WATER QUALITY STATUS REPORT ● REPORT NO. 58

TRIBUTARIES OF THE NORTHEAST WORLEY AGRICULTURAL PLANNING PROJECT
Kootenai County, Idaho
1986

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INTRODUCTION

Impacts to water quality of Lake Coeur d'Alene due to non-point source runoff from agricultural land was studied through field sampling. Stream samples were taken in an attempt to estimate stream loading to the lake. Lake samples were also taken in an attempt to compare stream water quality to the receiving body. Duration of sampling was for one water year, and thus has certain limitations with respect to yearly climatological variation.

The study area, as defined, contains three watersheds. Water quality was sampled at five locations in two of the watersheds during the 1984/1985 water year. Cave creek (also known as Hazelgate Creek) was sampled in two locations, one near the confluence of the lake and another site, just below agricultural land, yet above recent logging activity. East Fork of 16 to 1 Creek was sampled in two locations, one where it crosses the Cave Bay road and another, also just below agricultural land, yet above recent logging activity. West Fork 16 to 1 Creek was sampled at one location, also on the Cave Bay Road. Mowry Creek, also known as Aberdeen Lodge Creek, was not sampled due to inaccessibility of the site in winter and spring conditions. See Appendix A for stream and lake sampling sites.

Snow accumulation in the watershed was considerable this water year, with approximately five inches of snow water equivalent by late January. Gradual thaw conditions began in February characterized by warm sunny days and cold nights. Very little snow melt could be attributed to warm rain associated with Pacific Northwest frontal systems, as is typical in the Palouse.

In most locations, soil beneath the snow cover was not frozen. This allowed infiltrative capacity to exceed melt. It was not until middle March when light rain on saturated, thawed and bare ground was any significant amount of sediment delivered to the stream channels. Spring rain was shortlived and streamflows dropped to unmeasurable quantities by early April. Dry sunny conditions prevailed throughout most of April. Rains in late April failed to produce any significant runoff due to low soil moisture.

Primary constituents of concern during runoff are the contributions of nitrogen, phosphorus and sediment to Lake Coeur d'Alene. These contribute significantly to eutrophication of the lake and subsequent filling of bays. Metals contributed by the watersheds sampled were typically below the detection limits of the lab and much lower than the receiving waters and are not considered to have an impact.

PHYSICAL DESCRIPTION OF THE WATERSHED

The three watersheds contain approximately 5100 acres, of which approximatley 3000 acres are in dryland agricultural use. Three major streams drain the area into three bays of Lake Coeur d'Alene. The streams are all intermittent and have northeast aspects. Upper reaches of the streams dissect agricultural plateaus at elevations of 2500 to 2800 ft. Lower reaches of the streams dissect steep wooded breaks that drop quickly to the lake at an elevation of 2120-2138 (max pool variation of Lake Coeur d'Alene).

Upper reaches of the streams exhibit shallow profiles with stream banks of unconsolidated alluvial material derived from silt loam soils. The lower reaches exhibit relatively steep profiles, high velocities and scoured bed material of basalt.

METHODOLOGY

Stream samples were taken on precipitation or runoff event basis, as necessary. Significant precipitation did not occur until late March, at which time samples were taken daily. Prior to this, snow melt was continuous and gradual. Thus, samples were taken on a weekly basis. Most samples during snow melt were taken during the middle afternoon to approximate mean daily flow.

Paired samples of flow and water quality were taken whenever possible. There were times both early and late in the runoff season, in which samples were taken, but flow was to low to measure. As such 6 to 9 sets of paired data were accumulated through the water year from each sampling site. This is fewer samples than was anticipated, and proved insufficient to develope sediment rating curves or stage/discharge relationships.

Samples were taken in cubitainers and preserved in the field or within 2 hours after being taken. Stream flow was measured with a wading rod and direct reading Marsch-McBirney flow meter. Stream cross sections were established and located prior to runoff and used during the entire season. Staff gauges were also placed prior to runoff. A cresting staff gauge was placed on each of the three streams monitored. These gauges utilized a staff gauge inside a pipe to recorded peak flows via powdered cork inside the pipe. These crest gauges were used to estimate the magnitudes of flows that occured since the last sampling. Peak flows were not incorporated into the data base due to a weak stage/discharge relationship and unknown water quality at those flows.

RESULTS AND DISCUSSION

NITRATE LOADING

Typical nitrate-nitrite concentrations in NE Worley streams were 5-10 mg/l (as N) with highs up to 25 mg/l. Nitrogen contributions were predominately in oxidized forms (nitrate-nitrite). Organic nitrogen by total kjeldahl (approx. 5% of nitrate-nitrite present) and ammonia nitrogen (approx. 1% of nitrate-nitrite present) were almost insignificant as would be expected from this type of watershed. (ie. low organic content of the soil and regular synthetic fertilizer applications)

In contrast, lake samples showed significantly lower total nitrogen concentrations of which, kjeldahl nitrogen was the predominate form. This is to be expected due to the biological uptake of nitrate/nitrite and subsequent conversion to biomass.

EPA Region X Water Quality Index (WQI)[2] sets a maximum level of 0.3 mg/l for nitrate. This level was exceeded in most of the samples taken. Due to water temperature and time of runoff, eutrophication did not occur in the stream or bays. However, this input to the lake could contribute to eutrophication in the future when light and temperature conditions are more favorable in the lake at a later date. See Appendix B for nitrogen loading data.

PHOSPHORUS LOADING

Total phosphorus loading was typically 0.1-0.3 mg/l (as P) with a high of 0.82 mg/l. Dissolved ortho-phosphorus was the predomonate form early in the runoff year when sediment contributions were low. Later in the runoff season, hydrolyzable phosphorus was higher (up to 50% of total phosphorus) due to its association with the mineral content of sediment. Most hydrolyzable phosphorus is chemically associated with the mineral content of sediment and is not available for algal production. An unknown amount of phosphorus is also adsorbed onto sediment and buried on the bottom. Although deposited on the lake bottom, currents, boat activity and/or wave action may reintroduce it into the water column. Assimilation by macrophytes rooted into the sediments can tap these nutrients for growth.

EPA Region X WQI[2] has set a maximum level of 0.05-0.1 mg/l for total phosphorus. This level was exceeded in most of the samples taken. Biologically available dissolved ortho-phosphorus alone, exceeded the above mentioned WQI limits for total phosphorus in many of the samples taken. See Appendix B for total phosphorus loading data.

SEDIMENT DELIVERY

Runoff was minimal for this study year, and delivery of significant quantities of sediment was limited to approximately one week in late March. Physical evidence of erosion in the watershed was very limited. Only one field in the West Fork 16 to 1 watershed showed signs of significant soil loss. Even so, soil loss in this watershed averaged only 0.26 tons/acre of cropland. (See figure 1, below) Average soil loss for the Palouse is approximately 15 tons/acre for an average year. This is 58 times the worst case for the 1984/1985 water year. Actual rill measurements taken by SCS in 1980 for 67 sites in NE Worley documented an average of 13.3 tons/acre of cropland.[3]

FIGURE 1

Total Nutrient and Sediment Loading to Lake CDA
for 1984/1985.*

TRIBUTARY	NITROGEN (KG AS N)	PHOSHORUS (KG AS P)	SEDIMENT (TONS)	SEDIMENT (TONS/AC)
Cave Ck. (lower)	6122	105	3.95	0.021
West Fork 16:1	1628	120	25.67	0.262
East Fork 16:1 (lower)	1045	36	5.52	0.08

*These loadings were calculated for the lower stations of Cave Creek, East Fork 16 to 1 and the West Fork of 16 to 1 Creek. Both sites were below the impact area of logging done the previous summer. Sites above the logging impact area showed higher suspended sediment concentrations than those sites below the logging impact area. These lower sites were used for loading calculations since an impact to the lake was at question. It is suspected that the newly logged areas (a large amount of slash placed in streams and skidding done through streams) served as filters or resevoirs for the sediment load routed to them under the given conditions. This seems contrary to standard belief for logging practice. This stored sediment will undoubtedely be routed to the lake in future high flows.

The delivery of sediment physically impacts shallow bays by filling. This limits boat access to the bays which is a major concern to lake users. Filling of the bays also allows encroachment of macrophyte growth, thereby tapping burried nutrients previously removed from the water column. Macrophyte growth in the summer prohibits boat access even where depth of draft is adequate.

METALS

Stream and lake samples were analyzed for total zinc, copper, cadmium and arsenic. Stream samples consistently showed metals concentrations below the detection limits of the lab. The concentrations were also consistently lower than those found in the lake. This is to be expected due to the input of metals, particularly zinc (typically 50-200 µg/L), from the Silver Valley via the Coeur d'Alene River. As such, metals analyses were deleted from the latter stream samples.

PH

Stream pH values ranged from 6.4 to 7.4 as run by the State of Idaho Bureau of Laboratories in

Coeur d'Alene, Idaho. PH of the lake samples taken ranged from 6.6 to 7.0 also as run by the State Lab. Field measurements of pH in the lake ranged from 7.0 to 8.0.

DISSOLVED OXYGEN

Dissolved oxygen in the streams was greater than or equal to 90% of saturation when measured. High reaeration due to turbulence and low oxygen demand due to low temperatures, precluded any further field measurements of DO.

LOADING CONTRIBUTIONS OF NE WORLEY COMPARED TO OTHER TRIBUTARIES

In an attempt to compare nutrient and sediment loading of the NE Worley watersheds to other contributions, the following comparison was made.

On April 17, a set of lake samples were taken. General appearance of water quality in the lake on this day was at or near its yearly low. Turbidity was high (secchi disk measurements of 1-2 meters compared to 6-7 meters at other times) and the lake was littered with floating debris, signifying seasonly high flows from the major watersheds. This date also coincided closely with peak flows of the St. Joe and Coeur d'Alene Rivers; which are the major tributaries to the lake.[4] The six days prior to that date approximate the six day high flow for the water year.

It can be assumed that in-lake water quality on April 17 was a direct result of the water quality of the three major tributaries mentioned above, since watersheds like those in NE Worley had failed to produce significant runoff for 2-3 weeks. As such, average water quality parameters for total nitrogen (0.13 mg/l), total phosphorus (0.02 mg/l) and total suspended sediment (4.0 mg/l) in Lake CDA on April 17, were assumed to be that of the major tributaries on the previous week. Flows for these major tributaries were totaled and the total nutrient and sediment loading were calculated for this 6-day high flow. The relative contributions of NE Worley for the entire season compared to the 6-day high flow of the major tributaries are: nitrate-nitrite 2.8%, total phosphorus 0.48%, suspended sediment 1.5%. Assuming an average yearly inflow to the lake of 6334.7 cfs[1], the NE Worley streams (Cave Ck. and 16 to 1 Cks.) accounted for only 0.02% of the total inflow. The above NE Worley streams account for only 0.086% of the land area that drains to the lake.

The above comparison makes some fairly gross assumptions, but is better than no comparison at all. True in-stream loadings of nitrogen, phosphorus and suspended sediment would likely be higher, since considerable sedimentation takes place prior to the points of sampling (three bays in NE Worley, at the mouth of the CDA River and a mid-lake control point). How the total yearly loading of these tributaries compares to the 6-day high flow is also purely speculative. When one considers the relative size of the NE Worley watersheds and their contributions of flow to the other major watersheds, the nutrient contributions become more significant.

COMPARISONS OF THE NE WORLEY WATERSHEDS

The most significant sediment load was contributed by the West Fork 16 to 1. The West Fork 16 to 1 was the only watershed that showed significant soil erosion. Even by visual inspection, this stream was always more turbid than the other streams. Total loading of this tributary was five to six times higher than that of Cave Creek.

Watersheds of East Fork of 16 to 1 and Cave Creek have some existing practices of conservation tillage. Common practices are grassed waterways, crop residue cover, rough texture tillage and reduced tillage. In contrast, the West Fork 16 to 1 watershed showed fewer conservation practices, with one field in particular that was tilled deep in fall and left smooth with no residue cover.

Worst and best case conditions for sediment and nutrient delivery to Lake Coeur d'Alene were seen at West Fork 16 to 1 and Cave Creek respectively. Appendix C compares total nitrogen, total phosphorus and total suspended sediment for the two creeks mentioned above. Figure 2 below, lists a statistical summary of mean and standard deviation for total nitrogen, total phosphorus and total suspended sediment for the discrete sampling sequence for the 1984/1985 water year. Keep in mind that these statistical values are not time weighted or flow weighted. Flow weighting of the values would increase the mean and decrease the standard deviation for all of the parameters.

FIGURE 2
STASTICAL SUMMARY OF NUTRIENT AND SEDIMENT
CONCENTRATIONS BY TRIBUTARY
FOR 1984/1985 WATER YEAR
(mg/L)

TRIBUTARY	TOTAL SEDIMENT		TOTAL NITROGEN		TOTAL NITROGEN	
	MEAN	STD. DEV.	MEAN	STD. DEV.	MEAN	STD. DEV.
Lower cave Ck.	24.7	30.8	8.4	4.7	0.14	0.062
West Fk. 16:1	219	356	7.94	4.02	0.29	~~0.27~~
East Fk. 16:1	140	222.7	11.9	6.7	0.243	0.21

As expected, best management practices in the Cave Creek watershed reduced the delivery of total suspended sediment and total phosphorus, but had very little effect on total nitrogen.

CONCLUSIONS AND RECOMMENDATIONS

Even though the year was very atypical with regards to soil erosion, high concentrations of nitrogen and phosphorus were found in the streams of NE Worley. Nitrogen loading was typically 15 to 30 times the recommended EPA Region X in-stream criteria. Typical phosphorus loadings were 2 to 3 times that of the EPA recommended in-stream criteria.

Knowing the loading that an atypical, low runoff year can produce, it would be expected that a normal year would produce greater amounts of nitrogen, phosphorus and especially sediment. Eutrophication has definitly begun in The NE Worley bays as well as many other bays on Lake Coeur d'Alene. Nutrient loading from land based activities (particularly agriculture in NE Worley bays) in the watersheds of these bays only accelerates the process. Reduction of nutrient loading is the first place to start when trying to extend the useful life (recreational access and aesthetic appeal) of the bays. Any reduction in nutrient loading would be welcome to the situation.

In summary, runoff and sediment delivery from the watersheds was minimal this past water year. Most conditions that typically produce runoff did not develop as expected. For practical purposes, it can be said that infiltration capacity exceeded melt and rainfall for the entire runoff season.

Yearly variation of sediment and nutrient load to the lake is likely to be very large. It is this author's speculation that 90% of the sediment delivered to the lake, may be moved by a 10-50 yr storm event. It is possible that differences between low , typical and high runoff years may be related by orders of magnitude. (ie. A low year being 1/10 to 1/100th of a typical year and a high year being 10 to 100 times that of a typical year.) With this in mind, pre and post BMP implementation studies must be carefully designed in order to obtain valid results. Many years of record are needed in order to have any statistical significance.

Placement of sediment collection vessels in a representative pattern on the bottom of the bays that could be retreived in future years could be of value. No other studies of this nature are known at this time, but could prove useful for determining the actual physical accumulation of sediment in the bays. This could estimate the sedimentation process, but would not document the nutrient load to the lake.

Physical accumulation of sediment in the bays could also be measured by stratigraphic correlation of core samples. Use of the 1981 eruption of Mt. St. Helens as a stratigraphic horizon would help determine the average yearly accumulation of sediment since 1981. This is being attempted in a pilot study being conducted by Myron Molnau at University of Idaho. Actual coring has taken place and results will be available in the near future.

LITERATURE CITED

1. Meckel Engineering, Brown and Caldwell Engineers Kootenai County Lakes Master Plan, Kootenai County Engineering and Planning Departments. May 1983

2. IDHW, Idaho Water Quality Status Report, Idaho Department of Health and Welfare, Division of Environment, Water Quality Bureau; 1984

3. Kootenai-Shoshone Soil Conservation District, Preliminary Investigation of North East Worley Watershed Project, Coeur d'Alene, Idaho 1980

4. Gutengerg, Stewart A., USGS, Water Resources Division Sandpoint, Idaho 1985

APPENDIX A

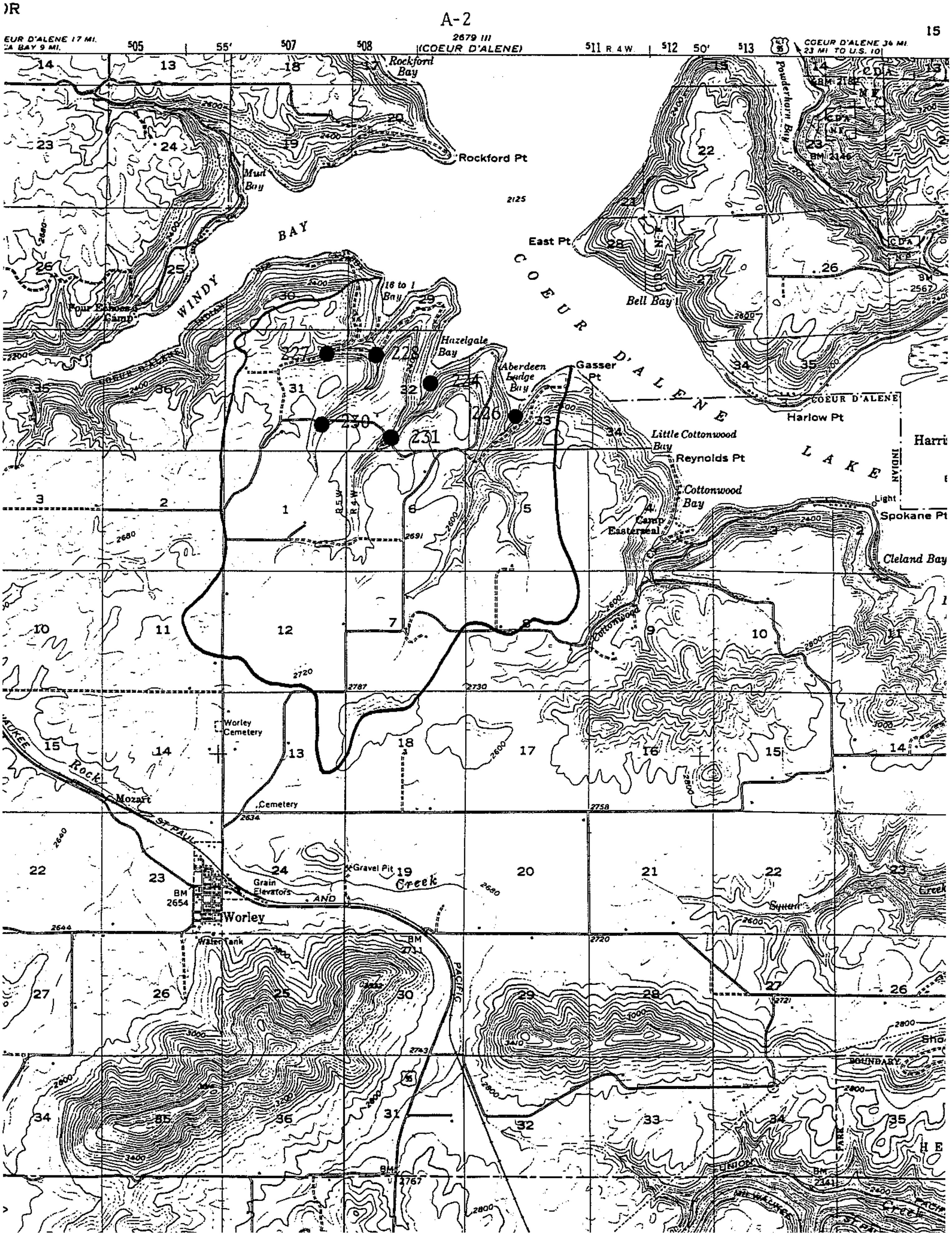
NORTHEAST WORLEY PROJECT SAMPLING SITES
INTENSIVE SURVEY NO. 841605

STORET NO.	LOCATION
2000222	Lake CDA-Wolf Lodge Bay
2000223	Cave bay-200 meters from mouth, just off docks
2000224	Cave Creek-100 meters upstream from mouth
2000225	16 to 1 Bay at mid-bay 200 meters from mouth
2000226	16 to 1 Creek at mouth (Inaccessible-not used)
2000227	West Fork 16 to 1 -100 meters above road culvert on Cave Bay Road
2000228	East Fork 16 to 1 Creek at Cave Bay road
2000229	Mowry Bay-mid bay, 200 meters from mouth
2000230	East Fork 16 to 1 at Mowry Bay Road
2000231	Cave Creek at Mowry Bay Road
2000232	Open water control-midway between Rockford and East Points
2000233	Lake CDA-mouth of CDA River

See Appendix D for a map of the lake sampling sites

STREAM SAMPLING LOCATIONS

A-2



APPENDIX B

LOADING DATA FOR STREAM SAMPLING SITES

The following charts include the basic loading data for total nitrogen, total phosphorus and total suspended sediment. These loading calculations are for the lower Cave Creek site, the lower East Fork 16 to 1 Creek and the West Fork 16 to 1. Calculations were done using MIRCRSOFT MULTIPLAN electronic spreadsheet. Conditions of flow and water quality at any sampling time are assumed to continue unchanged until the next sampling time.

