OPERATIONAL ECOLOGICAL

MONITORING PROGRAM

FOR

WNP-2

ANNUAL REPORT 1984

Washington Public Power Supply System
Environmental Programs
3000 George Washington Way
Richland, Washington 99352

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EXECUTIVE SUMMARY

This report presents the results of the Ecological Monitoring Program (EMP) conducted in the vicinity of Supply System Nuclear Plant No. 2 during March 1983 through December 1984. The objectives of the EMP are to measure environmental effects of operation and provide preoperational baseline data to be used in identifying long-term trends and operational impacts in the areas of aquatic ecology, water quality and terrestrial ecology. Based on plant operational levels, data collected March 1983 through October 1984 could be considered preoperational and data from November-December 1984 - operational.

Benthic macrofauna studies revealed no changes in species composition, density and biomass that could be attributed to WNP-2 operation. Benthos density and biomass were highest in summer and lowest in winter. Chironomidae and Hydropsychidae accounted for 88 percent of the organisms counted and 71 percent of the measured biomass. Periphyton biomass (TOM) measurements were comparable for the preoperational and operational data sets. TOM was usually low in the spring and high in summer and fall.

No fish were observed impinged on the intake screens and fouling of the screens was normal with only algae and insects observed. Corbicula (clams) were found in the river pump house but not in WNP-2 site systems. An October 1984 bioassay of Chinook salmon in cooling tower water resulted in no mortality after 96-hours.

Water quality in the Columbia River in 1983-1984 met Washington States Class A standards for the measured parameters. The water quality measurements were comparable to preoperational data and based on the data, it appears that WNP-2 operation does not appreciably impact Columbia River water quality.

Due to a range fire and cold spring, the 1984 bird species number and densities were lower than previous years. Red-wing blackbirds, western meadowlarks, white-crowned sparrows and California quail comparised 64.2 percent of the birds observed. Overall, deer densities were highest in the south shrub area for spring and fall surveys; however, densities measured near WNP-2 are low compared to other areas sampled in and out of Washington State. Similar to previous years, highest rabbit densities were in the shrub areas north and south of WNP-2.

Herbaceous vegetation at all site was dominated by Bromus tectorum and varied among sites with the higher cover values occurring at grassland sites. Most grassland sites had lower herbaceous phytomass than shrub sites. Shrub density remained relatively stable over time. Chemical analyses showed study area soils to be within or below reported ranges. Sulfate, chloride and copper concentrations in plant materials were relatively consistent from 1980 through 1984.

ACKNOWLEDGMENTS

This annual report, prepared by Washington Public Power Supply System, describes the aquatic, terrestrial and water quality programs for Nuclear Project No. 2 (WNP-2).

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1.0 INTRODUCTION

1.1 BACKGROUND

Washington Public Power Supply System (Supply System) began site preparation for Nuclear Plant Number 2 (WNP-2) near Richland, Washington in March 1973. WNP-2 loaded fuel in December 1983, reached approximately 75 percent thermal load in November 1984, and began commercial operation in December 1984 (Figure 1-1).

The Site Certification Agreement (SCA) for WNP-2, executed on May 17, 1972, between the State of Washington and the Supply System requires that ecological monitoring be conducted during the preoperational and operational phases of site development and use. The Washington State Energy Facility Site Evaluation Council (EFSEC) approved a change in 1978 to the technical scope of environmental monitoring required by the SCA (EFSEC Resolution No. 132, January 23, 1978). In 1980, the aquatic and water quality portions of the preoperational monitoring were terminated (EFSEC Resolution No. 166, March 24, 1980). The following year the preoperational and operational terrestrial monitoring program scope for WNP-2 was modified (EFSEC Resolution No. 193, May 26, 1981). Prior to operation, the council reviewed the preoperational aquatic monitoring data and approved the operational monitoring program (EFSEC Resolution No. 214, November 8, 1982).

The Supply System in 1974 retained Battelle, Pacific Northwest Laboratories (BNW) to conduct the preoperational aquatic monitoring for WNP-2. The results of aquatic studies performed from September 1974 through August 1978 are presented in various reports (1-1 through 1-5). From August 1978 through March 1980 the aquatic studies were performed by Beak Consultants, Inc. (1-6). In 1982 the Supply System analyzed the 1974-1980 aquatic data and presented the results and a recommended operational monitoring program to EFSEC (1-7). The operational program was accepted with minor modifications and initiated in March 1983. Based on plant thermal and water discharges consistent operational monitoring conditions did not exist until the Fall 1984 (Figures 1-1 through 1-3).

Terrestrial monitoring was initiated in 1974 and was conducted by BNW until 1979 (1-8 through 1-11). Beak Consultants, Inc. performed the vegetation monitoring program from 1980-1982 (1-12 through 1-14). Since 1983 Supply System scientists have been responsible for the vegetation aspects of the program (1-15). During 1981, the animal studies program was taken over by Supply System scientists and results were reported annually (1-16 through 1-18).

This report presents the results of the Ecological Monitoring Program (EMP) for the period March 1983 through December 1984.

1.2 THE SITE

The WNP-2 plant site is located 19 KM (12 miles) north of Richland, Washington in Benton County (Figure 1-1). The Supply System has leased 441 hectares (1089 acres) from the U.S. Department of Energy's Hanford Site for WNP-2.

WNP-2 is situated near the middle of a relatively flat, essentially featureless plain which is best described as shrub-steppe. Sagebrush and bitterbrush are interspersed with native perennial and alien annual grasses and extend in northerly, westerly and southerly directions for several miles from the site. Approximatly 5 KM (3 1/4 miles) to the east, the site is bounded by the Columbia River.

The aquatic and water quality sampling stations are located near the west bank of the Columbia River at approximately River Mile 352. Sampling was limited to the main channel Benton County side which, near the site, averages 371 m (1218 ft) wide at river elevation of 105 m (345 ft) and ranges to 7.3 m (24 ft) deep. Sampling stations have been established in the river both upstream and downstream from the plant intake and discharge structures. The river-level in this area fluctuates considerably diurnally and from day-to-day in response to release patterns at the Priest Rapids Dam (River mile 397) alternately exposing and covering large areas of river bottom. The river bottom within the study area varies from exposed Ringold conglomerate to boulders, cobble, gravel, and sand. River velocities at the surface average approximately 2 meters (5-6 feet) per second in this area of the river, and water temperature varies from approximately 0 to 22°C.

The flow of the Columbia River at WNP-2 is controlled by releases from Priest Rapids Dam. The minimum flow is established at 1019.4 m^3/s (36,000 cfs), while average and maximum flows are 3398.1 m^3/s (120,000 cfs) and 9911.1 m^3/s (350,000 cfs), respectively.

The terrestrial sampling locations are all within a 8 Km (5 mile) radius from WNP-2. The topography is flat to gently rolling, gradually increasing from an elevation of 114 m (375 ft) at the riparian sampling locations to approximately 152 m (500 ft) at more distant shrubgrass sample sites.

1.3 OBJECTIVES

The purpose of the Ecological Monitoring Program is to determine the effects of WNP-2 on the environment. Prior to operation the EMP provided baseline data on the aquatic and terrestrial communities. Specifically, the ecological studies provide information about the biota near the site, including species composition, relative abundance, and seasonal and spatial distribution. The aquatic ecology program monitors benthos, periphyton and fish in order that current results can be compared with previously collected data to assess WNP-2 operational impacts. The water quality program provides baseline information and physical and chemical data to evaluate the impact of WNP-2 cooling tower discharges on the Columbia River. The terrestrial ecology program provides for collection of baseline and operational data to be used in assessments for mitigation purposes and cooling tower drift impacts.

1.4 SCOPE

A summary of the field sampling for data presented in the 1984 EMP is illustrated in Table 1-1. The aquatic program is composed of several components, which include benthic macrofauna (Section 2.0), periphyton (Section 3.0), water quality (Section 4.0), fish impingement and intake structure fouling surveys (Section 5.0), Corbicula (clam) surveys (Section 6.0) and fish bioassay (Section 9.0). The terrestrial program components includes terrestrial-vegetation studies (Section 7.0) and terrestrial-animal studies (Section 8.0). Based on WNP-2's operational schedule, fish drift and thermal plume studies are planned for 1985.

1.5 REFERENCES

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1-13 Preoperational Terrestrial Monitoring Studies Near WNP-1, 2 and 4, May through December 1981, Beak Consultants, Inc., Portland, OR, March 1982.

1-14 Preoperational Terrestrial Monitoring Studies Near WNP-1, 2 and 4, May through August 1982, Beak Consultants, Inc., Portland, OR, November 1982.

1-15 Preoperational Terrestrial Monitoring Studies Near WNP-1, 2 and 4, 1983, Washington Public Power Supply System, Richland, WA, May 1985.

1-16 Preoperational Animal Studies Near WNP-1, 2 and 4, 1983, Washington Public Power Supply System, Richland, WA, April 1982.

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1-18 Preoperational Animal Studies Near WNP-1 and 2, 1983, Washington Public Power Supply System, Richland, WA, January 1984.

TABLE 1-1

SUMMARY OF 1983-1984 ECOLOGICAL MONITORING PROGRAM
(Year and Month Sampled)

Task	1983										1984											
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Aquatic Ecology																						
Benthic Macrofauna(1)										X			X			X			X			
Periphyton																						
Gradient(1)			X	X	X		X	X		X	X		X	X		X	X		X	X		X
Core(1)		X		X			X			X			X			X			X			X
Corbicula Survey								X									X				X	
Fish Impingement							X	X					X				X	X	X	X(2)	X	
Water Quality		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Terrestrial Ecology																						
Vegetation															X							
Soil & Plant Chemistry															X							
Deer/Rabbit Survey															X					X		
Bird Survey															X					X		

(1) Denotes beginning and/or end of sampling period.

(2) October sampling done in late September due to scheduling problems.

FIGURE 1-1

WNP-2 Electrical Generation
May-December 1984

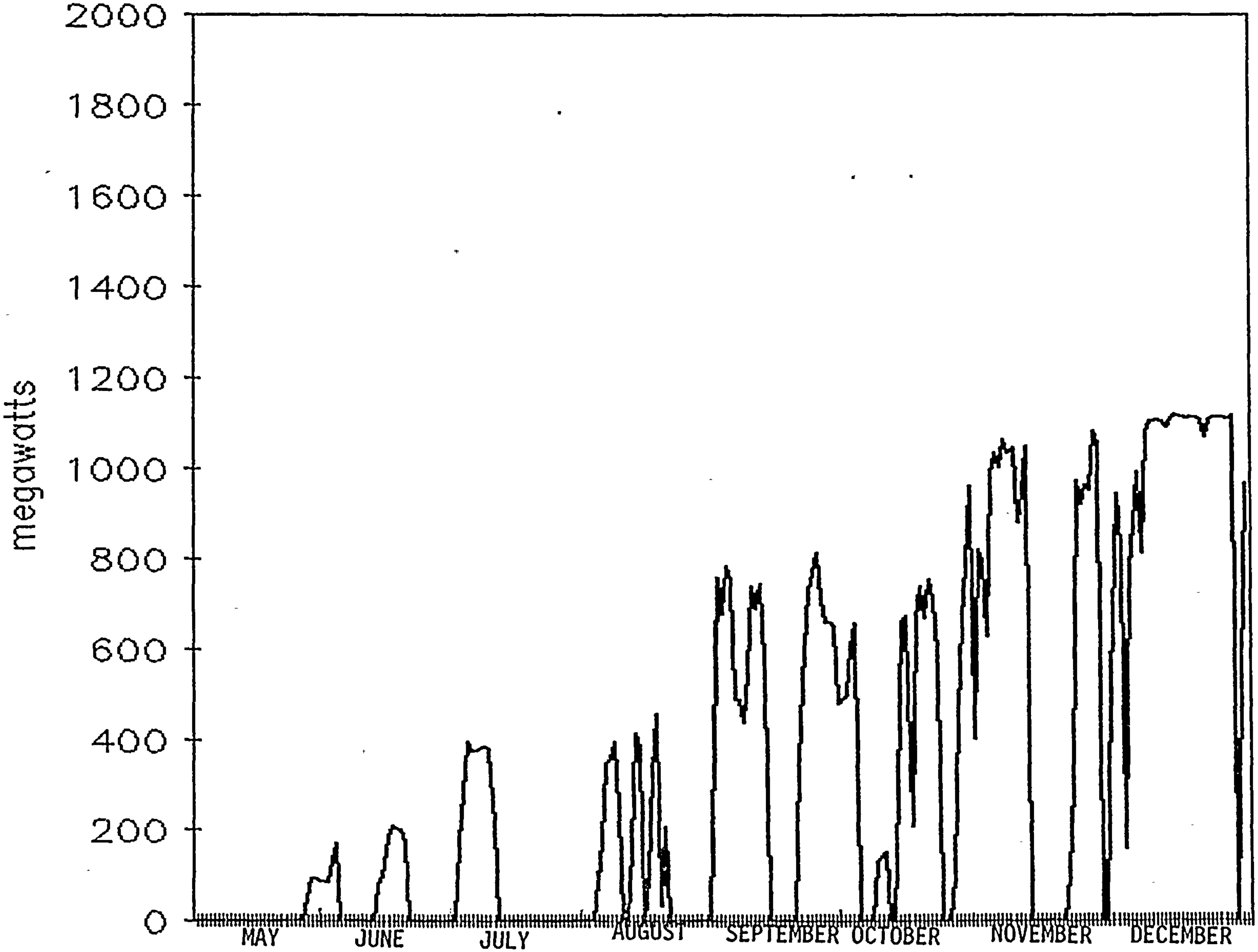


FIGURE 1-2

WNP-2 Monthly Mean Discharge
April 1983 – December 1984

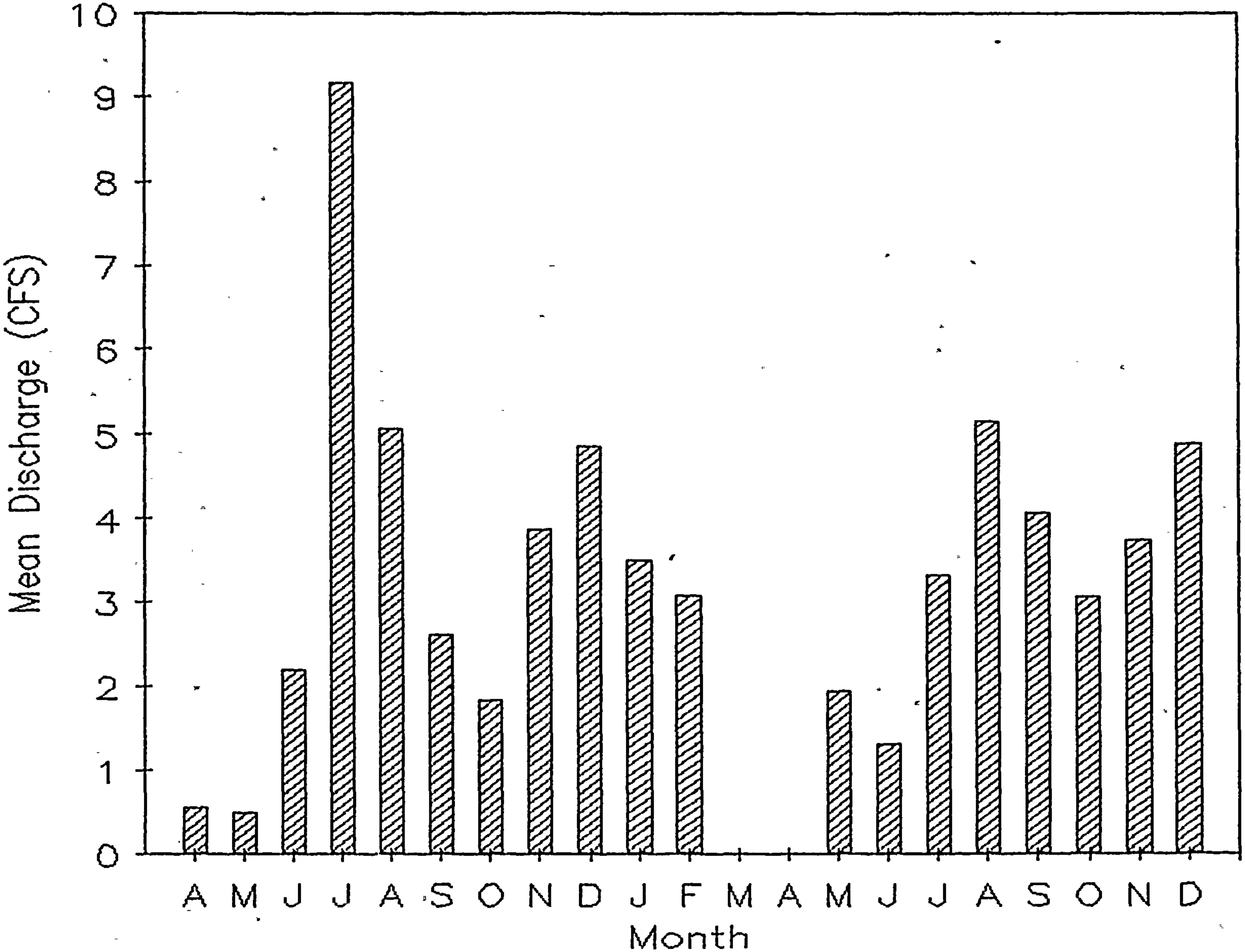
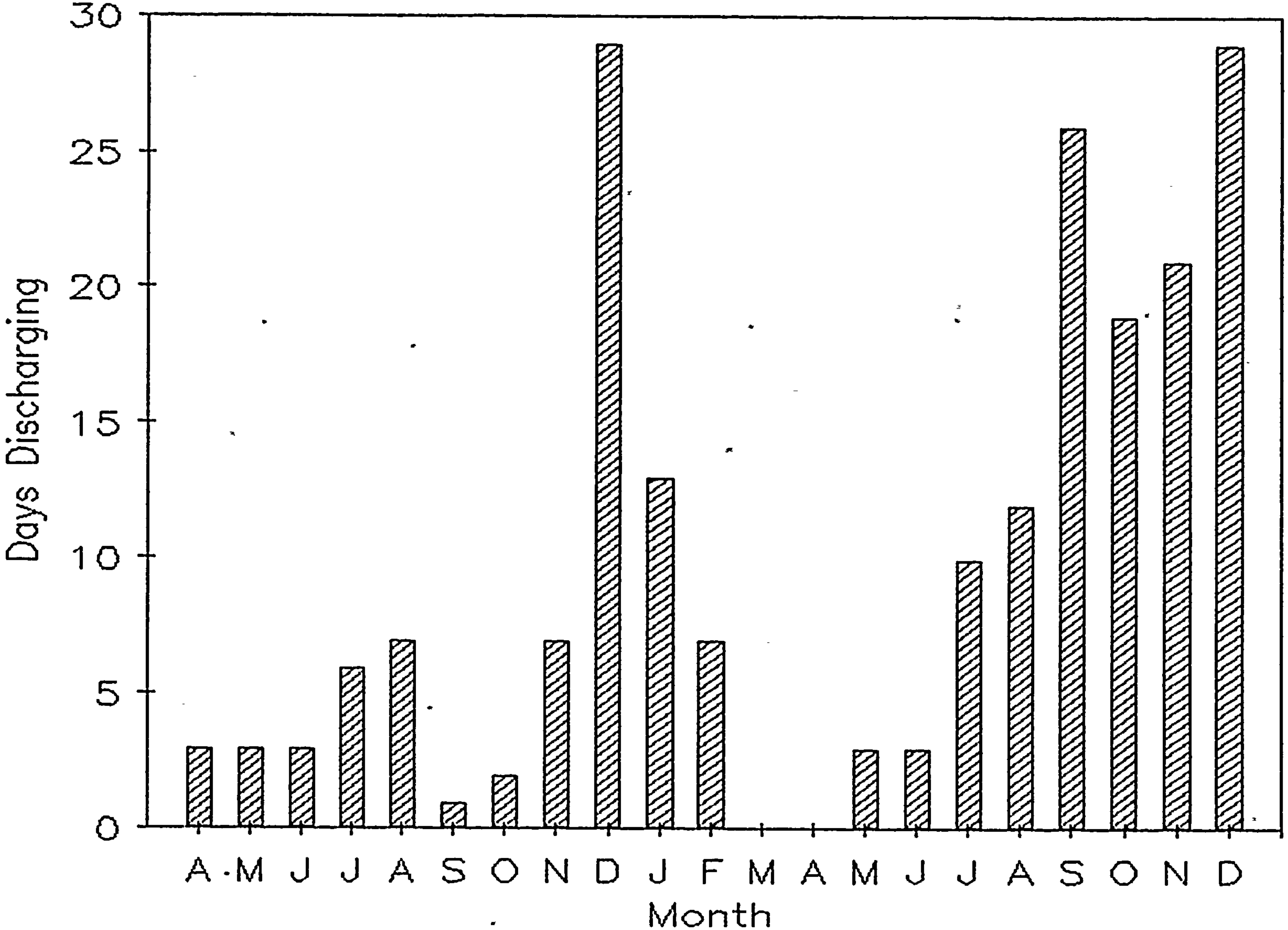


FIGURE 1-3

Number of Days Per Month Discharging
WNP-2
April 1983 — December 1984



2.0 BENTHIC MACROFAUNA

2.1 INTRODUCTION

Benthic macrofauna are the most susceptible Columbia River organisms monitored in respect to possible impacts from WNP-2 discharges. Sensitivity to chemical and thermal stress and a life cycle with limited mobility enable these organisms to serve as excellent monitors of environmental perturbations (2-1) Benthos populations have been measured in the Columbia River's Hanford Reach from 1974 to the present as detailed in Section 1.0 of this report. This study was designed to detect changes within the benthic community which may result from operation of WNP-2. The Energy Facility Site Evaluation Council required the Supply System in Resolution No. 214 to conduct this work. This study covers the period September 1983 to September 1984 (Table 2-1). The start of operation of WNP-2 (i.e., consistently greater than 75% thermal power) occurred in November 1984.

2.2 MATERIALS AND METHODS

The artifical substrate method of collecting benthos was continued to be consistent with preoperational studies conducted since January, 1975. This method (1-2) incorporates a nickel-chrome plated wire basket (Figure 2-1) covering 412.9 cm^2 (64 inches) of the river bottom. Each basket sampler (Figure 2-1) contained 14 smooth river rocks measuring between 5.08 cm and 7.62 cm (2 to 8 inches) in diameter. Eight stations (Figure 2-2) are sampled with 3 replicates placed at each station (Figure 2-3). Following 3 months of incubation time Scuba divers retrieved the baskets in 600 micron mesh bags.

Samples were iced, transported to the Ecological laboratory, where rocks, bags and baskets were brushed, cleaned and rinsed into a 600 micron (U.S. #30 sieve) sieving bucket. Sieved contents were stained with Rose Bengal and then preserved with alcohol. Samples were sorted to taxonomic categories (usually family), identified using keys (2-2, 2-3, 2-4), enumerated, and measured for blotted wet weight to 0.1 mg. A quality assurance evaluation was performed on 10% of the samples with rotation among sample processors. Detailed procedures were incorporated into the Environmental Programs Instruction Manual (EPI 13-2.2 and EPI 13-2.4).

Data Analysis included calculating densities, and biomass for individual taxa and graphical comparisons were developed. Statistical analysis included Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT).

The identification of organisms was carried to a lower level than practiced by past consultants and some organisms were noted which have not been previously listed (i.e.; the mayfly, Tricorythidae; clams; and amphipods). Nematodes and mites, due to identification problems, were either lumped (mites) into a general category or sorted and preserved (nematodes) but not counted or weighted. To standardize taxanomic classifications (i.e., Lithoglyphus/Fluminicola and Lanx/Fisherola) it was decided to use the EPA Bio-Storet Master List of Aquatic Organisms (2-5).

2.3 RESULTS AND DISCUSSION

The density and biomass of benthic macrofauna collected during this study are summarized in Tables 2-2, 2-3, and 2-4 respectively.

Both density and biomass were at their peak during the summer quarter with mean values of 88,000 organisms or 200 grams per square meter for all stations combined. The winter quarter averaged 3,477 organisms or 33 grams per square meter.

The centerline stations' (1, 7M, 11M, and 8) density and biomass values are presented in Figures 2-4 and 2-5. Biomass varied greater than density and appears to be less consistent, therefore, density was used for most evaluation approaches. The seasonal density changes (centerline stations) were more consistent than biomass with the Summer Quarter's density highest and Fall Quarter about 50% fewer. Spring Quarter densities were approximately 1/2 of Fall's while Winter Quarter measured very low densities at all stations. Densities at Station 8 (Figures 2-6, 2-7, 2-8, 2-9) exceeded those measured at 7M and 11M for all seasons except Summer Quarter. Densities measured at station 7M exceeded stations 1 and 11M for all seasons except the Fall Quarter.

Crossriver station (East, Midline, West) differences are presented in Figures 2-10, 2-11, 2-12, and 2-13. The west stations (7W and 11W) appeared more consistent in density.

The low densities and biomass levels observed at all stations during Winter Quarter may not necessarily indicate seasonal fluctuations in the benthic community (1-6, 2-2) but may be due to a winter type hibernation in response to cold temperatures. Reduced activity in response to lower metabolic requirements may reduce the rate at which recolonizing of the samplers occurs. The fluctuations in benthic macrofauna densities/biomass are the result of the births, deaths, immigration, and emigration of the natural substrate benthos community surrounding the samples and may not always provide an accurate measure of the natural bethic community. If the recolonization rate is the same for all stations (and it should be barring outside stress, ie., WNP-2 discharge) then stations should be comparable even in the Winter Quarter.

Of the organisms enumerated during the period of this report (Table 2.2), Chironomidae were the most numerous (67,745 or 48%) followed closely by Hydropsychidae (55,440 or 40%). Hydropsychidae were by far the most important component of biomass (301g or 67%). Mollusca comprised 4% of the organisms counted and 25% of the biomass measured. Hydropsychidae and Mollusca combined represent 92% of the total biomass measured. A detailed breakdown of benthic macrofauna data (seasons, stations, taxa) is presented in Appendix A-1.

A two way ANOVA was conducted on both density and biomass with station and season as the independent variables. Stations, season, and interaction effects were all significant at the 0.01 level for biomass. Only season, however, had a significant effect on density (personal communication, W. Davis III).

In order to further explore the differences, one-way ANOVAS were conducted on total density and total biomass by station for each season (Table 2-5). Duncan's multiple range test was also performed in order to specify which cells differed.

Results of the DMRT are presented in Table 2-6 for those cases with significant F statistics ($\alpha = 0.05$). From this information, we conclude that there are differences between stations for both biomass and density. Furthermore, these differences are not consistent between seasons. This is the same conclusion arrived at for biomass with the two-way ANOVA, but differs when density is the indicator. The conclusion difference is probably due to the overwhelming impact of the summer data set on the two-way ANOVA. During the summer, the one-way ANOVA indicated a biomass but no density difference between stations.

During the three seasons where there were significant density differences, Station 8 had the highest total count. Station 1 exhibited the lowest value in both seasons with a biomass difference (Table 2-6) and in two of the three seasons with a density difference. These two stations differ from the other six stations in both current flow and depth. Both have lower currents and Station 1 is approximately twice as deep while Station 8 is half as deep as the other stations.

Further one-way ANOVAs and DMRTs were conducted on the four groups of organisms. (Hydropsychidae larvae, Chironomidae larvae and pupae, and the snail Fluminicola) The results of the ANOVAs are presented in Table 2-7, the DMRTs are presented in Tables 2-8 and 2-9 for density and biomass respectively.

As before, Stations 1 and 8 stand out as different from the others. For Fluminicola they were always the two low density stations and one of them was always the low biomass station. Among the other taxa, Station 8 represented the high value station 13 out of 15 instances while Station 1 was lowest or next to lowest 6 times.

Among the mid-river stations, Stations 7M and 11M were always the two low stations for Fluminicola density and biomass. The ordering of the other four stations (7E, 7W, 11E, 11W) appears to be random.

2.4 REFERENCES

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2-3 Ward, H.B. and G.C. Whipple. 1959. Freshwater Biology. 2nd Edition.

2-4 Merritt, R.W. and K.W. Cummins. 1978. An Introduction to the Aquatic Insects of North American.

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Table 2-1

MACROBENTHOS PROGRAM SAMPLING PERIODS
September 1983 to September 1984

Date	Period
September 9, 1983 to December 9, 1983	Fall 1983
December 9, 1983 to March 5, 1984	Winter 1984
March 5, 1984 to June 4, 1984	Spring 1984
June 4, 1984 to September 1984	Summer 1984

TABLE 2.2

TOTAL COUNT AND WEIGHT OF ALL ORGANISMS COLLECTED FROM SEPTEMBER 1983 - SEPTEMBER 1984(1)

SPECIES, LIFESTAGE	TOTAL COUNT	TOTAL GRAMS
CADDISFLY-HYDROPSYCHIDAE, LARVAE	54489	290.28
MIDGES-CHIRONOMIDAE, LARVAE	50583	9.03
MIDGES-CHIRONOMIDAE, PUPAE	16801	7.13
SNAIL-FLUMINICOLA	4752	86.71
BLACKFLY-SIMULIDAE, LARVAE	3027	6.23
MAYFLY-BAETIDAE, NYMPH	2422	1.49
CADDISFLY-LEPTOCERIDAE, LARVAE	1920	1.46
BLACKFLY-SIMULIDAE, PUPAE	1133	3.37
CADDISFLY-HYDROPSYCHIDAE, PUPAE	942	10.90
MAYFLY-EPHEMERELLIDAE, NYMPH	732	1.58
SNAIL-FISHEROLA	726	22.36
CADDISFLY-HYDROPTILIDAE, LARVAE	644	.14
OLIGOCHAETE	390	.02
SNAIL-PARAPHOLYX	387	2.53
MIDGES-CHIRONOMIDAE, ADULT	361	.11
MAYFLY, NYMPH	243	.09
CADDISFLY-PSYCHOMYIIDAE, LARVAE	224	.14
MITES-ADULT	162	.06
CADDISFLY-HYDROPTILIDAE, PUPAE	88	.02
CADDISFLY-GLOSSOSOMATIDAE, LARVAE	60	.28
CLAMS	39	.06
MOTH-PYRALIDAE, LARVAE	24	.09
MAYFLY-TRICORYTHODES, NYMPH	24	.02
SNAIL-PHYSA	23	.59
BLACKFLY-SIMULIDAE, ADULT	16	.02
MAYFLY-HEPTAGENIIDAE, NYMPH	11	.01
CADDISFLY-HYDROPSYCHIDAE, ADULT	9	.10
SNAIL-LIMNAE	8	.36
CADDISFLY-PSYCHOMYIIDAE, PUPAE	8	.01
MOLLUSC	7	.08
CADDISFLY-GENERAL, ADULT	3	.05
SCUDS/SHRIMPS	2	.00
MITES-GENERAL, LARVAE	2	.00
FLY-GENERAL, ADULT	2	.02
FLAT-WORM	2	---
WATER FLEAS, DAPHNIA	1	.00
MOTH-PYRALIDAE, NYMPH	1	.01
CADDISFLY-LEPTOCERIDAE, PUPAE	1	.00
CADDISFLY-GLOSSOSOMATIDAE, PUPAE	1	.00
BEETLES-ELMIDAE, ADULT	1	.00
UNIDENTIFIED	-	3.79
ROUND-WORM	-	----
TOTAL	140,271	449.14

(1) Hydropsychidae larvae, and Chironomidae larvae and and pupae estimated by subsampling during summer 1984.

TABLE 2-3

DENSITY OF BENTHIC MACROFAUNA
BY SAMPLE QUARTER AND STATION
(Number/meter^2)

	SUM	MEAN	STD DEV	N
ALL DATA	3397341.6000	35761.4905	34621.2854	95
FALL 83	860971.5000	35873.8125	12643.6435	24
STATION 1	148807.4000	49602.4667	16498.7648	3
STATION 7W	121777.9000	40592.6333	11881.1210	3
STATION 7M	79078.4000	26359.4667	2650.5251	3
STATION 7E	77261.7000	25753.9000	6063.6573	3
STATION 11W	111823.5000	37274.5000	10144.9359	3
STATION 11M	87046.4000	29015.4667	9656.0871	3
STATION 11E	84431.2000	28143.7333	8810.1473	3
STATION 8	150745.0000	50248.3333	5374.0327	3
WINTER 84	83436.7000	3476.5292	1964.6650	24
STATION 1	3511.8000	1170.6000	300.8388	3
STATION 7W	9470.0000	3156.6667	915.9545	3
STATION 7M	8767.4000	2922.4667	920.8258	3
STATION 7E	13417.8000	4472.6000	739.5821	3
STATION 11W	9736.2000	3245.4000	297.5455	3
STATION 11M	4480.3000	1493.4333	286.9364	3
STATION 11E	12424.8000	4141.6000	1069.7841	3
STATION 8	21628.4000	7209.4667	1768.1274	3
SPRING 84	428910.8000	17871.2833	8442.2250	24
STATION 1	27174.9000	9058.3000	5285.9220	3
STATION 7W	69099.3000	23033.1000	4340.1895	3
STATION 7M	51152.3000	17050.7667	1762.7376	3
STATION 7E	30904.6000	10301.5333	1249.4028	3
STATION 11W	68276.1000	22758.7000	2185.5014	3
STATION 11M	45388.0000	15129.3333	5230.2020	3
STATION 11E	37637.8000	12545.9333	2174.2174	3
STATION 8	99277.8000	33092.6000	7120.5843	3
SUMMER 84	2024022.6000	88000.9826	23162.6076	23
STATION 1	249465.9000	83155.3000	19122.4671	3
STATION 7W	231155.2000	77051.7333	22079.2026	3
STATION 7M	316135.2000	105378.4000	26778.3744	3
STATION 7E	135131.2000	67565.6000	23862.3083	2
STATION 11W	219456.9000	73152.3000	6926.5532	3
STATION 11M	298099.7000	99366.5667	35462.4154	3
STATION 11E	288258.0000	96086.0000	28555.9317	3
STATION 8	286320.5000	95440.1667	11595.3754	3

TABLE 2-4

BIOMASS OF BENTHIC MACROFAUNA
BY SAMPLE QUARTER AND STATION

(Grams/meter^2)

	SUM	MEAN	STD DEV	N
ALL DATA	10878.3311	114.5087	81.3726	95
FALL 83	3707.1463	154.4644	55.4571	24
STATION 1	511.9354	170.6451	66.7748	3
STATION 7W	571.4976	190.4992	57.6661	3
STATION 7M	410.9455	136.9818	25.8253	3
STATION 7E	426.6546	142.2182	45.7273	3
STATION 11W	436.9940	145.6647	21.2848	3
STATION 11M	458.2617	152.7539	55.3729	3
STATION 11E	598.0524	199.3508	90.6877	3
STATION 8	292.8051	97.6017	45.4510	3
WINTER 84	781.1598	32.5483	38.4079	24
STATION 1	11.8386	3.9462	0.9138	3
STATION 7W	74.8398	24.9466	15.3979	3
STATION 7M	37.9867	12.6622	3.8178	3
STATION 7E	333.3275	111.1092	25.8308	3
STATION 11W	48.1130	16.0377	13.0834	3
STATION 11M	20.9307	6.9769	2.8874	3
STATION 11E	209.8397	69.9466	26.9112	3
STATION 8	44.2838	14.7613	3.7455	3
SPRING 84	1790.0119	74.5838	38.1967	24
STATION 1	97.5604	32.5201	27.4818	3
STATION 7W	332.6208	110.8736	27.2421	3
STATION 7M	189.1173	63.0391	17.4297	3
STATION 7E	288.8306	96.2769	68.3402	3
STATION 11W	280.7401	93.5800	23.9450	3
STATION 11M	142.2246	47.4082	20.4417	3
STATION 11E	233.1030	77.7010	37.9270	3
STATION 8	225.8151	75.2717	26.0287	3
SUMMER 84	4600.0131	200.0006	59.6597	23
STATION 1	359.3828	119.7943	40.0953	3
STATION 7W	658.5120	219.5040	18.4788	3
STATION 7M	875.4253	291.8084	16.9067	3
STATION 7E	393.1721	196.5860	44.3562	2
STATION 11W	522.5142	174.1714	27.1157	3
STATION 11M	742.3460	247.4487	38.8757	3
STATION 11E	490.3275	163.4425	30.9147	3
STATION 8	558.3332	186.1111	56.4306	3

TABLE 2-5

SUMMARY OF ONE-WAY ANOVA
OF STATION DENSITY OR BIOMASS VERSUS SEASON

Is there a station difference

Period	Density		Biomass	
	F	P(F)	F	P(F)
Fall 83	3.245	0.0243*	1.034	0.4460
Winter 84	12.710	0.0000	18,817	0.0000
Spring 84	11.191	0.0000	1.718	0.1750
Summer 84	0.934	0.5093	6.592	0.0011

*Significant probabilities underlined.

TABLE 2-6

SUMMARY OF DUNCANS MULTIPLE RANGE TEST ON SEASONS WITH SIGNIFICANT BETWEEN STATION DENSITY OR BIOMASS DIFFERENCES (= 0.05)

Density								
Fall	7E	7M	11E	11M	11W	7W	1	8
Winter	1	11M	7M	7W	11W	11E	7E	8
Spring	1	7E	11E	11M	7M	11W	7W	8
Biomass								
Winter	1	11M	7M	8	11W	7W	11E	7E
Summer	1	11E	11W	8	7E	7W	11M	7M

NOTES:

1. Stations are listed in ascending order by size from left to right.
2. Seasons not shown have had no significant differences.

TABLE 2-7

SUMMARY OF ONE-WAY ANOVA
FOR SELECTED TAXA COMPARING STATIONS (α = 0.05)

	Density		Biomass	
	F	P(F)	F	P(F)
Hydropsychidae larvae				
Fall	2.044	0.1120	0.624	0.7291
Winter	4.273	0.0077*	0.979	0.4792
Spring	9.786	0.0001	3.237	0.0245
Summer	6.404	0.0013	7.066	0.0008
Chironomidae larvae				
Fall	3.17	0.0263	1.610	0.2032
Winter	5.672	0.0020	8.048	0.0003
Spring	6.766	0.0008	2.462	0.0643
Summer	1.450	0.2575	0.869	0.5519
Chironomidae larvae				
Fall	1.625	0.1990	0.986	0.4749
Winter	8.681	0.0002	11.498	0.0000
Spring	9.126	0.0001	3.705	0.0142
Summer	3.620	0.0174	1.703	0.1828
Snail-Fluminicola				
Fall	4.058	0.0097	3.137	0.0276
Winter	14.861	0.0000	12.900	0.0000
Spring	3.048	0.3007	3.620	0.0157
Summer	11.185	0.0001	9.449	0.0002

*Significant probabilities are underlined.

TABLE 2-8

SUMMARY OF DUNCANS MULTIPLE RANGE TEST ON TAXA WITH SIGNIFICANT BETWEEN STATION DENSITY DIFFERENCES ($\alpha = 0.05$)

Hydropsychidae Larvae								
Winter	11E	11W	11E	7M	1	7E	7W	8
Spring	7E	1	11E	11M	7M	11W	7W	8
Summer	1	11E	7E	7W	11W	11M	7M	8
Chironomidae Larvae								
Fall	11E	11M	7E	11W	7M	7W	1	8
Winter	1	7E	11M	11E	7W	11W	7M	8
Spring	1	7E	11E	11M	7M	11W	7W	8
Chironomidae Pupae								
Winter	1	7E	11M	7W	11E	7M	11W	8
Spring	7E	1	11E	7M	11M	7W	11W	8
Summer	11W	11E	11M	8	7E	7W	1	7M
Snail-*Fluminicola*								
Fall	8	1	7M	11M	11W	7E	7W	11E
Winter	1	8	7M	11M	11W	7W	11E	7E
Spring	8	1	11M	7M	7E	7W	11E	11W
Summer	1	8	11M	7M	11E	7W	11W	7E

NOTES:

1. Stations are listed in ascending order by size from left to right.
2. Seasons not shown have had no significant differences.

TABLE 2-9

SUMMARY OF DUNCANS MULTIPLE RANGE TEST ON TAXA WITH SIGNIFICANT BETWEEN STATION BIOMASS DIFFERENCES ($\alpha = 0.05$)

Hydropsychidae Larvae								
Spring	7E	11E	1	11M	7W	7M	11W	8
Summer	7E	1	11E	11W	7W	8	11M	7M
Chironomidae Larvae								
Winter	1	11M	7E	11E	7W	11W	7M	8
Spring	11M	11E	7E	1	7W	7M	11W	8
Chironomidae Pupae								
Winter	1	11M	7E	11E	7W	11W	7M	8
Spring	11E	7E	11M	1	7M	7W	11W	8
Snail-*Fluminicola*								
Fall	8	1	7M	11M	11W	7E	7W	11E
Winter	1	8	7M	11M	11W	7W	11E	7E
Spring	8	7M	1	11M	7E	11E	11W	7W
Summer	1	8	7M	11M	11W	11E	7W	7E

NOTES:

1. Stations are listed in ascending order by size from left to right.
2. Seasons not shown have had no significant differences.

