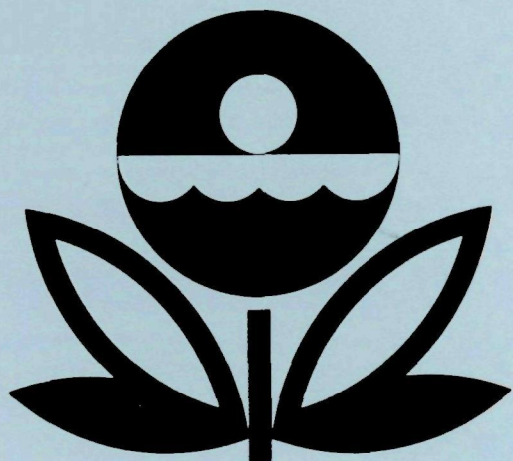


**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES**



REPORT
ON
HOLBROOK RESERVOIR
OTERO COUNTY
COLORADO
EPA REGION VIII
WORKING PAPER No. 772

**CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA**

REPORT
ON
HOLBROOK RESERVOIR
OTERO COUNTY
COLORADO
EPA REGION VIII
WORKING PAPER No. 772

WITH THE COOPERATION OF THE
COLORADO DEPARTMENT OF HEALTH
AND THE
COLORADO NATIONAL GUARD
JULY, 1977

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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 Colorado Department of Health for professional involvement, to the Colorado National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples.

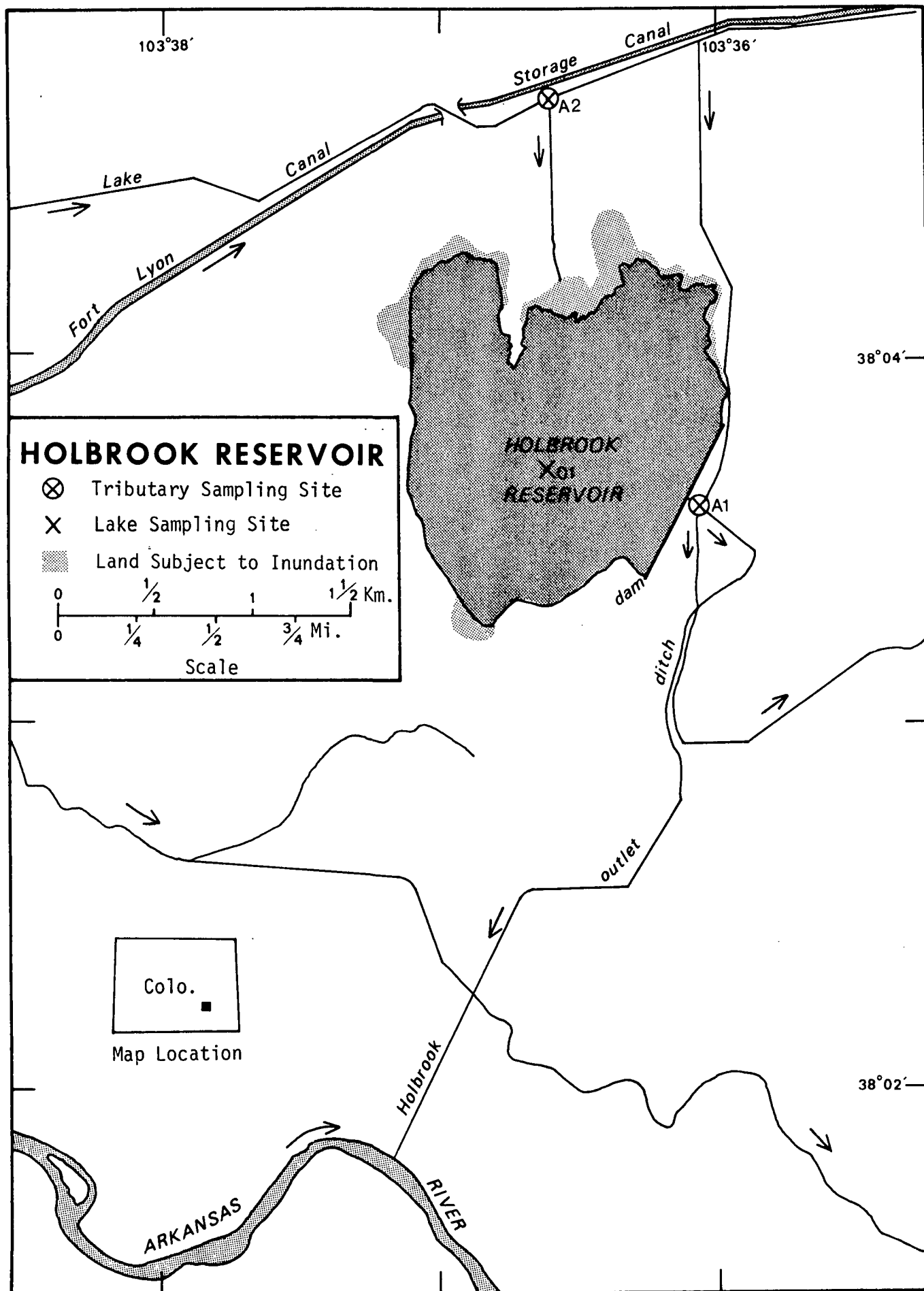
The staff of the Water Quality Control Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