	1	2	3	4	5	6
1						
2	TOTAL PHOSPHORUS LOADING FOR LOWER EAST FORK OF 16:1 CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	2/28/85	3/7/85	7	0.1	1.02	1.746444
6	3/7/85	3/23/85	16	0.09	0.18	0.6340032
7	3/23/85	3/24/85	1	0.17	1.56	0.6486792
8	3/24/85	3/28/85	4	0.26	5.62	14.296381
9	3/28/85	4/1/85	1	0.22	1.33	0.7156996
10	4/1/85	4/2/85	1	0.7	9.24	15.820728
11	4/2/85	4/3/85	1	0.16	4.8	1.878528
12						0
13						0
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	35.740463
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	TOTAL PHOSPHORUS LOADING FOR WEST FORK 16:1 CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	31	0.07	0.1	0.530782
6	2/22/85	2/28/85	6	0.16	0.69	1.6202304
7	2/28/85	3/7/85	7	0.13	1.51	3.3610486
8	3/7/85	3/23/85	16	0.1	0.65	2.54384
9	3/23/85	3/24/85	1	0.18	2.99	1.3164372
10	3/24/85	3/28/85	4	0.82	10.36	83.117037
11	3/28/85	4/1/85	4	0.23	2.04	4.5906528
12	4/1/85	4/2/85	1	0.69	12.26	20.691692
13	4/2/85	4/3/85	1	0.22	5.02	2.7013624
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	120.47308
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	TOTAL PHOSPHORUS LOADING FOR LOWER CAVE CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	32	0.07	0.3	1.643712
6	2/22/85	2/28/85	6	0.08	0.85	0.997968
7	2/28/85	3/7/85	7	0.17	5.24	15.252278
8	3/7/85	3/19/85	12	0.09	3.15	8.321292
9	3/19/85	3/23/85	4	0.15	13.75	20.1795
10	3/23/85	3/24/85	1	0.12	7.54	2.2131408
11	3/24/85	3/28/85	4	0.19	20.59	38.275986
12	3/28/85	4/1/85	4	0.13	5.17	6.5758264
13	4/1/85	4/2/85	1	0.28	17.87	12.238806
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29						0
30					TOTAL	105.69851
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	TOTAL NITRATE/NITRITE LOADING FOR LOWER CAVE CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	32	1.17	0.3	27.473472
6	2/22/85	2/28/85	6	4.53	0.85	56.509938
7	2/28/85	3/7/85	7	11.2	5.24	1004.8559
8	3/7/85	3/19/85	12	18.8	3.15	1738.2254
9	3/19/85	3/23/85	4	8.06	13.75	1084.3118
10	3/23/85	3/24/85	1	7.14	7.54	131.68188
11	3/24/85	3/28/85	4	6.96	20.59	1402.1098
12	3/28/85	4/1/85	4	8	5.17	404.66624
13	4/1/85	4/2/85	1	6.24	17.87	272.75052
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL LOADIN	6122.585
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	TOTAL NITRATE/NITRITE LOADING FOR WEST FORK OF 16:1 CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	31	4.64	0.1	35.183264
6	2/22/85	2/28/85	6	4.98	0.69	50.429671
7	2/28/85	3/7/85	7	7.2	1.51	186.15038
8	3/7/85	3/23/85	16	14.7	0.65	373.94448
9	3/23/85	3/24/85	1	6.23	2.99	45.563354
10	3/24/85	3/28/85	4	5.91	10.36	599.05084
11	3/28/85	4/1/85	4	6.68	2.04	133.32852
12	4/1/85	4/2/85	1	4.69	12.26	140.64353
13	4/2/85	4/3/85	1	5.17	5.02	63.482016
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	1627.7761
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

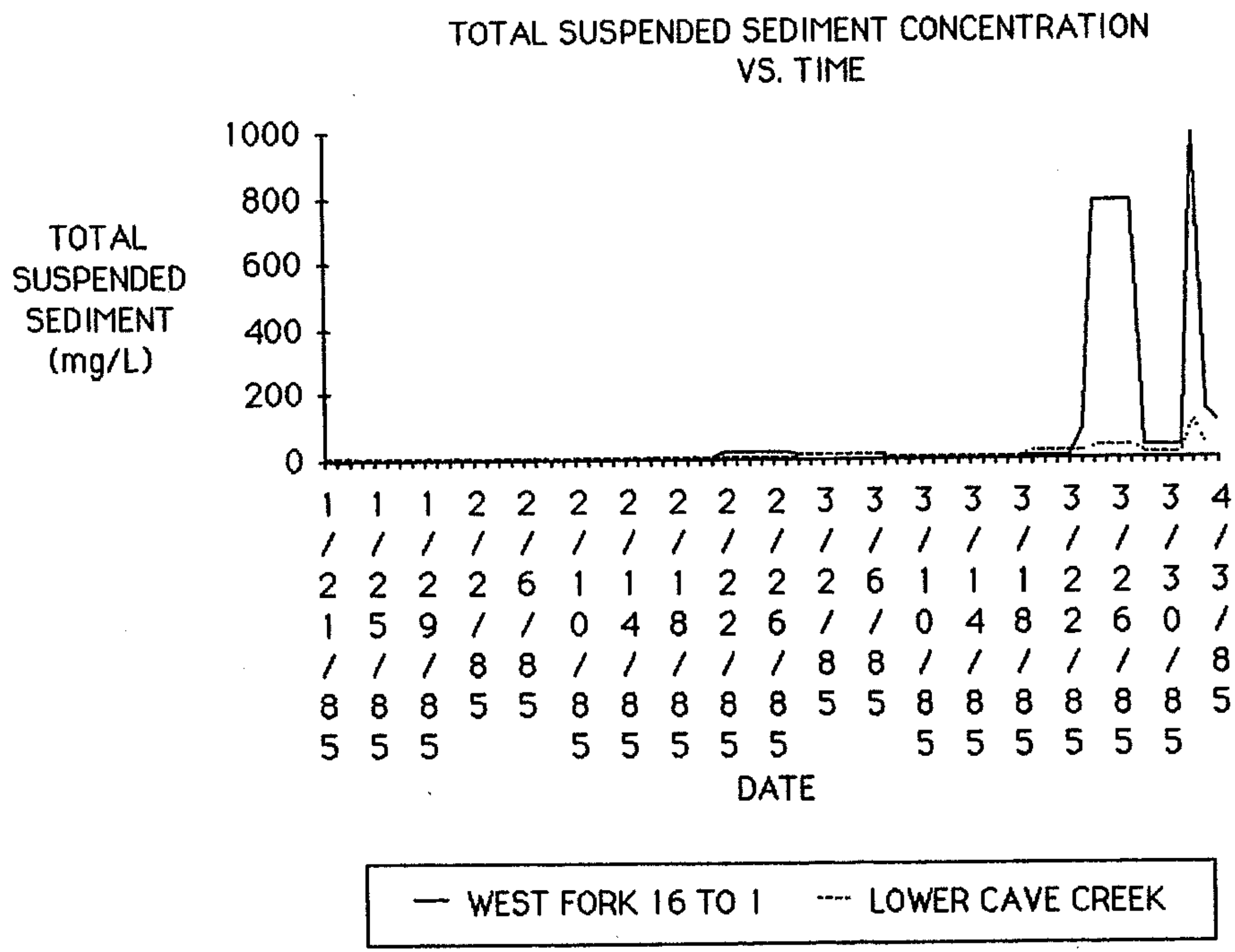
	1	2	3	4	5	6
1	TOTAL NITRATE/NITRITE LOADING FOR LOWER/EAST FORK 16:1 CREEK					
2	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
3	2/28/85	3/7/85	7	12.2	1.02	213.06617
4	3/7/85	3/23/85	16	25.4	0.18	178.92979
5	3/23/85	3/24/85	1	7.43	1.56	28.351097
6	3/24/85	3/28/85	4	6.59	5.62	362.35827
7	3/28/85	4/1/85	1	11.6	1.33	37.736888
8	4/1/85	4/2/85	1	5.14	9.24	116.16935
9	4/2/85	4/3/85	1	9.2	4.8	108.01536
10						0
11						0
12						0
13						0
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27					TOTAL	1044.6269
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	SEDIMENT LOADING FOR LOWER CAVE CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	32	1	0.3	23.4816
6	2/22/85	2/28/85	6	6	0.85	74.8476
7	2/28/85	3/7/85	7	12	5.24	1076.6314
8	3/7/85	3/19/85	12	3	3.15	277.3764
9	3/19/85	3/23/85	4	24	13.75	3228.72
10	3/23/85	3/24/85	1	19	7.54	350.41396
11	3/24/85	3/28/85	4	34	20.59	6849.387
12	3/28/85	4/1/85	4	12	5.17	606.99936
13	4/1/85	4/2/85	1	112	17.87	4895.5222
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	17383.38
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

	1	2	3	4	5	6
1						
2	SEDIMENT LOADING FOR WEST FORK OF 16:1 CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	1/21/85	2/22/85	31	1	0.1	7.5826
6	2/22/85	2/28/85	6	24	0.69	243.03456
7	2/28/85	3/7/85	7	15	1.51	387.8133
8	3/7/85	3/23/85	16	8	0.65	203.5072
9	3/23/85	3/24/85	1	88	2.99	643.59152
10	3/24/85	3/28/85	4	785	10.36	79569.358
11	3/28/85	4/1/85	4	32	2.04	638.69952
12	4/1/85	4/2/85	1	982	12.26	29448.177
13	4/2/85	4/3/85	1	148	5.02	1817.2802
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	112959.04
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

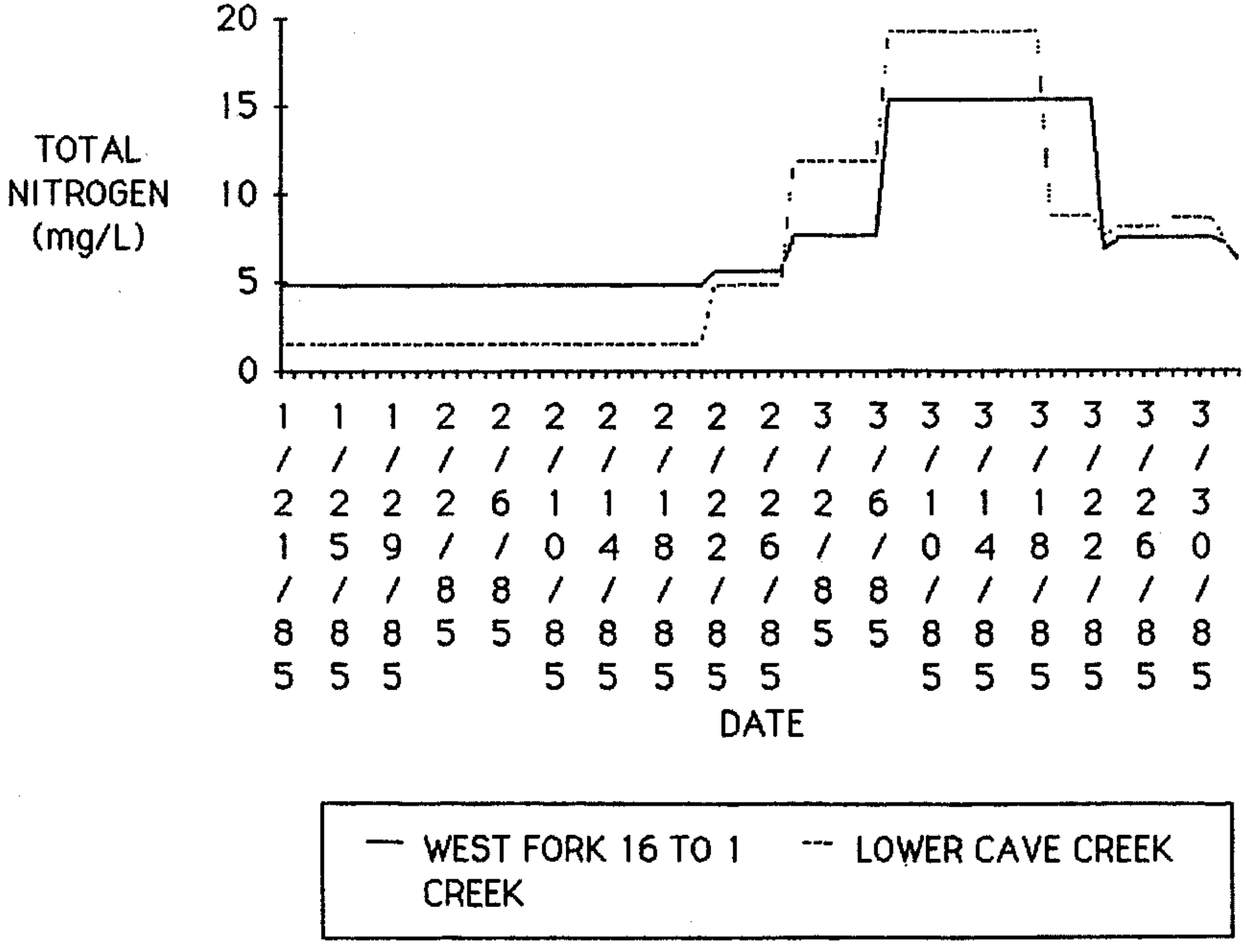
	1	2	3	4	5	6
1						
2	SEDIMENT LOADING FOR LOWER EAST FORK 16:1 CREEK					
3						
4	DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
5	2/28/85	3/7/85	7	4	1.02	69.85776
6	3/7/85	3/23/85	16	11	0.18	77.48928
7	3/23/85	3/24/85	1	67	1.56	255.65592
8	3/24/85	3/28/85	4	128	5.62	7038.2182
9	3/28/85	4/1/85	1	30	1.33	97.5954
10	4/1/85	4/2/85	1	679	9.24	15346.106
11	4/2/85	4/3/85	1	120	4.8	1408.896
12						0
13						0
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0
22						0
23						0
24						0
25						0
26						0
27						0
28						0
29					TOTAL	24293.819
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

APPENDIX C



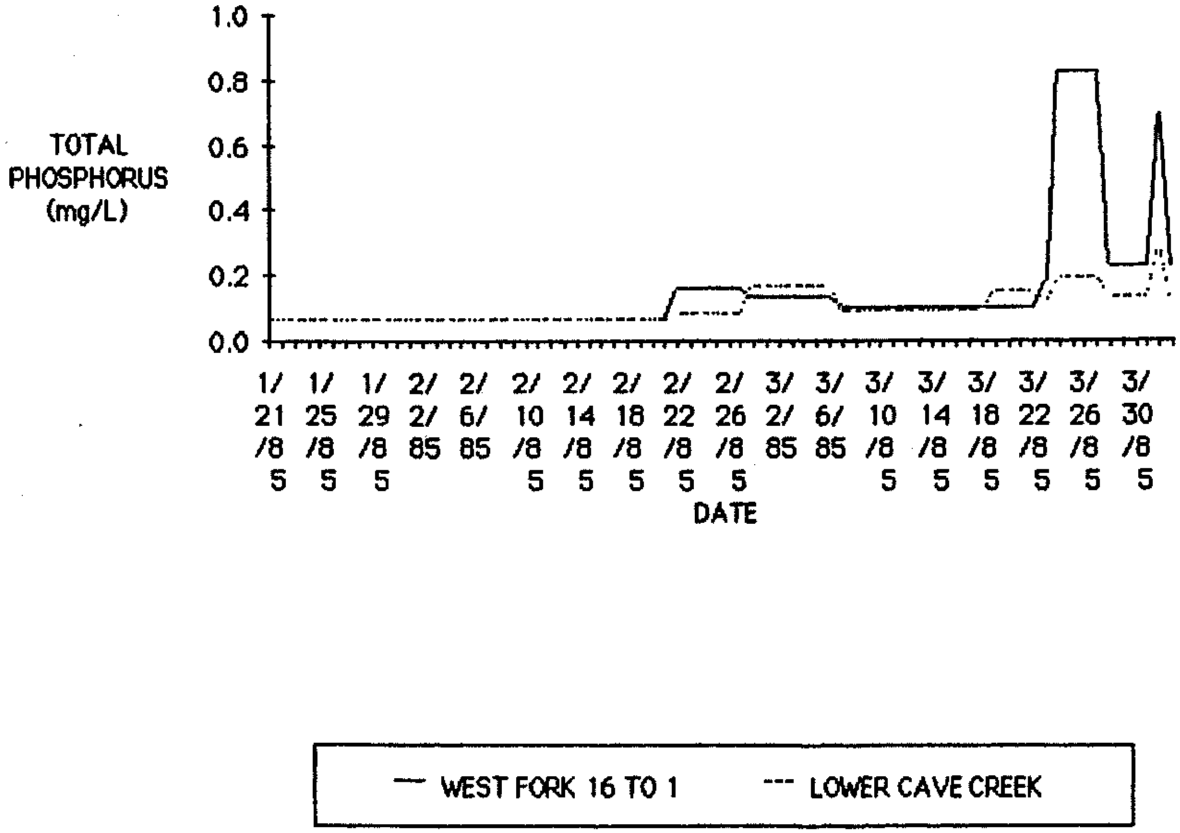
TOTAL SUSPENDED SEDIMENT CONCENTRATION
VS. TIME
TOTAL SUSPENDED SEDIMENT (mg/L)
1000
800
600
400
200
0
1/21/85
1/25/85
1/29/85
2/2/85
2/6/85
2/10/85
2/14/85
2/18/85
2/22/85
2/26/85
3/2/85
3/6/85
3/10/85
3/14/85
3/18/85
3/22/85
3/26/85
3/30/85
4/3/85
DATE
WEST FORK 16 TO 1
LOWER CAVE CREEK

TOTAL NITROGEN CONCENTRATION VS. TIME



EPA REGION X WATER QUALITY INDEX FOR TOTAL NITROGEN IS 0.5 mg/L

TOTAL PHOSPHORUS VS. TIME



EPA REGION X WATER QUALITY INDEX FOR TOTAL PHOSPHORUS IS 0.05 mg/L

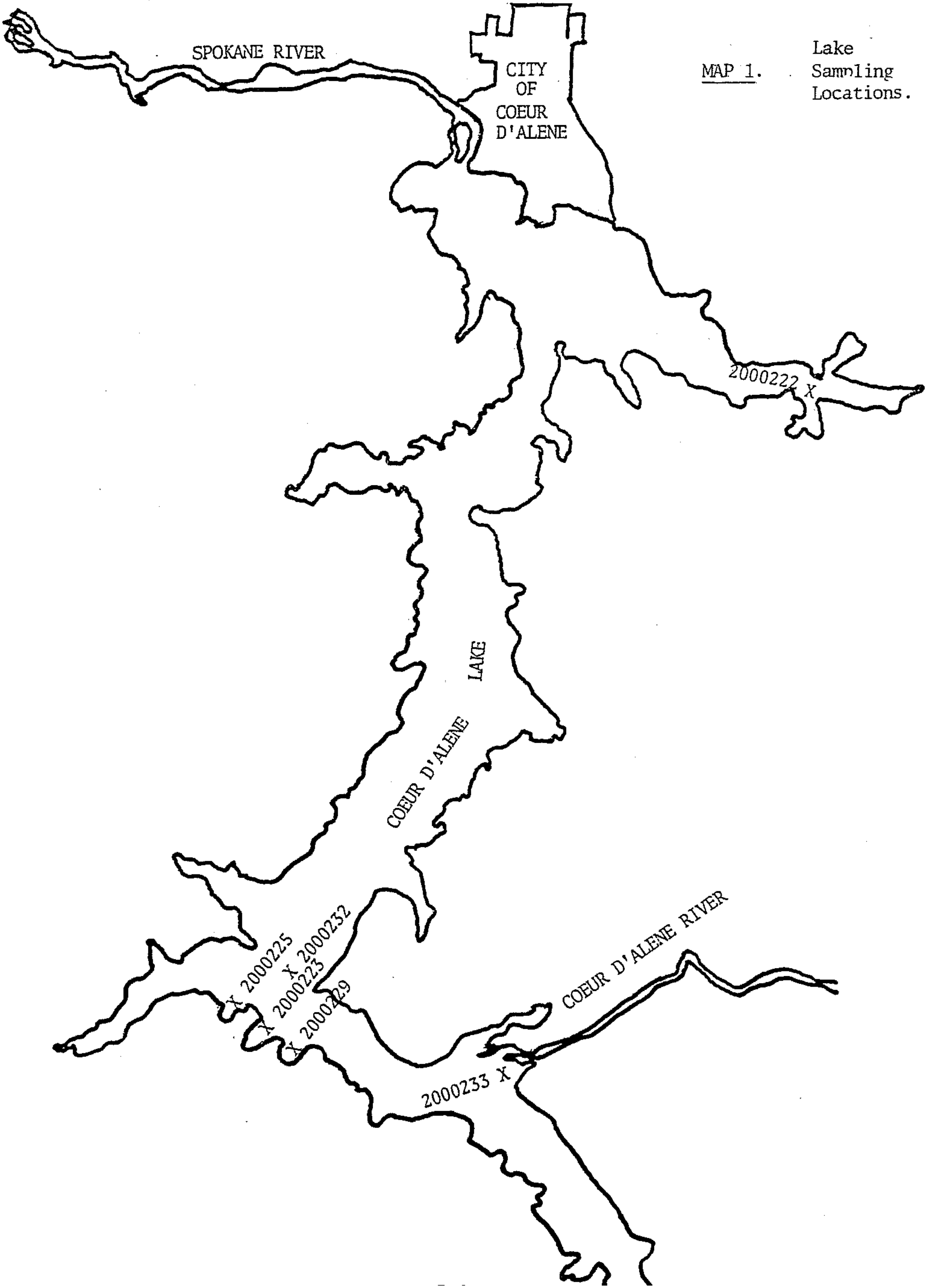
APPENDIX D

Lake Coeur d'Alene Water Quality

Map 1 shows the location of lake sampling sites used throughout and on occasion during the study. Figures 1 - 27 and Table 1 - 12 present the results of analyses performed on composite samples of the euphotic zone. A report of the results of algal bioassays performed by the U. S. EPA - Environmental Research Laboratory (Corvallis) for the determination of algal growth potential is included at the end of this section.

