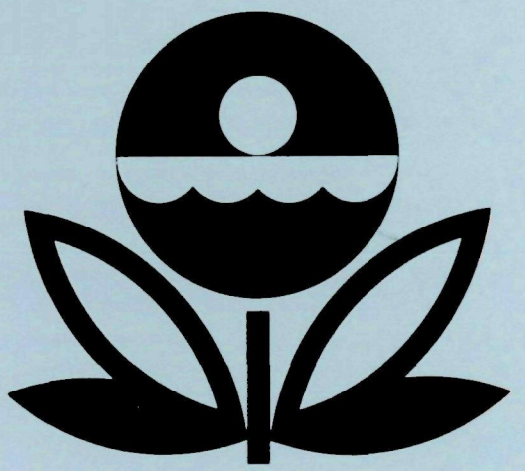
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

IRON GATE RESERVOIR

SISKIYOU COUNTY

CALIFORNIA

EPA REGION IX

WORKING PAPER No. 749

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPORT

ON

IRON GATE RESERVOIR

SISKIYOU COUNTY

CALIFORNIA

EPA REGION IX

WORKING PAPER No. 749

WITH THE COOPERATION OF THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

AND THE

CALIFORNIA NATIONAL GUARD

JUNE, 1978

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 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 concentration (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 California State Water Resources Control Board and the nine Regional Water Quality Control Boards for professional involvement, to the California National Guard for conducting the tributary sampling phase of the Survey, and to those California wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Division of Planning and Research of the State Water Resources Control Board provided invaluable lake documentation and counsel during the Survey, coordinated the reviews of the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

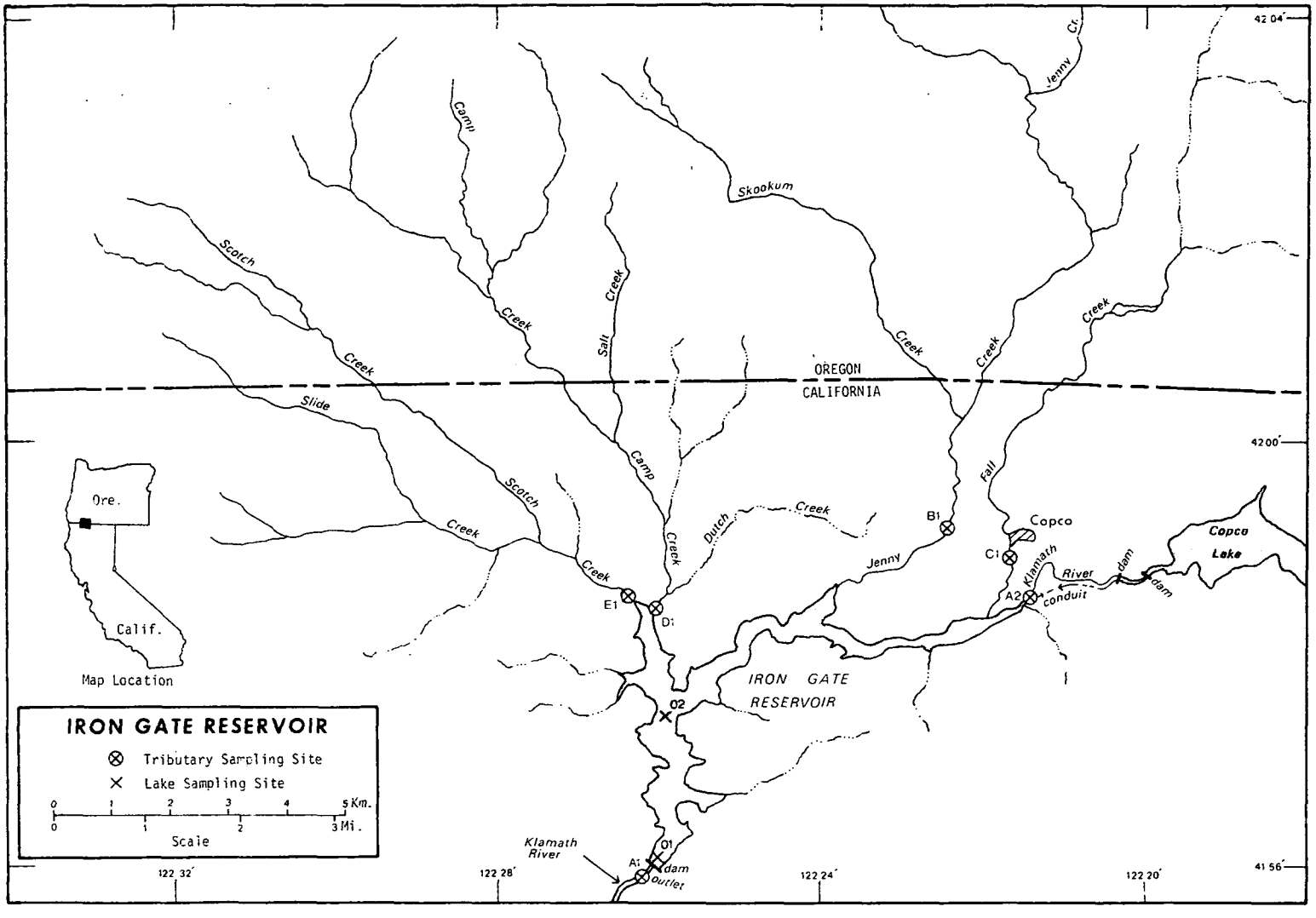
Major General Glen C. Ames, the Adjutant General of California, and Project Officer Second Lieutenant Terry L. Barrie, who directed the volunteer efforts of the California National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of California

