomonas</u> sp. 4. <u>Cryptomonas</u> sp. 5. <u>Oocystis</u> sp. Other genera	308 308 166 142 95 <u>120</u>
	Total	1,137
10/02/74	1. <u>Carteria</u> sp. 2. <u>Chroomonas</u> sp. 3. <u>Nitzschia</u> sp. 4. <u>Stephanodiscus</u> sp. 5. <u>Cryptomonas</u> sp. Other genera	660 616 572 484 440 <u>1,455</u>
	Total	4,227

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll a (µg/l)</u>
04/12/74	1	21.5
	2	18.0
06/27/74	1	1.2
	2	2.0
10/02/74	1	7.7
	2	24.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

<u>Spike (mg/l)</u>	<u>Ortho P Conc. (mg/l)</u>	<u>Inorganic N Conc. (mg/l)</u>	<u>Maximum yield (mg/l-dry wt.)</u>
Control	0.005	0.242	5.8
0.050 P	0.055	0.242	8.3
0.050 P + 1.0 N	0.055	1.242	18.6
1.0 N	0.005	1.242	5.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Marion Reservoir was high at the time the sample was collected (04/12/74). Also, the significant increase in yield with the addition of phosphorus alone indicates that the reservoir was phosphorus limited at that time. Note that the addition of only nitrogen resulted in a yield essentially the same as that of the control.

The reservoir data indicate phosphorus limitation as well. The mean inorganic nitrogen/orthophosphorus ratios were 16/1 or greater at all sampling stations and times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas 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 month of June when three samples were collected at most of the sites. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Silver Creek at station C-1 and the mean annual ZZ flow.

The operator of the Canton wastewater treatment plant provided monthly effluent samples; however, corresponding flow data were not available. Therefore, nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m³/capita/day.

A. Waste Sources:

1. Known municipal* -

<u>Name</u>	<u>Pop. Served</u>	<u>Treatment</u>	<u>Mean Flow (m³/d)</u>	<u>Receiving Water</u>
Canton	854	tr. filter	323.2	North Cotton- wood River

2. Known industrial - None

* Treatment plant questionnaire.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg P/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
N. Cottonwood River	4,715	46.1
b. Minor tributaries & immediate drainage (non-point load) -	4,100	40.1
c. Known municipal STP's -		
Canton	970	9.5
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>435</u>	<u>4.3</u>
Total	10,220	100.0

2. Outputs -

Reservoir outlet - N. Cottonwood River 2,850

3. Net annual P accumulation - 7,370 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg N/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
N. Cottonwood River	64,055	40.1
b. Minor tributaries & immediate drainage (non-point load) -	65,750	41.2
c. Known municipal STP's -		
Canton	2,905	1.8
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>26,915</u>	<u>16.9</u>
Total	159,625	100.0

2. Outputs -

Reservoir outlet - N. Cottonwood River 52,510

3. Net annual N accumulation - 107,115 kg.

D. Non-point Nutrient Export by Subdrainage Area:

<u>Tributary</u>	<u>kg P/km²/yr</u>	<u>kg N/km²/yr</u>
N. Cottonwood River	22	260

E. Mean Nutrient Concentrations in Ungaged Streams:

<u>Tributary</u>	<u>Mean Total P Conc. (mg/l)</u>	<u>Mean Total N Conc. (mg/l)</u>
French Creek	0.164	2.250
Silver River	0.089	1.428
Perry River	0.162	1.829

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). 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	0.41	0.30	6.4	4.3

Vollenweider phosphorus loadings
(g/m²/yr) based on mean depth and mean
hydraulic retention time of Marion Reservoir:

"Dangerous" (eutrophic loading)	0.26
"Permissible" (oligotrophic loading)	0.13

V. LITERATURE REVIEWED

Prophet, Carl W., Joy E. Prather, and N. Leon Edwards, 1970. Comparison of summer water quality features in three Grand River reservoirs, Kansas. Emporia St. Res. Studies, vol. XVIII (4), KS St. Teachers Coll., Emporia.

Stoltenberg, Gerald A., 1975. Personal communication (reservoir morphometry). KS Dept. of Health & Environment, Topeka.

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.

