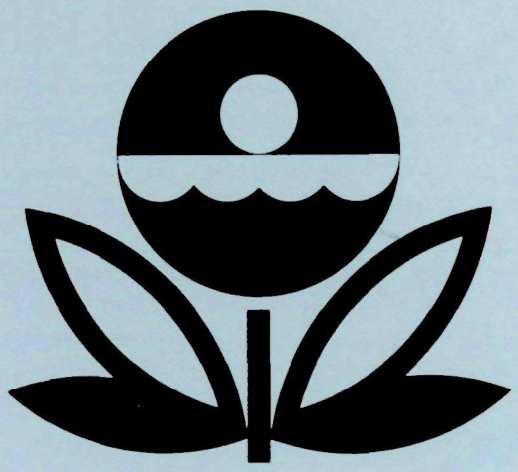
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

LUNA LAKE

APACHE COUNTY

ARIZONA

EPA REGION IX

WORKING PAPER No. 729

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPORT

ON

LUNA LAKE

APACHE COUNTY

ARIZONA

EPA REGION IX

WORKING PAPER No. 729

WITH THE COOPERATION OF THE

ARIZONA STATE DEPARTMENT OF HEALTH

AND THE

ARIZONA NATIONAL GUARD

AUGUST, 1977

REPORT ON LUNA 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. 729

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.

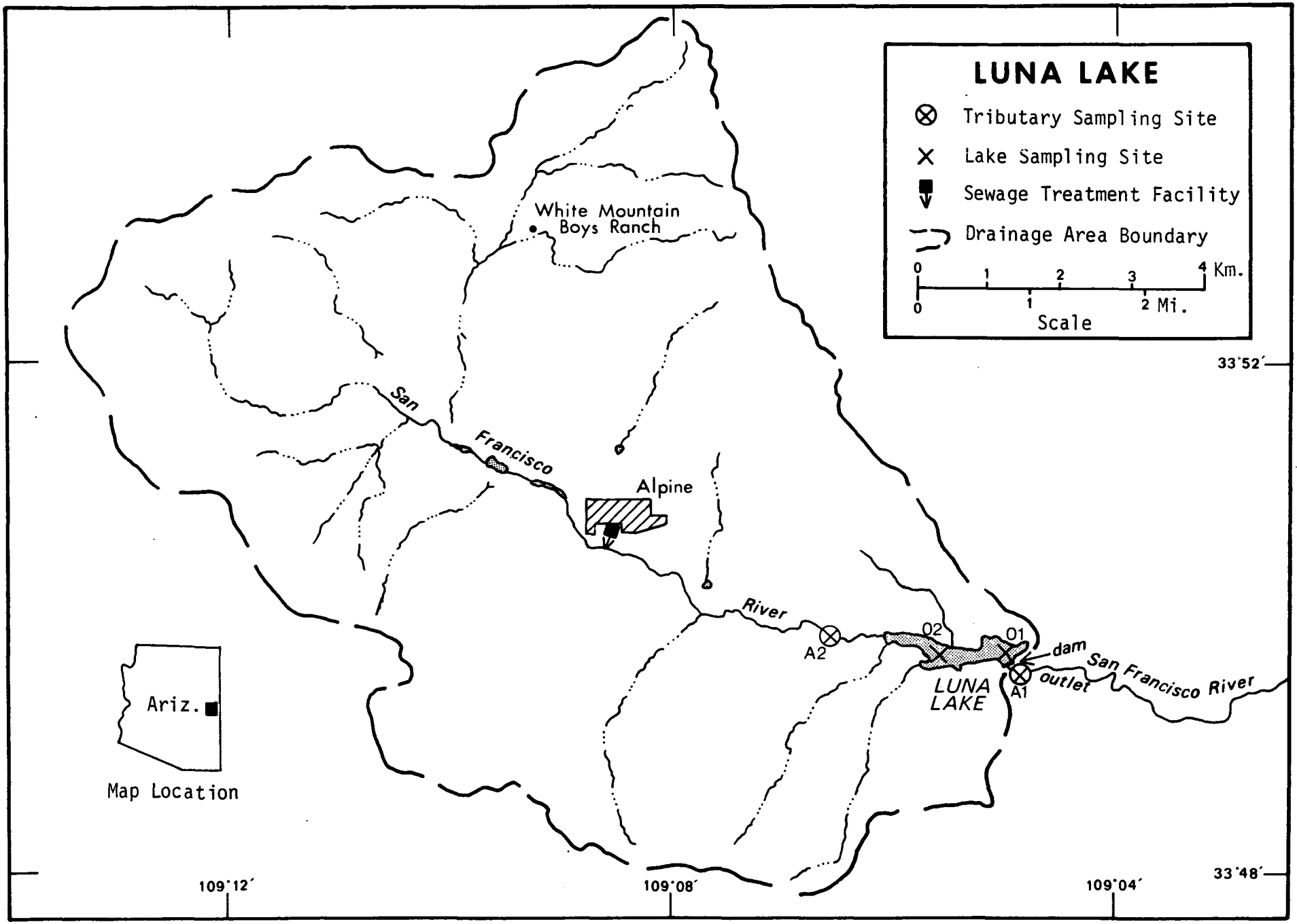
Major General John G. Smith, the Adjutant General of Arizona, and Project Officer Colonel Richard A. Colson, who directed the volunteer efforts of the Arizona National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