Name	County
Amador	Amador
Boca	Nevada
Britton	Shasta
Casitas	Ventura
Crowley	Mono
Don Pedro	Tuolumne
Elsinore	Riverside
Fallen Leaf	El Dorado
Hennessey	Napa
Henshaw	San Diego
Iron Gate	Siskiyou
Lopez	San Luis Obispo
Mary	Mono
Mendocino	Mendocino
Nicasio	Marin
Lower Otay	San Diego
Pillsbury	Lake
Santa Margarita	San Luis Obispo
Shasta	Shasta
Shaver	Fresno
Silver	Mono
Tahoe	El Dorado, Placer, CA; Carson City, Douglas, Washoe, NV
Tulloch	Calaveras, Tuolumne
Lower Twin	Mono
Upper Twin	Mono


42 04'
Jenny Cr.
Camp Creek
Skookum Creek
Scotch Creek
Salt Creek
OREGON
CALIFORNIA
Slide Creek
Scotch Creek
Camp Creek
Dutch Creek
Jenny Creek
Fall Creek
4200'
Ore.
Calif.
Map Location
B1
Copco
C1
Copco Lake
Klamath River
dam
conduit
A2
E1
D1
IRON GATE RESERVOIR
O2
O1
A1
Klamath River
dam
outlet
IRON GATE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
0 1 2 3 4 5 Km.
0 1 2 3 Mi.
Scale
122 32'
122 28'
122 24'
122 20'
41 56'

IRON GATE RESERVOIR

STORET NO. 0611

I. CONCLUSIONS

A. Trophic Condition*:

Survey data indicate that Iron Gate Reservoir is eutrophic. It ranked last in overall trophic quality when the 24 California lakes and reservoirs sampled in 1975 were compared using a combination of six parameters**. Twenty-one of the water bodies had less median total phosphorus, 22 had less median dissolved orthophosphorus, 23 had less median inorganic nitrogen, 14 had less mean chlorophyll a, and 17 had greater mean Secchi disc transparency. Significant depression of dissolved oxygen with depth occurred at both sampling stations in July and at station 1 in October.

Nuisance level algal blooms, depletion of dissolved oxygen at depth, and fish kills have been observed in the reservoir (Johns, 1975).

B. Rate-Limiting Nutrient:

The algal assay results indicate the reservoir was nitrogen limited in March and October. The reservoir data indicate nitrogen limitation at all stations and sampling times.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted Iron Gate Reservoir during the sampling year.

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* Trophic assessment is based on levels of nutrients, dissolved oxygen, and chlorophyll a; phytoplankton kinds and numbers; and transparency (Allum et al., 1977).

** See Appendix A.

2. Non-point sources--Non-point sources contributed the entire phosphorus loading to the lake during the sampling year. The Klamath River contributed about 98% of the total load.

The estimated phosphorus loading of 109.97 $g/m^2/yr$ is about 22 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). Since most of the load is in the outflow of naturally eutrophic Klamath Lake, it appears little can be done to improve the trophic condition of Iron Gate Reservoir.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 3.39 kilometers^2.
2. Mean depth: 21.4 meters.
3. Maximum depth: 64.0 meters.
4. Volume: 72.522 x 10^6 m^3.
5. Mean hydraulic retention time: 11 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Klamath River	11,181.0	70.400
Fall Creek	37.8	0.230
Camp Creek	43.3	0.283
Minor tributaries & immediate drainage -	573.4	3.570
Totals	11,835.5	74.483