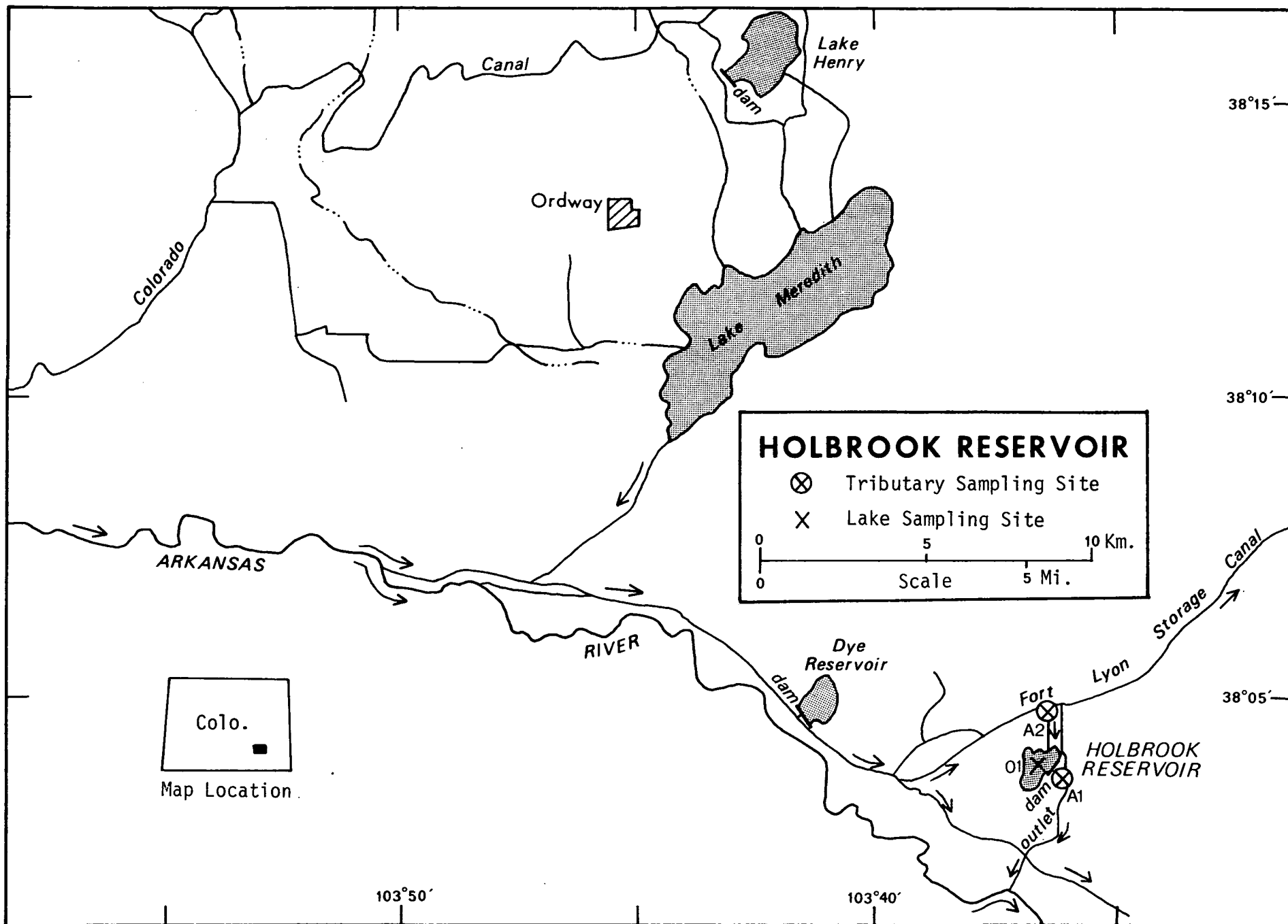
Lt. Colonel Paul A. Parsons, the Deputy Adjutant General of Colorado, and Project Officer Colonel Hershel C. Yeargan, who directed the volunteer efforts of the Colorado National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS

STATE OF COLORADO

<u>NAME</u>	<u>COUNTY</u>
Barker	Boulder
Barr	Adams
Blue Mesa	Boulder
Cherry Creek	Arapohoe
Cucharas	Huerfano
Dillon	Summit
Grand	Grand
Green Mountain	Summit
Holbrook	Otero
Meredith	Crowley
Milton	Weld
Navajo	Archuleta, CO; San Juan, Rio Arriba, NM
Shadow Mountain	Grand





HOLBROOK RESERVOIR

STORET NO. 0809

I. INTRODUCTION

Accurate flow data could not be provided for Holbrook Reservoir by the U.S. Geological Survey because water enters and leaves through ungaged inlet and outlet canals. Therefore, this report primarily pertains to the lake sampling data. However, results of analyses of tributary samples are presented in Appendix D.

II. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Holbrook Reservoir is eutrophic. It ranked ninth in overall trophic quality when the 13 Colorado lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Nine of the water bodies has less median total phosphorus, nine had less median dissolved orthophosphorus, eight had less median inorganic nitrogen, 11 had less mean chlorophyll a, and all of the others had greater mean Secchi disc transparency.

Survey limnologists reported algal blooms in August and October and estimated that macrophytes occupied 30% of the shoreline shallows at those times.

B. Limiting Nutrient Study:

The results of the algal assay indicate that nitrogen was limiting at the time the sample was taken (05/06/75).

The reservoir data indicate nitrogen limitation in May and October and phosphorus limitation in August.

* See Appendix A.

III. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]A. Morphometry^{††}:

1. Surface area: 2.72 kilometers².
2. Mean depth: 2.5 meters.
3. Maximum depth: 6.4 meters.
4. Volume: 6.908×10^6 m³.

B. Precipitation*:

1. Year of sampling: 25.3 centimeters.
2. Mean annual: 31.8 centimeters.

† Table of metric conversions--Appendix B.

†† Anderson, 1974.

* See Working Paper No. 175, "...Survey Methods, 1973-1976".

IV. WATER QUALITY SUMMARY

Holbrook Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, a near-surface sample for physical and chemical parameters was collected from one station on the reservoir (see map, page v). During each visit, a depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration, and a similar sample was taken for chlorophyll a analysis. During the first visit, a single 18.9-liter depth-integrated sample was collected for algal assays.

The sampling results are presented in full in Appendix C and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR HOLBROOK LAKE
STORET CODE 0809

PARAMETER	1ST SAMPLING (5/ 6/75)				2ND SAMPLING (8/22/75)				3RD SAMPLING (10/ 7/75)			
	1 SITES				1 SITES				1 SITES			
	RANGE	MEAN	MEDIAN		RANGE	MEAN	MEDIAN		RANGE	MEAN	MEDIAN	
TEMP (C)	13.6 - 13.6	13.6	13.6		21.6 - 21.6	21.6	21.6		18.3 - 18.3	18.3	18.3	
DISS OXY (MG/L)	***** -*****				6.0 - 6.0	6.0	6.0		***** -*****			
CNDCTVY (MCMOM)	1650. - 1650.	1650.	1650.		2368. - 2368.	2368.	2368.		1812. - 1812.	1812.	1812.	
PH (STAND UNITS)	8.1 - 8.1	8.1	8.1		8.6 - 8.6	8.6	8.6		8.9 - 8.9	8.9	8.9	
TOT ALK (MG/L)	147. - 147.	147.	147.		10. - 10.	10.	10.		85. - 85.	85.	85.	
TOT P (MG/L)	0.127 - 0.127	0.127	0.127		0.367 - 0.367	0.367	0.367		0.329 - 0.329	0.329	0.329	
ORTHO P (MG/L)	0.028 - 0.028	0.028	0.028		0.002 - 0.002	0.002	0.002		0.037 - 0.037	0.037	0.037	
NO2+NO3 (MG/L)	0.020 - 0.020	0.020	0.020		0.020 - 0.020	0.020	0.020		0.020 - 0.020	0.020	0.020	
AMMONIA (MG/L)	0.050 - 0.050	0.050	0.050		0.140 - 0.140	0.140	0.140		0.030 - 0.030	0.030	0.030	
KJEL N (MG/L)	1.700 - 1.700	1.700	1.700		3.100 - 3.100	3.100	3.100		3.000 - 3.000	3.000	3.000	
INORG N (MG/L)	0.070 - 0.070	0.070	0.070		0.160 - 0.160	0.160	0.160		0.050 - 0.050	0.050	0.050	
TOTAL N (MG/L)	1.720 - 1.720	1.720	1.720		3.120 - 3.120	3.120	3.120		3.020 - 3.020	3.020	3.020	
CHLRPYL A (UG/L)	28.7 - 28.7	28.7	28.7		146.9 - 146.9	146.9	146.9		160.2 - 160.2	160.2	160.2	
SECCHI (METERS)	0.3 - 0.3	0.3	0.3		0.2 - 0.2	0.2	0.2		0.3 - 0.3	0.3	0.3	