Analysis parameters included profiles of the water column for dissolved oxygen, temperature, pH and specific conductivity, and general water chemistry parameters. Sampling and analysis procedures, however, emphasized the algal nutrients nitrogen and phosphorus. Concentrations of zinc, lead, mercury and cadmium were assessed. Bacteriological water quality was also determined.

Results show that no change in lake water quality directly attributable to agricultural runoff was detected in 16:1, Cave and Mowry Bays; this was not unexpected in view of the magnitude of dilution of the agricultural runoff upon entry into Coeur d'Alene Lake. Results also show that zinc levels in lake waters are probably high enough to inhibit algal growth, and that the Coeur d'Alene and St. Joe Rivers profoundly influence lake water quality, especially during spring runoff.



MAP 1. Lake Sampling Locations.

Figure 2. 1984 Secchi Disk Transparencies

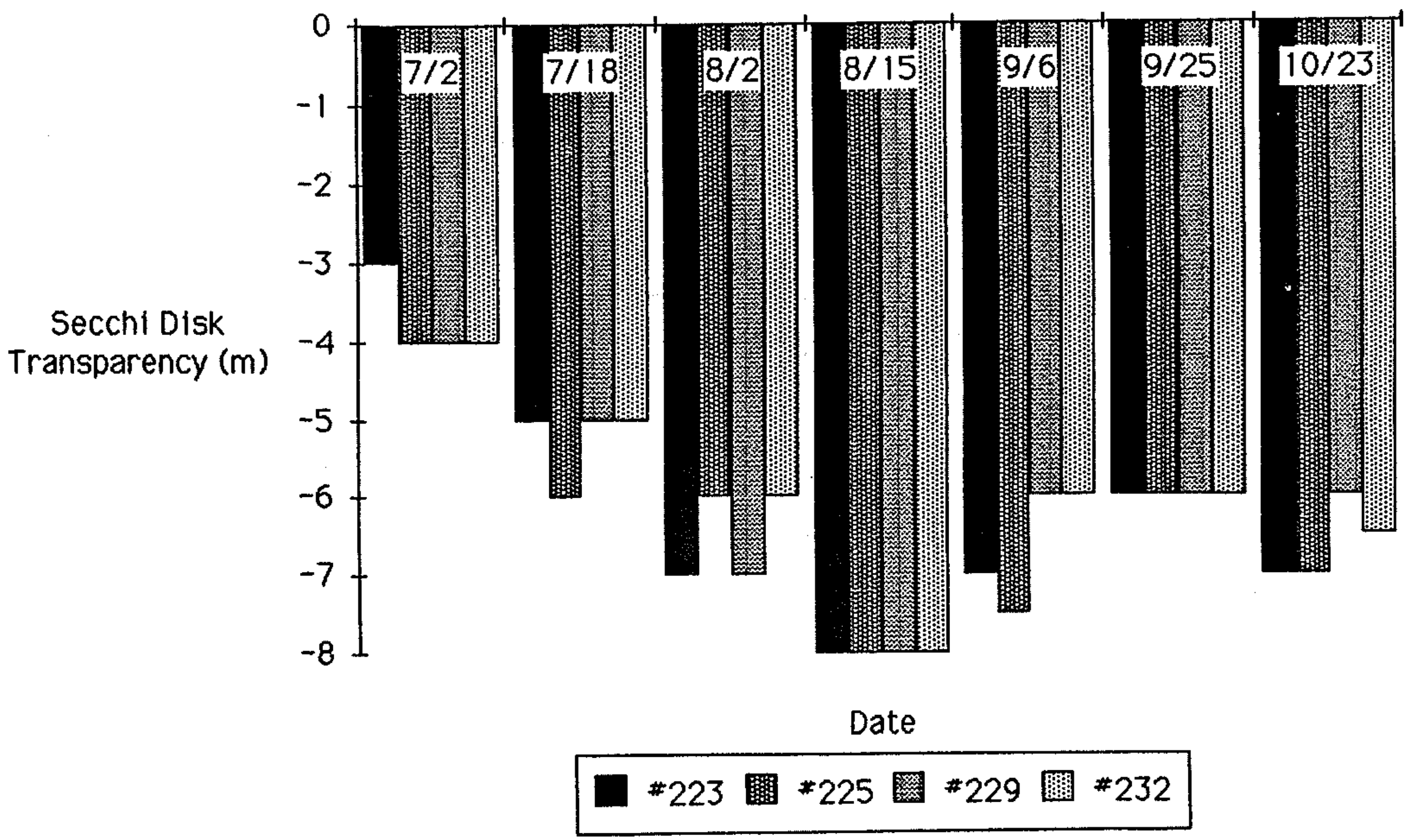


Figure 2. Average 1984 Phosphorus Concentrations by Station

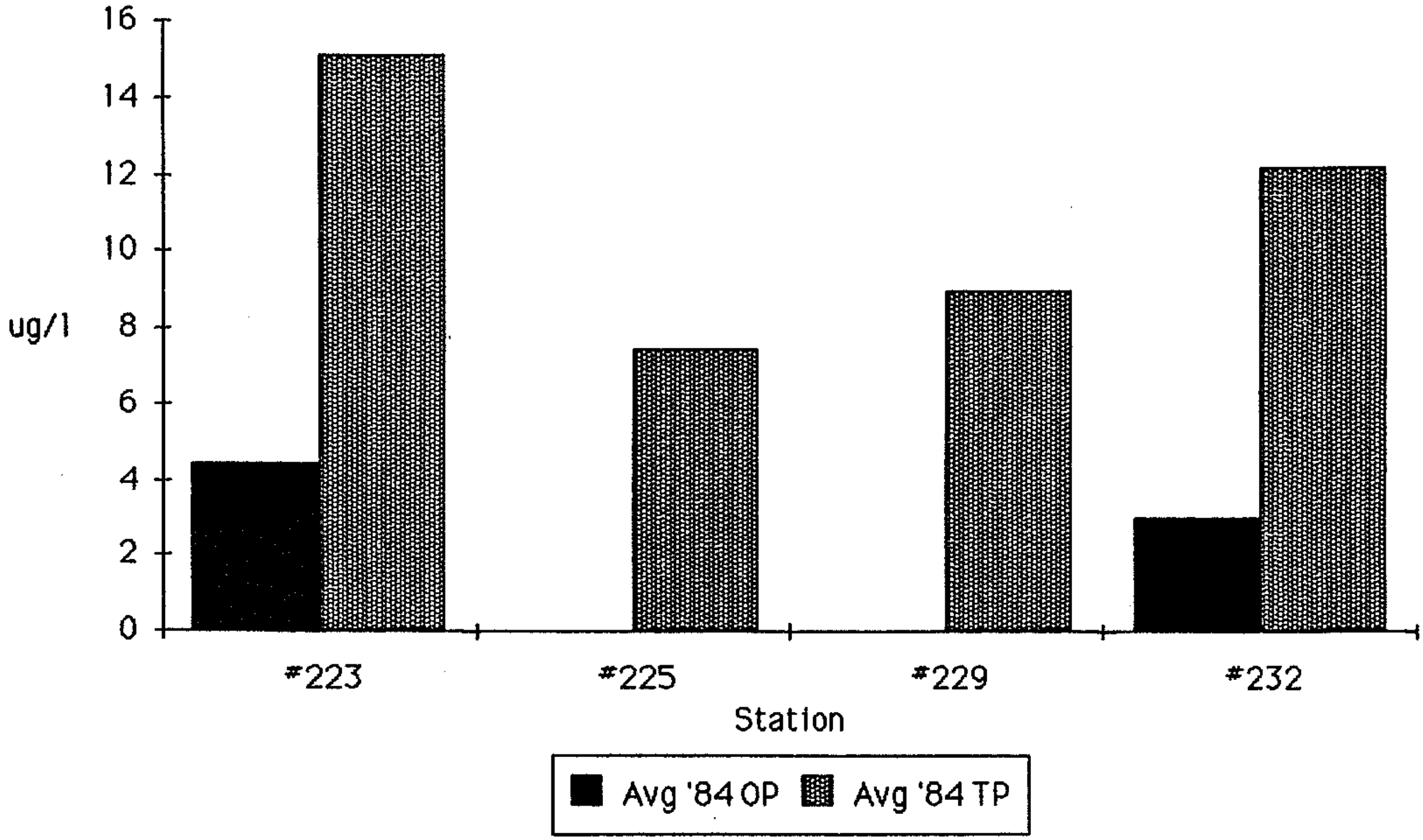


Figure 3. Average 1984 Nitrogen Concentrations by Station

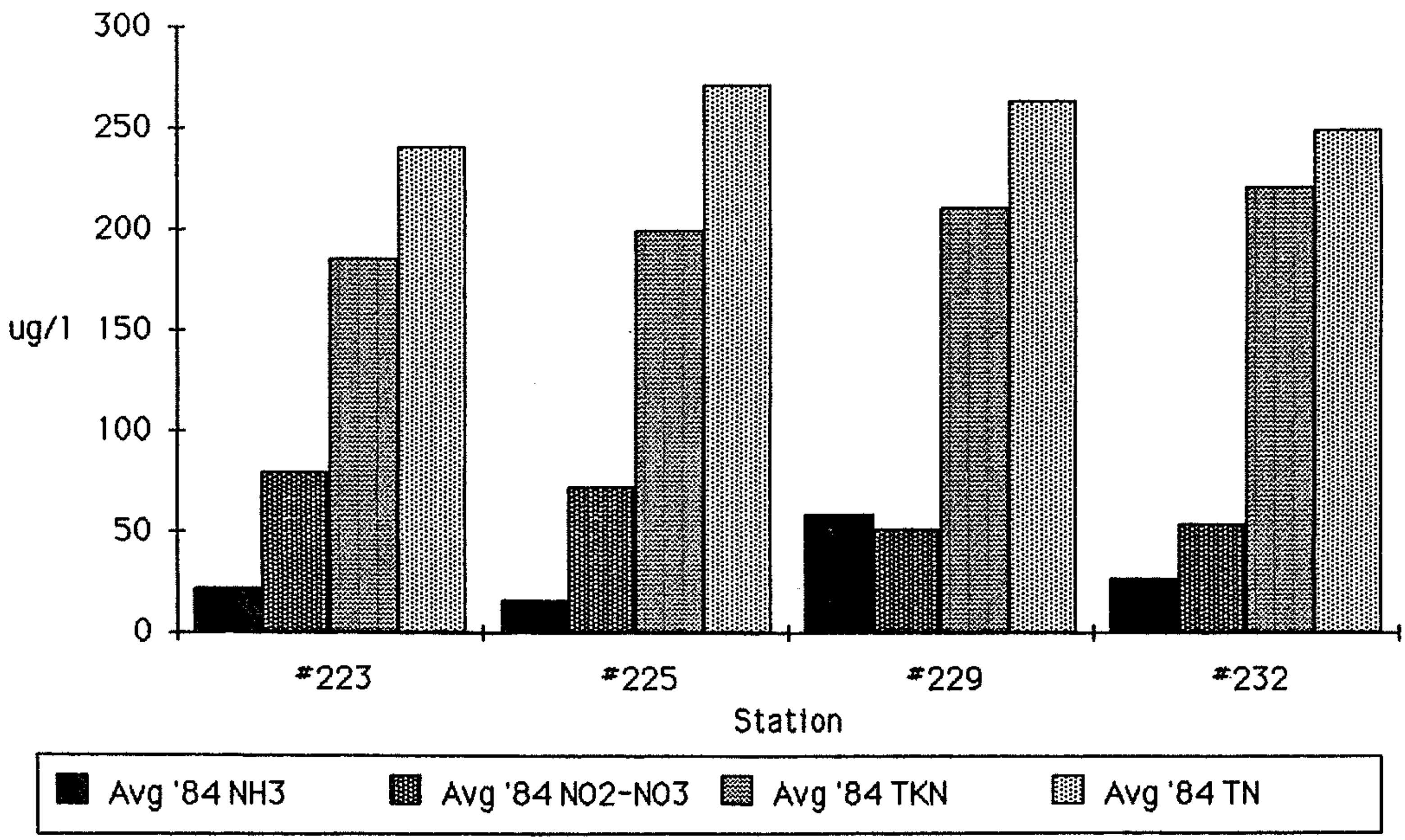
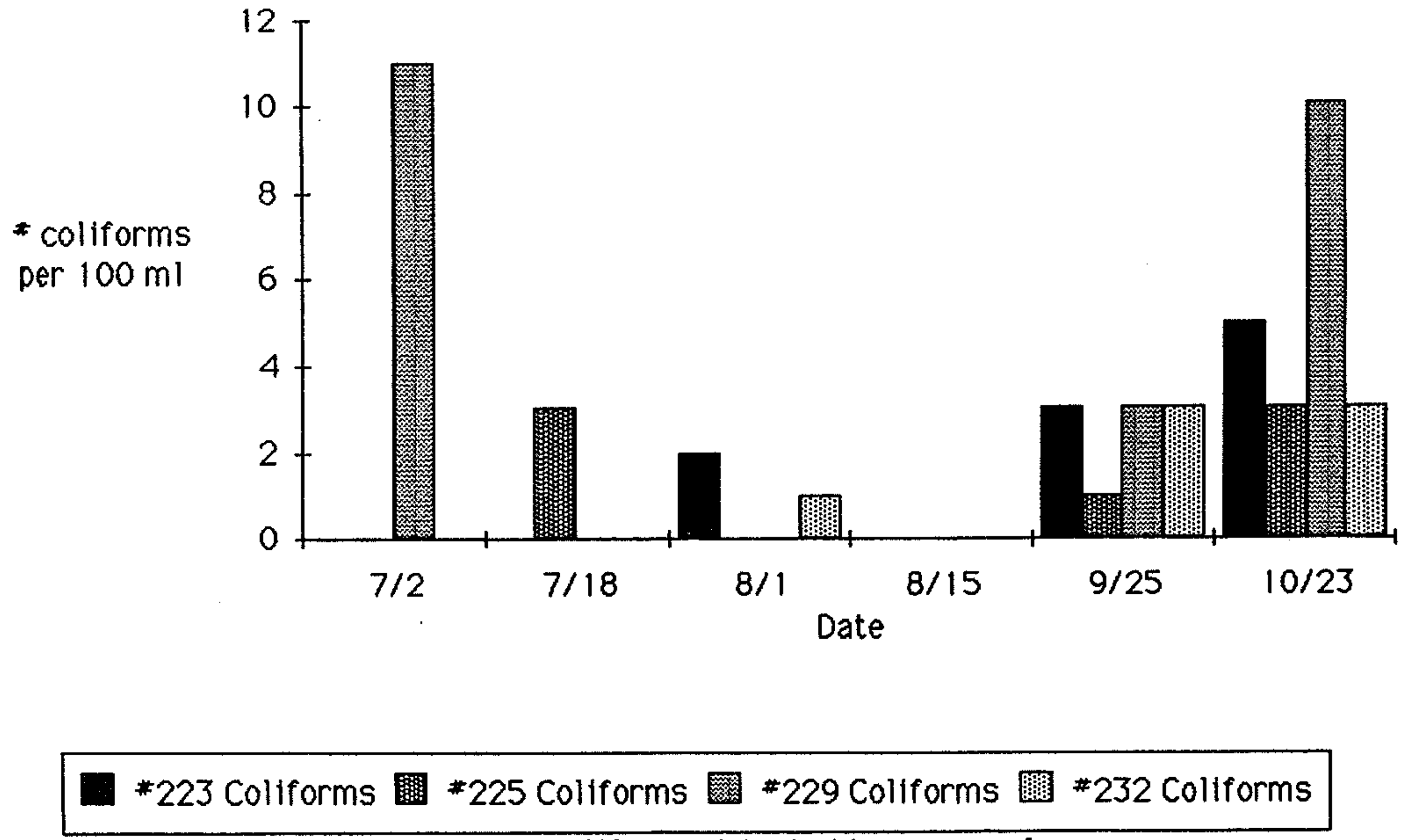


Figure 4. 1984 Coliform Bacteria / 100 mls



NOTE: No fecal coliforms detected in any sample.

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Figure 5. Zinc Concentrations in Coeur d'Alene Lake - 1985