2. Outlet -

Klamath River	11,838.9**	74.483**

C. Precipitation***:

1. Year of sampling: 45.4 centimeters.
2. Mean annual: 51.0 centimeters.

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† Table of metric conversions--Appendix B.
†† Dendy, 1974.
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Iron Gate Reservoir was sampled three times in 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). 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 46.0 meters at station 1 and 37.8 meters at station 2.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR IRON GATE RESERVOIR
STORET CODE 0611

PARAMETER	1ST SAMPLING (3/27/75) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/16/75) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/31/75) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	3.9 - 5.3	4.6	4.6	3.9 - 21.2	13.8	15.5	7.9 - 12.4	10.9	11.3
DISS OXY (MG/L)	9.4 - 11.4	10.9	10.8	1.4 - 9.8	5.6	5.1	1.2 - 7.2	5.5	6.2
CNDCTVY (MCROMO)	123. - 196.	164.	169.	133. - 168.	150.	148.	142. - 164.	151.	151.
PH (STAND UNITS)	7.8 - 8.0	7.9	7.9	7.0 - 9.1	7.9	7.7	6.9 - 7.3	7.2	7.3
TOT ALK (MG/L)	64. - 82.	69.	69.	58. - 81.	71.	70.	74. - 91.	78.	77.
TOT P (MG/L)	0.170 - 0.206	0.184	0.182	0.096 - 0.298	0.168	0.133	0.181 - 0.318	0.212	0.190
ORTHO P (MG/L)	0.090 - 0.125	0.109	0.112	0.066 - 0.278	0.139	0.117	0.130 - 0.290	0.161	0.144
NO2+NO3 (MG/L)	0.410 - 0.520	0.465	0.465	0.020 - 0.570	0.253	0.115	0.140 - 0.580	0.476	0.550
AMMONIA (MG/L)	0.200 - 0.270	0.230	0.230	0.030 - 0.200	0.080	0.055	0.180 - 0.330	0.247	0.240
KJEL N (MG/L)	1.000 - 1.500	1.150	1.100	0.400 - 1.500	0.708	0.600	1.000 - 1.700	1.155	1.100
INORG N (MG/L)	0.610 - 0.780	0.695	0.690	0.050 - 0.760	0.333	0.175	0.450 - 0.810	0.730	0.765
TOTAL N (MG/L)	1.500 - 1.910	1.615	1.570	0.580 - 1.520	0.962	0.835	1.360 - 1.840	1.646	1.665
CHLRPYL A (UG/L)	11.1 - 21.6	16.3	16.3	1.4 - 2.3	1.8	1.8	0.3 - 0.6	0.4	0.4
SECCHI (METERS)	0.6 - 0.6	0.6	0.6	2.1 - 2.7	2.4	2.4	1.5 - 1.5	1.5	1.5

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/27/75	1. Cryptomonas sp.	1,976
	2. Stephanodiscus sp.	1,297
	3. Chroomonas (?) sp.	247
	4. Pennate diatoms	62
	5. Euglena sp.	62
	Other genera	60
	Total	3,704
07/16/75	1. Schroederia sp.	435
	2. Synedra sp.	73
	3. Cryptomonas sp.	73
	4. Melosira sp.	73
	5. Aphanizomenon sp.	36
	Total	690
10/31/75	1. Oscillatoria sp.	133
	2. Cryptomonas sp.	80
	3. Aphanizomenon sp.	53
	4. Stephanodiscus sp.	53
	5. Chroomonas (?) sp.	27
	Total	346

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/27/75	1	11.1
	2	21.6
07/16/75	1	1.4
	2	2.3
10/31/75	1	0.6
	2	0.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.100	0.656	26.7
0.050 P	0.150	0.656	28.1
0.050 P + 1.0 N	0.150	1.656	62.0
1.0 N	0.100	1.656	54.5

b. October sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.140	0.765	33.2
0.050 P	0.190	0.765	34.0
0.050 P + 1.0 N	0.190	1.765	65.5
1.0 N	0.140	1.765	64.3

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Iron Gate Reservoir was very high at the times the assay samples were collected (03/27/75 and 10/31/75). Also, the

significant increases in yield with the addition of nitrogen alone indicate the reservoir was limited by nitrogen at those times. Note that the addition of phosphorus alone did not result in yields significantly larger than those of the controls.

The reservoir data also indicate nitrogen limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 6/1 or less on each sampling occasion.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the California National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v). Sampling was begun in November, 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 California District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Fall and Dutch creeks at stations C-1 and D-1 and the mean annual ZZ flow.