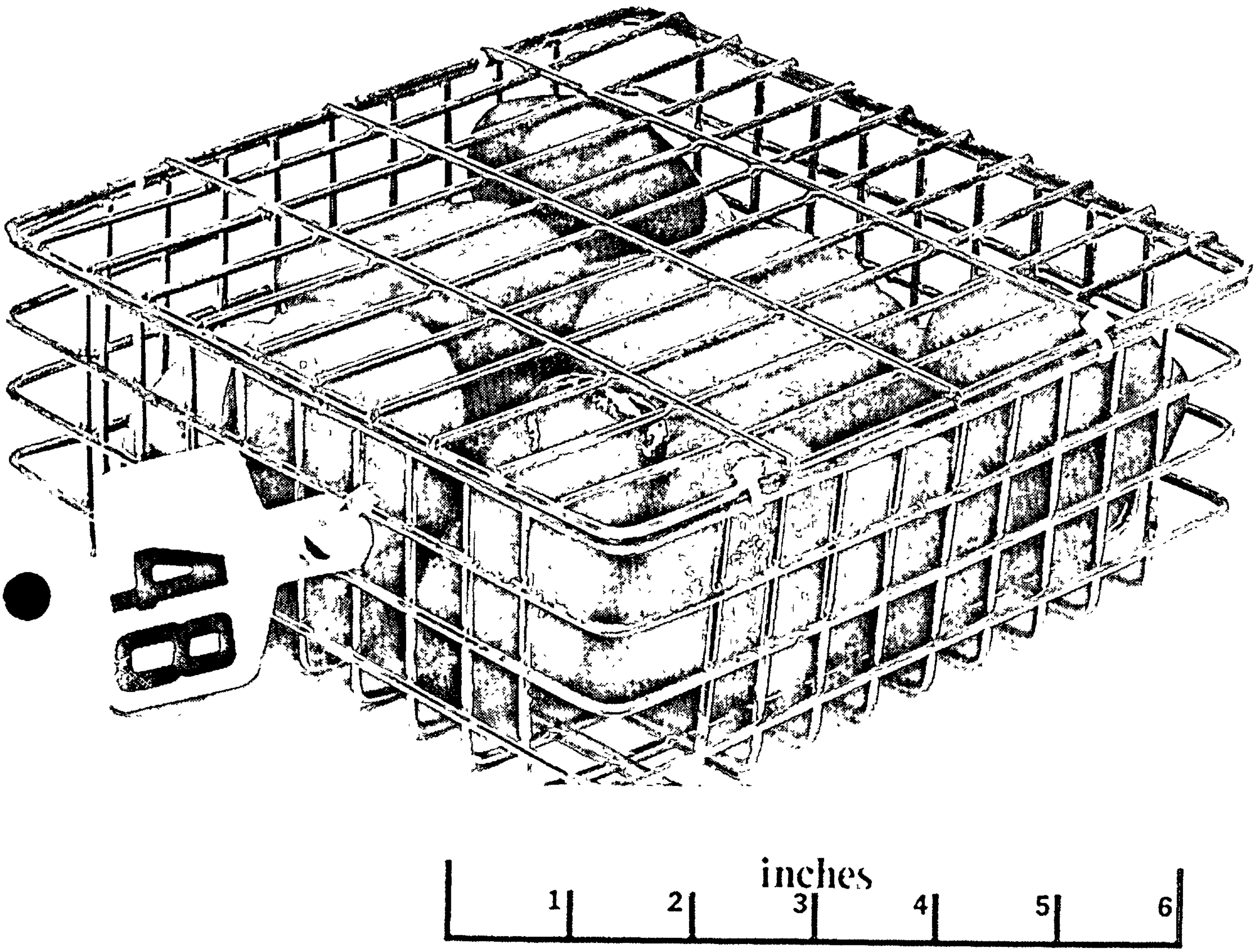


Figure 2.1 Sampler Used to Collect Benthic Macrofauna in Columbia River

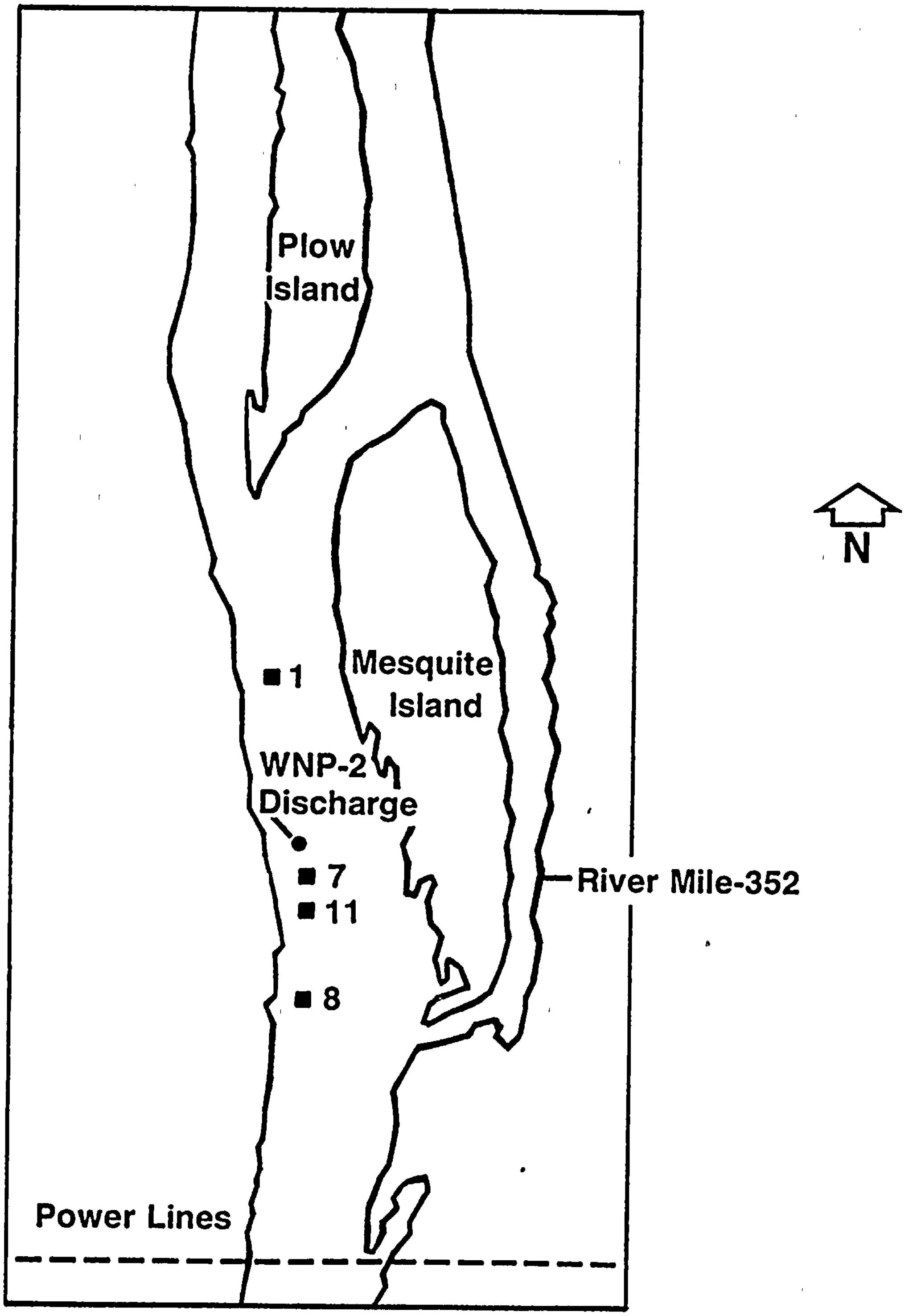


Figure 2.2 Location of Sampling Stations in the Columbia River

850381-2A

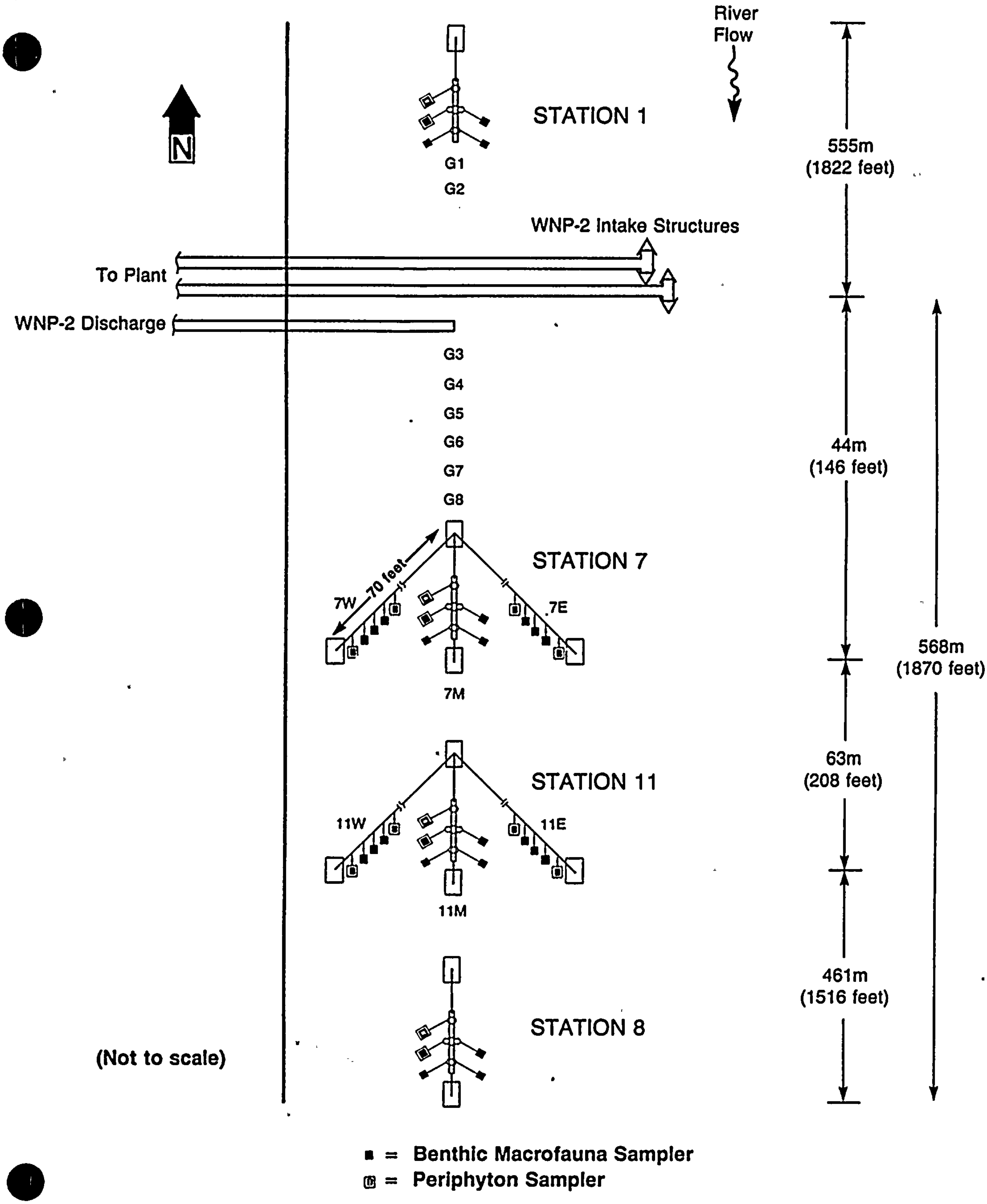


Figure 2.3 Diagrammatic Representation of the Aquatic Sampling Stations in the Columbia River

850381-7A

Figure 2-4 Benthos Total Density at centerline stations

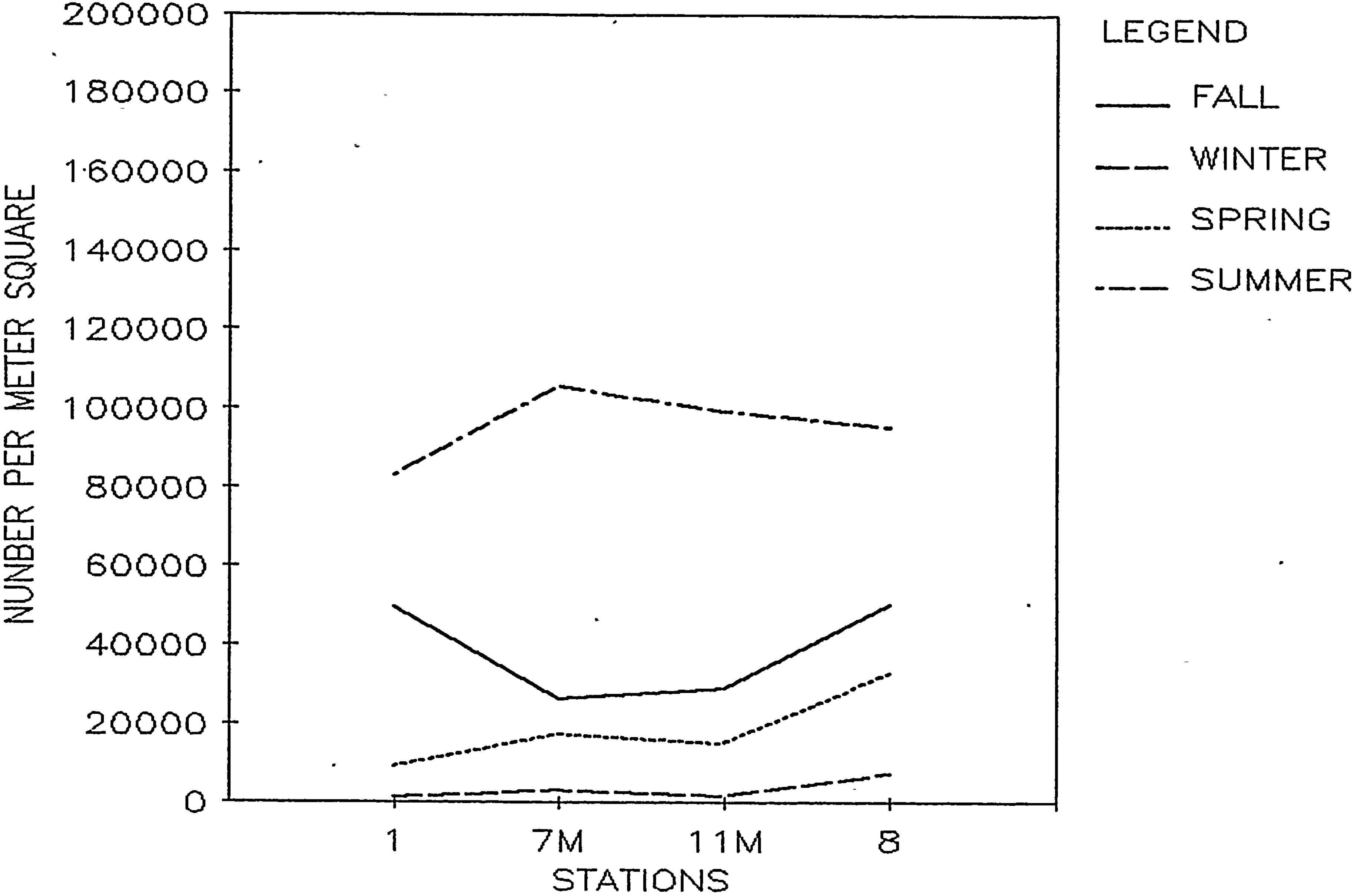


Figure 2-5 Benthos Total Biomass at centerline stations

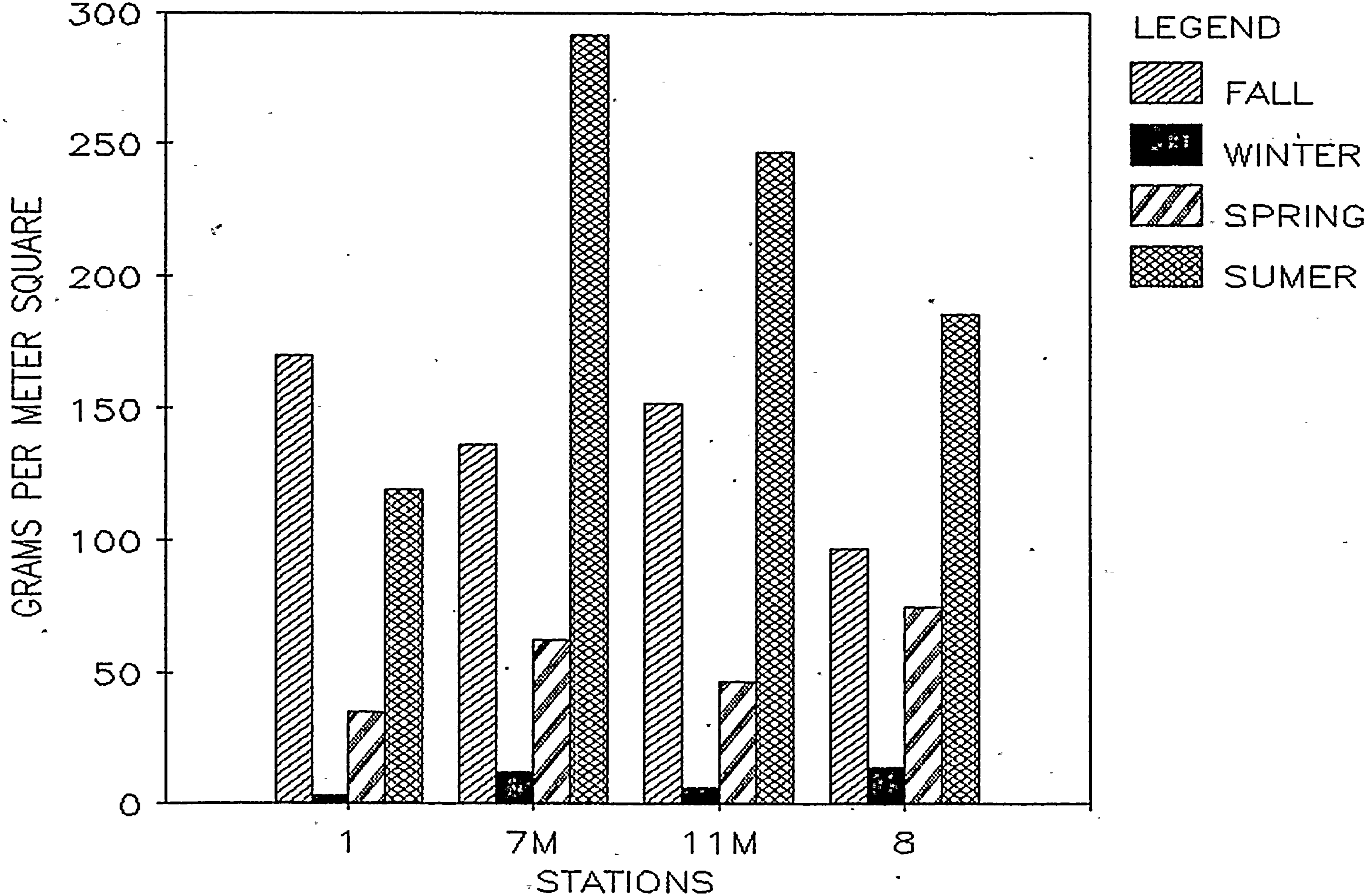


Figure 2-6 FALL 83
Benthos Total Density
at centerline stations

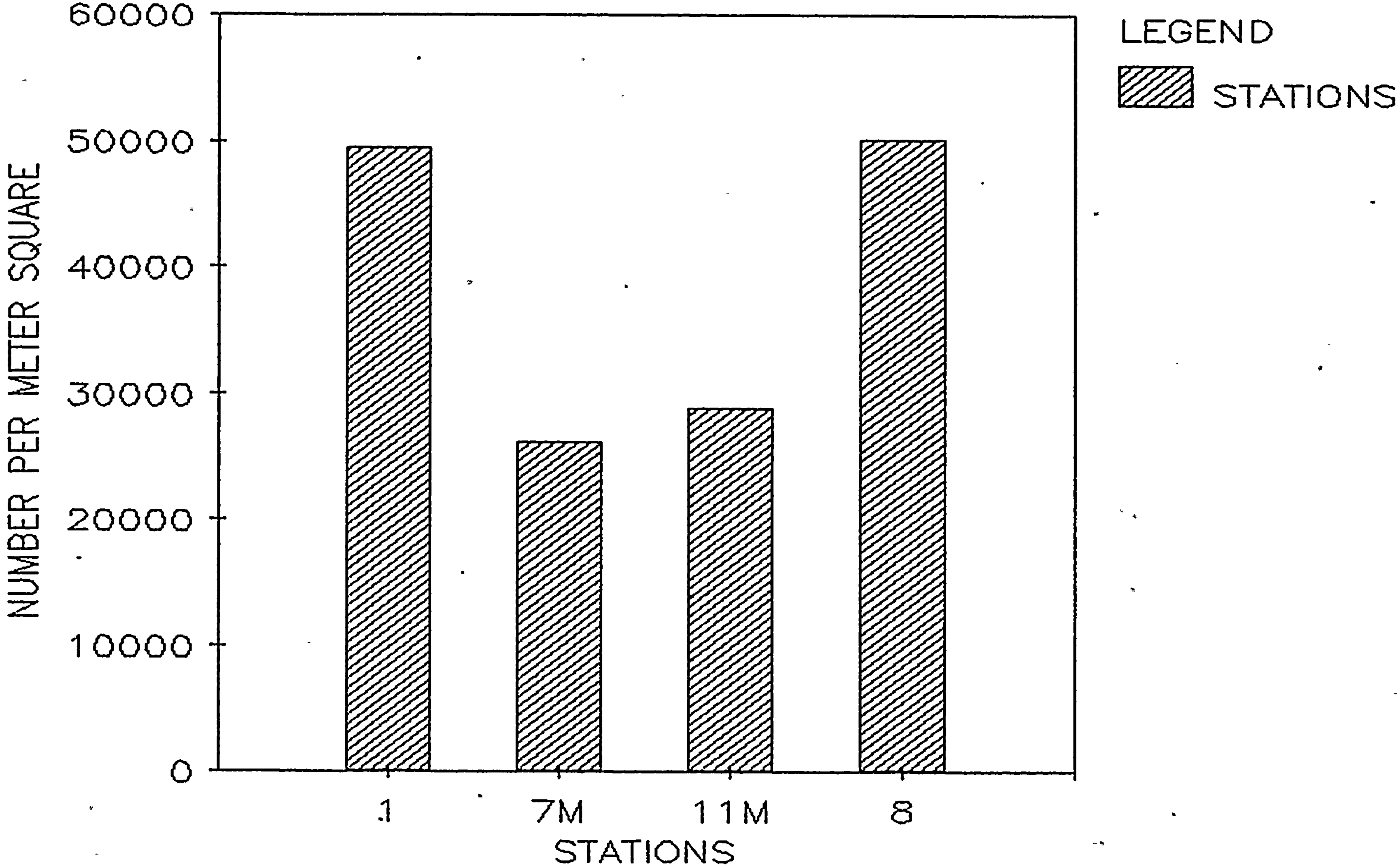


Figure 2-7 WINTER 84
Benthos Total Density
at centerline stations

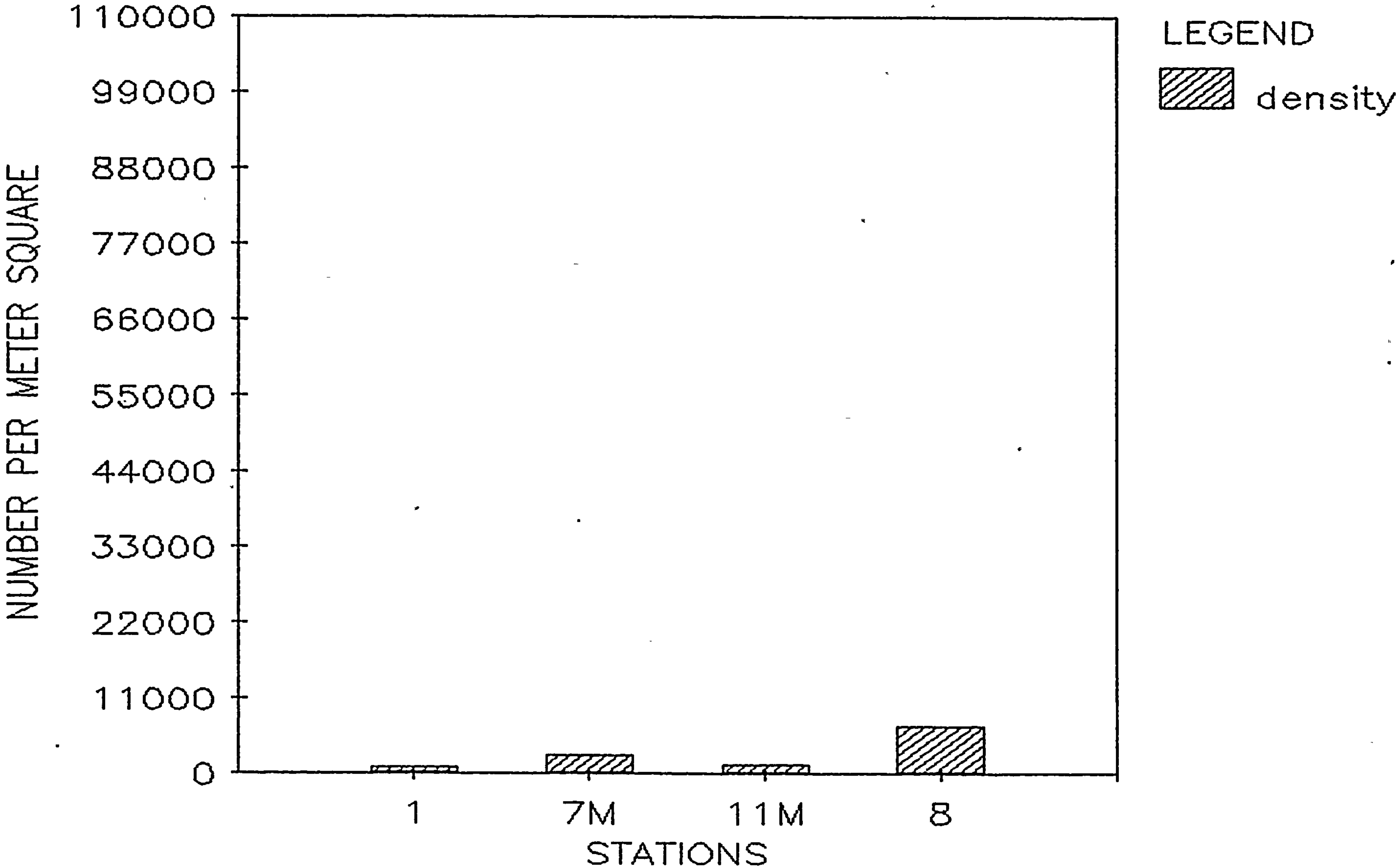


Figure 2-8 SPRING 84
Benthos Total Density
at centerline stations

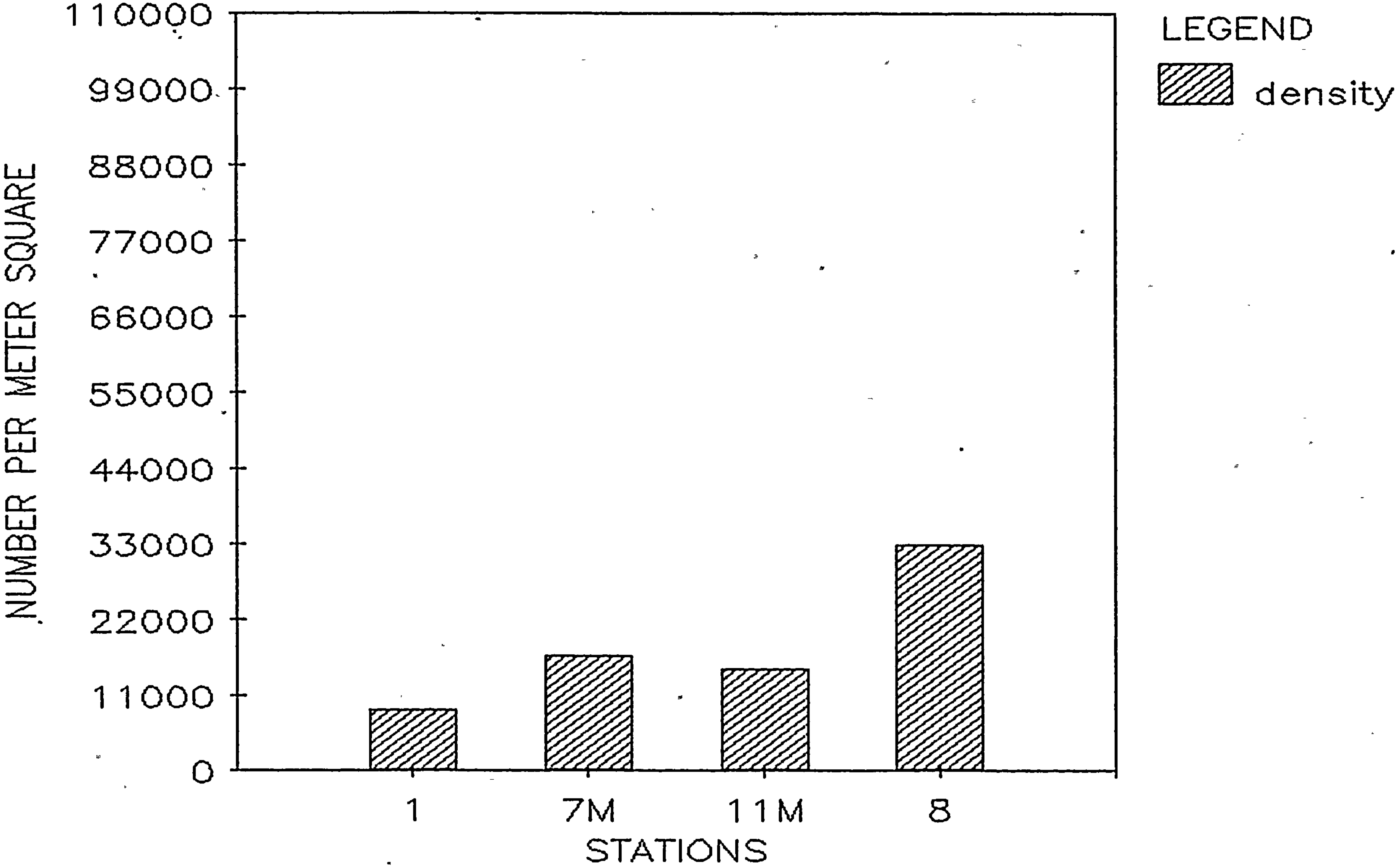


Figure 2-9 SUMMER 84
Benthos Total Density
at centerline stations

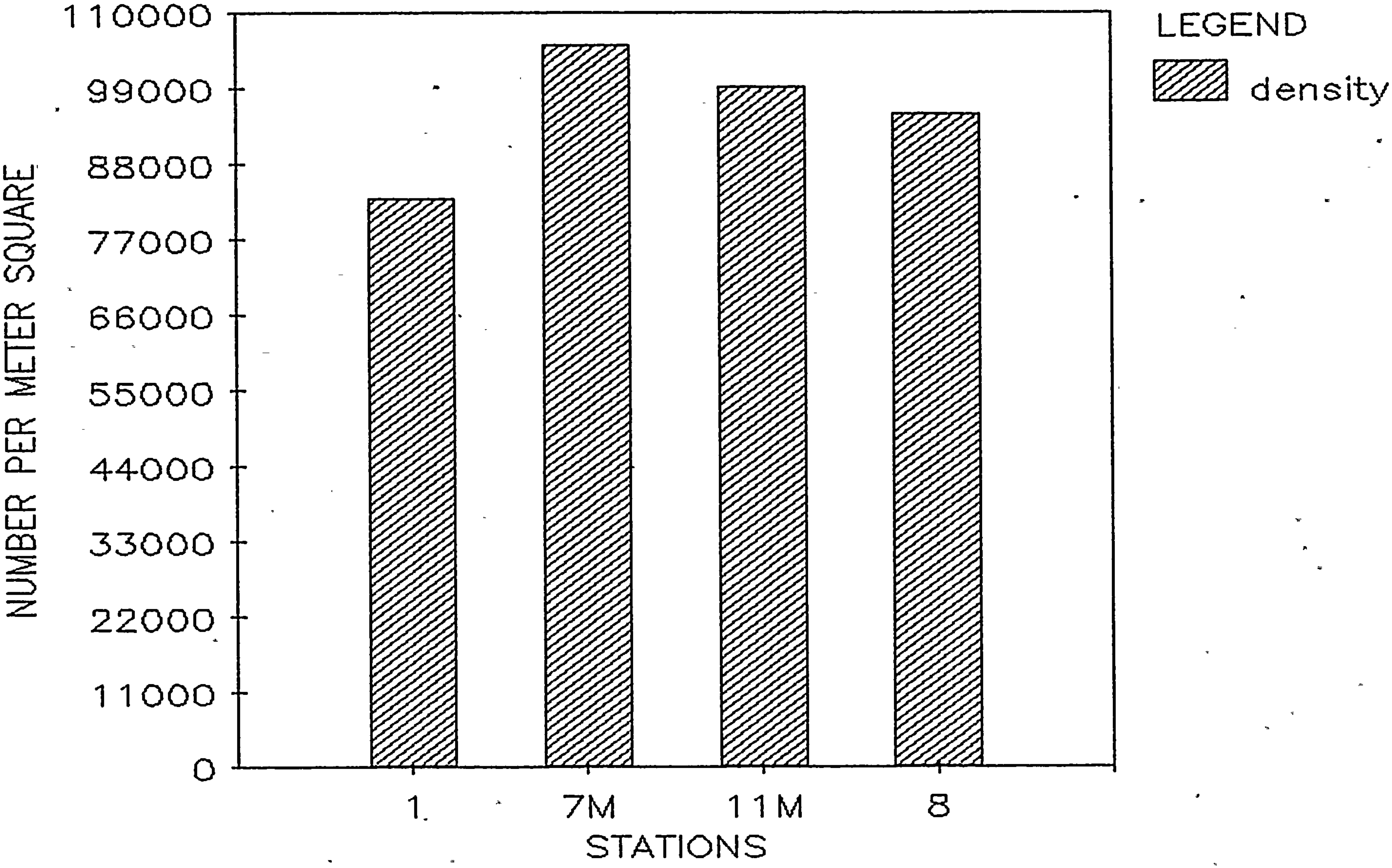


Figure 2-10 FALL 83
Benthos Total Density
at cross river stations

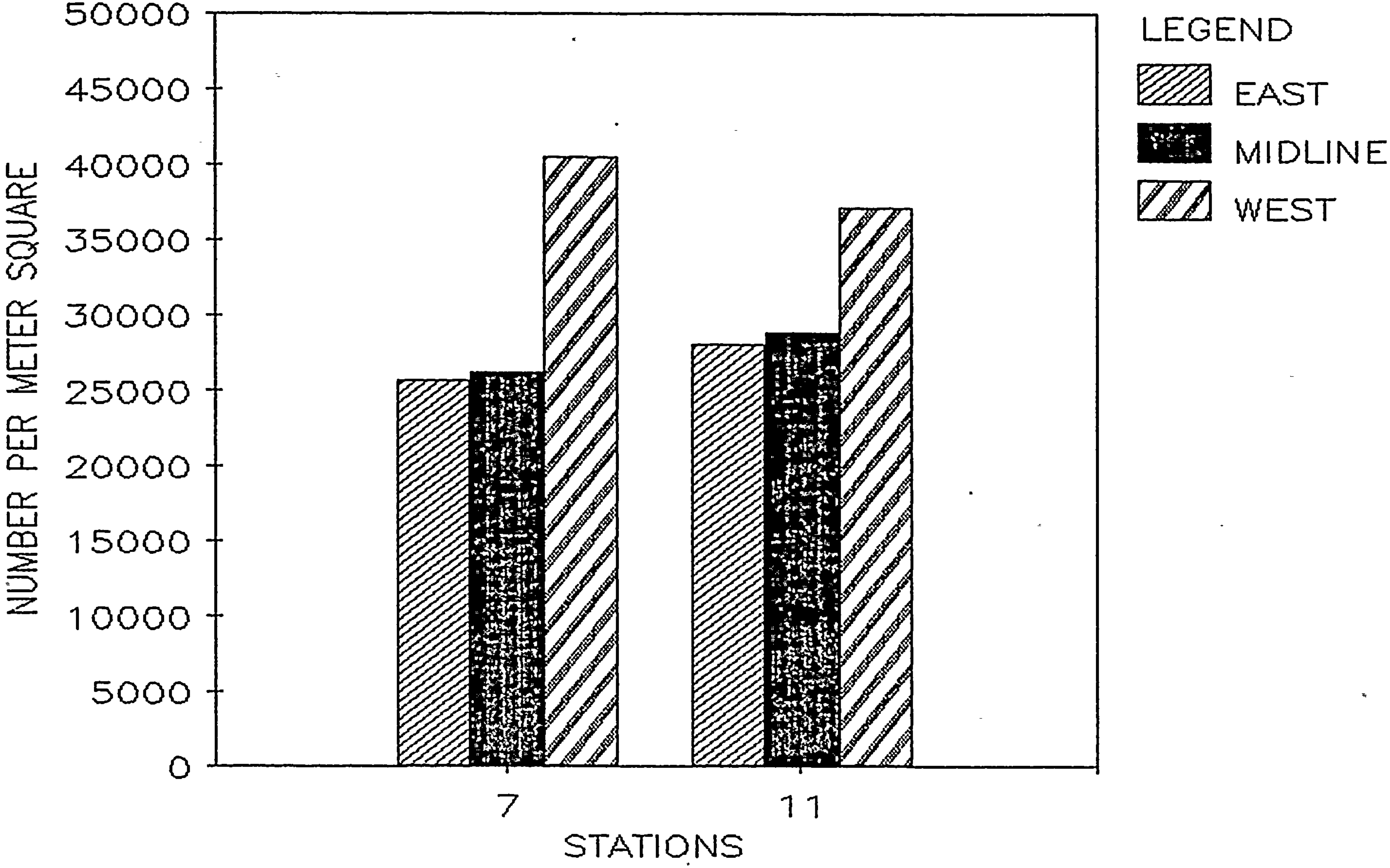


Figure 2–11 WINTER 84
Benthos Total Density
at cross river stations

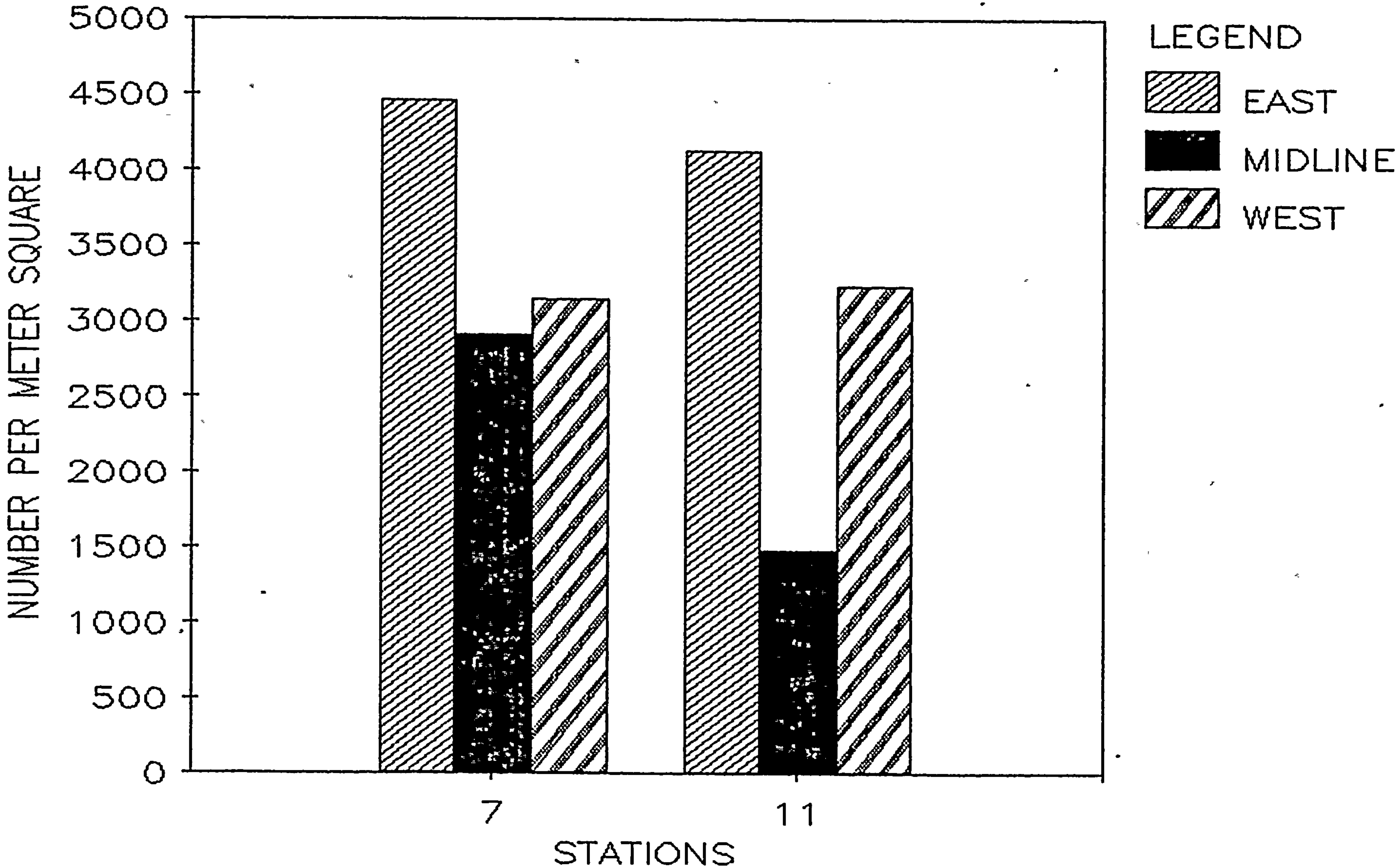


Figure 2-12 SPRING 84
Benthos Total Density
at cross river stations

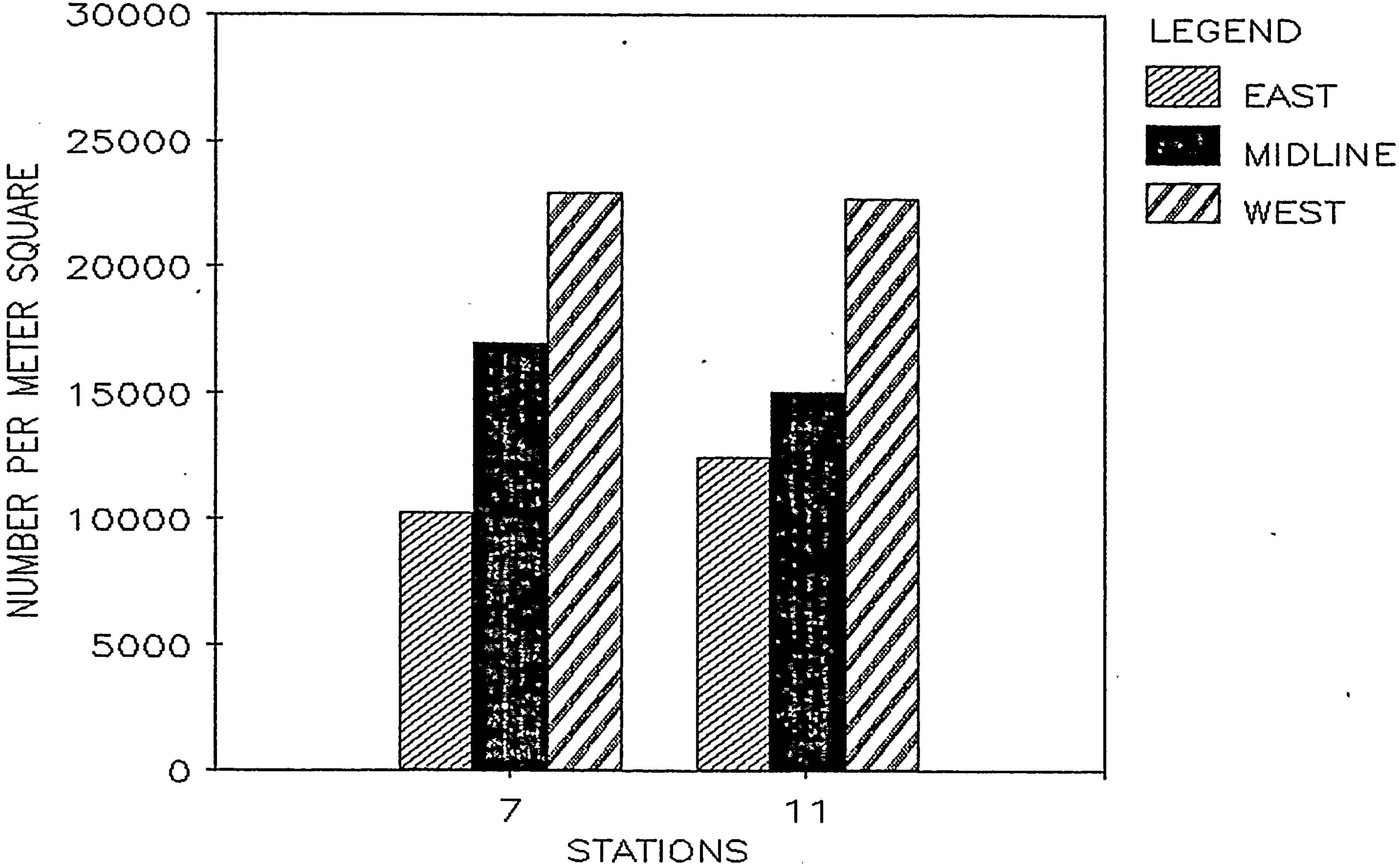
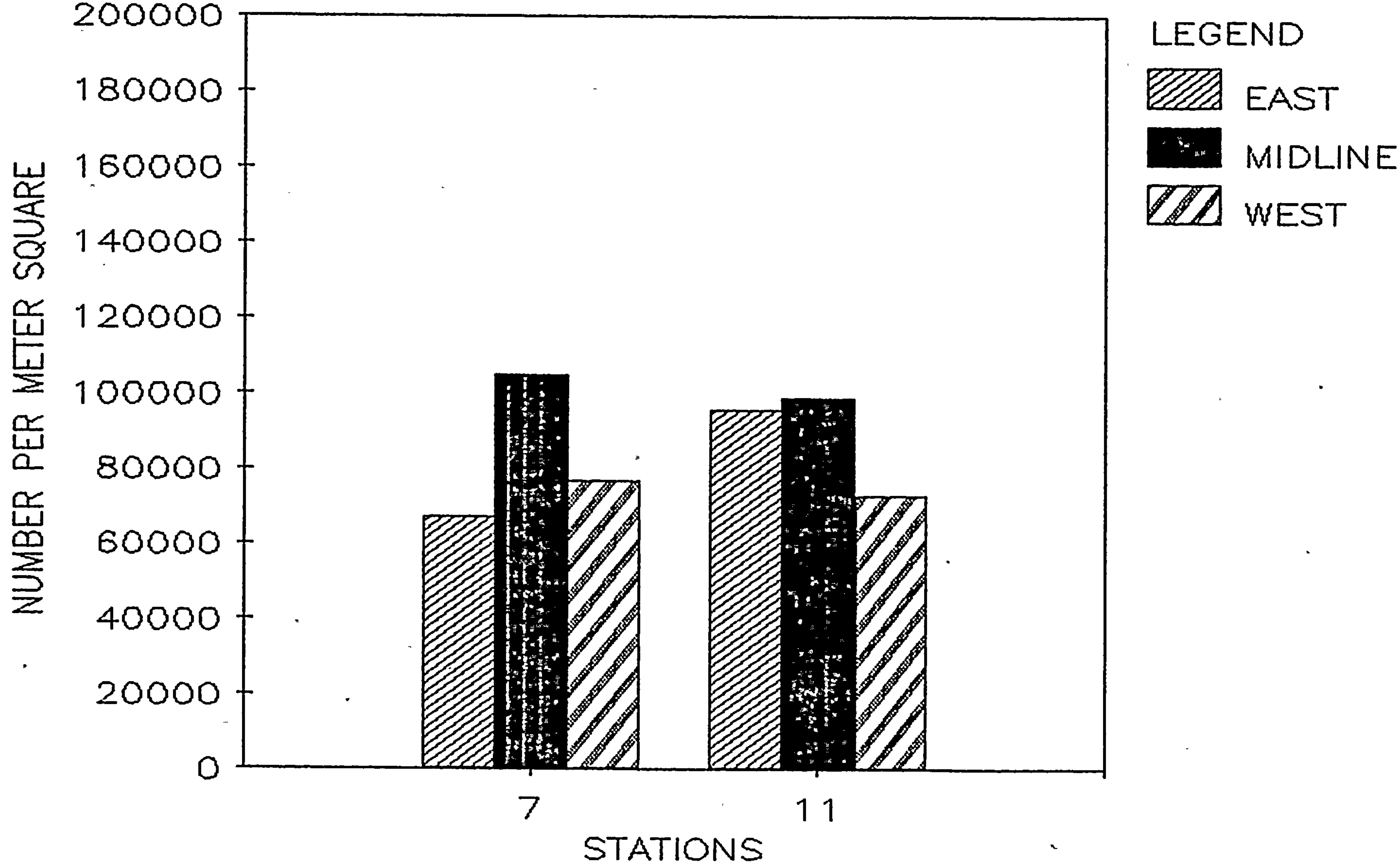


Figure 2–13 SUMMER 84
Benthos Total Density
at cross river stations



3.0 PERIPHYTON

3.1 INTRODUCTION

Periphyton cam be a useful biological indicator of water quality because it forms a vital link in the aquatic food chain and is sensitive to thermal and chemical discharges (3-1). Because periphyton is attached to the substrate, any impact that occurs tends to be largest at its source and smaller as distance from the source increases, making the cause more easily identifiable. Periphyton was sampled near WNP-2 from 1977 to 1980 in studies that preceded those reported on in this section.

During previous preoperational sampling, diatoms dominated the benthic microflora in the Columbia River near WNP-2 due to favorable environmental conditions including cool water temperatures (3-2). Elevated temperatures from power-plant discharge could change this balance, though, causing increased periphyton biomass, reduced species diversity, or changed species composition (3-2 to 3-5). However, a study of the thermal tolerance of Columbia River periphyton indicated that an increase of as much as ten degrees centigrade above ambient river temperature significantly changed (increased) biomass only during a short period in winter with the domination of diatoms persisting (3-4). Total residual chlorine concentrations of near 0.1 ppm, as in the discharge, can also affect periphyton by reducing growth (3-6), but dilution of discharge water in the mixing zone rapidly lowers the concentration to levels that should not be harmful. This mixing also quickly reduces elevated temperatures, so thermal and chemical conditions that could measurably affect the natural periophyton community are likely to be experienced only within about 6m of the outfall, even under the worst-case conditions with a river flow of 36,000 cfs and a blowdown rate of 15 cfs (3-7, 3-8).

This report section includes data collected between March 1983 and December 1984. Because WNP-2 did not become fully operational until fall of 1984 (Figure 1-1), most of this data is considered to be preoperational. Any conclusions drawn from the small amount of operational data that has been included must be very limited. Specific objectives of the periphyton program

were to verify field and laboratory techniques, to collect additional preoperational data, and to monitor operational impacts as the power plant came into service.

3.2 MATERIALS AND METHODS

Periphyton samples were collected from the Columbia River in the vicinity of WNP-2 from March 1983 to December 1984. Two groups of stations were sampled. Eight stations used in earlier preoperational studies (1-1 to 1-6) were sampled on a quarterly basis (Table 3-1). They will be referred to as the core program and are situated such that one is 555m upstream of the WNP-2 discharge port, six others are spaced over the length and breadth of the discharge plume, and another is 568m downstream of the discharge port, beyond the plume influence (Figure 2-3). Quarters will represent seasons as follows: December-February=Winter, March-May=Spring, June-August=Summer, September-November=Fall.

Because the impact of WNP-2 on the aquatic environment is expected to be small, six additional stations were established close to the discharge port. They will be referred to as the gradient program and are situated at 6.1m intervals along the discharge plume center-line, beginning at the discharge port and extending downstream 30.5m (Figure 2-3). These stations will be exposed to a gradient of thermal and chemical conditions resulting from the spreading and mixing of the discharge plume. Two control stations, 6.1 meters apart, were established near core Station 1. Samples were collected every six weeks to provide a large sample size and thorough seasonal coverage (Table 3-1). Gradient program sampling periods will be referred to as early or late portions of seasons, e.g. early winter or late winter.

Sampling and analysis methods were the same for the core and gradient programs. Samples were collected using glass slide diatometers emplaced and retrieved by scuba divers (Figure 3-1). Two replicate diatometers were located at each station, and from each diatometer, two slides were scraped into crucibles for determination of total organic matter (TOM) and two were preserved in case determination of species composition is required at a later date. Crucibles were dried at 105 degrees centigrade until a constant weight had been reached,

ashed for one hour at 500 degrees centigrade, rewet, and dried to constant weight again at 105 degrees centigrade. TOM was the calculated difference between dry weight and ashed weight. Surveillance (QA) reweighings were performed on at least 10 percent of the crucibles from each sampling date.

A detailed description of field and laboratory methods can be found in references 3-9 to 3-11. These methods closely follow those used for earlier preoperational studies at WNP-2 (1-1 to 1-6).

3.3 RESULTS AND DISCUSSION

Mean periphyton biomass at core program stations range from 0.14 g/square meter at station 11E during Spring 1983 to 3.67 g/square meter at Station 8 during Winter 1984 (Table 3-2). The general seasonal pattern was a spring low followed by higher values during the other three seasons, but the relative rankings of summer, fall, and winter were not consistent (Figure 3-2). The only major divergence from this pattern occured at Station 8, which had a high TOM value in the Spring of 1983.