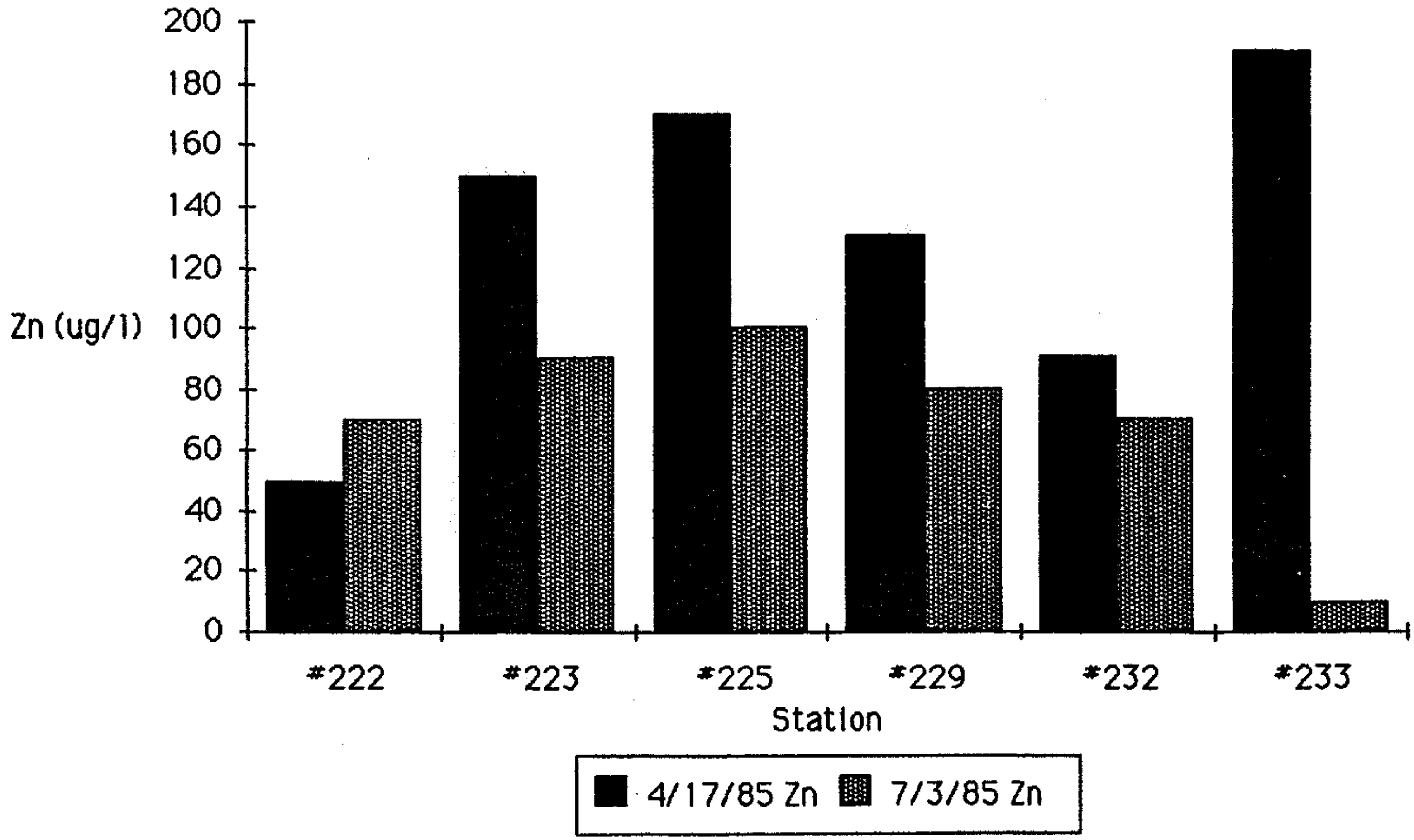


Figure 6. Station #2000223 Phosphorus Concentrations

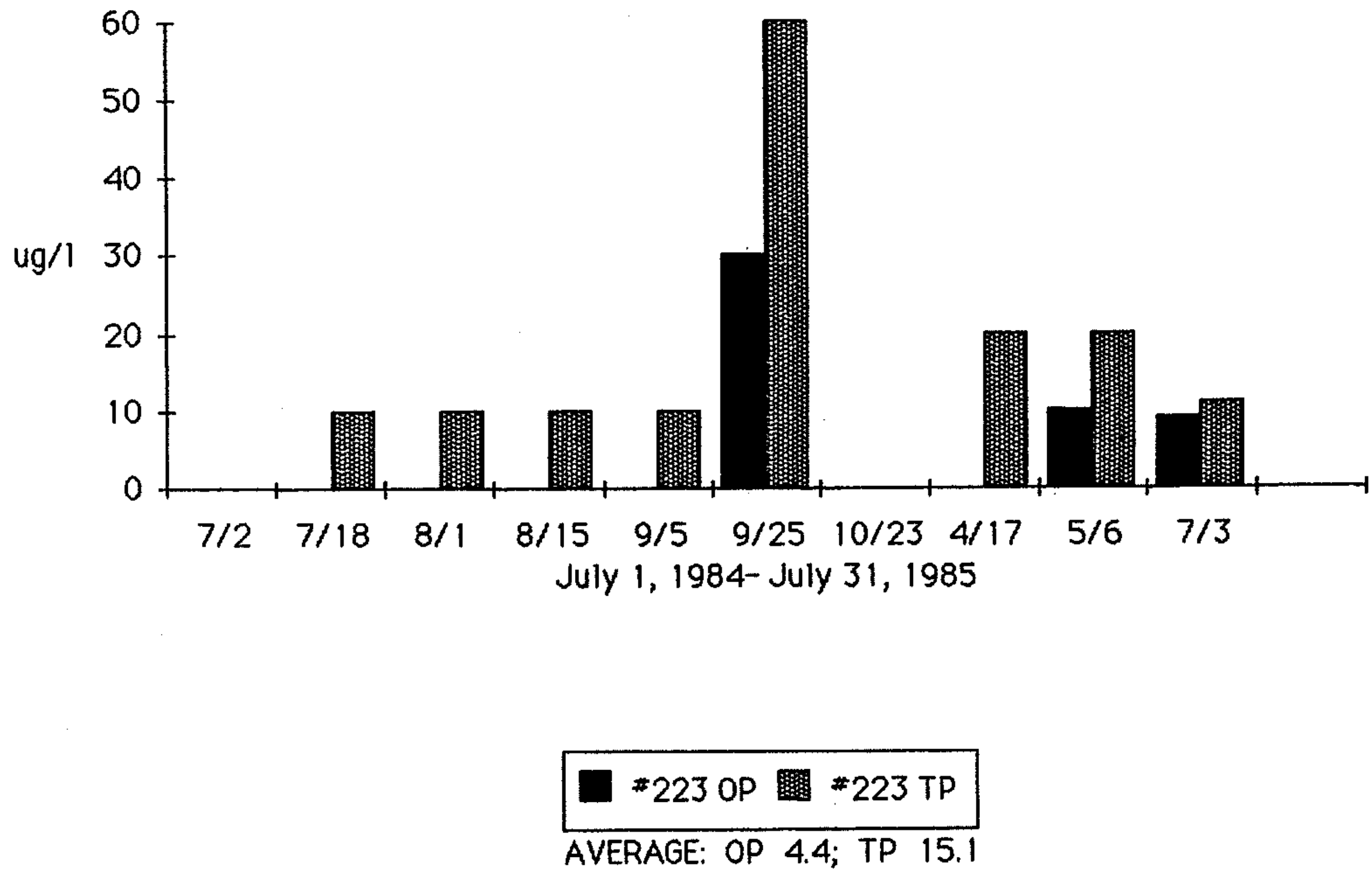
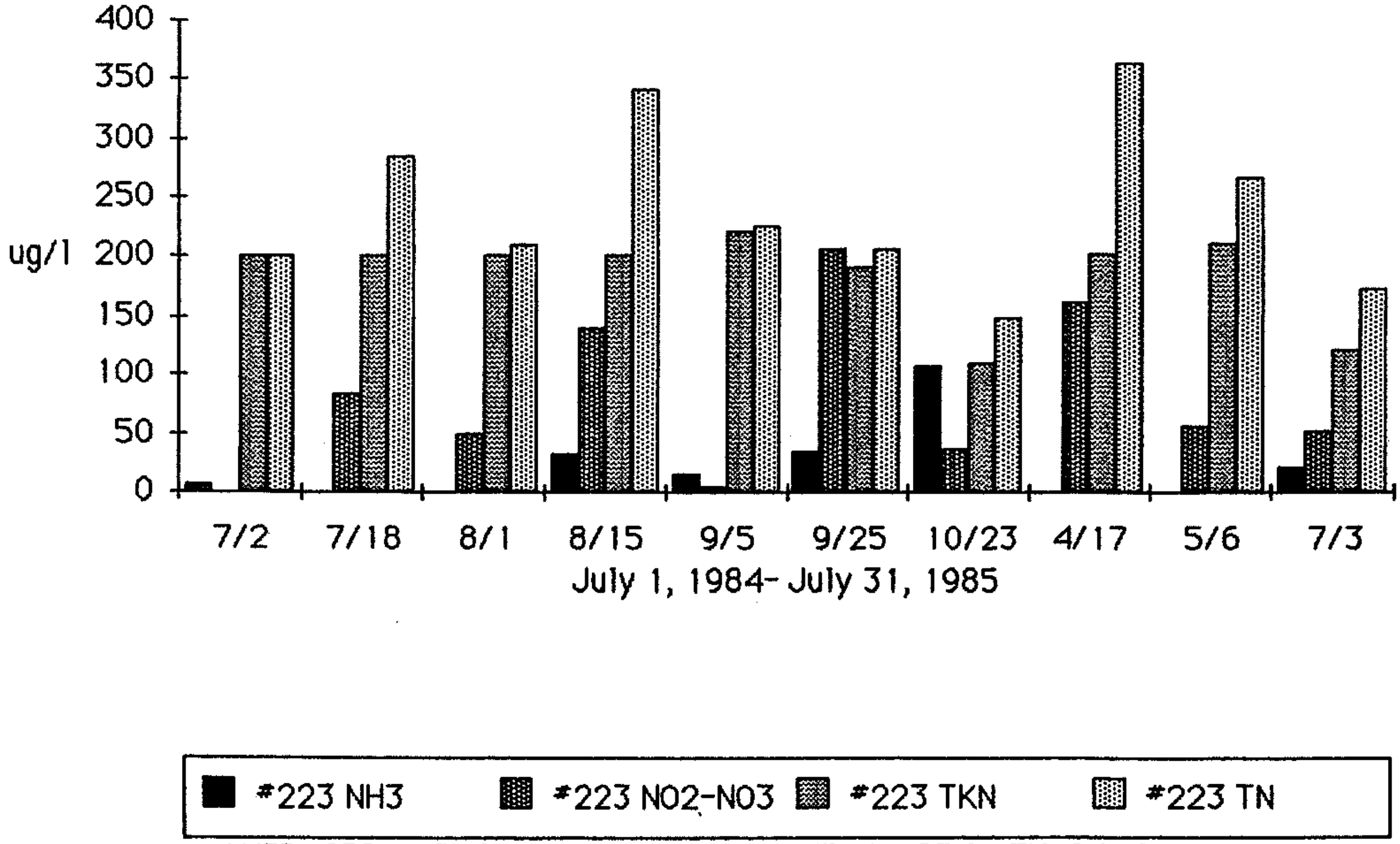
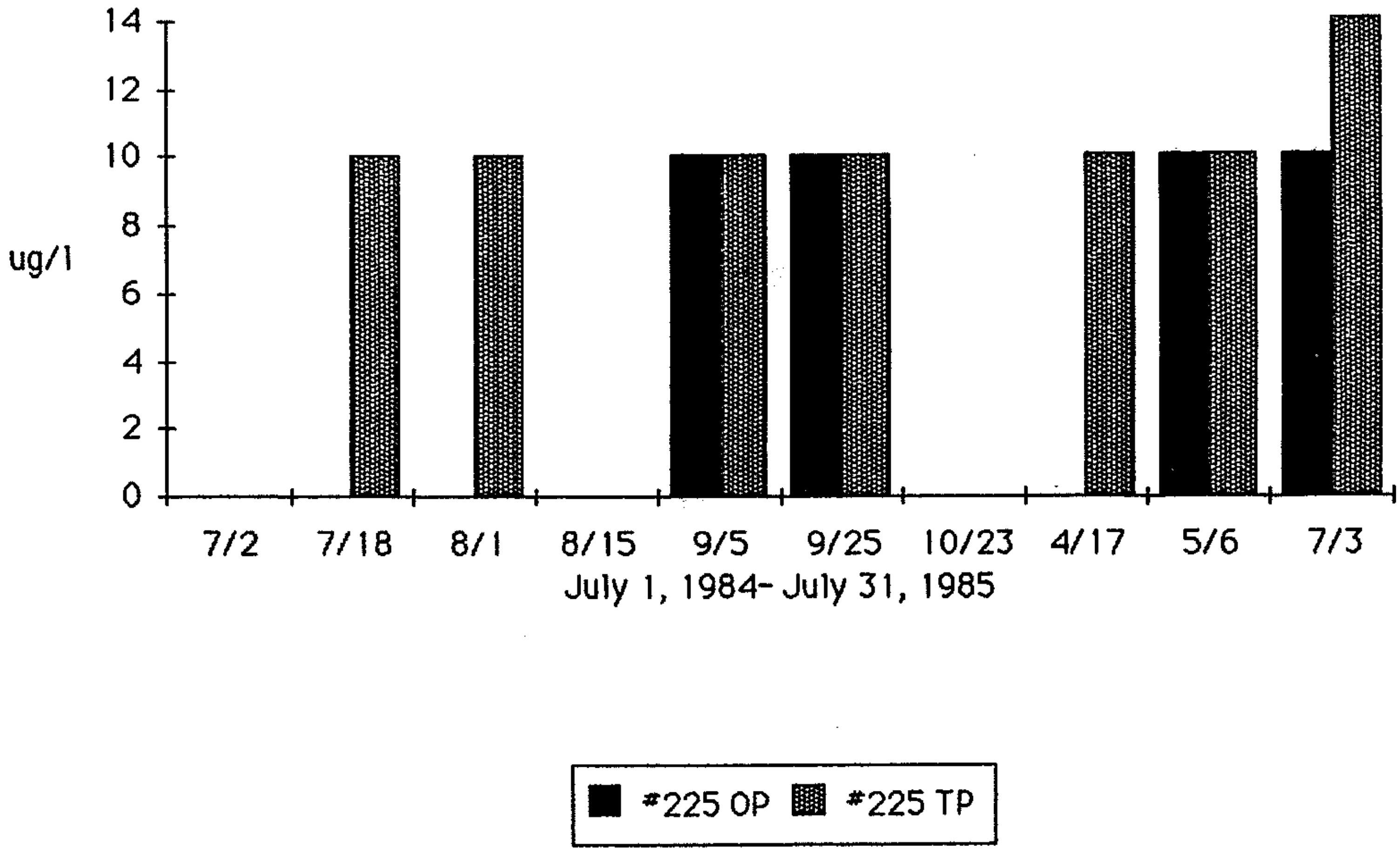


Figure 7. Station #2000223 Nitrogen Concentrations



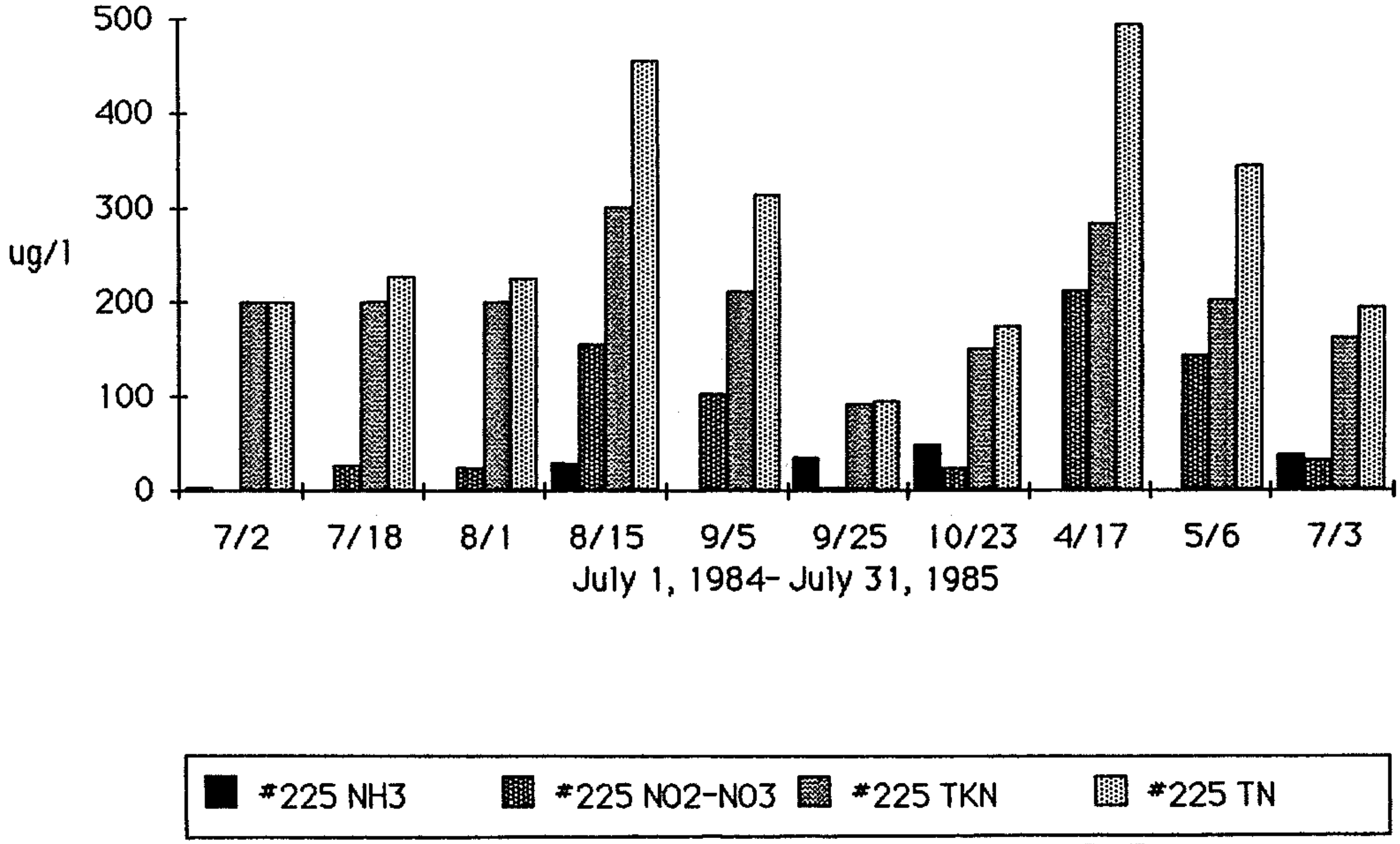
AVERAGES: NH3 21.6; NO2-NO3 79.0; TKN 185.0; TN 241.0

Figure 8. Station #2000225 Phosphorus Concentrations



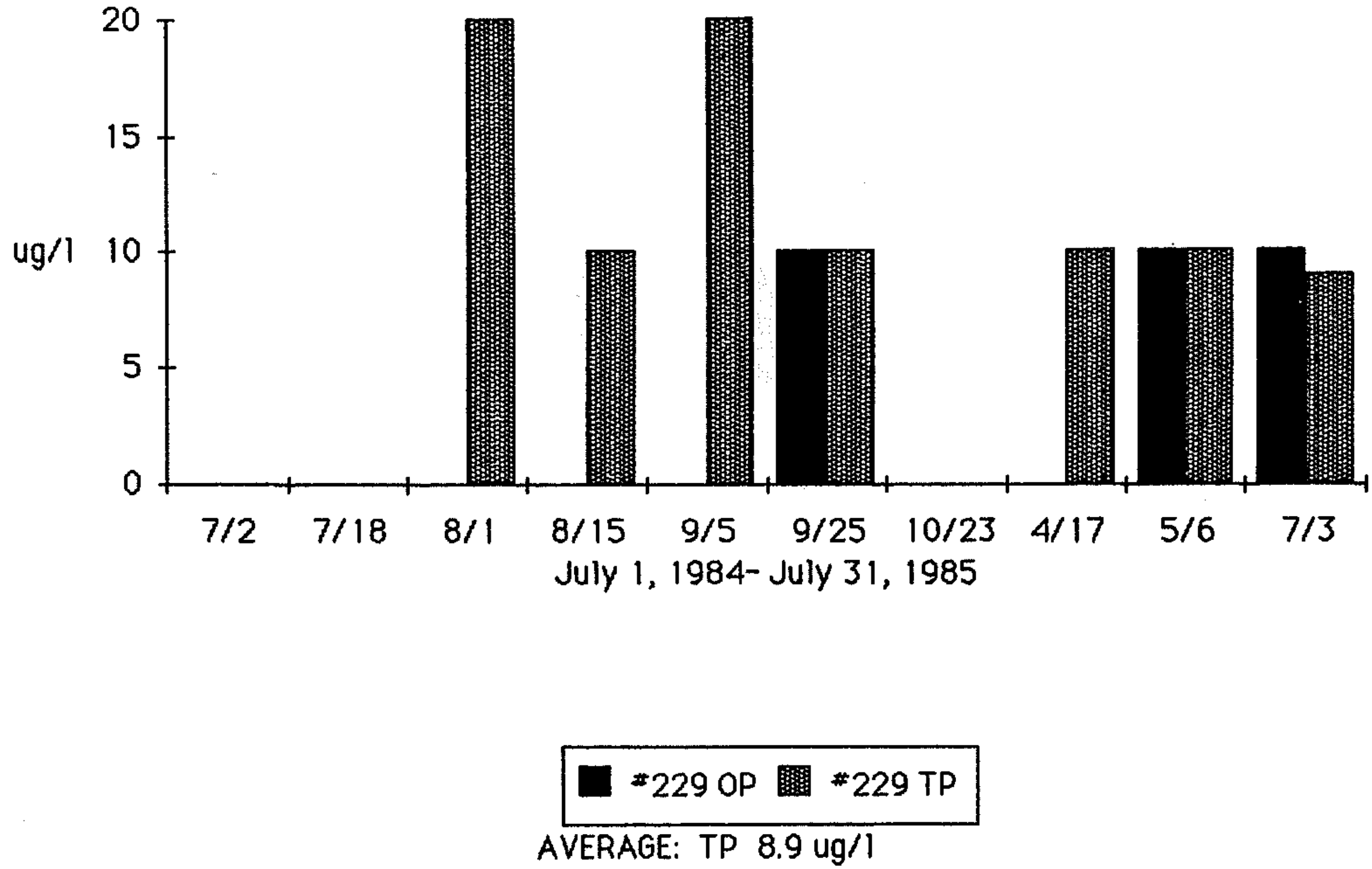
AVERAGE: TP 7.4 ug/l

Figure 9. Station #2000225 Nitrogen Concentrations



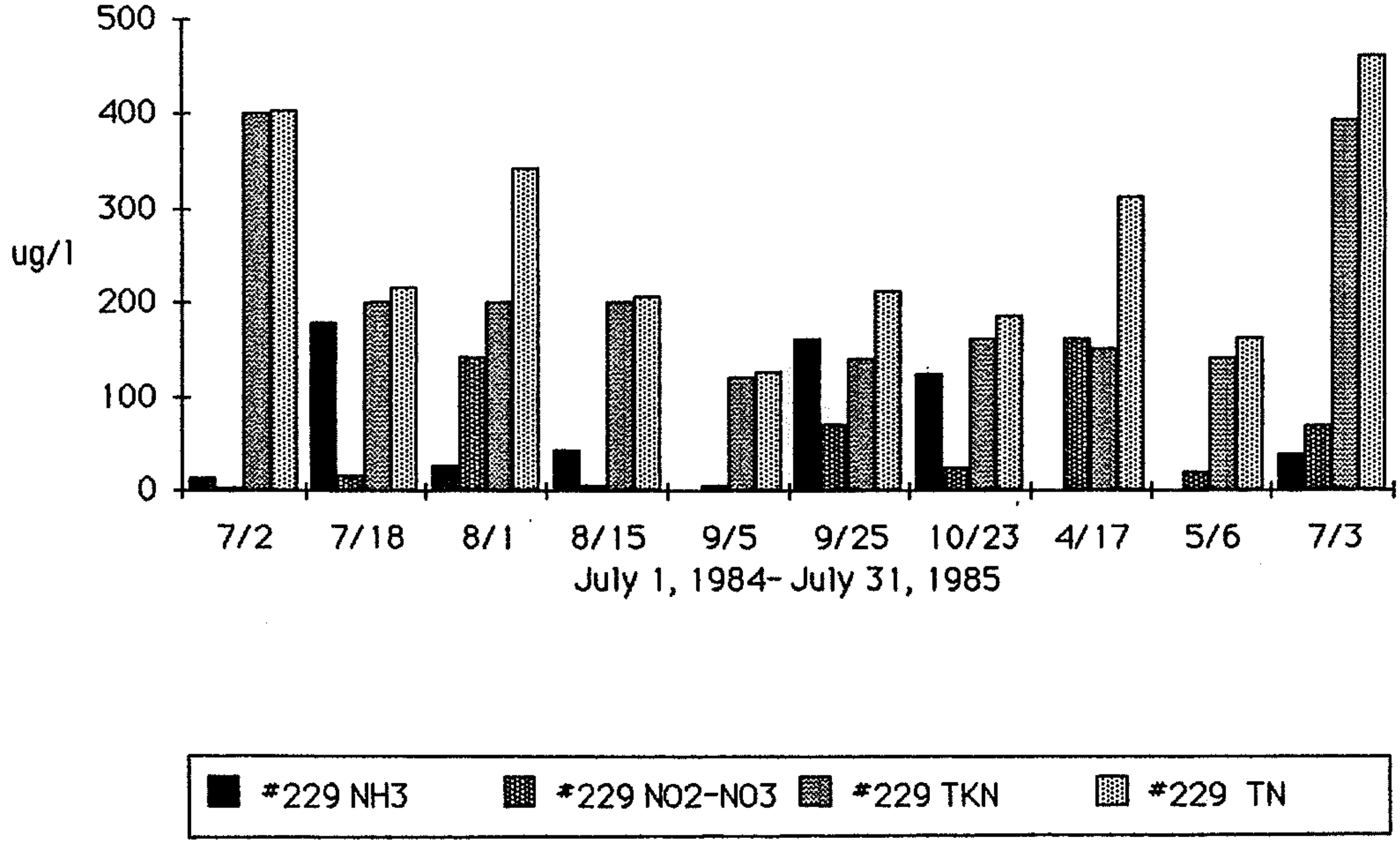
AVERAGE: NH3 15.4; NO2-NO3 72.3; TKN 199.0; TN 271.3