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


LUNA LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
0 1 2 3 4 Km.
0 1 2 Mi.
Scale
White Mountain
Boys Ranch
San
Francisco
River
Alpine
A2
O2
O1
dam
San Francisco River
outlet
A1
LUNA
LAKE
Ariz.
Map Location
33°52′
33°48′
109°12′
109°08′
109°04′

REPORT ON LUNA LAKE, ARIZONA

STORET NO. 0404

I. CONCLUSIONS

A. Trophic Condition:*

Based on Survey data and field observations, Luna Lake 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.

Chlorophyll *a* values in the lake ranged from 1.7 µg/l to 4.2 µg/l with a mean of 3.4 µg/l. Potential for primary production as measured by algal assay control yields was high throughout the sampling year. Of the 11 Arizona lakes sampled in 1975, none had higher median total phosphorus values (0.182 mg/l), 7 had higher median inorganic nitrogen levels (0.050 mg/l) and none had higher median orthophosphorus values (0.131 mg/l) than Luna Lake.

Survey limnologists reported floating mats of algae during April sampling and algal blooms on the June and September sampling dates.

*See Appendix E.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Luna Lake was limited by available nitrogen during both sample collection times (04/30/75, 10/06/75). The lake data further suggest primary limitation by nitrogen in Luna Lake throughout the sampling year.

C. Nutrient Controllability:

1. Point sources -

During the sampling year, point sources were calculated to contribute 18.4% of the total phosphorus load to Luna Lake. The Alpine Conservation Center contributed this entire load.

The present phosphorus loading of 1.90 g $P/m^2/yr$ to Luna Lake is over three times that proposed by Vollenweider (1975) as "eutrophic" for a lake of such volume and retention time. While elimination of point source loading to the lake would substantially reduce the overall load, nutrient input would still exceed Vollenweider's eutrophic level. Evaluation of surrounding land use practices is needed to determine "nonpoint" nutrient sources before further recommendations on nutrient controllability can be made.

2. Nonpoint sources -

Nonpoint sources, including precipitation, contributed 81.6% of the total phosphorus load to Luna Lake during the sampling year. The San Francisco River contributed 64.9% and ungaged drainage areas were estimated to have contributed 15.8% of the total.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by N.L. Rathbun (1974). Tributary flow data were provided by the Arizona 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 in included as Appendix A.

