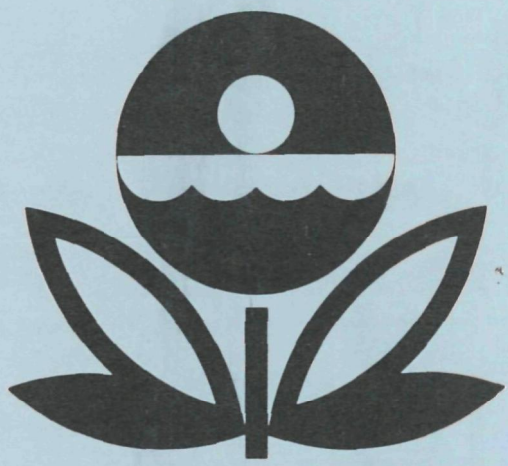
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

LAKE FRANCES

ADAIR COUNTY

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 588

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

☆G.P.O. 699-440

REPORT

ON

LAKE FRANCES

ADAIR COUNTY

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 588

WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

OKLAHOMA NATIONAL GUARD

MARCH, 1977

REPORT ON LAKE FRANCES

ADAIR 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. 588

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

March 1977

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.

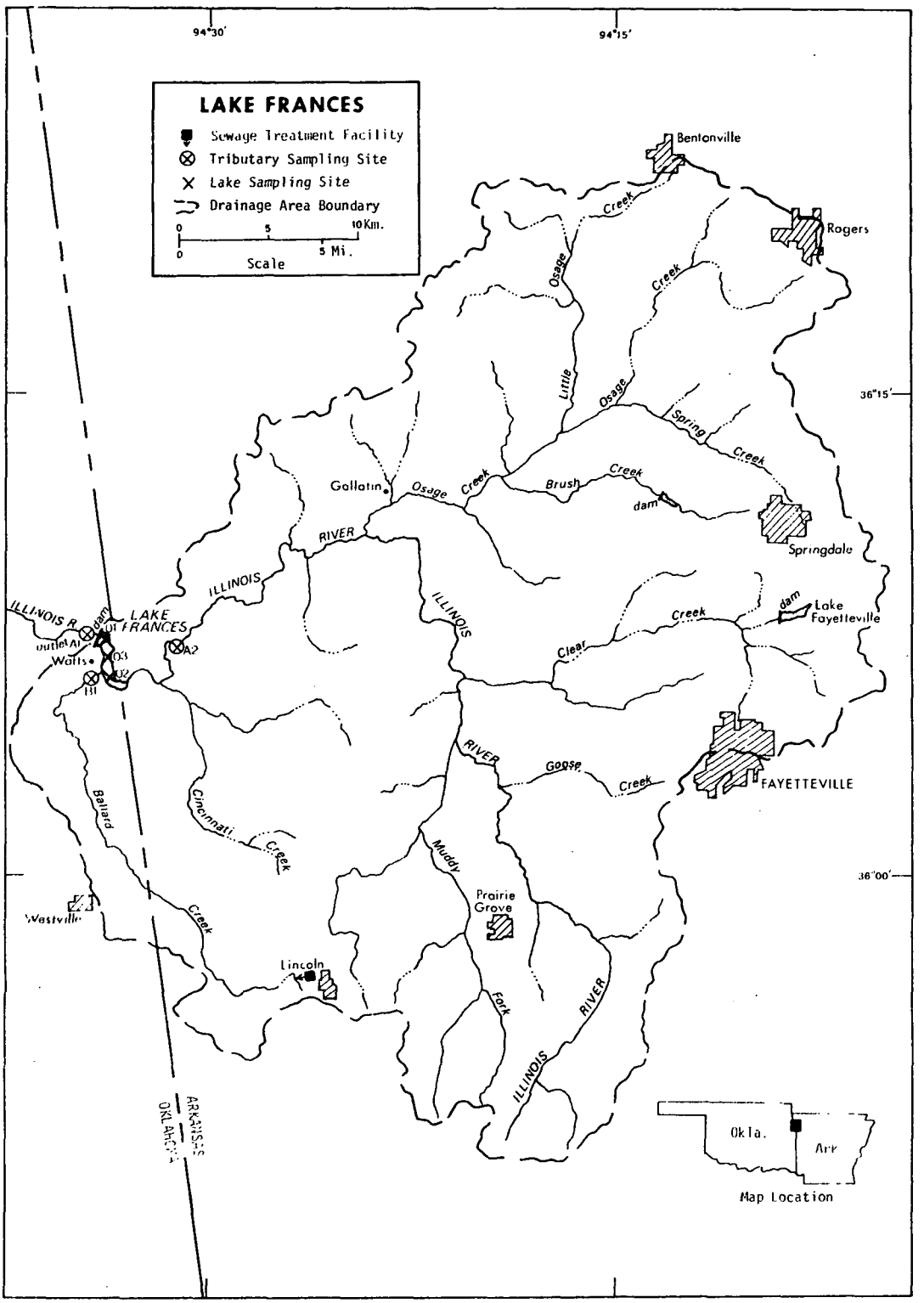
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis W. Milligan and Major James O. Haney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