Statistical analyses were performed to determine the affect of station, seasonal, and yearly factors on periphyton biomass at core program stations. A three way ANOVA (Table 3-3) found that TOM varied significantly between seasons, stations, and years (alpha=0.05). A Duncan's multiple range test (DMRT) on combined data (stations and years pooled) showed spring values to be significantly lower than those of other periods, but other seasonal distinctions were not made (Figure 3-3a). A DMRT comparing stations found that although 8 and 11W frequently ranked high and 1 was often low, statistically significant differences between stations were not consistent over time (Table 3-4). This last test was performed on data sets from individual sampling periods because the stability of station rankings over time is of special interest when comparing control and treatment locations during preoperational and operational conditions. Based on its results, Stations 7W, 7M, 7E, 11M, and 11E appear to be quite similar, whereas Station 1 is less productive and Stations 11W and 8 are more productive in terms of periphyton biomass. This statement holds for both the preoperational period and the single operational data set that was collected during Fall of 1984.

Mean periphyton biomass at gradient program stations ranged from 0.042 g/square m at Station G4 in early Winter 1984 to 2.62 g/square meter at Station G3 in late Summer 1984 (Table 3-2). These values were considerably lower than those observed at the same time for the core program. The general seasonal pattern was similar for the two programs to the extent that TOM was usually low in the spring and high in summer and fall; however, for the gradient program, TOM was usually lower during the winter (Figure 3-4). Only Station G2, one of the controls, deviated markedly from this pattern by attaining fairly high biomass values in winter of 1984.

Statistical analyses were performed on gradient program data to determine the importance of station, seasonal, and yearly factors. A three way ANOVA (Table 3-5) indicated that all three factors were of statistical significance (alpha=0.05). It is also noteworthy that the only significant interaction was between seasons and years, indicating that statistically detectable differences between stations were consistent over time. A Duncan's multiple range test comparing stations during individual sampling periods showed that there were not significant differences between stations during all periods, but Stations G3 and G4 located immediately downstream of the discharge frequently ranked high in terms of TOM, whereas control Station G1 often ranked low during the preoperational period (Table 3-2). In contrast, although between station differences were not clearcut, during the operational period, Station G3 consistently ranked low. However, in view of the small amount of operational data so far collected, it is too early to assess the cause of this situation or to know if it will persist to form a meaningful trend. A DMRT on combined data (stations and years pooled) showed that early winter through early summer values (December-June) were significantly lower than those of late summer and early fall (July-September), and late fall values were intermediate (Figure 3-3b).

Core program data presented in this report is in agreement with earlier periphyton studies at WNP-2 (1-1 to 1-6). Seasonal trends observed from March 1983 through December 1984 were the same as those seen in the past; seasonal, yearly, and station factors were statistically significant for both the recent and the earlier data sets; and station and season differences were similar for the two periods. TOM values observed during the ongoing program are within

the reported range of 0.13 g/m^2 to 12.6 g/m^2 reported for past studies at WNP-2. Exceptionally high TOM values of from 15.5 to 26.7 g/square meter reported in 1977 are questionable and have been excluded from this comparison. The suspect observations were concurrent with peak macrofauna density and the ratio of TOM to chlorophyll "a" (autotrophic index) was one fourth to one half of other reported values, suggesting that considerable macrofauna biomass may have been included in these TOM measurements.

Many factors can affect periphyton biomass accumulation on glass slides, but it is difficult to know which are most important in the case of the WNP-2 program. The observed seasonal differences are likely due, in some degree, to seasonal variation in light availability and temperature. Wolf et. al. (3-12) showed that phytoplankton production was less near the Columbia River bottom than at the surface or in mid-water, and attributed the differences to reduced light intensity at greater depth. Owens (3-4) found that periphyton biomass accumulated more rapidly during the winter in heated Columbia River water than at ambient river temperature under otherwise similar conditions. Differences between stations may also be partly due to variation in light intensity related to water depth. Biomass accumulations were consistently lowest at core Station 1, the deepest, and greatest at Station 8, the shallowest. Other factors such as current velocity may also be important, but have not been characterized sufficiently for evaluation at this time.

3.4 REFERENCES

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3-5 Coutant, C.C. and B.B. Owens. 1970. "Productivity of Periphyton Communities under Thermal STress," in BNWL-1306, Vol. 1, Part 2, p. 3.1, Pacific Northwest Laboratories, Richland, Wash.

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3-7 Nakatani, R.E. in hearings on Application TPPSEC 71-1 before State of Washington Thermal Power Plant Site Evaluation Council, Figure 13, Exhibit 49.

3-8 Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, April 1, 1968, Washington, D.C.

3-9 WNP-2 Periphyton Collection Procedure, Rev. 1, December 1983. Washington Public Power Supply System, Richland, Wash.

3-10 WNP-2 Periphyton Laboratory Procedure. Rev. 1, December 1983. Washington Public Power Supply System, Richland, Wash.

3-11 Periphyton Data Forms Procedure. Rev. 0, Washington Public Power Supply System, Richland, Wash.

3-12 Wolf, E.G., T.L. Page, and D.A. Neitzel. 1976. Phytoplankton community: primary productivity, pigment concentration, species composition and relative abundance of phytoplankton and physiochemical analyses. In: Final report on aquatic ecological studies conducted at the Hanford Generating Project, 1973-1974. WPPSS Columbia River Ecology Studies Vol. 1. Prepared for Washington Public Power Supply System under contract 2311201335 with United Engineers and Constructors, Inc., by Battelle, Pacific Northwest Laboratories, Richland, Wash. 216pp.

TABLE 3-1

PERIPHYTON CORE AND GRADIENT PROGRAM SAMPLING PERIODS, SPRING 1983 THROUGH FALL 1984

Program	Sampling Period	Year	Period Name
Core	March 7 to June 16	1983	Spring
	June 16 to September 19		Summer
	September 19 to December 8		Fall
	December 8 to March 5	1984	Winter
	March 5 to June 4		Spring
	June 4 to September 5		Summer
	September 5 to December 5		Fall
Gradient	April 20 to June 15	1983	Late Spring
	June 15 to July 26		Early Summer
	July 26 to September 19		Late Summer
	September 19 to October 31		Early Fall
	October 31 to December 7		Late Fall
	December 7 to January 23	1984	Early Winter
	January 23 to March 5		Late Winter
	March 5 to April 23		Early Spring
	April 23 to June 7		Late Spring
	June 7 to July 16		Early Summer
	July 16 to September 4		Late Summer
	September 4 to October 18		Early Fall
	October 18 to December 12		Late Fall

TABLE 3-2

MEAN PERIPHYTON TOM (g/m^2) BY SEASONS AT CORE AND GRADIENT PROGRAM STATIONS, MARCH 1983 THROUGH DECEMBER 1984

Program	Season	Year	1	7W	7M	7E	11W	11M	11E	8
Core	Spring	1983		.56			.60	.50	.14	3.14
	Summer		1.22	2.13	2.20	2.10	2.46	1.35	1.92	2.49
	Fall		.94	1.87	1.73	1.70	2.30	2.26	2.10	2.08
	Winter	1984	.34	.86	1.73	1.51	3.10	1.88	1.89	3.67
	Spring		.49	1.01	.80	.90	1.24	.88	.77	1.59
	Summer		2.23	2.18	1.85	2.77	3.06	2.36	2.30	2.58
	Fall		.78	2.14	2.43	2.16	3.09	2.72	3.18	3.46
			G1	G2	G3	G4	G5	G6	G7	G8
Gradient	Late Spring	1983	1.03	.81	1.06	1.13	.67	.71	.75	.47
	Early Summer		.44	.37	.49	.80	.40	.48	.35	.58
	Late Summer		.68	1.59	1.65	1.80	1.79	1.88	2.18	1.68
	Early Fall		.97	1.10	1.99	2.48	1.96	1.80	1.85	1.68
	Late Fall		.38	.34	.68	.45	.42	.73	.19	.48
	Early Winter	1984	.13	.12	.21	.04	.21	.13	.15	.1[illegible]
	Late Winter		.24	.14	.43	.10	.25	.20	.12	.23
	Early Spring		.18	.06	.22	1.03	.28	.38	.16	.31
	Late Spring		.22	.35	.18	.46	.37	.38	.37	.27
	Early Summer		.92	.60	.51	.42	.48	.44	.38	.31
	Late Summer		.94	.44	2.62	2.01	1.44	1.05	.84	.97
	Early Fall		.83	1.04	.99	1.33	1.58	1.02	1.47	1.30
	Late Fall		1.01	.57	.50	1.16	1.32	1.38	.64	1.37

TABLE 3-3

THREE FACTOR ANOVA PERFORMED ON PERIPHYTON CORE PROGRAM TOM DATA COLLECTED FROM MARCH 1983 TO DECEMBER 1984

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	113.814	11	10.347	19.764	0.000
Season	66.085	3	22.028	42.079	0.000
Station	56.020	7	8.003	15.287	0.000
Year	8.235	1	8.235	15.731	0.000
Explained	113.814	11	10.347	19.764	0.000
Residual	101.559	194	0.524		
Total	215.373	205	1.051		

TABLE 3-4

HOMOGENEOUS SUBSETS OF CORE PROGRAM PERIPHYTON STATIONS AS DETERMINED BY DUNCAN'S MULTIPLE RANGE TEST. CONNECTING LINES INDICATE NO SIGNIFICANT DIFFERENCE BETWEEN MEANS (ALPHA = 0.05). STATIONS ARE LISTED IN ASCENDING ORDER BY SIZE OF MEAN, FROM LEFT TO RIGHT

Start Date	Season	Homogeneous Subsets							
3/7/83	Spring	11E	11M	7W	11W	8			
6/15/83	Summer	1	11M	11E	7E	7W	7M	11W	8
9/19/83	Fall	1	7E	7M	7W	8	11E	11M	11W
12/8/83	Winter	1	7W	7E	7M	11M	11E	11W	8
5/5/84	Spring	1	11E	7M	11M	7E	7W	11W	8
6/4/84	Summer	7M	7W	1	11E	11M	8	7E	11W
9/5/84	Fall	1	7W	7E	7M	11M	11W	11E	8

TABLE 3-5

THREE FACTOR ANOVA PERFORMED ON PERIPHYTON GRADIENT PROGRAM TOM DATA COLLECTED FROM MARCH 1983 TO DECEMBER 1984

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	61.147	11	5.559	18.116	0.000
Season	50.605	3	16.868	54.974	0.000
Station	7.044	7	1.006	3.279	0.002
Year	2.024	1	2.024	6.598	0.011
2-Way Interaactions	9.902	31	0.319	1.041	0.411
Seasonal NSTA	4.780	21	0.228	0.742	0.789
Season YR	3.564	3	1.188	3.871	0.010
NSTA YR	1.523	7	0.218	0.709	0.664
3-Way Interactions	5.672	21	0.270	0.880	0.617
Season NSTA YR	5.672	21	0.270	0.880	0.617
Explained	76.720	63	1.218	3.969	0.000
Residual	104.939	342	0.307		
Total	181.659	405	0.449		

TABLE 3-6

HOMOGENEOUS SUBSETS OF GRADIENT PROGRAM PERIPHYTON STATIONS AS DETERMINED BY DUNCAN'S MULTIPLE RANGE TEST. CONNECTING LINES INDICATE NO SIGNIFICANT DIFFERENCE BETWEEN MEANS (ALPHA = 0.05). STATIONS ARE LISTED IN ASCENDING ORDER BY SIZE OF MEAN, FROM LEFT TO RIGHT

Start Date	Season	Homogeneous Subsets							
4/20/83	Late Spring	G8	G5	G6	G7	G2	G1	G3	G4
6/15/83	Early Summer	G7	G2	G5	G1	G6	G3	G8	G4
7/26/83	Late Summer	G1	G2	G3	G8	G5	G4	G6	G7
9/19/83	Early Fall	G1	G8	G6	G7	G5	G3	G2	G4
10/31/83	Late Fall	G7	G2	G1	G5	G4	G8	G3	G6
12/7/83	Early Winter	G4	G2	G1	G6	G7	G8	G5	G3
1/23/84	Late Winter	G4	G7	G2	G6	G8	G1	G5	G3
3/5/84	Early Spring	G2	G7	G1	G3	G5	G8	G6	G4
4/23/84	Late Spring	G3	G1	G8	G2	G5	G7	G6	G4
6/7/84	Early Summer	G8	G7	G4	G6	G5	G3	G2	G1
7/16/84	Late Summer	G2	G7	G1	G8	G6	G5	G4	G3
9/4/84	Early Fall	G1	G3	G6	G2	G8	G4	G7	G5
10/18/84	Late Fall	G3	G2	G7	G1	G4	G5	G8	G6

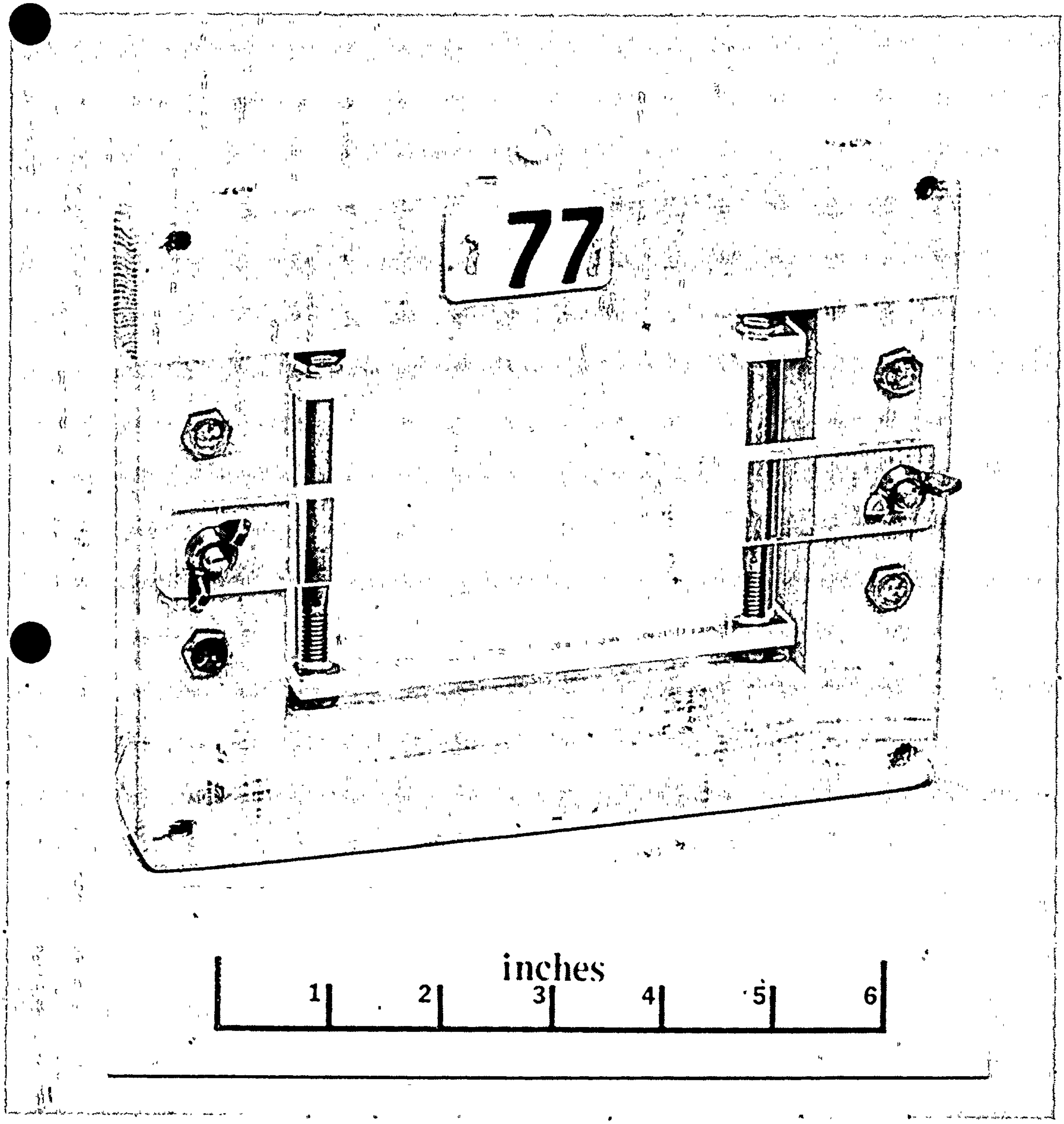


Figure 3-1 Glass slide diatometer used in Plant 2 periphyton program

850381-10A

Figure 3-2 Periphyton biomass (TOM) by season at core program stations.
WI = winter, SP = spring, SU = summer, FA = fall.

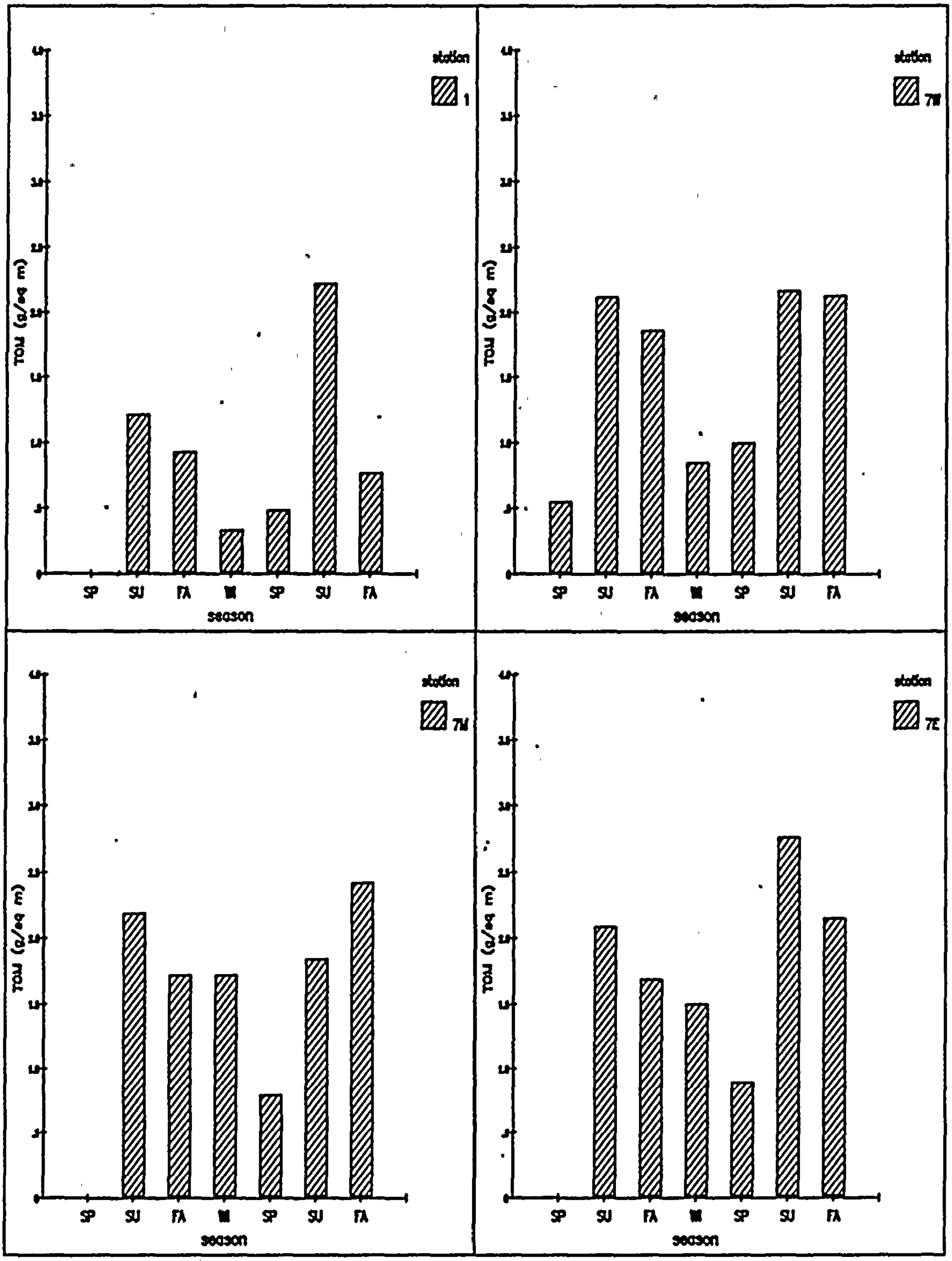


Figure 3-2 (Continued)

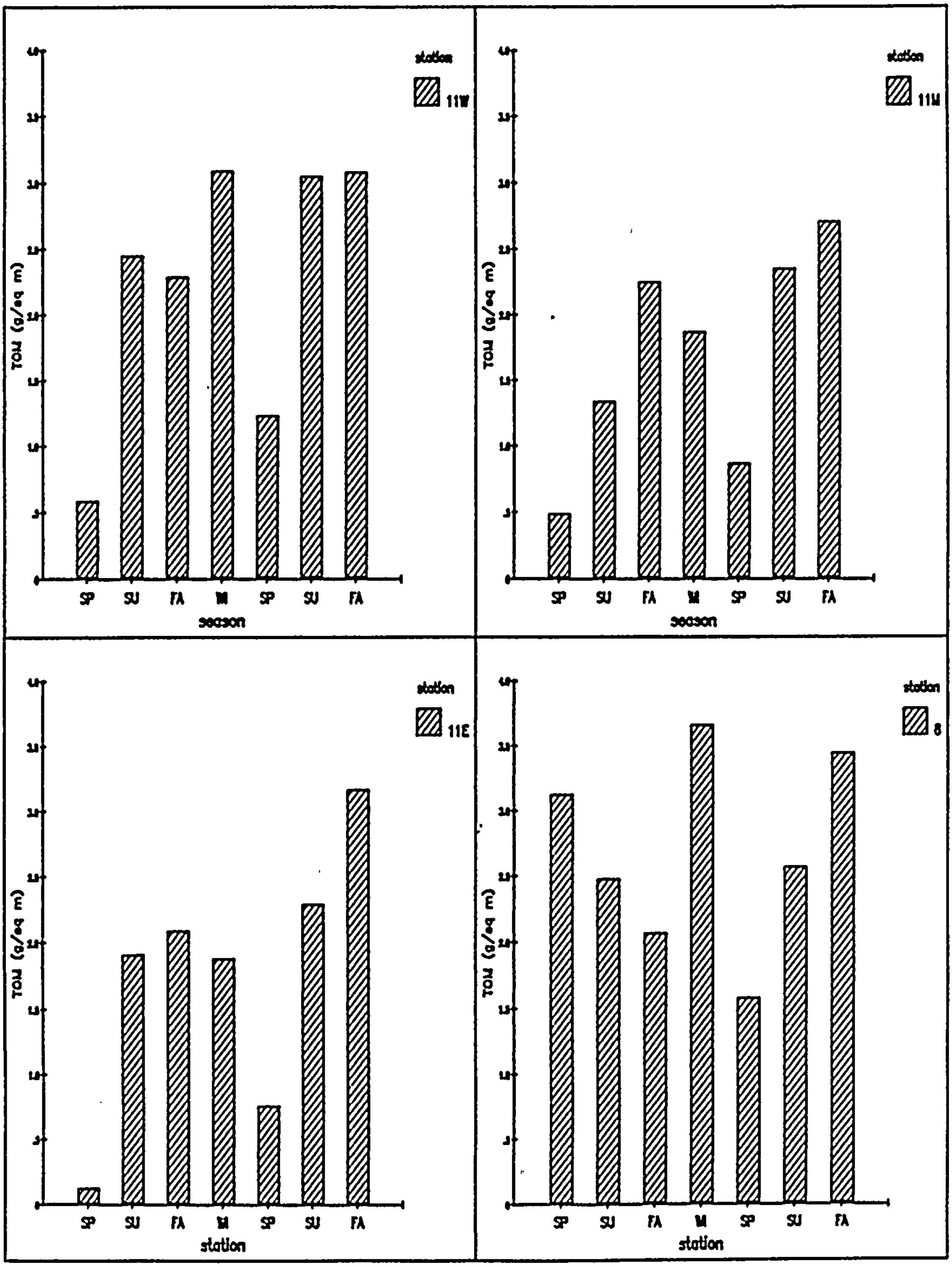


Figure 3-3 Homogeneous subsets of seasons (stations combined) as determined by Duncan's multiple range test for a) core, and b) gradient programs. Connecting lines indicate no significant difference (alpha = 0.05). WI = winter, SP = spring, SU = summer, FA = fall, E = early, L = late.

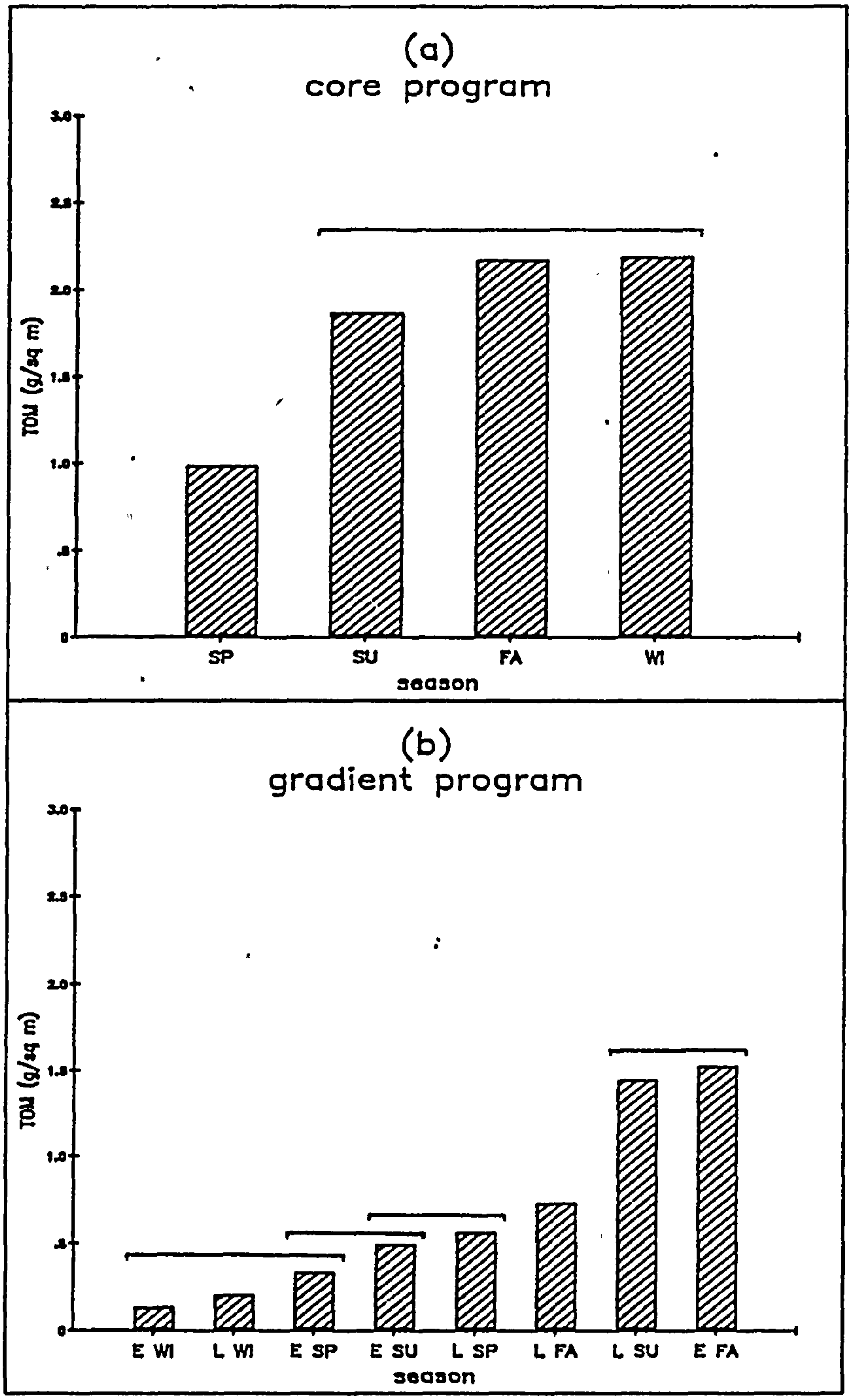


Figure 3-4 Periphyton biomass (TOM) by season at gradient program stations. WI = winter, SP = spring, SU = summer, FA = fall, E = early, L = late.

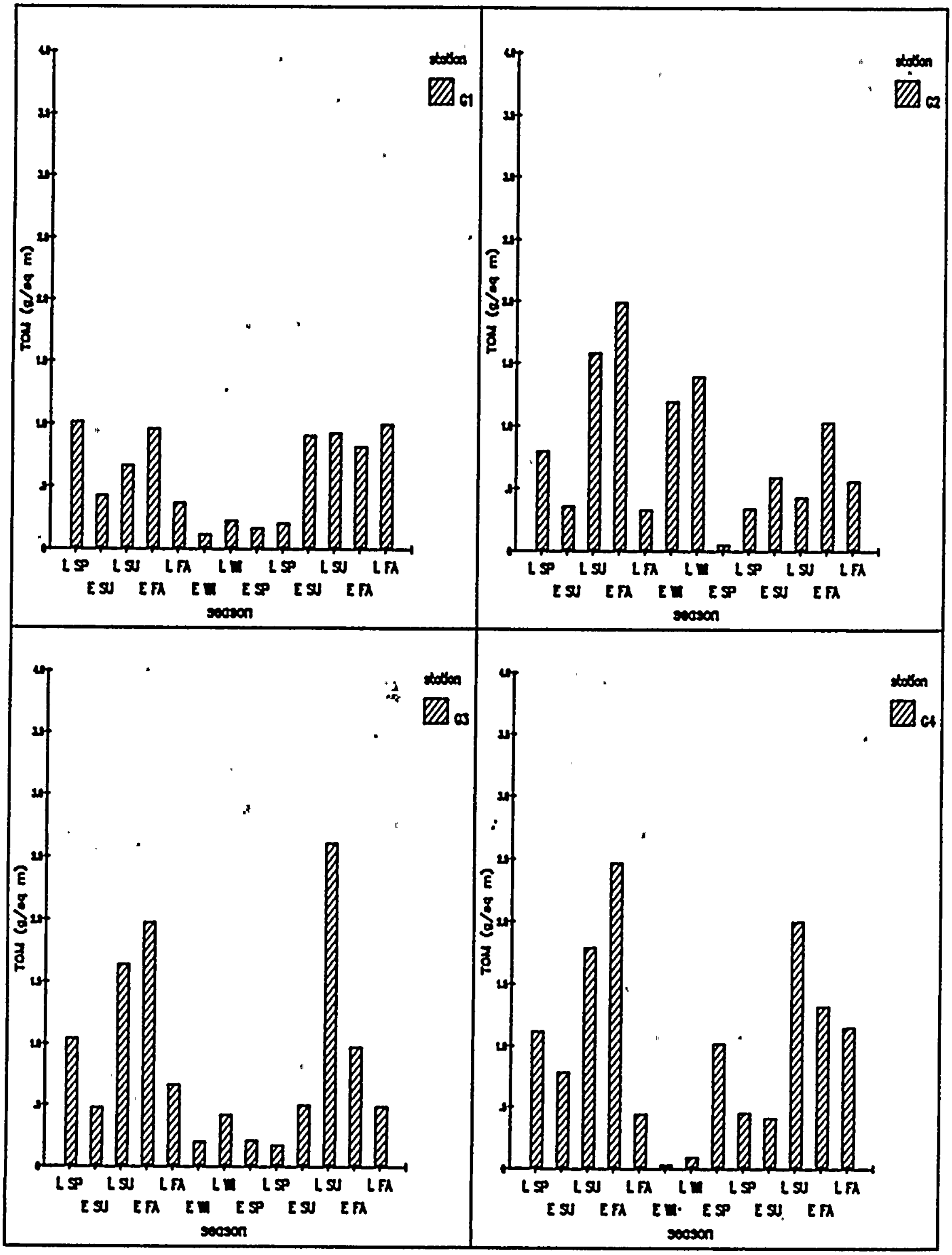
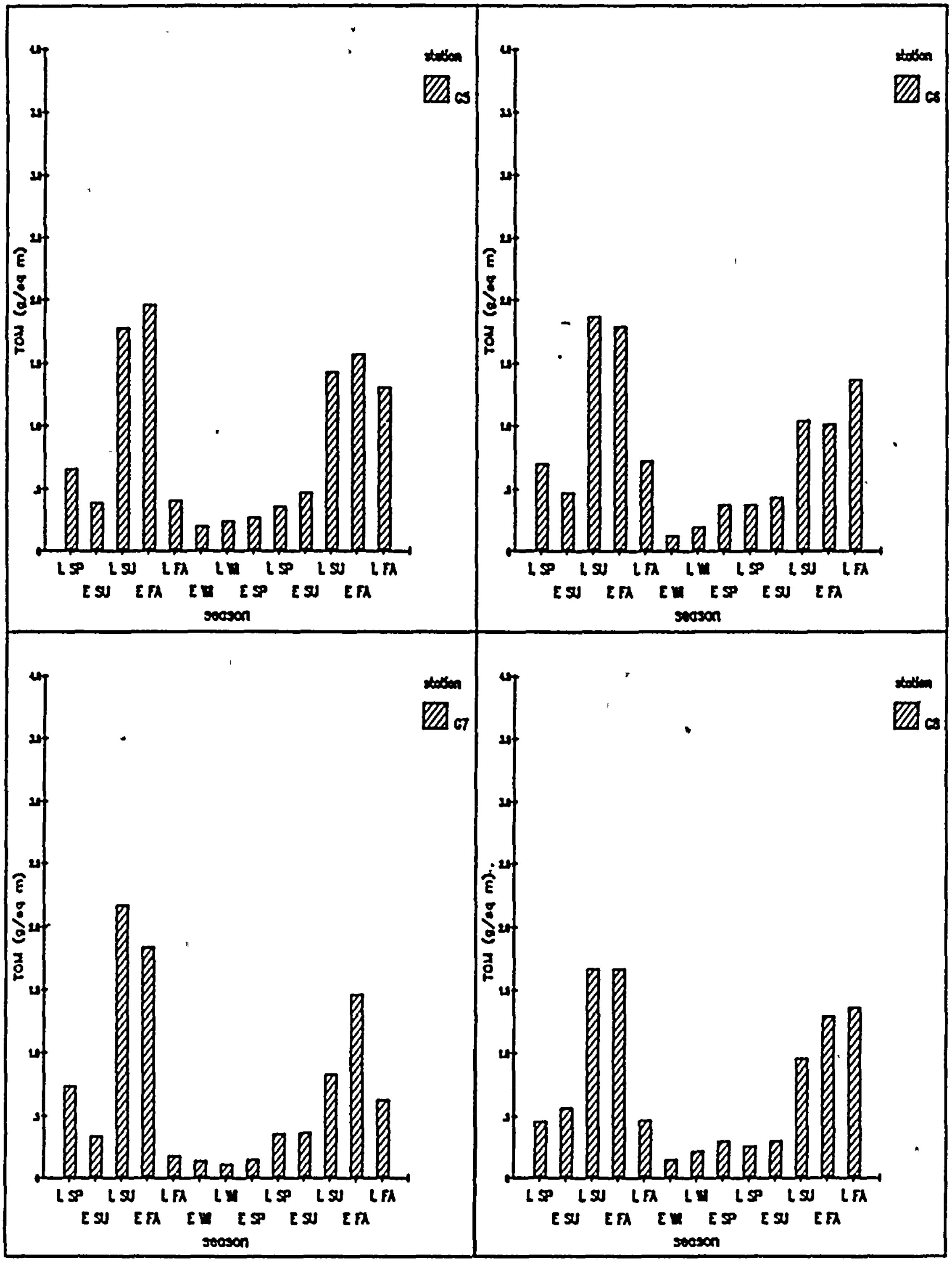


Figure 3-4 (Continued)



4.0 WATER QUALITY

4.1 INTRODUCTION

The water quality monitoring program was initiated in April 1983 to document the chemical character of the Columbia River in the vicinity of the WNP-2 discharge. The monitoring data is used to assess if chemical changes in the Columbia River result from WNP-2 cooling tower blowdown. The program is performed to comply with EFSEC Resolution No. 214. Based on plant operation (Figure 1-1), data collected from April 1983 through October 1984 could still be considered preoperational and operational data thereafter.

4.2 MATERIALS AND METHODS

Columbia River surface water was sampled monthly April 1983 through December 1984. Samples were collected near River Mile 352 from four stations numbered 1, 7, 11, and 8 (Figure 2-2). Station 1 is upstream of the WNP-2 intake and discharge and represents a control. Station 7 provides a measure of nearfield discharge effects. Station 11 at 91 meters (300 feet) downstream from the discharge represents the extremity of the mixing zone allowed by WNP-2's National Pollution Discharge Elimination System (NPDES) permit. Station 8 is approximately 549 meters (1800 feet) downstream from the discharge and represents a location where the discharge is fully mixed in the Columbia River.

The samples were analyzed for temperature, dissolved oxygen (DO), pH, conductivity, turbidity, total alkalinity, total hardness, filterable residue (total dissolved solids), nonfilterable residue (total suspended solids), ammonia-nitrogen, nitrate-nitrogen, total phosphorus, orthophosphorus, sulfate, oil and grease, total residual chlorine, total copper, total iron, total zinc and total nickel. A summary of water quality parameters, stations and sample frequencies is presented in Table 4-1.

In addition, a well water sample is collected from WNP-2 if the well is being used for drinking water. The well water sample is collected quarterly and analyzed for pH, alkalinity, nitrate-nitrogen, total phosphorus and orthophosphorus.

4.2.1 Sample Collection

Columbia River samples were collected by boat approximately 300 feet from the Benton County shore. Temperature, dissolved oxygen, pH, conductivity and total residual chlorine (April 1983 - September 1984) were determined in-situ with portable instruments. Water for total metal analyses was collected in one liter polypropylene cubitainers and kept on ice until delivered to the Supply Systems Environmental Programs Laboratory (EPL). In the laboratory the metals samples were acidified to 0.5% with concentrated Ultrex (J.T. Baker) nitric acid. Determinations for filterable residue, non-filterable residue, sulfate, total phosphorus, orthophosphorus, ammonia-nitrogen, nitrate-nitrogen, turbidity, total alkalinity and total hardness were made on water samples collected in 3.8 liter polypropylene cubitainers and kept on ice until delivered to the Supply System's Radiological Services Laboratory (RSL). Water for oil and grease analysis was skimmed from the surface into solvent rinsed borosilicate glass bottles. After collection, samples were placed on ice and transported to the RSL for analysis. Starting in October 1984 water for total residual chlorine analysis was collected in one liter polypropylene cubitainers and kept on ice until delivered to the EPL.

Well water samples were collected in one liter cubitainers from Well No. 3 by WNP-2 Plant personnel. Samples were collected in 1983 but not 1984 due to sample tracking problems.

4.2.2 Field Equipment and Measurement

Surface temperature and dissolved oxygen measurements were made using a Yellow Springs Instruments (YSI) model 57 meter. Temperature was recorded to within 0.1 C after the probe had been allowed to equilibrate in the river for a minimum of one minute. The field probe was calibrated, every two months, against an NBS-traceable thermometer in the laboratory.

The DO meter was air-calibrated prior to each field sample date per manufacturer's instruction. In addition, Winkler DO measurements were made every two months and results were compared to the field probe.

Conductivity measurements were made with a YSI model 33 SCT meter. Prior to each sample date, measurements of conductivity standards were performed.

pH measurements were made with either a Beckman Monitor II (April 1983 - April 1984) or IBM-ECMI05, Model 2A (May 1984 - December 1984). Prior to each use the instrument was calibrated using pH standards buffers of 7.0, 4.0, and 10.0. If necessary the probes were adjusted to within 0.1 unit of the standards.

Total residual chlorine measurements were made in the field from October 1983 - September 1984 using a Fisher-Porter Chlorine Titrator, Series 17T 200. A 50 ug/l total residual chlorine control sample was prepared prior to instrument use and measurements were made in duplicate to within $\pm$ 10 μg/l. Beginning in October 1984 total residual chlorine samples were analyzed in the laboratory using an IBM Model EC250 chlorine analyzer.

4.2.3 Laboratory Measurements

Total Residual chlorine (October - December 1984) total copper, total zinc, total iron and total nickel were determined by Supply System Environmental Programs personnel. The remaining analyses were performed by Supply System's Radiological Services personnel. Sample holding times followed those recommended by U.S. Environmental Protection Agency (USEPA: 4-1). Analyses were performed per USEPA (4-1) approved methods (Table 4-2). NHS, Inc., Richland, Washington performed the analysis of well water samples using USEPA approved procedures.

4.3 RESULTS AND DISCUSSION

4.3.1 Temperature

Columbia River temperatures varied seasonally with minimum and maximum measured temperatures of 3.0°C at all stations in January and February 1984 and 19.2°C at station 8 in August 1984, respectively (Table 4-3). Mean temperatures ranged from 11.0°C (stations 1 and 7) to 11.8°C (stations 11 and 8). For any sample period the largest inter-station difference in temperature

(0.4°C) occurred in July 1984 between station 7 and stations 11 and 8 and in September 1984 between station 1 and stations 11 and 8. The samples through time and both upstream and downstream of the WNP-2 discharge indicate minimal, if any, temperature change on Columbia River surface water as a result of warm water discharges from WNP-2.

4.3.2 Dissolved Oxygen (DO)

The mean and range of DO measurements for each sample station are presented in Table 4-3. Columbia River DO concentrations ranged from 9.3 mg/l in August and September 1983 to 13.6 mg/l in February 1984. The mean DO concentrations ranged from 11.1 mg/l at station 11 to 11.3 mg/l at stations 1 and 8.

DO concentrations were inversely related to river temperature as would be expected from solubility laws. DO levels were never below the 8 mg/l requirement for Class A waters (i.e. Columbia River: 4-2) indicating good water quality with respect to dissolved oxygen throughout the year.

The largest interstation difference in DO of 0.5 mg/l occurred between stations 1, 7, 11 (9.5 mg/l) and station 8 (10.0 mg/l) in September 1984. Based on the data presented in Table 4-3, it appears that WNP-2 cooling tower discharges have had little, if any effect on DO levels in the Columbia River.

4.3.3 pH

Columbia River mean pH values ranged from 7.88 at station 1 to 8.04 at station 8 (Table 4-3). pH varied with a measured minimum of 7.30 at station 1 in February 1984 and a maximum of 8.43 at station 8 in May 1984.

The pH requirement for Class A waters is from 6.5 to 8.5 (4-2) and measured pH's were within this range. pH measurements generally agree with historical data for the Columbia River (4-3).

The variation in pH between sample stations is small. The largest difference of 0.5 standard units occurred between station 1 (pH 7.50) and station 11 (pH 8.00) in August 1983. Based on the data, it appears that WNP-2 operation does not appreciably impact pH values of the Columbia River.

4.3.4 Conductivity and Total Residual Chlorine (TRCl)

Conductivity is a measure of the ionic content of a solution. Columbia River conductivity measurements ranged from 112 umhos/cm at 25°C at station 7 in June 1983 to 171 umhos/cm at 25°C at station 8 in February 1984 (Table 4-3). Station mean conductivities ranged from 141 umhos/cm at 25°C at stations 7 and 11 to 142 umhos/cm at 25°C at stations 1 and 8. The largest difference in conductivity (i.e. 8 umhos/cm) occurred between station 11 (135 umhos/cm) and station 8 (143 umhos/cm) in September 1984. The conductivity results are very comparable to those reported in earlier studies of the Columbia River (4-3).

Total residual chlorine measurements for all stations from April 1983 through September 1984 were less than the measured detection limit of 20 ug/l. From October through December 1984 TRCl measurements at all station were zero. The lower TRCl values for the three month period is attributable to use of an IBM chlorine analyzer which has a very low limit of detection.

4.3.5 Total Copper, Total Zinc, Total Iron and Total Nickel

Columbia River mean total copper values ranged from 1.2 ug/l at station 1 to 1.8 ug/l at station 11 (Table 4-4). Individual copper measurements ranged from $<$ 1.0 ug/l to 6.0 ug/l. The largest difference in copper (i.e. 5 ug/l) occurred between stations 1, 7 and 8 (1 ug/l) and station 11 (6 ug/l) in May 1983. Our copper results show good agreement with earlier studies. In 1962, Silker (4-4) analyzed 27 Columbia River samples collected upstream of WNP-2 and reported a mean copper concentration of 4.3 ug/l. Neutron activation analysis of Columbia River water was done in 1968-1969 by Cushing and Rancitelli (4-5), they reported a mean copper concentration of 1.4 ug/l. Florence and Batley (4-6) state that total copper concentrations in the range

of 0.3 - 3.0 ug/l are found in many unpolluted fresh-water rivers throughout the world. Based on this information, the Columbia River would generally be in that category.

Mean total zinc measurements ranged from 6.9 ug/l at station 7 to 7.8 ug/l at station 11 (Table 4-4). Individual zinc measurements ranged from <1.0 ug/l at station 11 in September 1983 to 21.0 ug/l at station 11 in January 1984. Generally, the highest zinc measurements were recorded during the winter months. The greatest inter-station difference (i.e. 8 ug/l) occurred between stations 1 and 7 (1 ug/l) and station 8 (9 ug/l) in October 1983. The average zinc measurements for the present study are lower than the 18.2 and 14.0 ug/l mean zinc concentrations reported by Silker (4-4) and Cushing and Rancitelli (4-5).

Columbia River mean iron concentrations were generally the same at each sample location and ranged from 54.9 ug/l at station 7 to 58.4 ug/l at station 1 (Table 4-4). The greatest inter-station difference in concentration of 39 ug/l occurred between station 1 (242 ug/l) and stations 7 and 8 (203 ug/l) in June 1983. Iron concentrations in June 1983 were higher compared to other sample dates. River flow for the June 1983 sampling (184,000 cfs) was higher than for any other sample date.

Mean total nickel concentrations were generally low, 0.9 ug/l at stations 7 and 11 to 1.0 ug/l at stations 1 and 8 (Table 4-4). Nickel concentrations showed little variation (<1.0 to 3.0 ug/l) through time or between sample locations.

4.3.6 Turbidity, Alkalinity, Hardness and Oil and Grease

Turbidity is a measure of the suspended matter that interferes with the passage of light through water. In the Columbia River, measured turbidities were low and ranged from 0.6 nephelometric turbidity units (NTU) to 5.4 NTU (Table 4-5). No seasonal or sample location differences were evident. The largest difference of 1.3 NTU occurred in May 1983 between station 1 (3.0 NTU) and stations 7, 11 and 8 (1.7 NTU).

The alkalinity of a water is a measure of its capacity to neutralize acids and is generally due to the presence of carbonates, bicarbonates, phosphates, silicates, borates, and hydroxides. Columbia River alkalinities ranged from 37.5 to 74.0 mg/l as calcium carbonate with sample location means from 49.1 to 50.6 mg/l (Table 4-5). Consistent temporal and spatial alkalinity differences were not observed based on measurements from April 1983 through December 1984. The high reading at station 1 in May 1984 is thought to be a spurious value.

Hardness indicates the quantity of divalent metallic cations present in the system, principally calcium and magnesium ions. Hardness ranged from 51.8 to 75.0 mg/l as calcium carbonate (Table 4-5). Mean hardness values ranged from 63.2 mg/l at station 1 to 64.1 mg/l at station 11.

Columbia River oil and grease concentrations were typically low (Table 4-5). Oil and grease values ranged from <0.2 mg/l to 2.6 mg/l, whereas station mean concentratios ranged from 0.3 to 0.4 mg/l. In June and August 1984, oil and grease concentrations at all sample locations were greater than 1.0 mg/l, while the concentrations for all other times were less than 1.0 mg/l.