A. Lake Morphometry:

1. Surface area: 0.30 km^2.
2. Mean depth: 2.5 meters.
3. Maximum depth: 6.3 meters.
4. Volume: 0.742 x 10^6 m^3.
5. Mean hydraulic retention time: 107 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 San Francisco River	75.4	0.10
Minor tributaries and immediate draingage -	17.8	0.01
Total	93.2	0.11
2. Outlet - A-1 San Francisco River	93.5	0.08

C. Precipitation:

1. Year of sampling: 32.0 cm.
2. Mean annual: 28.8 cm.

III. LAKE WATER QUALITY SUMMARY

Luna Lake was sampled three 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 one or more 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 4.6 meters at Station 01 and the surface at Station 02. 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.

STORET CODE 0404

A. PHYSICAL AND CHEMICAL CHARACTERIS CS

PARAMETER	(4/30/75) S** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/18/75) 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	3	9.3- 10.1	10.0	0.0- 1.5	3	14.1- 15.0	15.0	0.0- 1.5	3	14.3- 15.4	15.2	0.0- 1.5
MAX DEPTH**	2	9.3- 9.9	9.6	0.0- 4.6	2	14.1- 14.7	14.4	0.0- 4.6	2	14.3- 14.9	14.6	0.0- 4.6
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	3	7.6- 8.0	7.8	0.0- 1.5	3	8.0- 8.2	8.0	0.0- 1.5	3	4.8- 9.0	7.0	0.0- 1.5
MAX DEPTH**	2	7.6- 8.0	7.8	0.0- 4.6	2	7.4- 8.2	7.8	0.0- 4.6	2	2.8- 9.0	5.9	0.0- 4.6
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	3	192.- 231.	221.	0.0- 1.5	3	219.- 226.	225.	0.0- 1.5	3	146.- 174.	147.	0.0- 1.5
MAX DEPTH**	2	192.- 230.	211.	0.0- 4.6	2	220.- 225.	223.	0.0- 4.6	2	148.- 174.	161.	0.0- 4.6
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	3	8.4- 8.6	8.4	0.0- 1.5	3	9.3- 9.5	9.3	0.0- 1.5	3	7.9- 8.8	8.7	0.0- 1.5
MAX DEPTH**	2	8.4- 8.6	8.5	0.0- 4.6	2	9.3- 9.5	9.4	0.0- 4.6	2	8.6- 8.8	8.7	0.0- 4.6
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	3	84.- 97.	96.	0.0- 1.5	3	98.- 103.	100.	0.0- 1.5	3	91.- 116.	94.	0.0- 1.5
MAX DEPTH**	2	84.- 97.	91.	0.0- 4.6	2	98.- 103.	101.	0.0- 4.6	2	97.- 116.	107.	0.0- 4.6
TOTAL P (MG/L)												
0.-1.5 M DEPTH	3	0.164-0.182	0.181	0.0- 1.5	3	0.154-0.171	0.160	0.0- 1.5	3	0.245-0.658	0.282	0.0- 1.5
MAX DEPTH**	2	0.164-0.197	0.180	0.0- 4.6	2	0.151-0.160	0.155	0.0- 4.6	2	0.296-0.658	0.477	0.0- 4.6
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	3	0.116-0.133	0.131	0.0- 1.5	3	0.102-0.128	0.108	0.0- 1.5	3	0.207-0.334	0.241	0.0- 1.5
MAX DEPTH**	2	0.116-0.130	0.123	0.0- 4.6	2	0.108-0.128	0.118	0.0- 4.6	2	0.263-0.334	0.298	0.0- 4.6
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	3	0.020-0.020	0.020	0.0- 1.5	3	0.020-0.030	0.020	0.0- 1.5	3	0.020-0.040	0.030	0.0- 1.5
MAX DEPTH**	2	0.020-0.020	0.020	0.0- 4.6	2	0.020-0.020	0.020	0.0- 4.6	2	0.020-0.040	0.030	0.0- 4.6
AMMONIA (MG/L)												
0.-1.5 M DEPTH	3	0.020-0.030	0.020	0.0- 1.5	3	0.020-0.080	0.020	0.0- 1.5	3	0.040-0.060	0.050	0.0- 1.5
MAX DEPTH**	2	0.020-0.030	0.025	0.0- 4.6	2	0.020-0.020	0.020	0.0- 4.6	2	0.040-0.120	0.080	0.0- 4.6
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	3	0.500-0.700	0.600	0.0- 1.5	3	0.700-0.800	0.800	0.0- 1.5	3	0.600-1.000	0.800	0.0- 1.5
MAX DEPTH**	2	0.500-0.700	0.600	0.0- 4.6	2	0.500-0.800	0.650	0.0- 4.6	2	0.800-1.000	0.900	0.0- 4.6
SECCHI DISC (METERS)												
	1	1.4- 1.4	1.4		1	4.0- 4.0	4.0		2	1.2- 4.0	2.6	