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


LAKE FRANCES
Sewage Treatment Facility
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 5 10Km.
0 5 Mi.
Scale
94°30'
94°15'
36°15'
36°00'
Bentonville
Rogers
Springdale
Lake Fayetteville
FAYETTEVILLE
Prairie Grove
Lincoln
Gallatin
Westville
Watts
LAKE FRANCES
ILLINOIS R.
dam
outlet
A1
A2
A3
111
112
Osage Creek
Little Osage Creek
Spring Creek
Brush Creek
dam
ILLINOIS RIVER
Clear Creek
Goose Creek
Muddy Fork
Cincinnati Creek
Ballard Creek
ARKANSAS
OKLAHOMA
Okla.
Ark
Map Location

REPORT ON LAKE FRANCES, OKLAHOMA

STORET NO. 4008

I. CONCLUSIONS

A. Trophic Condition:*

On the basis of field observations and Survey data, Lake Frances is considered eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Potential for primary production as measured by algal assay control yield was extremely high in this turbid lake on both sampling occasions. Chlorophyll a values ranged from 0.1 µg/l to 17.6 µg/l with a mean of 8.0 µg/l. Of the 16 Oklahoma lakes (including Texoma Lake) sampled in 1974, none had higher median total phosphorus or inorganic nitrogen levels than Lake Frances, and only 1 had higher median orthophosphorus values.

Survey limnologists reported abundant emergent vegetation in the southern portion of the lake and a strong sewage odor during July sampling.

*See Appendix E.

B. Rate-Limiting Nutrient:

Algal assay results suggest that Lake Frances was limited by available phosphorus levels in the spring, and by some undetermined minor nutrient in the fall as a result of the extremely high levels of available phosphorus and nitrogen in the lake.

C. Nutrient Controllability:

1. Point sources -

The mean annual phosphorus load from point sources identified within 40 stream-km (25 miles) of Lake Frances was estimated to be 0.7% of the total phosphorus load. The city of Lincoln contributed the entire fraction.

The present overall phosphorus loading of 36.70 g $P/m^2/yr$ is about 14 times that proposed by Vollenweider (1975) as "eutrophic" for lakes with such volume and hydraulic retention time. Vollenweider's model may not be applicable for lakes with short hydraulic retention times (3 days for Lake Frances), or in which epilimnetic light penetration is severely reduced by the presence of suspended sediments in the surface waters; nevertheless, the lake is obviously eutrophic and phosphorus loading would have to be substantially reduced to produce any water quality improvement in the lake.

2. Nonpoint sources -

The mean annual phosphorus load not attributable to nearby point sources was 99.3% of the total reaching the lake. The Illinois River contributed 89.2%, and ungaged drainage areas were estimated to contribute 10.0%.