4.3.7 Ammonia-Nitrogen, Nitrate-Nitrogen, Total Phosphorus and Orthophosphorus

Ammonia and nitrate are forms of nitrogen commonly found in water systems. Both nitrate and ammonia are assimilated by plants and converted to proteins. Common sources of nitrate and ammonia to the aquatic system are breakdown of organic matter in the soil, industrial discharges, fertilizers and septic tank leachate.

Ammonia concentrations ranged from <.010 to .110 mg-N/l (Table 4-6). Mean ammonia concentrations ranged from .016 mg-N/l at Station 1 to .024 mg-N/l at station 11. Nitrate concentrations averaged from .108 mg-N/l at station 1 to .104 mg-N/l at station 11 (Table 4-6). Individual nitrate measurement ranged from <.010 mg-N/l to .180 mg-N/l. Season or station location patterns in ammonia or nitrate concentration were not evident.

Phosphorus is a required nutrient for plant growth and while found in certain minerals, is commonly added to streams through fertilizers, treated sewage, and septic tank leachate.

Measured total phosphorus concentrations ranged from .006 to .068 mg-P/l with mean values from .027 to .029 mg-P/l (Table 4-6). Orthophosphorus concentration followed a similar pattern and ranged from .001 to .047 mg-P/l. Mean concentrations by sample location ranged from .019 at station 7 to .021 mg-P/l at stations 11 and 8. No seasonal or spatial trends were obvious for either total or orthophosphorus.

4.3.8 Sulfate, Total Dissolved Solids and Total Suspended Solids

Mean sulfate concentrations ranged from 11.9 mg/l at station 8 to 12.2 mg/l for stations 1 and 11 (Table 4-7). Individual sulfate measurements ranged from 7.0 to 16.5 mg/l. Generally, sulfate concentrations between stations were similar with the largest difference of 4.0 mg/l occurring in July 1984 between stations 7 and 8. Sulfuric acid is added at WNP-2, to control circulating water pH, and a by-product is the production of sulfate. Based on the river measurements WNP-2 discharges are not appreciably altering river sulfate concentrations.

Total dissolved solids or total filterable residue, TDS, is defined as that portion of the total residue that passes through a glass fiber filter and remains after ignition at 180°C for one hour. Total dissolved solids do not necessarily represent only the dissolved constituents but may also include colloidal materials and some small particulates. The mean TDS measured in the Columbia River varied from 82.8 at station 8 to 83.8 mg/l at station 1 (Table 4-7). There were no consistent differences in TDS concentrations between stations or through time.

Total suspended solids (TSS) or total nonfilterable residue is the retained material on a standard glass fiber filter after filtration of a well-mixed sample. TSS concentrations were generally low and varied from <0.5 to 7.9 mg/l (Table 4-7). Mean TSS concentrations ranged from 3.2 mg/l at station 7 to 3.7 mg/l at station 8.

4.3.9 Quarterly Drinking Well Measurements

The 1983 quarterly drinking well water samples results for pH, alkalinity, nitrate-nitrogen, total phsophorus and orthophosphorus are presented in Table 4-8. pH values ranged from 7.7 to 7.8 and are comparable to river pH measurements (Table 4-3). The same conclusion is true for the other parameters which had the following value ranges: alkalinity, 45-69 mg/l, nitrate-nitrogen .07-.16 mg/l, total phosphorus < 0.06-1.8 mg/l and orthophosphorus, <0.02-0.06 mg/l.

4.4 REFERENCES

4-1 Methods for Chemical Analysis of Water and Wastes, Water Quality Office Analytical Control Laboratory, Environmental Protection Agency, 1983.

4-2 Washington State Water Quality Standards, Water Quality Planning Office of Water Programs, Department of Ecology, 1977. 32p.

4-3 Washington Public Power Supply System, 1982. Supply System Nuclear Projects Nos. 1 and 4 Environmental Report, Docket Nos. 59-460 and 50-513, Section 2.4.

4-4 Silker, W.B. 1964. Variations in elemental concentrations in the Columbia River. Limnol. Oceanogr. 9, 540-545.

4-5 Cushing, C.E., and L.A. Rancitelli. 1972. Trace element analyses of Columbia River water and phytoplankton. Northwest Science 46(2): 115-121.

4-6 Florence, T.M. and G.E. Batley. 1977. Determination of the chemical forms of trace metals in natural waters with special reference to copper, lead, cadmium and zinc. Talanta 24: 151-158.

TABLE 4-1

SUMMARY OF WATER QUALITY PARAMETERS, STATIONS, AND SAMPLING FREQUENCIES, 1983 - 1984

	Stations				
Parameter	1	7	11	8	Wells in Vicinity of Plant Site +
Quantity (flow)	-	C**	-	-	-
Temperature	M	M/C**	M	M	-
Dissolved Oxygen	M	M	M	M	-
pH	M	M/C**	M	M	Q
Turbidity	M	M	M	M	-
Total Alkalinity	M	M	M	M	Q
Filterable Residue (Total Dissolved Solid)	M	M	M	M	-
Nonfilterable Residue (Suspended Solids)	M	M	M	M	-
Conductivity	M	M	M	M	-
Iron (Total)	M	M	M	M	-
Copper (Total)	M	M	M	M	-
Nickel (Total)	M	M	M	M	-
Zinc (Total)	M	M	M	M	-
Sulfate	M	M	M	M	-
NH_4^+ Nitrogen	M	M	M	M	-
NO_3^- Nitrogen	M	M	M	M	Q
Ortho Phosphorus	M	M	M	M	Q
Total Phosphorus	M	M	M	M	Q
Oil and Grease	M	M	M	M	-
Chlorine, Total Residual	M	M/D**	M	M	-
Hardness	M	M	M	M	-

Symbols Key

C = Continuous
M = Monthly
Q = Quarterly
D = Daily, when chlorine is added
* Refer to Figure 2-1 for station location
**Monitored by plant staff on cooling tower blowdown line and reported to EFSEC in quarterly NPDES reports.
+ Samples will be collected if wells are being used for drinking water
- Analysis not required

TABLE 4-2

SUMMARY OF WATER QUALITY PARAMETERS AND EPA METHOD NUMBER

Parameter	EPA Method Number
Water Temperature (°C)	120.1
Turbidity, (NTU)	180.1
Conductivity (umhos/cm) at 25°C	120.1
Dissolved Oxygen (mg/l) probe	360.1
Dissolved Oxygen (mg/l) Modified Winkler	360.2
pH (Standard Unit)	150.1
Total Alkalinity (mg/l as $CaCO_3$)	310.1
Total Hardness (mg/l as $CaCO_3$)	130.2
Oil and Grease (mg/l)	413.2
Nitrogen, Ammonia, Total (mg/l as N)	350.2
Nitrate Nitrogen, Total (mg/l as N)	352.1
Total Phosphorus (mg/l as P)	365.2
Ortho Phosphorus (mg/l as P)	365.2
Sulfate (mg/l as SO_4)	375.4
Total Copper (ug/l as Cu)	220.2
Total Iron (ug/l as Fe)	236.2
Total Nickel (ug/l as Ni)	249.2
Total Zinc (ug/l as Zn)	289.2
Total Residual Chlorine (ug/l)	330.1
Filterable Residue: Total Dissolved Solids (mg/l)	160.1
Non-Filterable Residue: Total Suspended Solids (mg/l)	160.2

TABLE 4-3 FIELD WATER QUALITY MONITORING DATA, APRIL 1983 - DECEMBER 1984

Sample Date	Water Temperature, c				Dissolved Oxygen, mg/l				pH, Standard Units				Conductivity, μmhos/cm at 25 c			
	1+	7	11	8	1	7	11	8	1	7	11	8	1	7	11	8
04/12/83	7.2	7.2	7.2	7.3	12.4	12.6	12.6	12.8	7.85	7.40	7.75	7.80	164	162	159	159
05/10/83	10.2	10.1	10.2	10.2	12.6	12.4	12.4	12.4	8.30	8.40	8.40	8.40	149	150	149	149
06/08/83	14.6	14.6	14.6	14.6	12.1	12.1	12.1	12.1	7.50	7.80	7.60	7.60	113	112	114	114
07/12/83	17.2	17.2	17.2	17.2	10.0	9.9	9.9	9.8	7.70	8.30	8.10	8.10	124	125	125	126
08/16/83	19.0	19.0	19.1	19.2	9.3	9.3	9.3	9.3	7.50	7.80	8.00	7.90	124	126	125	125
09/07/83	18.0	18.0	18.0	18.0	9.3	9.4	9.3	9.6	7.95	8.00	8.00	8.15	135	133	133	134
10/19/83	14.3	14.3	14.3	14.3	9.4	9.4	9.5	9.8	7.55	7.85	7.80	8.05	129	127	127	127
11/14/83	11.5	11.5	11.5	11.2	10.8	10.8	10.2	10.4	7.80	7.90	8.10	8.20	138	136	138	136
12/13/83	7.7	7.5	7.6	7.4	10.8	10.7	10.7	10.8	7.75	7.80	7.85	7.85	150	149	149	150
01/17/84	3.0	3.0	3.0	3.0	12.8	12.4	12.5	12.6	7.55	7.60	7.65	7.55	158	158	156	156
02/22/84	3.0	3.0	3.0	3.0	13.6	13.6	13.4	13.4	7.30	7.85	7.85	8.10	168	164	164	171
03/13/84	4.1	4.1	4.1	4.1	13.4	13.3	13.3	13.3	7.80	7.80	7.75	7.60	164	164	169	167
04/18/84	7.0	7.0	7.0	7.1	12.9	12.7	12.8	12.8	7.95	8.20	7.80	7.90	151	151	151	151
05/22/84	10.7	10.8	10.8	10.9	12.4	12.2	12.2	12.8	*8.26	8.34	8.30	8.43	156	154	154	156
06/19/84	13.8	13.6	13.6	13.8	12.4	12.0	12.0	12.2	8.27	8.25	8.22	8.27	125	126	127	126
07/11/84	16.2	16.4	16.0	16.0	10.8	10.8	10.6	10.8	8.10	8.07	8.17	8.18	-	-	-	-
08/08/84o	19.0	19.0	19.1	19.1	9.6	9.5	9.4	9.5	8.06	8.07	8.04	8.10	122	121	118	121
09/17/84	18.5	18.7	18.9	18.9	9.5	9.5	9.5	10.0	8.27	8.30	8.31	8.33	139	139	135	143
10/09/84	16.3	16.3	16.4	16.3	9.6	9.7	9.8	10.0	8.01	8.08	8.06	8.14	137	137	135	136
11/14/84	10.2	10.2	10.2	10.2	10.2	10.1	10.1	10.6	8.00	8.04	8.07	8.16	136	136	136	136
12/18/84	5.0	5.0	5.0	4.9	12.4	12.2	12.2	12.2	7.96	7.89	7.97	8.07	148	148	153	148
Mean	11.7	11.7	11.8	11.8	11.3	11.2	11.1	11.3	7.88	7.99	7.99	8.04	142	141	141	142
Standard Deviation	5.5	5.5	5.5	5.5	1.5	1.5	1.5	1.4	0.29	0.26	0.22	0.25	16	15	16	16
Range	3 -19	3 -19	3 -19.1	3.0-19.2	9.3-13.6	9.3-13.6	9.3-13.4	9.3-13.4	7.3-8.3	7.4-8.4	7.6-8.4	7.55-8.43	113-168	112-164	114-169	114-171

+ = Sample location.
* = Used Beckman pH meter - April 1983 - April 1984, and IBM meter May 1984 - December 1984
- = No sample,meter at factory for repair
o = IBM conductivity meter used.

TABLE 4-4 METALS MONITORING, APRIL 1983 - DECEMBER 1984

Sample Date	Copper, µg/l				Zinc, µg/l				Iron, µg/l				Nickel, µg/l			
	1*	7	11	8	1	7	11	8	1	7	11	8	1	7	11	8
04/12/83	<1	<1	1	1	11	8	10	10	81	67	84	76	<1	<1	<1	<1
05/10/83	1	1	6	1	9	9	10	10	64	61	63	61	<1	<1	<1	<1
06/08/83	2	2	1	2	5	4	4	3	242	203	219	203	3	2	2	3
07/12/83	2	2	2	2	4	3	3	4	64	51	55	70	2	3	2	2
08/16/83	1	1	1	1	5	4	2	3	33	35	31	31	2	1	<1	1
09/07/83	1	1	1	<1	1	2	<1	2	28	29	32	25	1	<1	<1	<1
10/19/83	1	1	1	1	1	1	7	9	33	32	32	48	<1	<1	<1	<1
11/14/83	1	1	1	1	8	6	3	3	30	26	26	25	<1	<1	<1	1
12/13/83	1	1	2	1	16	9	15	10	38	36	30	36	<1	<1	<1	<1
01/17/84	1	2	4	1	16	18	21	16	70	70	70	67	<1	<1	<1	<1
02/22/84	1	1	1	1	19	20	19	20	36	55	38	31	<1	<1	<1	<1
03/13/84	1	1	1	1	8	6	6	6	40	35	38	35	<1	<1	<1	<1
04/18/84	2	2	2	5	6	4	6	4	37	40	41	40	1	1	<1	1
05/22/84	1	2	1	1	11	10	13	10	65	58	68	62	1	1	1	1
06/19/84	1	1	1	1	6	6	5	5	78	79	78	79	1	1	1	1
07/11/84	1	1	2	1	4	4	5	4	55	54	61	54	1	1	3	3
08/08/84	2	2	2	2	4	4	5	5	55	53	51	61	1	2	1	1
09/17/84	1	2	2	1	6	7	7	6	47	45	46	38	1	<1	<1	<1
10/09/84	1	1	1	1	8	6	8	6	51	54	52	46	<1	<1	1	<1
11/14/84	2	1	1	1	5	6	5	5	50	42	50	43	1	<1	1	<1
12/18/84	1	1	3	1	9	8	9	9	30	28	27	29	<1	1	<1	<1
$\bar{X}$	+1.2	+1.3	1.8	+1.3	7.7	6.9	+7.8	7.1	58.4	54.9	56.8	55.2	+1.0	+0.9	+0.9	+1.0
SD	0.5	0.5	1.3	0.9	4.8	4.7	5.4	4.5	45.1	37.0	40.9	37.8	0.7	0.7	0.7	0.8
R	<1-2	<1-2	1-6	<1-5	1-19	1-20	<1-21	2-20	28-242	26-203	26-219	25-203	<1-3	<1-3	<1-3	<1-3

*Station Location
$\bar{X}$ = Mean
SD = Standard Deviation
R = Range
\+ = Samples below detection limits were considered as one-half the detection limit for calculation of means.

TABLE 4- 5 TURBIDITY, ALKALINITY, HARDNESS AND OIL AND GREASE MEASUREMENTS, APRIL 1983 - DECEMBER 1984

Sample Date	Turbidity, NTU				Alkalinity, mg/l as $CaCO_3$				Hardness, mg/l as $CaCO_3$				Oil & Grease, mg/l			
	1+	7	11	8	1	7	11	8	1	7	11	8	1	7	11	8
04/12/83	2.6	2.7	2.9	2.7	57.5	56.0	58.5	57.0	71.7	72.5	72.5	72.5	<0.2	< 0.2	< 0.2	0.4
05/10/83	3.0	1.7	1.7	1.7	55.0	55.0	55.0	55.0	68.0	68.0	69.0	68.5	0.8	0.3	0.6	0.9
06/08/83	5.2	5.4	5.4	5.3	44.5	46.0	44.0	45.0	51.8	53.3	52.8	53.4	0.4	0.3	0.5	0.3
07/12/83	1.1	1.2	1.2	1.3	37.5	43.5	42.0	42.5	57.0	57.0	56.0	55.0	0.3	< 0.2	< 0.2	0.2
08/16/83	0.8	0.8	1.0	1.0	46.5	46.5	47.5	47.0	59.0	62.0	61.0	61.0	<0.2	< 0.2	< 0.2	< 0.2
09/07/83	0.9	0.8	1.0	1.0	45.0	45.0	46.0	44.0	64.0	62.0	63.0	63.0	<0.2	< 0.2	< 0.2	< 0.2
10/19/83	0.9	0.9	0.8	0.8	45.0	43.5	42.0	40.0	59.0	59.0	59.0	59.0	<0.2	< 0.2	< 0.2	< 0.2
11/14/83	0.8	0.8	0.8	0.7	40.0	45.0	40.0	40.0	61.0	62.0	63.0	62.0	0.2	0.6	< 0.2	< 0.2
12/13/83	0.8	0.8	0.9	0.7	42.5	42.5	42.5	42.5	70.0	69.0	70.0	66.0	<0.2	< 0.2	< 0.2	< 0.2
01/17/84	1.7	1.7	1.7	1.7	55.0	55.0	50.0	55.0	67.5	65.0	66.0	66.0	0.2	0.6	< 0.2	< 0.2
02/22/84	1.1	1.3	1.0	1.2	55.0	55.0	55.0	55.0	74.0	72.0	71.0	71.0	0.2	0.7	0.8	0.4
03/13/84	5.2	4.7	4.8	4.6	55.0	60.0	60.0	55.0	73.0	72.0	76.0	75.0	0.9	0.5	0.4	0.6
04/18/84	1.8	1.7	1.7	1.8	60.0	60.0	55.0	55.0	68.0	70.0	68.0	68.0	<0.2	0.3	< 0.2	0.4
05/22/84	1.5	1.6	1.5	1.4	70.0	50.0	47.5	47.5	69.0	70.0	70.0	70.5	0.2	0.2	0.4	< 0.2
06/19/84	1.7	1.5	1.7	1.7	47.2	48.5	46.5	47.2	52.5	57.0	55.0	55.0	2.5	2.4	1.9	2.6
07/11/84	1.2	1.2	1.0	1.2	41.0	51.5	47.5	45.0	52.0	54.0	55.0	55.0	0.3	0.2	< 0.2	< 0.2
08/18/84	1.1	1.0	1.0	1.0	47.5	47.5	47.5	46.0	53.0	54.0	54.0	53.0	1.7	1.0	1.0	1.2
09/17/84	0.9	1.0	0.9	0.9	52.5	52.5	52.5	52.5	61.0	61.5	62.0	64.0	<0.2	< 0.2	< 0.2	< 0.2
10/09/84	1.0	1.2	1.2	1.0	52.5	52.5	52.5	52.5	65.0	65.0	65.0	65.0	<0.2	< 0.2	< 0.2	< 0.2
11/14/84	1.0	1.1	1.0	1.1	46.0	46.0	47.5	47.5	64.5	64.5	65.0	65.0	<0.2	< 0.2	< 0.2	< 0.2
12/18/84	0.6	0.7	0.6	0.6	65.0	60.0	60.0	60.0	66.5	69.5	72.5	69.5	<0.2	< 0.2	< 0.2	< 0.2
Mean	1.7	1.6	1.6	1.6	50.5	50.6	49.5	49.1	63.2	63.8	64.1	63.7	0.4*	0.4*	0.3*	0.4*
Standard Deviation	1.3	1.2	1.3	1.2	8.4	5.8	6.1	6.0	7.1	6.3	6.9	6.6	0.6	0.5	0.5	0.6
Range	.6-5.2	.7-5.4	.6-5.4	.6-5.3	37.5-70.	42.5-60.	40.-60.	40-60	51.8-74	53.3-72.5	52.8-76	53-75.	<.2-2.5	<.2-2.4	<.2-1.9	<.2-2.6

+ = Sample location.

* = Samples below detection limits were considered as one-half the detection limit for calculation of means.

TABLE 4-6 AMMONIA-NITROGEN, NITRATE-NITROGEN, TOTAL PHOSPHORUS AND ORTHOPHOSPHORUS MEASUREMENTS
APRIL 1983 - DECEMBER 1984

Sample Date	Ammonia-Nitrogen, mg/l as N				Nitrate-Nitrogen, mg/l as N				Total Phosphorus, mg/l as P				Orthophosphorus, mg/l as P			
	1*	7	11	8	1	7	11	8	1	7	11	8	1	7	11	8
04/12/83	<.010	<.010	<.010	<.010	.130	.140	.130	.110	.040	.040	.040	.040	.030	.030	.040	.040
05/10/83	<.010	.015	.013	.012	.038	.047	.041	.062	.042	.038	.040	.038	.025	.024	.026	.036
06/08/83	.063	.076	.071	.080	.085	.077	.087	.073	.054	.055	.052	.052	.045	.047	.045	.047
07/12/83	.078	.097	.077	.085	.041	.035	.030	.035	.029	.029	.068	.035	.029	.030	.028	.025
08/16/83	.021	.021	.033	.013	.042	.042	.042	.032	.031	.035	.034	.042	.021	.018	.020	.018
09/07/83	.014	.014	.015	.020	.055	.043	.046	.038	.029	.030	.032	.029	.015	.015	.019	.016
10/19/83	.028	.039	.060	.033	.105	.105	.115	.095	.024	.024	.022	.022	.013	.012	.011	.009
11/14/83	.016	.018	.017	.012	.180	.170	.170	.180	.028	.028	.026	.025	.019	.019	.018	.018
12/13/83	.041	.100	.051	.080	.180	.170	.180	.180	.029	.029	.029	.028	.024	.024	.024	.024
01/17/84	<.010	<.010	<.010	<.010	.170	.170	.140	.170	.040	.040	.040	.040	.040	.030	.040	.030
02/22/84	<.010	<.010	<.010	<.010	.160	.170	.150	.160	.040	.040	.040	.040	.040	.040	.040	.040
03/13/84	<.010	<.010	<.010	<.010	.160	.160	.160	.150	.040	.040	.040	.040	.020	.020	.040	.040
04/18/84	<.010	<.010	<.010	<.010	.160	.160	.150	.140	.010	.010	.010	.010	.010	.010	.010	.010
05/22/84	<.010	<.010	<.010	<.010	.170	.160	.160	.160	.010	.010	.010	.010	.010	.010	.010	.010
06/19/84	<.010	<.010	<.010	<.010	.110	.130	.120	.180	.010	.020	.010	.020	.004	.004	.005	.004
07/11/84	<.010	<.010	<.010	<.010	.060	.050	.060	.050	.006	.009	.010	.023	.001	.002	.005	.020
08/08/84	<.010	<.010	<.010	<.010	.060	.050	.060	.050	.010	.010	.010	.010	.003	.003	.003	.002
09/17/84	<.010	<.010	<.010	<.010	.020	<.010	<.010	.030	.020	.014	.011	.012	.007	.006	.008	.006
10/09/84	<.010	<.010	<.010	<.010	.060	.100	.070	.070	.010	.010	.010	.010	.010	.010	.010	.010
11/14/84	<.010	<.010	<.010	<.010	.110	.090	.130	.100	.030	.030	.030	.030	.020	.020	.020	.020
12/18/84	<.010	<.010	.110	<.010	.170	.130	.130	.130	.028	.032	.040	.025	.024	.026	.026	.022
Mean	.016	.021	.024	.019	.108	.105+	.104+	.105	.027	.027	.029	.028	.020	.019	.021	.021
Standard Deviation	.021	.031	.031	.027	.056	.056	.053	.056	.013	.013	.016	.013	.012	.012	.013	.013
Range	<.010-.078	<.010-.100	<.010-.110	<.010-.085	.020-.180	<.010-.170	<.010-.180	.030-.180	.006-.054	.009-.055	.010-.068	.010-.052	.001-.045	.002-.047	.003-.045	.002-.047

* = Sample location.

+ = Samples below detection limits were considered as one-half the detection limit for calculation of means.

TABLE 4 - 7 SULFATE, TOTAL DISSOLVED SOLIDS AND TOTAL SUSPENDED SOLIDS MEASUREMENTS, APRIL 1983 - DECEMBER 1984

Sample Date	Sulfate, mg/l				Total Dissolved Solids, mg/l				Total Suspended Solids, mg/l			
	1+	7	11	8	1	7	11	8	1	7	11	8
04/12/83	15.8	15.4	15.4	15.8	130.0	119.0	133.0	111.0	4.4	4.3	4.4	4.2
05/10/83	11.5	12.2	13.0	12.2	91.5	87.5	87.5	87.0	5.9	6.1	6.2	6.0
06/08/83	10.5	12.2	11.2	10.5	62.0	64.0	64.0	62.5	7.6	4.9	7.9	7.6
07/12/83	10.0	10.7	9.3	9.8	62.0	63.0	60.5	60.5	3.7	4.6	4.4	4.6
08/16/83	11.5	11.5	11.2	10.3	69.5	67.5	70.5	50.5	3.5	3.0	3.6	2.9
09/07/83	10.0	10.1	10.1	10.1	61.5	62.5	58.5	68.0	3.9	3.8	3.2	2.9
10/19/83	10.0	10.0	10.0	10.1	69.5	70.5	74.5	73.5	2.4	2.2	2.4	2.8
11/14/83	10.2	10.2	10.2	10.2	78.5	77.5	78.5	78.0	2.5	2.5	2.3	2.3
12/13/83	12.5	12.5	12.5	12.5	78.0	75.5	81.5	82.0	1.4	1.2	1.2	1.1
01/17/84	14.4	14.1	14.1	14.1	151.0	149.0	147.0	163.0	0.8	1.6	1.5	2.2
02/22/84	11.8	11.5	11.5	11.8	72.0	95.0	63.0	76.0	3.1	2.4	2.0	7.0
03/13/84	14.3	14.3	14.5	13.5	79.0	75.0	80.0	81.0	2.2	2.4	2.4	2.5
04/18/84	14.2	14.2	14.2	14.2	80.0	78.0	86.0	85.0	3.9	1.5	3.6	2.5
05/22/84	14.5	14.2	13.5	14.0	127.0	126.0	123.0	118.0	6.1	5.4	5.9	6.6
06/19/84	11.5	11.0	12.2	10.5	71.0	65.0	75.0	70.0	4.1	5.3	6.4	4.9
07/11/84	9.5	7.0	10.5	11.0	71.0	66.0	70.0	70.0	5.8	4.3	4.6	4.8
08/08/84	9.5	7.7	9.0	9.0	88.0	84.0	85.0	92.0	5.2	3.4	5.0	4.2
09/17/84	10.1	10.7	10.2	8.8	92.0	92.0	99.0	92.0	3.5	3.0	3.3	2.4
10/09/84	15.1	15.0	15.0	15.1	72.0	83.0	68.0	68.0	3.2	2.6	2.9	3.0
11/14/84	16.5	14.2	13.5	13.8	91.0	90.0	87.0	91.0	< 0.5	1.6	2.6	2.4
12/18/84	12.5	14.0	14.5	12.5	63.0	68.0	60.0	60.0	1.8	0.9	< 0.5	< 0.5
Mean	12.2	12.0	12.2	11.9	83.8	83.7	83.4	82.8	* 3.6	3.2	* 3.6	* 3.7
Standard Deviation	2.2	2.3	2.0	2.1	24.2	22.8	24.1	24.6	1.9	1.5	1.9	1.9
Range	9.5-16.5	7.0-15.4	9.0-15.4	8.8-15.8	61.5-151.0	62.5-149.0	58.5-147.0	50.5-163.0	<0.5-7.6	0.9-6.1	<0.5-7.9	<0.5-7.6

+ = Sample Location

* = Samples below detection limit were considered as one-half for calculation of means.

TABLE 4-8 QUARTERLY DRINKING WELL MONITORING MEASUREMENTS APRIL 1983 - DECEMBER 1983

Sample Date	pH Standard Units	Alkalinity mg/l	Total Phosphorus mg/l	Orthophosphorus mg/l	Nitrate-Nitrogen mg/l
06-03-83	7.70	45	0.18	0.06	0.07
09-26-83	7.76	51	< 0.08	0.03	0.12
12-27-83	7.80	69	< 0.06	< 0.02	0.16

5.0 FISH IMPINGEMENT AND INTAKE STRUCTURE FOULING SURVEYS

5.1 INTRODUCTION

Columbia River water is removed through two perforated stainless steel intake structures (Figure 5-1) and pumped to WNP-2 where it is primarily used to replace cooling water loss to evaporation and drift. Each intake structure is 107 cm (42 in) in diameter and approximately 6 m (20 ft) long. Water is removed through two 2 m (6.5 ft) pipe sections perforated with 0.95 cm (3/8 in) circular holes. A 91 cm (36 in) diameter perforated internal sleeve is used to equalize flow. Abnormal or emergency conditions may result in a 47,300 to 94,600 per minute (lpm) (12,500 to 25,000 gallons per minute (gpm)) being removed from one in take structure, with the respective modeled (5-1) entrance velocity of 0.2 to 0.34 mps (0.50 and 1.1 feet per second (fps)) (Figure 5-2 and 5-3). Under normal operating conditions 12,500 gpm is removed through both intake structures (24,000 lpm or 6,250 gpm per structure) with an estimated entrance velocity of 0.05 mps (0.15 fps). River velocity measured near the perforated pipes range between 1.22 to 1.53 mps (4 to 5 fps) (Table 5-1). Inspections of the intake structures are to be conducted monthly March through November commencing when WNP-2 reaches 75 percent thermal load (Section 1.1).

5.2 METHODS AND MATERIALS

Historical studies were conducted between 1978-1979 (1-6, 5-2) using scuba divers. The divers report any fish impingement, the need for maintenance and unusual conditions; such as, accumulation of submerged debris, plugging of water entrance orifices by periphyton, and the location, size, numbers, and species of fish within the immediate area of the intakes. In addition to visual surveys, video tape records of fouling at 4 stations on the structures are made in the Spring and Fall.

5.3 RESULTS AND DISCUSSION

While the plant achieved consistent thermal loads exceeding 75 percent in November 1984 several surveys were conducted previous to this point.

Seven surveys (Table 5-1) were conducted between October 1983 and November 1984. At no time were any fish observed impinged on the intake screens. No fouling other than normal algae and insects were observed. No large sponge colonies were observed. Inconsistent operation of WNP-2 due to startup testing caused fluctuations in pumping rates.

The October 1983 survey established four stations, approximately 400 cm^2 or 64 in^2, (two stations per intake structure) where video records are made in the spring and fall of each year. These tapes provide a permanent record for monitoring change in periphyton fouling.

The March 1984 survey coincided with the release of 2+ million spring chinook smolts near Ringold averaging between 7 to 9 fish per pound, 15.2 to 17.8 cm (6 to 7 inches) in length.

Several species of fish have been observed near the intake structures: bass, suckers, redside shinners, and white fish. No negative interactions between the intake structures and fish have been observed.

5.4 REFERENCES

5-1 Washington Public Power Supply System, 1977. WNP-2 Environmental Report Operating License Stage.

5-2 Mudge, J.E., G.S. Jeane II, K.P. Campbell, B.R. Eddy and L.E. Foster. 1981. Evaluation of a Perforated Pipe Intake Structure for Fish Protection. Advanced Intake Technology for Power Plant Cooling Water Systems Available from NTIS.

TABLE 5-1

IMPINGEMENT/FOULING SURVEYS

Date	TMU[1] Pumping Rate (GPM)[2]	Estimated River Flow (CFS)[3]	River Velocity (FPS)[4]	Video Record
October 20, 1983	7,000	68,000	-	Yes
March 26, 1984	5,000	74,000	3 to 4	Yes
July 16, 1984	5,000	130,000	-	-
August 21, 1984	9,000	60,000	-	-
September 6, 1984	17,000	73,000	-	-
September 26, 1984	22,000	75,000	5 to 6	Yes
November 7, 1984	21,000	52,000	4.3	-

[1]TMU = Tower Make Up pumphouse located on the Columbia River.

[2]Gallons per minute.

[3]Cubic feet per second.

[4]Feet per second.

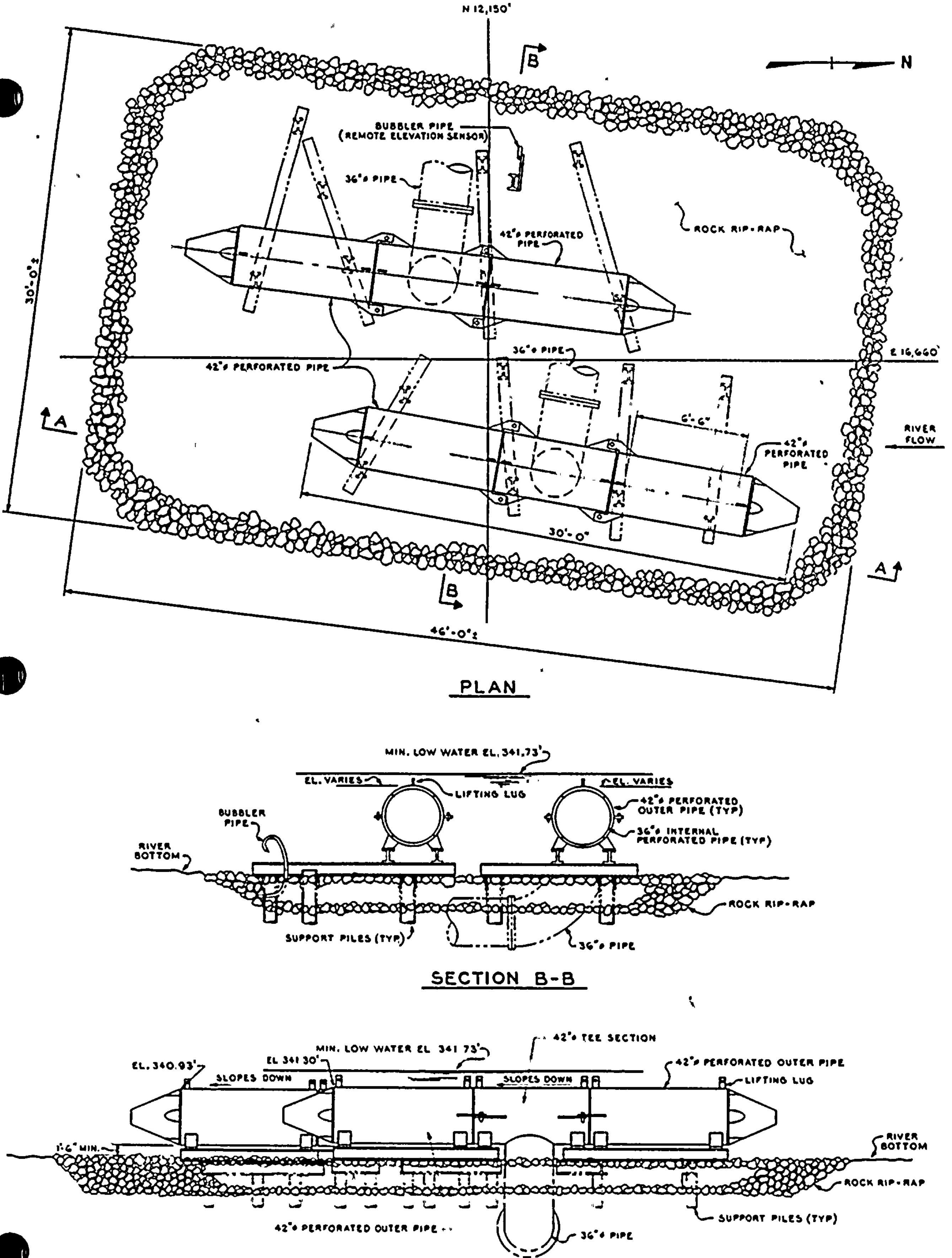


Figure 5-1 Vertical and Cross Sectional Views of WNP-2 Intake Structure

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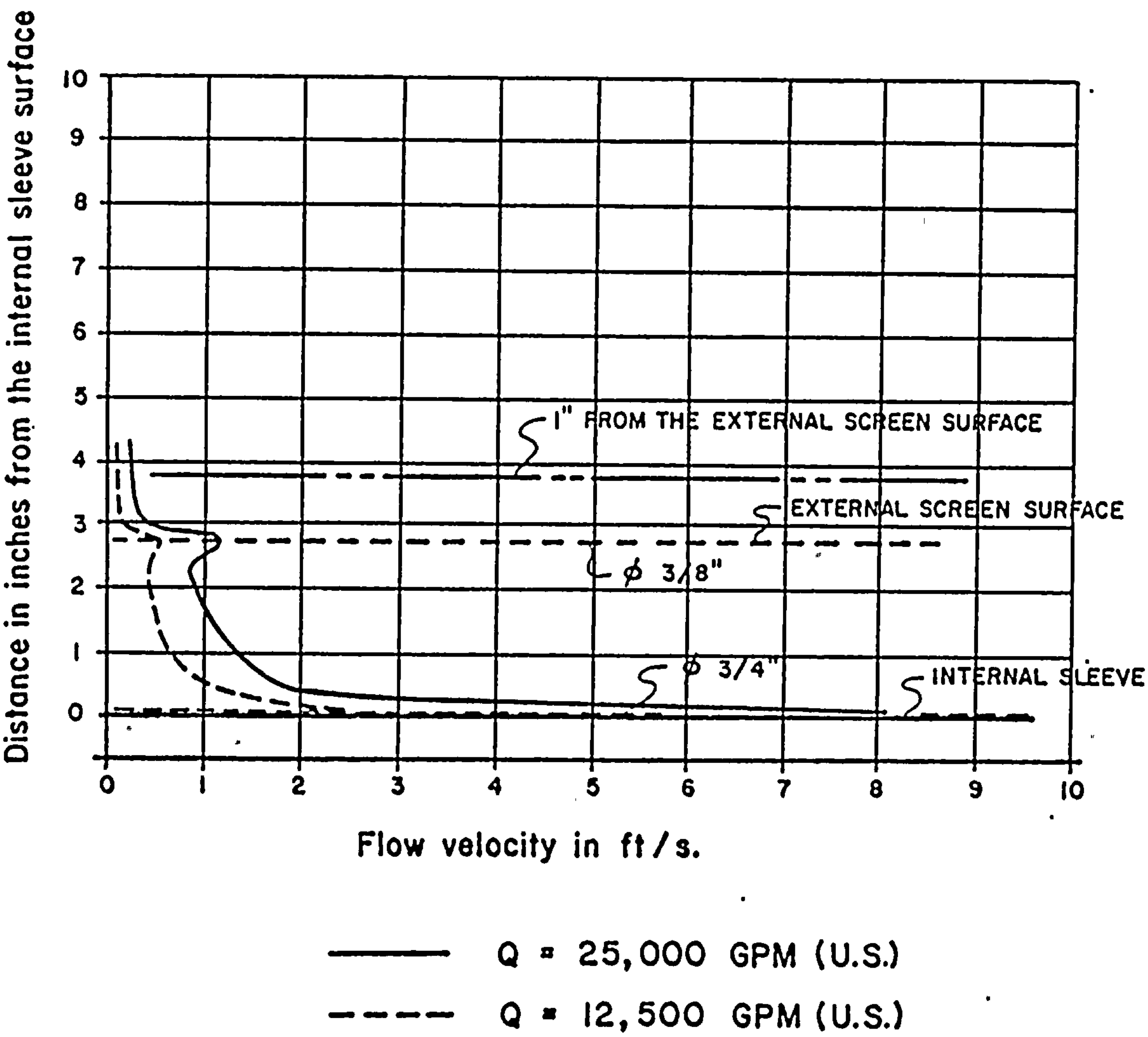


Figure 5.2 Perforated Pipe Intake, Distance vs. Intake Flow Velocities

850381-4A

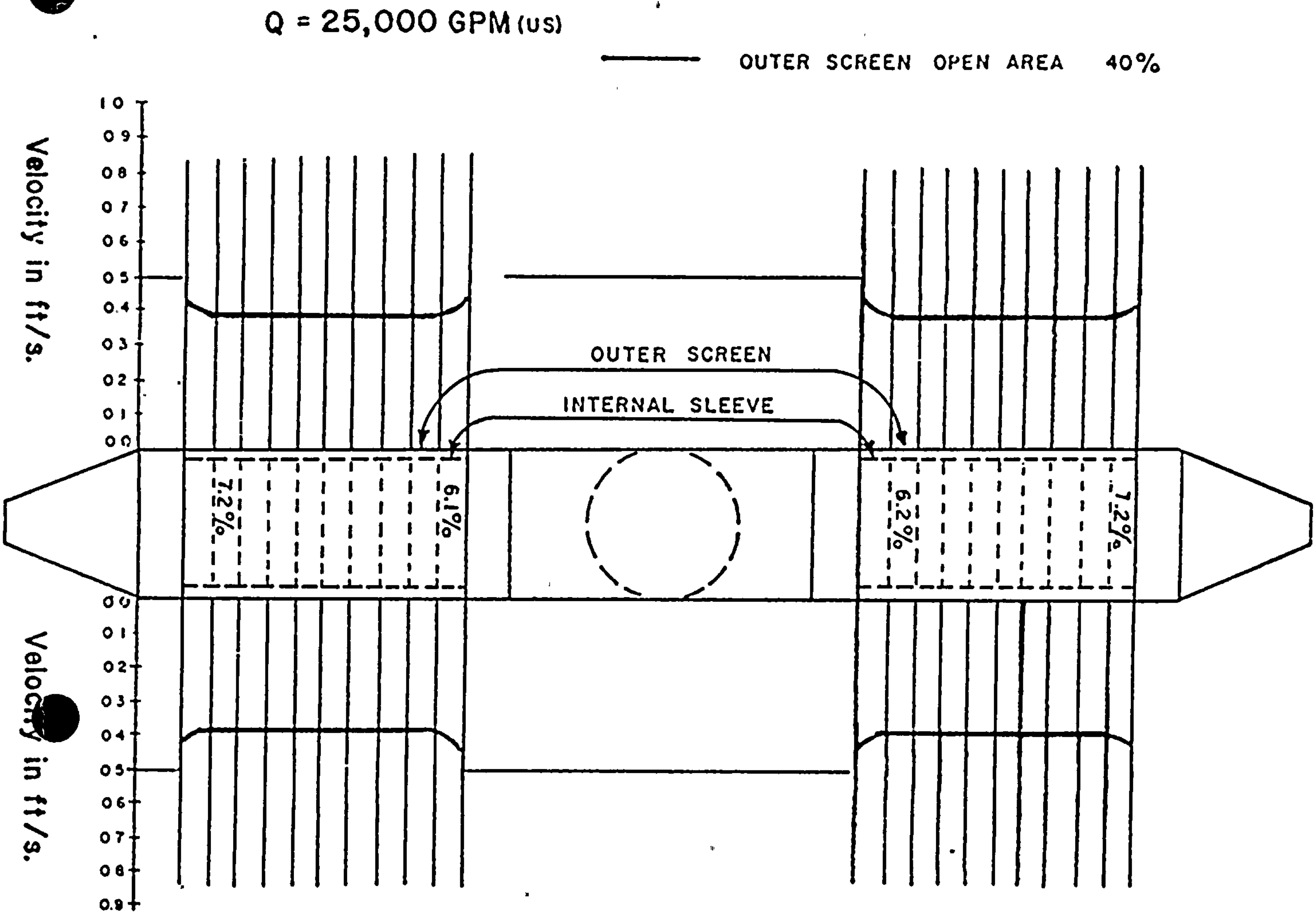


Figure 5-3 Perforated Pipe Intake Velocity Distribution 3/8 in. Away from Screen Surface

850381-3A

6.0 CORBICULA (CLAM) SURVEYS

6.1 INTRODUCTION

The Asiatic clam (Corbicula) has become a water system maintenance and production problem for many plants using raw river or lake water throughout the United States. Originally introduced into the US in the Columbia River near Knappton, Washington in 1938 (6-1), by 1982 the clam had been reported from 35 of the continental states (6-2). Initial reports of the clams becoming a nuisance were in 1953 from southern California. In 1960 the Tennessee Valley Authority reported cooling water system plugging problems at steam units. In 1980 biofouling by Corbicula of safety-related system components necessitated shutdown of Arkansas Nuclear One. Corbicula biofouling problems are usually limited to water systems using fresh untreated water. The majority of damage is due to plugging by clam shells (screen plugging by clam bodies following massive natural die offs have been recorded) but pump impeller damage has also been documented (6-1).

The clams live from 1 to 6 years and in warm water may grow to 21 mm (0.8 in.), 31 mm (1.2 in.), 36 mm (1.4 in.) and 40 mm (1.6 in.) after 1, 2, 3, and 4 years, respectively. The clams incubate their young in their gill cavity (6-1). The veliger larvae are discharged and passively carried by water currents for several hours by which time the pediveliger larvae has developed a foot and byssal thread to help attachment to any substrate (6-1).

Densities of 10,000 to 20,000 clams/m^2 have been reported (6-3). Spring and Fall spawning has been reported for some populations. Corbicula clams can inhabit water down to 12 m (40 feet) and are not susceptible to desiccation, enabling them to be transported for distances by man or water fowl.

6.2 MATERIALS AND METHODS

The Nuclear Regulatory Commission (NRC) in Inspection and Enforcement Bulletin 81-03 requested licensees to determine whether Corbicula clams were present in the vicinity of their station. If the potential for biofouling by Corbicula existed, the licensee was to develop a monitoring program to prevent or detect cooling/emergency water systems degradation.

Scuba dives above and below the WNP-2 river water intakes (River Mile 352) identified that the clams were present and an inspection program was designed in 1981. Inspections by scuba divers of the River Pump House (TMU), cooling tower basins, circulating water pumphouse, and the auxillary cooling spray ponds were undertaken. Additional inspections of screens and water boxes within the plant have been infrequently conducted.

6.3 RESULTS AND DISCUSSION

Between November 1983 and November 1984 samples were collected (see Table 6-1) and reviewed for Corbicula clams at the following locations: River Pump House, TMU (three surveys); Cooling Tower Basins (three surveys); Spray Ponds (two surveys): Turbine Building Service Water System (two surveys) and single surveys were conducted of the Circulating Water Pump House Basin and the Main Condenser Water Box.

Clams or relic shells have been found only at the River Pump House. The three surveys recovered 18 live clams and 14 relic valves (one half of the clams shell). Also collected was one large fresh water mussel (Margaritifera). Several live Corbicula clams were observed in the rip rap at the foot of the river intakes (see Figure 5-1).

In summary, live Corbicula clams and a Margaritifera mussel have been identified from the River Pump House (TMU). No live clams or mussels, or relic shells have been able to survive the 3-1/2 mile pipeline travel to the plant or the plants biofouling control system. Monitoring inspections are continuing.

6.4 REFERENCES

6-1 Smith, A.L., et al. 1979. Clams-A Growing Threat to Inplant Water Systems. Plant Engineering. June 14, 1979. File No. 7510.

6-2 McMahon, R.F., 1982. The Occurrence and Spread of the Introduced Asiatic Freshwater Clam, Corbicula fluminea (Müller), In North America: 1924-1982. The Nautilus, Vol. 96(4).

6-3 Dreier, H. and J.A. Tranquilli. 1980. Reproduction, Growth Distribution, and Abundance of Corbicula in an Illinois Cooling lake from the Lake Sangchris Study. Illinois Natural History Survey Bull. 32(3).

