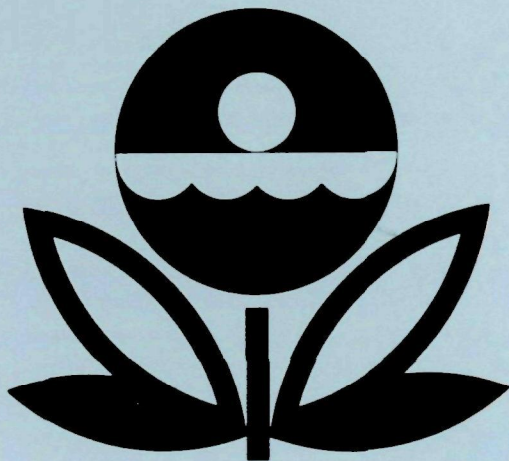


**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES**



REPORT
ON
HELLS CANYON RESERVOIR
BAKER AND WALLOWA COUNTIES, OREGON
ADAMS AND IDAHO COUNTIES, IDAHO
EPA REGION X
WORKING PAPER No. 829

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

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WITH THE COOPERATION OF THE
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY,
THE IDAHO DEPARTMENT OF HEALTH AND WELFARE,
AND THE OREGON NATIONAL GUARD
APRIL, 1978

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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 Oregon Department of Environmental Quality and the Idaho Department of Health and Welfare for professional involvement and to the Oregon National Guard for conducting the tributary sampling phase of the Survey.

William H. Young, Director; Harold L. Sawyer, Administrator, and the staff of the Water Quality Control Division of the Oregon Department of Environmental Quality; and the staff of the Division of Environment of the Idaho Department of Health and Welfare 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.

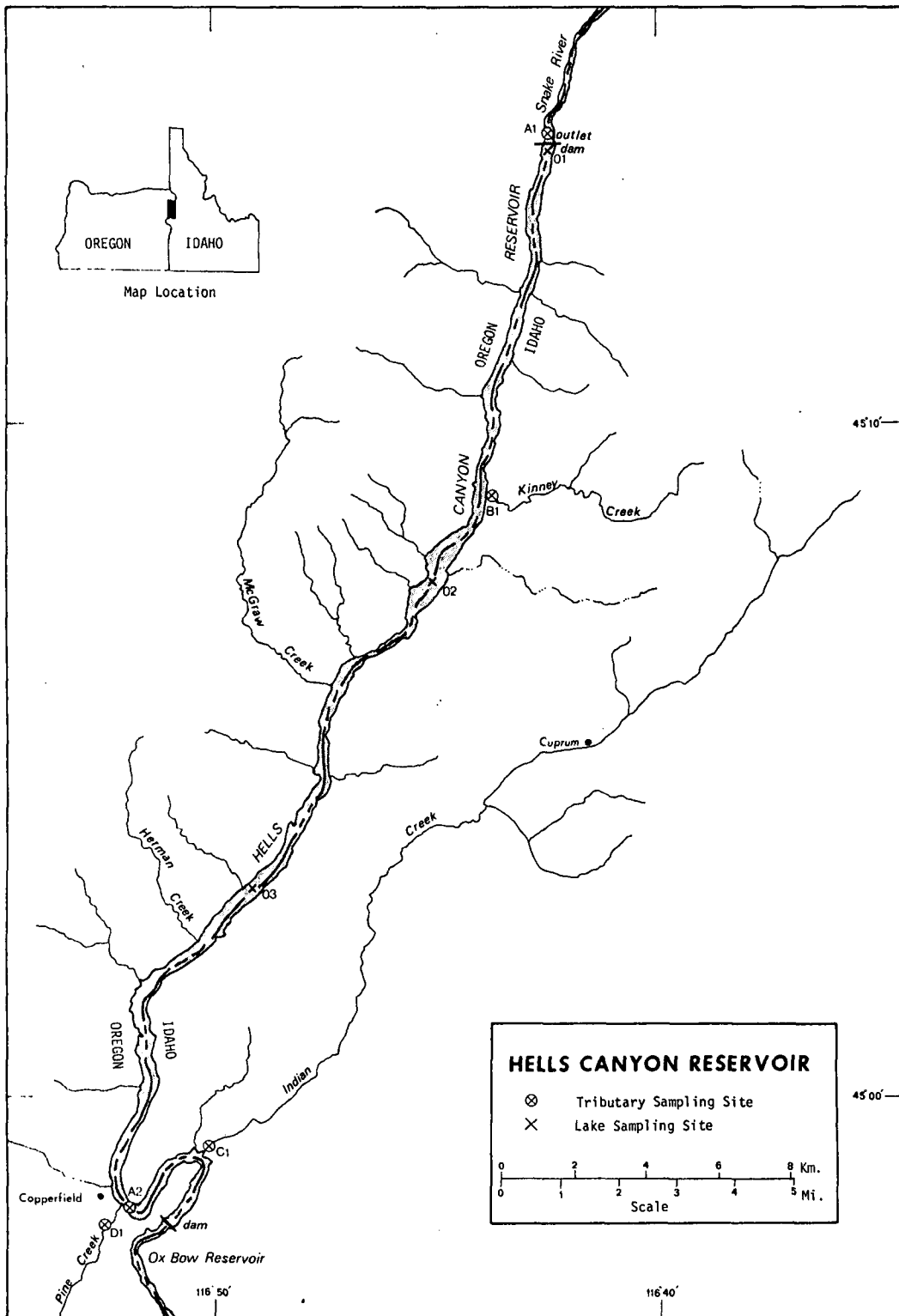
Brigadier General Richard A. Miller, the Adjutant General of Oregon, and Project Officer Lt. Colonel John Mewha, who directed the volunteer efforts of the Oregon National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES and RESERVOIRS