No known wastewater treatment plants impacted Iron Gate 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) -		
Klamath River	367,020	98.5
Fall Creek	240	0.1
Camp Creek	525	0.1
b. Minor tributaries & immediate drainage (non-point load) -	4,955	1.3
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	60	< 0.1
Total	372,800	100.0

2. Outputs -

Reservoir outlet - Klamath River 345,290

3. Net annual P accumulation - 27,510 kg.

* 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) -		
Klamath River	3,976,450	97.3
Fall Creek	5,025	0.1
Camp Creek	8,655	0.2
b. Minor tributaries & immediate drainage (non-point load) -	91,420	2.3
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	3,660	0.1
Total	4,085,210	100.0

2. Outputs -

Reservoir outlet - Klamath River 4,944,425

3. Net annual N loss - 859,215 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Klamath River	33	356
Fall Creek	6	133
Camp Creek	12	200

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Jenny Creek	0.036	0.686
Scotch Creek	0.036	1.117

* See Working Paper No. 175.

F. 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	109.97	8.12	1,205.1	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Iron Gate Reservoir:

"Dangerous" (eutrophic loading)	4.90
"Permissible" (oligotrophic loading)	2.45

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the reservoir, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, unsampled point sources discharging directly to the reservoir, or (probably) insufficient outlet sampling in relation to the relatively short hydraulic retention time. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's former National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

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Johns, Gerald E., 1975. Personal communication (trophic condition of the reservoir). CA Water Res. Contr. Bd., Sacramento.

Malueg, Kenneth W., D. Phillips Larsen, Donald W. Schults, and Howard T. Mercier; 1975. A six-year water, phosphorus, and nitrogen budget for Shagawa Lake, Minnesota. Jour. Env. Qual., vol. 4, no. 2, pp. 236-242.

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
0601	AMADOR RESERVOIR	0.040	0.390	408.667	22.383	14.600	0.020
0602	BOCA LAKE	0.012	0.040	372.833	1.700	6.800	0.003
0603	LAKE BRITTON	0.067	0.115	448.500	4.811	11.200	0.047
0604	CASITAS RESERVOIR	0.029	0.050	400.250	3.192	14.000	0.014
0605	CROWLEY LAKE	0.046	0.045	374.750	5.800	12.200	0.034
0606	DON PEDRO RESERVOIR	0.013	0.060	381.733	3.564	11.400	0.004
0607	LAKE ELSINORE	0.469	0.120	489.214	70.572	8.000	0.092
0608	FALLEN LEAF RESERVOIR	0.007	0.040	24.357	0.786	8.800	0.005
0609	LAKE HENNESSEY	0.027	0.060	416.000	4.525	15.000	0.012
0610	LAKE HENSHAW	0.138	0.070	461.000	26.783	9.800	0.073
0611	IRON GATE RESERVOIR	0.184	0.690	440.333	6.217	13.800	0.124
0614	LOPEZ LAKE	0.371	0.090	372.000	8.658	15.000	0.343
0615	LAKE MARY	0.010	0.040	296.000	2.550	10.600	0.002
0616	LAKE MENDOCINO	0.020	0.050	436.500	3.100	9.400	0.008
0617	NICASIO RESERVOIR	0.055	0.345	482.778	6.633	9.800	0.013
0618	LOWER OTAY RESERVOIR	0.058	0.180	447.250	15.933	15.000	0.013
0619	LAKE PILLSBURY	0.022	0.060	466.667	6.389	8.200	0.008
0620	SANTA MARGARITA LAKE	0.037	0.070	400.000	9.122	14.800	0.014
0621	SHASTA LAKE	0.021	0.060	381.542	4.087	9.000	0.015
0622	SHAVER	0.014	0.060	346.400	1.700	7.400	0.004
0623	SILVER LAKE	0.012	0.055	356.000	1.800	7.000	0.003
0624	TULLOCK RESERVOIR	0.025	0.060	433.000	13.878	7.400	0.009
0625	UPPER TWIN LAKES	0.015	0.040	300.200	3.340	7.400	0.004
0626	LOWER TWIN LAKES	0.014	0.040	248.000	2.900	11.400	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
0601	AMADOR RESERVOIR	35 (8)	4 (1)	43 (10)	9 (2)	17 (4)	26 (6)	134
0602	BOCA LAKE	89 (20)	98 (22)	70 (16)	91 (21)	100 (23)	91 (20)	539
0603	LAKE BRITTON	17 (4)	22 (5)	17 (4)	48 (11)	43 (10)	17 (4)	164
0604	CASITAS RESERVOIR	43 (10)	74 (17)	48 (11)	70 (16)	22 (5)	37 (8)	294
0605	CROWLEY LAKE	30 (7)	78 (18)	65 (15)	43 (10)	30 (7)	22 (5)	268
0606	DON PEDRO RESERVOIR	83 (19)	54 (11)	57 (13)	61 (14)	37 (8)	78 (17)	370
0607	LAKE ELSINORE	0 (0)	17 (4)	0 (0)	0 (0)	78 (18)	9 (2)	104
0608	FALLEN LEAF RESERVOIR	100 (23)	87 (19)	100 (23)	100 (23)	70 (16)	70 (16)	527
0609	LAKE HENNESSEY	48 (11)	54 (11)	39 (9)	52 (12)	4 (0)	52 (12)	249
0610	LAKE HENSHAW	13 (3)	33 (7)	13 (3)	4 (1)	54 (12)	13 (3)	130
0611	IRON GATE RESERVOIR	9 (2)	0 (0)	26 (6)	39 (9)	26 (6)	4 (1)	104
0614	LOPEZ LAKE	4 (1)	26 (6)	74 (17)	26 (6)	4 (0)	0 (0)	134
0615	LAKE MARY	96 (22)	87 (19)	91 (21)	83 (19)	48 (11)	100 (23)	505
0616	LAKE MENDOCINO	65 (15)	70 (16)	30 (7)	74 (17)	61 (14)	63 (14)	363
0617	NICASIO RESERVOIR	26 (6)	9 (2)	4 (1)	30 (7)	54 (12)	46 (10)	169
0618	LOWER OTAY RESERVOIR	22 (5)	13 (3)	22 (5)	13 (3)	4 (0)	46 (10)	120
0619	LAKE PILLSBURY	57 (13)	41 (9)	9 (2)	35 (8)	74 (17)	63 (14)	279
0620	SANTA MARGARITA LAKE	39 (9)	33 (7)	52 (12)	22 (5)	13 (3)	37 (8)	196
0621	SHASTA LAKE	61 (14)	54 (11)	61 (14)	57 (13)	65 (15)	30 (7)	328
0622	SHAVER	78 (18)	41 (9)	83 (19)	96 (22)	87 (19)	78 (17)	463
0623	SILVER LAKE	89 (20)	65 (15)	78 (18)	87 (20)	96 (22)	91 (20)	506
0624	TULLOCK RESERVOIR	52 (12)	54 (11)	35 (8)	17 (4)	87 (19)	57 (13)	302
0625	UPPER TWIN LAKES	70 (16)	98 (22)	87 (20)	65 (15)	87 (19)	78 (17)	485
0626	LOWER TWIN LAKES	74 (17)	87 (19)	96 (22)	78 (18)	37 (8)	91 (20)	463