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 CHLOR \AA	15- MIN DO	MEDIAN DISS ORTHO P
2001	CEDAR BLUFF RESERVOIR	0.017	0.055	431.667	4.217	10.800	0.004
2002	COUNCIL GROVE	0.069	0.830	485.889	9.789	10.400	0.028
2003	ELK CITY	0.030	0.590	490.400	3.212	14.000	0.003
2004	FALL RIVER RESERVOIR	0.053	0.470	488.667	7.683	9.200	0.016
2005	JOHN REDMOND RESERVOIR	0.118	1.250	492.667	9.467	8.200	0.066
2006	KANOPOLIS RESERVOIR	0.056	0.640	487.000	16.033	10.200	0.011
2007	MARION RESERVOIR	0.052	0.430	483.667	12.400	9.000	0.010
2008	MELVERN RESERVOIR	0.034	0.265	459.111	30.400	14.400	0.007
2009	MILFORD RESERVOIR	0.079	0.710	466.333	18.883	12.800	0.036
2010	NORTON RESERVOIR	0.122	0.110	476.750	21.360	8.000	0.036
2011	PERRY RESERVOIR	0.055	0.970	478.571	5.614	13.400	0.017
2012	POMONA RESERVOIR	0.040	1.240	481.333	8.312	13.000	0.021
2013	TORONTO RESERVOIR	0.067	0.425	488.500	6.583	13.000	0.011
2014	TUTTLE CREEK RESERVOIR	0.162	0.970	470.667	11.278	13.600	0.067
2015	WILSON RESERVOIR	0.023	0.265	445.222	8.867	13.400	0.004

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	2001	CEDAR BLUFF RESERVOIR	539
2	2015	WILSON RESERVOIR	439
3	2007	MARION RESERVOIR	357
4	2003	ELK CITY	350
5	2004	FALL RIVER RESERVOIR	328
6	2008	MELVERN RESERVOIR	326
7	2013	TORONTO RESERVOIR	303
8	2010	NORTON RESERVOIR	292
9	2011	PERRY RESERVOIR	279
10	2006	KANOPOLIS RESERVOIR	271
11	2012	POMONA RESERVOIR	267
12	2002	COUNCIL GROVE	230
13	2009	MILFORD RESERVOIR	214
14	2005	JOHN REDMOND RESERVOIR	164
15	2014	TUTTLE CREEK RESERVOIR	139

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
2001	CEDAR BLUFF RESERVOIR	100 (14)	100 (14)	100 (14)	93 (13)	57 (8)	89 (12)	539
2002	COUNCIL GROVE	29 (4)	29 (4)	36 (5)	43 (6)	64 (9)	29 (4)	230
2003	ELK CITY	86 (12)	50 (7)	7 (1)	100 (14)	7 (1)	100 (14)	350
2004	FALL RIVER RESERVOIR	57 (8)	57 (8)	14 (2)	71 (10)	79 (11)	50 (7)	328
2005	JOHN REDMOND RESERVOIR	14 (2)	0 (0)	0 (0)	50 (7)	93 (13)	7 (1)	164
2006	KANOPOLIS RESERVOIR	43 (6)	43 (6)	29 (4)	21 (3)	71 (10)	64 (9)	271
2007	MARION RESERVOIR	64 (9)	64 (9)	43 (6)	29 (4)	86 (12)	71 (10)	357
2008	MELVERN RESERVOIR	79 (11)	82 (11)	86 (12)	0 (0)	0 (0)	79 (11)	326
2009	MILFORD RESERVOIR	21 (3)	36 (5)	79 (11)	14 (2)	50 (7)	14 (2)	214
2010	NORTON RESERVOIR	7 (1)	93 (13)	64 (9)	7 (1)	100 (14)	21 (3)	292
2011	PERRY RESERVOIR	50 (7)	18 (2)	57 (8)	86 (12)	25 (3)	43 (6)	279
2012	POMONA RESERVOIR	71 (10)	7 (1)	50 (7)	64 (9)	39 (5)	36 (5)	267
2013	TORONTO RESERVOIR	36 (5)	71 (10)	21 (3)	79 (11)	39 (5)	57 (8)	303
2014	TUTTLE CREEK RESERVOIR	0 (0)	18 (2)	71 (10)	36 (5)	14 (2)	0 (0)	139
2015	WILSON RESERVOIR	93 (13)	82 (11)	93 (13)	57 (8)	25 (3)	89 (12)	439

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 KANSAS

05/03/76

LAKE CODE 2007 MARION

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 518.0

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS)												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
2007A1	518.0	0.71	0.74	1.73	1.64	2.07	2.35	1.87	0.57	1.33	1.19	1.10	0.68	1.33
2007A2	246.6	0.37	0.48	1.08	1.10	1.50	1.59	1.53	0.51	0.62	0.68	0.37	0.37	0.85
2007ZZ	271.4	0.57	0.76	1.50	1.70	2.61	2.69	2.41	1.33	1.42	1.27	0.68	0.59	1.46