The high loading rate of the Illinois River, as it enters Lake Frances, is partly due to unmeasured discharges upstream rather than nonpoint contributions. Waste sources not contained in the National Eutrophication Survey (NES) sampling of Lake Frances, due to their distance from the reservoir, include the cities of Springdale, Rogers, and Prairie Grove (EPA, 1971). Additional studies to determine the impact of these contributions on Lake Frances are needed before a nutrient budget for the lake can be defined.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were 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 NES Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 2.31 km^2.
2. Mean depth: 1.8 meters.
3. Maximum depth: 9.8 meters.
4. Volume: 4.158 x 10^6 m^3.
5. Mean hydraulic retention time: 3 days.

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

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
A-2 Illinois River	1,352.0	13.54
Minor tributaries and immediate drainage -	290.4	2.93
Totals	1,642.4	16.47
2. Outlet - A-1 Illinois River	1,644.6	14.88

C. Precipitation:

1. Year of sampling: 137.3 cm.
2. Mean annual: 113.1 cm.

III. LAKE WATER QUALITY SUMMARY

Lake Frances 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 01 was sampled once, Station 03 was sampled 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 0.6 meters at Station 01, 0.9 meters at Station 02, and 1.2 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.

LAKE FRANCES
STORET CODE 4008

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(4/ 3/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/14/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(10/18/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	4	16.8- 16.9	16.8	0.0- 0.6	4	19.6- 20.1	20.0	0.0- 0.9	4	15.2- 17.3	16.3	0.0- 1.2
MAX DEPTH**	2	16.8- 16.9	16.8	0.6- 0.6	2	19.6- 20.0	19.8	0.9- 0.9	2	15.2- 16.7	15.9	0.9- 1.2
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	2	9.0- 9.4	9.2	0.6- 0.6	2	6.8- 7.2	7.0	0.9- 0.9	4	7.0- 12.5	10.7	0.0- 1.2
MAX DEPTH**	2	9.0- 9.4	9.2	0.6- 0.6	2	6.8- 7.2	7.0	0.9- 0.9	2	7.0- 11.0	9.0	0.9- 1.2
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	4	188.- 190.	189.	0.0- 0.6	4	165.- 169.	167.	0.0- 0.9	4	215.- 221.	216.	0.0- 1.2
MAX DEPTH**	2	188.- 190.	189.	0.6- 0.6	2	165.- 168.	167.	0.9- 0.9	2	215.- 221.	218.	0.9- 1.2
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	4	7.6- 7.8	7.7	0.0- 0.6	4	7.5- 7.7	7.6	0.0- 0.9	4	7.5- 8.3	7.9	0.0- 1.2
MAX DEPTH**	2	7.6- 7.6	7.6	0.6- 0.6	2	7.5- 7.6	7.5	0.9- 0.9	2	7.5- 8.2	7.8	0.9- 1.2
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	4	96.- 101.	99.	0.0- 0.6	4	74.- 77.	76.	0.0- 0.9	4	116.- 118.	117.	0.0- 1.2
MAX DEPTH**	2	96.- 100.	98.	0.6- 0.6	2	74.- 76.	75.	0.9- 0.9	2	117.- 118.	118.	0.9- 1.2
TOTAL P (MG/L)												
0.-1.5 M DEPTH	4	0.136-0.179	0.155	0.0- 0.6	4	0.098-0.101	0.101	0.0- 0.9	4	0.143-0.232	0.172	0.0- 1.2
MAX DEPTH**	2	0.136-0.169	0.152	0.6- 0.6	2	0.101-0.101	0.101	0.9- 0.9	2	0.143-0.232	0.187	0.9- 1.2
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	4	0.075-0.095	0.093	0.0- 0.6	4	0.084-0.088	0.086	0.0- 0.9	4	0.096-0.141	0.104	0.0- 1.2
MAX DEPTH**	2	0.075-0.093	0.084	0.6- 0.6	2	0.084-0.086	0.085	0.9- 0.9	2	0.096-0.141	0.118	0.9- 1.2
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	4	1.830-1.890	1.860	0.0- 0.6	4	1.550-1.960	1.725	0.0- 0.9	4	1.320-1.650	1.480	0.0- 1.2
MAX DEPTH**	2	1.860-1.890	1.875	0.6- 0.6	2	1.630-1.960	1.795	0.9- 0.9	2	1.450-1.650	1.550	0.9- 1.2
AMMONIA (MG/L)												
0.-1.5 M DEPTH	4	0.040-0.050	0.040	0.0- 0.6	4	0.030-0.090	0.055	0.0- 0.9	4	0.020-0.060	0.035	0.0- 1.2
MAX DEPTH**	2	0.040-0.050	0.045	0.6- 0.6	2	0.050-0.060	0.055	0.9- 0.9	2	0.020-0.060	0.040	0.9- 1.2
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	4	0.300-0.400	0.400	0.0- 0.6	4	0.200-0.600	0.300	0.0- 0.9	4	0.200-0.300	0.200	0.0- 1.2
MAX DEPTH**	2	0.300-0.400	0.350	0.6- 0.6	2	0.200-0.300	0.250	0.9- 0.9	2	0.200-0.200	0.200	0.9- 1.2
SECCHI DISC (METERS)												
	2	0.3- 0.3	0.3		2	0.4- 0.5	0.4		2	0.5- 0.6	0.5	