* 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
04/30/75	1. Cryptomonas	2,990
	2. Chroomonas?	1,627
	3. Cyclotella	308
	4. Synedra	132
	5. Ankistrodesmus	88
	Other genera	44
	Total	5,189
06/18/75	1. Oscillatoria	420
	2. Anabaena	262
	3. Fragilaria	210
	4. Aphanizomenon	105
	5. Cryptomonas	105
	Other genera	---
	Total	1,102
10/06/75	1. Cryptomonas	34
	2. Oscillatoria	34
	3. Nitzschia	34
	Other genera	---
	Total	102

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
04/30/75	01	4.2
	02	---
06/18/75	01	4.0
	02	1.7
10/06/75	01	3.1
	02	4.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 04/30/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.110	0.044	6.2
0.05 P	0.160	0.044	6.9
0.05 P + 1.0 N	0.160	1.044	36.3
1.00 N	0.110	1.044	33.5

b. 10/06/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.280	0.140	13.3
0.05 P	0.330	0.140	13.7
0.05 P + 1.0 N	0.330	1.140	47.9
1.00 N	0.280	1.140	48.6

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum*, indicate that the potential for primary productivity in Luna Lake was high at both sample collection times (04/30/75, 10/06/75). In both samples, the addition of nitrogen alone and in combination with phosphorus produced a significant increase in growth over that of the control, indicating nitrogen limitation. Spikes of only phosphorus did not stimulate growth significantly beyond control yields.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were less than one on all three sampling occasions further suggesting primary limitation by nitrogen (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).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Arizona 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 December 1974, and was completed in November 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Arizona 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 San Francisco River, at Station A-2 and multiplying the means by the ZZ area in km^2.

Nutrient loads for the Alpine Conservation Center wastewater treatment plant were calculated from provided monthly chemistry data and estimated flows.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Alpine Conservation Center	112	Activated Sludge	0.042**	Unnamed Creek/ San Francisco River

2. Known industrial - None

*Provided by treatment plant operator.
**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 San Francisco River	370	64.9
b. Minor tributaries and immediate drainage (nonpoint load) -	90	15.8
c. Known municipal STP's -		
Alpine Conservation Center	105	18.4
d. Septic tanks - None Known		
e. Known industrial - None		
f. Direct precipitation* -	5	0.9
Total	570	100.0%
2. Outputs - A-1 San Francisco River	540	
3. Net annual P accumulation -	30	

*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 San Francisco River	3,165	69.9
b. Minor tributaries and immediate drainage (nonpoint load) -	750	16.6
c. Known municipal STP's -		
Alpine Conservation Center	285	6.3
d. Septic tanks - None Known		
e. Known industrial - None		
f. Direct precipitation* -	325	7.2
Total	4,525	100.0%

2. Outputs - A-1 San Francisco River 2,320

3. Net annual N accumulation - 2,205

*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
San Francisco River	5	42

E. Yearly Loadings:

In the following table, the existing phosphorus 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 Luna Lake	1.90
Vollenweider's "eutrophic" loading	0.58
Vollenweider's "oligotrophic" loading	0.29

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.