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 518.0
 SUM OF SUB-DRAINAGE AREAS = 518.0 TOTAL FLOW IN = 27.72
 TOTAL FLOW OUT = 15.97

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2007A1	10	74	0.181	13	0.212				
	11	74	0.784	10	0.173				
	12	74	0.309	15	0.198				
	1	75	1.085	12	0.221				
	2	75	1.860						
	3	75	1.832	9	0.736				
	4	75	1.985	13	2.407				
	5	75	0.631	4	0.906	18	0.821		
	6	75	3.936	15	5.918	27	0.311		
	7	75	5.663	13	0.736				
	8	75	0.170	30	0.161				
	9	75	0.221	14	0.212				
2007A2	10	74	0.878	13	26.901				
	11	74	0.538	10	1.104				
	12	74	0.453	15	0.283				
	1	75	0.481	12	0.708				
	2	75	1.501						
	3	75	1.303	9	0.425				
	4	75	0.227	13	0.481				
	5	75	0.850	4	0.765	18	0.227		
	6	75	6.230	15	0.283	27	1.444	29	1.133
	7	75	0.680	13	0.062				
	8	75	0.453	30	1.472				
	9	75	0.119	14	0.085				
2007ZZ	10	74	0.266						
	11	74	0.963						
	12	74	0.736						
	1	75	0.708						
	2	75	2.379						
	3	75	1.841						
	4	75	1.671						
	5	75	1.472						
	6	75	10.194						
	7	75	1.048						
	8	75	1.218						
	9	75	0.266						

APPENDIX D
PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/05/03

200701
 38 22 27.0 097 04 45.0 4
 MARION RESERVOIR
 20115 KANSAS

100491

11EPALES 2111202
 0035 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	WATER TEMP CENT	00010 DO MG/L	00300 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 TALK 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
74/04/12	15 00	0000	11.0		10	405	8.35	143	0.040	0.700	0.360	0.011
	15 00	0005	11.0	10.0		397	8.35	143	0.030	0.700	0.330	0.005
	15 00	0015	11.0	10.2		398	8.30	142	0.050	0.700	0.350	0.005
	15 00	0030	11.0	10.2		402	8.15	191	0.040	0.800	0.600	0.010
74/06/27	09 55	0000	22.5	7.4	20	475	8.30	119	0.090	0.600	1.020	0.026
	09 55	0005	22.5	6.6		475	8.30	122	0.050	0.500	1.130	0.022
	09 55	0010	22.5	6.6		474	8.40	116	0.070	0.400	1.120	0.022
	09 55	0020	22.5	6.4		475	8.30	129	0.080	0.500	1.160	0.021
	09 55	0025	22.4	6.0		474	8.30	122	0.060	0.400	1.150	0.021
74/10/02	10 00	0000	15.5	8.6	30	440	8.42	129	0.050	0.300	0.220	0.009
	10 00	0005	15.5	8.8		438	8.40	126	0.050	0.300	0.230	0.010
	10 00	0015	15.5	8.4		432	8.42	126	0.050	0.300	0.230	0.010
	10 00	0030	15.4	8.8		432	8.38	125	0.080	0.300	0.220	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	PHOS-TOT MG/L P	32217 CHLRPHYL UG/L	00031 INCDT LT A REMNING PERCENT
74/04/12	15 00	0000	0.087	21.5	
	15 00	0005	0.070		
	15 00	0015	0.137		
	15 00	0030	0.086		
74/06/27	09 55	0000	0.052	1.2	
	09 55	0002			50.0
	09 55	0005	0.050		
	09 55	0010	0.050		1.0
	09 55	0020	0.046		
	09 55	0025	0.052		
74/10/02	10 00	0000	0.022	7.7	
	10 00	0005	0.020		
	10 00	0015	0.020		
	10 00	0030	0.020		

STORET RETRIEVAL DATE 76/05/03

200702
38 24 30.0 097 07 40.0 4
MARION RESERVOIR
20115 KANSAS

100491

11EPALES 2111202
0015 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	WATER TEMP CENT	00010 DO	00300 TRANSP	00077 SECCHI	00094 FIELD	00400 PH	00410 TALK	00610 NH3-N CACO3	00625 TOT KJEL N	00630 NO2&NO3 N-TOTAL	00671 PHOS-DIS ORTHO MG/L P
74/04/12	15 20	0000	12.0			10	421	8.30	146	0.080	1.000	0.350	0.007
	15 20	0005	11.9	10.0			420	8.30	144	0.060	0.800	0.310	0.006
	15 20	0010	11.9	10.0			420	8.30	140	0.070	0.800	0.380	0.006
74/06/27	10 35	0000	23.3	6.8		10	488	8.40	126	0.090	0.700	1.150	0.022
	10 35	0005	23.3	7.0			488	8.40	124	0.090	0.600	1.160	0.024
	10 35	0010	23.3	7.0			488	8.40	124	0.110	0.600	1.180	0.023
74/10/02	09 40	0000	15.1	9.8		18	428	8.60	124	0.070	0.500	0.080	0.007
	09 40	0005	15.1	9.8			429	8.60	125	0.020	0.500	0.050	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	PHOS-TOT MG/L P	00665 CHLRPHYL UG/L	32217 INCDT LT A REMNING PERCENT	00031
74/04/12	15 20	0000	0.105		18.0	
	15 20	0005	0.063			
	15 20	0010	0.081			
74/06/27	10 35	0000	0.079		2.0	
	10 35	0002				1.0
	10 35	0005	0.088			
	10 35	0010	0.084			
74/10/02	09 40	0000	0.050		24.0	
	09 40	0002				1.0
	09 40	0005	0.044			

APPENDIX E

**TRIBUTARY AND WASTEWATER
TREATMENT PLANT DATA**

STORET RETRIEVAL DATE 76/05/04

2007A1
38 21 55.0 097 04 40.0 4
N COTTONWOOD RIVER
20 7.5 MARION
O/MARION RESERVOIR 100491
SEC RD BRDG .4 MI SE OF MARION DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

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
74/10/13	10 36		0.200	1.000	0.270	0.030	0.065
74/11/10	10 16		0.196	1.200	0.060	0.030	0.070
74/12/15	10 15		0.096	0.400	0.015	0.010	0.030
75/01/12	11 20		0.112	2.300	0.152	0.024	0.060
75/04/13	12 30		0.045	0.600	0.025	0.015	0.040
75/05/04	10 00		0.035	2.600	0.120	0.015	0.060
75/06/15	11 10		0.115	1.500	0.065	0.015	0.060
75/06/18	10 05		0.055	0.750	0.135	0.025	0.070
75/06/27	15 00		0.250	0.550	0.015	0.025	0.080
75/07/13	13 45		0.080	0.650	0.005K	0.010	0.060
75/08/30	09 00		0.330	1.150	0.030	0.055	0.120
75/09/14	11 00		0.160	0.650	0.037	0.025	0.105

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/03/04

2007A2
38 29 08.0 097 13 50.0 4
N COTTONWOOD RIVER
20 7.5 DURHAM
T/MARION RESERVOIR 100491
SEC RD BRDG AT W EDGE OF DURHAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	NO2610	00625	00610	00671	00665
FROM	OF		N-TOT	TOT KJEL	N	PHOS-DIS	PHOS-TOT
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
74/10/13	11	50	1.00	4.600	0.065	0.125	0.390
74/11/10	11	30	1.00	1.700	0.050	0.065	0.190
74/12/15	11	00	0.50	0.600	0.090	0.025	0.060
75/01/12	13	00	1.00	2.700	0.120	0.040	0.150
75/04/13	13	25	0.50	2.300	0.060	0.141	0.150
75/05/04	11	15	0.50	1.050	0.170	0.065	0.140
75/06/18	11	00	1.00	0.900	0.075	0.090	0.160
75/06/27	11	45	1.00	1.550	0.050	0.095	0.220
	15	40	0.50	1.330	0.012	0.065	0.200
75/06/29	10	45	0.25	0.900	0.020	0.015	0.070
75/07/13	14	30	0.075	0.650	0.020	0.015	0.060
75/08/30	12	10	0.035	3.900	0.070	0.160	0.730
75/09/14	11	45	0.020	0.900	0.040	0.070	0.230

STORET RETRIEVAL DATE 76/05/04

200781
38 22 45.0 097 12 20.0 4
FRENCH CREEK
20 7.5 DURHAM
T/MARION RESERVOIR 100491
SEC RD BRDG 8 MI S OF DURHAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	NO2&N03	00630 TOT KJEL	00625 NH3-N N	00610 TOTAL	00671 PHOS-DIS ORTHO	00665 PHOS-TOT MG/L P
FROM TO	OF DAY	FEET	MG/L	MG/L	MG/L	MG/L	MG/L P	MG/L P
74/10/13	11	12		0.464	0.600	0.110	0.045	0.045
74/11/10	10	45		1.280	1.200	0.100	0.020	0.110
74/12/15	10	30		0.552	0.500	0.035	0.005	0.040
75/01/12	11	40		1.600	7.800	0.660	0.136	0.690
75/04/13	12	55		0.280	1.050	0.125	0.110	0.160
75/05/04	10	30		0.520	1.650	0.500	0.050	0.140
75/06/15	11	30		1.200	1.400	0.065	0.105	0.240
75/06/18	10	35		0.780	0.900	0.125	0.005K	0.100
75/06/29	11	20		0.900	1.350	0.070	0.065	0.200
75/07/13	14	00		0.250	0.550	0.020	0.010	0.050
75/08/30	11	30		0.210	1.000	0.070	0.015	0.150
75/09/14	11	20		0.470	0.500	0.050	0.005	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2007C1
38 26 05.0 097 12 20.0 4
SILVER CREEK
20 7.5 DURHAM
T/MARION RESERVOIR 100491
SEC RD BRDG 4.1 MI SSE OF DURHAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	NO2&N03	00630	00625	NH3-N	00610	00671	00665
FROM	OF		N-TOTAL	TOT	KJEL		TOTAL	PHOS-DIS	PHOS-TOT
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L P	MG/L P
74/10/13	11	30		0.240	2.300		0.065	0.010	0.110
74/11/10	11	00		0.504	1.100		0.210	0.010	0.070
74/12/15	10	15		0.464	0.500		0.050	0.005K	0.020
75/04/13	13	04		0.270	1.450		0.120	0.010	0.160
75/05/04	10	45		0.290	1.600		0.210	0.015	0.090
75/06/18	10	43		0.260	0.600		0.040	0.005	0.075
75/06/29	13	30		0.690	1.200		0.150	0.060	0.160
75/07/13	14	15		0.260	0.400		0.020	0.005K	0.030
75/09/14	11	30		0.220	0.500		0.055	0.010	0.090

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2007D1
38 29 35.0 097 18 45.0 4
PERRY CREEK
20 7.5 WALDECK
T/MARION RESERVOIR 100491
SEC RD BRDG 5 MI W OF DURHAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	NO2&NO3	00630	00625	00610	00671	00665
FROM	OF		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
74/10/13	12	20		0.072	1.200	0.022	0.020	0.155
74/11/10	11	50		0.200	2.500	0.070	0.015	0.100
74/12/15	11	15		0.152	0.300	0.025	0.010	0.020
75/04/13	13	30		0.060	2.200	0.045	0.020	0.080
75/05/04	11	00		0.135	1.150	0.095	0.010	0.100
75/06/15	11	55		1.200	1.450	0.070	0.105	0.240
75/06/18	11	25		0.160	1.850	0.030	0.025	0.400
75/06/29	12	00		0.630	1.450	0.100	0.020	0.110
75/09/14	11	50		0.250	1.500	0.040	0.015	0.250

STORET RETRIEVAL DATE 76/05/04

2007AA TF2007AA P000854
 38 23 00.0 097 25 30.0 4
 CANTON
 20 7.5 CANTON
 T/MARION RESERVOIR 091193
 COTTONWOOD RIVER
 11EPALES 2141204
 0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 MG/L	00625 TOT KJEL MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L	00665 PHOS-TOT MG/L P	50051 FLOW RATE MG/L P	50053 CONDUIT FLOW-MGD INST MGD
75/02/20	13 30		6.000	18.000	3.950	3.300	8.000		
75/03/26	16 45		5.200	15.000	2.200	7.500	8.800		
75/04/28	09 00		6.400	7.000	0.050K	8.400	8.600		
75/05/14			16.500	11.500	0.050K	5.400	10.500		
75/06/03	09 00		8.500	7.600	0.480	6.200	7.750		
75/06/16	09 30		16.000	2.900	0.110	4.000	6.700		
75/07/09	10 30		15.400	3.800	0.030	3.600	7.500	0.975	
75/08/04	08 00		4.100	16.000	1.550	2.600	8.200		
75/08/18	08 45		16.800	4.800	0.044	6.900	6.900		
75/09/08	08 30		14.000	3.600	0.025K	6.500	6.600		
75/09/30	15 00		16.800	9.600	0.040	7.300	8.100		
75/10/29	13 45		18.900	8.600	0.041	5.200	8.300		
75/11/03	09 00		18.000	4.900	0.100	6.650	9.050		

K VALUE KNOWN TO BE
 LESS THAN INDICATED