Figure 10. Station #2000229 Phosphorus Concentrations



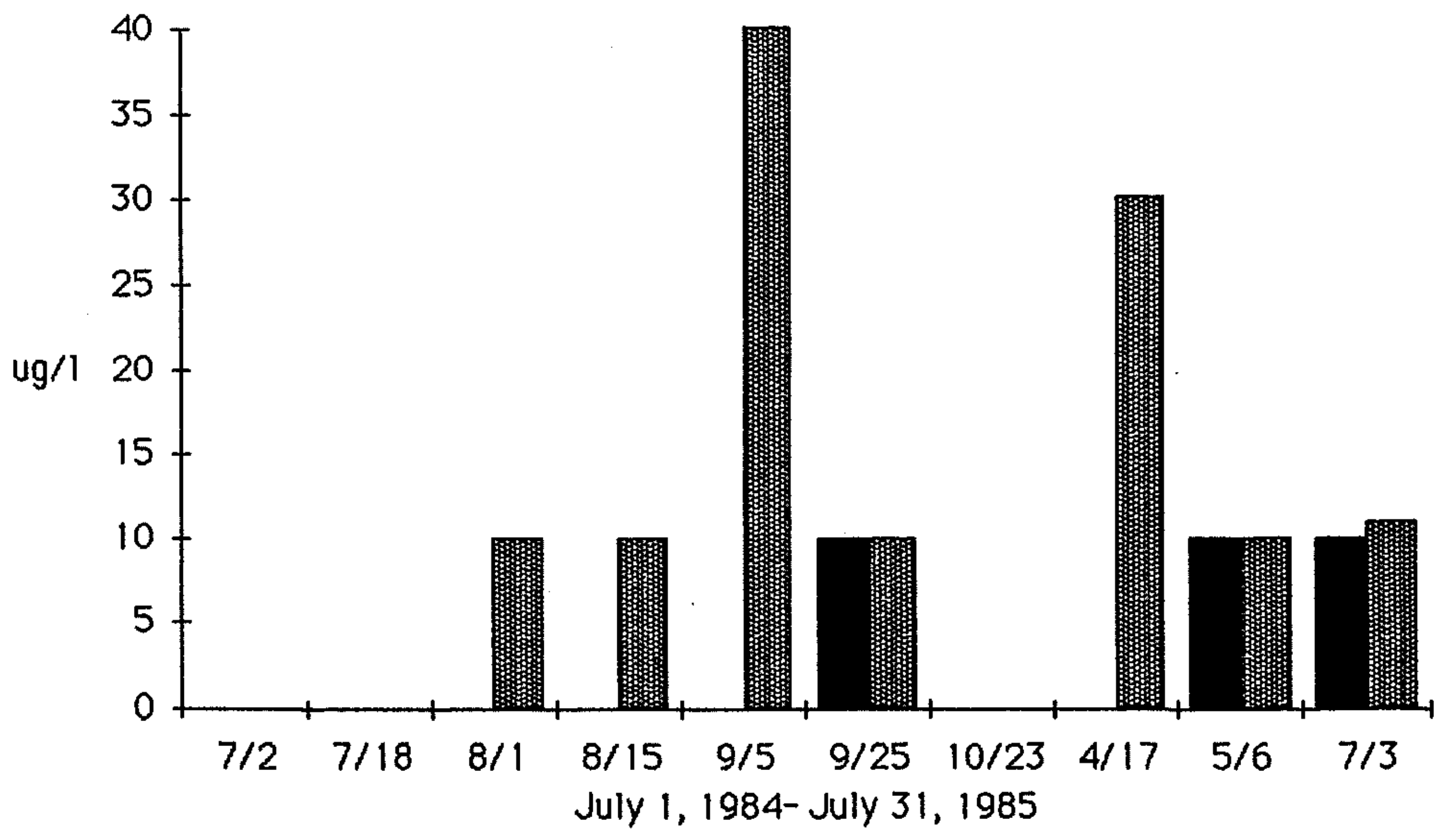
D-12

Figure 11. Station #2000229 Nitrogen Concentrations



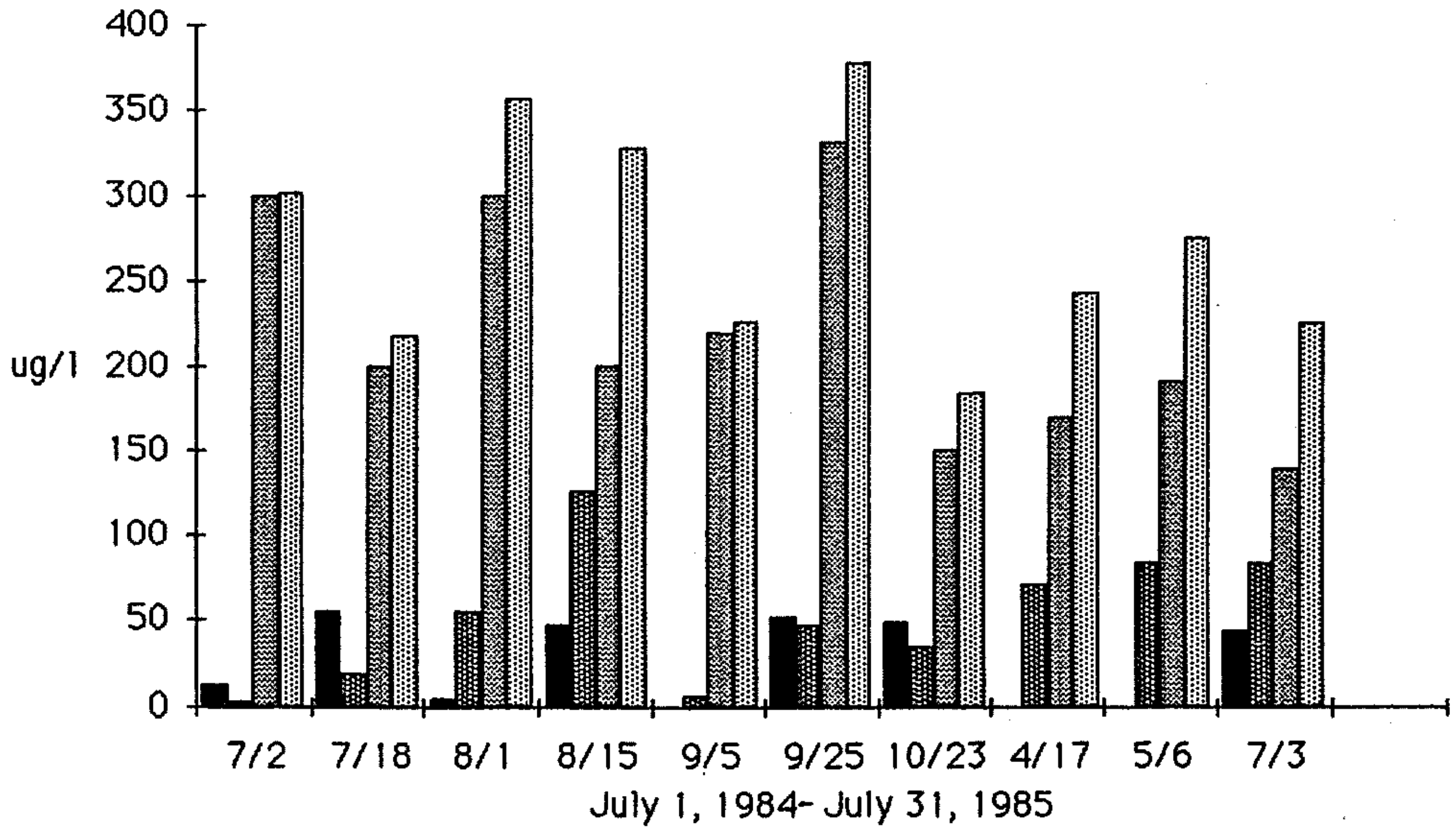
AVERAGE: NH3 58.4; NO2-NO3 51.9; TKN 210.0; TN 261.9

Figure 12. Station #2000232 Phosphorus Concentrations



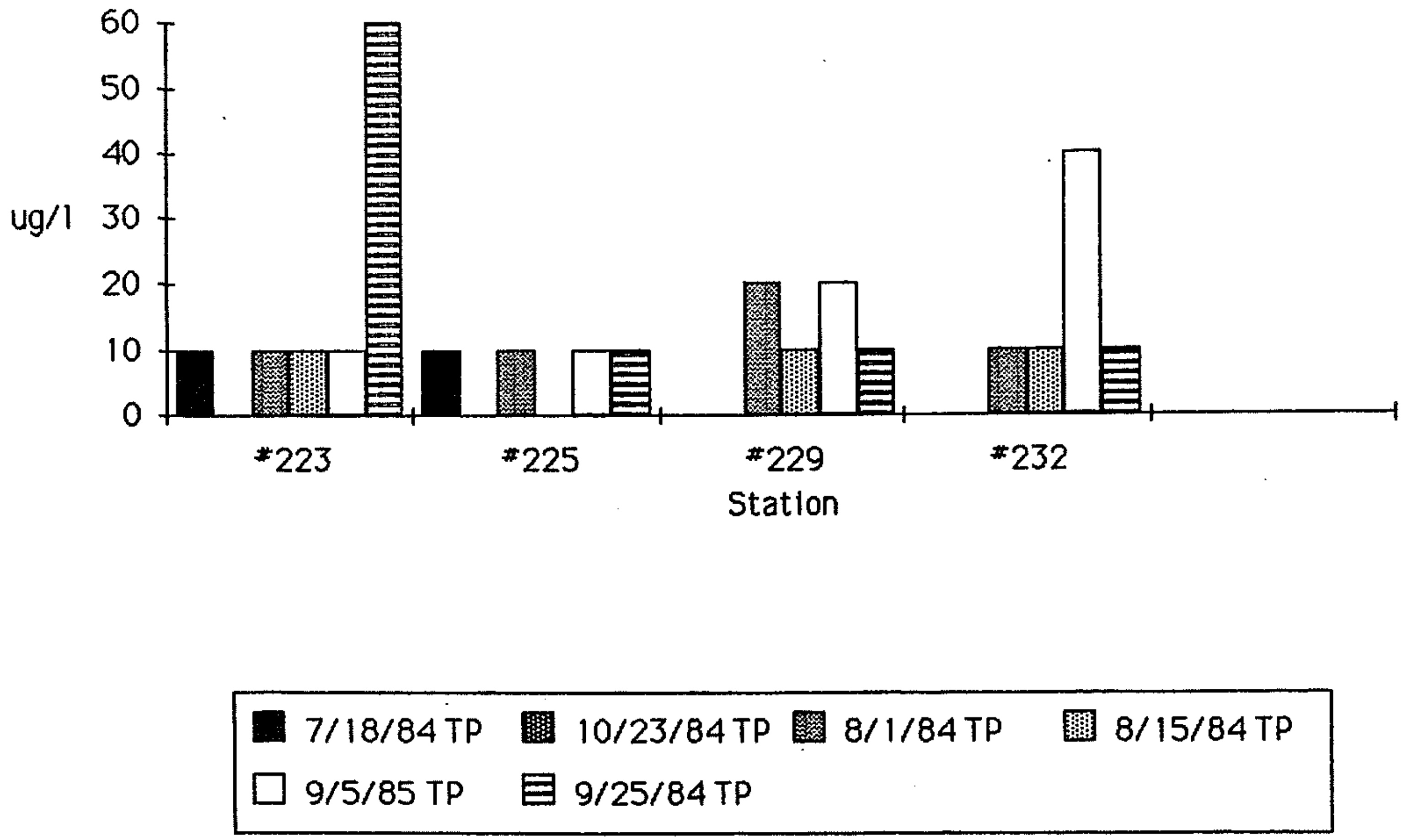
AVERAGE: OP 3.0; TP 12.1

Figure 13. Station #2000232 Nitrogen Concentrations



AVERAGE: NH3 26.6; NO2-NO3 53.1; TKN 220.0; TN 248.3

Figure 14. 1984 Total Phosphorus Concentrations



NOTE: The majority of observations were values below the detection limit of 10 ug/l.

Figure 15. 7/2/84 Nitrogen Concentrations

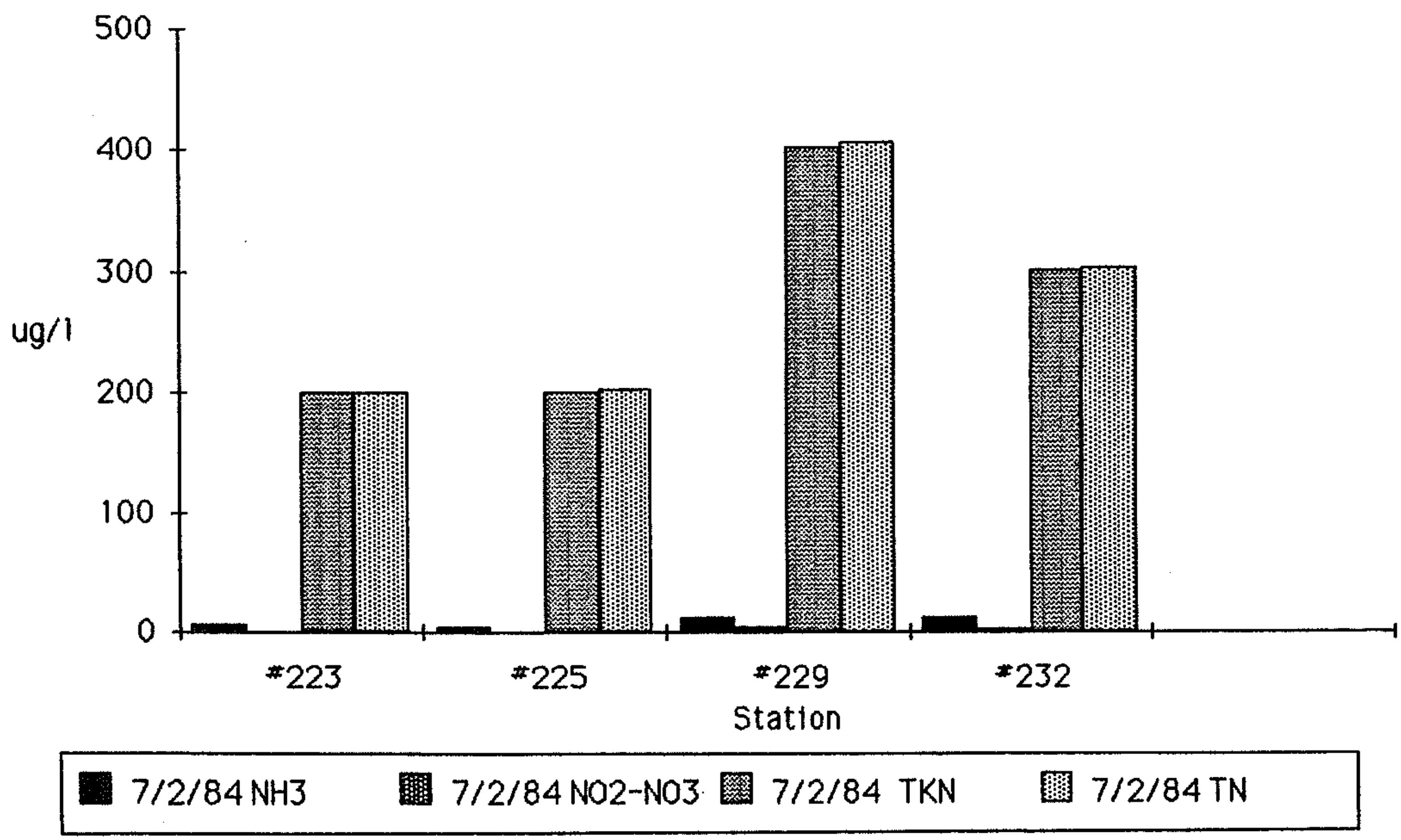


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Table 1. July 2,1984 Nitrogen Data