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0602	BOCA LAKE	539
2	0608	FALLEN LEAF RESERVOIR	527
3	0623	SILVER LAKE	506
4	0615	LAKE MARY	505
5	0625	UPPER TWIN LAKES	485
6	0626	LOWER TWIN LAKES	463
7	0622	SHAVER	463
8	0606	DON PEDRO RESERVOIR	370
9	0616	LAKE MENDOCINO	363
10	0621	SHASTA LAKE	328
11	0624	TULLOCK RESERVOIR	302
12	0604	CASITAS RESERVOIR	294
13	0619	LAKE PILLSBURY	279
14	0605	CROWLEY LAKE	268
15	0609	LAKE HENNESSEY	249
16	0620	SANTA MARGARITA LAKE	196
17	0617	NICASIO RESERVOIR	169
18	0603	LAKE BRITTON	164
19	0614	LOPEZ LAKE	134
20	0601	AMADOR RESERVOIR	134
21	0610	LAKE HENSHAW	130
22	0618	LOWER OTAY RESERVOIR	120
23	0607	LAKE ELSINORE	104
24	0611	IRON GATE RESERVOIR	104

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

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 08/17/77

LAKE CODE 0611 IRON GATE RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 11838.9

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0611A1	11838.9	118.95	107.05	144.72	121.21	75.33	30.87	20.70	27.47	37.10	48.99	72.22	92.04	74.56
0611A2	11181.0	80.11	91.95	111.10	99.26	84.14	56.68	38.54	39.80	48.12	55.68	66.00	75.07	70.40
0611C1	37.8	0.27	0.31	0.27	0.25	0.22	0.20	0.19	0.18	0.19	0.19	0.20	0.25	0.23
0611D1	43.3	0.031	0.063	0.094	0.938	1.030	1.104	0.086	0.018	0.009	0.009	0.007	0.017	0.283
0611ZZ	7.1	2.07	4.28	4.56	7.44	8.19	8.76	3.22	1.84	1.21	0.27	0.42	0.73	3.57

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 11838.9
SUM OF SUB-DRAINAGE AREAS = 11269.2
TOTAL FLOW IN = 895.59
TOTAL FLOW OUT = 896.65

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0611A1	11	74	76.739	16	82.119				
	12	74	84.951	7	80.703				
	1	75	87.216	19	87.499				
	2	75	95.145	22	88.632				
	3	75	131.673	8	112.984				
	4	75	121.479	12	111.285				
	5	75	110.153	4	137.903				
	6	75	37.095	5	55.501				
	7	75	22.031	13	20.388				
	8	75	31.149	25	33.131				
	9	75	45.590	14	44.741				
	10	75	68.810						
0611A2	11	74	77.588	16	79.287				
	12	74	82.119	7	79.287				
	1	75	81.269	19	84.667				
	2	75	84.951	22	83.818				
	3	75	117.515	8	88.915				
	4	75	97.693	12	91.180				
	5	75	86.366	4	114.117				
	6	75	25.287	5	43.608				
	7	75	17.415	13	4.786				
	8	75	26.590	25	30.582				
	9	75	41.909	14	39.927				
	10	75	67.677						

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 08/17/77

LAKE CODE 0611 IRON GATE RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0611C1	11	74	1.104	16	1.104				
	12	74	1.133	7	1.133				
	1	75	1.246	19	1.246				
	2	75	1.218	22	1.189				
	3	75	1.189	8	1.161				
	4	75	1.246	12	1.218				
	5	75	1.218	4	1.331				
	6	75	1.019	5	0.963				
	7	75	1.019	13	1.048				
	8	75	1.019	25	1.048				
	9	75	1.076	14	1.076				
	10	75	1.104						
0611D1	11	74	0.011	16	0.0				
	12	74	0.025	7	0.0				
	1	75	0.042	19	0.017				
	2	75	0.079	22	0.014				
	3	75	0.136	8	0.014				
	4	75	1.274	12	0.793				
	5	75	1.444	4	1.359				
	6	75	0.680	5	0.963				
	7	75	0.054	13	0.082				
	8	75	0.017	25	0.014				
	9	75	0.011	14	0.014				
	10	75	0.040						
0611ZZ	11	74	1.133						
	12	74	1.841						
	1	75	4.814						
	2	75	9.061						
	3	75	11.100						
	4	75	16.849						
	5	75	19.397						
	6	75	8.976						
	7	75	3.341						
	8	75	2.832						
	9	75	2.407						
	10	75	0.765						

APPENDIX D

PHYSICAL and CHEMICAL DATA

061101
41 56 05.0 122 26 02.0 3
IRON GATE RESERVOIR
06093 CALIFORNIA

140191

11EPALES 2111202
0069 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
75/03/27	14 10	0000	5.2	10.8	24	195	7.85	66	0.270	1.000	0.500	0.116
	14 10	0005	5.3	10.8		193	7.85	64	0.250	1.000	0.510	0.122
	14 10	0015	5.2	10.8		189	7.80	65	0.250	1.100	0.520	0.125
	14 10	0030	5.2	10.8		190	7.80	67	0.260	1.000	0.520	0.121
	14 10	0045	5.2	10.7		196	7.80	68	0.250	1.000	0.520	0.124
	14 10	0065	4.9	10.8		191	7.85	82	0.240	1.000	0.500	0.118
75/07/16	10 10	0000	21.1	9.0	108	168	8.80	69	0.090	1.500	0.020	0.074
	10 10	0005	21.2	8.6		164	8.80	68	0.040	0.700	0.020K	0.084
	10 10	0015	17.0	4.4		143	7.90	69	0.060	0.600	0.060	0.118
	10 10	0040	14.0	4.6		133	7.50	66	0.030	0.600	0.150	0.116
	10 10	0090	4.6	2.6		137	7.15	77	0.030	0.600	0.560	0.159
	10 10	0146	3.9	8.6		144	7.00	81	0.120	0.900	0.570	0.185
75/10/31	13 45	0000	11.9	7.0	60	164	7.10	77	0.240	1.100	0.570	0.141
	13 45	0005	11.8	6.4		157	7.30	76	0.240	1.200	0.560	0.144
	13 45	0015	11.3	6.2		150	7.30	76	0.240	1.000	0.560	0.145
	13 45	0050	10.5	5.8		143	7.30	75	0.260	1.200	0.460	0.147
	13 45	0090	10.3	5.0		142	7.20	78	0.280	1.100	0.430	0.156
	13 45	0120	9.9	1.8		142	7.00	79	0.330	1.000	0.360	0.202
	13 45	0151	7.9	1.2		151	6.90	91	0.310	1.700	0.140	0.290