STATE OF OREGON

<u>NAME</u>	<u>COUNTY</u>
Brownlee	Baker, OR; Washington, ID
Diamond	Douglas
Hells Canyon	Baker, Wallowa, OR; Adams, Idaho, ID
Hills Creek	Lane
Owyhee	Malhuer
Oxbow	Baker, OR; Adams, ID
Suttle	Jefferson
Waldo	Lane



HELLS CANYON RESERVOIR

STORET NO. 4103

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Hells Canyon Reservoir is eutrophic. It ranked nineteenth in overall trophic quality when the 21 Oregon and Idaho lakes and reservoirs sampled in 1975 were compared using a combination of six water quality parameters*. Fifteen of the water bodies had less median total phosphorus, 19 had less median dissolved orthophosphorus and inorganic nitrogen, 18 had less mean chlorophyll a, and 16 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at station 1 in August.

Survey limnologists noted a few emergent macrophytes along the shoreline in April. The rather high chlorophyll a concentrations in April and August indicate possible bloom conditions at those times.

B. Rate-Limiting Nutrient:

The algal assay results are not considered representative of conditions in the reservoir at the times the samples were collected due to significant changes in nutrient concentrations in the samples during shipment from the field to the laboratory.

The reservoir data indicate phosphorus limitation in April and nitrogen limitation in August and September.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known point sources directly impacted Hells Canyon Reservoir during the sampling year. However, point sources which discharge to the Snake River upstream may be of significance since nearly 94% of the total phosphorus load leaving Brownlee Reservoir* reaches Hells Canyon Reservoir via Oxbow Reservoir*.

The present phosphorus loading of 93.11 g/m²/year is 12 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). Although Vollenweider's model may not be applicable to water bodies with short hydraulic retention times, the trophic condition of Hells Canyon Reservoir is evidence of excessive nutrient loads. Any improvement in water quality would involve the minimization of nutrient loads from both non-point sources and the point sources impacting upstream Brownlee Reservoir.

2. Non-point sources--As considered in this report, "non-point" sources include those contributing nutrients as a result of human activities (e.g., agricultural practices, urbanization, extractive processes, etc.) as well as natural sources (i.e., direct precipitation, leaf fall, wild birds and animals, etc.).

The apparent non-point source phosphorus contribution accounted for all of the load to Hells Canyon Reservoir during the sampling year. However, as noted above, much of the load is due to point sources upstream beyond the 40-kilometer Survey limit**.

* Respectively, Working Paper No. 827 and 832.

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

The Snake River contributed 95.0% of the total phosphorus load, Indian Creek contributed 0.4%, and Pine Creek contributed 3.2%. The ungaged minor tributaries and immediate drainage contributed an estimated 1.4%.

The phosphorus export rates of Indian and Pine creeks, 39 and 51 kg/km²/year, were quite high as compared to the rate of the Snake River (5 kg/km²/year) and may indicate the influence of land-use practices in the immediate drainage area. A further investigation would be needed to determine this. However, water quality improvement in Hells Canyon Reservoir would still require reduction of the nutrients impacting the Snake River which contributed 94% of the load.

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

1. Surface area: 10.12 kilometers².
2. Mean depth: 20.4 meters.
3. Maximum depth: 64.9 meters.
4. Volume: $206.881 \times 10^6 \text{ m}^3$.
5. Mean hydraulic retention time: 4 days.

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

1. Tributaries -

<u>Name</u>	<u>Drainage area (km²)*</u>	<u>Mean flow (m³/sec)*</u>
Snake River	188,810.9	532.660
Indian Creek	102.8	1.940
Pine Creek	595.7	10.860
Minor tributaries & immediate drainage -	<u>327.4</u>	<u>8.490</u>
Totals	189,836.8	553.950**

2. Outlet -

Snake River	189,846.9***	553.950
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C. Precipitation****:

1. Year of sampling: 27.0 centimeters.
2. Mean annual: 27.3 centimeters.

† Table of metric equivalents--Appendix B.