July 2, 1984

7/2/84 NH_3

Station	ug/1
#223	6
#225	4
#229	13
#232	12
	0

7/2/84 NO_2-NO_3

Station	ug/1
#223	0
#225	0
#229	4
#232	2
	0

7/2/84 TKN

Station	ug/1
#223	200
#225	200
#229	400
#232	300
	0

7/2/84 TN

Station	ug/1
#223	200
#225	201
#229	404
#232	302
	0

Table 16. 7/18/84 Nitrogen Concentrations

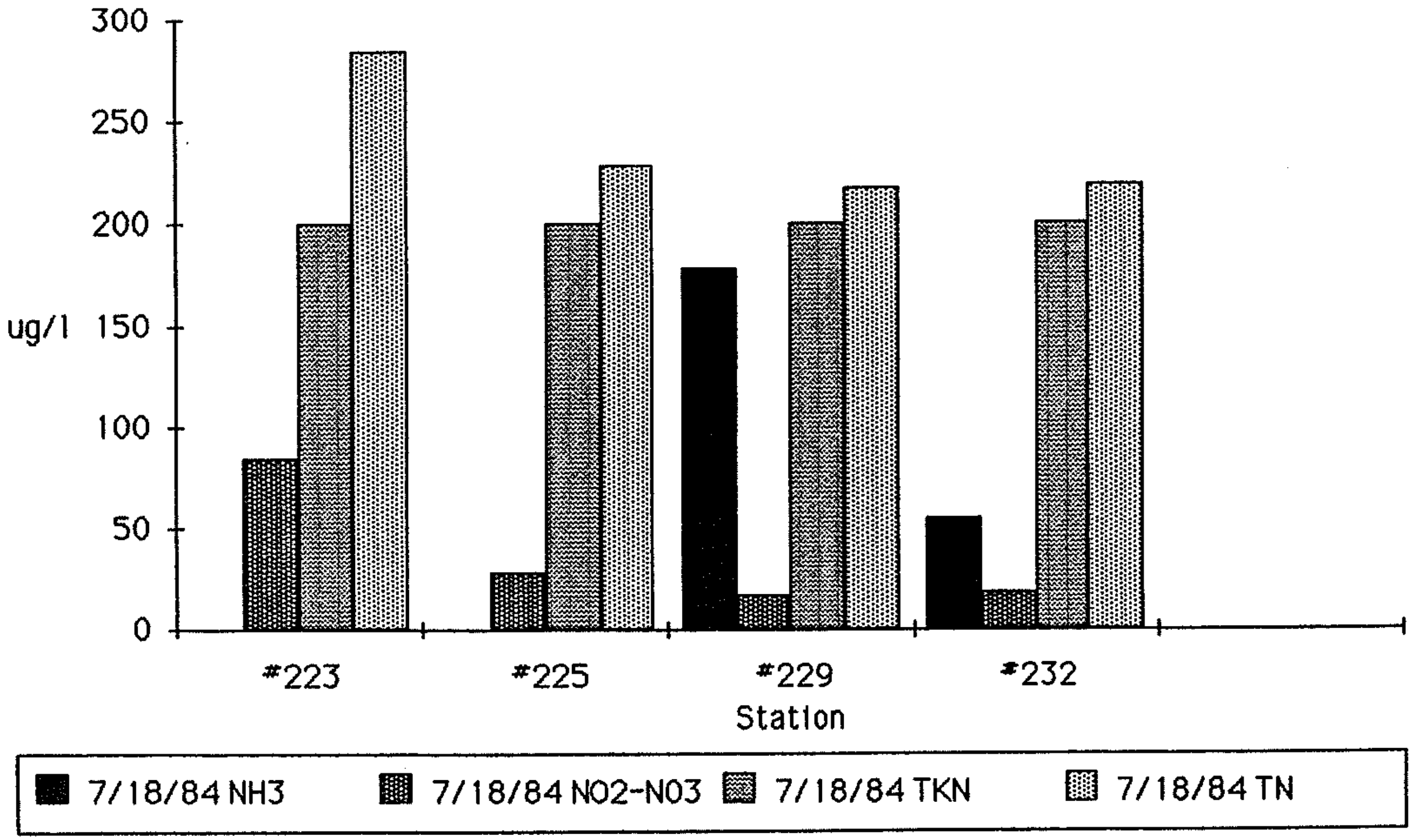

Table 2. July 18, 1984 Nitrogen Data

July 18, 1984

7/18/84 NH_3

Station	ug/l
#223	0
#225	0
#229	178
#232	55
	0

7/18/84 NO_2-NO_3

Station	ug/l
#223	84
#225	28
#229	17
#232	18
	0

7/18/84 TKN

Station	ug/l
#223	200
#225	200
#229	200
#232	200
	0

7/18/84 TN

Station	ug/l
#223	284
#225	228
#229	217
#232	218
	0

Figure 17. 8/1/84 NITROGEN CONCENTRATIONS

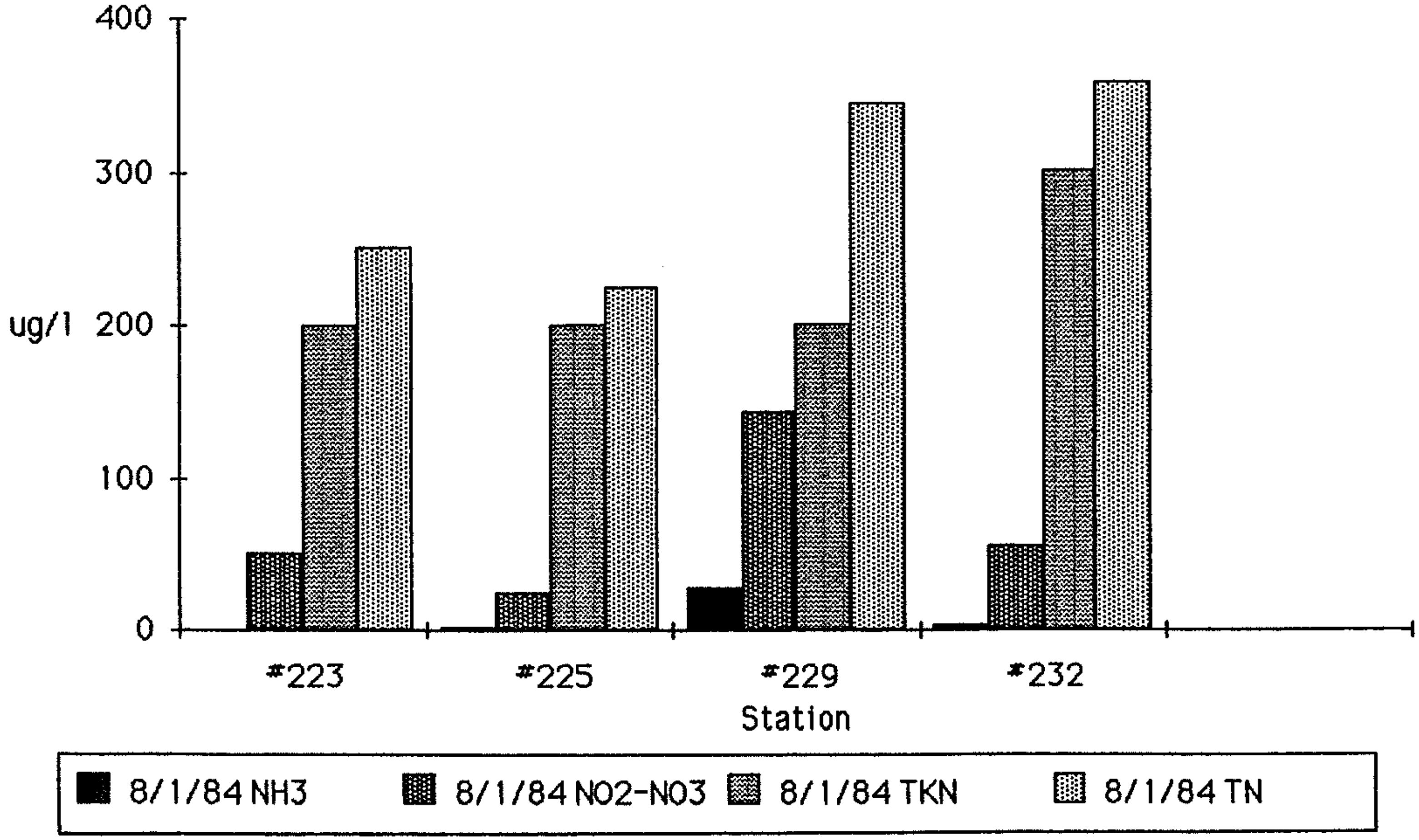

Table 3. August 1, 1984 Nitrogen Data.

August 1, 1984

8/1/84 NH_3

Station	ug/l
#223	0
#225	1
#229	28
#232	4
	0

8/1/84 NO_2-NO_3

Station	ug/l
#223	50
#225	25
#229	143
#232	56
	0

8/1/84 TKN

Station	ug/l
#223	200
#225	200
#229	200
#232	300
	0

8/1/84 TN

Station	ug/l
#223	250
#225	225
#229	343
#232	356
	0

Figure 18. 8/14/84 Nitrogen Concentrations

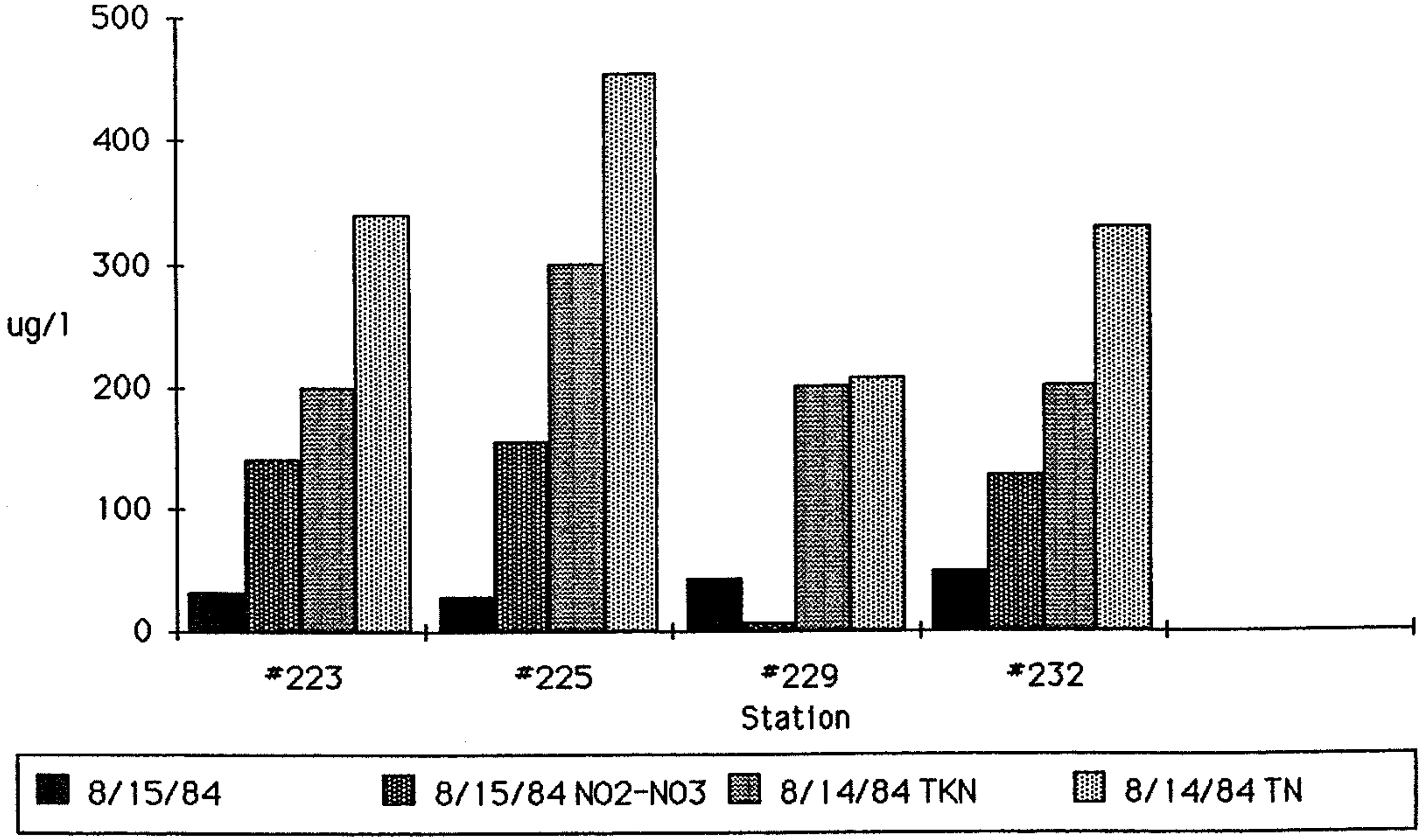

Table 4. August 15, 1984 Nitrogen Data

August 15, 1984

8/15/84 NH_3

Station	ug/l
#223	32
#225	29
#229	43
#232	48
	0

8/15/84 NO_2-NO_3

Station	ug/l
#223	140
#225	154
#229	6
#232	127
	0

8/15/84 TKN

Station	ug/l
#223	200
#225	300
#229	200
#232	200
	0

8/15/84 TN

Station	ug/l
#223	340
#225	454
#229	206
#232	327
	0

Figure 19. 9/5/84 Nitrogen Concentrations

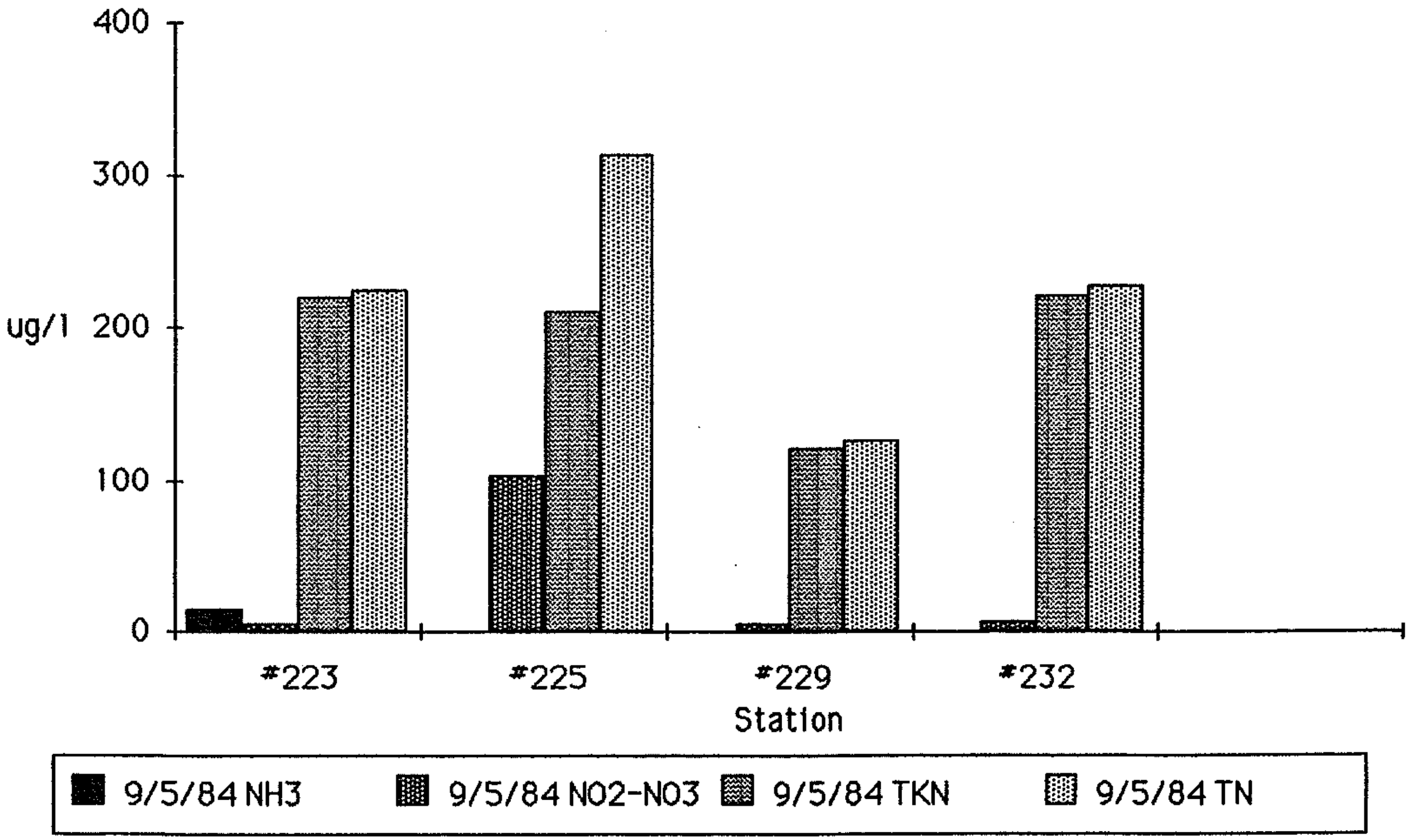

Table 5. September 5, 1985 Nitrogen Data

September 5, 1984

9/5/84 NH_3

Station	ug/1
#223	15
#225	0
#229	0
#232	0
	0

9/5/84 NO_2-NO_3

Station	ug/1
#223	5
#225	103
#229	5
#232	6
	0

9/5/84 TKN

Station	ug/1
#223	220
#225	210
#229	120
#232	220
	0

9/5/84 TN

Station	ug/1
#223	225
#225	313
#229	125
#232	226
	0

Figure 20. 9/25/84 Nitrogen Concentrations

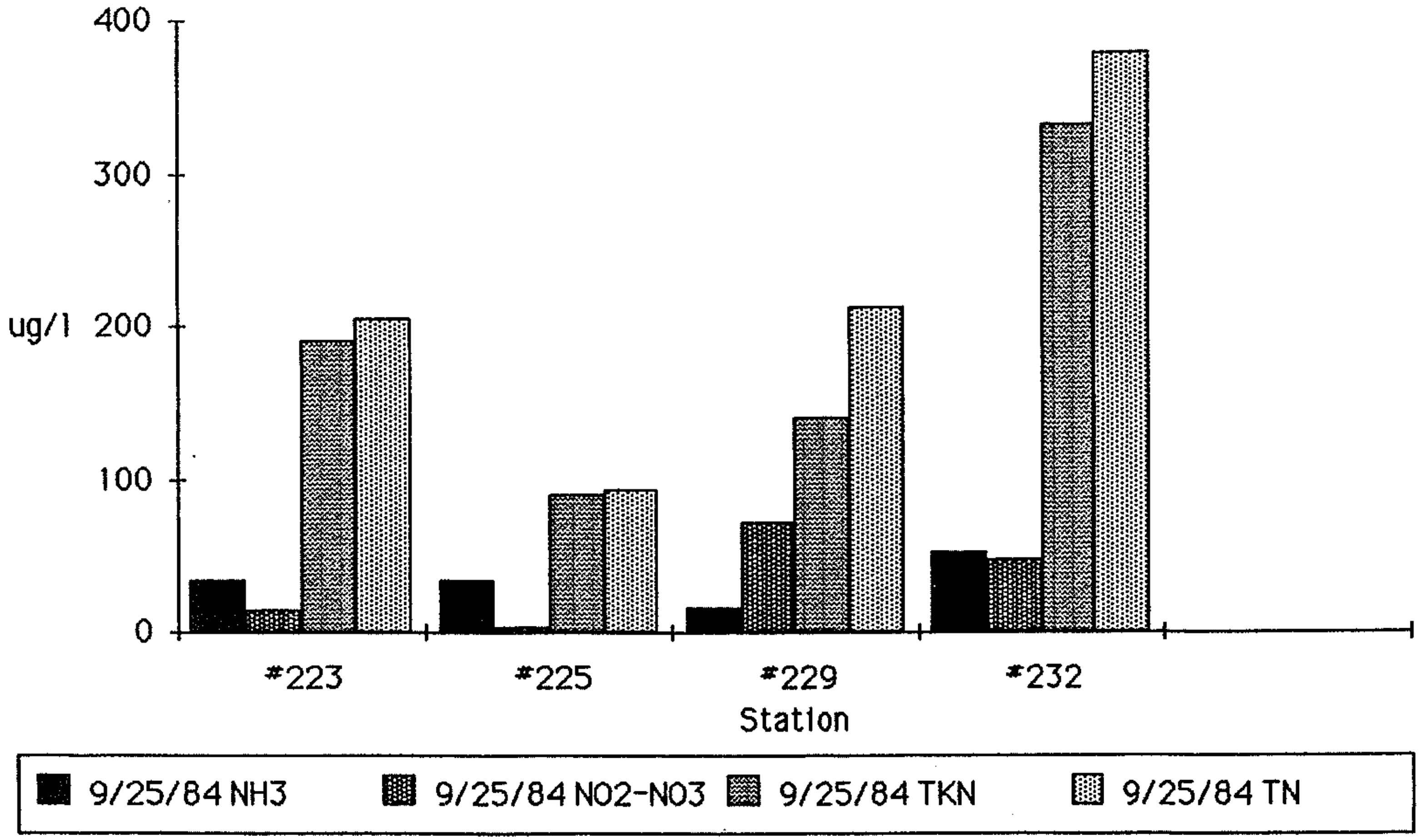

Table 6. September 24, 1984 Nitrogen Data

September 25, 1984

9/25/84 NH_3

Station	ug/1
#223	34
#225	35
#229	16
#232	53
	0

9/25/84 NO_2-NO_3

Station	ug/1
#223	15
#225	3
#229	71
#232	47
	0

9/25/84 TKN

Station	ug/1
#223	190
#225	90
#229	140
#232	330
	0

9/25/84 TN

Station	ug/1
#223	205
#225	93
#229	211
#232	377
	0

Figure 21. 10/23/84 Nitrogen Concentrations

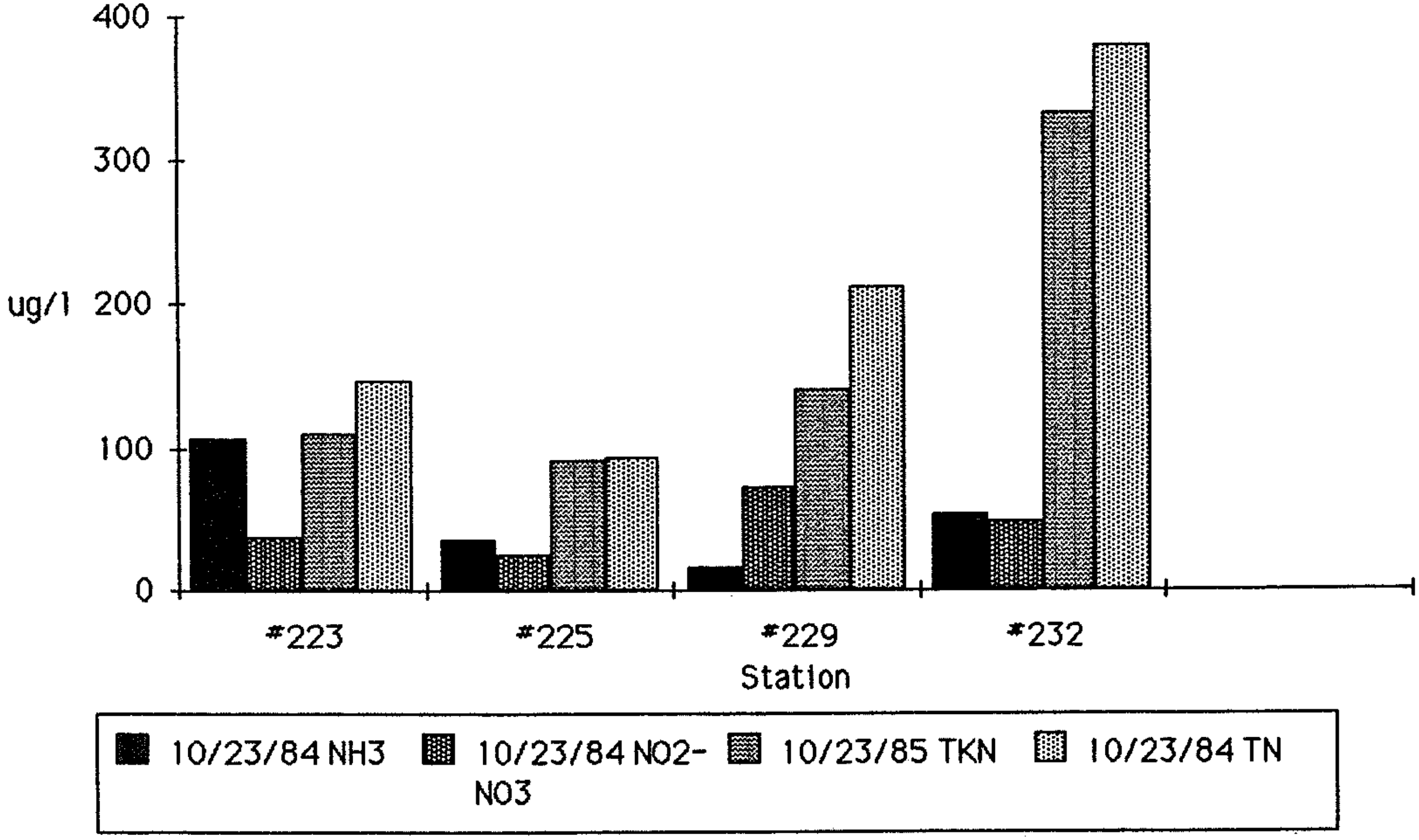

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Table 7. October 23, 1984 Nitrogen Data

October 23, 1984

10/23/84 NH_3

Station	ug/1
#223	107
#225	35
#229	16
#232	53

10/23/84 NO_2-NO_3

Station	ug/1
#223	37
#225	24
#229	71
#232	47

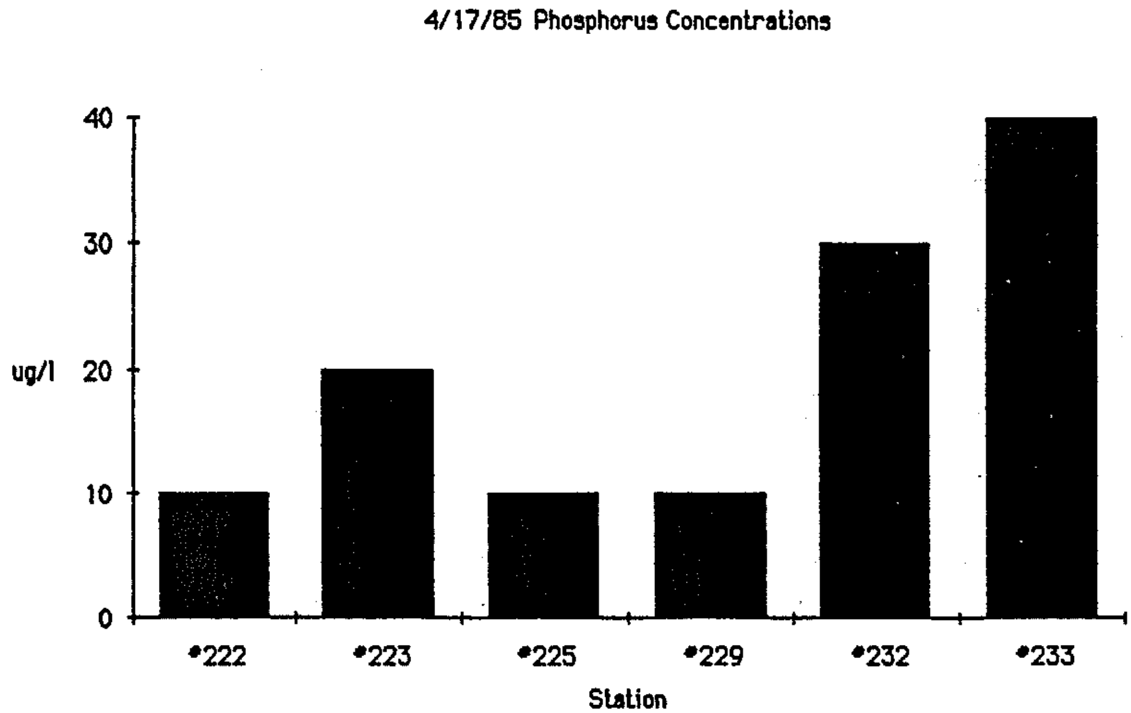
10/23/84 TKN

Station	ug/1
#223	110
#225	90
#229	140
#232	330

10/23/84 TN

Station	ug/1
#223	147
#225	93
#229	211
#232	377

Figure 22.



NOTE: Ortho-P analyses not conducted.

Figure 23. 4/17/85 Nitrogen Concentrations

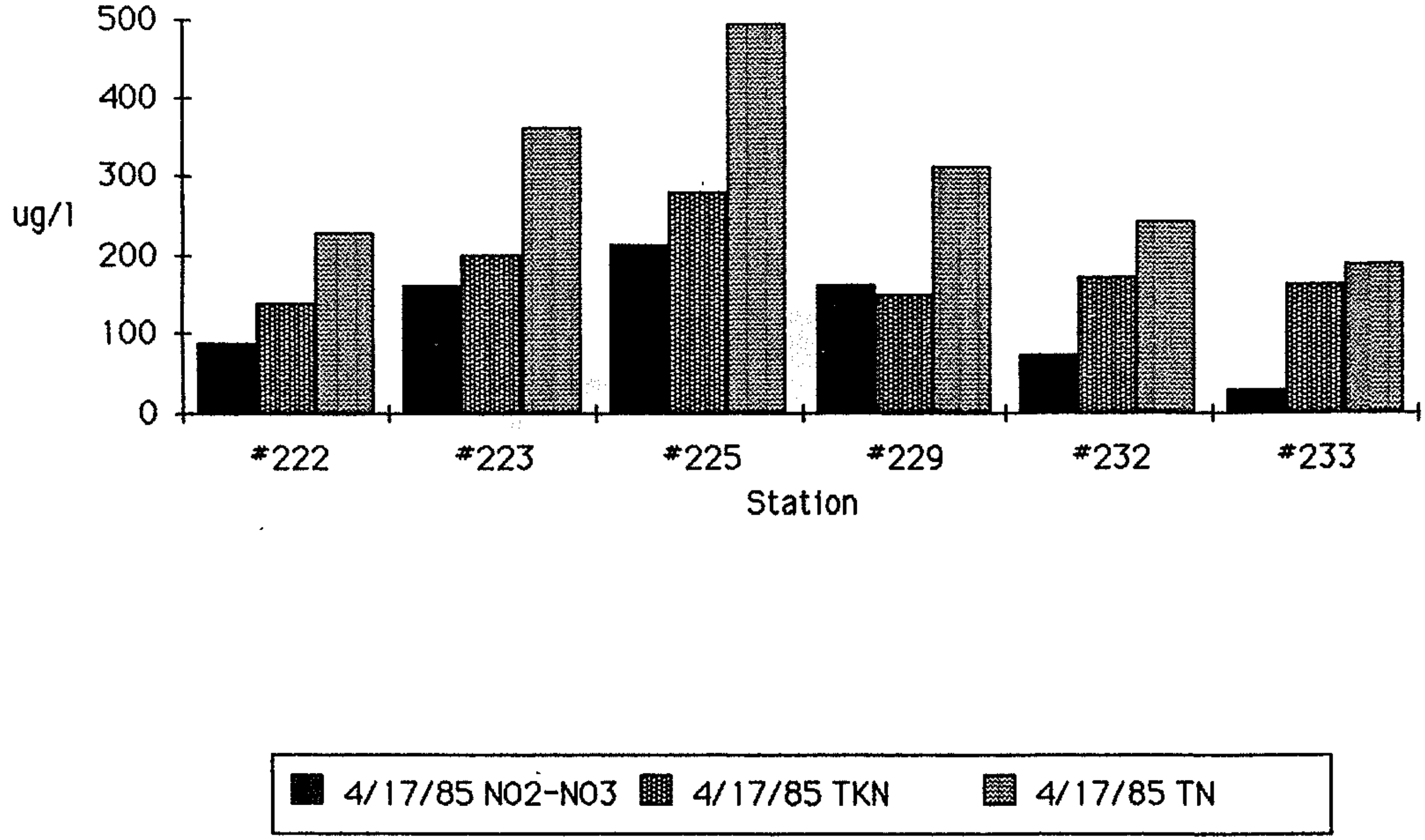


Table 8. April 17, Nitrogen Data

4/17/85 NO_2-NO_3

Station	ug/l
#222	88
#223	161
#225	211
#229	161
#232	72
#233	28

4/17/85 TN

Station	ug/l
#222	228
#223	361
#225	491
#229	311
#232	242
#233	188

4/17/85 TKN

Station	ug/l
#222	140
#223	200
#225	280
#229	150
#232	170
#233	160

Figure 24.

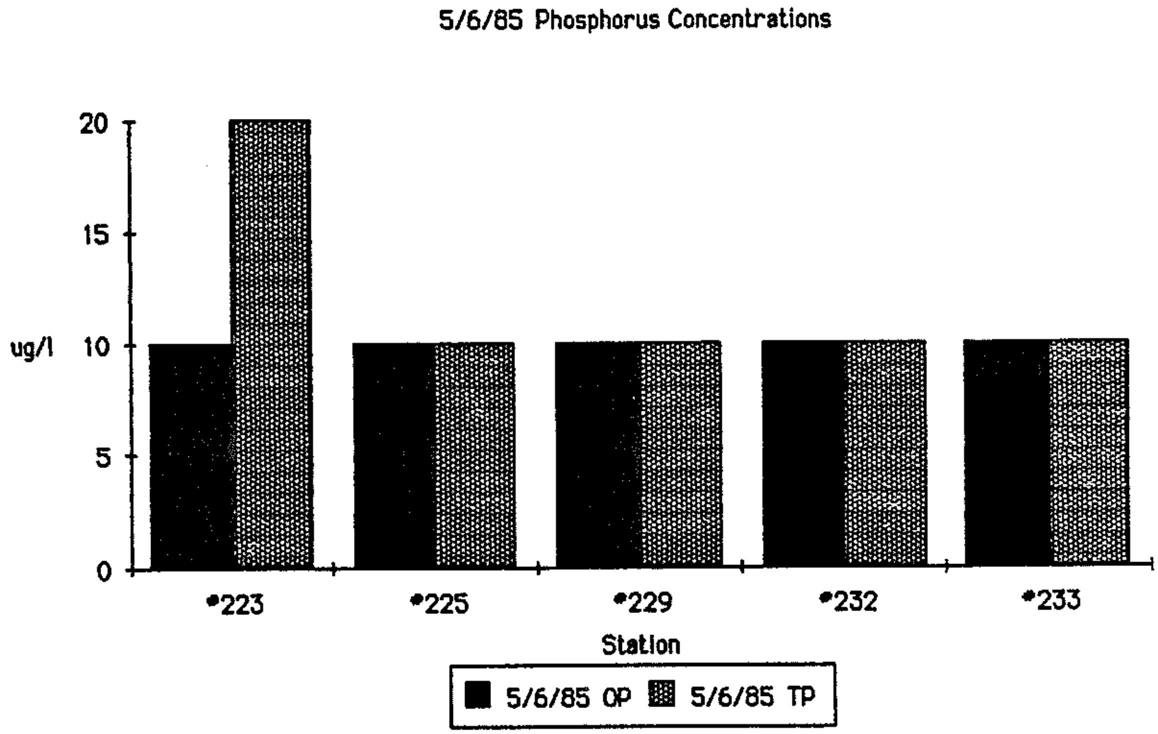


Table 9. May 6, 1984 Phosphorus Data

5/6/85 TP

Station	ug/1
#223	20
#225	10
#229	10
#232	10
#233	10

5/6/85 OP

Station	ug/1
#223	10
#225	10
#229	10
#232	10
#233	10

Figure 25. 5/6/85 Nitrogen Concentrations

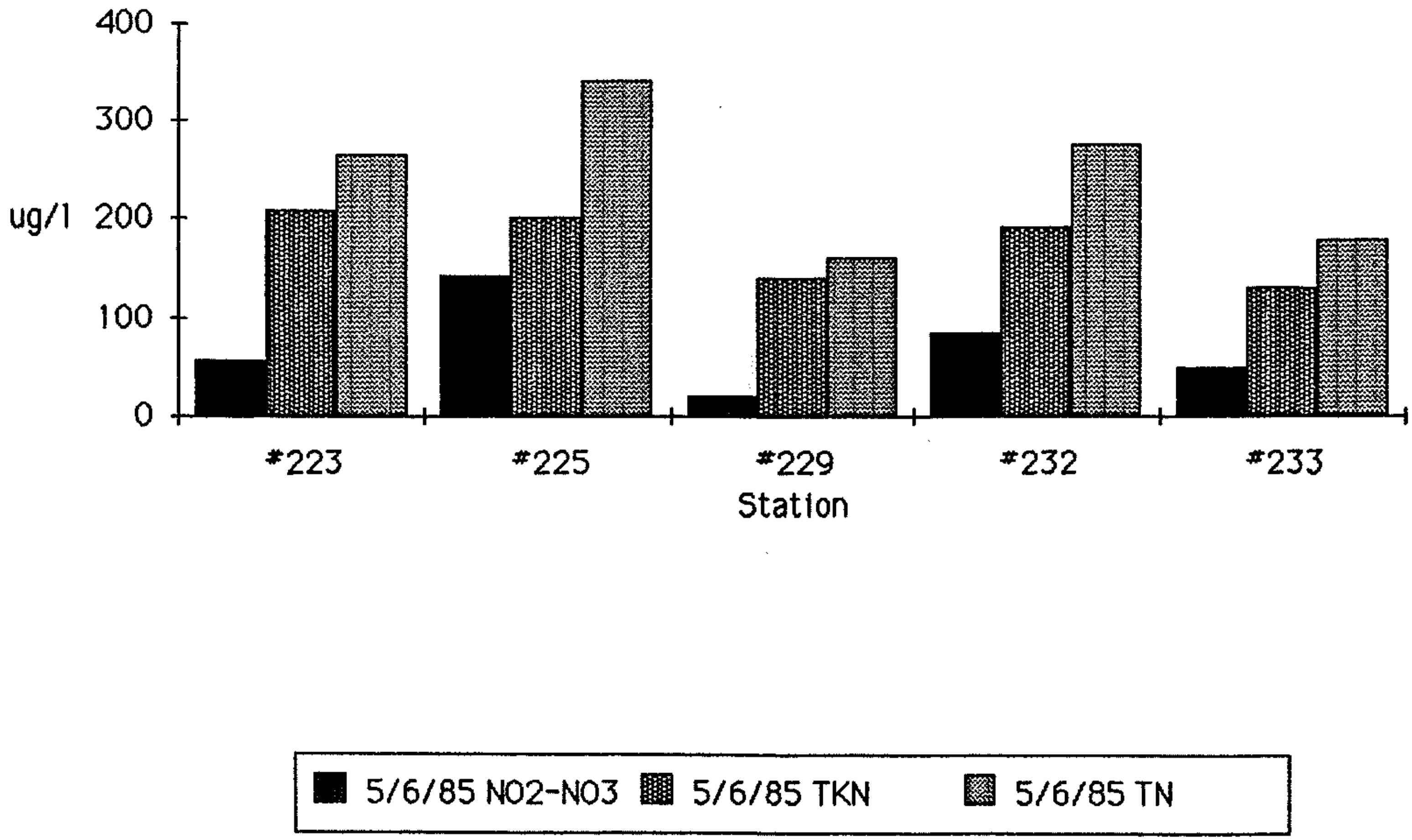


Table 10.

5/6/85 NO_2-NO_3

Station	ug/l
#223	56
#225	142
#229	20
#232	84
#233	49

5/6/85 TKN

Station	ug/l
#223	210
#225	200
#229	140
#232	190
#233	130

5/6/85 TN

Station	ug/l
#223	266
#225	342
#229	160
#232	274
#233	179

Figure 26.

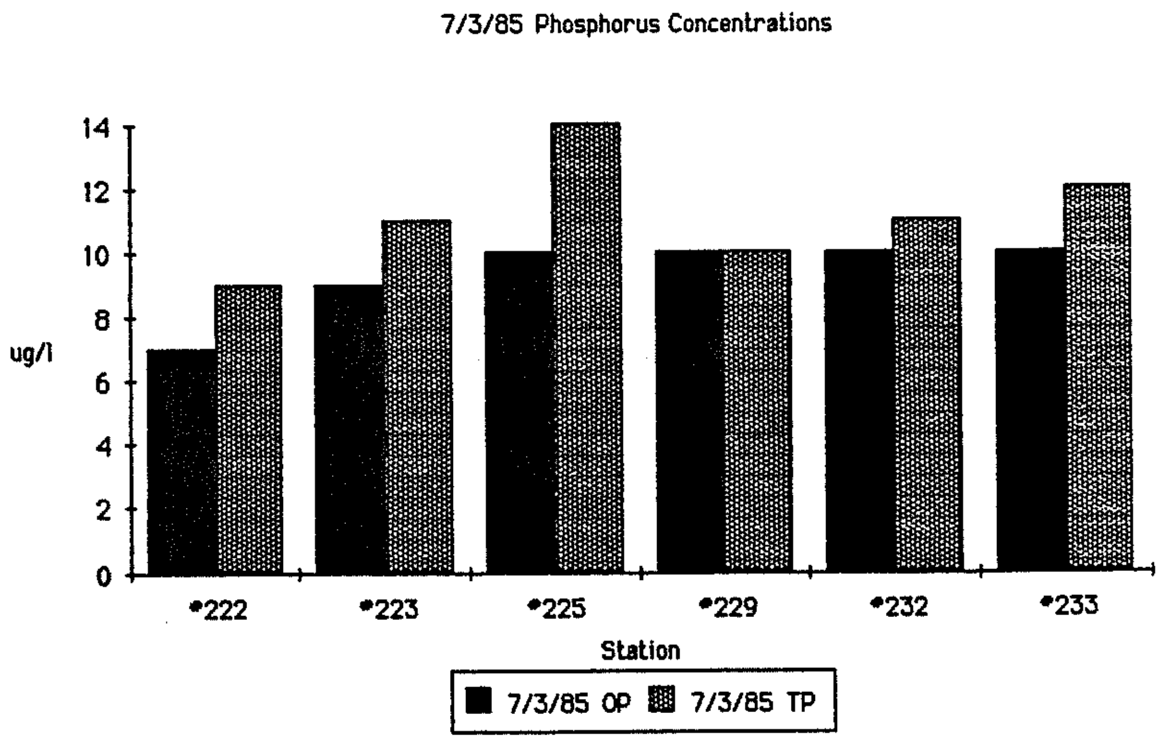


Table 11. July 3, 1985 Phosphorus Data

7/3/85 TP

Station	ug/1
#222	0
#223	11
#225	14
#229	10
#232	11
#233	12

7/3/85 OP

Station	ug/1
#222	7
#223	9
#225	10
#229	10
#232	10
#233	10

Figure 27. 7/3/85 Nitrogen Concentrations

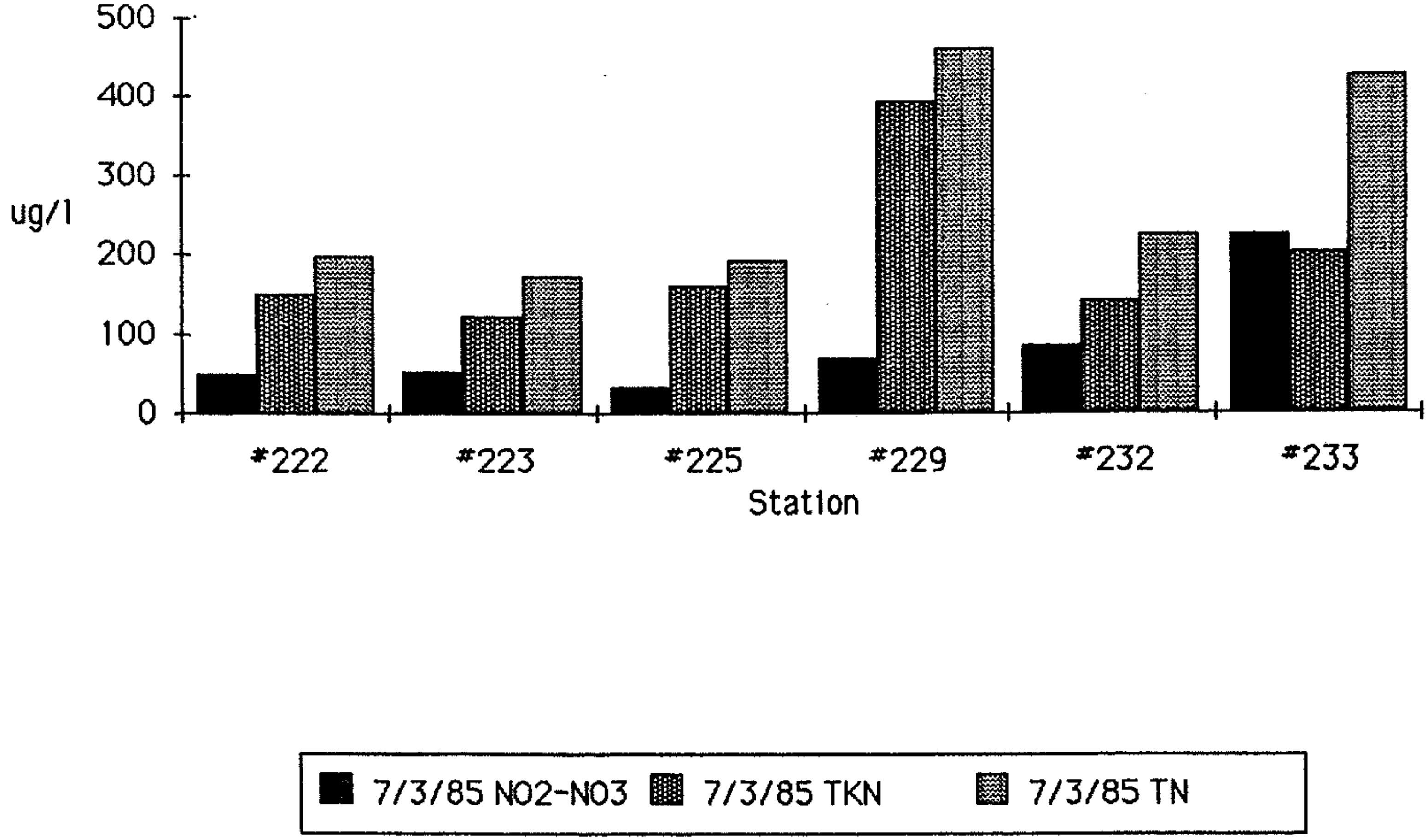


Table 12.

7/3/85 NO_2-NO_3

Station	ug/l
#222	48
#223	52
#225	32
#229	68
#232	84
#233	222

7/3/85 TKN

Station	ug/l
#222	150
#223	120
#225	160
#229	390
#232	140
#233	200

7/3/85 TN

Station	ug/l
#222	198
#223	172
#225	192
#229	458
#232	224
#233	422

REPORT ON THE RESULTS OF ALGAL ASSAYS PERFORMED ON WATERS COLLECTED IN LAKE COEUR D' ALENE, IDAHO

BY

JOSEPH C. GREENE, MICHAEL A. LONG AND CATHY LEE BARTELS

U.S. ENVIRONMENTAL PROTECTION AGENCY
CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY
HAZARDOUS MATERIALS ASSESSMENT TEAM
200 S.W. 35TH STREET
CORVALLIS, OREGON 97333

ALGAL ASSAYS WERE PERFORMED ON LAKE COEUR D' ALENE AT THE REQUEST OF REPRESENTATIVES OF THE DIVISION OF ENVIRONMENT, DEPARTMENT OF HEALTH AND WELFARE, STATE OF IDAHO. WATER SAMPLES WERE COLLECTED BY EMPLOYEES OF THE DIVISION OF ENVIRONMENT IN AUTOCLAVABLE CONTAINERS FURNISHED BY EPA. SAMPLES WERE SHIPPED BY THE US POSTAL SERVICE AND WERE GENERALLY RECEIVED IN TWO TO THREE DAYS.

ALGAL ASSAYS WERE PERFORMED FOLLOWING THE METHODS OUTLINED IN THE SELENASTRUM CAPRICORNUTUM ALGAL ASSAY BOTTLE TEST (MILLER, GREENE AND SHIROYAMA, 1978).

FOUR WATER SAMPLES WERE COLLECTED AT 2 STATIONS ON LAKE COEUR D' ALENE DURING THE PERIOD FROM AUGUST 8, TO OCTOBER 14, 1984. THE STATIONS WERE:

CAVE BAY (HAZELGATE BAY) - 200 METERS FROM MOUTH JUST OFF DOCKS;

MID LAKE OPEN WATER CONTROL - MIDWAY BETWEEN ROCKFORD AND EAST POINTS.

FIVE OF THE 8 LAKE COEUR D' ALENE WATER SAMPLES CONTAINED SUFFICIENT QUANTITIES OF ZINC TO CAUSED REDUCED GROWTH IN THE ALGAL CULTURES. THE LABORATORY ALGAL RESPONSE ESTABLISHES THAT THE ZINC ANALYSIS IS REAL AND THE MEASURED CONCENTRATION IS BIOLOGICALLY ACTIVE. HOWEVER, ONE MUST NOT PLACE TOO MUCH EMPHASIS ON THIS INFORMATION RELATIVE TO A POTENTIAL EFFECT OF ZINC ON INDIGENOUS ALGAL SPECIES. THE INDIGENOUS ALGA, LONG EXPOSED TO THE METALS ORIGINATING FROM SOURCES UP THE SOUTH FORK OF THE COEUR D' ALENE RIVER, MAY NOT RESPOND TO THESE LEVELS OF METAL.

SELENASTRUM CULTURES ARE SENSITIVE TO THE HEAVY METALS PRESENT IN THESE WATERS, THEREFORE, ONE MUST EXERCISE CAUTION IN INTERPRETING

THE ALGAL GROWTH POTENTIAL TEST RESULTS.

THE APPENDED 14-DAY ALGAL GROWTH POTENTIAL TEST RESULTS CONTAIN A COLUMN LABELED "LIMITING FACTORS". IN THOSE SAMPLES WHICH INDICATE GROWTH INHIBITION CAUSED BY HEAVY METALS (*M*), THE CONTROL YIELDS ARE IN FACT THOSE THAT HAVE BEEN SPIKED WITH *EDTA* TO REMOVE THE EFFECTS OF HEAVY METALS INHIBITION THROUGH CHELATION.

AFTER THE METALS INHIBITION WAS FACTORED OUT, THE DATA INDICATE THAT 3 OF THE *L*AKE *C*OEUR D' *A*LENE SAMPLES WERE OF LOW PRODUCTIVITY (0.00-0.10 MG DRY WEIGHT/L) AND THE REMAINING 5 SAMPLES WERE MODERATELY PRODUCTIVE (0.11-0.80 MG DRY WEIGHT/L) BASED ON THE PRODUCTIVITY SCALE DEVELOPED BY *M*ILLER, *M*ALONEY AND *G*REENE (1974).

CHEMICAL ANALYSIS OF THE NUTRIENTS NITRATE, NITRITE, AMMONIA, TOTAL PHOSPHORUS AND ORTHO PHOSPHORUS PRODUCED RESULTS SO LOW THAT THEY COULD NOT BE USED TO TEST THE GROWTH POTENTIAL RESULTS OR PREDICT THE GROWTH LIMITING NUTRIENTS. ONLY PERFORMANCE OF THE ALGAL ASSAY GROWTH POTENTIAL TEST COULD GENERATE DATE THAT WOULD ALLOW FOR THESE INTERPRETATIONS. THE ORTHO PHOSPHORUS ANALYSIS OF THE *C*AVE *B*AY SAMPLE COLLECTED SEPTEMBER 1984 IS OBVIOUSLY INCORRECT. THE PREDICTED PHOSPHORUS LIMITED ALGAL YIELD WAS 11.61 MG DRY WEIGHT/L. THE ACTUAL YIELD WAS 0.02 MG DRY WEIGHT/L IN THE PHOSPHORUS GROWTH-LIMITED SAMPLE THAT HAD BEEN SPIKED WITH 1.00 MG *N*/L. THE RESULTS WERE IDENTICAL WITH OR WITHOUT THE ADDITION OF *EDTA*.

REFERENCES

*M*ILLER, *W.E.*, *J.C.* *G*REENE AND *T.* SHIROYAMA. 1978. SELENASTRUM CAPRICORNUTUM *P*RINTZ *A*LGAL *A*SSAY *B*OTTLE *T*EST: *E*XPERIMENTAL *D*ESIGN, *A*PPLICATION, AND *D*ATA *I*NTERPRETATION *P*ROTOCOL. *U.S.* *E*NVIRONMENTAL *P*ROTECTION *A*GENCY, *C*ORVALLIS, *O*REGON. *EPA*-600/9-78-018.

*M*ILLER *W.E.*, *T.E.* *M*ALONEY AND *J.C.* *G*REENE. 1974. ALGAL *P*RODUCTIVITY IN 49 LAKE WATERS AS DETERMINED BY ALGAL ASSAYS. *W*ATER *R*ES. 8:667-679.

US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE COEUR D' ALENE, KOOTENAI CO., IDAHO
STATION: MID LAKE #10 - OPEN WATER CONTROL - MIDWAY BETWEEN ROCKFORD AND EAST POINTS.
STORET NO.: 2000232
PRETREATMENT: AUTOCLAVED AND FILTERED

NOTE	SAMPLE DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
		NUTRIENT SPIKES (MG/LITER)										
	08/01/84	0.37	2.31	2.00	23.16	0.53	0.64	2.52	32.22	N/P/M	6334004	0.023
	08/15/84	0.16	0.19	3.64	30.80	0.13	0.17	3.76	34.63	P/N	6335002	-
	09/05/84	0.04	0.11	0.78	0.99	0.03	0.02	1.32	21.92	N/P/M	6338001	0.055
	10/23/84	0.26	0.37	3.80	23.56	0.27	0.16	2.69	21.51	P/N	6344002	-

P=PHOSPHORUS; N=NITROGEN; E=EDTA; M=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	ZN	CA	MG	S
			MG /LITER			
080184	081084A	6334023	0.023	5.939	1.649	-
081584	091384A	6335002	-	-	-	-
090584	091384C	6338001	0.055	6.222	1.734	-
102384	110284	6344002	<	6.092	1.797	2.028

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
080184	081084A	6334004	<0.010	<0.005	-	-	-	<0.005	-
081584	091384A	6335002	-	-	-	-	-	-	-
090584	091384C	6338001	<0.010	<0.005	-	-	0.049	<0.005	-
102384	110284	6344002	<0.010	0.027	0.027	1.03	0.013	<0.005	-

(-) THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE COEUR D' ALENE, KOOTENAI CO., IDAHO
STATION: CAVE BAY (HAZELGATE BAY) - 200 METERS FROM MOUTH, JUST OFF DOCKS [#1].
STORET NO.: 2000223
PRETREATMENT: AUTOCLAVED AND FILTERED

NOTE	SAMPLE DATE	NUTRIENT SPIKES (MG/LITER) CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
	08/01/84	0.68	0.19	1.21	33.07	0.22	0.45	2.13	33.84	P/N	6334005	-
	08/15/84	0.30	0.34	2.01	9.29	0.68	0.40	3.28	32.52	H/P/N	6335001	-
	09/05/84	0.03	0.02	0.99	0.75	0.03	0.02	1.66	23.48	H/P/N	6338002	0.053
	10/23/84	0.09	0.21	1.13	8.04	0.28	0.15	1.57	16.76	H/P/N	6344003	0.026

P=PHOSPHORUS; N=NITROGEN; E=EDTA; H=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

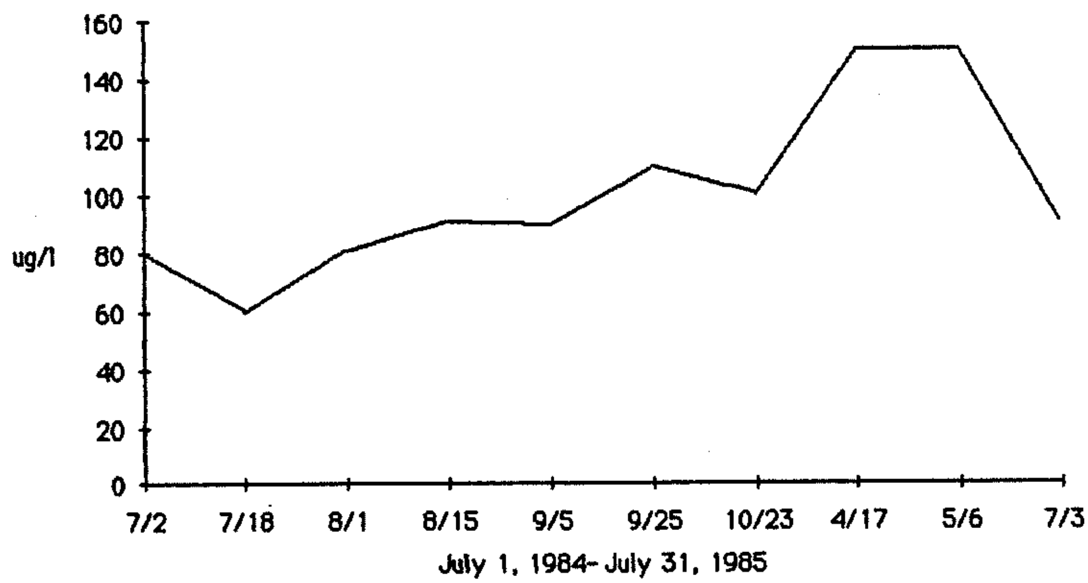
SAMPLE DATE	ALGAL TEST CODE	CERL ID	MG /LITER ZN	CA	MG	S
080184	081084B	6334024	<	5.742	1.607	-
081584	091384B	6335001	-	-	-	-
090584	091384D	6338002	0.053	6.357	1.759	-
102384	110284	6344003	0.026	6.292	1.844	2.082

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
080184	081084B	6334005	<0.010	<0.005	-	-	-	<0.005	-
081584	091384B	6335001	-	-	-	-	-	-	-
090584	091384D	6338002	<0.010	<0.005	-	-	0.032	0.027	11.61
102384	110284	6344003	<0.010	0.001	0.001	0.04	0.014	<0.005	-

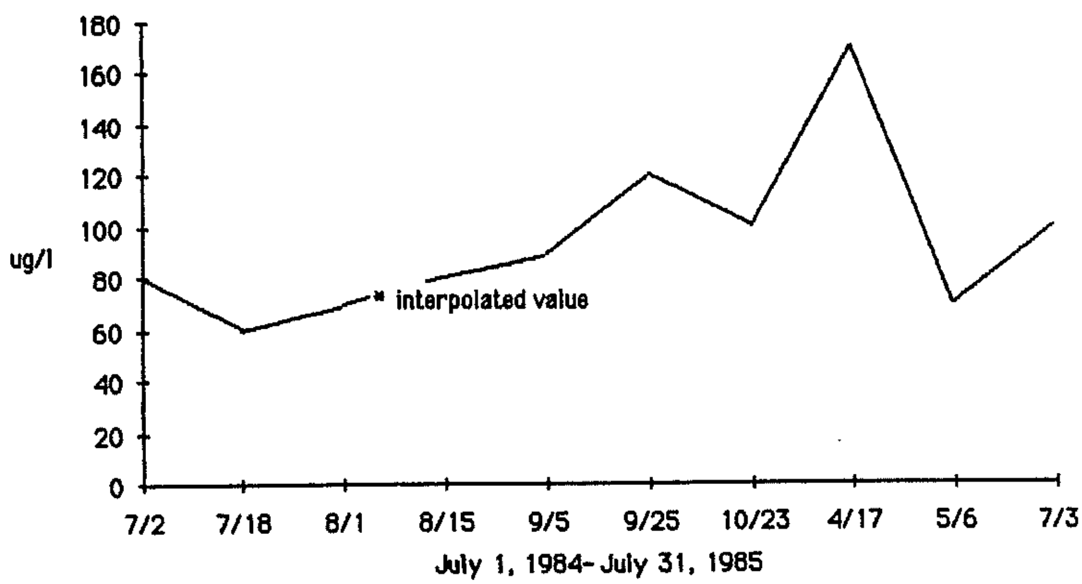
(-) THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

Station #2000223 Zinc Concentrations



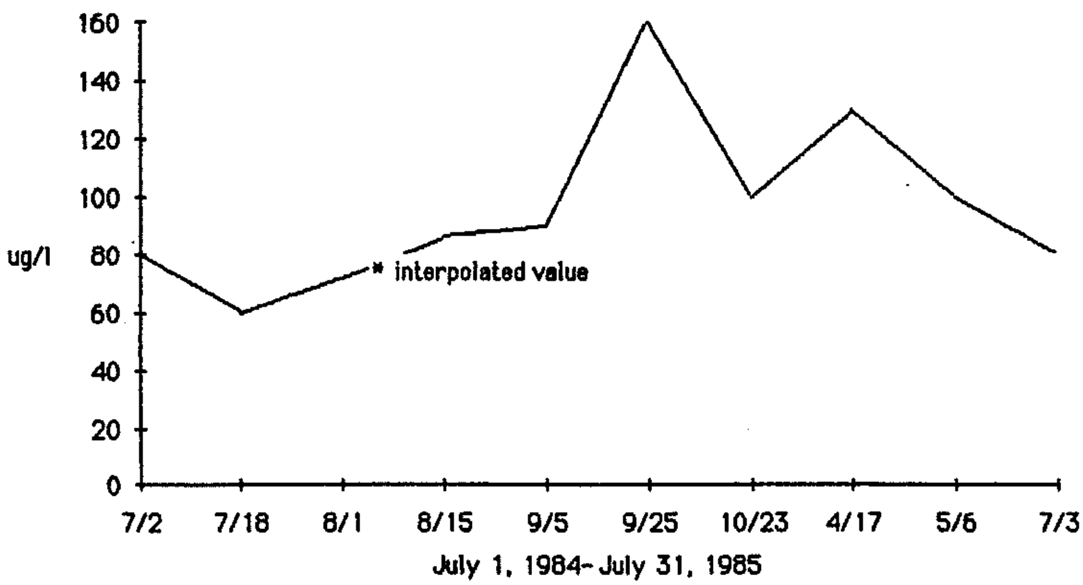
AVERAGE: Zn 100.2 ug/l

Station #2000225 Zn Concentrations



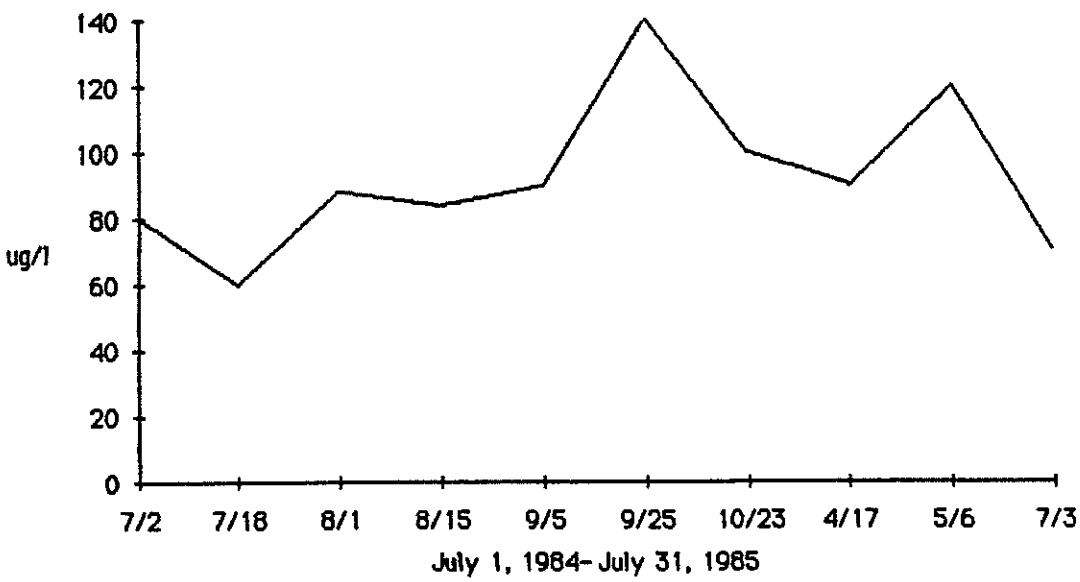
AVERAGE: Zn 94.1 ug/l

Station #2000229 Zn Concentrations



AVERAGE: Zn 95.8 ug/l

Station #2000232 Zinc Concentrations



AVERAGE: Zn 92.2 ug/l