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/27	14 10	0000	0.170	11.1	
	14 10	0005	0.181		
	14 10	0015	0.178		
	14 10	0030	0.179		
	14 10	0045	0.173		
	14 10	0065	0.175		
75/07/16	10 10	0000	0.103	1.4	
	10 10	0005	0.101		
	10 10	0015	0.128		
	10 10	0040	0.139		
	10 10	0090	0.177		
	10 10	0146	0.275		
75/10/31	13 45	0000	0.195	0.6	
	13 45	0005	0.189		
	13 45	0015	0.190		
	13 45	0050	0.205		
	13 45	0090	0.220		
	13 45	0120	0.277		
	13 45	0151	0.318		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

061102
41 57 25.0 122 25 55.0 3
IRON GATE RESERVOIR
06093 CALIFORNIA

140191

11EPALES 2111202
0128 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
75/03/27	14 15	0000	4.2	11.2	22	123	7.95	69	0.220	1.500	0.410	0.097
	14 15	0005	4.2	11.2		124	7.95	70	0.210	1.200	0.430	0.098
	14 15	0015	4.1	11.2		124	7.95	71	0.200	1.200	0.430	0.093
	14 15	0055	3.9	9.4		143	8.00	70	0.200	1.300	0.420	0.090
	14 15	0090	3.9	11.4		148	7.95	70	0.210	1.100	0.410	0.094
	14 15	0124	3.9	11.4		150	7.95	68	0.200	1.400	0.410	0.108
75/07/16	10 45	0000	20.9	9.8	84	166	9.10	71	0.040	0.800	0.060	0.066
	10 45	0005	20.5	9.7		157	8.90	70	0.030	0.600	0.020	0.069
	10 45	0015	18.0	5.6		153	8.00	58	0.090	0.500	0.080	0.106
	10 45	0040	13.0	2.0		141	7.40	68	0.050	0.400	0.410	0.153
	10 45	0075	6.9	1.4		146	7.20	75	0.180	0.600	0.530	0.257
	10 45	0110	4.7	1.4		149	7.10	76	0.200	0.700	0.560	0.278
75/10/31	13 30	0000	12.4	6.6	60	155	7.20		0.180	1.000		0.133
	13 30	0005	11.3	6.2		154	7.25	74	0.210	1.100	0.560	0.141
	13 30	0015	11.3	6.6		152	7.25	77	0.210	1.100	0.580	0.142
	13 30	0046	10.9	7.2		147	7.30	76	0.220	1.200	0.540	0.130

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/27	14 15	0000	0.185	21.6	
	14 15	0005	0.187		
	14 15	0015	0.183		
	14 15	0055	0.186		
	14 15	0090	0.201		
	14 15	0124	0.206		
75/07/16	10 45	0000	0.113	2.3	
	10 45	0005	0.096		
	10 45	0015	0.122		
	10 45	0040	0.184		
	10 45	0075	0.280		
	10 45	0110	0.298		
75/10/31	13 30	0000	0.181	0.3	
	13 30	0005	0.186		
	13 30	0015	0.187		
	13 30	0046	0.183		

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

0611A1
41 55 50.0 122 26 20.0 4
KLAMATH RIVER
06 15 COPCO
O/IRON GATE RESERVOIR 140191
BNK FRM COPCO RD .1 M BELO IRON GATE DAM
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
74/11/16	10 00		0.660	1.200	0.300	0.150	0.180
74/12/07	09 35		0.736	1.500	0.375	0.135	0.190
75/01/19	09 35		0.672	1.300	0.480	0.105	0.120
75/02/22	10 30		0.660	5.900	0.368	0.120	0.170
75/03/08	09 55		0.672	1.400	0.312	0.152	0.160
75/04/12	13 05		0.175	0.900	0.065	0.060	0.130
75/05/04	11 30		0.065	1.050	0.035	0.050	0.080
75/06/05	16 20		0.005	0.800	0.015	0.040	0.080
75/07/13	10 20		0.070	2.300	0.052	0.085	0.120
75/08/25	14 00		0.090	1.950	0.150	0.130	0.160
75/09/14	14 05		0.195	1.100	0.155	0.165	0.200
75/11/08	10 20		0.460	1.400	0.199	0.128	0.170

STORET RETRIEVAL DATE 76/09/24

0611A2
41 58 15.0 122 19 55.0 4
KLAMATH RIVER
06 15 COPCO
T/IRON GATE RESERVOIR 140191
PP&L BRDG 1 MI S OF COPCO
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
74/11/16	12 05		0.640	1.400	0.240	0.135	0.180
74/12/07	10 50		0.768	2.000	0.590	0.135	0.190
75/01/19	11 12		0.672	1.300	0.573	0.115	0.130
75/02/22	11 55		0.704	1.500	0.360	0.176	0.190
75/03/08	11 10		0.768	1.600	0.288	0.168	0.180
75/04/12	14 45		0.045	1.150	0.060	0.055	0.140
75/05/04	12 50		0.130	0.800	0.045	0.070	0.090
75/06/05	15 30		0.070	1.150	0.045	0.085	0.120
75/07/13	11 35		0.045	1.500	0.050	0.080	0.120
75/08/25	15 10		0.175	1.050	0.110	0.165	0.200
75/09/14	15 26		0.310	1.400	0.155	0.185	0.230
75/11/08	11 20		0.410	1.600	0.260	0.110	0.190