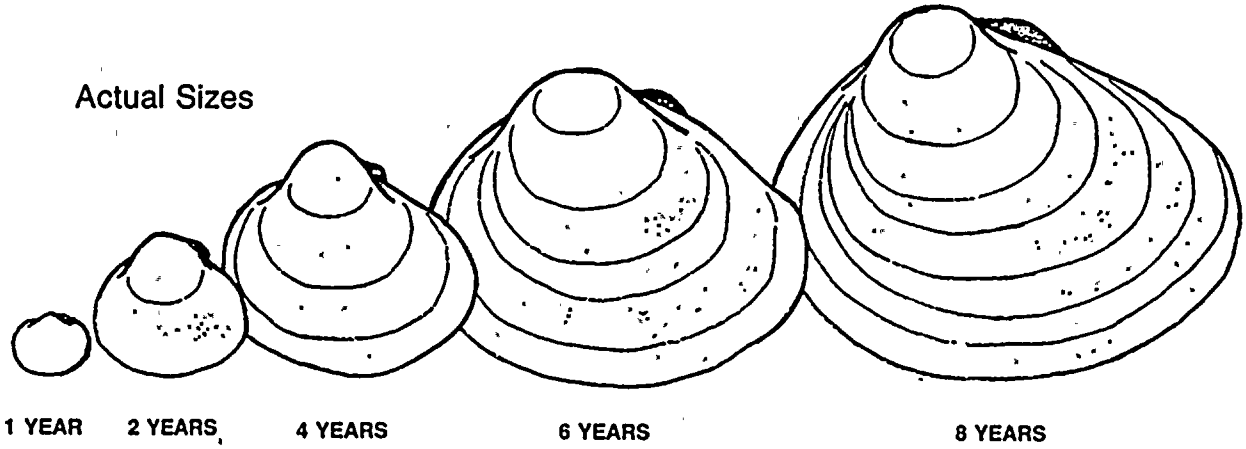
TABLE 6-1

SUMMARY OF CORBICULA CLAM SURVEYS

Date	Location	Observation
November 1983	TMU	2 live clams
	CT	None observed
	SP	None observed
	Main Condenser	None observed
May 1984	TBSWS	None observed
	TBSWS	None observed
July 1984	CT	None observed
	SP	None observed
	TMU	1 live adult, 4 relic valves
November 1984	CWPH	None observed
	CT	None observed
	TMU	15 live adult, 10 relic valves

Legend

TMU = Pumphouse at River
CT = Cooling Tower Basin
SP = Spray Ponds
TBSWS = Turbine Building Service Water System
CWPA = Circ. Water Pump House Basin



The clam is hermaphroditic. The ova (A) are produced in the inner gills, develop to trochophores (B to D), and then become veligers (E to G). The veligers are discharged through the exhalent siphon into the surrounding water. They can be passively carried with plankton by water currents for a few hours after discharge from the adult. For this reason, water systems pumping directly from infested waters can take large numbers of larvae into the system.

The next stage is the pediveliger (H and I). At this stage, the organism is similar to the veliger except for development of a foot that serves as an anchor and also for locomotion. The larvae (J and K) take on adult characteristics, becoming sexually mature in approximately 6 to 9 months. The foot's adhesive power is improved by byssal thread that anchor the small clam to nearby substrate that can incude plant intake, heat-exchanger, and distribution piping.

From Smith, A.L. 1979

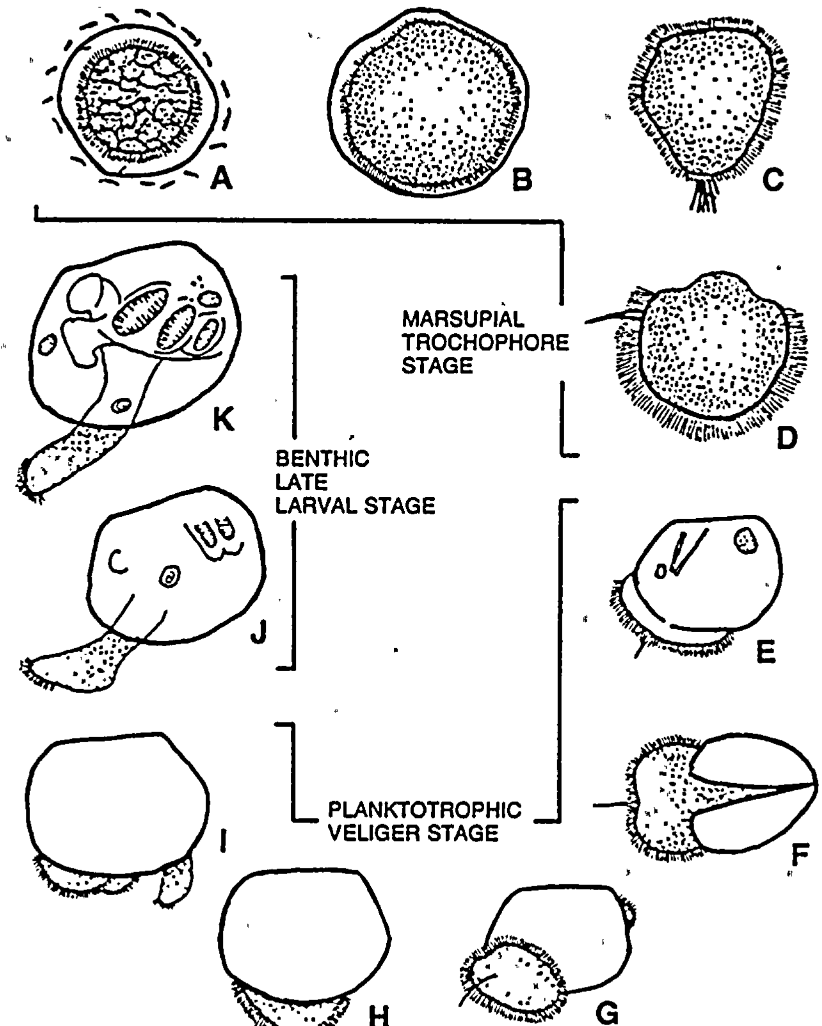


Figure 6.1 Corbicula Size and Larval Development

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7.0 TERRESTRIAL - VEGETATION

7.1 INTRODUCTION

In 1974, Battelle Northwest was awarded a contract to conduct preoperational terrestrial monitoring for Washington Public Power Supply System Nuclear projects 1, 2, and 4 (7-1, 7-2, 7-3, 7-4). In 1980, Beak Consultants Inc. took over the program and continued through 1982 (7-5, 7-6, 7-7) when the Supply System assumed responsibility (7-8). Vegetation studies were conducted from May 7 through May 14, 1984 as a continuation of the program.

The purpose of the vegetation studies is to identify any impact of cooling tower operation upon the surrounding plant communities as well as any edaphic impacts. The program includes the measurement of herbaceous and shrub canopy cover, shrub density, herbaceous phytomass, vegetation chemistry, and soil chemistry. Soil chemical parameters measured include pH, carbonate, bicarbonate, fluoride, sulfate, chloride, sodium, potassium, calcium, magnesium, copper, zinc, lead, chromium, nickel, cadmium, mercury and conductivity. Vegetation chemistry includes extractable sulfate, chloride and total copper. The study will provide pre- and post-operational data for future comparisons and meets the requirements of Washington State Energy Facility Site Evaluation Council (EFSEC) Resolutions 193 and 194 dated May 26, 1981.

WNP-2 is located approximately 5 km from the west bank of the Columbia River and 19 km north of the Richland Washington city center (Figure 7-1). Elevation ranges from 114 m at the river to approximately 152 m at the most distant study plots. Climatically, the area exhibits rather extreme seasonal temperature fluctuations with a mean maximum July temperature of about 33 degrees C and a January mean minimum temperature of -4 degrees C. Annual rainfall averages 20 cm with less than 25% falling between April and October (7-9).

The site lies within the boundaries of the Columbia Basin, an extensive area south of the Columbia River between the Cascade Range and Blue Mountains in Oregon and approximately two thirds of the area lying east of the Cascades in Washington. Underlying the study area is the Columbia River Basalt Formation,

a vast area formed during the Miocene epoch from huge lava outflows and ranging in thickness from 600 to 1500 meters (7-10). All of the soils in the Columbia Basin were apparently formed under grassland conditions, however, a diversity of soil types exists most of which correlate to regional climatic differences. The dominant soils include Camborthids, Haploxerolls, Xerorthents, Haplargids, Haplaquolls, Torripsamments and Rockland (7-10).

The plant communities within the region are generally described as shrub-steppe communities consisting of various layers of perennial grasses overlayed by a discontinuous layer of shrubs. In general moisture relations are insufficient to support any arborescent species except along streambanks.

Most of the plant growth in the region occurs quickly during May and June followed by a gradual death of herbaceous foilage as the summer progresses. Frequently, perennial and annual forbs, such as *Psoralea lanceolata*, and *Bromus tectorum* will exhibit a burst of growth during the fall before the first frost occurs and winter dormancy begins. The cold wet winters will support the growth of some species at least on an intermittent basis.

Daubenmire (7-11) divided the Columbia Basin Shrub Steppe region into nine zonal associations based upon climax vegetation. These zones have differentiated in response to various climatic and edaphic conditions including temperature, precipitation, soil type, etc. WNP-2 is located within the driest of the nine zones known as the *Artemisia-Agropyron* association. The region occupies the central portion of the Columbia Basin and extends west to the foothills of the cascade range (Figure 7-2). The zone includes four distinct layers of vegetation: (1) a layer of shrubs dominated by *Artemisia tridentata*, *Purshia tridentata*, *Chrysothamnus nauseosus* and *C. viscidiflorus* with a few other shrubs occasionally present; (2) a layer of caespitose perennial grasses dominated by *Agropyron spicatum*, *Sitanion hystrix*, *Stipa comata* and *Agropyron dasystachum*; (3) A layer of herbaceous annual and perennial forbs extending to approximately 15 cm from the soil surface. These include such species as *Bromus tectorum*, *Festuca octoflora*, *Poa sandbergii*, *Astragalus sclerocarpus*, *Brodiaea douglasii*, *Descurainia pinnata*, *Phlox*

longifolia, and Plantago pategonica; (4) A crustose layer of lichens and mosses including Tortula brevipes, Aloina rigida, Bryum argenteum and Candelaria vitellina.

Epiphytic lichens (e.g., Candelaria concolor, Physcia grisea and Letharia vulpina) as well as mosses (e.g., Tortula ruralis) are common on the stems of Artemisia and Purshia.

Structural and successional changes in Artemisia-Agropyron community structure have been associated with grazing, farming and periodic fires. Grazing was probably of only minor importance in this region prior to the arrival of European settlers as only deer, elk, and antelope were present in large numbers prior to the introduction of the horse. It appears that buffalo were never a major grazing factor in this region as they were in the great plains (7-12).

When cattle were introduced in 1834 (7-11) their numbers increased rapidly to an estimated 200,000 by 1855 (7-13). The result of the grazing pressure created by large herds of cattle, sheep and horses was to reduce the presence of the large perennial grasses and to increase the presence of certain alien species which were well adapted to the steppe, most notably Bromus tectorum.

It appears that fire was not a major factor in the development of steppe vegetation climaxes prior to the introduction of cattle. Daubenmire (7-11) indicated that steppe aborigines would have had little use for controlled fires since few game animals could be harvested through its use. Bromus tectorum was introduced into the state in about 1890 (7-14). Today it has become ubiquitous through the Artemisia-Agropyron zone. It is the most common plant to move into an area which has been grazed excessively, burned or abandoned after cultivation. Even though B. tectorum may be preceded by other aggressive annuals such as Sisymbrium altissimum or Salsola kali, they generally will be reduced to a minor role in a few seasons. Once established, it appears that Bromus tectorum seldom gives up its claim to overgrazed or abandoned soils. Bromus communities appear to remove sufficient soil moisture so as to prevent recolonization by native perennial grasses such as Agropyron

(7-11). Also, the early development of the Bromus seedling which occurs in the fall at the beginning of the rainy season and the continued development of its root system during the winter (7-15) help to assure the success of this alien species by permitting maximum usage of available soil moisture during the spring months. Also, its root system is capable of extending beyond two meters. (7-16)

Although Bromus tectorum is highly palatable to livestock in its early stages of development, its introduction has markedly and irreversibly degraded the steppe vegetation by displacing native perennial grasses following disturbances. In addition, its high yearly variation in productivity and high flammability increase its undesirability as a permanent member of the steppe vegetation.

Sampling was conducted at each of nine permanent sites, 4 grassland sites, G01-G04, and 5 shrub sites, S01-S05. Figure 7-1 shows the location of each site. The orientation of the various components including transects and productivity plots within each community are depicted in Figure 7-3. Sites G01, G02, and G03 are extensively disturbed grassland areas dominated by annuals within close proximity to the plant. They are devoid of shrubs and consist largely of introduced Eurasian species including Bromus tectorum, Draba verna, Sisymbrium altissimum, Microsteris gracilis var. humilior, Holosteum umbellatum, Descurainia pinnata, Salsola kali, Franseria acanthicarpa, and Amsinckia lycopsoides. Site G04, located approximately 2 miles south of WNP-2, was at one time severely disturbed by overgrazing, but appears to be in a relatively advanced stage of recovery as evidenced by the high cover values exhibited by the perennial grasses Stipa comata and Poa sandbergii.

Sites S01 and S03 are highly disturbed sites located approximately 2 km from WNP-2. They are mixed shrub sites characterized by the presence of Artemisia tridentata, Purshia tridentata, Chrysothamnus nauseous, C. viscidiflorus, Opuntia polyacantha, and Eriogonum niveum together with a variety of bunch grasses, Bromus tectorum, and a variety of annual and perennial forbs. Site

S05 lies approximately 8 km southeast of WNP-2. The site was a mixed shrub community, however, a fire in 1981 destroyed most of the shrubs reducing the cover to less than 1%. Site S02 lies on the periphery of a series of sand dune clusters which occur sporadically in west central Benton County along the Columbia River. The S02 sampling plot occurs within a stabilized area well below the average height of the dunes. It supports a population of *Purshia tridentata*, *Chrysothamnus nauseosus*, and *C. viscidiflorus*. Beneath the shrub canopy is usually an abundance of litter and a dense population of *Bromus tectorum*. Well represented between shrubs are *Poa sanbergii*, *Agropyron spicatum*, *Achillea millefolium*, *Cymopteris terebinthinus*, *Draba verna*, *Holosteum umbellatum* and *Microsteris gracilis* var. *humilior*. On the leeward side of adjacent large dunes are found populations of *Agropyron dasystachyum* and *Rumex venosus* while the windward sides contain chiefly *Psoralea lanceaolata* and *Elymus flavescens*. On some of the more stabilized dune surfaces occur *Koeleria cristata*, *Oryzopsis hymenoides*, *Stipa comata*, *Penstemon acuminatus*, *Arenaria franklinii*, *Cryptantha leucophaea* and *Fritillaria Pudica*. Also observed near the S02 boundary was a mature population of *Leptodactylon pungens*.

Given the low precipitation level of the region, operation of the cooling towers should increase the concentration of some components of the cooling water matrix in the regional soil profile. In time, these concentrations could reach levels which would inhibit the growth of native or cultivated vegetation living within the drift zone. The nature and extent of these effects can only be determined by monitoring such parameters as productivity, vegetation cover and frequency, and soil chemistry over time and comparing the data with pre-operational baseline studies.

Extrapolating predictive dose-response data on salt drift damage to vegetation in a natural situation is difficult, if not impossible. Using predictive models and a variety of assumptions the salt deposition rates presented in Table 7-1 were estimated as part of required preoperational monitoring and environmental impact analysis. Since salt drift transport is largely determined by local meteorology, predictive models and laboratory situations may not be representative of cooling tower drift under actual plant operating conditions.

Predicted isopleths of salt drift deposition from the operation of the mechanical draft cooling towers of WNP-2, based on conservative assumptions, are presented in Figures 7-4 and 7-5. It is evident that if all the salt were to be confined to the soil profile, values as high as 16,000 pounds per acre could be realized over the 40 year operating life of the plant. The most commonly used parameter for estimating the overall quantity of salt present within a soil is the electrical conductivity of a saturation extract or water leachate from the soil sample. It appears that little or nothing is known of the salt tolerance of most of the plant species living within the shrub steppe region surrounding WNP-2. However, much data exists relating cultivated plant productivity and soil conductivity. Table 7-2 summarizes some data relating soil conductivity to three levels of yield reductions in several species of cultivated plants. (7-17)

7.2 MATERIALS AND METHODS

Fifty microplots (20 cm x 50 cm) were placed at 1-m intervals on alternate sides of the herbaceous transect (Figure 7-3). Canopy cover was estimated for each species occurring within a microplot using Daubenmire's (7-18) cover classes. Data were recorded on standard data sheets.

Quality assurance was accomplished by twice sampling three randomly selected microplots on each herbaceous transect. The entire transect was resampled if cover estimates for any major species (>50 percent frequency) differed by more than one cover class.

Estimates of cover for five major herbaceous species were compared among the nine study sites in each year and among 1980, 1981, 1982, 1983, and 1984 at each site using a two-way repeated measures analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) multiple comparisons at the 5 percent probability level (7-19). The five herbaceous species examined were: *Bromus tectorum*, *Poa sandbergii*, *Descurainia pinnata*, *Phlox longifolia* and *Sisymbrium altissimum*. Repeated measures on the same microplot through time helped control the large naturally occurring differences among microplots which could otherwise have overshadowed any differences through years and year-site interactions.

Multiple comparison analyses were used to test for site-to-site differences. No transformations were applied to herbaceous cover data because the large sample sizes (50 microplots) permitted application of normal distribution theory to the resulting mean cover data.

7.2.1 Herbaceous Phytomass

Phytomass sampling was conducted concurrently with cover sampling. Phytomass sampling plots were randomly located within an area adjacent to the permanent transects or plots (Figure 7-3). At each study site, all live herbaceous vegetation rooted in five randomly located microplots (20 x 50 cm) was clipped to ground level and placed in paper bags. Each bag was stapled shut and labeled with site code, plot number, date and personnel.

Sample bags were transported to the EOF laboratory, opened, and placed in a drying oven at 50 degrees C for 24 hours. Following drying, the bags were removed singly from the oven and their contents immediately weighed to the nearest 0.1 g. Laboratory quality assurance consisted of independently reworking 10 percent of the phytomass samples to assess data validity and reliability.

Estimates of phytomass sample weights for total herbaceous plants were compared among the nine study sites in each year and among 1980, 1981, 1982, 1983 and 1984 at each site using a two-way analysis of variance (ANOVA) and SNK multiple comparisons. All tests were made at the 5 percent probability level.

7.2.2 Shrub Canopy Cover

Five 50-m lines were used to measure shrub canopy cover in each of the five shrub plots (Figure 7-3). Whenever a shrub was crossed by a tape stretched between the end posts, its species and the distance (cm) at which it intercepted the line were recorded. For each shrub plot, intercept distances of each species along all five lines were summed to give a total intercept distance. From this, a shrub canopy cover value (percent) was obtained by dividing total intercept distance by total line length.

Quality assurance procedures consisted of twice sampling one major species along a randomly selected shrub transect. Resampling was conducted if intercept lengths differed by more than 10 percent.

Cover estimates for key shrub species were compared among the five shrub study sites in each year and among 1980, 1981, 1982, and 1983 at each site using a two-way repeated measures analysis of variance (ANOVA) and SNK multiple comparisons. All tests were made at the 5 percent probability level.

7.2.3 Shrub Density

Individual live shrubs were counted and recorded by species within each of the four strips delineated by shrub intercept transects (Figure 7-3). Numbers per strip were summed to obtain shrub density by species for the entire 1000 m^2 plot. Sampling was concurrent with cover sampling.

Quality assurance consisted of resampling one randomly selected species within one strip. Resampling was conducted if the count difference exceeded one individual.

7.2.4 Soil Chemistry

At each of the nine grassland and shrub sites, one 500 ml soil sample was collected from the top 15 cm of soil with a clean stainless steel trowel. The sample was placed in two 250-ml sterile plastic cups with lids, labeled and refrigerated at 4 degrees C. Eighteen parameters were analyzed in each sample including pH, bicarbonate, carbonate, conductivity, sulfate, chloride, fluoride, copper, zinc, nickel, cadmium, lead, mercury, chromium, calcium, magnesium, sodium and potassium. Samples were analyzed for pH, bicarbonate, carbonate, sulfate, chloride and conductivity according to Methods of Soil Analysis (7-20). Samples for zinc, calcium, magnesium, sodium and potassium were analyzed by flame atomic absorption spectroscopy according to Methods For Chemical Analysis of Water and Wastes (7-21). Mercury was analyzed by cold vapor atomic absorption spectroscopy according to EPA (7-21). Samples for copper, cadmium, lead, nickel and chromium were analyzed by graphite furnace

atomic absorption spectroscopy according to EPA (7-21). Fluoride samples were analyzed by specific ion electrode utilizing a sodium carbonate fusion analysis developed at AM Test Laboratories Inc., Seattle, Washington (Appendix B). Aliquots of soil for trace metal analyses were digested according to Procedures for Handling and Chemical Analysis of Sediment and Water Samples (7-22). Preservation times and conditions, when utilized, were according to EPA (7-21).

Laboratory quality control comprised approximately 20% of the sample analysis load. National Bureau of Standards river sediment samples were digested and analyzed along with each batch of soil samples. Routine quality assurance analyses included internal laboratory standards, externally prepared EPA controls, reagent blanks and yearly blind EPA performance samples.

7.2.5 Vegetation Chemistry

Samples of *Bromus tectorum*, *Poa sandbergii*, *Artemisia tridentata* and *Purshia tridentata* were collected at each site. Two species were substituted at some of the sites due to absence of one or more of those listed above. Substitute species were *Phlox longifolia* and *Sisymbrium altissimum*. Samples were collected at the same time as soil samples and as close to the soil sampling site as possible. Sufficient quantities of leafy material of each species were collected to yield at least five grams of dry weight. The clipped material was sealed in a plastic bag, labeled and refrigerated at 4 degrees C until analyzed.

In the laboratory, the clipped plant tissue was oven dried to a constant weight, ground in a Wiley mill and digested according to Plumb (7-22). Sulfate was analyzed by nephalometry and chloride by mercuric chloride titration according to EPA (7-21). Copper was analyzed by graphite furnace atomic spectroscopy according to EPA (7-21).

7.3 RESULTS AND DISCUSSION

During the 1984 season, 52 plant taxa were observed in the study area. These are presented in Table 7-3. Table 7-4 lists by year the species of vascular plants observed during field activities from 1975-1984.

7.3.1 Herbaceous Cover

Herbaceous cover data for 1984 are contained in the appendix and summarized in Table 7-5. Figures 7-6, 7-7, 7-8 and 7-9 provide a comparison with the data of previous years.

Total herbaceous cover averaged 63.42% in the study area. At grassland sites average herbaceous cover was 73.98% and at shrub sites it was 56.60%. Bromus tectorum tended to dominate herbaceous vegetation in the study area, accounting for 42.81% of total herbaceous cover. However, at site G04 it accounted for only 9.6% of the total herbaceous cover.

Herbaceous cover was higher in 1984 than in 1983 (64.32% vs. 61.51%) however well within the ranges experienced in previous years. Although annual precipitation was lower in 1984 than in 1983 (7.27 vs. 7.98 inches), many factors other than precipitation exert an influence on yearly fluctuations in cover values. These include other climatic and edaphic factors, the cyclic production of seed (7-16) and litter thickness.

Perennial grasses averaged 6.82% or 10.75% of the total in comparison to 8.37% and 13.6% in 1983. Poa sandbergii was the most abundant perennial grass at all sites except G03 and S05 where it did not occur. Perennial grasses were absent at site G03 and were dominated by Stipa comata at site S05.

Annual forb cover averaged 11.73% as opposed to 10.81% in 1983 and still lower in 1982 and 1981. As in previous years the most abundant annual forbs were Draba verna (2.14%), Holosteum umbellatum (6.48%) and Microsteris gracilis (1.22%).

Perennial forb cover for 1984 averaged 1.65% which approximates the 2.00% described in 1983. Overall, there has been little fluctuation since 1975 in the perennial forb cover, which would be expected since perennials are less susceptible to short-term climatic fluctuations than annuals.

Species frequency showed relatively little change between 1983 and 1984 (Table 7-6). Bromus tectorum was present in nearly all of the microplots sampled. Site S05 had the greatest variety of annual forbs present, while site S04 contained the greatest variety of perennials.

Statistical comparisons among 1980, 1981, 1982, 1983, and 1984 herbaceous cover data for the five dominant species showed that significant differences among years and sites continued to occur (Table 7-7). The occurrence of significant year-by-site interactions for all species indicated that further testing for cover differences among sites within each year and among years at each site would be appropriate (Table 7-7). Tables 7-8 and 7-9 show the results of SNK multiple comparison tests which, although less powerful than the ANOVA (7-23), show at which sites differences occurred. Bromus tectorum and Poa sandbergii cover values differed significantly among sites in each year. Although groups of sites with similar cover values occurred, they were not consistent among years. For instance, Bromus tectorum cover did not differ significantly between sites S02 and S04 in any year nor between sites S01 and S05 in 1980, 1981, and 1984. However, in 1982 and 1983 the difference between sites S01 and S05 was significant and in 1982 was the greatest of all pairwise comparisons. The fire which occurred at site S05 in 1981 was undoubtedly responsible for the latter differences. Phlox longifolia and Descurainia pinnata cover values showed significant differences among sites in 1980 and 1983. Sisymbrium altissimum cover was similar across all sites in 1980, showed significant differences among some sites in 1981 and 1984, was similar at all sites except S05 in 1982, and was similar at all sites except S03 and S05 in 1983. This was probably due to its role as an early seral species which tends to be abundant following a disturbance, then decreases as time passes without further disturbance. The fire which occurred at site S05 in July 1981 almost certainly contributed to the high cover of Sisymbrium altissimum at that site in 1982.

Bromus tectorum cover values showed significant differences over time at all sites except S04. *Descurainia pinnata* cover values have generally been less than one percent at all sites. In 1983 *Descurainia pinnata* values rose above 1% at sites S01, S02, S04 and S05, however it was reduced dramatically in 1984 and was absent from sites G01, G02, G04, S02 and S03. In 1984 significant differences occurred at all sites except G01, G02, G03, G04 and S03.

The diversity of species at each site remained much the same as in previous years. Sites S02 and S05 had the greatest number of species present (16 and 17, respectively).

Of the total number of herbaceous species present within the study sites a number are alien species, that is, species which due to a disturbance of one kind or another (e.g., overgrazing, fire, farming etc.) have migrated into the area and have displaced, at least temporarily, species which are native to the area. A study over time of species composition relative to alien and native species may give some insite as to the occurence and extent of community disruption caused by environmental disturbances. Plots of percent total herbaceous cover for alien and native species over time for each site are presented in Figures 7-10 to 7-18. An overall decrease in percent cover of native species relative to total cover appears to be occuring at all sites except S02, S05 and G04 since 1980..

Some concern was raised with the practice of converting data to cover class midpoints for the ANOVA in that within-station variability would be reduced and thus increase the probability of rejecting the hypothesis of no difference between "treatment levels" (stations or years). In an effort to assess this hypothesis, the 1980-1983 data was analyzed using a Kruskal-Wallis nonparametric test and the results compared to the parametric ANOVA. Cover classes (ordinal data) were used for the Kruskal-Wallis test and cover class midpoints (ratio scale data) were used for the parametric ANOVA. One group of comparisons tested for differences between stations using each data subset defined by a single year and species, and another group tested for differences between

years using each data set defined by a single station and species. The total number of comparisons made was 60 and the number of decisions not in agreement was 1 at the 5% significance level.

number of rejections (ANOVA)	=	42
number of rejections (KW)	=	41
number of acceptances (ANOVA)	=	18
number of acceptances (KW)	=	19
number of decisions in agreement	=	59
number of decisions not in agreement	=	1

7.3.2 Herbaceous Phytomass

Average production of herbaceous phytomass in 1984 was 89.24 g/m^2 dry weight. Production varied widely among sites, from 42.5 g/m^2 at site S05 to 133 g/m^2 at site G03 (Figure 7-19). Statistical comparisons of 1980, 1981, 1982, 1983 and 1984 herbaceous phytomass values showed significant year-by-site interactions (Table 7-10, top). SNK multiple comparison tests were therefore made among sites for each year and among years for each site. Comparisons among years at each site (Table 7-10, bottom) showed significant differences in herbaceous phytomass production from year to year at 4 sites, G01, G02, G03, S02. In 1984 no statistically significant differences in herbaceous phytomass production between any sites occurred (Table 7-11). In 1984, grassland sites averaged higher herbaceous phytomass than shrub sites and Site G03 had the highest phytomass production of all sites.

Average herbaceous phytomass production at grassland sites and at shrub sites is shown graphically in Figure 7-20. The grassland average shows considerably more variability from year to year than does the shrub average. Table 7-12 shows phytomass values for each site in each year. Figure 7-9 shows average herbaceous cover values at grassland and shrub sites since 1975, for comparison with phytomass averages in Figure 7-19.

7.3.3 Shrub Cover and Density

Shrub cover and density data for 1984 are included in Appendix B. Table 7-13 summarizes shrub cover data. There are four shrub species present in the study area: Artemisia tridentata, Purshia tridentata, Chrysothamnus nauseosus, and Chrysothamnus viscidiflorus. Eriogonum niveum (a subshrub) and Opuntia polyacantha (a cactus) are also present.

Artemisia tridentata is the major shrub at sites S03 and S04. At site S03 Chrysothamnus nauseosus and Eriogonum niveum are minor community components. Chrysothamnus viscidiflorus occurs sporadically at site S04. Purshia tridentata is the major shrub at sites S01 and S02. Artemisia tridentata and Eriogonum niveum are important community components at site S01 and Chrysothamnus viscidiflorus is a minor component. Chrysothamnus nauseosus and Chrysothamnus viscidiflorus are both present at site S02, but only the latter is abundant. Site S05, which burned in 1981, was a mixed shrub site at which Artemisia and Purshia shared dominance and Chrysothamnus nauseosus, Chrysothamnus viscidiflorus, Eriogonum niveum and Opuntia polyacantha were present in lesser amounts.

Statistical comparisons of 1980, 1981, 1982, 1983, and 1984 shrub cover values are presented in Table 7-14. Neither Chrysothamnus species differed significantly among years but did among sites. Artemisia tridentata cover showed significant differences both among sites and among years, but changes in cover values were inconsistent as shown by the significant year-by-site interaction (Table 7-14). Purshia tridentata cover showed significant site and year differences and interactions. Multiple comparisons among sites showed that Artemisia tridentata cover did not change significantly over time at sites S02, and S03 and S05 (Table 7-15). Site S04 had significantly higher Artemisia cover than the other four sites in all five years (Table 7-16), and there were no significant differences among sites S01, S02, S03, and S05 in any of the 5 years. Analysis of Purshia tridentata cover showed 3 significant groupings of sites in 1980 and 1981 (Table 7-16). Site S02 had significantly greater Purshia cover in all 5 years. Sites S03, S04, and S05 (the lowest cover value grouping) were those sites with little or no Purshia present. The

significant differences among years which occurred in some sites could be due to a reduction in number of shrubs at these sites. Additional data would be necessary before a possible trend could be identified. Some of the differences could also be due to wind induced variability in transect placement, as was discussed previously (7-6).

Figure 7-21 shows average shrub cover from 1975 through 1984. Despite the lack of shrubs at site S05 in 1984, it was felt that it should continue to be considered a shrub site. Unlike the grassland sites (which were designated as "burned" sites prior to 1980), some shrub data exist for site S05. The surrounding area is occupied by shrubs which could provide a source of seed, so reestablishment of both Purshia and Artemisia could occur within a few years.

Shrub cover and density at the five sample sites in 1984 are shown in Figures 7-22 and 7-23. Figure 7-24 shows the values for shrub density at each site for 1980, 1981, 1982, 1983 and 1984.

7.3.4 Soil Chemistry

The results of the 1984 soil analyses are presented in Table 7-17 and are shown graphically in Figures 7-25 to 7-30. In addition, concentrations of each parameter for each site from 1980 to 1984 are presented in Figures 7-31 to 7-44. Methods of soil analysis are not well standardized and thus the reader is cautioned that some variability is inherent in analytical results obtained at different laboratories.

In general, analyses indicated soils of the study area to be within reported ranges (7-24, 7-25, 7-26, 7-27, and 7-28). As evidenced by Table 7-17, values for calcium, chromium, copper, lead, and potassium are at the lower end of ranges reported in the literature. The 1981, 1982 and 1983 mean values for chloride (8.1 µg/g and 2.9 µg/g, respectively) fall below reported ranges. Mean values for sodium are also below reported ranges. Zinc mean values in all three years are relatively close to the means recorded by other authors.

The baseline levels of virtually all the chemical parameters remain relatively low when compared with the previously discussed means and ranges for these same parameters. In the long term, this fact may be most influential in the evaluation of operational impacts on vegetation and soils. The ability of a soil to attenuate introduced chemicals (e.g., salt drift) is somewhat dependent on the baseline levels of these chemicals. Thus, chemicals which occur at low concentrations in undisturbed soils are more likely to be attenuated than are chemicals which occur at relatively high concentrations in undisturbed soils. Additionally, the ability of a soil to attenuate introduced materials depends to a very great extent on the texture of the soil, and especially on the clay fraction of the soil.

Certain types of clay colloids carry ionic charges which enable them to adsorb various chemical substances, thus rendering these substances non-reactive and consequently nontoxic.

Soils of the study area are very sandy and therefore contain a low percentage of clay. Soils were textured in the field at each sample site. Seven sample site soils were determined to be loamy sand while soils at the other two sample sites (S01, S02) were sand. It is obvious from the preceding discussion that these soils could be expected to attenuate less introduced material (i.e., salt drift) than soils with higher percentages of clay fractions.

Electrical conductivity (EC) is an index of soil salinity. Soils with EC measurements of 2000 umhos or less present virtually no salinity hazard to plant growth. Thus, the ECs recorded at the Supply System study site are extremely low. The low EC values are not unexpected, as the elements most often associated with soil salinity (i.e., calcium, magnesium, and sodium) are also low in the soils tested.

In summary, soils of the study area are slightly alkaline, not at all saline, and in the low-to-normal range for most trace elements. Inflation of these values due to salt drift should be readily detectable, should it occur in the years to come.

7.3.5 Vegetation Chemistry

The results of the 1984 vegetation chemical analyses are presented in Table 7-18 and are shown graphically in Figures 7-45, 7-46 and 7-47. As in previous years Sisymbrium altissimum had sulfate concentrations considerably higher than those of the other taxa analyzed. Copper concentrations ranged from 3.0 to 10.9 ug/g for all species examined. Extractable chloride concentrations were similar to those reported in previous years.

Examination of vegetation chemistry data from 1980 to 1984 shows that sulfate concentrations are very low for all species except Sisymbrium altissimum. Mean sulfate concentration for the study area has increased slightly over the five years. Chloride concentrations are relatively consistent over time, although individual sample values for Artemisia tridentata and Sisymbrium altissimum vary widely from site to site and year to year. Copper and chloride concentrations in Bromus tectorum and Poa sandbergii between 1980 and 1984 are presented graphically in Figures 7-48 to 7-51.

7.3.6 Summary and Conclusions

7.3.6.1 Herbaceous Cover

Herbaceous cover varied among sites, with the higher cover values usually occurring at grassland sites.

Herbaceous vegetation at all sites was dominated by Bromus tectorum. Statistical comparisons of 1980, 1981, 1982, 1983 and 1984 herbaceous cover showed significant differences among sites in each year occurring for Bromus tectorum and Poa sanbergii. Bromus tectorum also differed significantly among years at all sites except S04. Some differences over time occurred for the other four herbaceous species examined, but not consistently. Changes in species composition occurred at most sites, primarily among annual forbs. The diversity of herbaceous species at each site did not show much change, with shrub sites generally having more diverse herbaceous vegetation. The 1981 fire at site S05 appeared to benefit forb cover relative to total herbaceous

cover, a phenomenon that has been reported previously (7-6). Annual cover sampling has resulted in decreasing relative variability, even though wide variations in cover continue. Continued annual sampling will increase the likelihood that post-operational changes in herbaceous cover will be detectible.

7.3.6.2 Herbaceous Phytomass

Significant differences were observed in the estimated production of herbaceous phytomass among some of the nine sampling sites, with most grassland sites having lower herbaceous phytomass than shrub sites. Site S02 had the highest herbaceous phytomass production. Significant differences among years occurred at 3 sites.

7.3.6.3 Shrub Cover and Density

Artemisia tridentata is the major shrub species at two of the five sites. Purshia tridentata is more abundant at two sites, but at neither site does Purshia cover exceed ten percent. At the fifth site (S05) shrubs were destroyed by fire in 1981. Chrysothamnus nauseosus and Chrysothamnus viscidiflorus are minor components of the shrub communities. Significant differences in shrub cover for Purshia tridentata and Artemisia tridentata occurred over time and among sites. Significant differences between sites for all 4 species occurred. In addition, significant differences between years and year-site interactions for Purshia tridentata and Artemisia tridentata occurred. Shrub density appeared to remain relatively stable over time, with some year-to-year variation.

7.3.6.4 Soil and Vegetation Chemistry

Chemical analyses showed study area soils to be within or below reported ranges. Most elemental mean values were evenly clustered about those reported in previous years. Electrical conductivity values were extremely low, and the elements most often associated with high conductivity values were also present in low concentrations. Soils of the study area are slightly alkaline, not at all saline, and in the low to normal ranges for most trace elements.

Sulfate, chloride and copper concentrations in plant materials were relatively consistent from 1980 through 1984, although Sisymbrium altissimum showed extreme variability each year. No obvious correlation between soil and vegetation chemical concentrations is apparent at this time.

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TABLE 7-1

SALT DEPOSITION RATE VERSUS DISTANCE

Distance from Tower (miles)	Salt Deposition (lb/acre yr): Equal Direction Frequency	Salt Deposition (lb/acre yr): 9%(a) from Single Direction	Salt Deposition (lb/acre yr): 20% (b) from Single Direction	% of Normal 48 in. of Irrigation: Equal Direction Frequency	% of Normal 48 in. of Irrigation: 9% from Single Direction	% of Normal 48 in. of Irrigation: 20% from Single Direction
0 to 0.22	nil	nil	nil	nil	nil	nil
0.22 to 0.28	271.0	390.0	867.0	29.0	42.0	93.0
0.28 to 0.33	166.0	239.0	531.0	18.0	26.0	58.0
0.33 to 0.6	0.4	0.6	1.3	0.04	0.06	0.13
0.6 to 3	0.7	1.0	2.2	0.07	0.10	0.22
3	0.7	1.0	2.2	0.07	0.10	0.22

(a) 16-point compass presumed. Maximum wind direction frequency observed at WNP-2 site was 9%. Measurement elevation was 23 ft.

(b) 16-point compass presumed. Maximum wind direction frequency observed at HMS site was 20%. Measurement elevation was 400 ft.

TABLE 7-2

THE ELECTRICAL CONDUCTIVITY AT WHICH 10, 25 AND 50% YIELD REDUCTIONS CAN BE EXPECTED FOR VARIOUS AGRICULTURAL CROPS

	Percent Yield Reduction		
	10*	25	50
Field Crops	EC	EC	EC
Barley	11.9	15.8	17.5
Sugarbeets	10.0	13.0	16.0
Cotton	9.9	11.9	16.0
Safflower	7.0	11.0	14.0
Wheat	7.1	10.0	14.0
Sorghum	5.9	9.0	11.9
Soybean	5.2	6.9	9.0
Sesbania	3.8	5.7	9.0
Rice	5.1	5.9	8.0
Corn	5.1	5.9	7.0
Broadbean	3.1	4.2	6.2
Flax	2.9	4.2	6.2
Beans	1.1	2.1	3.0
Vegetable Crops			
Beets	8.0	9.7	11.7
Spinach	5.7	6.9	8.0
Tomato	4.0	6.6	8.0
Broccoli	4.0	5.9	8.0
Cabbage	2.5	4.0	7.0
Potato	2.5	4.0	6.0
Corn	2.5	4.0	6.0
Sweetpotato	2.5	3.7	6.0
Lettuce	2.0	3.0	4.8
Bellpepper	2.0	3.0	4.8
Onion	2.0	3.4	4.0
Carrot	1.3	2.5	4.2
Beans	1.3	2.0	3.2
Forage Crops			
Bermudagrass	13.0	15.9	18.1
Tall wheatgrass	10.9	15.1	18.1
Crested wheatgrass	5.9	11.0	18.1
Tall fescue	6.8	10.4	14.7
Barley hay	8.2	11.0	13.5
Perennial rye	7.9	10.0	13.0
Hardinggrass	7.9	10.0	13.0
Birdsfoot trefoil	5.9	8.1	10.0
Beardless wildrye	3.9	7.0	10.8
Alfalfa	3.0	4.9	8.2
Orchardgrass	2.7	4.6	8.1
Meadow foxtail	2.1	5.5	6.4
Clovers, alsike and red	2.1	2.5	4.2

*millimhos/cm @ 25c

TABLE 7-3

VASCULAR PLANTS OBSERVED DURING MAY 1984 FIELD WORK

	Common Name
APIACEAE	Parsley Family
Cymopterus terebinthinus (Hook.) T.&G. var. *terebinthinus*	Turpentine cymopterus
Lomatium macrocarpum (Nutt.) Coult & Rose	Large-fruit lomatium
ASTERACEAE	Aster Family
Achillea millefolium L.	Yarrow
Antennaria dimorpha (Nutt.) T&G	Low pussy-toes
Artemisia tridentata Nutt.	Big sagebrush
Balsamorhiza careyana Gray	Carey's balsamroot
Chrysothamnus nauseosus (Pall.) Britt	Gray rabbitbrush
Chrysothamnus viscidiflorus (Hook.) Nutt	Green rabbitbrush
Crepis atrabarba Heller	Slender hawksbeard
Franseria acanthicarpa Hook.	Bur ragweed
Layia glandulosa (Hook.) H&A	White daisy tidytips
Tragopogon dubius Scop.	Yellow salsify
Aster canescens (Pursh)	Hoary Aster
BORAGINACEAE	Borage Family
Amsinckia lycopsoides Lehm.	Tarweed fiddleneck
Cryptantha circumscissa (H&A) Johnst.	Matted cryptantha
Cryptantha pterocarya (Torr.) Greene	Winged cryptantha
BRASSICACEAE	Mustard Family
Descurainia pinnata (Walt.) Britt.	Western tansymustard
Draba verna L.	Spring draba
Erysimum asperum (Nutt.) DC.	Prairie rocket
Sisymbrium altissimum L.	Tumblemustard
CACTACEAE	Cactus Family
Opuntia polyacantha Haw.	Starvation cactus
CARYOPHYLLACEAE	Pink Family
Arenaria franklinii Dougl. var. *franklinii*	Franklin's sandwort
Holosteum umbellatum L.	Jagged chickweed
CHENOPODIACEAE	Chenopod Family
Salsola kali L.	Russian thistle

TABLE 7-3 (Continued)

	Common Name
FABACEAE	Pea Family
Astragalus purshii Dougl.	Wooly-pod milk-vetch
Astragalus sclerocarpus Gray	Stalked-pod milk-vetch
Psoralea lanceolata Pursh	Lance-leaf scurf-pea
HYDROPHYLLACEAE	Waterleaf Family
Phacelia hastata Dougl.	Whiteleaf phacelia
Phacelia linearis (Pursh) Holz.	Threadleaf phacelia
LILIACEAE	Lily Family
Brodiaea douglasii Wats.	Douglas' brodiaea
Fritillaria pudica	Chocolate lily
LOASACEAE	Blazing-star Family
Mentzelia albicaulis Dougl.	White-stemmed mentzelia
ONAGRACEAE	Evening-primrose Family
Oenothera pallida Lindl. var. *pallida*	White-stemmed evening-primrose
PLANTAGINACEAE	Plantain Family
Plantago patagonica Jacq.	Indian-wheat
POACEAE	Grass Family
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass
Bromus tectorum L.	Cheatgrass
Festuca octoflora Walt.	Six-weeks fescue
Koeleria cristata Pers.	Prairie Junegrass
Oryzopsis hymenoides (R&S) Ricker	Indian ricegrass
Poa sandbergii Vasey	Sandberg's bluegrass
Sitanion hystrix (Nutt.) Smith	Bottlebrush squirreltail
Stipa comata Trin & Rupr.	Needle-and-thread
POLEMONIACEAE	Phlox Family
Gilia sinuata Dougl.	Shy gilia
Leptodactylon pungens (Torr.) Nutt.	Granite gilia
Microsteris gracilis (Hook.) Greene var. *humilior* (Hook.) Cronq.	Pink microsteris
Phlox longifolia	Long-leaf phlox

TABLE 7-3 (Continued)

	Common Name
POLYGONACEAE	Buckwheat Family
Eriogonum niveum Dougl.	Snow buckwheat
Rumex venosus Pursh	Wild begonia
ROSACEAE	Rose Family
Purshia tridentata (Pursh) DC.	Antelope bitterbursh
SANTALACEAE	Sandalwood Family
Comandra umbellata (L.) Nutt.	Bastard toad-flax
SCROPHULARIACEAE	Figwort Family
Penstemon acuminatus Dougl.	Sand-dune penstemon
RANUNCULACEAE	Buttercup Family
Delphinium nuttallianum Pritz. ex Walpers	Larkspur

TABLE 7-4

VASCULAR PLANTS OBSERVED DURING FIELD ACTIVITIES, 1975-1984

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Annual Grasses										
Bromus tectorum	X	X	X	X	X	X	X	X	X	X
Festuca octoflora	X					X	X	X	X	X
Festuca sp.		X		X						
Perennial Grasses										
Agropyron cristatum							X	X	X	X
Agropyron dasystachyum				X			X	X	X	X
Agropyron spicatum						X	X	X	X	X
Koeleria cristata				X		X	X	X	X	X
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X
Poa sandbergii							X	X	X	X
Poa Scabrella							X	X	X	X
Sitanion hystrix						X		X	X	X
Stipa comata		X		X	X	X	X	X	X	X
Stipa thurberiana					X					

TABLE 7-4 (Continued)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Annual Forbs										
Franseria acanthicarpa	X		X	X	X			X	X	X
Amsinckia lycopsoides	X	X	X	X	X	X	X	X	X	X
Amsinckia menziesii							X	X		
Chenopodium leptophyllum			X							
Cryptantha pterocarya		X		X		X	X	X	X	X
Cryptantha circumscissa	X	X	X	X	X	X	X	X	X	X
Descurainia pinnata	X	X	X	X	X	X	X	X	X	X
Draba verna	X	X		X	X	X	X	X	X	X
Epilobium paniculatum	X	X	X	X	X					
Erysimum asperum							X	X	X	X
Gilia minutiflora					X				X	
Gilia sinuata						X		X	X	X
Holosteum umbellatum	X	X		X	X	X	X	X	X	X
Lagophylla ramosissima						X				
Layia glandulosa			X		X			X	X	X
Microsteris gracilis	X	X	X	X	X	X	X	X	X	X
Phacelia hastata							X	X	X	X
Phacelia linearis				X		X	X	X	X	X
Phacelia sp.		X								
Plantago patagonica	X	X		X	X	X	X	X	X	X
Plectritis macrocera		X							X	

TABLE 7-4 (Continued)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Polemonium micranthum	X			X						
Salsola kali	X	X	X	X	X	X	X	X	X	X
Sisymbrium altissimum	X	X	X	X	X	X	X	X	X	X
Tragopogon dubius				X			X	X	X	X
Perennial Forbs										
Achillea millefolium	X	X	X			X	X	X	X	X
Antennaria dimorpha						X	X	X	X	X
Arenaria franklinii var. *franklinii*						X	X	X	X	X
Aster canescens (*Machaeranthera canescens*)		X			X				X	X
Astragalus lyallii			X							
Astragalus purshii	X	X				X	X	X	X	X
Astragalus sclerocarpus						X	X	X	X	X
Astragalus sp.				X						
Balsamorhiza careyanna	X	X		X	X	X	X	X	X	X
Brodiaea douglasii	X	X		X	X	X	X	X	X	X
Brodiaea howellii				X						
Calochortus macrocarpus	X				X					
Comandra umbellata	X		X	X	X	X	X	X	X	X
Crepis atrabarba		X	X	X	X	X	X	X	X	X
Cryptantha leucophaea						X	X	X	X	

TABLE 7-4 (Continued)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Cymopterus terebinthinus	X			X		X	X	X	X	X
Delphinium sp.				X					X	X
Erigeron divergens							X			
Fritillaria pudica									X	X
Lomatium macrocarpum	X		X		X	X	X	X	X	X
Lomatium sp.				X						
Oenothera pallida	X	X	X	X	X	X	X	X	X	X
Penstemon acuminatus							X	X	X	X
Penstemon sp.						X				
Phlox longifolia	X	X	X	X	X	X	X	X	X	X
Psoralea lanceolata	X	X	X	X	X		X	X	X	X
Rumex venosus				X		X	X	X	X	X
Sphaeralcea munroana								X	X	
Shurbs, subshrubs, cacti										
Artemisia tridentata	X	X	X	X	X	X	X	X	X	X
Chrysothamnus nauseosus	X	X	X	X	X	X	X	X	X	X
Chrysothamnus viscidiflorus	X	X	X	X		X	X	X	X	X
Eriogonum niveum	X	X	X	X	X	X	X	X	X	X
*Leptodactylon pungens**									X	X
Opuntia polyacantha	X			X		X	X	X	X	X
Purshia tridentata	X	X	X	X	X	X	X	X	X	X

TABLE 7-5

MEAN HERBACEOUS COVER VALUES (%) BY SPECIES FOR EACH SAMPLING SITE, 1984

	G01	G02	G03	G04	S01	S02	S03	S04	S05	Average
Annual Grasses										
Bromus tectorum	60.85	71.3	60.85	9.6	41.5	32.45	39.35	33.9	36.5	42.92
Festuca octoflora						0.3		2.4		0.3
Total Annual Grass Cover	60.85	71.35	60.8	9.6	41.5	32.7	39.3	36.3	36.5	43.21
Perennial Grasses										
Agropyron spicatum						0.6			0.05	0.07
Poa sandbergii	1.2	4.45		12.85	1.85	8.2	11.55	8.55		5.4
Stipa comata				12.15						1.39
Total Perennial Grass Cover	1.2	4.4		24.9	1.8	8.8	11.5	8.5	.3	6.82
Annual Forbs										
Amsinckia lycopsoides			0.05						1.15	0.13
Cryptantha pterocarya						0.10		0.05		0.02
Cryptantha circumscissa						0.10		0.10	0.30	0.05
Descurainia pinnata			.1		.15			.7	.2	0.15
Draba verna	2.0	2.75	2.05	2.3	2.55	1.1	2.4	1.2	2.9	2.14
Franseria acanthicarpa								.05		0.05
Gilia sinuata						0.10			0.05	0.02
Holosteum umbellatum	16.6	4.0	13.85	3.65	7.85	4.75	3.5	0.35	3.75	6.48
Layia glandulosa						0.05			0.3	0.04
Mentzelia albicaulis						0.15			0.10	0.03
Microsteris gracilis	0.55	2.2	1.85	.05	1.7	.65	1.5	1.55	0.9	1.22
Phacelia linearis						0.8			0.1	0.1
Plantago pategonica				0.95			2.9		1.95	0.64
Salsola kali	.65	.35	1.4	.7			.7		.4	0.48
Sisymbrium altissimum	0.85	0.4	0.15	0.3			0.1		1.3	0.34
Tragopogon dubius	.3							.05		0.04
Total Annual Forb Cover	20.5	9.7	19.2	7.8	12.2	8.0	11.1	3.8	13.3	11.73
Perennial Forbs										
Achillea millefolium				0.05		1.0		0.15		0.13
Astragalus sclerocarpus								2.0		0.22
Balsamorhiza careyana								4.35		0.48
Brodiaea douglasii							0.05			0.19
Crepis atrabarba							0.55			0.06
Cymopteris terebinthinus	0.15	0.05				3.0				0.36
Oenothera pallida			0.1		0.3				.65	0.08
Phlox longifolia				0.8			0.15			0.14
Rumex venosus	0.5									0.06
Total Perennial Forb Cover	0.60	0.1	1.1	1.2	0.3	4.0	.6	6.40	.6	1.65
TOTAL HERBACEOUS COVER	83.15	85.50	81.1	43.5	55.8	53.5	62.5	55.0	50.7	63.43

TABLE 7-6

MEAN FREQUENCY VALUES (PERCENT) BY SPECIES FOR EACH SAMPLING SITE, 1984

	G01	G02	G03	G04	S01	S02	S03	S04	S05
Annual Grasses									
Bromus tectorum	100	100	100	94	100	98	100	100	100
Festuca octoflora						12		86	
Perennial Grasses									
Agropyron spicatum									2
Poa sandbergii	48	90		88	14	48	100	46	
Stipa comata				76					4
Annual Forbs									
Amsinckia lycopsoides			2						36
Cryptantha circumscissa						4		4	12
Cryptantha pterocarya						2		2	
Descurainia pinnata			4		6	10		28	8
Draba verna	80	100	82	92	72	44	96	48	96
Franseria acanthicarpa								2	
Gilia sinuata						4			2
Holosteum umbellatum	100	80	100	96	86	54	100	14	100
Layia glandulosa						2			12
Mentzelia albicaulis						6			4
Microsteris gracilis	22	88	74	2	68	26	60	62	36
Phacelia linearis						22			4
Plantago pategonica				28			86		48
Salsola kali	26	14	56	28	4	2	28		16
Sisymbrium altissimum	34	16	6	12			4		32
Tragopogon dubius	12							2	
Perennial Forbs									
Achillea millefolium				2		10		6	
Astragalus sclerocarpus								4	
Balsamorhiza careyana								12	
Brodiaea douglasii	2	6	40	16			2	2	
Crepis atrabarba							12		
Cymopteris terebinthinus	6	2				14			
Oenothera pallida			4						26
Phlox longifolia				12	2		6		
Rumex venosus	10								
	11	9	10	12	8	16	11	15	17

TABLE 7-7

ANALYSIS OF VARIANCE FOR HERBACEOUS COVER, 1980 THROUGH 1984

Key Species	Source	d.f[1]	F-Ratio[2]
Bromus tectorum	Site	8;2205	79.62**
	Year	4;2205	105.77**
	Year x Site	32;2205	5.92**
Poa sandbergii	Site	8;2205	105.97**
	Year	4;2205	59.15**
	Year x Site	32;2205	19.21**
Phlox longifolia	Site	8;2205	12.40**
	Year	4;2205	17.26**
	Year x Site	32;2205	5.55**
Descurainia pinnata	Site	8;2205	16.11**
	Year	4;2205	15.16**
	Year x Site	32;2205	5.40**
Sisymbrium altissimum	Site	8;2205	18.45**
	Year	4;2205	12.76**
	Year x Site	32;2205	3.48**

[1] Degrees of freedom (d.f.): first value is numerator d.f. and second value is denominator d.f.

[2] *denotes significant difference at $\alpha = 0.05$ level
**denotes significant difference at $\alpha = 0.01$ level
ns denotes no significant difference at $\alpha = 0.05$ level

TABLE 7-8

ANALYSIS OF HERBACEOUS COVER: COMPARISONS AMONG SITES

Key Species	Years	SNK Multiple Comparison Test[1]								
Bromus tectorum	1980	G04	S03	S04	S01	S02	S05	G01	G03	G02
	1981	S04	G03	S02	S03	S05	S01	G01	G02	G03
	1982	S05	G04	S02	S04	S03	G01	G02	G03	S01
	1983	G04	S05	S03	S04	S02	G02	G01	S01	G03
	1984	G04	S02	S04	S05	S03	S01	G01	G03	G02
Poa sandbergii	1980	S05	G03	S01	S02	S04	G04	S03	G01	G02
	1981	S05	G03	S01	S02	S04	S03	G04	G01	G02
	1982	S05	S01	G03	S04	S02	G01	G02	G04	G03
	1983	G03	S05	G01	S01	S04	S02	G04	S03	G02
	1984	G03	S05	G01	S01	G02	S02	G04	S03	G04
Phlox longifolia	1980	G01	G02	G03	S02	S04	G05	S01	S03	G04
	1981	G02	G02	G03	S01	S02	S05	S04	S03	[illegible]
	1982	G01	G02	G03	S01	S02	S04	S05	S03	G04
	1983	G01	G02	G03	S01	S04	S05	S02	G04	S03
	1984	G01	G02	G03	S02	S04	S05	S03	S01	G04
Descurainia pinnata	1980	G01	G02	S03	G03	G04	S05	S04	S02	S01
	1981	G01	G02	S05	G04	S03	G03	S02	S01	S04
	1982	G01	G02	S01	S03	G04	S02	G03	S04	S05
	1983	G01	G02	G04	S03	G03	S01	S04	S05	S02
	1984	G01	G02	G04	S03	G03	S01	S05	S02	S04
Sisymbrium altissimum	1980	G02	S01	S02	S04	G03	S03	G01	G04	S05
	1981	S02	S04	S01	G02	G03	G04	S03	G01	S05
	1982	S03	S04	G02	G03	S01	G04	S02	G01	S05
	1983	S01	S02	S04	G01	G02	G03	G04	S03	S05
	1984	S01	S02	S04	S03	G03	G04	G02	G01	S05

[1] Sites are listed in ascending order of mean cover for each year and sites not significantly different at the α 0.05 level are underlined.

TABLE 7-9

ANALYSIS OF HERBACEOUS COVER: TESTS FOR DIFFERENCES AMONG YEARS AT EACH SITE AND MULTIPLE COMPARISONS AMONG YEARS AT SITES HAVING SIGNIFICANT YEAR DIFFERENCES

Key Species	Site	d.f.[1]	F-Ratio[2]	SNK Multiple Comparison Test[3]				
Bromus tectorum	G01	4;245	17.65**	1982	1983	1984	1980	1981
	G02	4;245	57.64**	1983	1982	1984	1980	1981
	G03	4;245	19.76**	1982	1984	1983	1980	1981
	G04	4;245	19.98**	1984	1980	1983	1982	1981
	S01	4;245	11.13**	1984	1980	1982	1983	1981
	S02	4;245	9.19**	1982	1984	1983	1980	1981
	S03	4;245	14.43**	1980	1983	1982	1984	1981
	S04	4;245	1.82NS					
	S05	4;245	31.27**	1982	1983	1984	1982	1981
Poa sandbergii	G01	4;245	23.92**	1984	1983	1982	1981	1980
	G02	4;245	97.22**	1984	1982	1983	1981	1980
	G03	4;245	1.35NS					
	G04	4;245	4.50**	1983	1984	1982	1981	1980
	S01	4;245	1.96NS					
	S02	4;245	1.6 NS					
	S03	4;245	4.08*	1984	1981	1983	1982	1980
	S04	4;245	1.05NS					
	S05	4;245	0.0 NS					
Phlox longifolia	G01	4;245	0.0 NS					
	G02	4;245	0.0 NS					
	G03	4;245	0.0 NS					
	G04	4;245	6.70**	1982	1983	1981	1984	1980

TABLE 7-9 (Continued)

Key Species	Site	d.f.[1]	F-Ratio[2]	SNK Multiple Comparison Test[3]				
Phlox longifolia	S01	4;245	2.11NS					
	S02	4;245	3.13*	1980	1981	1982	1984	1983
	S03	4;245	10.26**	1982	1984	1981	1983	1980
	S04	4;245	2.04NS					
	S05	4;245	0.0 NS					
Descurainia pinnata	G01	4;245	0.0 NS					
	G02	4;245	1.0 NS					
	G03	4;245	.64NS					
	G04	4;245	.50NS					
	S01	4;245	8.71**	1982	1984	1981	1983	1980
	S02	4;245	7.64**	1982	1981	1984	1980	1983
	S03	4;245	0.50NS					
	S04	4;245	3.04*	1981	1984	1982	1980	1983
	S05	4;245	3.48*	1981	1984	1980	1982	1983
Sisymbrium altisimum	G01	4;245	9.75**	1983	1982	1984	1980	19[illegible]
	G02	4;245	4.61**	1980	1982	1983	1984	1981
	G03	4;245	1.68NS					
	G04	4;245	4.19**	1982	1983	1984	1980	1981
	S01	4;245	0.92NS					
	S02	4;245	0.93NS					
	S03	4;245	5.92**	1982	1984	1983	1980	1981
	S04	4;245	6.68**	1981	1982	1983	1984	1980
	S05	4;245	4.48*	1983	1984	1980	1981	1982

[1]Degrees of freedom (d.f.): First value is numerator d.f. and second value is denominator d.f.

[2] *denotes significant difference at $\alpha = 0.05$ level
**denotes significant difference at $\alpha = 0.01$ level
NS denotes no significant difference at $\alpha = 0.05$ level

[3]Comparison for sites with significant interaction among years only.

TABLE 7-10

ANALYSIS OF HERBACEOUS PHYTOMASS: TWO-WAY ANALYSIS OF VARIANCE AND TESTS FOR DIFFERENCES AMONG YEARS AT EACH SITE AND MULTIPLE COMPARISONS AMONG YEARS AT SITES HAVING SIGNIFICANT YEAR DIFFERENCES

ANALYSIS OF VARIANCE (ANOVA)

Source	d.f.[1]	F-Ratio[2]
Site	8;180	3.1**
Year	4;180	7.90**
Site x Year	32;180	2.65**

Site	d.f.	F-Ratio	SNK Multiple Comparison Test				
G01	4;20	4.97*	1983	1982	1984	1980	1981
G02	4;20	8.98**	1982	1980	1984	1983	1981
G03	4;20	6.72**	1980	1982	1983	1984	1981
G04	4;20	1.39NS					
S01	4:20	1.58NS					
S02	4;20	3.06NS	1982	1984	1980	1981	1983
S03	4;20	2.73*					
S04	4;20	.77NS					
S05	4;20	2.20NS					

[1] Degrees of freedom (d.f.): first value is numerator d.f. and second value is denominator d.f.

[2] *Denotes significant difference at $\alpha = 0.05$ level
**Denotes significant difference at $\alpha = 0.01$ level
NS Denotes no significant difference at $\alpha = 0.05$ level

TABLE 7-11

ANALYSIS OF HERBACEOUS WEIGHT: COMPARISONS AMONG SITES

Year	SNK Multiple Comparison Test[1]								
1980	S01	S03	G03	S02	G02	S05	S04	G04	G01
1981	S03	S04	S05	S02	G04	S01	G01	G02	G03
1982	S03	S02	S04	G02	G03	G01	S01	G04	S05
1983	S03	G03	S04	G01	G04	S05	G02	S01	S02
1984	S05	S02	G04	S04	G01	S03	S01	G02	G03

[1]Sites are listed in ascending order of mean herbaceous weight and sites not significantly different at the α 0.05 level are underlined.

TABLE 7-12

COMPARISON OF HERBACEOUS PHYTOMASS, 1975 THROUGH 1984

Mean Dry Weight (g/m^2)

Site	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G01	359	108	21	166	64	160	200	90	77	94
G02	302	258	11	162	37	68	255	60	137	116
G03	-	-	-	-	-	53	261	62	64	133
G04	-	-	-	-	-	79	159	113	82	67
S01	126	137	4	173	21	36	180	98	171	104
S02	144	98	7	128	28	63	115	24	232	57
S03	88	177	7	115	16	43	31	22	54	95
S04	-	-	-	-	-	78	52	39	68	93
S05	-	-	-	-	-	71	81	184	136	43

TABLE 7-13

SUMMARY OF SHRUB COVER (5) AT FIVE STUDY SITES, 1984

SHRUBS	S01	S02	S03	S04	S05	$\bar{X}$
Artemisia tridentata	3.79	-	5.62	16.58	-	5.20
Chrysothamnus nauseosus	-	0.45	1.05	-	-	0.30
Chrysothamnus viscidiflorus	-	1.45	-	0.29	0.19	0.39
Purshia tridentata	8.96	19.92	-	-	-	5.78
TOTAL SHRUB COVER	12.75	21.82	6.67	16.87	0.19	11.67
SUBSHRUB						
Eriogonum niveum	4.51	-	0.02	-	0.47	1.00
CACTUS						
Opuntia polyacantha	-	-	-	-	0.95	0.19
TOTAL COVER	17.26	21.82	6.69	16.87	1.61	12.86

TABLE 7-14

ANALYSIS OF VARIANCE FOR SHRUB COVER, 1980 THROUGH 1984

Key Species	Source	d.f.[1]	F-Ratio[2]
Artemisia tridentata	Site	4;100	63.65**
	Year	4;100	20.06**
	Year x Site	16;100	7.26**
Purshia tridentata	Site	4;100	175.11**
	Year	4;100	48.40**
	Year x Site	16;100	25.81**
Chrysothamnus nauseosus	Site	4;100	7.24**
	Year	4;100	2.02 ns
	Year x Site	16;100	1.25 ns
Chrysothamnus viscidiflorus	Site	4;100	7.14**
	Year	4;100	1.80 ns
	Year x Site	16;100	0.78 ns

[1]Degrees of freedom (d.f.): first value is numerator d.f. and second value is denominator d.f.

[2] *denotes significant difference at α 0.05 level
**denotes significant difference at α 0.01 level
ns denotes no significant difference at α 0.05 level

TABLE 7-15

ANALYSIS OF SHRUB COVER: TESTS FOR DIFFERENCES AMONG YEARS AT EACH SITE AND MULTIPLE COMPARISONS AMONG YEARS AT SITES HAVING SIGNIFICANT YEAR DIFFERENCES

Key Species	Site	d.f.[1]	F-Ratio[2]	SNK Multiple Comparison Test				
Artemisia tridentata	S01	4;16	6.95**	1982	1980	1981	1984	1983
	S02	4;16	0.0 NS					
	S03	4;16	0.35 NS					
	S04	4;16	24.36**	1982	1981	1980	1984	1983
	S05	4;16	NS					
Purshia tridentata	S01	4;16	15.96**	1981	1980	1982	1983	1984
	S02	4;16	37.28**	1981	1982	1980	1983	1984
	S03	4;16	0.0 NS					
	S04	4;16	0.0 NS					
	S05	4;16	3.87*	1982	1983	1984	1981	1980

Chrysothamnus nauseosus — No significant year effect for any station

Chrysothamnus viscidiflorus — No significant year effect for any station

[1] Degrees of freedom (d.f.): first value is numerator d.f. and second value is denominator d.f.

[2] *denotes significant difference at α 0.05 level
**denotes significant difference at α 0.01 level
ns denotes no significant difference at α 0.05 level

TABLE 7-16

ANALYSIS OF SHRUB COVER: COMPARISONS AMONG SITES

Key Species	Years	SNK Multiple Comparison Test[1]				
Artemisia tridentata	1980	S02	S05	S01	S03	S04
	1981	S02	S05	S03	S01	S04
	1982	S02	S05	S01	S03	S04
	1983	S02	S05	S01	S03	S04
	1984	S02	S05	S01	S03	S04
Purshia tridentata	1980	S03	S04	S05	S01	S02
	1981	S03	S04	S05	S01	S02
	1982	S03	S04	S05	S01	S02
	1983	S03	S04	S05	S01	S02
	1984	S03	S04	S05	S01	S02
Chrysothamnus nauseosus	1980-1982	S01	S04	S02	S05	S03
	1983	S01	S04	S02	S05	S03
	1984	S01	S04	S05	S02	S03
Chrysothamnus viscidiflorus	1980-1982	S03	S01	S05	S04	S02
	1983	S03	S01	S05	S04	S02
	1984	S01	S03	S05	S04	S02

[1]Sites are listed in ascending order of mean cover and sites not significantly different at the α 0.05 level are underlined.

TABLE 7-17

1984 SOIL CHEMISTRY

	G01	G02	G03	G04	S01	S02	S03	S04	S05
pH (1:2 soil to water)	7.47	7.30	7.36	7.20	6.82	8.04	7.30	6.43	6.95
Conductivity (1:2 soil to water) umhos/cm	25	31	34	29	22	40	26	25	30
Sulfate ug/gm	3	3	7	4.25	1	1.5	5.5	0	5
Chloride ug/gm	6	7	6.2	6.1	5.8	7.5	6.2	4.6	8.6
Copper ug/gm	10.4	11.1	9.5	8.7	10	8	9.5	10.9	9.5
Lead ug/gm	2.9	2.5	2.4	2.3	2.3	1.6	2.6	2.7	3.3
Cadmium ug/gm	0.07	0.06	0.06	0.07	0.05	0.03	0.11	0.05	0.06
Chromium ug/gm	7.9	8.1	5.8	4.6	5.8	6.8	5.4	6.6	6
Nickel ug/gm	11.6	10.8	10.6	7.9	9.7	12.3	9.9	9.9	9.7
Zinc ug/gm	42.9	45.1	41	39.5	42.8	25.6	41.6	41	42.7
Sodium %	0.033	0.031	0.033	0.031	0.032	0.026	0.044	0.034	0.032
Potassium %	0.24	0.24	0.16	0.13	0.17	0.08	0.16	0.18	0.15
Calcium %	0.23	0.23	0.26	0.25	0.26	0.38	0.27	0.27	0.27
Mercury ug/gm	0.008	0.007	0.007	0.004	0.007	0.002	0.005	0.009	0.007
Fluoride ug/gm	271	278	239	268	297	229	301	271	196
Bicarbonate (meq HCO_3 /gm)	0.00085	0.00021	0.00035	0.00034	0.0009	0.00057	0.00055	0.0003	0.00038
Magnesium %	0.48	0.47	0.42	0.40	0.45	0.39	0.41	0.45	0.41

TABLE 7-18

1984 VEGETATION CHEMISTRY

	Site	POSA*	BRTE*	SIAL*	PHLO*	PUTR*	ARTR*
Copper (g/g)	G01	3.6	6.2	2.8	7.0		
	G02	4.2	5.9	7.3	4.0		
	G03	6.9	7.1	6.7	6.8		
	G04	8.9	6.0	6.7	7.8		
	S01	2.5	4.3			4.2	6.9
	S02	4.3	4.1		5.5	4.7	
	S03	3.2	4.1		4.9		10.3
	S04	3.4	3.4		4.4		10.9
	S05	3.5	3.8			4.3	6.8
Extractable Sulfate (%)	G01	0.045	0.051	0.725	0.040		
	G02	0.032	0.044	0.974	0.032		
	G03	0.033	0.052	0.646	0.030		
	G04	0.096	0.032	(0.489)	0.034		
	S01	0.026	0.032			0.019	0.037
	S02	0.026	0.026		0.049	0.061	
	S03	0.018	0.028		0.024		0.029
	S04	0.048	0.034		(.019)		0.018
	S05	0.038	0.043			0.028	0.042
Extractable Chloride (%)	G01	0.2	0.13	0.32	0.16		
	G02	0.1	0.24	0.5	0.17		
	G03	0.18	0.28	0.4	0.14		
	G04	0.14	0.16	(.29)	0.13		
	S01	0.15	0.16			0.07	0.35
	S02	0.18	0.09		0.14	0.12	
	S03	0.17	0.18		0.17		0.3
	S04	0.15	0.15		(.15)		0.4
	S05	0.17	0.22			0.1	0.26

*POSA = *Poa Sandbergii*
BRTE = *Bromus tectorum*
SIAL = *Sisymbrium altissium*
PHLO = *Phlox longifolia*
PUTR = *Purshia tridentata*
ARTR = *Artemisia tridentata*

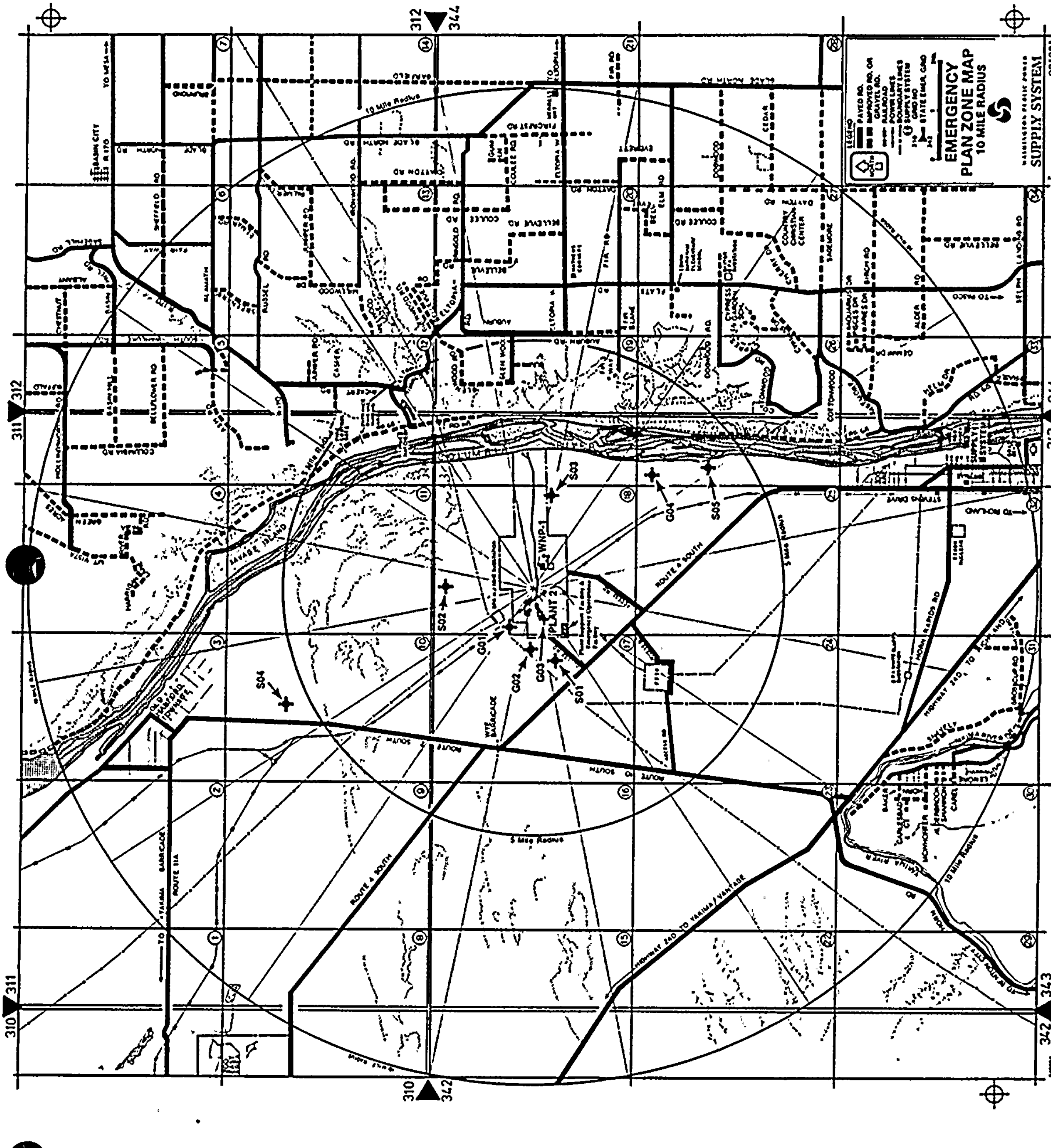


FIGURE 7-1
Location Map

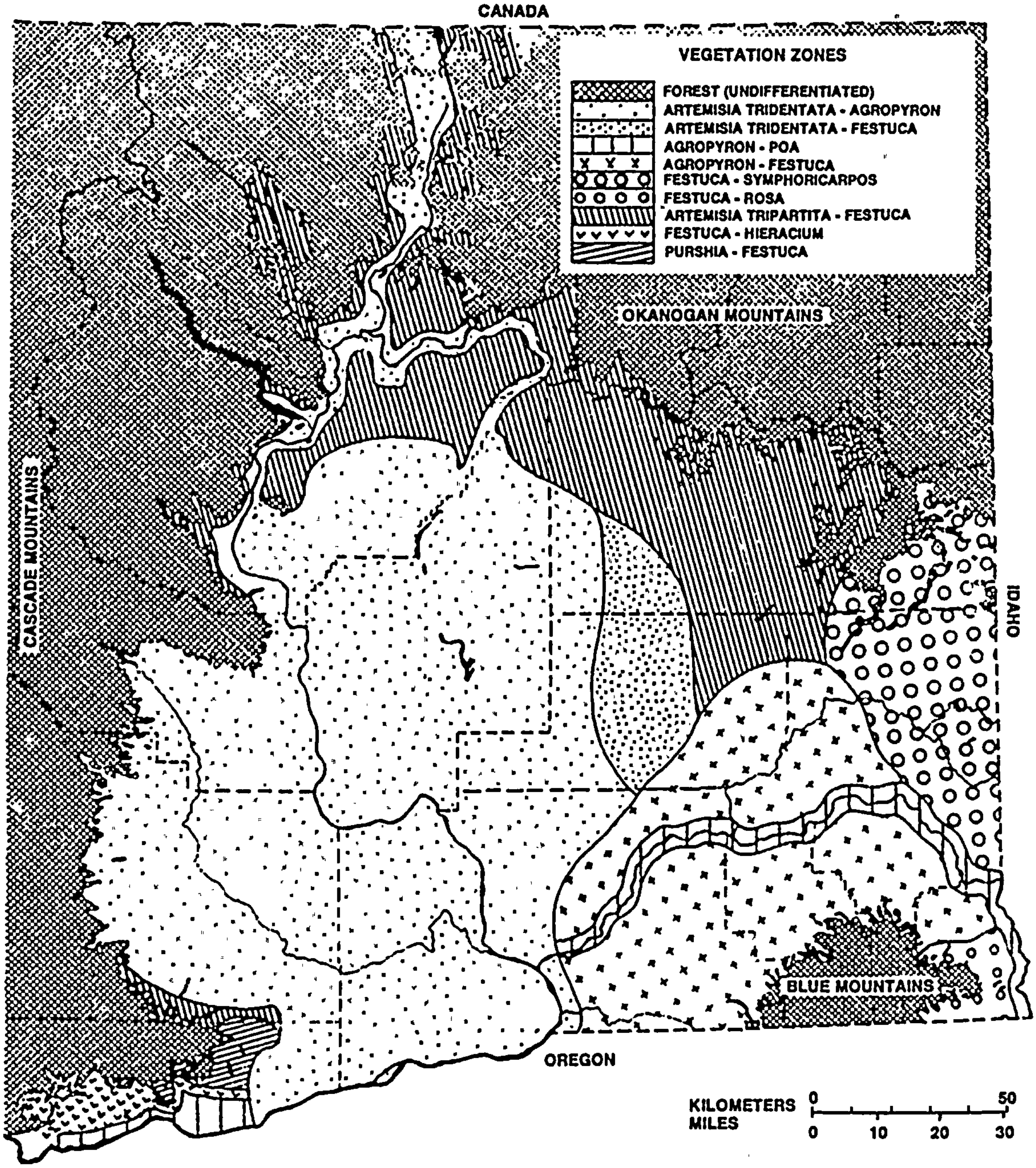


FIGURE 7-2

Columbia Basin Floristic Zones

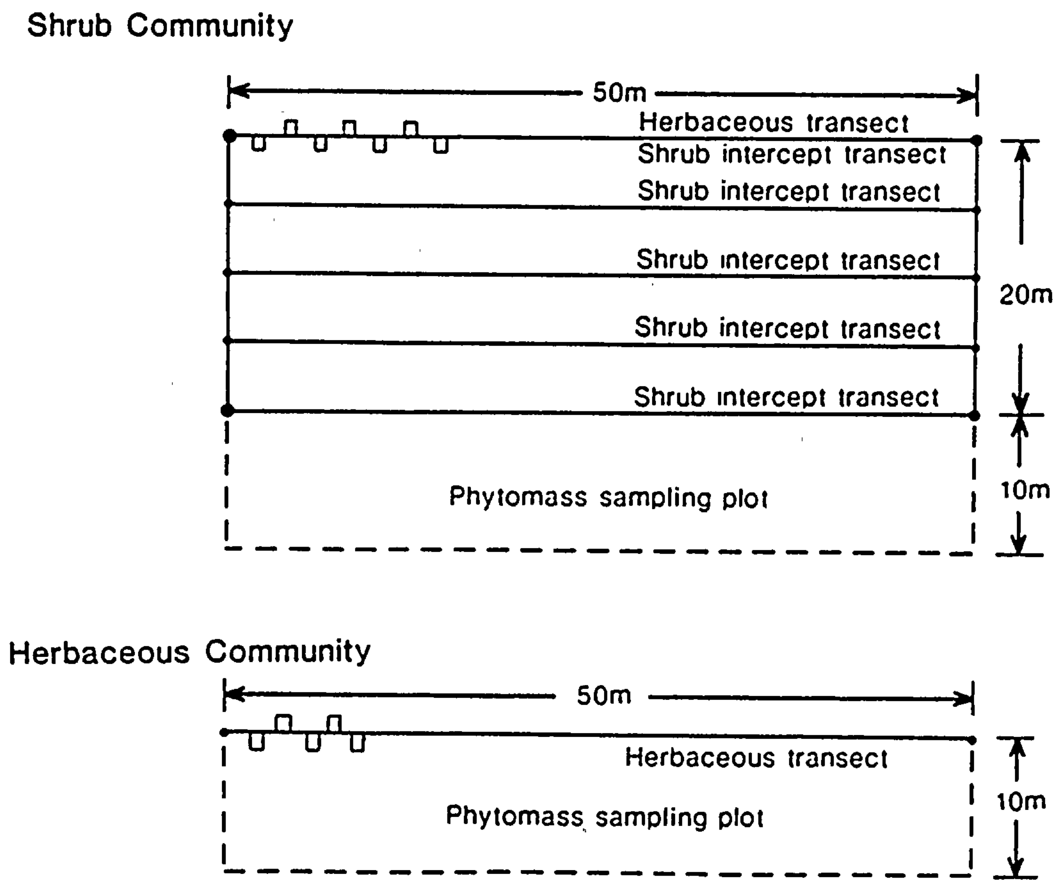


FIGURE 7-3

SITE LAYOUT

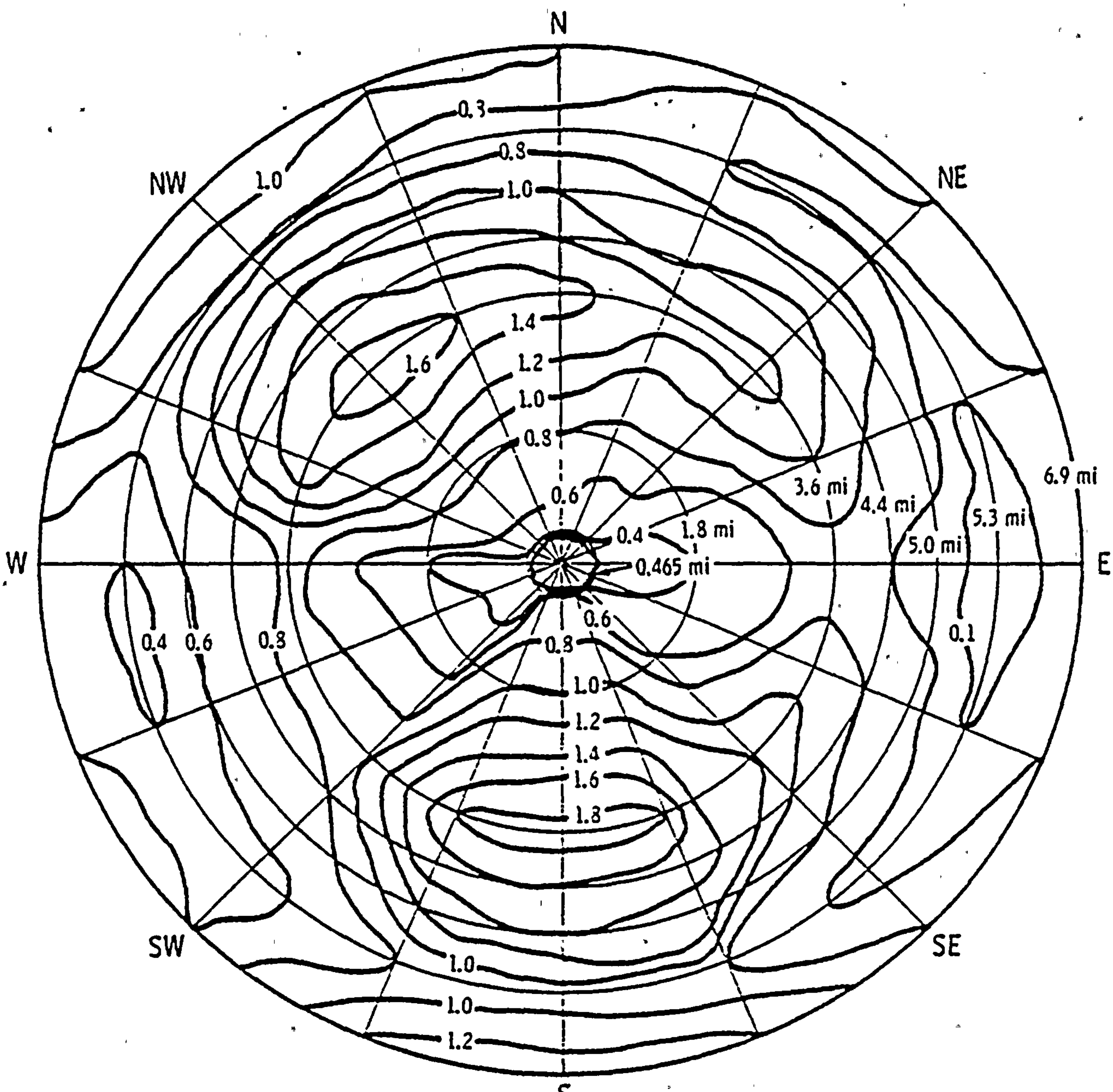


FIGURE 7-4

Isopleth of Salt Deposition (lbs/acre/year).

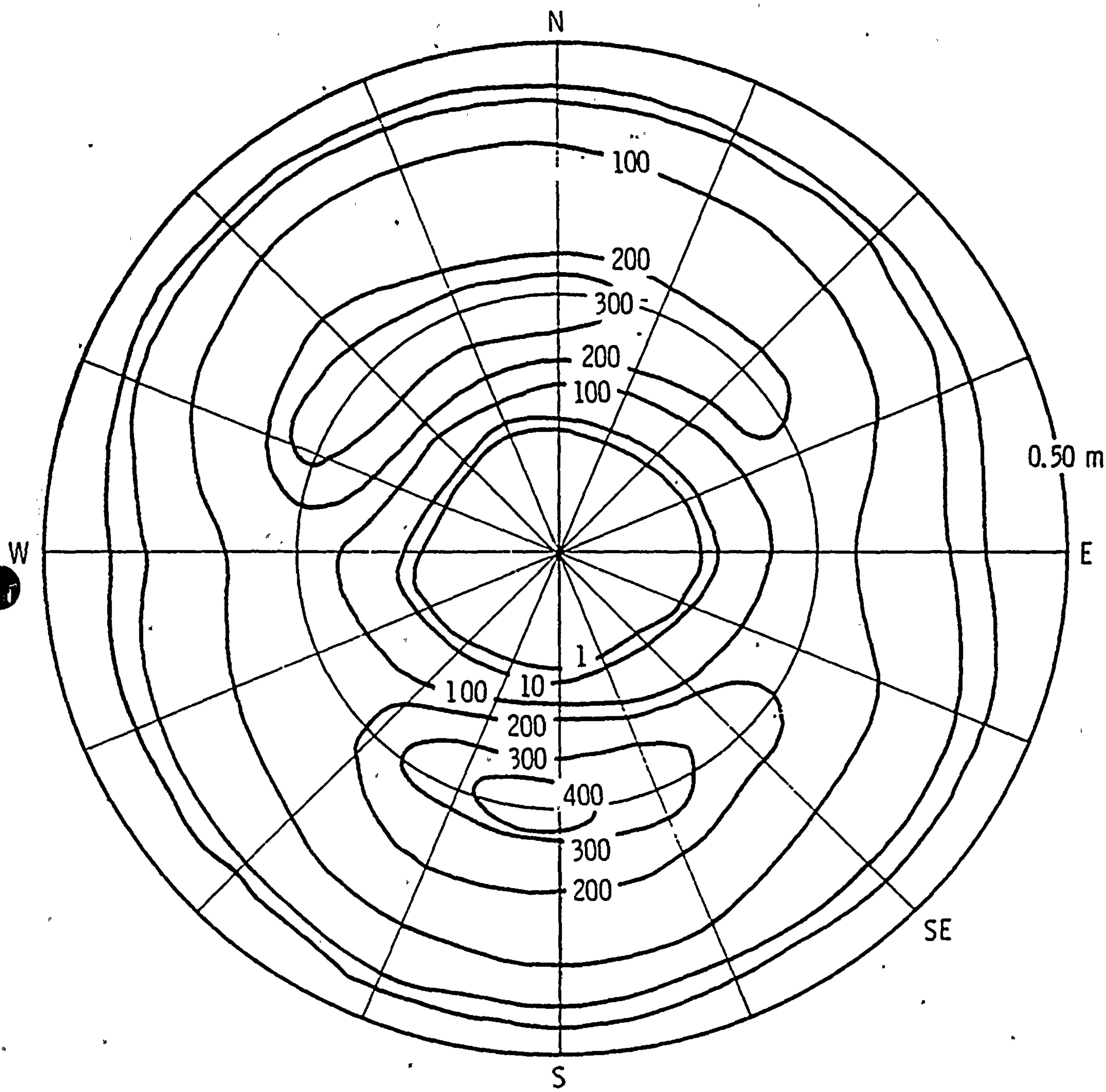


FIGURE 7-5

Isopleth of Salt Deposition

FIGURE 7-6

MEAN HERBACEOUS COVER 1975 THROUGH 1977

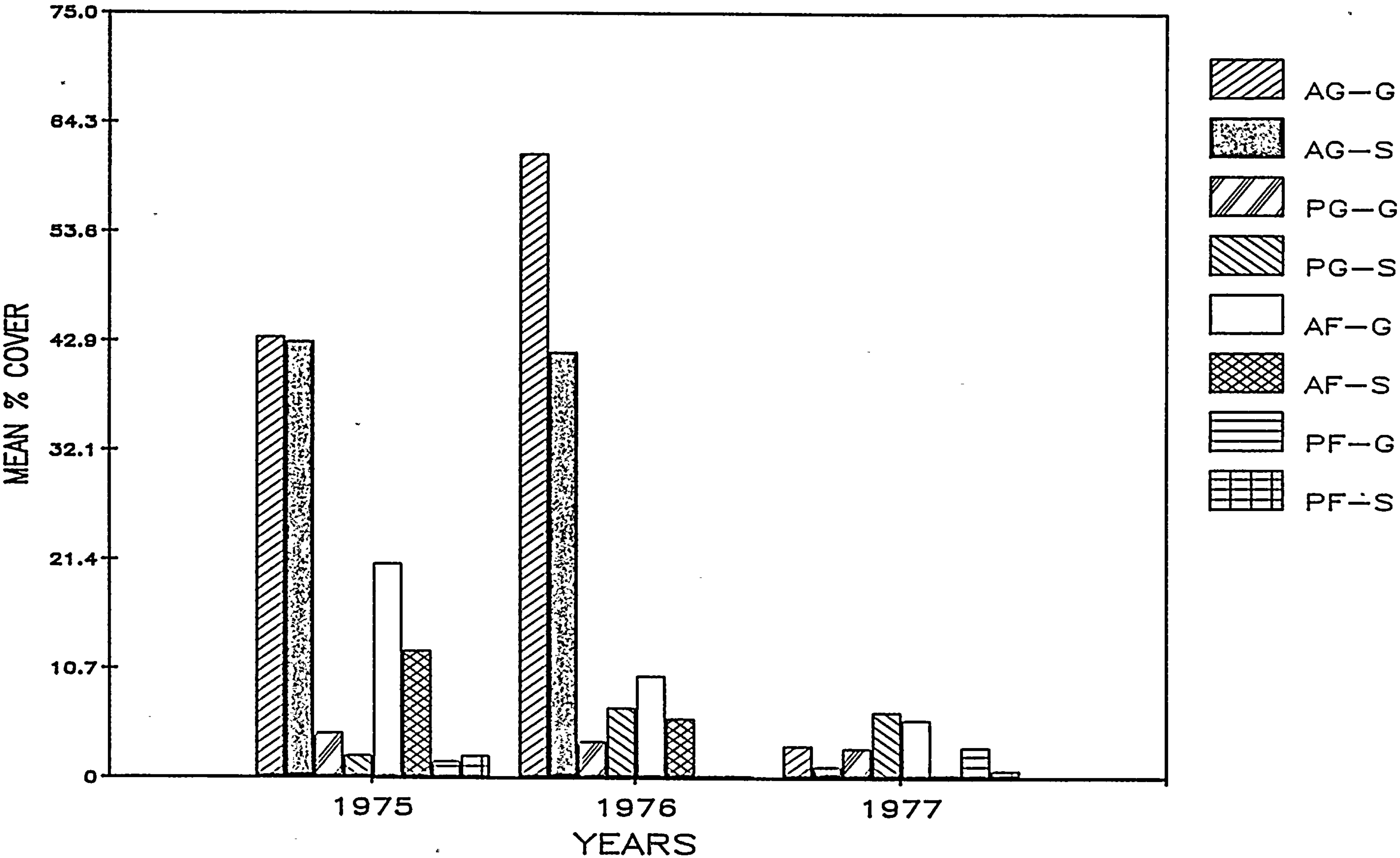


FIGURE 7-7

MEAN HERBACEOUS COVER 1978 THROUGH 1980

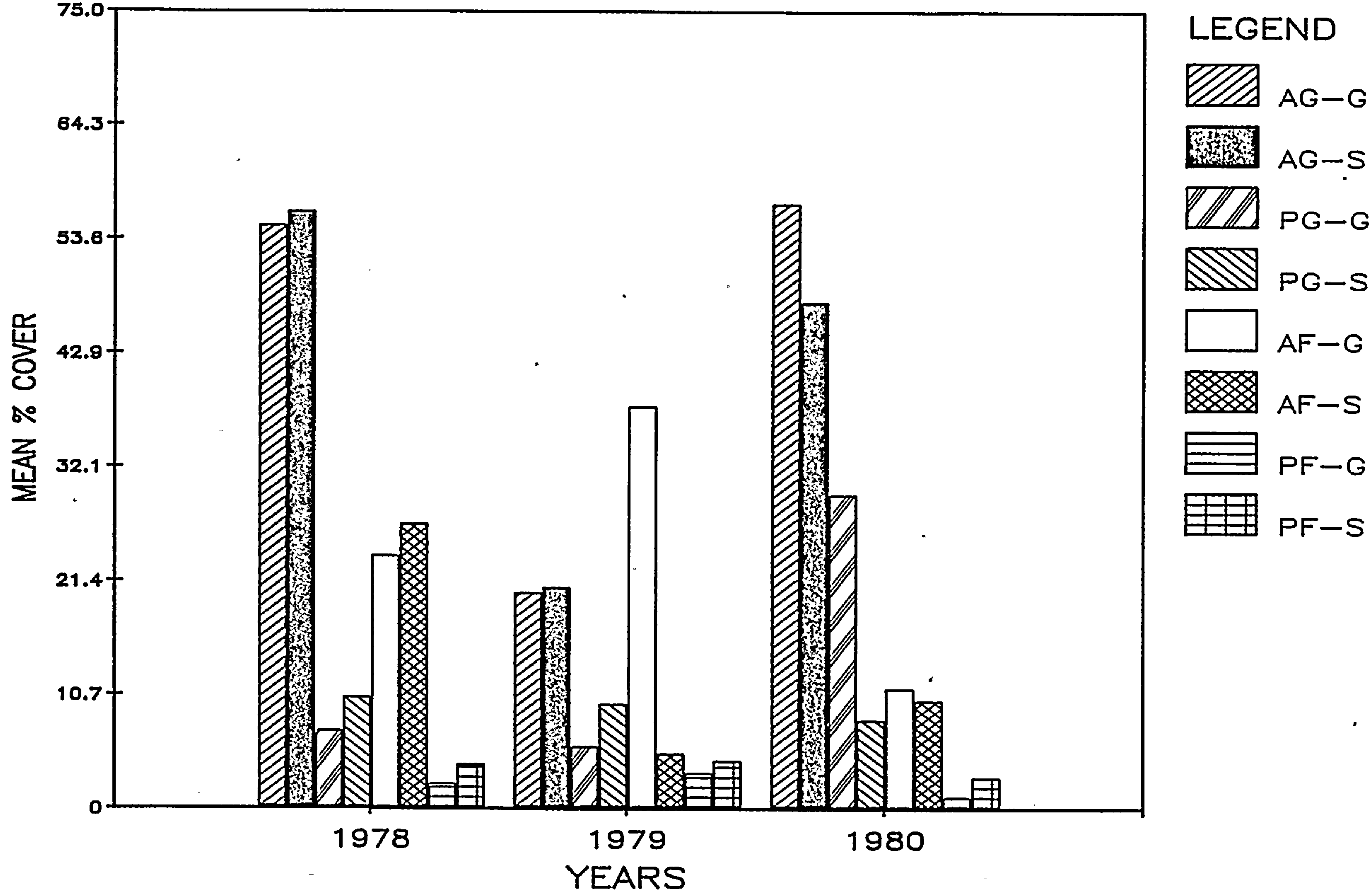


FIGURE 7-8

MEAN HERBACEOUS COVER 1981 THROUGH 1984

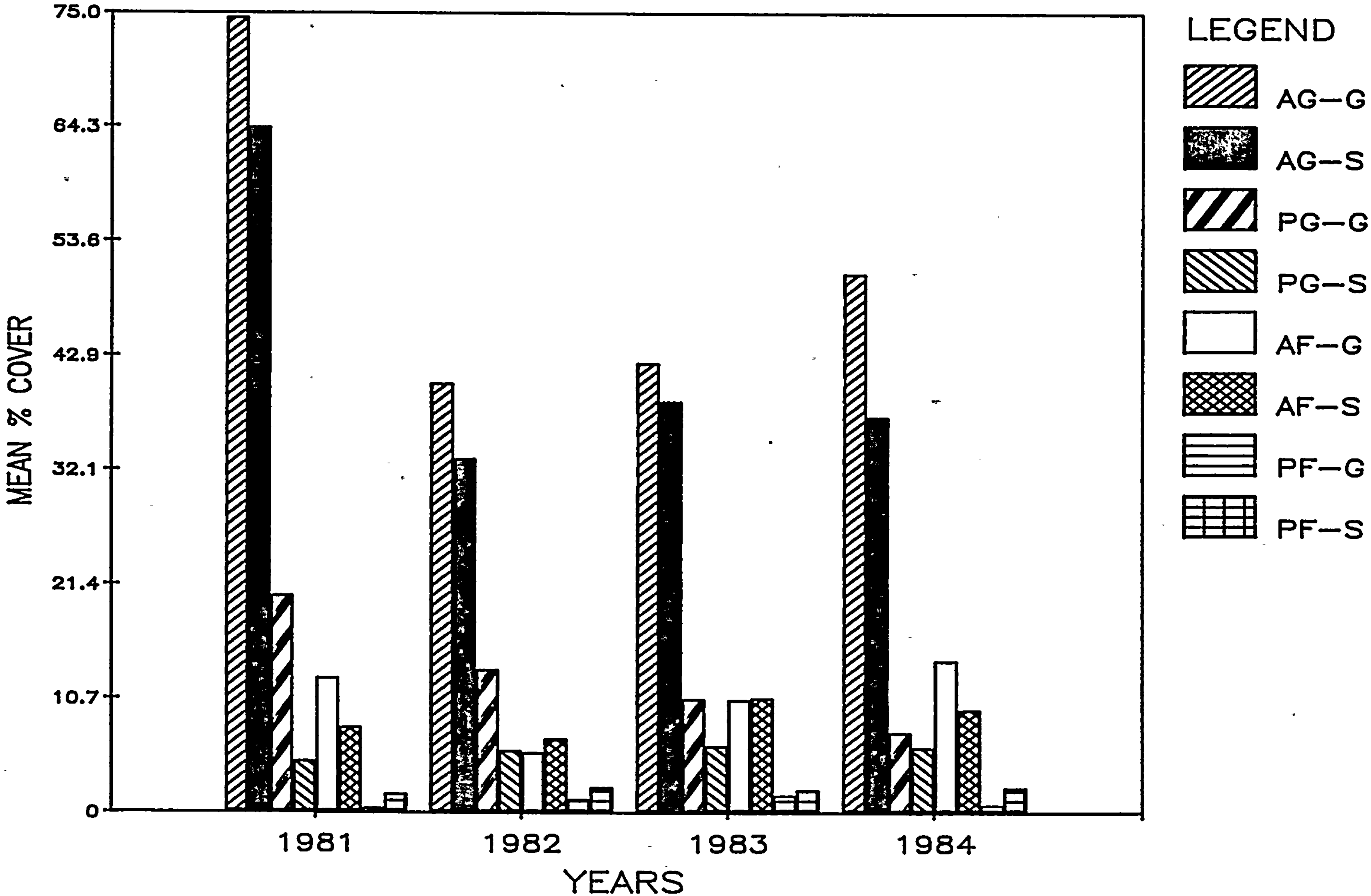


FIGURE 7-9

MEAN HERBACEOUS COVER GRASSLAND AND SHRUB SITES 1975 THROUGH 1984

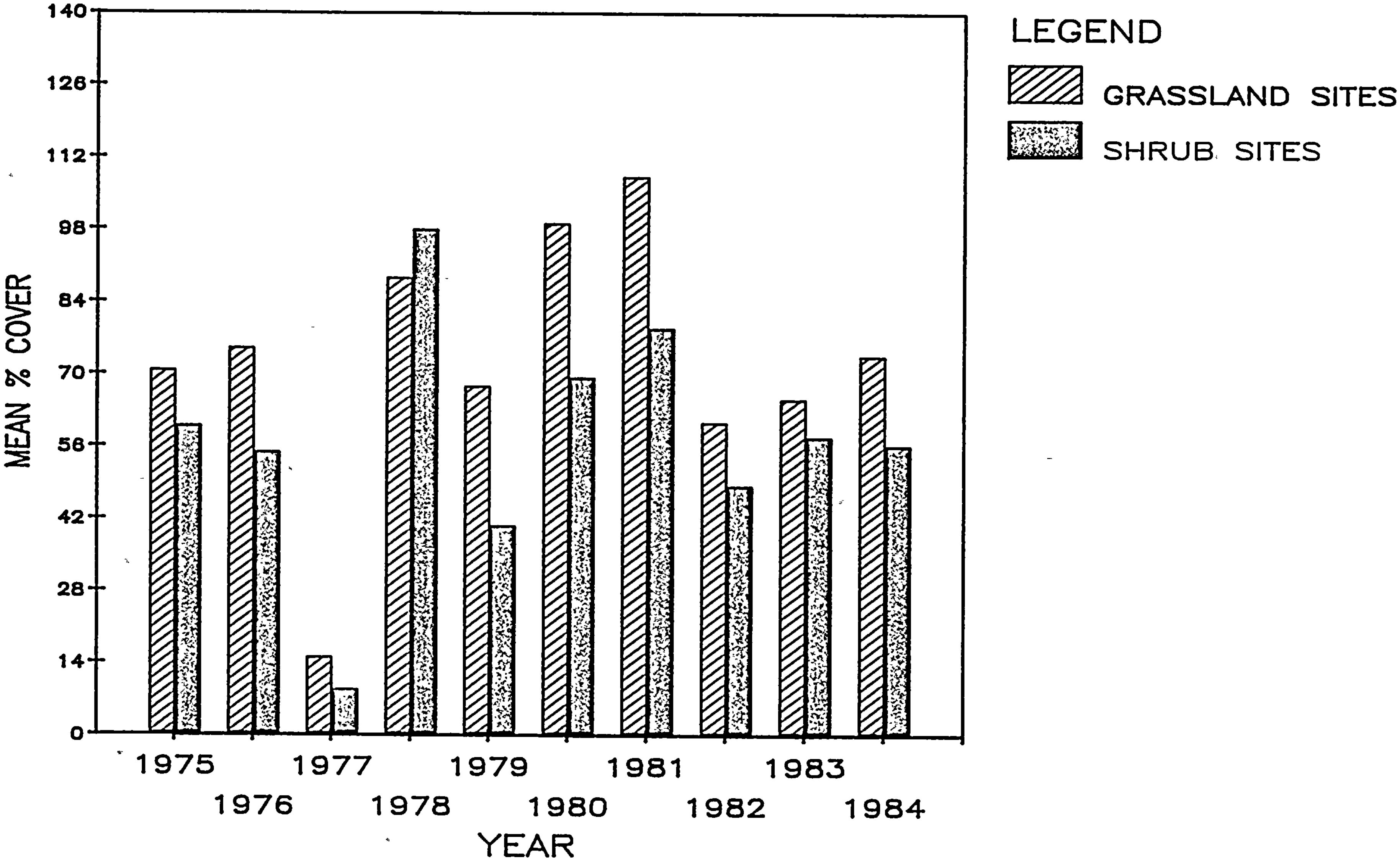


FIGURE 7-10

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1975 THROUGH 1984 SAMPLING SITE G01

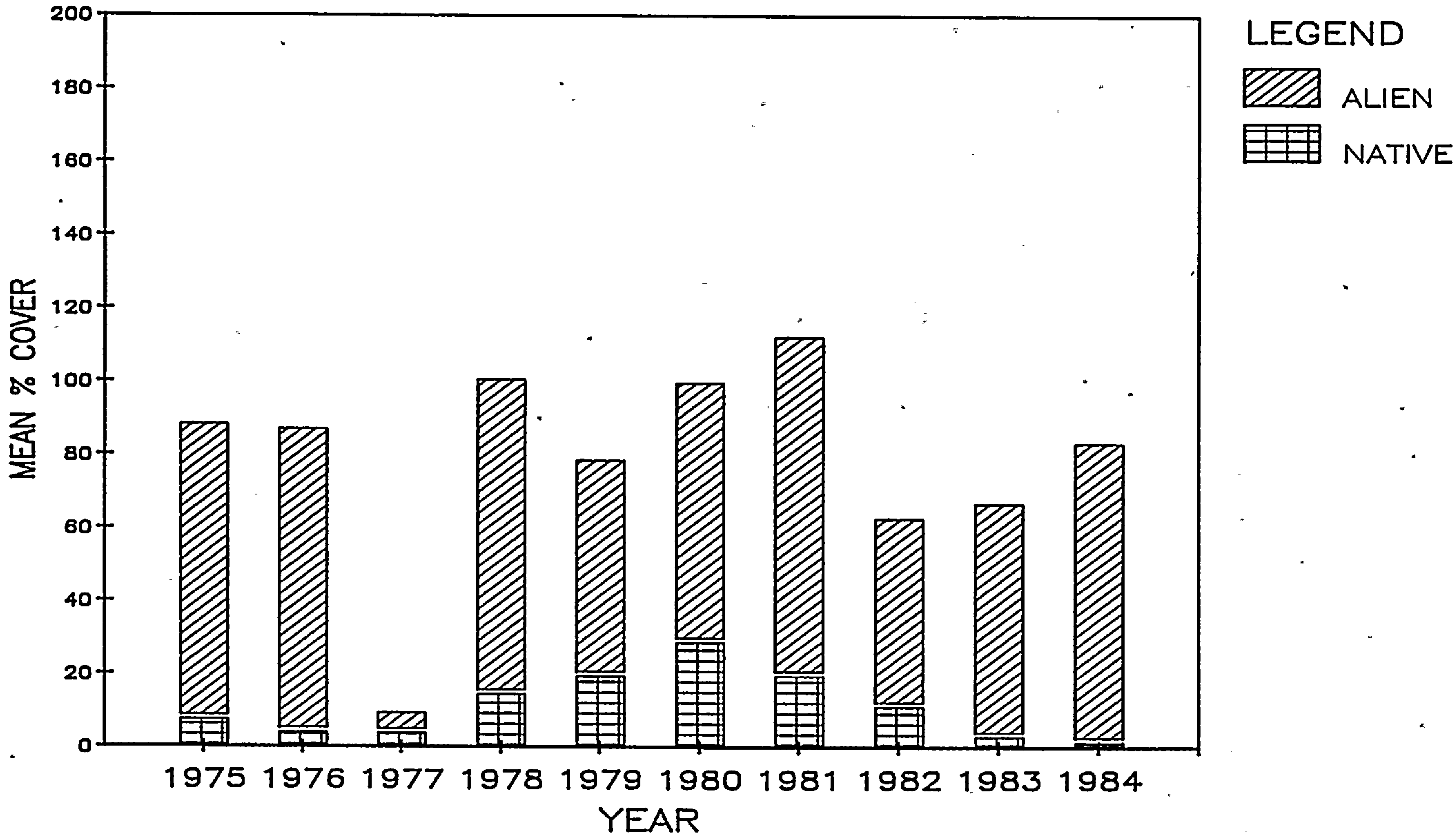


FIGURE 7-11

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1975 THROUGH 1984 SAMPLING SITE G02

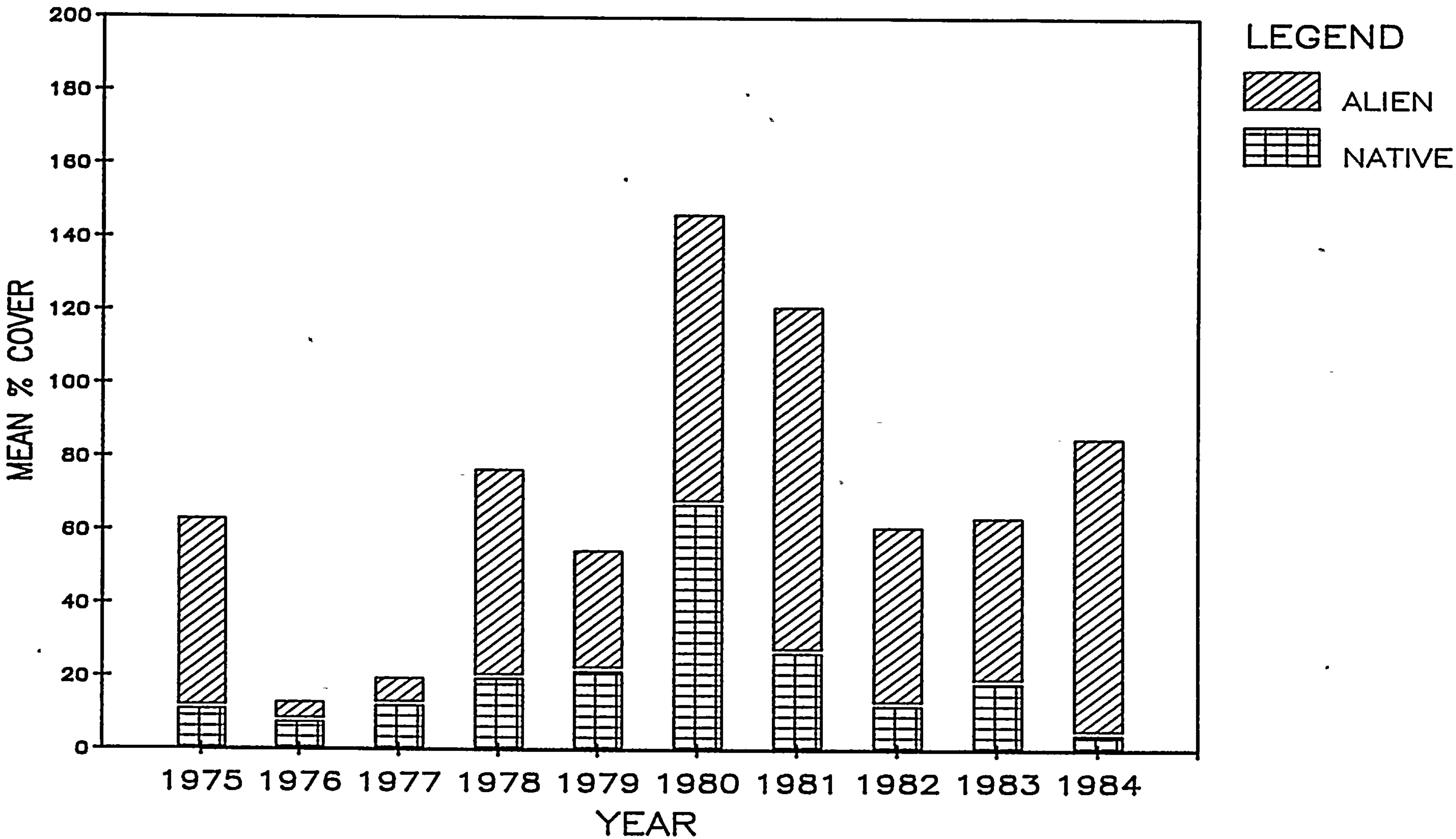


FIGURE 7-12

MEAN HERBACEOUIS COVER ALIEN AND NATIVE SPECIES 1980 THROUGH 1984 SAMPLING SITE G03

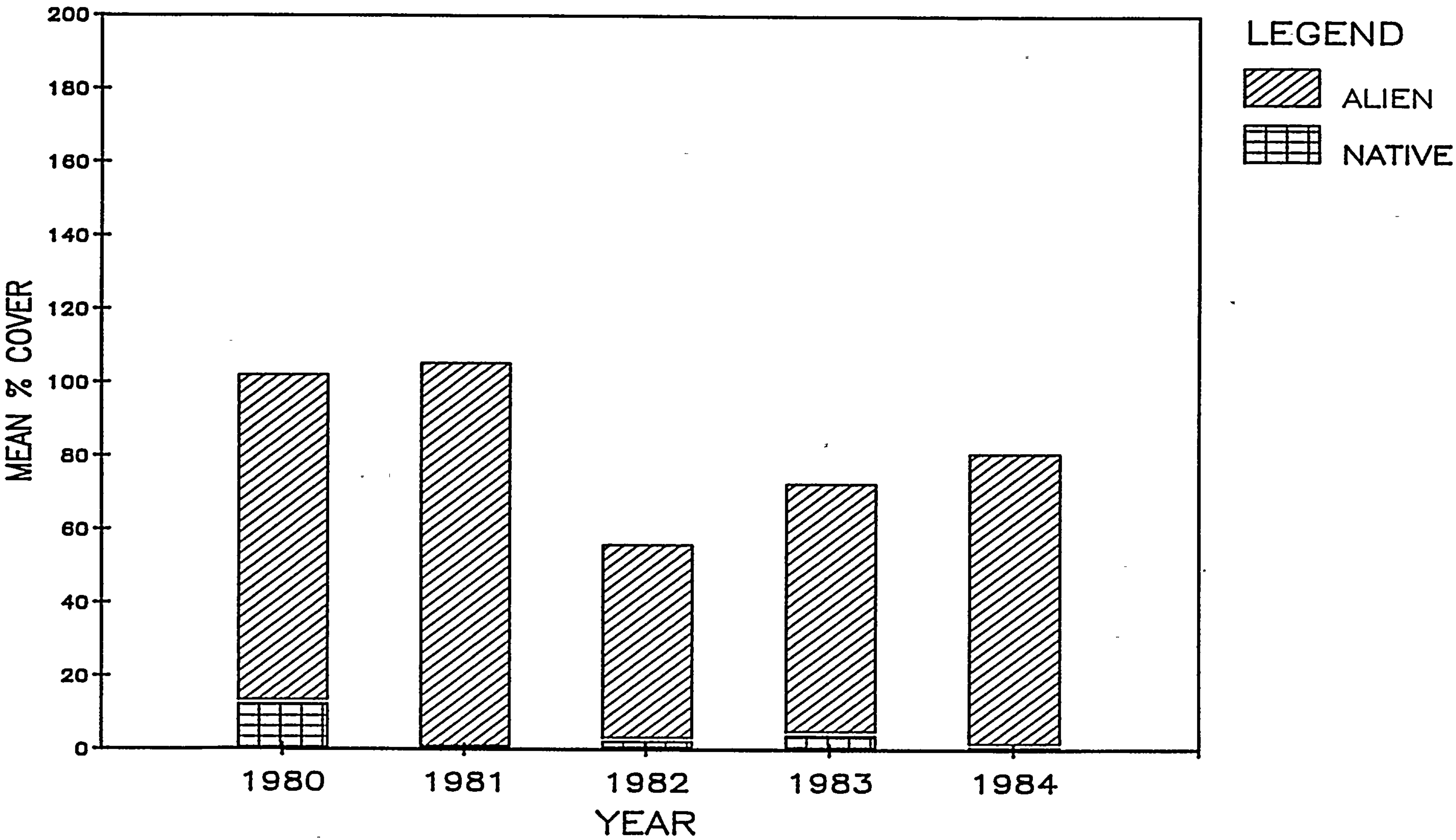


FIGURE 7-13

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1980 THROUGH 1984 SAMPLING SITE G04

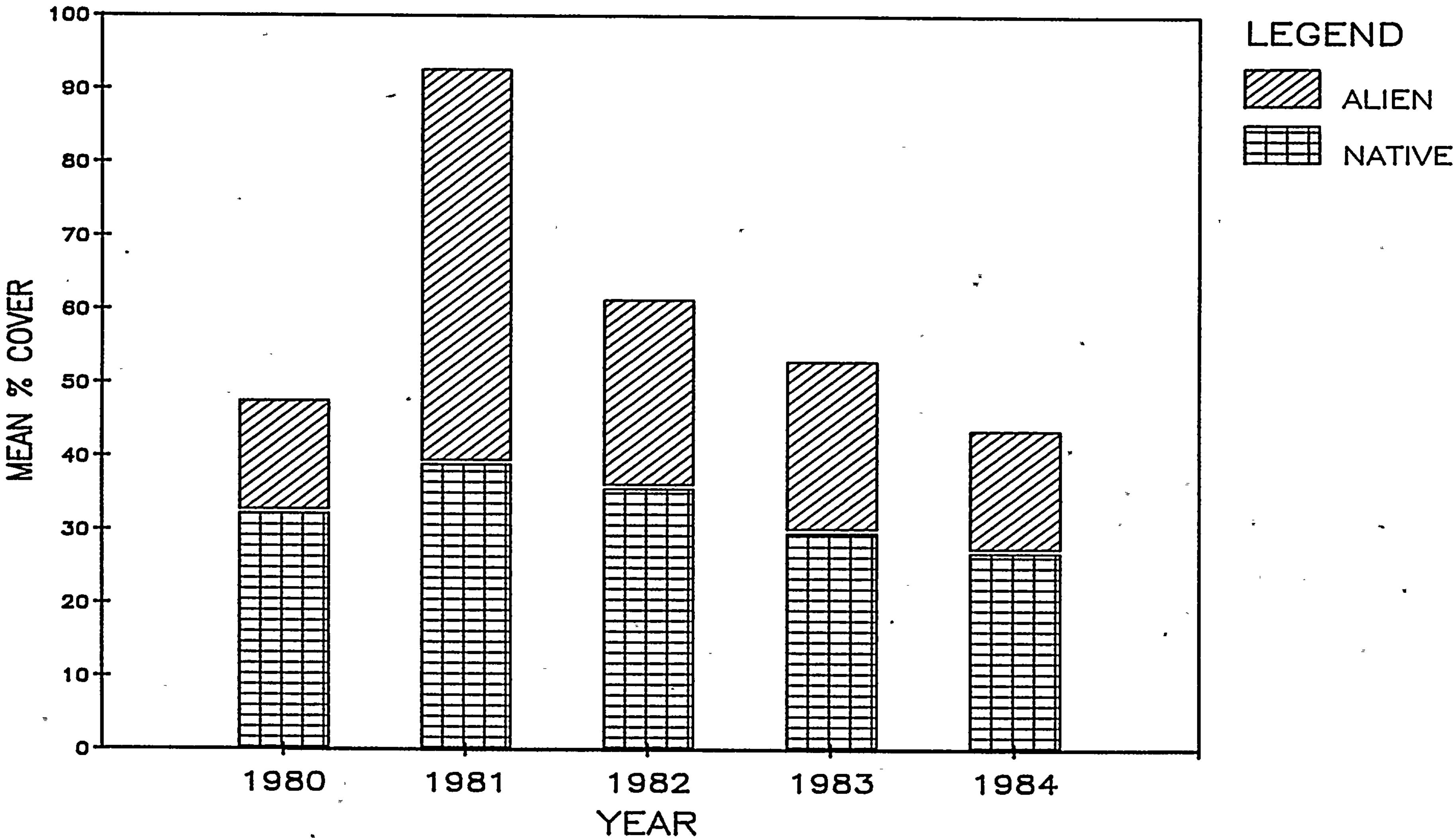


FIGURE 7-14

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1975 THROUGH 1984 SAMPLING SITE S01

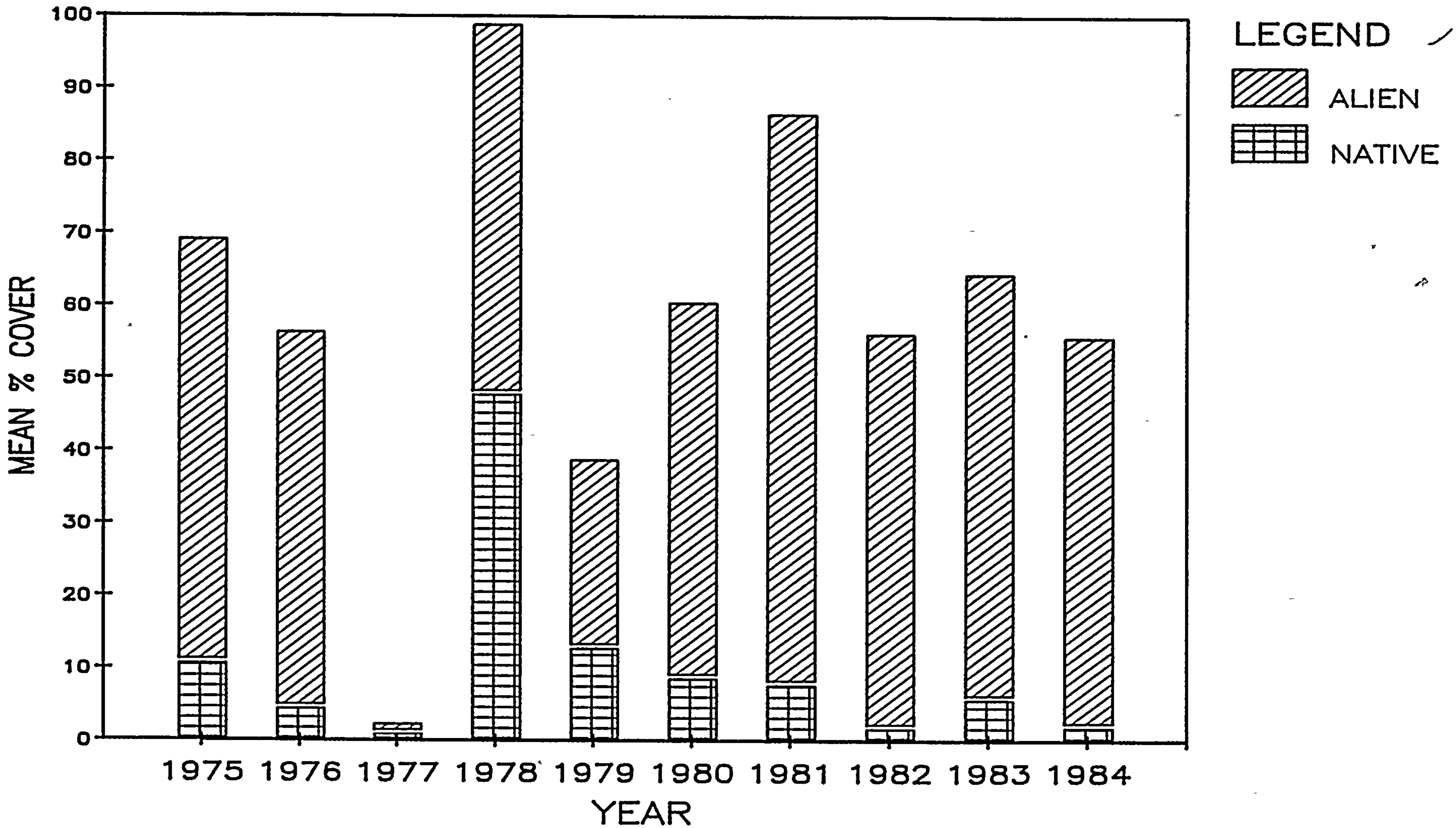


FIGURE 7-15

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1975 THROUGH 1984 SAMPLING SITE S02

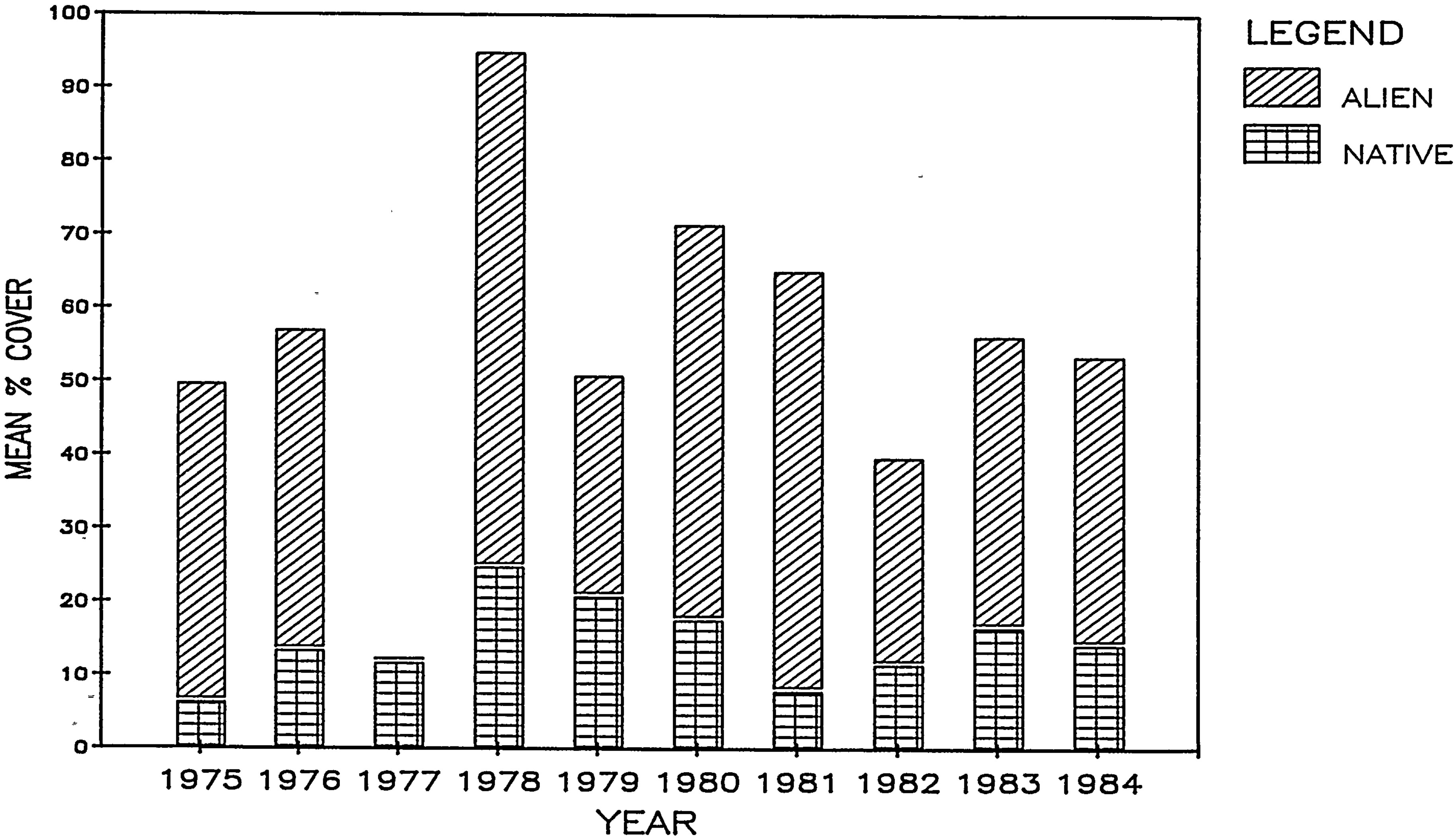


FIGURE 7-16

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1975 THROUGH 1984 SAMPLING SITE S03