†† McHugh, 1972.

* For limits of accuracy, see Working Paper No. 175.

** Sum of inflows adjusted to equal outflow.

*** Includes area of reservoir.

**** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Hells Canyon Reservoir 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 or more depths at three 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 collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 48.8 meters at station 1, 29.0 meters at station 2, and 16.2 meters at station 3.

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 HELLS CANYON RESERVOIR
STORET CODE 4103

PARAMETER	1ST SAMPLING (4/ 8/75)				2ND SAMPLING (8/ 4/75)				3RD SAMPLING (9/15/75)			
	3 SITES				3 SITES				3 SITES			
	RANGE	MEAN	MEDIAN		RANGE	MEAN	MEDIAN		RANGE	MEAN	MEDIAN	
TEMP (C)	6.6 - 7.0	6.7	6.7		18.1 - 23.4	21.5	21.4		21.0 - 22.3	21.4	21.2	
DISS OXY (MG/L)	13.4 - 14.6	14.4	14.6		2.6 - 11.2	7.4	7.1		4.6 - 7.8	5.7	5.4	
CNDCTVY (MCROMO)	235. - 243.	238.	237.		240. - 269.	258.	260.		396. - 421.	412.	412.	
PH (STAND UNITS)	8.4 - 8.5	8.5	8.5		8.0 - 9.4	8.7	8.6		8.1 - 8.3	8.2	8.2	
TOT ALK (MG/L)	135. - 140.	138.	138.		98. - 107.	103.	103.		152. - 164.	159.	159.	
TOT P (MG/L)	0.079 - 0.093	0.087	0.087		0.029 - 0.061	0.040	0.041		0.065 - 0.080	0.072	0.073	
ORTHO P (MG/L)	0.027 - 0.051	0.041	0.042		0.006 - 0.049	0.021	0.021		0.052 - 0.067	0.060	0.062	
NO2+NO3 (MG/L)	0.680 - 0.780	0.752	0.770		0.020 - 0.320	0.194	0.245		0.570 - 0.690	0.650	0.680	
AMMONIA (MG/L)	0.040 - 0.050	0.043	0.040		0.020 - 0.050	0.035	0.035		0.020 - 0.020	0.020	0.020	
KJEL N (MG/L)	0.200 - 0.800	0.370	0.350		0.200 - 0.400	0.300	0.300		0.200 - 0.400	0.222	0.200	
INORG N (MG/L)	0.720 - 0.830	0.795	0.810		0.050 - 0.360	0.229	0.270		0.590 - 0.710	0.670	0.700	
TOTAL N (MG/L)	0.970 - 1.540	1.122	1.100		0.400 - 0.570	0.494	0.500		0.770 - 1.080	0.872	0.880	
CHLRPYL A (UG/L)	17.2 - 27.9	22.6	22.8		9.6 - 33.4	24.4	30.3		7.5 - 10.0	9.1	9.8	
SECCHI (METERS)	0.7 - 0.8	0.7	0.7		1.8 - 2.9	2.4	2.4		1.8 - 2.9	2.3	2.1	

B. Biological characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml</u>
04/08/75	1. <u>Stephanodiscus sp.</u>	7,332
	2. <u>Asterionella sp.</u>	296
	3. <u>Melosira sp.</u>	148
	4. <u>Fragilaria sp.</u>	111
	5. <u>Surirella sp.</u>	111
	Other genera	<u>334</u>
	Total	8,332
08/04/75	1. <u>Fragilaria sp.</u>	6,928
	2. <u>Melosira sp.</u>	3,322
	3. <u>Asterionella sp.</u>	608
	4. <u>Skeletonema sp.</u>	405
	5. <u>Cryptomonas sp.</u>	162
	Other genera	<u>163</u>
	Total	11,588
09/15/75	1. <u>Chroomonas (?) sp.</u>	795
	2. <u>Melosira sp.</u>	614
	3. <u>Stephanodiscus sp.</u>	36
	4. <u>Cryptomonas sp.</u>	36
	5. <u>Schroederia sp.</u>	<u>36</u>
	Total	1,517

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll <u>a</u> (μg/l)</u>
04/08/75	1	27.9
	2	17.2
	3	22.8
08/04/75	1	33.4
	2	30.3
	3	9.6
09/15/75	1	7.5
	2	9.8
	3	10.0

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the reservoir at the times samples were collected (04/08/75 and 09/15/75) due to significant nutrient changes in the samples during shipment from the field to the laboratory.

The reservoir data indicate phosphorus limitation in April and nitrogen limitation in August and September. The mean inorganic nitrogen/orthophosphorus ratios were 18/1 or greater at all stations in April and 13/1 or less at all stations in August and September.

