REPORT

ON

E. V. SPENCE RESERVOIR

COKE COUNTY

TEXAS

EPA REGION VI

WORKING PAPER No. 658

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

MARCH, 1977

CONTENTS

F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to 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 fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division 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 Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

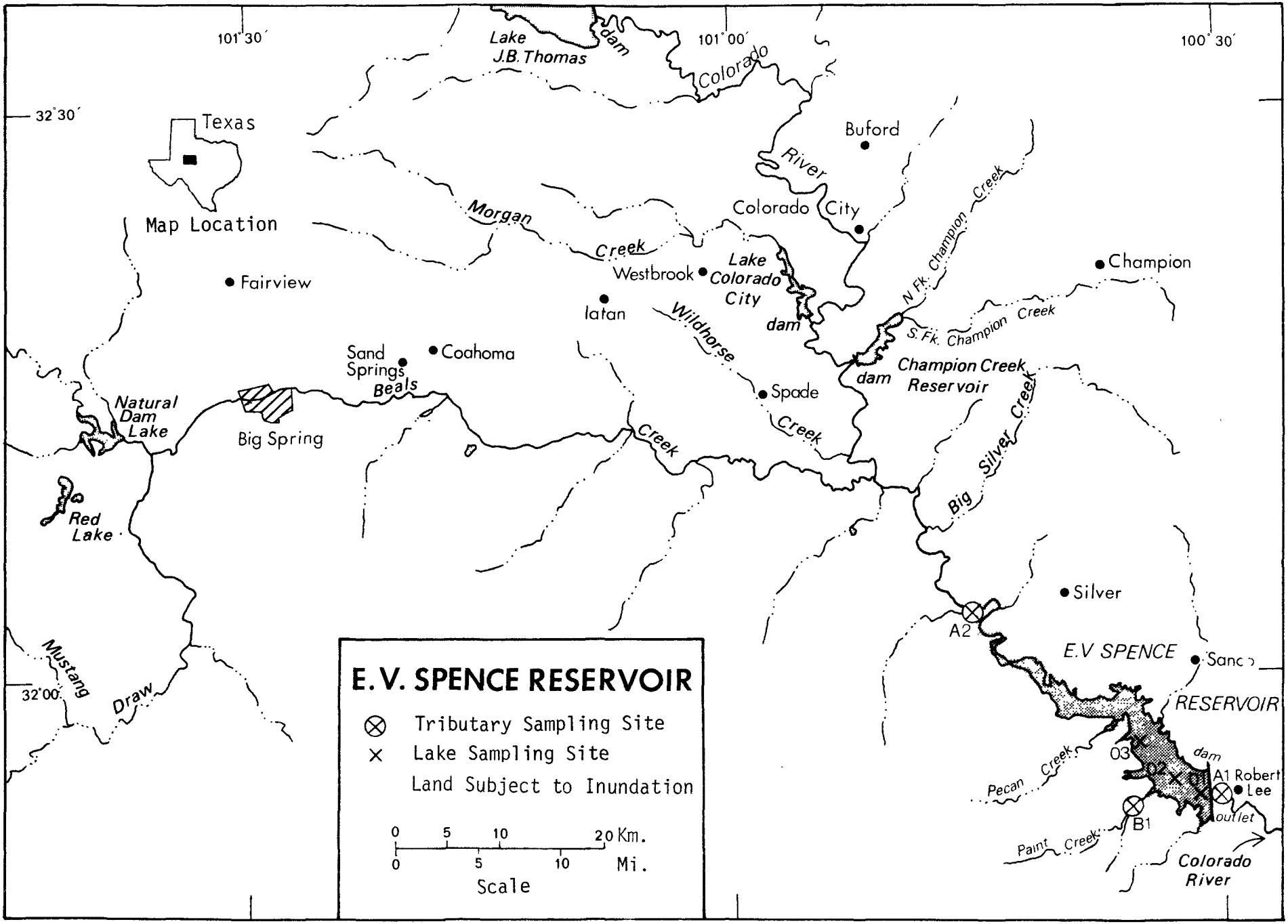
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


101°30′
101°00′
100°30′
32°30′
32°00′
Lake J.B. Thomas
dam
Colorado River
Texas
Map Location
Buford
Colorado City
Morgan Creek
Lake Colorado City
dam
Westbrook
Fairview
Iatan
Wildhorse Creek
N Fk. Champion Creek
S. Fk. Champion Creek
Champion
Champion Creek Reservoir
dam
Sand Springs
Coahoma
Beals Creek
Spade
Big Silver Creek
Natural Dam Lake
Big Spring
Red Lake
Mustang Draw
Silver
A2
E.V SPENCE
RESERVOIR
Pecan Creek
O3
O2
O1
dam
A1 Robert Lee
outlet
B1
Paint Creek
Colorado River
E.V. SPENCE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
0 5 10 20 Km.
0 5 10 Mi.
Scale

E. V. SPENCE RESERVOIR

STORET NO. 4828

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that E. V. Spence Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

E. V. Spence Reservoir ranked eighteenth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Eighteen of the reservoirs had less and one had the same median total phosphorus, eight had less and two had the same median dissolved phosphorus, six had less and one had the same median inorganic nitrogen, 19 had less mean chlorophyll a, and 21 had greater mean Secchi disc transparency. Marked depression or depletion of dissolved oxygen with depth occurred at stations 1 and 2 in August.

Survey limnologists observed an algal bloom and rooted aquatic plants along the shoreline in August. Blue-green algae were dominant in the August and October phytoplankton samples.

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* See Appendix A.

B. Rate-Limiting Nutrient:

Because of significant losses of phosphorus in both algal assay samples between times of collection and the beginning of the assays, the results are not representative of conditions in the reservoir at the times the samples were taken (03/04/74 and 10/29/74).

The reservoir data indicate that phosphorus was the limiting nutrient at all stations in May and at station 3 in October, and nitrogen was limiting at all stations in March and at stations 1 and 2 in October.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted E. V. Spence Reservoir during the sampling year.

The present phosphorus loading of 0.55 $g/m^2/yr$ is more than twice that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). If Vollenweider's eutrophic level is applicable to Texas reservoirs, it is likely that the trophic quality of the reservoir will deteriorate unless the present phosphorus loading is reduced. However, Survey data indicate that all the phosphorus inputs are from non-point sources, and it is questionable whether such inputs can be controlled.

2. Non-point sources--Non-point sources contributed 100% of the phosphorus load to E. V. Spence Reservoir during the sampling year. The Colorado River added 94.0% of the total load, Paint Creek, 0.4%; and the ungaged tributaries were estimated to have contributed 2.4%.

The phosphorus export rates of the Colorado River and Paint Creek were 0.3 and 0.8 kg/km^2/yr, respectively. These rates are quite low compared to the rates of unimpacted tributaries of other reservoirs in the general area.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 25.62 kilometers^2.
2. Mean depth: 6.7 meters.
3. Maximum depth: >15.8 meters.
4. Volume: 171.654 x 10^6 m^3.
5. Mean hydraulic retention time: 7.1 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)*
Colorado River	40,124.3	1.830
Paint Creek	67.6	0.033
Minor tributaries & immediate drainage -	549.1	0.196
Totals	40,741.0	2.059

2. Outlet -

Municipal and irrigation diversion	0.0	0.710††
Colorado River	40,766.6	0.052
Totals	40,766.6**	0.762**

C. Precipitation***:

1. Year of sampling: 63.4 centimeters.
2. Mean annual: 48.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Ivie, 1976.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir; lesser outflow due to evaporation (Ivie, op. cit.)
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

E. V. Spence Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, 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 15.8 meters at station 1, 9.4 meters at station 2, and 6.7 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR E V SPENCE RESERVOIR
STORET CODE 4828

PARAMETER	1ST SAMPLING (3/ 4/74) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (5/15/74) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (8/ 5/74) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	11.1 - 14.1	12.8	13.1	21.4 - 23.9	23.2	23.3	24.6 - 25.5	25.3	25.4
DISS OXY (MG/L)	9.6 - 10.4	9.9	9.9	5.2 - 7.8	7.0	7.0	0.0 - 6.8	5.4	6.2
CNDCTVY (MCROMO)	1614. - 1785.	1692.	1705.	2155. - 2340.	2264.	2247.	2610. - 2703.	2675.	2683.
PH (STAND UNITS)	8.2 - 8.4	8.3	8.3	8.0 - 8.3	8.2	8.2	7.7 - 8.1	8.0	8.0
TOT ALK (MG/L)	135. - 154.	145.	148.	133. - 138.	135.	136.	******	**********	
TOT P (MG/L)	0.014 - 0.027	0.018	0.017	0.027 - 0.045	0.036	0.036	******	**********	
ORTHO P (MG/L)	0.006 - 0.010	0.008	0.008	0.005 - 0.011	0.006	0.006	******	**********	
NO2+NO3 (MG/L)	0.030 - 0.040	0.032	0.030	0.020 - 0.080	0.063	0.075	******	**********	
AMMONIA (MG/L)	0.020 - 0.040	0.028	0.030	0.030 - 0.110	0.064	0.070	******	**********	
KJEL N (MG/L)	0.400 - 0.700	0.555	0.600	0.400 - 0.800	0.567	0.500	******	**********	
INORG N (MG/L)	0.050 - 0.080	0.060	0.060	0.050 - 0.190	0.127	0.145	******	**********	
TOTAL N (MG/L)	0.440 - 0.730	0.586	0.630	0.420 - 0.880	0.630	0.580	******	**********	
CHLRPYL A (UG/L)	4.7 - 5.9	5.3	5.4	3.4 - 6.2	4.7	4.5	12.4 - 16.9	14.2	13.4
SECCHI (METERS)	0.7 - 0.9	0.8	0.8	0.4 - 1.1	0.7	0.7	0.9 - 1.8	1.4	1.4

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR E V SPENCE RESERVOIR
STORET CODE 4828

4TH SAMPLING (10/29/74)

PARAMETER	3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	17.9 - 19.3	18.7	18.7
DISS OXY (MG/L)	6.8 - 7.4	7.1	7.2
CNDCTVY (MCROMO)	1203. - 1686.	1529.	1657.
PH (STAND UNITS)	8.2 - 8.5	8.4	8.4
TOT ALK (MG/L)	98. - 107.	104.	105.
TOT P (MG/L)	0.036 - 0.074	0.050	0.040
ORTHO P (MG/L)	0.008 - 0.023	0.012	0.010
NO2+NO3 (MG/L)	0.020 - 0.250	0.084	0.020
AMMONIA (MG/L)	0.030 - 0.090	0.056	0.050
KJEL N (MG/L)	0.600 - 1.000	0.700	0.700
INORG N (MG/L)	0.070 - 0.280	0.140	0.090
TOTAL N (MG/L)	0.620 - 1.150	0.784	0.720
CHLRPYL A (UG/L)	19.7 - 24.8	22.8	24.0
SECCHI (METERS)	0.6 - 1.1	0.9	0.9

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Algal Units per ml
03/04/74	1. Tetraedron sp.	2,407
	2. Scenedesmus sp.	2,295
	3. Cryptomonas sp.	263
	4. Chroomonas sp.	226
	5. Synedra sp.	188
	Other genera	414
	Total	5,793
08/05/74	1. Oscillatoria sp.	13,345
	2. Raphidiopsis sp.	5,537
	3. Lyngbya sp.	3,691
	4. Dactylococcopsis sp.	2,343
	5. Tetraedron sp.	2,130
	Other genera	2,626
	Total	29,672
10/29/74	1. Oscillatoria sp.	13,268
	2. Dactylococcopsis sp.	6,761
	3. Tetraedron sp.	1,732
	4. Raphidiopsis sp.	887
	5. Oocystis sp.	507
	Other genera	2,958
	Total	26,113

* The May phytoplankton sample was lost in shipment.

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
03/04/74	1	4.7
	2	5.4
	3	5.9
05/15/74	1	3.4
	2	4.5
	3	6.2
08/05/74	1	12.4
	2	13.4
	3	16.9
10/29/74	1	19.7
	2	24.0
	3	24.8

C. Limiting Nutrient Study:

There was a significant loss of phosphorus in both algal assay samples between time of collection and the beginning of the assays. Therefore, the algal assay results are not representative of conditions in the reservoir at the times the samples were taken (03/04/74 and 10/29/74).

The reservoir data indicate nitrogen limitation at all stations in March and at stations 1 and 2 in October; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 9/1 or less. All stations were limited by phosphorus in May, as was station 3 in October; i.e., the mean N/P ratios were 17 to 1 or greater, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in September, 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 Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. The outlet and diversion loads were calculated using mean reservoir concentrations at station 1 and the mean annual outlet and diversion flows.

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

No known point sources impacted E. V. Spence Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Colorado River	13,275	94.0
Paint Creek	55	0.4
b. Minor tributaries & immediate drainage (non-point load) -	340	2.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	450	3.2
Total	14,120	100.0

2. Outputs -

Lake outlet - Diversions	670
Colorado River	50
Total	720

3. Net annual P accumulation - 13,400 kg.

* Ivie, 1976.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Colorado River	83,565	70.4
Paint Creek	1,070	0.9
b. Minor tributaries & immediate drainage (non-point load) -	6,365	5.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	27,660	23.3
Total	118,660	100.0

2. Outputs -

Lake outlet - Diversions	13,925
Colorado River	1,020
Total	14,945

3. Net annual N accumulation - 103,715 kg.

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

Tributary	kg P/km^2/yr	kg N/km^2/yr
Colorado River	0.3	2.1
Paint Creek	0.8	15.8

* Ivie, 1976.
** See Working Paper No. 175.