* 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
04/03/74	1. Synedra	476
	2. Centric Diatoms	449
	3. Chroomonas	264
	4. Asterionella	211
	5. Melosira	185
	Other genera	424
	Total	2,009
06/14/74	1. Melosira	103
	2. Cryptomonas	62
	3. Anabaena	41
	4. Aphanizomenon	21
	5. Asterionella	21
	Other genera	---
	Total	248
10/18/74	1. Cyclotella	1,745
	2. Skeletonema	1,325
	3. Cryptomonas	517
	4. Melosira	420
	5. Nitzschia	259
	Other genera	420
	Total	4,686

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
04/03/74	01	7.1
	02	8.9
	03	---
06/14/74	01	---
	02	0.1
	03	0.4
10/18/74	01	---
	02	13.7
	03	17.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 04/03/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	1.450	1.930	22.1
0.05 P	1.500	1.930	34.9
0.05 P + 1.0 N	1.500	2.930	39.0
1.00 N	1.450	2.930	19.1

b. 10/18/74

Control	0.105	1.300	31.5
0.05 P	0.155	1.300	18.0
0.05 P + 1.0 N	0.155	2.300	33.5
1.00 N	0.105	2.300	27.0

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Lake Frances was extremely high at both times samples were collected (04/03/74, 10/18/74). Chlorophyll a levels in the lake did not reflect the magnitude of this potential. Light extinction - not a factor under assay test conditions - is most likely limiting the phytoplankton standing crop in Lake Frances.

In the spring assay, increases in yield with the addition of phosphorus alone or nitrogen and phosphorus simultaneously suggest phosphorus is the primary limiting nutrient

in the lake. In fall, however, none of the nutrient additions resulted in a yield significantly greater than that of the control. Due to the high concentrations of available phosphorus and nitrogen in Lake Frances, it is not unlikely that some minor nutrient has reached the critical minimum required for lake productivity and become the limiting factor.

Mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 13/1, 21/1, and 14/1 in the spring, summer, and fall, respectively. However, further investigation is necessary before a definite determination of nutrient limitation in Lake Frances can be made.

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 October 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 concentrations in Ballard Creek at Station B-1 and mean annual ZZ flow.

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

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Lincoln (Arkansas)	525	Trickling filter	0.199**	Ballard Creek

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 Illinois River	75,645	89.2
b. Minor tributaries and immediate drainage (nonpoint load) -	8,500	10.0
c. Known municipal STP's -		
Lincoln	595	0.7
d. Septic tanks - Unknown	?	
e. Known industrial - None		
f. Direct precipitation* -	40	0.1
Totals	84,780	100.0

2. Output - A-1 Illinois River 66,540

3. Net annual P accumulation - 18,240

*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 Illinois River	1,123,305	84.6
b. Minor tributaries and immediate drainage (nonpoint load) -	200,415	15.1
c. Known municipal STP's -		
Lincoln	1,785	0.1
d. Septic tanks - Unknown	?	
e. Known industrial - None		
f. Direct precipitation* -	2,495	0.2
Totals	1,328,000	100.0

2. Output - A-1 Illinois River 1,069,760

3. Net annual N accumulation - 258,240

*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
Illinois River	56	831

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
B-1 Ballard Creek	0.092	2.169

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 Lake Frances	36.70
Vollenweider's "eutrophic" loading	2.54
Vollenweider's "oligotrophic" loading	1.27

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1971. "Inventory of Wastewater Treatment Facilities." EPA Publication No. OWP-1, Volume 6. Office of Media Programs, Office of Water Programs, Washington, D.C.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

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 4008 LAKE FRANCES

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 1644.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4008A1	1644.6	12.15	15.32	18.83	25.37	33.70	12.43	12.91	7.73	6.09	10.25	11.58	12.15	14.88
4008A2	1352.0	10.96	17.13	24.13	21.24	27.89	10.56	10.59	5.66	8.07	9.60	7.25	9.51	13.54
4008ZZ	292.7	2.38	3.68	5.21	4.59	6.03	2.29	2.29	1.22	1.76	2.07	1.56	2.07	2.93

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1644.6
SUM OF SUB-DRAINAGE AREAS = 1644.6
TOTAL FLOW IN = 197.74
TOTAL FLOW OUT = 178.51

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4008A1	11	74	66.828	2	86.083				
	12	74	17.613	14	20.530				
	1	75	22.993	18	16.537				
	2	75	51.537	15	16.933				
	3	75	65.129	8	25.967				
	4	75	24.551	12	21.662	20	17.188		
	5	75	21.691	3	41.909	19	11.468		
	6	75	20.785	21	17.811				
	7	75	11.157	19	6.570				
	8	75	8.580	16	19.001				
	9	75	28.289	6	6.286				
	10	75	9.911	8	9.061				
4008A2	11	74	39.644	2	31.149				
	12	74	11.610	14	18.689				
	1	75	18.972	8	18.689				
	2	75	37.378	15	16.707				
	3	75	69.093	8	22.653				
	4	75	18.406	12	19.822	20	16.424		
	5	75	34.547	3	32.848	19	11.327		
	6	75	6.796	21	16.990				
	7	75	8.835	19	6.230				
	8	75	16.707	16	22.653				
	9	75	2.832	6	2.549				
	10	75	9.061	8	6.796				
4008ZZ	11	74	48.139						
	12	74	14.158						
	1	75	22.937						
	2	75	45.590						
	3	75	84.101						
	4	75	22.370						
	5	75	41.909						
	6	75	8.212						
	7	75	10.760						
	8	75	20.388						
	9	75	3.398						
	10	75	11.044						

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 77/03/24

400801
36 07 30.0 094 30 54.0 4
LAKE FRANCES
40001 OKLAHOMA

100992

/TYPA/AMBNT/LAKE

11EPALES 04001002
0005 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
74/04/03	15	00 0000	16.8		10	188	7.80	101	0.040	0.400	1.830	0.095
	15	00 0002	16.8	9.4		188	7.60	100	0.040	0.300	1.890	0.075

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/03	15	00 0000	0.141	7.1	
	15	00 0002	0.136		

STORET RETRIEVAL DATE 77/03/24

400802
36 06 36.0 094 30 54.0 4
LAKE FRANCES
40001 OKLAHOMA

100992

/TYPA/AMBNT/LAKE

11EPALES 04001002
0006 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
74/04/03	15	15 0000	16.9		12	190	7.75	98	0.040	0.400	1.860	0.093
	15	15 0002	16.9	9.0		190	7.65	96	0.050	0.400	1.860	0.093
74/06/14	09	55 0000	20.0		18	169	7.70	77	0.030	0.300	1.820	0.083
	09	55 0003	19.6	7.2		168	7.60	76	0.050	0.200	1.960	0.086
74/10/18	13	10 0000	15.8	10.4	18	217	7.59	116	0.040	0.200	1.320	0.110
	13	10 0003	15.2	7.0		221	7.49	118	0.060	0.200K	1.650	0.141

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/03	15	15 0000	0.179	8.9	
	15	15 0002	0.169		
74/06/14	09	55 0000	0.098	0.1	
	09	55 0003	0.101		
74/10/18	13	10 0000	0.172	13.7	
	13	10 0003	0.232		
	13	10 0004			1.0

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 77/03/24

400803
36 07 12.0 094 30 54.0 4
LAKE FRANCES
40001 OKLAHOMA

100992

/TYPA/AMBNT/LAKE

11EPALES 04001002
0005 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
74/06/14	09 40	0000	20.1		14	165	7.60	76	0.090	0.600	1.550	0.087
	09 40	0003	20.0	6.8		165	7.50	74	0.060	0.300	1.630	0.084
74/10/18	13 30	0000	17.3	12.5	22	215	8.33	117	0.030	0.300	1.510	0.098
	13 30	0004	16.7	11.0		215	8.21	117	0.020K	0.200K	1.450	0.096

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/06/14	09 40	0000	0.101	0.4	
	09 40	0003	0.101		
74/10/18	13 30	0000	0.173	17.6	
	13 30	0004	0.143		
	13 30	0005			1.0

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 77/03/24

4008A1
36 08 15.0 094 33 55.0 4
ILLINOIS RIVER
40 ADAIR CO HWY MAP
0/LAKE FRANCES 100992
BANK SAMPLE JUST BELOW DAM
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
74/11/02	09	45	0.870	2.200	0.125	0.120	0.230
74/12/14	07	50	1.680	0.700	0.020	0.080	0.120
75/01/18	07	45	1.840	0.400	0.016		0.090
75/02/15	07	45	1.800	1.500	0.032	0.072	0.140
75/03/08	07	45	2.000	0.950	0.032	0.064	0.120
75/04/12	06	40	1.720	0.300	0.030	0.065	0.125
75/04/20	10	10	1.570	1.050	0.020	0.055	0.132
75/05/03	18	30	1.400	1.100	0.050	0.090	0.150
75/05/19	10	00	1.100	0.800	0.020	0.047	0.120
75/06/21	07	45	0.870	1.200	0.035	0.055	0.090
75/07/19	08	08	0.655	0.800	0.085	0.090	0.190
75/08/16	07	30	0.740	1.250	0.120	0.095	0.200
75/09/06	07	30	0.510	1.250	0.125	0.052	0.210
75/10/08	07	45	1.000	1.200	0.065	0.040	0.050

STORET RETRIEVAL DATE 77/03/24

4008A2
36 07 20.0 094 30 55.0 4
ILLINOIS RIVER
40 BENTON CO MAP
T/LAKE FRANCES 100992
2NDRY RD BRDG 4 MI S OF SILOAM SPRINGS
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
74/11/02	10 06		1.200	1.900	0.040	0.120	0.180
74/12/14	07 40		1.840	0.900	0.020	0.100	0.130
75/01/08	08 35		2.080	0.250	0.024	0.091	0.105
75/02/15	07 45		2.000	2.200	0.024	0.104	0.150
75/03/08	07 42		2.200	0.800	0.024	0.088	0.110
75/04/12	06 50		1.880	0.300	0.010	0.085	0.098
75/04/20	14 40		1.720	0.900	0.015	0.085	0.110
75/05/03	18 35		1.650	0.550	0.030	0.120	0.170
75/05/19	18 30		1.900	0.550	0.015	0.150	0.150
75/06/21	07 45		1.650	0.400	0.025	0.147	0.190
75/07/19	09 05		1.500	0.800	0.035	0.200	0.240
75/08/16	07 45		1.570	1.500	0.080	0.260	0.340
75/09/06	07 50		1.600	0.300	0.020	0.250	0.340
75/10/04	07 35		1.900	0.400	0.015	0.150	0.200

STORET RETRIEVAL DATE 77/03/24

400881
36 06 30.0 094 33 55.0 4
BALLARD CREEK
40 ADAIR CO HWY MAP
T/LAKE FRANCES
2NDRY RD BRDG AT SE EDGE OF WATTS
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
74/11/02	09 20		0.990	2.000	0.030	0.070	0.085
74/12/14	07 45		1.240	0.700	0.080	0.035	0.050
75/01/08	07 55		1.320	0.800	0.008	0.025	0.027
75/02/15	07 30		1.300	2.500	0.024	0.024	0.050
75/03/08	07 45		1.570	1.600	0.028	0.032	0.050
75/04/12	06 45		0.980	0.350	0.020	0.029	0.030
75/04/20	10 15		0.860	0.550	0.015	0.020	0.030
75/05/03	20 30		0.770	1.250	0.060	0.100	0.170
75/05/19	09 45		1.050	1.000	0.025	0.040	0.040
75/06/21	08 00		1.400	0.400	0.035	0.100	0.180
75/07/19	07 45		0.600	0.550	0.030	0.050	0.070
75/08/16	07 45		0.720	1.350	0.080	0.120	0.180
75/09/06	07 45		0.700	1.400	0.025	0.085	0.150
75/10/04	07 45		1.720	0.700	0.055	0.095	0.180

STORET RETRIEVAL DATE 77/03/24

4008XA TF4008XA P003000
35 49 30.0 094 38 45.0 4
STILWELL
40 ADAIR CO. MAP
T/LAKE FRANCES 100991
CANEY CREEK
11EPALES 00001004
0000 FEET DEPTH CLASS 00

/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	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/05/07	11	00							
CP(T)-			2.200	8.900	0.130	4.050	5.900	0.810	0.880
75/05/07	16	00							
75/05/28	11	00							
CP(T)-			3.300	10.500	0.840	7.300	7.300	0.450	0.799
75/05/28	16	00							
75/06/19	11	00							
CP(T)-			4.700	4.900	0.170	3.150	5.000	0.720	0.629
75/06/19	16	00							
75/07/09	11	00							
CP(T)-			7.000	13.500	0.610	9.750	12.500	0.482	0.524
75/07/09	16	00							
75/07/30	11	00							
CP(T)-			8.100	5.300	0.350	7.200	10.500	0.582	0.514
75/07/30	16	00							
75/08/21	11	00							
CP(T)-			16.400	15.500	2.800	12.150	13.500	0.419	0.485
75/08/21	15	00							
75/09/18	11	00							
CP(T)-			6.300	10.000	0.350	7.700	9.100	0.757	0.490
75/09/18	16	00							
75/11/13	11	00							
CP(T)-			9.850	11.000	0.050	7.600	10.000	0.373	0.394
75/11/13	16	00							

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF OKLAHOMA

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
4001	ALTUS RESERVOIR	0.041	0.060	468.625	14.750	8.400	0.010
4002	ARBUCKLE LAKE	0.020	0.070	443.600	7.027	14.600	0.008
4003	LAKE ELLSWORTH	0.037	0.070	459.400	8.430	9.400	0.009
4004	LAKE EUFAULA	0.081	0.405	482.513	4.383	14.200	0.029
4005	FORT CORB RESERVOIR	0.038	0.110	454.667	14.967	8.400	0.012
4006	FORT SUPPLY RESERVOIR	0.070	0.135	485.167	9.733	7.800	0.014
4007	FOSS DAM RESERVOIR	0.027	0.090	463.857	4.862	8.400	0.006
4008	LAKE FRANCES	0.142	1.780	484.333	7.973	8.200	0.093
4009	GRAND LAKE O' THE CHEROK	0.087	0.740	468.857	6.768	14.800	0.038
4010	LAKE HEFNER	0.057	0.250	461.000	5.667	9.000	0.036
4011	KEYSTONE RESERVOIR	0.136	0.690	484.303	21.427	14.900	0.096
4012	OOLOGAH LAKE	0.059	0.580	483.000	5.137	14.600	0.031
4013	TENKILLER FERRY RESERVOI	0.039	0.550	435.500	6.646	15.000	0.016
4014	LAKE THUNDERBIRD	0.027	0.150	465.000	8.422	12.000	0.009
4015	WISTER RESERVOIR	0.080	0.230	478.500	4.812	15.000	0.016
4834	TEXOMA LAKE	0.045	0.160	460.875	12.325	14.600	0.016

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)	87 (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)