IV. NUTRIENT LOADINGS (See Appendix E for data)

For the determination of nutrient loadings, the Oregon 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 January and February when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oregon District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampling tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station C-1, in $\text{kg}/\text{km}^2/\text{year}$, and multiplying by the ZZ area in km^2 .

No known wastewater treatment plants directly impacted Hells Canyon Reservoir during the sampling year.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg P/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Snake River	895,060	95.0
Indian Creek	3,985	0.4
Pine Creek	30,295	3.2
b. Minor tributaries & immediate drainage (non-point load) -	12,770	1.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>175</u>	<u>< 0.1</u>
Total	942,285	100.0

2. Outputs -

Reservoir outlet - Snake River 1,017,465

3. Net annual P loss - 75,180 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg N/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Snake River	25,222,530	97.4
Indian Creek	68,915	0.3
Pine Creek	367,060	1.4
b. Minor tributaries & immediate drainage (non-point load) -	219,360	0.8
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>10,925</u>	<u>< 0.1</u>
Total	25,888,790	100.0

2. Outputs -

Reservoir outlet - Snake River 21,630,255

3. Net annual N accumulation - 4,258,535 kg.

D. Non-point Nutrient Export by Subdrainage Area:

<u>Tributary</u>	<u>kg P/km²/yr</u>	<u>kg N/km²/yr</u>
Snake River	5	134
Indian Creek	39	670
Pine Creek	51	616

E. Mean Nutrient Concentrations in Ungaged Stream:

<u>Tributary</u>	<u>Mean Total P Conc. (mg/l)</u>	<u>Mean Total N Conc. (mg/l)</u>
Kinney Creek	0.042	0.654

* 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	93.11	loss*	2,558.2	420.8

Vollenweider phosphorus loadings
(g/m²/yr) based on mean depth and mean
hydraulic retention time of Hells Canyon Reservoir:

"Dangerous" (eutrophic loading)	7.60
"Permissible" (oligotrophic loading)	3.80

*. There was an apparent loss of phosphorus during the sampling year. This may have been due to solubilization of previously sedimented phosphorus, recharge with phosphorus-rich ground water, unsampled point sources discharging directly to the reservoir, or (probably) insufficient outlet sampling in relation to the very short hydraulic retention time of the reservoir.

V. LITERATURE REVIEWED

McHugh, Robert A., 1972. Interim study of some physical, chemical, and biological properties of selected Oregon lakes. OR Dept. of Environ. Qual., Portland.

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
1601	AMERICAN FALLS RESERVOIR	0.105	0.080	463.800	15.379	14.700	0.035
1602	CASCADE LAKE	0.032	0.060	415.067	8.081	14.800	0.009
1603	LAKE COEUR D'ALENE	0.017	0.040	380.348	10.391	12.200	0.005
1604	DWORSHAK RESERVOIR	0.010	0.080	401.866	2.420	7.400	0.009
1605	HAUSER	0.028	0.075	366.286	11.112	14.800	0.013
1606	HAYDEN LAKE	0.010	0.040	243.500	2.787	11.800	0.003
1607	ISLAND PARK RESERVOIR	0.034	0.050	391.778	9.322	12.800	0.012
1608	LAKE LOWELL	0.070	0.070	477.111	25.389	14.600	0.015
1609	MAGIC RESERVOIR	0.062	0.130	400.750	7.322	14.700	0.020
1610	PALISADES RESERVOIR	0.024	0.080	345.428	2.067	12.800	0.007
1611	LOWER PAYETTE	0.013	0.060	234.000	4.600	9.600	0.007
1612	LOWER TWIN LAKES	0.016	0.050	370.000	2.318	13.600	0.009
1613	UPPER TWIN LAKES	0.017	0.045	369.143	34.962	8.200	0.004
4101	BROWNLEE RESERVOIR	0.079	0.560	428.133	16.207	14.500	0.043
4102	DIAMOND LAKE	0.028	0.040	294.500	7.300	6.800	0.011
4103	HELLS CANYON RESERVOIR	0.068	0.640	429.111	18.722	12.400	0.045
4104	HILLS CREEK RESERVOIR	0.038	0.060	435.200	2.333	7.400	0.027
4105	OWYHEE	0.095	0.425	480.417	3.350	13.200	0.064
4106	OXBOW RESERVOIR	0.071	0.690	425.555	10.311	12.200	0.040
4107	SUTTLE LAKE	0.031	0.040	95.000	9.167	6.800	0.020
4108	WALDO LAKE	0.005	0.040	-100.000	0.350	6.800	0.006