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 ARIZONA 11/26/76

LAKE CODE 0404 LUNA LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 93.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0404A1	93.5	0.028	0.028	0.142	0.283	0.113	0.085	0.085	0.085	0.085	0.028	0.028	0.028	0.085
0404A2	75.4	0.051	0.113	0.255	0.453	0.113	0.014	0.014	0.023	0.028	0.042	0.042	0.051	0.100
0404ZZ	18.1	0.006	0.011	0.028	0.042	0.014	0.003	0.003	0.006	0.006	0.006	0.006	0.006	0.011

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 93.5
SUM OF SUB-DRAINAGE AREAS = 93.5
TOTAL FLOW IN = 1.34
TOTAL FLOW OUT = 1.02

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0404A1	12	74	0.003	8	0.001				
	1	75	0.014						
	2	75	0.003	1	0.014				
	3	75	0.283	8	0.453				
	4	75	0.566	5	0.340	18	0.425		
	5	75	0.227	2	0.425	18	0.170		
	6	75	0.042	15	0.034				
	7	75	0.071	16	0.099				
	8	75	0.034	16	0.034				
	9	75	0.042	11	0.051				
	10	75	0.011	13	0.011				
	11	75	0.011	15	0.011				
0404A2	12	74	0.020	8	0.023				
	1	75	0.014						
	2	75	0.023	1	0.014				
	3	75	0.283	8	0.340				
	4	75	0.566	5	0.453	18	0.453		
	5	75	0.198	2	0.453	18	0.142		
	6	75	0.008	15	0.001				
	7	75	0.001	16	0.001				
	8	75	0.001	16	0.001				
	9	75	0.023	11	0.062				
	10	75	0.003	13	0.002				
	11	75	0.014	15	0.011				
0404ZZ	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.0						
	5	75	0.0						
	6	75	0.0						
	7	75	0.0						
	8	75	0.0						
	9	75	0.0						
	10	75	0.0						
	11	75	0.0						

APPENDIX C

PHYSICAL AND CHEMICAL DATA

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

040401
33 49 45.0 109 05 00.0 3
LUNA LAKE
04001 ARIZONA

11EPALES 760109 2111202
0019 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
75/04/30	10 45	0000	10.1	7.8	55	231	8.45	97	0.020	0.600	0.020K	0.131
	10 45	0005	10.0	7.6		221	8.40	96	0.020K	0.500	0.020K	0.133
	10 45	0010	9.9	7.6		232	8.45	97	0.040	0.500	0.030	0.132
	10 45	0015	9.9	7.6		230	8.45	97	0.020K	0.500	0.020K	0.130
75/06/18	11 10	0000	15.0	8.0	156	226	9.30	100	0.080	0.800	0.030	0.102
	11 10	0005	15.0	8.0		219	9.30	98	0.020	0.700	0.020K	0.104
	11 10	0015	14.7	7.4		220	9.30	98	0.020	0.500	0.020K	0.106
75/10/06	09 45	0000	15.4	4.8	156	147	7.90	91	0.050	0.600	0.040	0.207
	09 45	0005	15.2	7.0		146	8.70	94	0.060	0.800	0.030	0.241
	09 45	0015	14.9	2.8		148	8.60	97	0.120	0.800	0.040	0.263

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/04/30	10 45	0000	0.181	4.2	
	10 45	0005	0.182		
	10 45	0010	0.191		
	10 45	0015	0.197		
75/06/18	11 10	0000	0.154	4.0	
	11 10	0005	0.171		
	11 10	0015	0.151		
75/10/06	09 45	0000	0.245	3.1	
	09 45	0005	0.282		
	09 45	0015	0.296		