E. 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	0.55	0.52	4.6	4.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of E. V. Spence Reservoir:

"Dangerous" (eutrophic loading)	0.20
"Permissible" (oligotrophic loading)	0.10

V. LITERATURE REVIEWED

Ivie, O. H., 1976. Personal communication (lake morphometry, diversions, and evaporation loss). Colorado River Municipal Water Dist., Big Springs.

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 CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
4801	AMISTAD LAKE	0.013	0.500	371.474	2.142	14.900	0.009
4802	BASTROP LAKE	0.022	0.090	419.917	12.392	15.000	0.007
4803	BELTON RESERVOIR	0.016	0.185	378.312	8.025	15.000	0.007
4804	BRAUNIG LAKE	0.134	0.150	461.625	22.762	14.800	0.062
4805	BROWNWOOD LAKE	0.027	0.100	470.375	4.887	14.400	0.007
4806	LAKE BUCHANAN	0.036	0.250	437.625	8.606	15.000	0.012
4807	CADDO LAKE	0.055	0.070	463.333	14.808	11.400	0.013
4808	CALAVERAS LAKE	0.038	0.060	461.667	22.500	13.000	0.007
4809	CANYON RESERVOIR	0.010	0.450	384.812	2.500	14.800	0.006
4810	LAKE COLORADO CITY	0.042	0.090	473.625	12.675	10.200	0.012
4811	CORPUS CRISTI LAKE	0.113	0.130	475.187	19.756	14.000	0.050
4812	DIVERSION LAKE	0.025	0.080	470.111	15.867	9.000	0.009
4813	EAGLE MOUNTAIN LAKE	0.024	0.070	469.625	5.662	11.000	0.008
4814	FT PHANTOM HILL LAKE	0.060	0.105	474.909	6.317	9.800	0.022
4815	GARZA LITTLE ELM RESERVO	0.045	0.380	475.782	14.156	14.600	0.018
4816	KEMP LAKE	0.023	0.110	455.000	10.217	10.400	0.007
4817	HOUSTON LAKE	0.097	0.260	486.187	16.650	12.400	0.036
4818	LAKE OF THE PINES	0.031	0.090	440.000	12.919	15.000	0.011
4819	LAVON RESERVOIR	0.063	0.180	485.333	5.400	8.800	0.018
4820	LIVINGSTON LAKE	0.196	0.555	465.469	16.112	15.000	0.128
4821	LYNDON B JOHNSON LAKE	0.042	0.420	456.500	8.100	14.900	0.013
4822	MEDINA LAKE	0.010	0.600	403.562	12.944	15.000	0.004
4823	LAKE MEREDITH	0.021	0.070	439.312	3.037	14.900	0.009
4824	PALESTINE LAKE	0.031	0.180	442.625	10.619	14.800	0.010
4825	POSSUM KINGDOM RESERVOIR	0.023	0.070	419.045	9.495	15.000	0.009
4826	SAN ANGELO RESERVOIR	0.098	0.140	481.000	24.675	10.200	0.011
4827	SAM RAYBURN RESERVOIR	0.029	0.150	439.458	6.267	15.000	0.009
4828	E V SPENCE RESERVOIR	0.036	0.080	462.583	11.775	15.000	0.008

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SOC-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
4829	SOMERVILLE LAKE	0.053	0.115	473.833	24.491	13.000	0.013
4830	STAMFORD LAKE	0.073	0.060	482.714	18.457	10.600	0.012
4831	STILLHOUSE HOLLOW RESERV	0.018	0.160	406.250	3.917	15.000	0.010
4832	TAWAKONI LAKE	0.046	0.100	466.417	18.246	13.200	0.013
4833	TEXARKANA LAKE	0.106	0.120	478.500	19.119	12.400	0.030
4834	TEXOMA LAKE	0.042	0.160	451.321	12.493	15.000	0.018
4835	TRAVIS LAKE	0.018	0.250	389.913	5.595	15.000	0.007
4836	TRINIDAD	0.389	0.110	479.500	24.300	10.000	0.240
4837	TWIN BUTTES RESERVOIR	0.029	0.250	454.917	8.708	14.800	0.009
4838	WHITE RIVER RESERVOIR	0.020	0.110	434.500	4.333	15.000	0.009
4839	WHITNEY LAKE	0.028	0.120	430.500	6.912	15.000	0.008

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
4801	AMISTAD LAKE	95 (36)	5 (2)	100 (38)	100 (38)	39 (14)	63 (21)	402
4802	BASTROP LAKE	79 (30)	76 (28)	82 (31)	47 (18)	17 (0)	92 (34)	393
4803	BELTON RESERVOIR	92 (35)	26 (10)	97 (37)	68 (26)	17 (0)	84 (31)	384
4804	BRAUNIG LAKE	5 (2)	42 (16)	50 (19)	8 (3)	49 (17)	5 (2)	159
4805	BROWNWOOD LAKE	66 (25)	70 (26)	29 (11)	87 (33)	58 (22)	84 (31)	394
4806	LAKE BUCHANAN	47 (18)	21 (7)	74 (28)	63 (24)	17 (0)	39 (14)	261
4807	CADDO LAKE	26 (10)	91 (33)	42 (16)	32 (12)	76 (29)	30 (10)	297
4808	CALAVERAS LAKE	45 (17)	100 (38)	47 (18)	11 (4)	67 (25)	92 (34)	362
4809	CANYON RESERVOIR	99 (37)	8 (3)	95 (36)	97 (37)	49 (17)	97 (37)	445
4810	LAKE COLORADO CITY	39 (14)	76 (28)	26 (10)	42 (16)	88 (33)	39 (14)	310
4811	CORPUS CRISTI LAKE	8 (3)	47 (18)	18 (7)	13 (5)	61 (23)	8 (3)	155
4812	DIVERSION LAKE	68 (26)	83 (31)	32 (12)	29 (11)	97 (37)	63 (21)	372
4813	EAGLE MOUNTAIN LAKE	71 (27)	91 (33)	34 (13)	79 (30)	79 (30)	76 (28)	430
4814	FT PHANTOM HILL LAKE	24 (9)	66 (25)	21 (8)	74 (28)	95 (36)	16 (6)	296
4815	GARZA LITTLE ELM RESERVO	34 (13)	13 (5)	16 (6)	34 (13)	55 (21)	21 (7)	173
4816	KEMP LAKE	76 (29)	61 (22)	55 (21)	55 (21)	84 (32)	92 (34)	423
4817	HOUSTON LAKE	16 (6)	16 (6)	0 (0)	24 (9)	72 (27)	11 (4)	139
4818	LAKE OF THE PINES	54 (20)	76 (28)	66 (25)	39 (15)	17 (0)	46 (17)	298
4819	LAVON RESERVOIR	21 (8)	29 (11)	3 (1)	84 (32)	100 (38)	21 (7)	258
4820	LIVINGSTON LAKE	3 (1)	3 (1)	39 (15)	26 (10)	17 (0)	3 (1)	91
4821	LYNDON B JOHNSON LAKE	39 (14)	11 (4)	53 (20)	66 (25)	39 (14)	30 (10)	238
4822	MEDINA LAKE	99 (37)	0 (0)	89 (34)	37 (14)	17 (0)	100 (38)	342
4823	LAKE MEREDITH	82 (31)	91 (33)	71 (27)	95 (36)	39 (14)	63 (21)	441
4824	PALESTINE LAKE	54 (20)	32 (12)	63 (24)	53 (20)	49 (17)	51 (19)	302
4825	POSSUM KINGDOM RESERVOIR	74 (28)	91 (33)	84 (32)	58 (22)	17 (0)	63 (21)	387
4826	SAN ANGELO RESERVOIR	13 (5)	45 (17)	8 (3)	0 (0)	88 (33)	46 (17)	200
4827	SAM RAYBURN RESERVOIR	59 (22)	39 (15)	68 (26)	76 (29)	17 (0)	63 (21)	322
[illegible]	[illegible]	50 (19)	83 (31)	45 (17)	50 (19)	17 (0)	76 (28)	321

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
4829	SOMERVILLE LAKE	29 (11)	55 (21)	24 (9)	3 (1)	67 (25)	30 (10)	208
4830	STAMFORD LAKE	18 (7)	97 (37)	5 (2)	18 (7)	82 (31)	39 (14)	259
4831	STILLHOUSE HOLLOW RESERV	88 (33)	37 (14)	87 (33)	92 (35)	17 (0)	51 (19)	372
4832	TAWAKONI LAKE	32 (12)	70 (26)	37 (14)	21 (8)	63 (24)	30 (10)	253
4833	TEXARKANA LAKE	11 (4)	51 (19)	13 (5)	16 (6)	72 (27)	13 (5)	176
4834	TEXOMA LAKE	39 (14)	34 (13)	61 (23)	45 (17)	17 (0)	21 (7)	217
4835	TRAVIS LAKE	88 (33)	21 (7)	92 (35)	82 (31)	17 (0)	84 (31)	384
4836	TRINIDAD	0 (0)	61 (22)	11 (4)	5 (2)	92 (35)	0 (0)	169
4837	TWIN BUTTES RESERVOIR	59 (22)	21 (7)	58 (22)	61 (23)	49 (17)	63 (21)	311
4838	WHITE RIVER RESERVOIR	84 (32)	61 (22)	76 (29)	89 (34)	17 (0)	63 (21)	390
4839	WHITNEY LAKE	63 (24)	51 (19)	79 (30)	71 (27)	17 (0)	76 (28)	357

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4809	CANYON RESERVOIR	445
2	4823	LAKE MEREDITH	441
3	4813	EAGLE MOUNTAIN LAKE	430
4	4816	KEMP LAKE	423
5	4801	AMISTAD LAKE	402
6	4805	BROWNWOOD LAKE	394
7	4802	BASTROP LAKE	393
8	4838	WHITE RIVER RESERVOIR	390
9	4825	POSSUM KINGDOM RESERVOIR	387
10	4835	TRAVIS LAKE	384
11	4803	BELTON RESERVOIR	384
12	4831	STILLHOUSE HOLLOW RESERV	372
13	4812	DIVERSION LAKE	372
14	4808	CALAVERAS LAKE	362
15	4839	WHITNEY LAKE	357
16	4822	MEDINA LAKE	342
17	4827	SAM RAYBURN RESERVOIR	322
18	4828	E V SPENCE RESERVOIR	321
19	4837	TWIN BUTTES RESERVOIR	311
20	4810	LAKE COLORADO CITY	310
21	4824	PALESTINE LAKE	302
22	4818	LAKE OF THE PINES	298
23	4807	CADDO LAKE	297
24	4814	FT PHANTOM HILL LAKE	296
25	4806	LAKE BUCHANAN	261
26	4830	STAMFORD LAKE	259
27	4819	LAVON RESERVOIR	258
28	4832	TAWAKONI LAKE	253

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	4821	LYNDON B JOHNSON LAKE	238
30	4834	TEXOMA LAKE	217
31	4829	SOMERVILLE LAKE	208
32	4826	SAN ANGELO RESERVOIR	200
33	4833	TEXARKANA LAKE	176
34	4815	GARZA LITTLE ELM RESERVO	173
35	4836	TRINIDAD	169
36	4804	BRAUNIG LAKE	159
37	4811	CORPUS CRISTI LAKE	155
38	4817	HOUSTON LAKE	139
39	4820	LIVINGSTON LAKE	91

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

LAKE CODE 4828 E. V. SPENCE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 40766.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4828A1	40766.6	0.006	0.008	0.011	0.017	0.020	0.227	0.057	0.142	0.085	0.017	0.008	0.028	0.052
4828A2	40124.3	0.23	0.28	1.59	1.08	3.71	2.04	1.22	7.56	2.78	0.54	0.59	0.23	1.83
4828B1	67.6	0.001	0.011	0.002	0.028	0.164	0.051	0.028	0.011	0.034	0.054	0.006	0.003	0.033
4828Z2	575.0	0.011	0.054	0.054	0.156	0.821	0.275	0.161	0.269	0.224	0.244	0.042	0.023	0.196

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 40766.6
SUM OF SUB-DRAINAGE AREAS = 40766.8

TOTAL FLOW IN = 24.56
TOTAL FLOW OUT = 0.63

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4828A1	9	74	0.0	8	0.0				
	10	74	0.0	5	0.0				
	11	74	0.0	2	0.0				
	12	74	0.0	8	0.0				
	1	75	0.0	5	0.0				
	2	75	0.0	1	0.0				
	3	75	0.0	2	0.0				
	4	75	0.0	6	0.0	20	0.0		
	5	75	0.0	4	0.0	25	0.0		
	6	75	0.0	22	0.0				
	7	75	0.0	20	0.0				
	8	75	0.0	3	0.0				
4828A2	9	74	8.382	8	0.037				
	10	74	13.309	5	0.340				
	11	74	1.501	2	4.672				
	12	74	0.595	7	0.623				
	1	75	0.510	5	0.651				
	2	75	0.708	1	0.906				
	3	75	0.252	2	0.368				
	4	75	0.136	6	0.170				
	5	75	5.154	4	0.057				
	6	75	0.538	22	0.170				
	7	75	6.145	20	20.983				
	8	75	5.890	3	2.860				

LAKE CODE 4828 E. V. SPENCE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4828B1	9	74	0.0	3	0.0				
	10	74	0.0	5	0.0				
	11	74	0.0	2	0.0				
	12	74	0.0	7	0.0				
	1	75	0.0	5	0.0				
	2	75	0.0	1	0.0				
	3	75	0.0	2	0.0				
	4	75	0.0	6	0.0	20	0.0		
	5	75	0.0	4	0.0	25	0.0		
	6	75	0.0	7	0.0	22	0.0		
	7	75	0.0	20	0.0				
	8	75	0.0	3	0.0				
4828ZZ	9	74	0.283						
	10	74	0.850						
	11	74	0.028						
	12	74	0.028						
	1	75	0.028						
	2	75	0.057						
	3	75	0.014						
	4	75	0.008						
	5	75	0.283						
	6	75	0.028						
	7	75	0.340						
	8	75	0.340						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/02/11

482801
31 55 24.0 100 33 43.0
E V SPENCE RESERVOIR
48081 TEXAS

11EPALES
3

21112v2
003R FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/04	13 00	0000	13.3		36	1705	8.40	137	0.030	0.500	0.030	0.008
	13 00	0005	13.3	10.4		1702	8.40	136	0.020	0.500	0.030	0.007
	13 00	0015	12.6	10.0		1661	8.35	135	0.020	0.500	0.030	0.008
	13 00	0032	11.1	9.6		1618	8.30	135	0.040	0.400	0.040	0.009
74/05/15	13 25	0000	23.3		43	2245	8.30	133	0.080	0.700	0.080	0.006
	13 25	0005	23.3	7.8		2241	8.30	133	0.060	0.500	0.070	0.006
	13 25	0015	23.1	7.8		2236	8.30	133	0.060	0.400	0.070	0.006
	13 25	0027	23.0	7.4		2233	8.25	135	0.030	0.400	0.020	0.005
74/08/05	13 45	0000	25.4	6.2	72	2662	7.90					
	13 45	0005	25.4	6.2		2662	8.00					
	13 45	0015	25.4	6.0		2662	8.00					
	13 45	0025	25.3	3.0		2658	7.80					
	13 45	0040	24.6	0.0		2610	7.70					
74/10/29	09 50	0000	19.2		36	1673	8.20	106	0.090	1.000	0.030	0.023
	09 50	0005	19.2	6.8		1686	8.25	105	0.060	0.700	0.020K	0.008
	09 50	0015	19.2			1682	8.30	106	0.070	0.600	0.020K	0.008
	09 50	0035	19.2			1682	8.30	107	0.070	0.700	0.020K	0.008
	09 50	0052	19.3	7.4		1683	8.30	107	0.090	0.700	0.020K	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/04	13 00	0000	0.014	4.7	
	13 00	0005	0.016		
	13 00	0015	0.014		
	13 00	0032	0.015		
74/05/15	13 25	0000	0.033	3.4	
	13 25	0005	0.027		
	13 25	0015	0.029		
	13 25	0027	0.028		
74/08/05	13 45	0000		12.4	
74/10/29	09 50	0000	0.044	19.7	
	09 50	0005	0.040		5.0
	09 50	0009			1.0
	09 50	0015	0.037		
	09 50	0035	0.040		
	09 50	0052	0.052		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/11

482802
31 56 25.0 100 35 09.0
E V SPENCE RESERVOIR
48081 TEXAS

11EPALES 2111202
3 0032 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/04	12 30	0000	13.8		32	1730	8.30	151	0.030	0.600	0.030	0.006
	12 30	0005	13.1	10.2		1710	8.40	153	0.020	0.500	0.030	0.008
	12 30	0015	12.2	10.2		1614	8.30	154	0.030	0.600	0.030	0.009
	12 30	0027	11.3	9.6		1629	8.20	153	0.030	0.600	0.030	0.009
74/05/15	13 05	0000	23.3		28	2256	8.30	137	0.070	0.800	0.070	0.007
	13 05	0005	23.3	7.4		2248	8.25	136	0.070	0.500	0.080	0.006
	13 05	0015	23.0	6.8		2230	8.00	136	0.040	0.500	0.020	0.005
	13 05	0031	21.4	5.2		2155	8.00	138	0.110	0.600	0.080	0.006
74/08/05	14 15	0000	25.5	6.0	54	2689	8.00					
	14 15	0005	25.5	6.2			8.00					
	14 15	0015	25.5	6.0		2689	8.10					
	14 15	0030	25.4	4.8		2677	7.90					
74/10/29	10 20	0000	18.7	7.4	42	1660	8.50	106	0.050	0.800	0.020K	0.008
	10 20	0005	18.7			1657	8.40	104	0.050	0.600	0.020K	0.018
	10 20	0015	18.6			1657	8.40	104	0.050	0.600	0.020K	0.008
	10 20	0031	18.5	6.8		1656	8.40	105	0.060	0.600	0.020K	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/04	12 30	0000	0.017	5.4	
	12 30	0005	0.018		
	12 30	0015	0.016		
	12 30	0027	0.020		
74/05/15	13 05	0000	0.036	4.5	
	13 05	0005	0.033		
	13 05	0015	0.036		
	13 05	0031	0.040		
74/08/05	14 15	0000		13.4	
	14 15	0011			1.0
74/10/29	10 20	0000	0.036	24.0	
	10 20	0005	0.040		
	10 20	0015	0.038		
	10 20	0031	0.038		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/02/11

482803
31 58 11.0 100 36 47.0
E V SPENCE RESERVOIR
48061 TEXAS

11EPALES
3

2111202
0020 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/04	12 05	0000	14.1		29	1785	8.40	146	0.030	0.700	0.030	0.007
	12 05	0005	13.1	9.8		1728	8.30	148	0.030	0.600	0.030	0.010
	12 05	0015	12.7	9.6		1729	8.30	151	0.030	0.600	0.040	0.009
74/05/15	12 40	0000	23.9		17	2340	8.20	136	0.070	0.800	0.080	0.006
	12 40	0005	23.9	6.6		2339	8.20	136	0.070	0.600	0.080	0.011
	12 40	0015	23.6	7.0		2327	8.15	137	0.070	0.500	0.080	0.007
	12 40	0021	23.4	6.6		2318	8.15	135	0.040	0.500	0.030	0.007
74/08/05	14 45	0000	25.2	6.8	36	2700	8.10					
	14 45	0005	25.2	6.4		2703	8.10					
	14 45	0015	25.0	6.4		2698	8.10					
	14 45	0022	24.9	6.4		2689	8.00					
74/10/29	10 45	0000	18.1	7.2	24	1214	8.40	98	0.030	0.900	0.250	0.014
	10 45	0005	18.1	7.4		1214	8.40	101	0.030	0.700	0.220	0.013
	10 45	0015	17.9	7.0		1207	8.35	99	0.040	0.600	0.220	0.013
	10 45	0022	17.9	7.2		1203	8.40	101	0.040	0.600	0.210	0.012

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/04	12 05	0000	0.022	5.9	
	12 05	0005	0.019		
	12 05	0015	0.027		
74/05/15	12 40	0000	0.045	6.2	
	12 40	0005	0.040		
	12 40	0015	0.044		
	12 40	0021	0.044		
74/08/05	14 45	0000		16.9	
74/10/29	10 45	0000	0.074	24.8	
	10 45	0002			5.0
	10 45	0003			1.0
	10 45	0005	0.073		
	10 45	0015	0.068		
	10 45	0022	0.069		

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/03/10

4E28A2
32 03 00.0 100 46 00.0 4
COLORADO RIVER
48 7.5 DEAD INDIAN
T/E V SPENCE RESERVOIR
2NDRY RD BRDG 5 MI W OF SILVER
TIEPLACES 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
74/09/08	10	55	0.008	1.000	0.035	0.040	0.130
74/10/05	12	30	0.024	1.000	0.045	0.015	0.060
74/11/02	12	45	0.704	1.000	0.135	0.110	0.230
74/12/07	10	30	0.064	2.600	0.032	0.120	0.200
75/01/05	08	30	0.072	2.100	0.040	0.370	0.520
75/02/01	14	30	0.012	1.800	0.032	0.224	0.360
75/03/02	09	00	0.005	1.750	0.030	0.105	0.250
75/04/06	10	30	0.010	1.350	0.065	0.105	0.230
75/04/20	10	00	0.010	0.550	0.067	0.093	0.221
75/04/25	12	30		3.200			0.190
75/05/04	10	00	0.010	1.450	0.040	0.085	0.190
75/06/22	09	00	0.010	1.330	0.045	0.055	0.175
75/07/20	11	00	0.005	0.950	0.025	0.035	0.120
75/08/03	10	00	0.010	1.000	0.025	0.225	0.340

STORET RETRIEVAL DATE 76/03/10

482481
31 53 10.0 100 35 07.0 4
PAINT CREEK
48 7.5 EDITH
T/E W SPENCE RESERVOIR
BRDG 1.4 M SW JCT HWY 58 2.8 M SE EDITH
TIERALES 2111294
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
75/06/07	11 06		0.180	0.850	0.170	0.015	0.055