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
1601	AMERICAN FALLS RESERVOIR	0 (0)	30 (5)	10 (2)	20 (4)	13 (2)	20 (4)	93
1602	CASCADE LAKE	45 (9)	58 (11)	35 (7)	50 (10)	3 (0)	65 (12)	256
1603	LAKE COEUR D'ALENE	75 (15)	93 (17)	55 (11)	30 (6)	58 (11)	90 (18)	401
1604	DWORSHAK RESERVOIR	93 (18)	30 (5)	40 (8)	80 (16)	83 (16)	65 (12)	391
1605	HAUSER	58 (11)	40 (8)	70 (14)	25 (5)	3 (0)	45 (9)	241
1606	HAYDEN LAKE	93 (18)	93 (17)	85 (17)	75 (15)	65 (13)	100 (20)	511
1607	ISLAND PARK RESERVOIR	40 (8)	68 (13)	50 (10)	40 (8)	43 (8)	50 (10)	291
1608	LAKE LOWELL	20 (4)	45 (9)	5 (1)	5 (1)	20 (4)	40 (8)	135
1609	MAGIC RESERVOIR	30 (6)	20 (4)	45 (9)	55 (11)	13 (2)	30 (6)	193
1610	PALISADES RESERVOIR	65 (13)	30 (5)	75 (15)	95 (19)	43 (8)	80 (16)	388
1611	LOWER PAYETTE	85 (17)	58 (11)	90 (18)	65 (13)	70 (14)	75 (15)	443
1612	LOWER TWIN LAKES	80 (16)	68 (13)	60 (12)	90 (18)	30 (6)	65 (12)	393
1613	UPPER TWIN LAKES	70 (14)	75 (15)	65 (13)	0 (0)	75 (15)	95 (19)	380
4101	BROWNLEE RESERVOIR	10 (2)	10 (2)	25 (5)	15 (3)	25 (5)	10 (2)	95
4102	DIAMOND LAKE	58 (11)	93 (17)	80 (16)	60 (12)	95 (18)	55 (11)	441
4103	HELLS CANYON RESERVOIR	25 (5)	5 (1)	20 (4)	10 (2)	50 (10)	5 (1)	115
4104	HILLS CREEK RESERVOIR	35 (7)	50 (10)	15 (3)	85 (17)	83 (16)	25 (5)	293
4105	OWYHEE	5 (1)	15 (3)	0 (0)	70 (14)	35 (7)	0 (0)	125
4106	OWBOW RESERVOIR	15 (3)	0 (0)	30 (6)	35 (7)	58 (11)	15 (3)	153
4107	SUTTLE LAKE	50 (10)	80 (16)	95 (19)	45 (9)	95 (18)	35 (7)	400
4108	WALDO LAKE	100 (20)	93 (17)	100 (20)	100 (20)	95 (18)	85 (17)	573

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4108	WALDO LAKE	573
2	1606	HAYDEN LAKE	511
3	1611	LOWER PAYETTE	443
4	4102	DIAMOND LAKE	441
5	1603	LAKE COEUR D'ALENE	401
6	4107	SUTTLE LAKE	400
7	1612	LOWER TWIN LAKES	393
8	1604	DWORSHAK RESERVOIR	391
9	1610	PALISADES RESERVOIR	388
10	1613	UPPER TWIN LAKES	380
11	4104	HILLS CREEK RESERVOIR	293
12	1607	ISLAND PARK RESERVOIR	291
13	1602	CASCADE LAKE	256
14	1605	HAUSER	241
15	1609	MAGIC RESERVOIR	193
16	4106	OXBOW RESERVOIR	153
17	1608	LAKE LOWELL	135
18	4105	OWYHEE	125
19	4103	HELLS CANYON RESERVOIR	115
20	4101	BROWNLEE RESERVOIR	95
21	1601	AMERICAN FALLS RESERVOIR	93

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 OREGON

08/11/76

LAKE CODE 4103 HELLS CANYON RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 189846.9

TRIBUTARY	SUR-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS)												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
4103A1	189846.9	625.80	756.06	716.42	758.89	673.94	656.95	342.63	319.98	396.44	447.41	453.07	521.03	553.95
4103A2	188810.9	597.49	713.58	676.77	716.42	634.30	620.14	336.97	325.64	396.44	447.41	444.57	501.21	532.66
4103C1	102.8	0.85	0.85	2.27	2.55	5.66	5.66	1.98	0.71	0.57	0.71	0.71	0.71	1.94
4103D1	595.7	11.50	11.67	15.77	15.86	29.53	26.87	5.01	1.19	1.36	1.97	3.60	6.14	10.86
4103ZZ	295.3	1.19	1.42	1.93	2.21	6.80	3.96	1.93	0.57	0.45	0.57	0.57	0.62	1.85

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 189846.9
SUM OF SUB-DRAINAGE AREAS = 189804.7