STORET RETRIEVAL DATE 76/09/24

061181
41 58 20.0 122 23 45.0 4
JENNY CREEK
06 15 COPCO
T/IRON GATE RESERVOIR 140191
500 FT UPSTRM FR BRDG ON COPCO RD
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
74/11/16	11	15	0.024	0.100K	0.030	0.020	0.020
74/12/07	10	20	0.009	0.200	0.015	0.017	0.040
75/01/19	10	35	0.024	0.100	0.008	0.025	0.025
75/02/22	11	28	0.062	0.100K	0.024	0.024	0.040
75/03/08	10	40	0.100	0.500	0.032	0.040	0.150
75/04/12	14	10	0.025	0.150	0.015	0.020	0.030
75/05/04	12	20	0.045	0.200	0.010		0.010
75/06/05	17	00	0.025	1.900	0.045	0.010	0.020
75/07/13	11	00	0.010	0.450	0.030	0.020	0.050
75/08/25	14	45	0.010	0.550	0.030	0.015	0.015
75/09/14	14	55	0.010	0.200	0.020	0.015	0.020
75/11/02	10	30	0.110	3.600	0.050	0.005K	0.030
75/11/08	10	55	0.015	0.400	0.045	0.020	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0611C1
41 58 05.0 122 21 55.0 4
FALL CREEK
06 15 COPCO
T/IRON GATE RESERVOIR 140191
BNK FRM COPCO RD .3 MI S OF COPCO
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
74/11/16	11	35	0.040	0.100K	0.012	0.025	0.025
74/12/07	10	35	0.040	0.100K	0.015	0.025	0.030
75/01/19	10	47	0.048	0.600	0.025	0.025	0.025
75/02/22	11	45	0.056	0.200	0.016	0.024	0.024
75/03/08	10	50	0.032	0.800	0.016	0.024	0.030
75/04/12	14	30	0.020	0.100	0.010	0.020	0.030
75/05/04	12	35	0.020	0.600	0.010		0.010
75/06/05	15	20	0.035	2.400	0.025	0.025	0.030
75/07/13	11	25	0.035	2.500	0.030	0.025	0.050
75/08/25	14	55	0.035	0.200	0.015	0.025	0.030
75/09/14	15	00	0.035	0.100	0.010	0.025	0.030
75/11/02	11	30	0.045		0.115	0.025	0.075
75/11/08	11	05	0.025	0.200	0.010	0.025	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/11/02

0611D1
41 58 20.0 122 26 15.0 4
CAMP CREEK
06093 15 COPCO
T/IRON GATE RESERVOIR 140191
300 FT UPSTRM FRM BRDG ON COPCO RD
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
75/01/19	10 12		0.008	0.200	0.010	0.060	0.060
75/02/22	11 05		0.032	0.500	0.016	0.080	0.123
75/03/08	10 25		0.008	0.700		0.072	0.100
75/04/12	13 50		0.005	0.700	0.020	0.065	0.080
75/05/04	12 05		0.005	0.250	0.015	0.021	0.030
75/06/05	16 50		0.125	1.450	0.020	0.025	0.040
75/07/13	10 55		0.020		0.035	0.020	
75/08/25	14 30		0.035	4.000	0.050	0.030	0.030
75/09/14	14 40		0.005	0.100	0.040	0.040	0.040
75/11/08	10 45		0.010	0.600	0.015	0.025	0.030

STORET RETRIEVAL DATE 76/09/24

0611E1
41 58 40.0 122 26 35.0 4
SCOTCH CREEK
06 15 COPCO
T/IRON GATE RESERVOIR 140191
COPCO RD BRDG 5.0 MI W OF COPCO
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
74/12/07	10 05		0.336	0.400	0.015	0.045	0.050
75/01/19	10 00		0.312	0.300	0.010	0.020	0.020
75/02/22	10 45		0.400	0.650	0.008K	0.032	0.032
75/03/08	10 15		0.160	0.600			0.080
75/04/12	13 30		0.095	0.600	0.010	0.020	0.020
75/05/04	11 50		0.045	0.200	0.010	0.010	0.020
75/06/05	10 40		0.015	2.400	0.025	0.020	0.030
75/07/13	10 45		0.020	2.400	0.035	0.030	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED