U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

FOSS RESERVOIR

CUSTER COUNTY

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 587

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

☆G.P.O. 699-440

REPORT

ON

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WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

OKLAHOMA NATIONAL GUARD

MARCH, 1977

REPORT ON FOSS RESERVOIR

CUSTER COUNTY, OKLAHOMA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 587

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

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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 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 nonpoint 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 the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Oklahoma Department of Pollution Control for professional involvement, to the Oklahoma National Guard for conducting the tributary sampling phase of the Survey, and to those Oklahoma wastewater treatment plant operators who provided effluent samples and flow data.

Dr. Denver Talley, Director, Oklahoma Department of Pollution Control; the staff of the Oklahoma Water Resources Board; and the staff of the Oklahoma State Department of Health reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

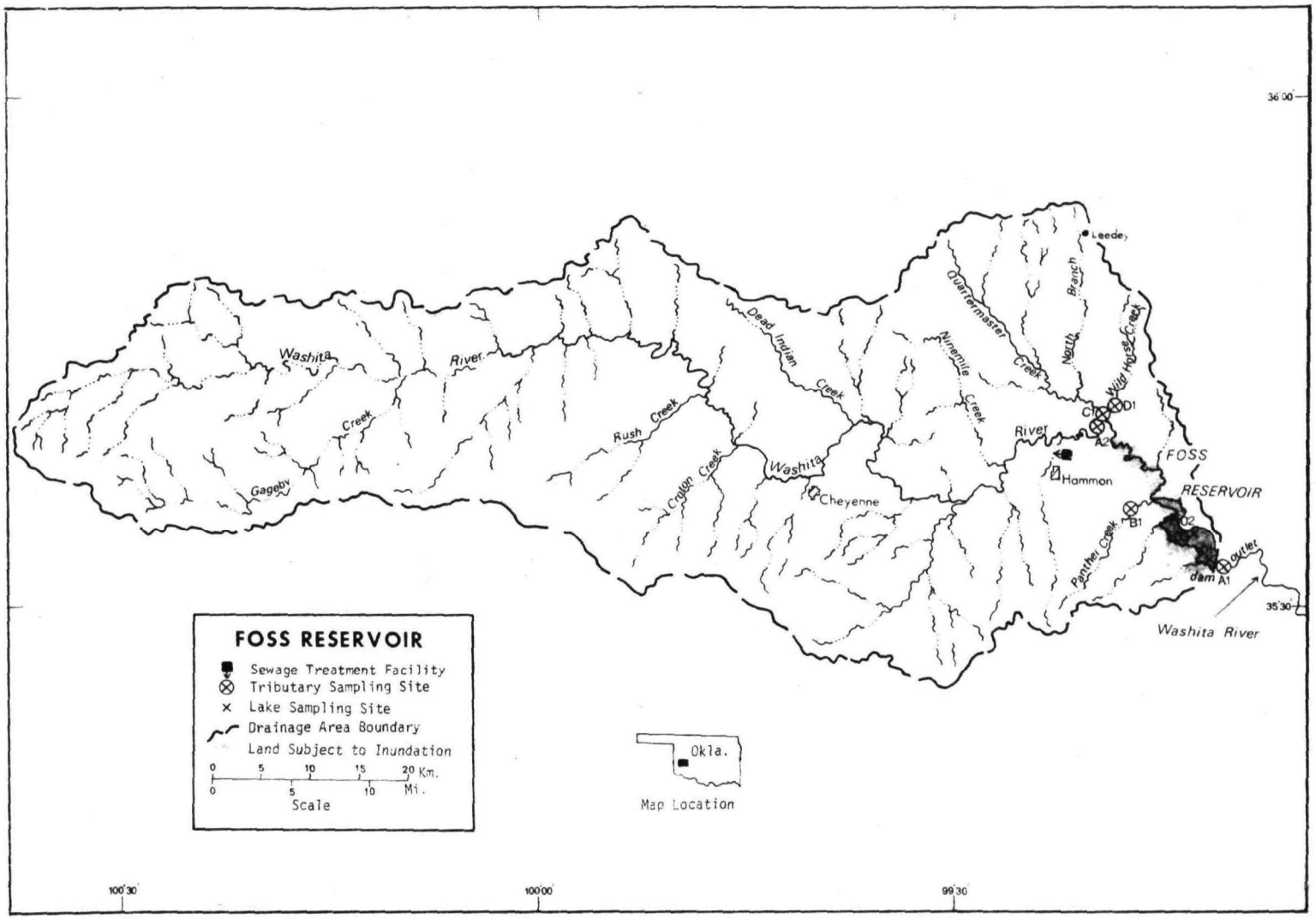
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis W. Milligan and Major James O. Haney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OKLAHOMA

LAKE NAME	COUNTY
Altus Reservoir	Greer, Kiowa
Arbuckle Lake	Murray
Lake Elsworth	Caddo, Comanche
Lake Eufaula	Haskell, McIntosh Okmulgee, Pittsburg
Fort Cobb Reservoir	Caddo
Fort Supply Reservoir	Woodward
Foss Dam Reservoir	Custer
Lake Frances	Adair
Grand Lake O' The Cherokees	Mayes, Delaware, Craig, Ottowa
Lake Hefner	Oklahoma
Keystone Reservoir	Tulsa, Creek, Osage, Pawnee
Oologah Lake	Nowata, Rogers
Tenkiller Ferry Reservoir	Cherokee, Sequoyah
Lake Thunderbird	Cleveland
Wister Reservoir	LeFlore


FOSS RESERVOIR
Sewage Treatment Facility
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Land Subject to Inundation
0 5 10 15 20 Km.
0 5 10 Mi.
Scale
Okla.
Map Location
Washita River
Creek
River
Rush Creek
Dead Indian Creek
Quartermaster Creek
Nimrnile Creek
North Branch
Wild Horse Creek
Crutcho Creek
Crutcho
Gageby
Cheyenne
Hammon
Leedey
FOSS
RESERVOIR
Panther Creek
dam
outlet
A1
A2
B1
B2
C1
D1
36°00
35°30
100°30
100°00
99°30

REPORT ON FOSS RESERVOIR, OKLAHOMA

STORET NO. 4007

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that Foss Reservoir is early eutrophic. Of the 16 Oklahoma lakes (including Lake Texoma) sampled in 1974, 14 had greater median total phosphorus values, 12 had greater median inorganic nitrogen levels, and 15 had greater median orthophosphorus values than Foss Reservoir. Chlorophyll a values in the lake ranged from 1.9 µg/l to 6.8 µg/l, with a mean of 4.9 µg/l. Potential for primary production as measured by algal assay control yield was low in both spring and autumm sampling. Secchi disc readings ranged from 0.5 m - 1.7 m, suggesting possible light limitation in portions of the reservoir.

Survey limnologists did not observe any nutrient-related problem conditions such as algal blooms or aquatic macrophytes during the visits to the lake. However, other studies (Ketelle and Uttormark, 1971; Oklahoma Department of Pollution Control, 1975) report that the reservoir is no longer of use as a municipal or industrial water supply due to an excessive accumulation of dissolved solids.

*See Appendix E.

B. Rate-Limiting Nutrient:

Mean inorganic nitrogen to orthophosphorus (N/P) ratios for the reservoir data were 8/1 and <6/1 in the spring and fall, respectively, indicating primary limitation by nitrogen, and 24/1 in June suggesting phosphorus limitation at that time. Algal assay results indicated primary limitation by phosphorus during spring and fall sampling, and low potentials for primary production in Foss Reservoir at those times.

C. Nutrient Controllability:

1. Point sources -

The mean annual phosphorus load from point sources was estimated to be 3.8% of the total load reaching Foss Reservoir during the 1974 sampling year. The city of Hammon contributed this entire load.

During the sampling year, outflows from Foss Reservoir were minimal or absent, and the Foss Reservoir outlet (Washita River, tributary A-1) was not sampled. It would appear that the lake intermittently acts as a nutrient sink, and any future proposed nutrient contributions to the reservoir should be considered in this light. However, additional sampling is needed to determine the true retention time and nutrient budget of Foss Reservoir before any conclusions as to nutrient controllability can be drawn.

2. Nonpoint sources -

Nonpoint sources (including precipitation) contributed 96.2% of the total phosphorus load to Foss Reservoir. The Washita River contributed 61.1% of the total, Quartermaster Creek contributed 18.4%, and ungaged drainage areas were estimated to have contributed 10.2%.

The phosphorus export rates of the Washita River and Quartermaster Creek were 2 and 4 $kg/km^2/yr$, respectively (see Section IV-D). The rates are quite comparable to the two gaged tributaries impacting nearby Altus Reservoir* (range of 2-3 $kg/km^2/yr$).

*See Working Paper No. 581, "Report on Altus Reservoir".

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the Oklahoma Department of Pollution Control; maximum depth was provided by the Oklahoma Water Resources Board. Tributary flow data were provided by the Oklahoma District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 35.61 km^2.
2. Mean depth: 8.9 meters.
3. Maximum depth: 36.0 meters.
4. Volume: 316.929 x $10^6 m^3$.
5. Mean hydraulic retention time: 15,948 days (43.7 yrs).

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

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
A-2 Washita River	3120.9	2.19
C-1 Quartermaster Creek	455.8	0.43
Minor tributaries and immediate drainage -	246.7	0.27
Totals	3823.4	2.89
2. Outlet - A-1 Washita River	3859.1	0.23

C. Precipitation:

1. Year of sampling: 63.2 cm.
2. Mean annual: 62.7 cm.

III. LAKE WATER QUALITY SUMMARY

Foss 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 three stations on the lake (Station 03 was sampled only twice) and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 15.2 meters at Station 01, 6.1 meters at Station 02, and 8.8 meters at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

FOSS DAM RESERVOIR
STORET CODE #007

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(3/29/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/10/74) S*** = 3 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(10/24/74) S*** = 3 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	4	10.3- 11.3	10.8	0.0- 1.5	6	23.1- 24.6	23.6	0.0- 1.5	6	16.7- 17.0	16.8	0.0- 1.5
MAX DEPTH**	2	10.3- 11.3	10.8	4.6- 10.7	3	22.1- 22.8	22.7	6.1- 15.2	3	16.7- 16.9	16.8	2.4- 10.1
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	2	9.5- 10.0	9.9	1.5- 1.5	6	7.6- 8.4	8.0	0.0- 1.5	6	8.0- 8.6	8.4	0.0- 1.5
MAX DEPTH**	2	9.8- 10.2	10.0	4.6- 10.7	3	6.6- 7.2	6.8	6.1- 15.2	3	8.0- 8.6	8.2	2.4- 10.1
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	4	15.-1577.	797.	0.0- 1.5	6	2082.-2162.	2120.	0.0- 1.5	6	1865.-1879.	1867.	0.0- 1.5
MAX DEPTH**	2	16.-1578.	797.	4.6- 10.7	3	2053.-2098.	2097.	6.1- 15.2	3	1867.-1875.	1867.	2.4- 10.1
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	4	8.2- 8.3	8.2	0.0- 1.5	6	8.2- 8.2	8.2	0.0- 1.5	6	8.3- 8.4	8.4	0.0- 1.5
MAX DEPTH**	2	8.2- 8.3	8.2	4.6- 10.7	3	8.2- 8.2	8.2	6.1- 15.2	3	8.3- 8.4	8.4	2.4- 10.1
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	4	139.- 162.	152.	0.0- 1.5	6	151.- 159.	155.	0.0- 1.5	6	142.- 145.	143.	0.0- 1.5
MAX DEPTH**	2	136.- 159.	148.	4.6- 10.7	3	153.- 160.	155.	6.1- 15.2	3	142.- 143.	143.	2.4- 10.1
TOTAL P (MG/L)												
0.-1.5 M DEPTH	4	0.026-0.050	0.037	0.0- 1.5	6	0.017-0.023	0.020	0.0- 1.5	6	0.029-0.041	0.034	0.0- 1.5
MAX DEPTH**	2	0.032-0.058	0.045	4.6- 10.7	3	0.020-0.047	0.023	6.1- 15.2	3	0.029-0.038	0.034	2.4- 10.1
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	4	0.009-0.012	0.010	0.0- 1.5	6	0.004-0.014	0.006	0.0- 1.5	6	0.004-0.010	0.004	0.0- 1.5
MAX DEPTH**	2	0.009-0.014	0.011	4.6- 10.7	3	0.003-0.006	0.005	6.1- 15.2	3	0.006-0.013	0.009	2.4- 10.1
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	4	0.040-0.040	0.040	0.0- 1.5	6	0.050-0.150	0.090	0.0- 1.5	6	0.020-0.030	0.020	0.0- 1.5
MAX DEPTH**	2	0.040-0.040	0.040	4.6- 10.7	3	0.030-0.130	0.100	6.1- 15.2	3	0.020-0.020	0.020	2.4- 10.1
AMMONIA (MG/L)												
0.-1.5 M DEPTH	4	0.040-0.050	0.045	0.0- 1.5	6	0.030-0.070	0.055	0.0- 1.5	6	0.020-0.030	0.020	0.0- 1.5
MAX DEPTH**	2	0.040-0.050	0.045	4.6- 10.7	3	0.060-0.080	0.070	6.1- 15.2	3	0.020-0.030	0.020	2.4- 10.1
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	4	0.700-0.800	0.700	0.0- 1.5	6	0.600-0.900	0.700	0.0- 1.5	6	0.400-1.200	0.600	0.0- 1.5
MAX DEPTH**	2	0.700-0.900	0.800	4.6- 10.7	3	0.600-0.800	0.600	6.1- 15.2	3	0.500-0.600	0.500	2.4- 10.1
SECCHI DISC (METERS)												
	2	0.5- 1.0	0.8		2	0.9- 1.7	1.3		3	0.6- 0.9	0.8	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/29/74	1. Dactylococcopsis	1,029
	2. Synedra	676
	3. Oscillatoria	412
	4. Ankistrodesmus	235
	5. Navicula	147
	Other genera	295
	Total	2,794
06/10/74	1. Oscillatoria	555
	2. Ankistrodesmus	149
	3. Merismopedia	85
	4. Chroomonas	64
	5. Mougeotia	64
	Other genera	321
	Total	1,238
10/24/74	1. Oscillatoria	2,864
	2. Oocystis	92
	3. Raphidiopsis	69
	4. Tetraedron	69
	5. Ankistrodesmus	23
	Other genera	116
	Total	3,233

2. Chlorophyll *a*

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
03/29/74	01	3.4
	02	6.1
	03	---
06/10/74	01	1.9
	02	3.5
	03	3.8
10/24/74	01	6.8
	02	6.8
	03	6.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum Yield (mg/l-dry wt.)
a. 03/29/74			
Control	0.010	0.095	0.1
0.05 P	0.060	0.095	2.5
0.05 P + 1.0 N	0.060	1.095	3.4
1.00 N	0.010	1.095	0.1
b. 10/24/74			
Control	0.008	0.093	0.2
0.05 P	0.058	0.093	1.9
0.05 P + 1.0 N	0.058	1.093	22.6
1.00 N	0.008	1.093	0.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Foss Reservoir was low at both times samples were collected (03/29/74, 10/24/74). The increases in yield with the addition of phosphorus alone or nitrogen and phosphorus simultaneously indicate phosphorus limitation. However, the very low response to simultaneous nitrogen and phosphorus spikes in the spring assay suggests that some other factor rapidly became growth limiting. The response noted in the corresponding fall assay run is a far more typical one. In both assays, the addition of nitrogen alone did not result in a yield significantly greater than that of the control. However, there were substantial losses in nutrients in the samples during storage and/or preparation for assay. The significance of the findings must therefore be tempered accordingly.

Mean N/P ratios in the lake data were 8/1 and <6/1 in the spring and fall, respectively, suggesting primary limitation by nitrogen at those times. The mean N/P ratio of 24/1 in June suggests phosphorus limitation at that time (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Oklahoma 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 April and May when two samples were collected. Sampling was begun in November 1974, and was completed in August 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oklahoma District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/year$, in Quartermaster Creek at Station C-1, and multiplying the means by the ZZ area in km^2.

Nutrient loads for the city of Hammon wastewater treatment plant were estimated at 1.134 kg P and 3.401 kg N/capita/year.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Hammon	325	Stabilization pond	0.123**	White Shield Creek/ Washita River

2. Known industrial - None

*U.S. EPA, 1971.
**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 (nonpoint load) -		
A-2 Washita River	5,915	61.1
C-1 Quartermaster Creek	1,775	18.4
b. Minor tributaries and immediate drainage (nonpoint load) -	985	10.2
c. Known municipal STP's -		
Hammon	370	3.8
d. Septic tanks* -	5	<0.1
e. Known industrial - None		
f. Direct precipitation** -	625	6.5
Totals	9,675	100.0

2. Output - A-1 Washita River ?

*Estimate based on 15 lakeshore residences.
**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source		kg N/yr	% of total
a.	Tributaries (nonpoint load) -		
	A-2 Washita River	118,385	60.7
	C-1 Quartermaster Creek	23,960	12.3
b.	Minor tributaries and immediate drainage (nonpoint load) -	13,075	6.6
c.	Known municipal STP's -		
	Hammon	1,105	0.6
d.	Septic tanks* -	160	0.1
e.	Known industrial - None		
f.	Direct precipitation** -	38,445	19.7
	Totals	195,130	100.0

2. Output - A-1 Washita River ?

*Estimate based on 15 lakeshore residences.
**Estimated (see NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Washita River	2	38
Quartermaster Creek	4	53

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
B-1 Panther Creek	0.230	1.830
D-1 Wild Horse Creek	0.075	2.849

Phosphorus levels in Panther Creek, tributary B-1, are substantially higher than those found in the other sampled tributaries of Foss Reservoir.

F. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" 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 "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not be applicable to water bodies with very short retention times or in which light penetration is severely restricted from high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Foss Reservoir	0.27
Vollenweider's "eutrophic" loading	0.09
Vollenweider's "oligotrophic" loading	0.05

V. LITERATURE

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VI. APPENDICES

APPENDIX A

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 B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OKLAHOMA 03/25/77

LAKE CODE 4007 FOSS DAM RES

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 3859.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4007A1	3859.1	0.102	0.076	0.102	0.184	0.311	0.396	0.283	0.595	0.241	0.201	0.198	0.108	0.234
4007A2	3129.9	0.68	0.85	1.05	1.87	6.63	5.04	2.75	1.25	2.15	2.32	0.85	0.71	2.19
4007C1	455.8	0.13	0.17	0.20	0.37	1.30	0.99	0.54	0.24	0.42	0.45	0.17	0.14	0.43
4007ZZ	282.3	0.082	0.105	0.127	0.229	0.793	0.623	0.340	0.150	0.263	0.280	0.105	0.085	0.266

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 3859.1
SUM OF SUB-DRAINAGE AREAS = 3859.1
TOTAL FLOW IN = 34.45
TOTAL FLOW OUT = 2.80

NOTE *** EVAP. ACCOUNTS FOR DIFF. IN INFLOW-OUTFLOW. MILLS,OK USGS.

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4007A1	11	74	1.557	3	8.382				
	12	74	0.368	15	0.396				
	1	75	0.283	19	0.340				
	2	75	0.708	16	0.481				
	3	75	0.623	16	0.623				
	4	75	0.396	6	0.510	20	0.396		
	5	75	0.708	27	0.311				
	6	75	2.832	27	0.425				
	7	75	3.908	27	9.316				
	8	75	1.133						
	9	75	0.340	14	0.283				
	10	75	0.283						
4007A2	11	74	1.727	3	9.203				
	12	74	0.368	15	0.623				
	1	75	0.368	19	0.566				
	2	75	1.048	15	0.453				
	3	75	1.076	16	1.076				
	4	75	0.793	5	0.708	19	0.708		
	5	75	2.407	4	0.736	18	3.115		
	6	75	2.407	24	1.218				
	7	75	2.690	10	0.765				
	8	75	0.821	10	0.765				
	9	75	1.359						
	10	75	0.255						

TRIBUTARY FLOW INFORMATION FOR OKLAHOMA 03/25/77

LAKE CODE 4007 FOSS DAM RES

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4007C1	11	74	0.425	3	4.417				
	12	74	0.065	15	0.085				
	1	75	0.054	19	0.006				
	2	75	0.227	15	0.113				
	3	75	0.195	16	0.195				
	4	75	0.144	6	0.110	19	0.113		
	5	75	0.623	4	1.133	18	1.133		
	6	75	0.736	24	0.034				
	7	75	1.104						
	8	75	0.311	10	0.142				
	9	75	0.057						
	10	75	0.028						
4007ZZ	11	74	0.263						
	12	74	0.040						
	1	75	0.034						
	2	75	0.142						
	3	75	0.122						
	4	75	0.091						
	5	75	0.396						
	6	75	0.453						
	7	75	0.680						
	8	75	0.193						
	9	75	0.034						
	10	75	0.017						

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 77/03/24

400701
35 32 28.0 099 11 14.0 3
FOSS DAM RESERVOIR
40039 OKLAHOMA
101491

/TYPA/AMBNT/LAKE

11EPALES 04001002
0040 FEET DEPTH CLASS 00

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
74/03/29	14	00 0000	10.3		40	1612	8.20	143	0.050	0.700	0.040	0.009
	14	00 0005	10.3	10.0		1612	8.20	139	0.040	0.700	0.040	0.009
	14	00 0015	10.3	10.0		1613	8.20	133	0.040	0.800	0.040	0.010
	14	00 0035	10.3	10.2		1613	8.20	136	0.040	0.700	0.040	0.009
74/06/10	14	35 0000	23.3	7.8	66	2118	8.20	151	0.060	0.800	0.100	0.004
	14	35 0005	23.1	7.6		2107	8.20	151	0.050	0.600	0.100	0.007
	14	35 0015	23.0	7.4		2101	8.10	152	0.060	0.600	0.100	0.009
	14	35 0030	22.9	7.2		2101	8.20	152	0.060	0.500	0.100	0.003
	14	35 0035	22.9	7.4		2103	8.20	153	0.060	0.600	0.100	0.003
	14	35 0040	22.9	7.0		2101	8.20	152	0.060	0.500	0.100	0.006
	14	35 0045	22.8	7.0		2102	8.20	153	0.060	0.600	0.100	0.006
	14	35 0050	22.7	6.6		2098	8.20	153	0.070	0.600	0.100	0.005
74/10/24	12	30 0000	16.7	8.4	35	1867	8.33	142	0.020	0.500	0.020K	0.005
	12	30 0005	16.7	8.0		1867	8.33	142	0.020	0.400	0.020K	0.005
	12	30 0020	16.7	8.0		1867	8.33	142	0.020	0.400	0.020K	0.010
	12	30 0033	16.7	8.0		1867	8.33	143	0.030	0.500	0.020K	0.013

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 77/03/24

400701
35 32 28.0 099 11 14.0 3
FOSS DAM RESERVOIR
40039 OKLAHOMA

101491

/TYPA/AMBNT/LAKE

11EPALES 04001002
0040 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/29	14	00 0000	0.026	3.4	
	14	00 0005	0.027		
	14	00 0015	0.024		
	14	00 0035	0.032		
74/06/10	14	35 0000	0.019	1.9	
	14	35 0002			50.0
	14	35 0005	0.022		
	14	35 0012			1.0
	14	35 0015	0.016		
	14	35 0030	0.012		
	14	35 0035	0.013		
	14	35 0040	0.013		
	14	35 0045	0.016		
	14	35 0050	0.023		
74/10/24	12	30 0000	0.029	6.8	
	12	30 0005	0.037		
	12	30 0020	0.030		
	12	30 0033	0.029		

STORET RETRIEVAL DATE 77/03/24

400702
35 35 15.0 099 13 50.0 3
FOSS DAM RESERVOIR
40039 OKLAHOMA

101491

/TYPA/AMBNT/LAKE

11EPALES 04001002
0020 FEET DEPTH CLASS 00

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
74/03/29	13 40	0000	11.3		20	1577	8.30	160	0.050	0.800	0.040	0.012
	13 40	0005	11.3	9.8		1577	8.30	162	0.040	0.700	0.040	0.011
	13 40	0015	11.3	9.8		1578	8.30	159	0.050	0.900	0.040	0.014
74/06/10	16 05	0000	24.6	8.2	36	2122	8.20	159	0.050	0.900	0.050	0.014
	16 05	0005	23.1	7.8		2082	8.20	155	0.030	0.600	0.060	0.006
	16 05	0020	22.1	6.8		2053	8.20	160	0.060	0.800	0.030	0.006
74/10/24	11 50	0000	16.8	8.6	24	1865	8.41	143	0.030	1.200	0.030	0.004
	11 50	0005	16.8	8.6		1865	8.41	145	0.020K	0.800	0.020K	0.004
	11 50	0008	16.8	8.6		1867	8.39	143	0.020	0.600	0.020K	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/29	13 40	0000	0.050	6.1	
	13 40	0005	0.048		
	13 40	0015	0.058		
74/06/10	16 05	0000	0.023	3.5	
	16 05	0001			50.0
	16 05	0005	0.018		
	16 05	0008			1.0
	16 05	0020	0.047		
74/10/24	11 50	0000	0.041	6.8	
	11 50	0005	0.037		
	11 50	0008	0.036		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 77/03/24

400703
35 34 14.0 099 12 31.0 4
FOSS DAM RESERVOIR
40039 OKLAHOMA
100691

/TYPA/AMBNT/LAKE

11EPALES 04001002
0033 FEET DEPTH CLASS 00

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
74/06/10	16 35	0000	24.2	8.2		2162	8.20	155	0.060	0.800	0.080	0.009
	16 35	0005	23.9	8.4		2152	8.20	155	0.070	0.600	0.150	0.004
	16 35	0015	22.9	7.2		2102	8.25	155	0.060	0.600	0.100	0.004
	16 35	0029	22.8	7.2		2097	8.20	155	0.080	0.600	0.130	0.003
74/10/24	12 05	0000	17.0	8.4	32	1879	8.39	142	0.020	0.700	0.020K	0.004
	12 05	0005	17.0	8.4		1879	8.39	144	0.020K	0.500	0.020K	0.010
	12 05	0015	17.0	7.2		1879	8.39	143	0.020K	0.500	0.020K	0.005
	12 05	0027	16.9	8.2		1875	8.37	142	0.020K	0.500	0.020K	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/06/10	16 35	0000	0.017	3.8	
	16 35	0005	0.022		
	16 35	0015	0.018		
	16 35	0029	0.020		
74/10/24	12 05	0000	0.032	6.6	
	12 05	0005	0.030		
	12 05	0015	0.029		
	12 05	0027	0.034		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 77/03/24

4007A2
35 40 45.0 099 19 25.0 4
WASHITA RIVER
40 15 HAMMON
T/FOSS RESERVOIR 101491
FARM RD BRDG 3.2 MI E OF HWY 34 JCT
11EPALES 04001004
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

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
74/11/03	14	05	0.368	2.300	0.025		
74/12/15	09	30	0.048	0.900	0.030	0.010	0.040
75/01/19	09	30	0.040	1.700	0.040	0.020	0.070
75/02/15	14	05	0.032	1.100	0.024	0.008	0.050
75/03/16	10	15	0.080	3.400	0.088		0.010K
75/04/05	13	20	1.570	0.550	0.065	0.005K	
75/04/19	09	45	0.005	1.400	0.030	0.010	0.040
75/05/04	20	40	0.010	0.600	0.030	0.010	0.040
75/05/18	10	15	0.050	1.580	0.055	0.070	0.260
75/06/24	20	40	0.075	1.450	0.035	0.035	0.380
75/08/10	10	20	0.280	0.650	0.030	0.030	0.090

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 77/03/24

400731
35 35 45.0 099 17 25.0 4
PANTHER CREEK
40 15 HAMMON
T/FOSS RESERVOIR 101491
FARM RD BRDG 6 MI SE OF HWY 34 JCT
/TYPA/AMBNT/STREAM 11EPALES 04001004
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
75/05/18	10	40	0.180	1.300	0.095	0.020	0.160
75/06/24	20	45	0.230	1.950	0.035	0.045	0.300

STORET RETRIEVAL DATE 77/03/24

4007C1
35 40 55.0 099 19 15.0 4
QUARTERMASTER CREEK
40 15 HAMMON
T/FOSS RESERVOIR 10149
FARM RD BRDG 3.2 MI SE OF HWY 34 JCT
11EPALES 04001004
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

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
74/11/03	14 30		0.352		0.045		
74/12/15	09 35		0.088	1.100	0.035	0.010	0.050
75/01/19	09 40		0.072	1.000	0.016	0.010	0.020
75/02/15	14 20		0.072	1.200	0.056	0.008K	0.040
75/03/16	10 30		0.152	3.700	0.040	0.008K	0.040
75/04/06	13 10		1.570	0.400	0.095	0.005K	0.040
75/04/19	10 30		0.055	0.500	0.030	0.005K	0.020
75/05/04	20 30		0.250	2.600	0.055	0.025	0.200
75/05/18	10 30		0.160	1.050	0.060	0.035	0.230
75/08/10	10 30		0.210	0.900	0.035	0.030	0.120

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 77/03/24

4007D1
35 41 50.0 099 18 30.0 4
WILD HORSE CREEK
40 15 HAMMON
T/FOSS RESERVOIR 101491
2NDRY RD BRDG 2.8 MI E OF HWY 34 JCT
1IEPALES 04001004
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

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
74/11/03	14	55	0.410	4.200	0.040	0.040	
74/12/15	09	40	2.624	1.800	0.035	0.005	0.040
75/01/19	09	50	1.320	3.350	0.048	0.015	
75/02/15	14	30	0.800	1.300	0.032	0.008K	0.030
75/03/16	11	00	1.800	4.300	0.256	0.008K	0.060
75/04/06	13	30	1.450	0.075	0.035	0.005	0.010K
75/04/19	10	07	0.630	1.300	0.040	0.010	0.140
75/05/04	20	15	0.230	2.700	0.070	0.025	
75/06/24	21	00	0.290	0.550	0.075	0.035	0.090
75/08/10	10	45	0.700	0.650	0.060	0.025	0.090

K VALUE KNOWN TO BE
LESS THAN INDICATED

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
4001	ALTUS RESERVOIR	60 (9)	100 (15)	47 (7)	13 (2)	80 (11)	73 (11)
4002	ARBUCKLE LAKE	100 (15)	90 (13)	93 (14)	53 (8)	33 (4)	93 (14)
4003	LAKE ELLSWORTH	80 (12)	90 (13)	80 (12)	33 (5)	60 (9)	87 (13)
4004	LAKE EUFAULA	20 (3)	33 (5)	27 (4)	100 (15)	47 (7)	33 (5)
4005	FORT COBB RESERVOIR	73 (11)	73 (11)	87 (13)	7 (1)	80 (11)	67 (10)
4006	FORT SUPPLY RESERVOIR	33 (5)	67 (10)	0 (0)	27 (4)	100 (15)	60 (9)
4007	FOSS DAM RESERVOIR	93 (14)	80 (12)	60 (9)	87 (13)	80 (11)	100 (15)
4008	LAKE FRANCES	0 (0)	0 (0)	7 (1)	47 (7)	93 (14)	7 (1)
4009	GRAND LAKE O' THE CHEROK	13 (2)	7 (1)	40 (6)	60 (9)	20 (3)	13 (2)
4010	LAKE HEFNER	47 (7)	40 (6)	67 (10)	73 (11)	67 (10)	20 (3)
4011	KEYSTONE RESERVOIR	7 (1)	13 (2)	13 (2)	0 (0)	13 (2)	0 (0)
4012	OOLOGAH LAKE	40 (6)	20 (3)	20 (3)	80 (12)	33 (4)	27 (4)
4013	TENKILLER FERRY RESERVOI	67 (10)	27 (4)	100 (15)	67 (10)	3 (0)	50 (7)
4014	LAKE THUNDERBIRD	87 (13)	60 (9)	53 (8)	40 (6)	53 (8)	80 (12)
4015	WISTER RESERVOIR	27 (4)	47 (7)	33 (5)	93 (14)	3 (0)	40 (6)
4834	TEXOMA LAKE	53 (8)	53 (8)	73 (11)	20 (3)	33 (4)	50 (7)