TOTAL FLOW IN = 6586.74
TOTAL FLOW OUT = 6668.60

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4103A1	10	74	501.208	20	419.089				
	11	74	498.376	23	501.208				
	12	74	532.357	14	376.614				
	1	75	639.961	4	639.961	25	665.446		
	2	75	773.050	9	552.178	22	991.090		
	3	75	993.921	9	1030.733				
	4	75	1404.516	13	1274.258				
	5	75	1489.466	17	1543.268				
	6	75	849.505	7	855.169				
	7	75	436.079						
	8	75	348.297	9	319.980				
	9	75	464.396	28	402.099				
4103A2	10	74	501.208	19	410.594				
	11	74	495.545	23	521.030				
	12	74	523.862	14	538.020				
	1	75	614.476	4	620.139	25	614.476		
	2	75	719.248	9	569.168	22	894.812		
	3	75	877.822	9	897.644				
	4	75	1268.595	13	1155.327				
	5	75	1347.882	17	82.119				
	6	75	733.406	7	744.733				
	7	75	413.426						
	8	75	328.475	9	311.485				
	9	75	444.574	28	430.416				

TRIBUTARY FLOW INFORMATION FOR OREGON

08/11/76

LAKE CODE 4103 HELLS CANYON RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4103C1	10	74	0.425	20	0.396				
	11	74	0.311	23	0.340				
	12	74	0.255	14	0.283				
	1	75	0.227	4	0.283	25	0.283		
	2	75	0.510	9	0.396	22	0.453		
	3	75	1.416	9	2.124				
	4	75	1.699	13	1.557				
	5	75	3.681	17	4.814				
	6	75	4.531	7	5.663				
	7	75	2.407						
	8	75	0.708	9	0.510				
	9	75	0.368	28	0.283				
4103D1	10	74	1.812	20	1.727				
	11	74	2.520	23	2.747				
	12	74	2.633	14	2.690				
	1	75	3.030	3	2.549	25	3.794		
	2	75	6.400	9	4.474	22	5.182		
	3	75	16.820	9	27.269				
	4	75	16.395	13	15.404				
	5	75	28.317	17	42.192				
	6	75	32.564	7	43.891				
	7	75	11.072						
	8	75	2.265	9	1.557				
	9	75	1.642	28	1.218				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/08/12

410301
45 14 15.0 116 42 08.0 3
HELLS CANYON RESERVOIR
41063 OREGON

130892

11EPALES 2111202
0155 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 CONDUCTVY 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
75/04/08	14 45	0000	6.6		26	241	8.45	139	0.040	0.300	0.770	0.043
	14 45	0005	6.8	14.6		235	8.45	140	0.040	0.200	0.770	0.036
	14 45	0015	6.7	14.4		236	8.45	137	0.050	0.200	0.770	0.035
	14 45	0050	6.6	14.6		239	8.50	138	0.040	0.400	0.770	0.051
	14 45	0100	6.6	14.4		237	8.50	136	0.050	0.300	0.770	0.048
	14 45	0150	6.6	14.6		239	8.50	135	0.050	0.400	0.780	0.041
75/08/04	07 30	0000	22.9	10.2	96	245	9.00	104	0.030	0.400	0.070	0.015
	07 30	0005	22.5	6.4		260	9.05	103	0.030	0.300	0.100	0.006
	07 30	0015	22.5	9.0		269	8.60	101	0.040	0.300	0.210	0.014
	07 30	0040	21.6	6.6		257	8.60	102	0.050	0.300	0.210	0.024
	07 30	0070	20.1	6.2		255	8.40	102	0.040	0.300	0.240	0.030
	07 30	0110	20.8	5.8		253	8.30	102	0.040	0.200	0.270	0.027
	07 30	0135	20.8	4.4		248	8.20	102	0.040	0.200	0.290	0.038
	07 30	0160	18.1	2.6		240	8.00	102	0.040	0.200	0.320	0.049
75/09/15	13 30	0000	22.2	7.2	115	407	8.20	152	0.020K	0.200	0.570	0.052
	13 30	0005	22.3	7.2		410	8.30	153	0.020K	0.200	0.580	0.055
	13 30	0018	22.0	7.8		410	8.30	155	0.020K	0.300	0.590	0.053
	13 30	0040	21.8	7.4		410	8.30	153	0.020K	0.200	0.580	0.054
	13 30	0075	21.2	5.6		405	8.15	153	0.020K	0.200	0.620	0.057
	13 30	0110	21.1	5.0		408	8.10	156	0.020K	0.200	0.640	0.057
	13 30	0145	21.0	4.6		396	8.10	153	0.020K	0.200K	0.620	0.056

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

410301
45 14 15.0 116 42 08.0 3
HELLS CANYON RESERVOIR
41063 OREGON

130892

11EPALES 2111202
0155 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/04/08	14 45	0000	0.086	27.9	
	14 45	0005	0.092		
	14 45	0015	0.088		
	14 45	0050	0.088		
	14 45	0100	0.090		
	14 45	0150	0.093		
75/08/04	07 30	0000	0.030	33.4	
	07 30	0005	0.029		
	07 30	0015	0.036		
	07 30	0040	0.038		
	07 30	0070	0.043		
	07 30	0110	0.046		
	07 30	0135	0.050		
	07 30	0160	0.061		
75/09/15	13 30	0000	0.078	7.5	
	13 30	0005	0.068		
	13 30	0018	0.065		
	13 30	0040	0.065		
	13 30	0075	0.068		
	13 30	0110	0.070		
	13 30	0145	0.076		

STORET RETRIEVAL DATE 76/08/12

410302
45 07 35.0 116 44 42.0 3
HELLS CANYON RESERVOIR
41063 OREGON

130892

11EPALES 2111202
0030 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 CONDUCTVY 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
75/04/08	11 45	0000	6.8	14.6	29	235	8.50	138	0.040	0.400	0.730	0.050
	11 45	0015	6.8	14.6		235	8.50	139	0.040	0.400	0.740	0.033
	11 45	0026	7.0	13.4		235	8.50	138	0.040	0.800	0.740	0.049
75/08/04	08 10	0000	23.4	10.4	72	269	9.00	103	0.020	0.400	0.040	0.008
	08 10	0005	23.4	11.2		261	9.40	103	0.030	0.400	0.020K	0.014
	08 10	0015	22.9	10.0		259	9.15	104	0.050	0.400	0.030	0.006
	08 10	0035	21.0	7.2		253	8.75	102	0.050	0.300	0.160	0.020
	08 10	0069	20.6	6.8		249	8.50	105	0.040	0.300	0.270	0.023
75/09/15	14 00	0000	21.8	5.8	72	421	8.20	158	0.020K	0.200	0.680	0.060
	14 00	0005	21.7	5.8		416	8.20	159	0.020K	0.200	0.680	0.063
	14 00	0015	21.3	5.6		415	8.20	163	0.020K	0.300	0.680	0.067
	14 00	0040	21.2	5.0		412	8.10	159	0.020K	0.200	0.680	0.066
	14 00	0070	21.1	5.2		412	8.10	162	0.020K	0.400	0.680	0.063
	14 00	0095	21.1	4.8		410	8.10	161	0.020K	0.200K	0.680	0.062

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/04/08	11 45	0000	0.087	17.2	
	11 45	0015	0.079		
	11 45	0026	0.084		
75/08/04	08 10	0000	0.033	30.3	
	08 10	0005	0.031		
	08 10	0015	0.034		
	08 10	0035	0.036		
	08 10	0069	0.044		
75/09/15	14 00	0000	0.069	9.8	
	14 00	0005	0.073		
	14 00	0015	0.073		
	14 00	0040	0.067		
	14 00	0070	0.075		
	14 00	0095	0.076		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

410303
45 02 58.0 116 48 35.0 3
HELLS CANYON RESERVOIR
41001 OREGON

130891

11EPALES 2111202
0999 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
75/04/08	10 25	0000	6.7	14.4	30	243	8.55	138	0.040	0.300	0.680	0.027
	10 25	0015	6.9			241						
75/08/04	08 35	0000	21.4	7.0	114	261	8.65	106	0.020	0.200	0.250	0.020
	08 35	0005	21.4	7.2		267	8.60	107	0.030	0.300	0.260	0.022
	08 35	0015	21.4	7.4		263	8.60	107	0.030	0.300	0.250	0.023
	08 35	0030	21.3	6.8		265	8.55	105	0.020	0.300	0.250	0.021
	08 35	0051	20.7	7.2		263	8.50	98	0.030	0.300	0.260	0.022
75/09/15	14 25	0000	21.4	5.4	84	420	8.20	164	0.020K	0.200	0.680	0.063
	14 25	0005		5.5		416	8.20	162	0.020K	0.200	0.680	0.064
	14 25	0015	21.2	5.4		416	8.20	163	0.020K	0.200	0.680	0.063
	14 25	0030	21.1	5.0		413	8.20	164	0.020K	0.200	0.690	0.064
	14 25	0053	21.0	5.0		415	8.15	164	0.020K	0.200K	0.690	0.064

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/04/08	10 25	0000	0.083	22.8	
75/08/04	08 35	0000	0.041	9.6	
	08 35	0005	0.047		
	08 35	0015	0.044		
	08 35	0030	0.044		
	08 35	0051	0.042		
75/09/15	14 25	0000	0.074	10.0	
	14 25	0005	0.071		
	14 25	0015	0.076		
	14 25	0030	0.080		
	14 25	0053	0.080		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/08/12

4103A1
 45 14 10.0 116 42 10.0 4
 SNAKE RIVER
 41 15 CUPRUM
 0/HELLS CANYON RESERVOIR 130892
 BELO HELLS CYN DAM 10.5 MI N OF CUPRUM
 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
74/10/20	12 30		0.768	0.200	0.025	0.075	0.075
74/11/23	14 40		0.920	0.300	0.035	0.055	0.060
74/12/14	16 00		1.010	0.400	0.060	0.045	0.050
75/01/04	14 30		1.040	0.200	0.065	0.045	0.050
75/01/25	13 22		0.850	0.200	0.016	0.024	0.030
75/02/09	13 50		0.768	0.800	0.032	0.016	0.050
75/02/22	15 00		0.720	0.400	0.044	0.016	0.040
75/03/09	13 30		0.790	0.600	0.028	0.024	0.060
75/04/13	13 15		0.470	1.550	0.045	0.020	0.070
75/05/17	13 15		0.060	0.600	0.025	0.015	0.100
75/06/07	14 40		0.085	1.350	0.055	0.010	0.045
75/08/09			0.260	0.550	0.025	0.025	0.060

STORET RETRIEVAL DATE 76/08/12

410381
45 08 30.0 116 43 30.0 4
KINNEY CREEK
41 15 CUPRUM
T/HELLS CANYON RESERVOIR 130892
PRVT PVD RD BRDG 6 MI S OF HELLS CYN 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
74/10/20	11 50		0.216	0.100K		0.020	0.020
74/11/23	14 10		0.248	0.100K	0.040	0.015	0.015
74/12/14	15 30		0.280	0.100	0.015	0.020	0.030
75/01/04	13 30		0.296	0.400	0.010	0.015	0.030
75/01/25	12 55		0.336	0.550	0.024	0.010	0.021
75/02/09	13 23		0.320	0.450	0.008	0.024	0.030
75/02/22	14 20		0.376	0.200	0.012	0.024	0.024
75/03/09	13 00		0.276	0.400	0.012	0.024	0.030
75/04/13	12 30		0.270	0.662	0.040	0.020	0.020
75/05/17	13 45		0.130	0.300	0.020	0.025	0.060
75/06/07	14 10		0.105	0.750	0.025	0.015	0.100
75/08/09			0.210	0.400	0.030	0.110	0.140
75/09/28	11 25		0.230	0.800	0.010	0.015	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

4103A2
44 08 10.0 116 50 15.0 4
SNAKE RIVER
41 15 COPPERFIELD
T/HELLS CANYON RESERVOIR 130791
BELO OXBOW DAM 1 MI SE OF COPPERFIELD
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
74/10/19	13 30		0.800	0.500	0.040	0.065	0.075
74/12/14	14 00		0.960	0.300	0.060	0.045	0.050
75/01/04	12 05		0.980	1.400	0.080	0.045	0.050
75/04/13	11 35		0.510	1.200	0.035	0.020	0.070

STORET RETRIEVAL DATE 76/08/12

4103C1
44 09 15.0 116 49 50.0 4
INDIAN CREEK
41 15 COPPERFIELD
T/HELLS CANYON RESERVOIR 130791
PRVT PVD RD BRDG 1.5 MI N OF OXBOW DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 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
74/10/20	15 30		0.048	0.400	0.010	0.010	0.010
74/11/23	13 00		0.056	0.500	0.050	0.010	0.010
74/12/14	14 00		0.112	0.400	0.010	0.010	0.010
75/01/04	12 55		0.590	1.700	0.015	0.019	0.020
75/01/25			1.060	0.600	0.024	0.016	0.016
75/02/09	12 00		0.272	0.100	0.040	0.016	0.020
75/02/22	13 30		0.392	0.100	0.016	0.024	0.030
75/04/13	11 45		1.100	1.450	0.025	0.035	0.100
75/06/07	13 30		0.460	0.400	0.005	0.025	0.050

STORET RETRIEVAL DATE 76/08/12

410301
44 57 21.0 116 52 15.0 4
PINE CREEK
41 15 COPPERFIELD
T/HELLS CANYON RESERVOIR 130892
GAGING STATN 1.8 MI S OF COPPERFIELD
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
74/11/23	11 30		0.048	1.100	0.050	0.010	0.020
74/12/14	12 00		0.104	0.300	0.010	0.015	0.020
75/01/03	10 00		0.192	0.700	0.030	0.022	0.040
75/01/25	10 00		0.320	0.200	0.016	0.016	0.020
75/02/09	10 00		0.552	0.500	0.056	0.024	0.050
75/02/22	11 00		0.704	0.700	0.016	0.024	0.035
75/03/09	10 50		0.870	1.000	0.008	0.048	0.180
75/04/13	09 35		0.520	2.400	0.085	0.020	0.060
75/05/17	14 15		0.125	0.300	0.035	0.020	0.140
75/06/07	11 00		0.115	0.500	0.015	0.015	0.120
75/08/09			0.025	0.650	0.020	0.020	0.050
75/09/28			0.015	0.600	0.010	0.005K	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED