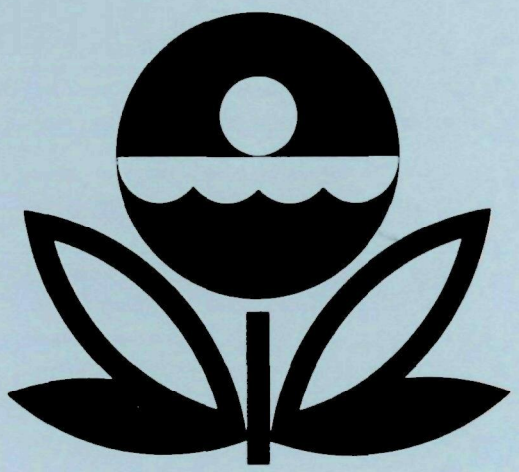
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

BIG LAKE

APACHE COUNTY

ARIZONA

EPA REGION IX

WORKING PAPER No. 726

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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WORKING PAPER No. 726

WITH THE COOPERATION OF THE

ARIZONA STATE DEPARTMENT OF HEALTH

AND THE

ARIZONA NATIONAL GUARD

AUGUST, 1977

REPORT ON BIG LAKE

APACHE COUNTY, ARIZONA

EPA REGION IX

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 726

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

August 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 Arizona State Department of Health for professional involvement, to the Arizona National Guard for conducting the tributary sampling phase of the Survey, and to those Arizona wastewater treatment plant operators who provided effluent samples and flow data.

The staffs of the Bureau of Water Quality Control, Environmental Health Services, Arizona State Department of Health, and the Arizona Game and Fish Department, 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.

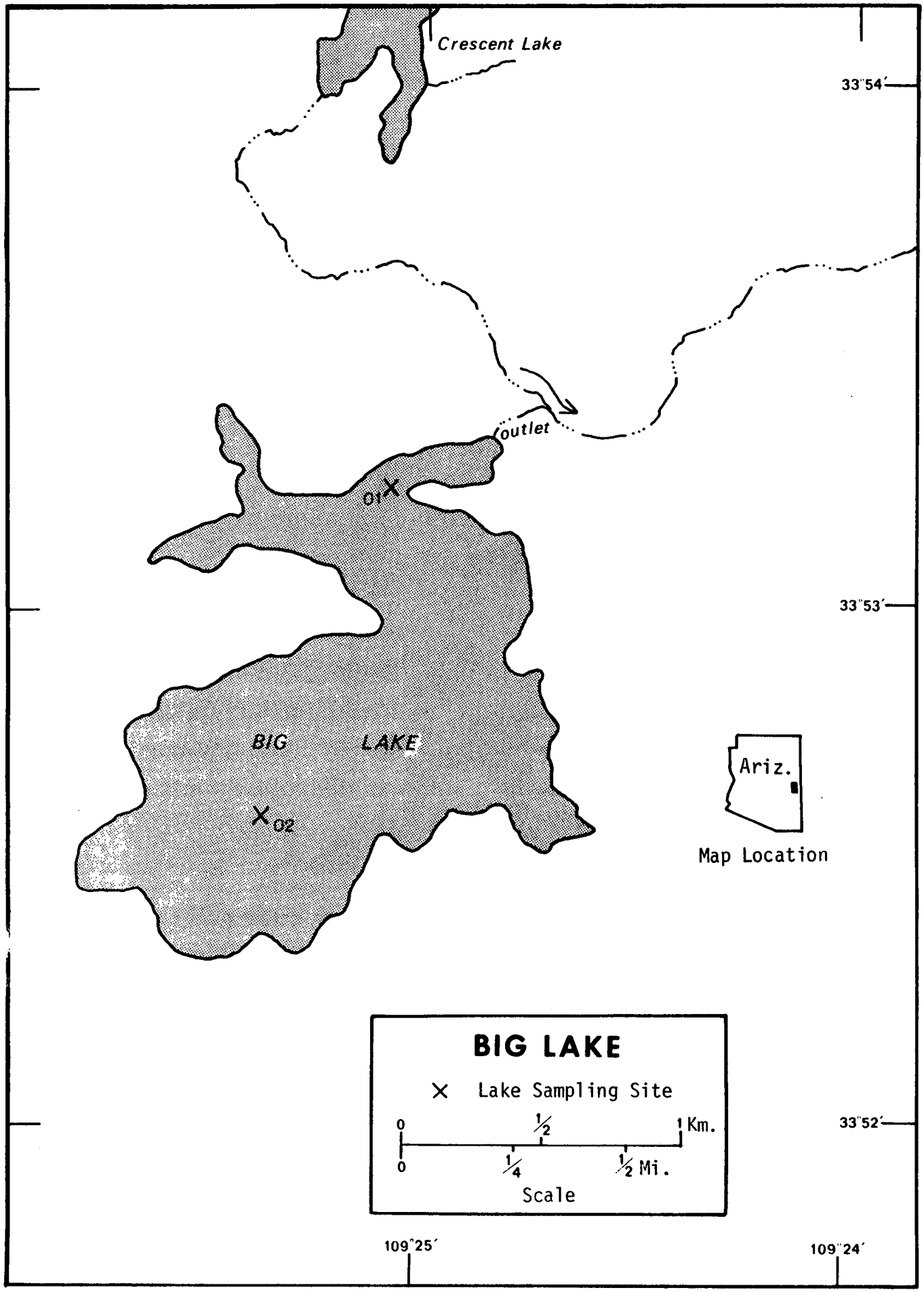
Major General John G. Smith, the Adjutant General of Arizona, and Project Officer Colonel Richard A. Colson, who directed the volunteer efforts of the Arizona National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARIZONA

LAKE NAME	COUNTY
Big Lake	Apache
Fools Hollow Lake	Navajo
Lake Havasu	Mohave (San Bernadino in CA)
Luna Lake	Apache
Lyman Lake	Apache
Lake Mohave	Mohave (Clark in NV)
Lake Pleasant	Yavapai, Maricopa
Lake Powell	Coconino (Kane, Garfield, San Juan in UT)
Rainbow Lake	Navajo
Theodore Roosevelt Lake	Gila
San Carlos Reservoir	Graham, Gila, Pinal


Crescent Lake
33°54′
outlet
01
33°53′
BIG LAKE
02
Ariz.
Map Location
BIG LAKE
Lake Sampling Site
0
1/2
1 Km.
0
1/4
1/2 Mi.
Scale
33°52′
109°25′
109°24′

REPORT ON BIG LAKE, ARIZONA

STORET NO. 0401

I. INTRODUCTION

Big Lake was included in the National Eutrophication Survey (NES) as a water body of special interest to the Arizona State Department of Health. Tributaries and nutrient sources were not sampled, and this report relates only to the lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that Big Lake is early eutrophic. Chlorophyll a values ranged from 1.3 µg/l to 4.0 µg/l, with a mean of 2.9 µg/l. Potential for primary production as measured by algal assay control yield was high in the summer and low in the fall. The median Secchi disc transparency was 114 inches (289.6 cm). Of the 11 Arizona lakes sampled in 1975, 5 had higher median total phosphorus values (0.032 mg/l), 3 had higher median inorganic nitrogen levels (0.090 mg/l) and 8 had higher median orthophosphorus values (0.007 mg/l) than Big Lake.

Survey limnologists reported an algal bloom throughout the lake on the October sampling date and submerged weeds in the southern end.

*See Appendix C.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Big Lake was colimited by available phosphorus and nitrogen levels during June sampling and phosphorus limited in October. The lake data suggest primary limitation by phosphorus in the summer and by nitrogen in the fall.

III. LAKE CHARACTERISTICS*

A. Lake Morphometry:**

1. Surface area: 1.94 km^2.†
2. Mean depth: 4.4 meters.
3. Maximum depth: 7.0 meters.
4. Volume: 8.634 x 10^6 m^3.††

B. Precipitation:

1. Year of sampling: 30.8 cm.
2. Mean annual: 63.2 cm.

*A table of metric/English conversions in included as Appendix A.
**Rathbun, Ned. 1974.
†Average value.
††Estimated value.

IV. LAKE WATER QUALITY SUMMARY

Big Lake was sampled two times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake 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, and 18.9-liter depth-integrated samples were composited for algal assays. The maximum depth sampled was 6.1 meters at both Stations 01 and 02. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix B and are summarized in IV-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 IV-B. Results of the limiting nutrient study are presented in IV-C.

BIG LAKE
STORET CODE 0401

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(5/19/75) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(10/ 6/75) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)								
0.-1.5 M DEPTH	4	12.5- 12.6	12.5	0.0- 1.5	4	14.9- 15.7	15.0	0.0- 1.5
MAX DEPTH**	2	12.5- 12.7	12.6	5.5- 6.1	2	14.9- 14.9	14.9	6.1- 6.1
DISSOLVED OXYGEN (MG/L)								
0.-1.5 M DEPTH	4	6.2- 7.4	6.6	0.0- 1.5	4	7.5- 7.8	7.7	0.0- 1.5
MAX DEPTH**	2	6.0- 7.6	6.8	5.5- 6.1	2	7.4- 8.0	7.7	6.1- 6.1
CONDUCTIVITY (UMHOS)								
0.-1.5 M DEPTH	4	112.- 114.	113.	0.0- 1.5	4	99.- 102.	99.	0.0- 1.5
MAX DEPTH**	2	113.- 114.	114.	5.5- 6.1	2	97.- 97.	97.	6.1- 6.1
PH (STANDARD UNITS)								
0.-1.5 M DEPTH	4	8.0- 8.1	8.0	0.0- 1.5	4	8.5- 8.6	8.5	0.0- 1.5
MAX DEPTH**	2	8.0- 8.0	8.0	5.5- 6.1	2	8.4- 8.6	8.5	6.1- 6.1
TOTAL ALKALINITY (MG/L)								
0.-1.5 M DEPTH	4	76.- 77.	77.	0.0- 1.5	4	76.- 77.	77.	0.0- 1.5
MAX DEPTH**	2	77.- 78.	78.	5.5- 6.1	2	76.- 76.	76.	6.1- 6.1
TOTAL P (MG/L)								
0.-1.5 M DEPTH	4	0.033-0.042	0.037	0.0- 1.5	4	0.022-0.050	0.028	0.0- 1.5
MAX DEPTH**	2	0.030-0.032	0.031	5.5- 6.1	2	0.022-0.049	0.035	6.1- 6.1
DISSOLVED ORTHO P (MG/L)								
0.-1.5 M DEPTH	4	0.009-0.019	0.012	0.0- 1.5	4	0.004-0.021	0.007	0.0- 1.5
MAX DEPTH**	2	0.004-0.011	0.007	5.5- 6.1	2	0.003-0.006	0.004	6.1- 6.1
NO2+NO3 (MG/L)								
0.-1.5 M DEPTH	4	0.080-0.080	0.080	0.0- 1.5	4	0.060-0.070	0.065	0.0- 1.5
MAX DEPTH**	2	0.070-0.090	0.080	5.5- 6.1	2	0.060-0.070	0.065	6.1- 6.1
AMMONIA (MG/L)								
0.-1.5 M DEPTH	4	0.180-0.230	0.205	0.0- 1.5	4	0.020-0.020	0.020	0.0- 1.5
MAX DEPTH**	2	0.200-0.200	0.200	5.5- 6.1	2	0.020-0.020	0.020	6.1- 6.1
KJELDAHL N (MG/L)								
0.-1.5 M DEPTH	4	1.000-1.200	1.100	0.0- 1.5	4	0.600-0.700	0.600	0.0- 1.5
MAX DEPTH**	2	1.000-1.000	1.000	5.5- 6.1	2	0.600-0.800	0.700	6.1- 6.1
SECCHI DISC (METERS)								
	0	*****-*****	*****		2	2.7- 3.0	2.9	

* 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
06/19/75	1. Cryptomonas	92
	2. Schroederia	23
	3. Cyst	23
	4. Trachelomonas	23
	5. Euglena	23
	Other genera	---
	Total	184
10/06/75	1. Aphanothece	480
	2. Melosira	137
	3. Chroomonas	137
	4. Asterionella	69
	5. Coelosphaerium	69
	Other genera	113
	Total	1,005

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
06/19/75	01	2.5
	02	4.0
10/06/75	01	1.3
	02	3.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 06/19/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.005	0.215	9.5
0.05 P	0.055	0.215	20.0
0.05 P + 1.0 N	0.055	1.215	27.3
1.00 N	0.005	1.215	13.6

b. 10/06/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.005	0.155	0.2
0.05 P	0.055	0.155	11.0
0.05 P + 1.0 N	0.055	1.155	16.8
1.00 N	0.005	1.155	0.2

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum*, indicate that the potential for primary productivity in Big Lake was high on the summer sampling date (06/19/75) and low during fall sampling (10/06/75). In the June assay, the addition of phosphorus and nitrogen separately both stimulated growth beyond the control yield, suggesting colimitation by the two nutrients. In the October assay, the increase in yield over that of the control in response to the addition of phosphorus as well as the lack of response to the addition of nitrogen, indicates phosphorus limitation. In both assays, maximum growth occurred with the addition of phosphorus and nitrogen simultaneously.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were approximately 26/1 and 12/1 in the summer and fall, respectively, suggesting primary limitation by phosphorus in the summer and nitrogen limitation in the fall (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

*For further information regarding the algal assay test procedure and selection of test organisms, see U.S. EPA (1971).

V. LITERATURE REVIEWED

Rathbun, Ned L. 1974. Personal Communication (lake morphometry). Arizona Game and Fish Department, Phoenix, Arizona.

U.S. Environmental Protection Agency. 1971. Algal Assay Procedure Bottle Test. National Eutrophication Research Program, Corvallis, Oregon.

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.

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

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION S -VEY
EPA-LAS VEGAS

040101
33 53 18.0 109 24 53.0 3
BIG LAKE
04001 ARIZONA

11EPALES 760109 2111202
0022 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
75/06/19	13 00	0000	12.5	6.2		113	8.15	77	0.190	1.200	0.080	0.019
	13 00	0005	12.5	6.6		112	8.10	77	0.180	1.000	0.080	0.015
	13 00	0018	12.5	7.6		113	8.05	78	0.200	1.000	0.090	0.011
75/10/06	10 30	0000	14.9	7.8	120	102	8.50	76	0.020K	0.700	0.070	0.006
	10 30	0005	14.9	7.5		99	8.55	76	0.020K	0.600	0.060	0.004
	10 30	0015	14.9	7.8		98	8.60	75	0.020K	0.600	0.060	0.003
	10 30	0020	14.9	8.0		97	8.60	76	0.020K	0.600	0.060	0.003

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/06/19	13 00	0000	0.033	2.5	
	13 00	0005	0.037		
	13 00	0018	0.032		
75/10/06	10 30	0000	0.032	1.3	
	10 30	0005	0.022		
	10 30	0015	0.026		
	10 30	0020	0.022		

K VALUE KNOWN TO BE LESS THAN INDICATED

APPENDIX C

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF ARIZONA

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Arizona lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in µg/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

040102
33 52 35.0 109 25 24.0 3
BIG LAKE
04001 ARIZONA

11EPALES 760109 2111202
0024 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
75/06/19	13	20 0000	12.6	7.4		113	8.00	77	0.220	1.200	0.080	0.009
	13	20 0005	12.6	6.6		114	8.00	76	0.230	1.000	0.080	0.009
	13	20 0020	12.7	6.0		114	8.00	77	0.200	1.000	0.070	0.004
75/10/06	10	15 0000	15.7	7.8	108	99	8.65	77	0.020K	0.600	0.060	0.021
	10	15 0005	15.2	7.6		99	8.55	77	0.020K	0.600	0.070	0.009
	10	15 0015	15.0	8.0		97	8.50	76	0.020	0.600	0.060	0.006
	10	15 0020	14.9	7.4		97	8.45	76	0.020	0.800	0.070	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
75/06/19	13	20 0000	0.038	4.0	
	13	20 0005	0.042		
	13	20 0020	0.030		
75/10/06	10	15 0000	0.050	3.8	
	10	15 0005	0.024		
	10	15 0015	0.023		
	10	15 0020	0.049		

K VALUE KNOWN TO BE LESS THAN INDICATED

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
0401	BIG LAKE	0.032	0.090	386.000	2.900	9.000	0.007
0402	FOOLS HOLLOW	0.059	0.090	466.600	10.683	14.800	0.014
0403	LAKE HAVASU	0.015	0.170	420.231	3.948	10.800	0.005
0404	LUNA LAKE	0.182	0.050	396.250	3.400	12.200	0.131
0405	LYMAN LAKE	0.099	0.060	484.667	2.633	9.000	0.056
0406	LAKE MOHAVE	0.017	0.240	369.667	4.404	8.600	0.010
0407	LAKE PLEASANT	0.027	0.040	449.154	9.808	14.900	0.004
0408	LAKE POWELL	0.009	0.400	239.000	1.333	12.200	0.010
0409	RAINBOW LAKE	0.046	0.045	440.750	16.367	12.000	0.009
0410	ROOSEVELT LAKE	0.020	0.040	429.917	4.073	14.000	0.008
0411	SAN CARLOS RESERVOIR	0.056	0.060	474.500	14.750	14.600	0.009
3201	LAKE MEAD	0.020	0.505	453.600	1.150	8.000	0.007

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
0401	BIG LAKE	45 (5)	41 (4)	82 (9)	73 (8)	77 (8)	73 (8)
0402	FOOLS HOLLOW	18 (2)	41 (4)	18 (2)	18 (2)	9 (1)	18 (2)
0403	LAKE HAVASU	91 (10)	27 (3)	64 (7)	55 (6)	64 (7)	91 (10)
0404	LUNA LAKE	0 (0)	73 (8)	73 (8)	64 (7)	41 (4)	0 (0)
0405	LYMAN LAKE	9 (1)	64 (7)	0 (0)	82 (9)	77 (8)	9 (1)
0406	LAKE MOHAVE	82 (9)	18 (2)	91 (10)	36 (4)	91 (10)	32 (3)
0407	LAKE PLEASANT	55 (6)	95 (10)	36 (4)	27 (3)	0 (0)	100 (11)
0408	LAKE POWELL	100 (11)	9 (1)	100 (11)	91 (10)	41 (4)	32 (3)
0409	RAINBOW LAKE	36 (4)	82 (9)	45 (5)	0 (0)	55 (6)	45 (5)
0410	ROOSEVELT LAKE	68 (7)	95 (10)	55 (6)	45 (5)	27 (3)	64 (7)
0411	SAN CARLOS RESERVOIR	27 (3)	55 (6)	9 (1)	9 (1)	18 (2)	55 (6)
3201	LAKE MEAD	68 (7)	0 (0)	27 (3)	100 (11)	100 (11)	82 (9)