K VALUE KNOWN TO BE LESS THAN INDICATED

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

040402
33 49 50.0 109 05 33.0 3
LUNA LAKE
04001 ARIZONA

11EPALES 760109 2111202
0004 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
75/04/30	11 05	0000	9.3	8.0		192	8.60	84	0.030	0.700	0.020K	0.116
75/06/18	11 30	0000	14.1	8.2		225	9.50	103	0.020K	0.800	0.020K	0.128
75/10/06	10 00	0000	14.3	9.0	48	174	8.80	116	0.040	1.000	0.020K	0.334

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/04/30	11 05	0000	0.164		
75/06/18	11 30	0000	0.160	1.7	
75/10/06	10 00	0000	0.658	4.0	

K VALUE KNOWN TO BE LESS
THAN INDICATED

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION S EY
EPA- LAS VEGAS

0404A1
33 49 38.0 109 04 45.0 4
SAN FRANCISCO RIVER
04 15 ALPINE
O/LUNA LAKE 110491
BNK BELO SPLWY 4.5 MI ESE OF ALPINE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/08	11 15		0.032	1.700	0.025	0.115	0.220
75/02/01	10 40		0.008	1.500	0.024	0.144	0.170
75/03/08	11 10		0.008	0.975	0.028	0.192	0.240
75/04/05	09 10		4.730	0.550		0.050	0.180
75/04/18	17 45		0.005	0.650	0.020	0.145	0.180
75/05/02	09 35		0.005	0.750	0.025	0.120	0.165
75/05/18	07 00		0.015	0.350	0.015	0.125	0.220
75/06/15	09 00		0.010	0.650	0.025	0.100	0.153
75/07/16	09 15		0.010	1.100	0.030	0.090	0.150
75/08/16	17 00		0.015	0.850	0.055	0.230	0.250
75/09/11	11 05		0.030	1.200	0.090	0.200	0.230
75/10/13	16 50		0.050	1.000	0.030	0.240	0.260
75/11/15	12 25		0.040	0.900	0.020	0.250	0.290

STORET RETRIEVAL DATE 75/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0404A2
33 49 55.0 109 06 30.0 4
SAN FRANCISCO RIVER
04 15 ALPINE
T/LUNA LAKE 110491
DRT RD BRDG 2.7 MI ESE OF ALPINE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/08	11 30		0.008	0.600	0.010	0.090	0.105
75/02/01	11 10		0.008	1.100	0.024	0.112	0.130
75/03/08	11 20		0.008	1.050	0.094	0.128	0.190
75/04/05	09 30		0.005	0.750	0.040	0.090	0.110
75/04/18	18 00		0.005	0.700	0.025	0.105	0.130
75/05/02	09 35		0.005	0.700	0.015	0.070	0.100
75/05/18	07 12		0.010	1.275	0.030	0.115	0.140
75/06/15	09 15		0.005	1.100	0.025	0.170	0.190
75/07/16	09 30		0.005	0.600	0.025	0.158	0.180
75/08/16	17 15		0.005	0.750	0.020	0.115	0.140
75/09/11	11 20		0.002	1.900	0.085	0.240	0.275
75/10/13	17 00		0.005	0.700	0.025	0.230	0.280
75/11/15	12 50		0.005	1.600	0.020	0.125	0.170

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0404XA AS0404XA P000112
33 51 00.0 109 08 30.0 4
ALPINE CORR. CENTER
04 15 ALPINE
T/LUNA LAKE 110491
UNNAMED CREEK
11EPALES 2141204
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	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/07/11	13 15		0.025	30.000	18.000	8.600	8.600		
75/07/31	14 00		0.025	15.500	7.400	6.800	7.600		
75/08/22			8.400	10.500	0.120	7.000	7.700		
75/09/15	08 45		3.400	5.700	0.100	2.900	3.500		
75/10/06	10 15		5.000	9.200	0.082	4.400	4.900		
75/11/10	10 30		5.200	20.000	0.043	5.300	10.000		
75/12/08	10 30		10.500	8.000	0.340	4.900	8.700		
76/01/19	15 30		11.500	6.200	0.037	4.800	5.800		
76/04/13	10 00			6.400			6.700		

APPENDIX E

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.

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)