B. Biological Characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml.</u>
05/06/75	1. <u>Oscillatoria sp.</u>	36,005
	2. <u>Synedra sp.</u>	16,440
	3. <u>Flagellates</u>	6,083
	4. <u>Stephanodiscus sp.</u>	2,137
	5. <u>Cryptomonas sp.</u>	1,973
	Other genera	<u>4,185</u>
	Total	66,823
08/22/75	1. <u>Anabaenopsis sp.</u>	34,071
	2. <u>Oscillatoria sp.</u>	11,005
	3. <u>Anabaena sp.</u>	2,111
	4. <u>Cryptomonas sp.</u>	2,111
	5. <u>Scenedesmus sp.</u>	1,508
	Other genera	<u>1,808</u>
	Total	52,614
10/07/75	1. <u>Anabaenopsis sp.</u>	31,245
	2. <u>Oscillatoria sp.</u>	13,077
	3. <u>Nitzschia sp.</u>	7,487
	4. <u>Cryptomonas sp.</u>	2,595
	5. <u>Stephanodiscus sp.</u>	799
	Other genera	<u>1,099</u>
	Total	56,302

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll <u>a</u> (μg/l)</u>
05/06/75	1	28.7
08/22/75	1	146.9
10/07/75	1	160.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

<u>Spike (mg/l)</u>	<u>Ortho P Conc. (mg/l)</u>	<u>Inorganic N Conc. (mg/l)</u>	<u>Maximum yield (mg/l-dry wt.)</u>
Control	0.042	0.192	63.3
0.050 P	0.092	0.192	69.4
0.050 P + 1.0 N	0.092	1.192	96.0
1.0 N	0.042	1.192	93.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Holbrook Lake was extremely high at the time the algal assay sample was collected (05/06/76).

There was a significant increase in yield when only nitrogen was added, but no such response occurred when only phosphorus was added. Therefore, nitrogen limitation is indicated at that time.

The reservoir data indicate nitrogen limitation in May and October (the mean inorganic nitrogen to orthophosphorus ratios were 3 to 1 and 1 to 1, respectively). However, phosphorus limitation is indicated in August (the mean N/P ratio was 80/1).

V. MEAN NUTRIENT CONCENTRATIONS IN UNGAGED STREAMS

<u>Tributary</u>	<u>Mean Total P Conc. (mg/l)</u>	<u>Mean Total N Conc. (mg/l)</u>
Outlet Ditch A-1	0.210	1.955
Ditch A-2	0.440	3.630

VI. LITERATURE REVIEWED

Anderson, R. Dennis, 1974. Personal communication (waterbody information and morphometry). CO Dept. of Health, Denver.

VII. 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
0801	BARKER RESERVOIR	0.023	0.045	419.000	5.333	9.400	0.006
0802	BARR LAKE	0.930	1.090	451.333	28.767	10.200	0.730
0803	BLUE MESA RESERVOIR	0.019	0.040	395.750	6.817	13.800	0.005
0804	CHERRY CREEK LAKE	0.054	0.040	469.333	23.322	10.000	0.007
0805	CUCHARAS RESERVOIR	0.263	0.040	490.000	27.400	14.800	0.015
0806	DILLON RESERVOIR	0.009	0.040	181.750	3.150	9.200	0.002
0807	GRAND LAKE	0.013	0.040	366.500	4.900	10.200	0.003
0808	GREEN MOUNTAIN RESERVOIR	0.010	0.040	391.167	5.833	9.100	0.002
0809	HOLBROOK LAKE	0.329	0.070	490.333	111.933	9.000	0.028
0810	LAKE MEREDITH	0.397	0.110	489.667	164.678	10.400	0.098
0811	MILTON RESERVOIR	0.846	2.280	429.333	5.900	9.200	0.808
0812	NAVAJO RESERVOIR	0.036	0.050	479.400	2.180	10.000	0.013
0813	SHADOW MOUNTAIN LAKE	0.020	0.040	427.000	5.700	9.200	0.003

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
0801	BARKER RESERVOIR	58 (7)	42 (5)	67 (8)	75 (9)	58 (7)	58 (7)	358
0802	BARR LAKE	0 (0)	8 (1)	42 (5)	17 (2)	29 (3)	8 (1)	104
0803	BLUE MESA RESERVOIR	75 (9)	87 (9)	75 (9)	42 (5)	8 (1)	67 (8)	354
0804	CHERRY CREEK LAKE	42 (5)	87 (9)	33 (4)	33 (4)	46 (5)	50 (6)	291
0805	CUCHARAS RESERVOIR	33 (4)	58 (6)	8 (1)	25 (3)	0 (0)	33 (4)	157
0806	DILLON RESERVOIR	100 (12)	58 (6)	100 (12)	92 (11)	75 (8)	96 (11)	521
0807	GRAND LAKE	83 (10)	87 (9)	92 (11)	83 (10)	29 (3)	79 (9)	453
0808	GREEN MOUNTAIN RESERVOIR	92 (11)	58 (6)	83 (10)	58 (7)	92 (11)	96 (11)	479
0809	HOLBROOK LAKE	25 (3)	25 (3)	0 (0)	8 (1)	100 (12)	25 (3)	183
0810	LAKE MEREDITH	17 (2)	17 (2)	17 (2)	0 (0)	17 (2)	17 (2)	85
0811	MILTON RESERVOIR	8 (1)	0 (0)	50 (6)	50 (6)	75 (8)	0 (0)	183
0812	NAVAJO RESERVOIR	50 (6)	33 (4)	25 (3)	100 (12)	46 (5)	42 (5)	296
0813	SHADOW MOUNTAIN LAKE	67 (8)	87 (9)	58 (7)	67 (8)	75 (8)	79 (9)	433

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0806	DILLON RESERVOIR	521
2	0808	GREEN MOUNTAIN RESERVOIR	479
3	0807	GRAND LAKE	453
4	0813	SHADOW MOUNTAIN LAKE	433
5	0801	BARKER RESERVOIR	358
6	0803	BLUE MESA RESERVOIR	354
7	0812	NAVAJO RESERVOIR	296
8	0804	CHERRY CREEK LAKE	291
9	0811	MILTON RESERVOIR	183
10	0809	HOLBROOK LAKE	183
11	0805	CUCHARAS RESERVOIR	157
12	0802	BARR LAKE	104
13	0810	LAKE MEREDITH	85

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

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/24

080901
38 03 45.0 103 36 38.0 3
HOLBROOK LAKE
08089 COLORADO

100191

11EPALES 2111202
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 CAC03 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
75/05/06	12 30	0000	13.6		11	1650	8.10	147	0.050	1.700	0.020K	0.028
75/08/22	10 35	0000	21.6	6.0	7	2368	8.60	10	0.140	3.100	0.020K	0.002K
75/10/07	14 30	0000	18.3		11	1812	8.90	85	0.030	3.000	0.020K	0.037

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/06	12 30	0000	0.127	28.7	
75/08/22	10 35	0000	0.367	146.9	
75/10/07	14 30	0000	0.329	160.2	

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

080941
38 03 37.0 103 36 06.0 4
HOLBROOK OUTLET DITCH
08 7.5 CHERAW
0/HOLBROOK RESERVOIR 100191
SEC RD BRDG 1.7 MI S OF ST RT 266
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	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
FROM	OF						
TO	DAY	FEET					
75/06/20	13	15	0.005	1.950	0.030	0.020	0.210

STORET RETRIEVAL DATE 76/09/24

0809A2
38 04 42.0 103 36 39.0 4
UNNAMED DITCH
08 7.5 CHERAW
T/HOLBROOK RESERVOIR 100191
ST RT 266 BRDG 6 MI WSW OF CHERAW
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
75/01/18	14 30		2.080	1.550	0.600	0.190	0.440