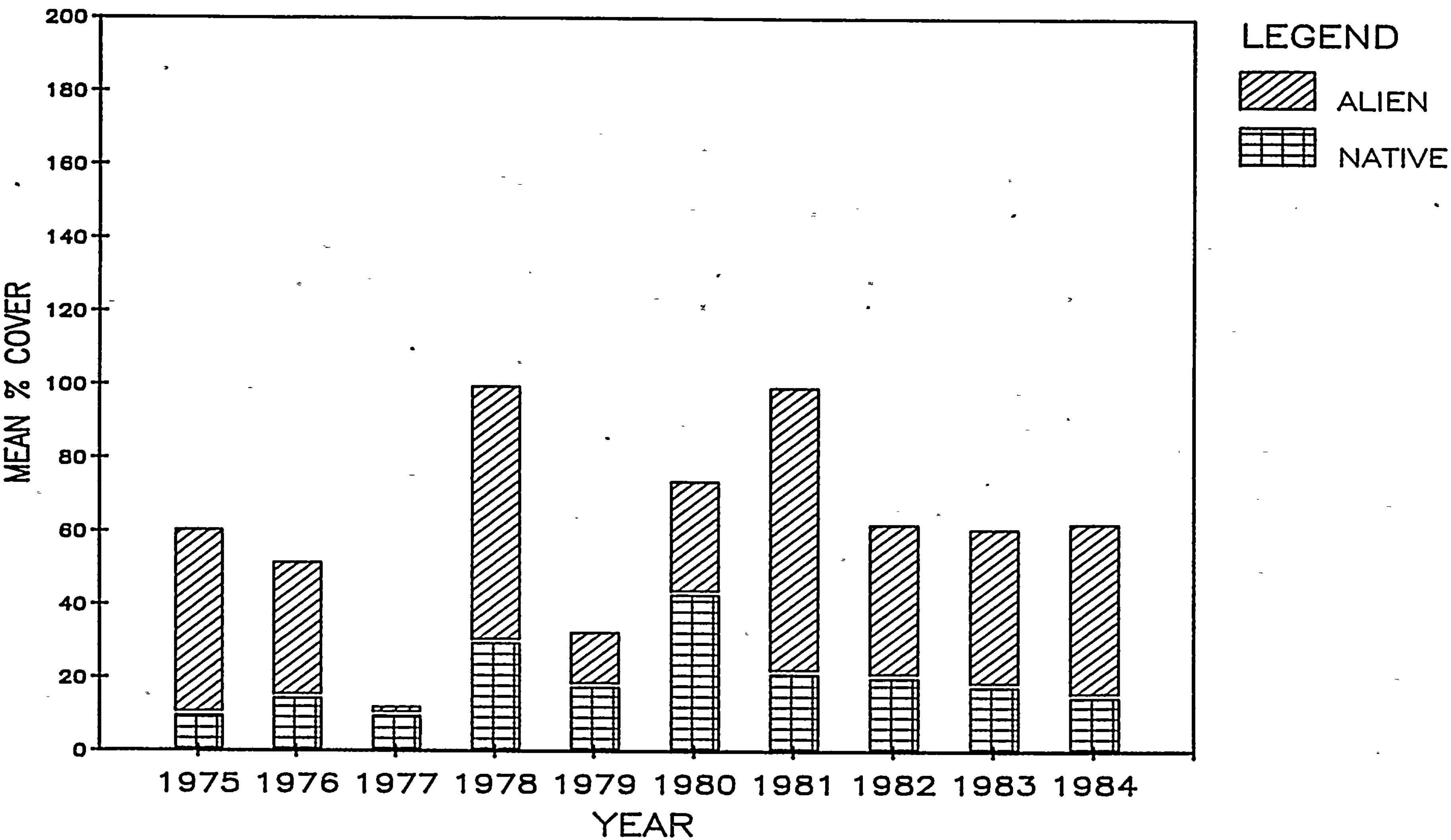


FIGURE 7-17

MEAN HERBACEOUS COVER ALIEN AND NATIVE SPECIES 1980 THROUGH 1984 SAMPLING SITE S04

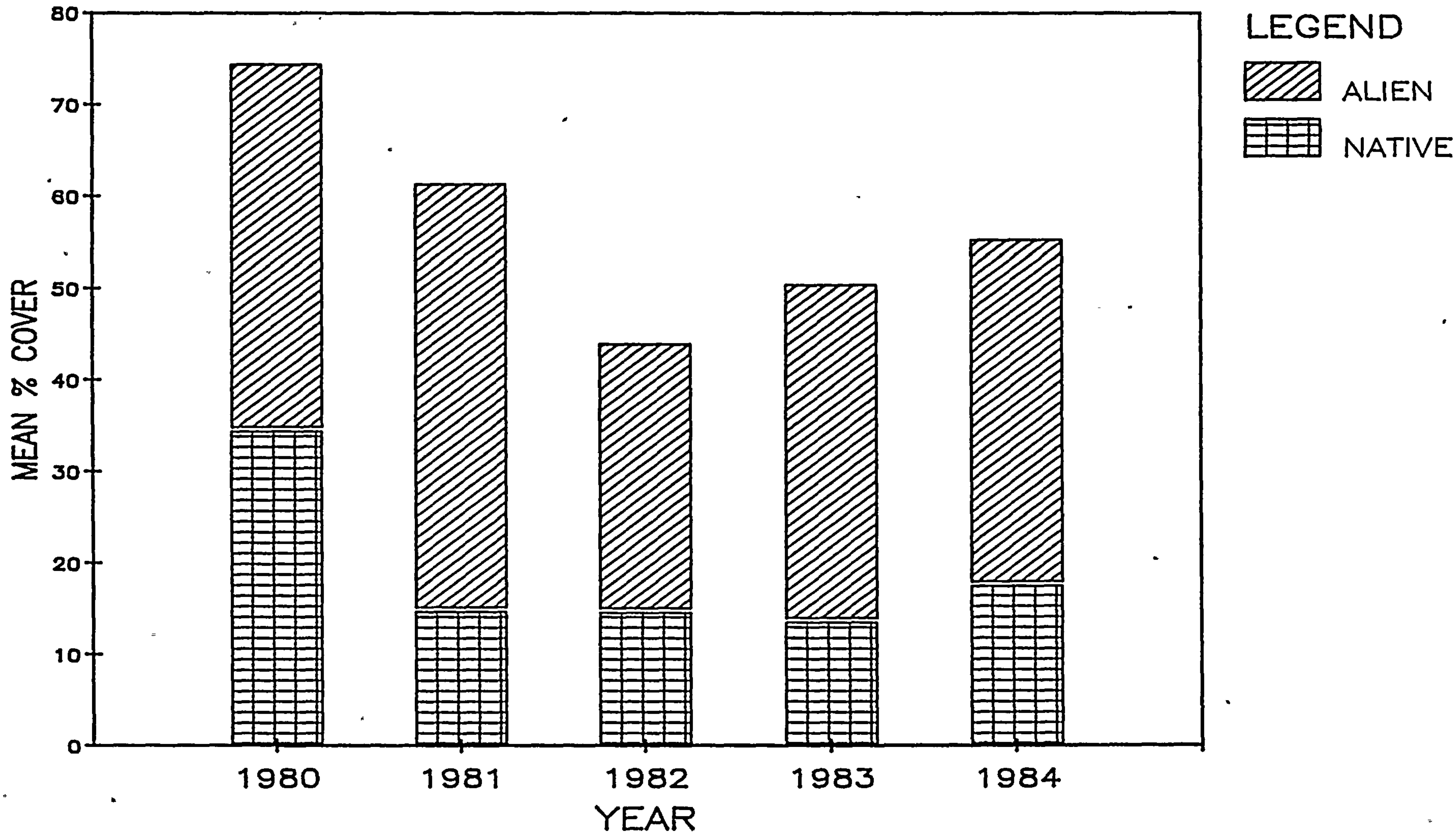


FIGURE 7-18

MEAN HERBACEOUS COVER
ALIEN AND NATIVE SPECIES
1980 THROUGH 1984
SAMPLING SITE S05

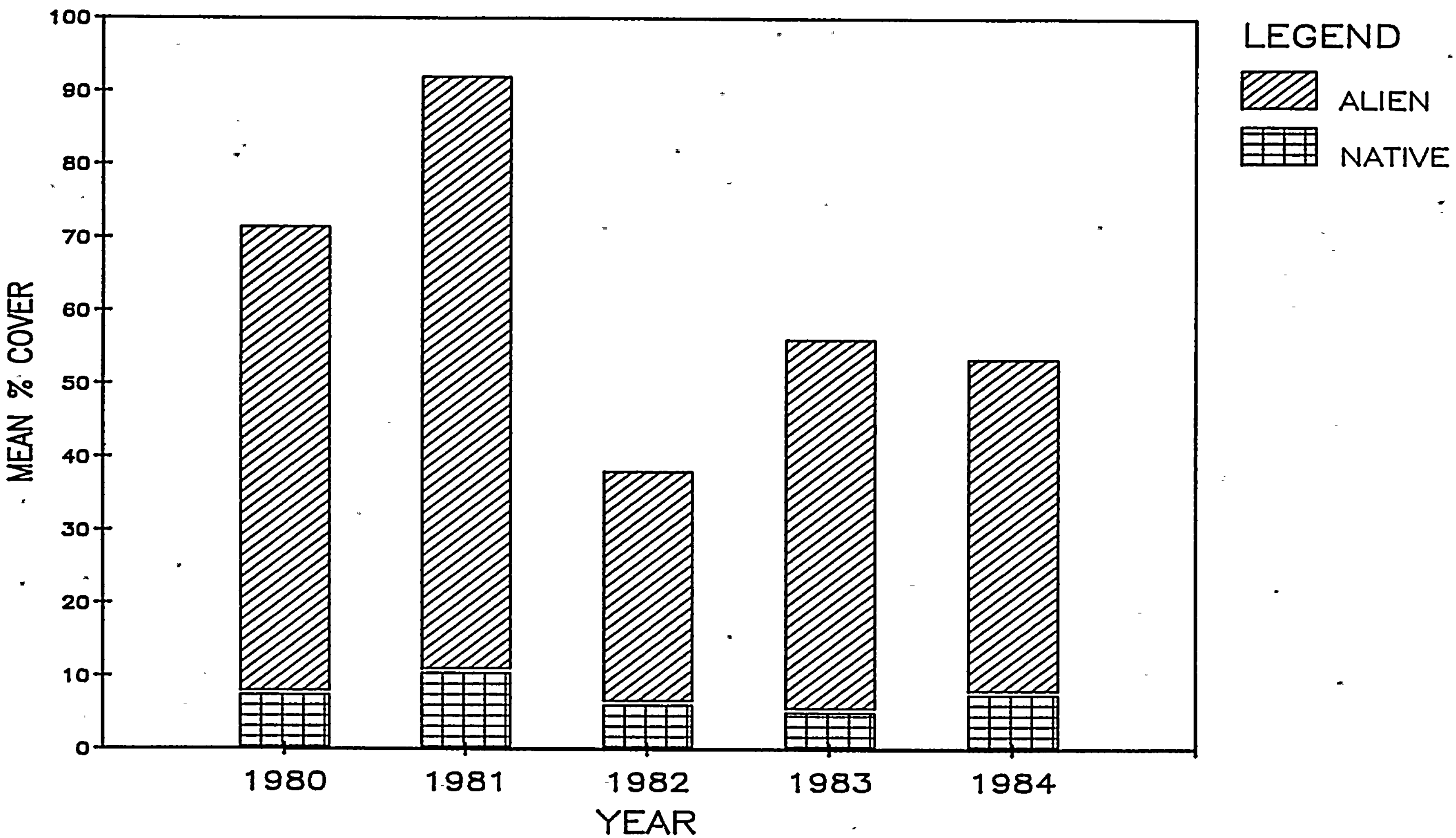


FIGURE 7-19

MEAN HERBACEOUS PHYTOMASS MAY 1984

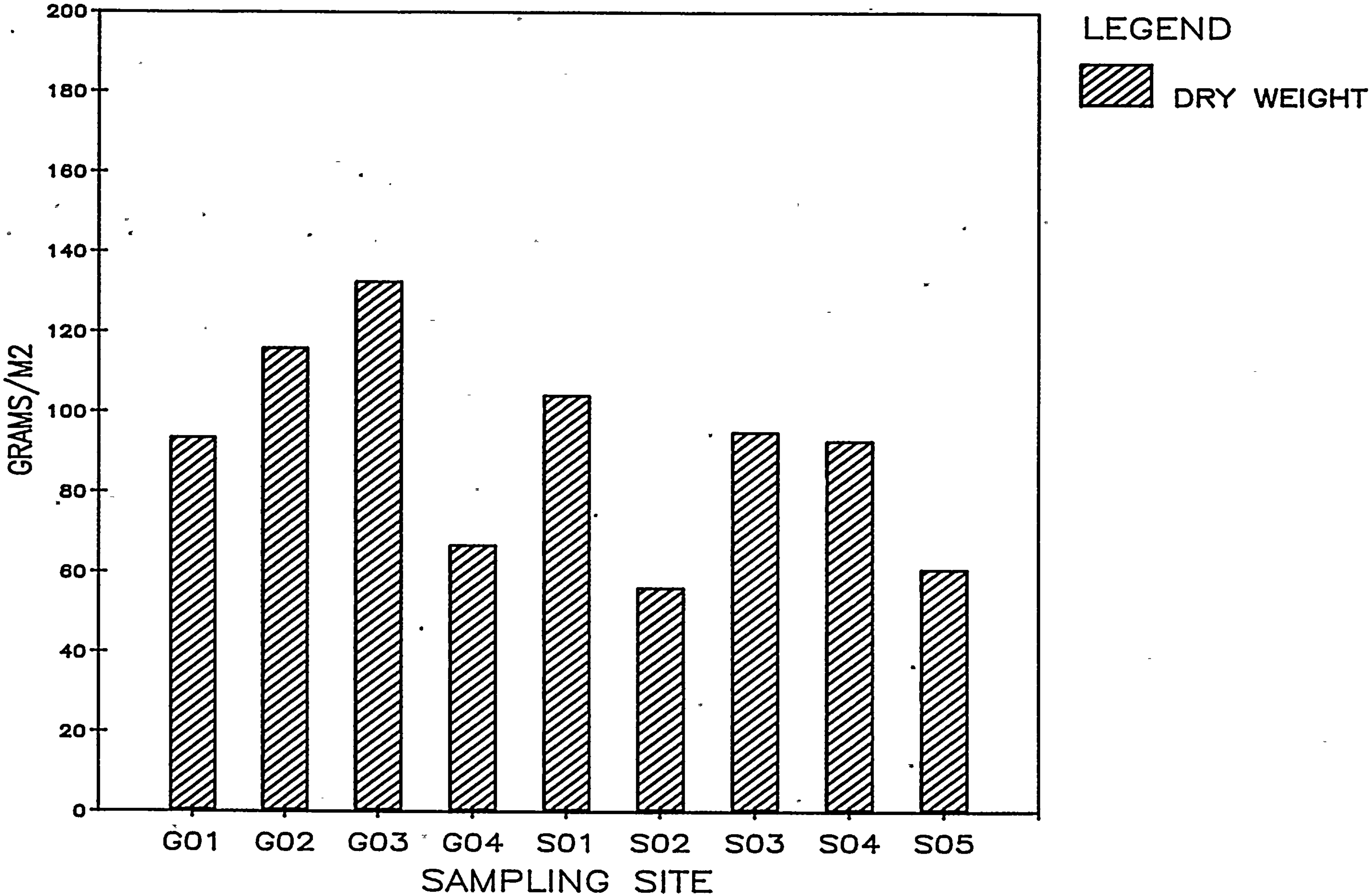


FIGURE 7-20

MEAN HERBACEOUS PHYTOMASS 1975 — 1984

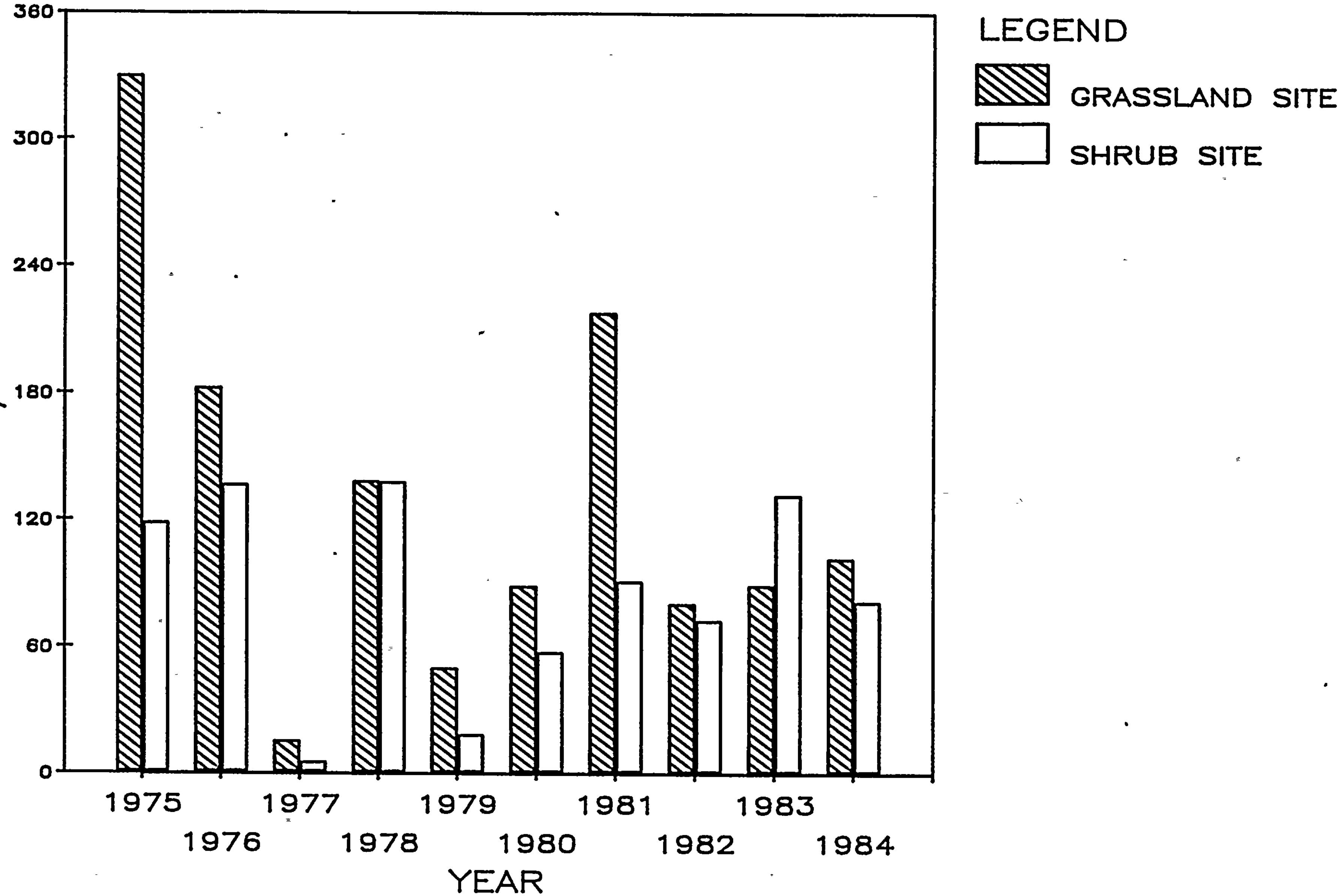


FIGURE 7-21

MEAN TOTAL SHRUB COVER 1975 THROUGH 1984 STATIONS S01 THROUGH S04

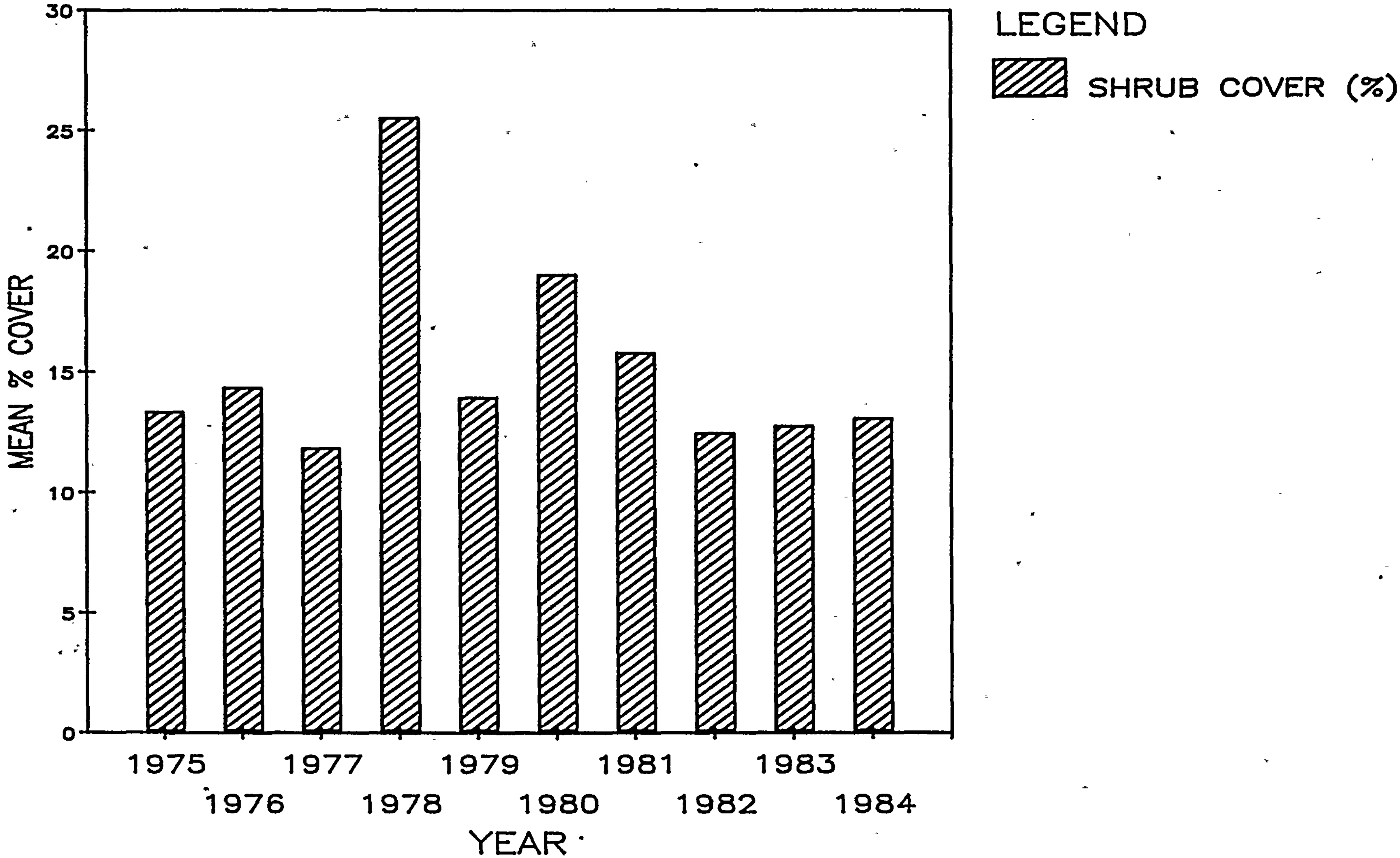


FIGURE 7-22

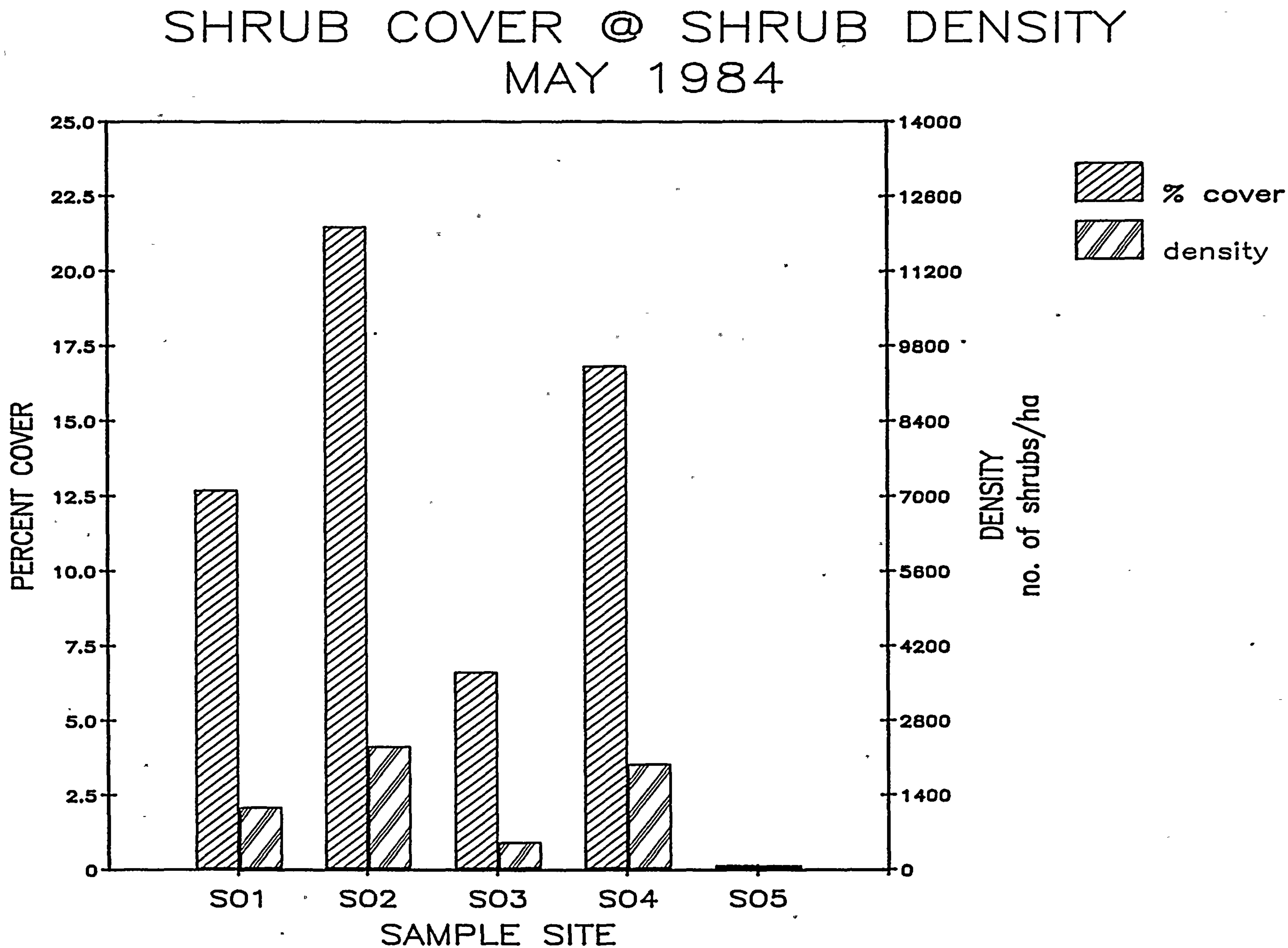
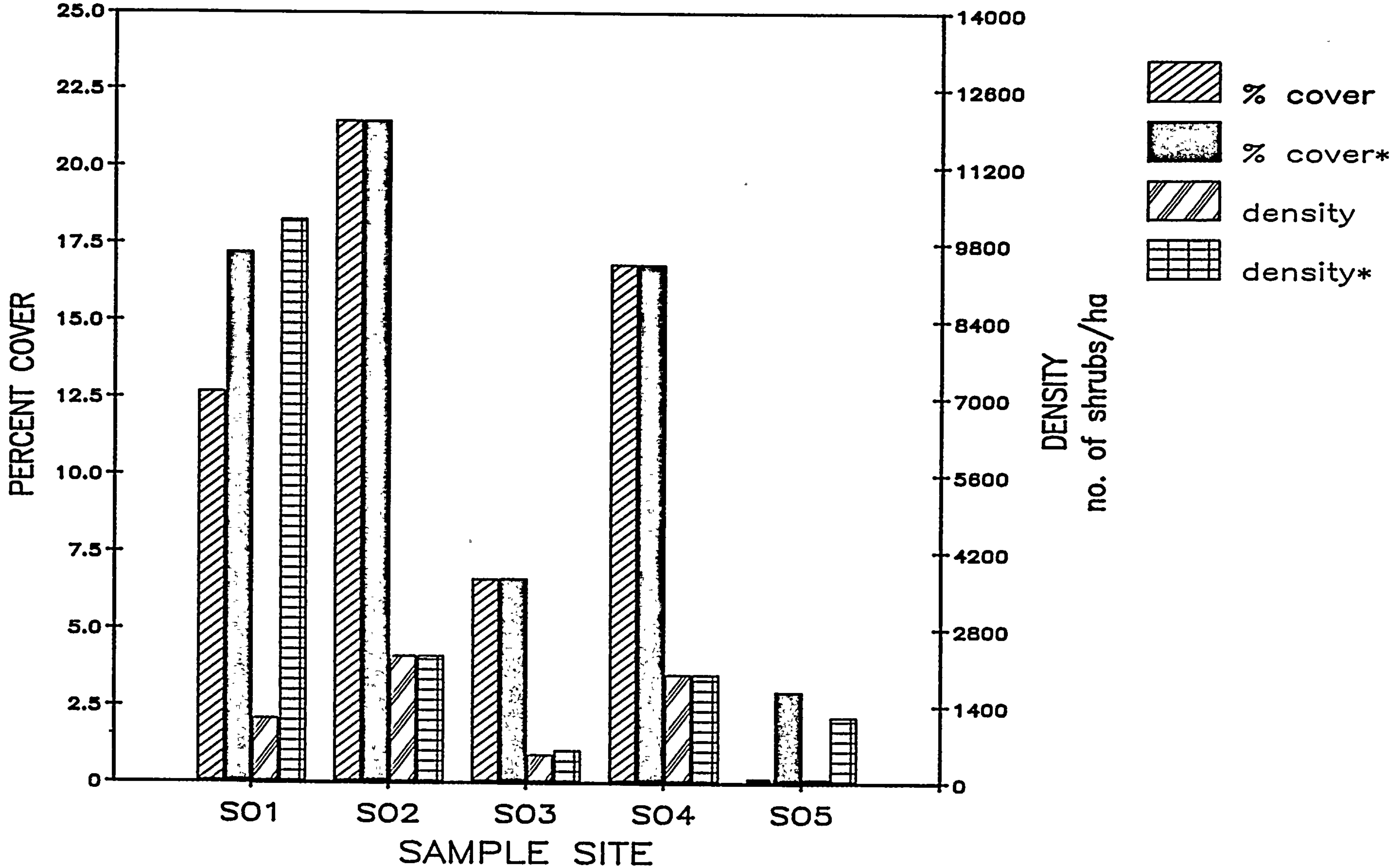

SHRUB COVER @ SHRUB DENSITY
MAY 1984
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0
PERCENT COVER
14000
12600
11200
9800
8400
7000
5600
4200
2800
1400
0
DENSITY
no. of shrubs/ha
% cover
density
S01
S02
S03
S04
S05
SAMPLE SITE

FIGURE 7-23

SHRUB COVER @ SHRUB DENSITY
MAY 1984



*incl. erni, oppo

FIGURE 7-24

COMPARISON OF SHRUB DENSITY 1980 THROUGH 1984

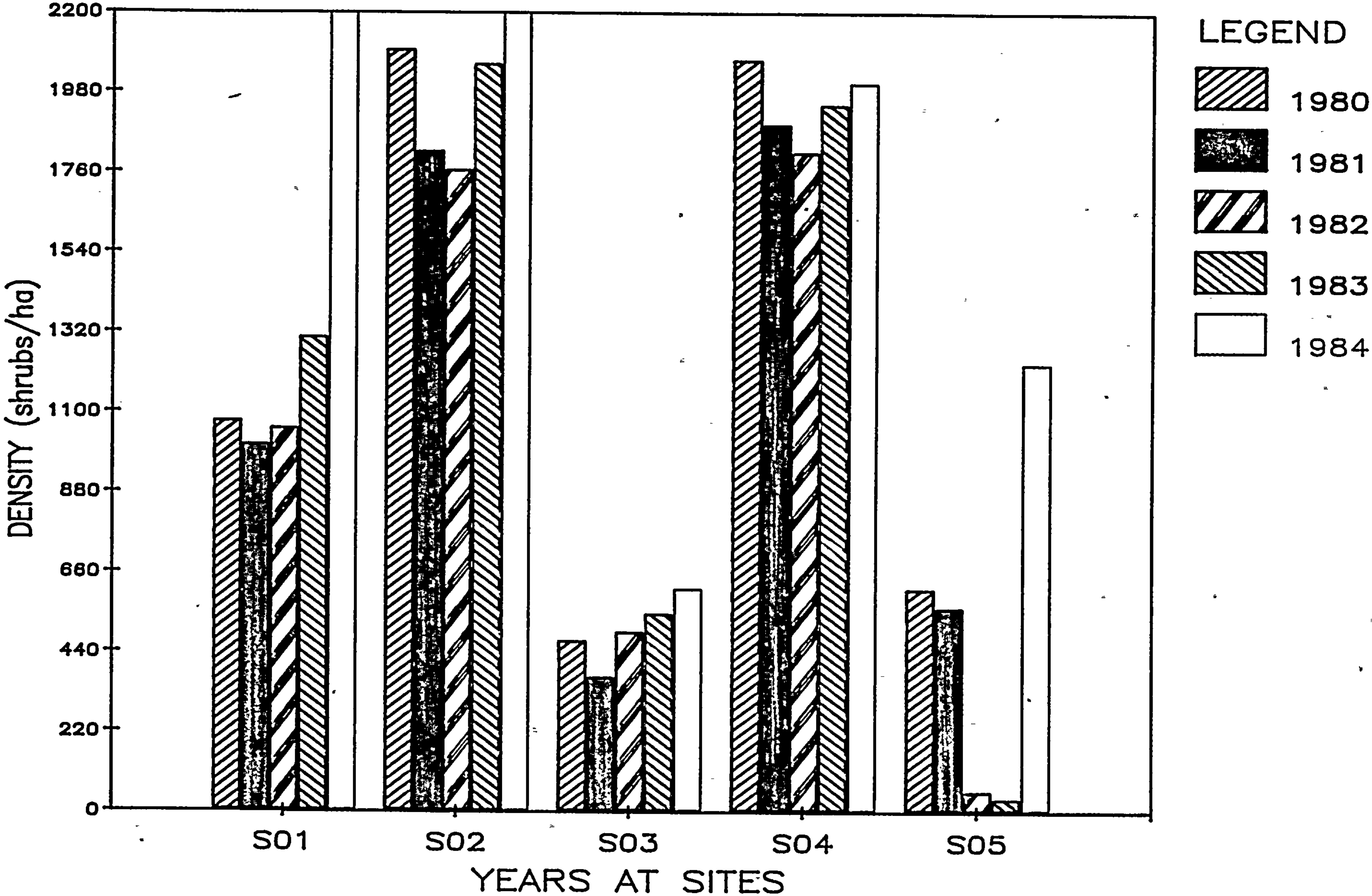


FIGURE 7-25

SOIL CHEMISTRY 1984
pH AND CONDUCTIVITY

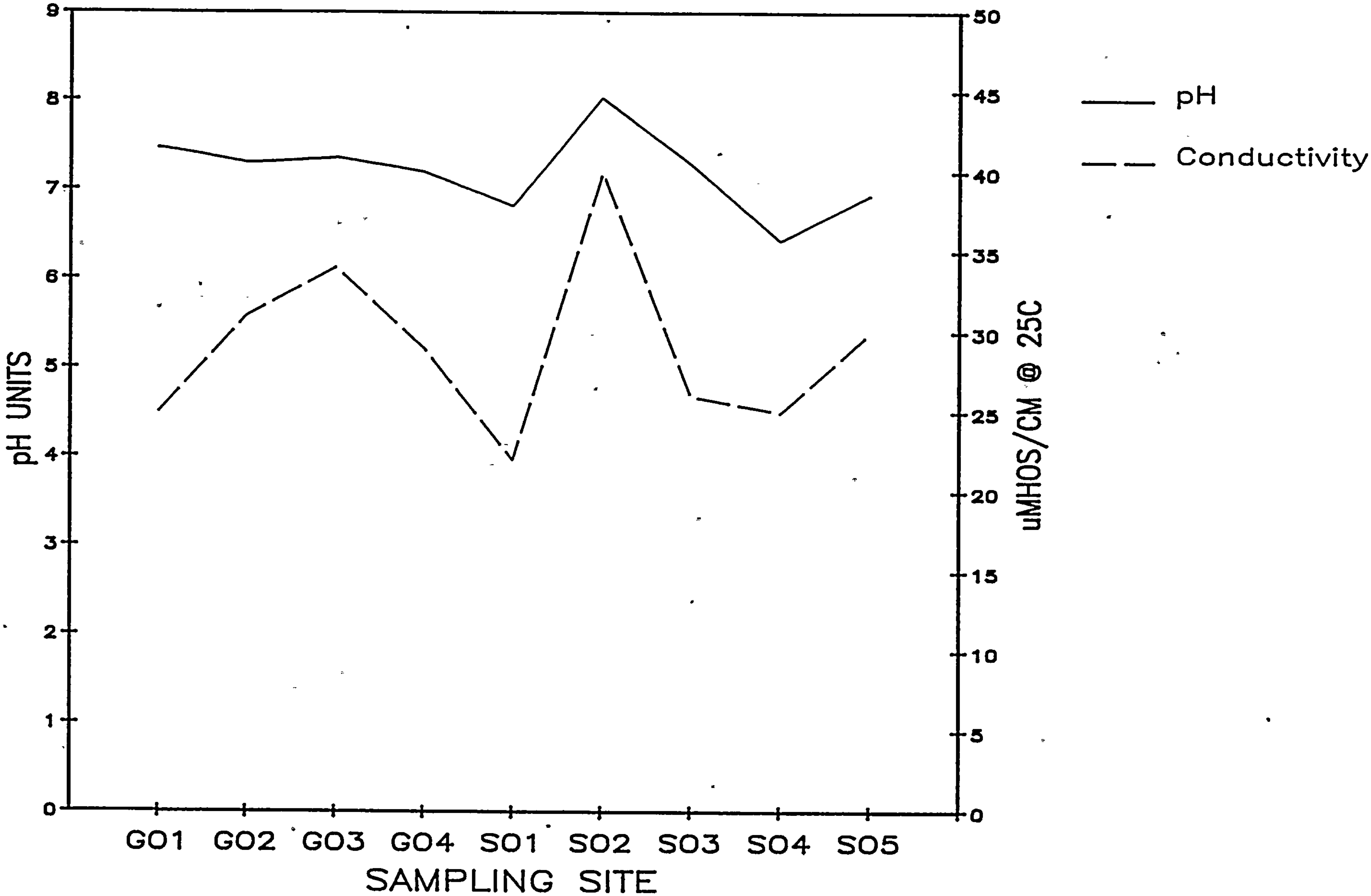
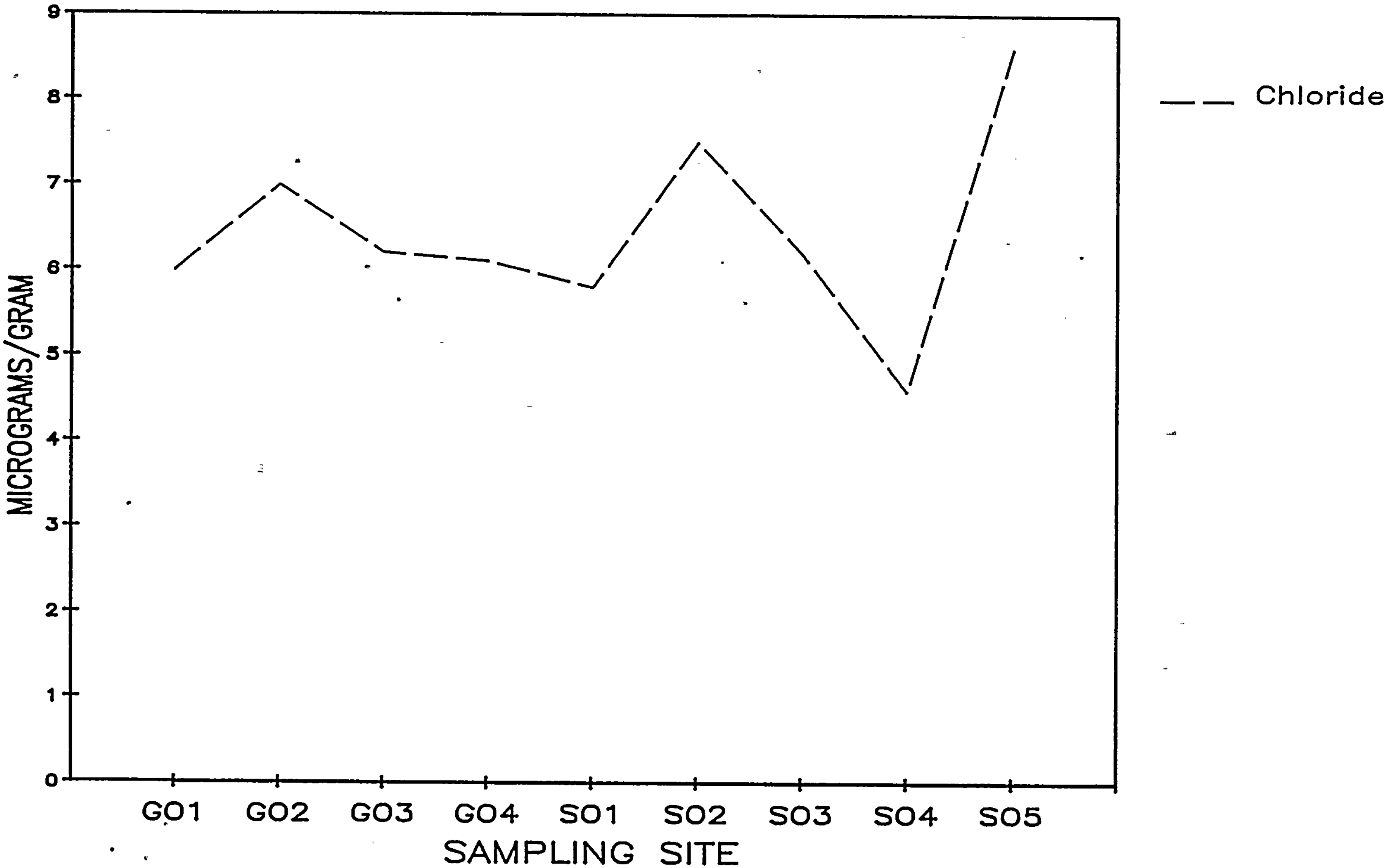


FIGURE 7-26

SOIL CHEMISTRY 1984
CHLORIDE AND SULFATE*



* sulfate below detection limit

FIGURE 7-27

SOIL LEAD, CADMIUM AND MERCURY 1984

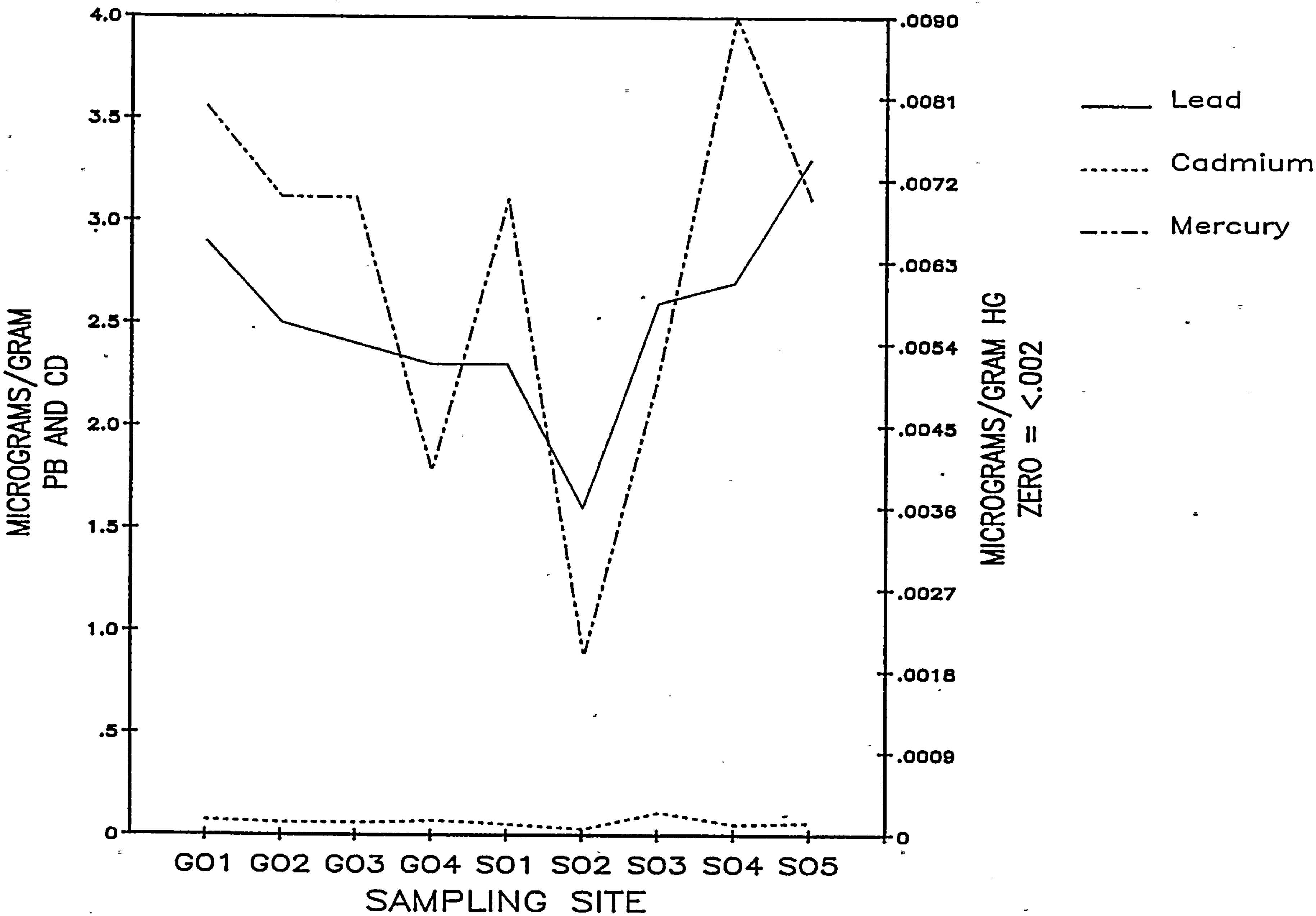


FIGURE 7-28

SOIL CHEMISTRY 1984
FLUORIDE AND BICARBONATE

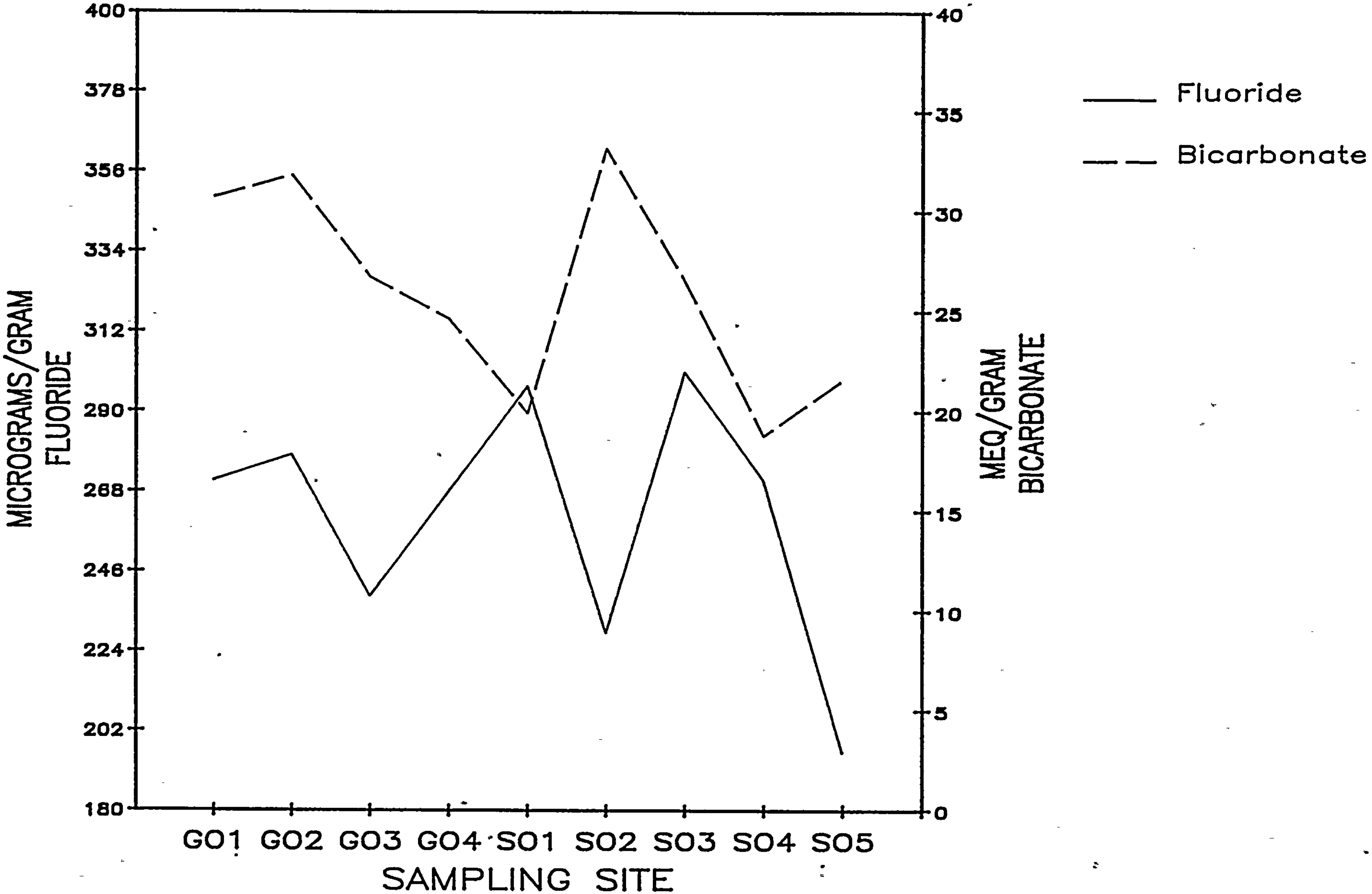


FIGURE 7-29

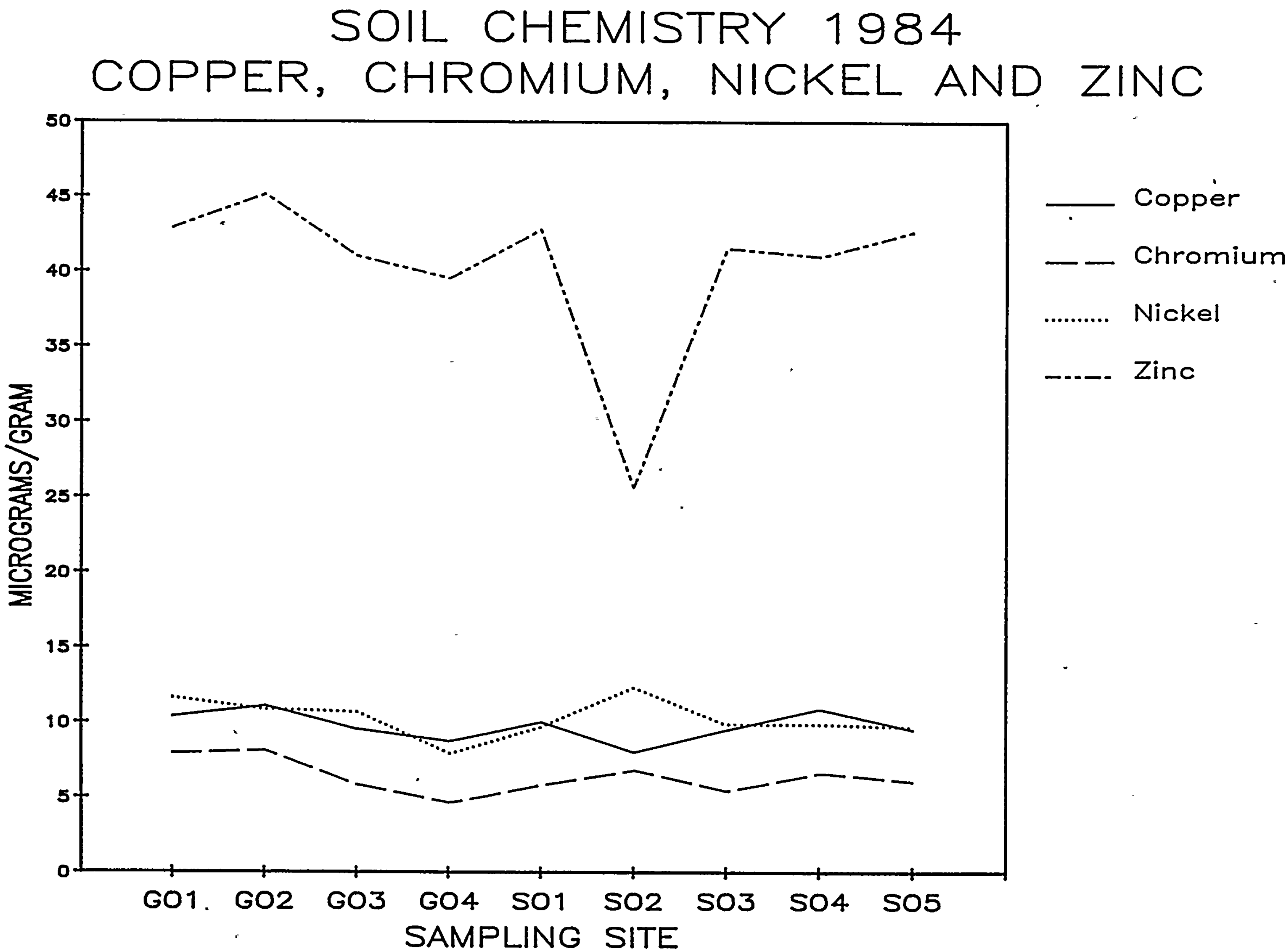

SOIL CHEMISTRY 1984
COPPER, CHROMIUM, NICKEL AND ZINC
50
45
40
35
30
25
20
15
10
5
0
MICROGRAMS/GRAM
G01
G02
G03
G04
S01
S02
S03
S04
S05
SAMPLING SITE
Copper
Chromium
Nickel
Zinc

FIGURE [illegible]-30

SOIL CHEMISTRY 1984
SODIUM, POTASSIUM, CALCIUM AND MAGNESIUM

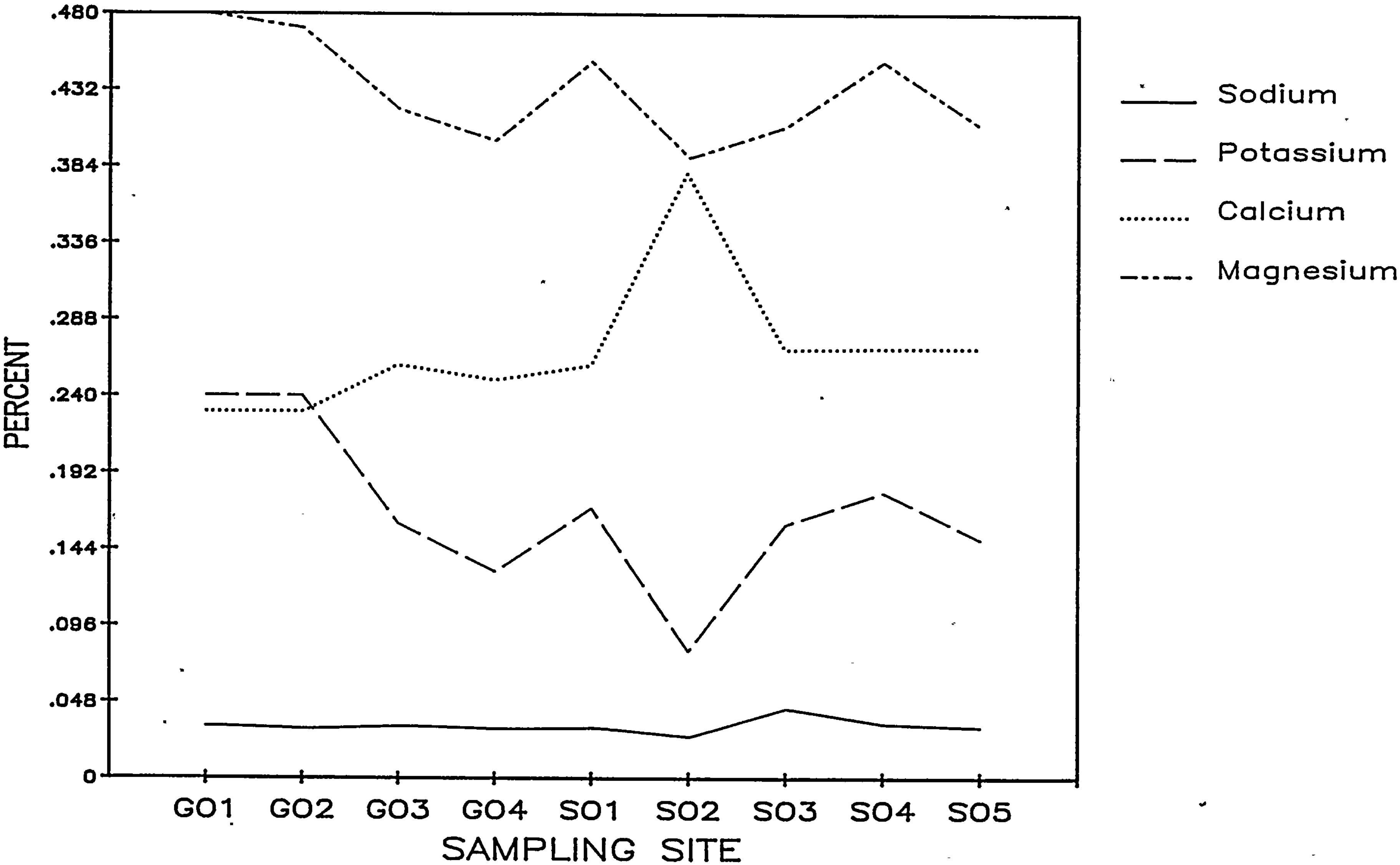


FIGURE 7-31

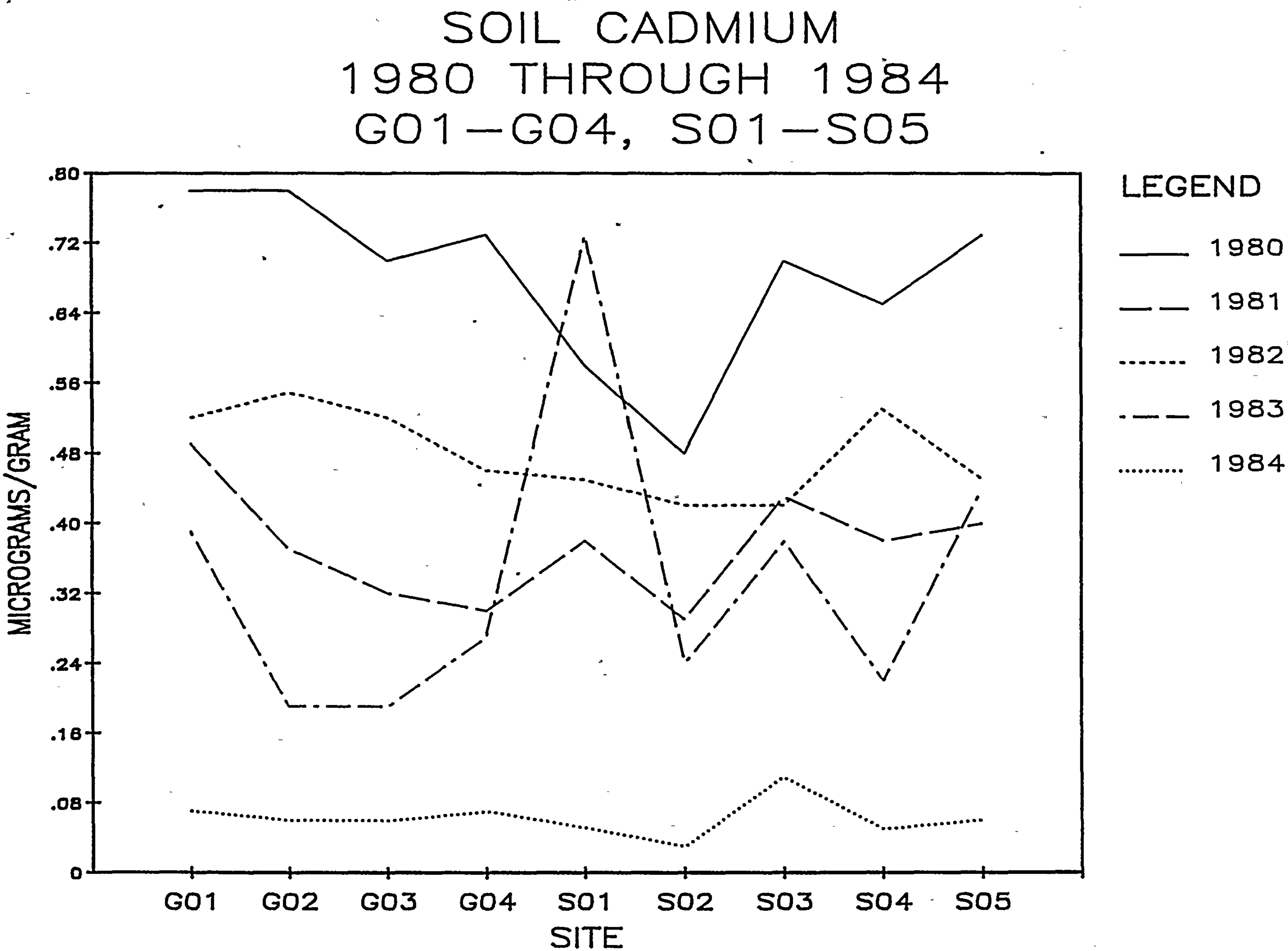

SOIL CADMIUM
1980 THROUGH 1984
G01–G04, S01–S05
MICROGRAMS/GRAM
.80
.72
.64
.56
.48
.40
.32
.24
.16
.08
0
G01
G02
G03
G04
S01
S02
S03
S04
S05
SITE
LEGEND
1980
1981
1982
1983
1984

FIGURE 7-32

SOIL CHLORIDE 1980 THROUGH 1984 SITES G01–G04, S01–S05

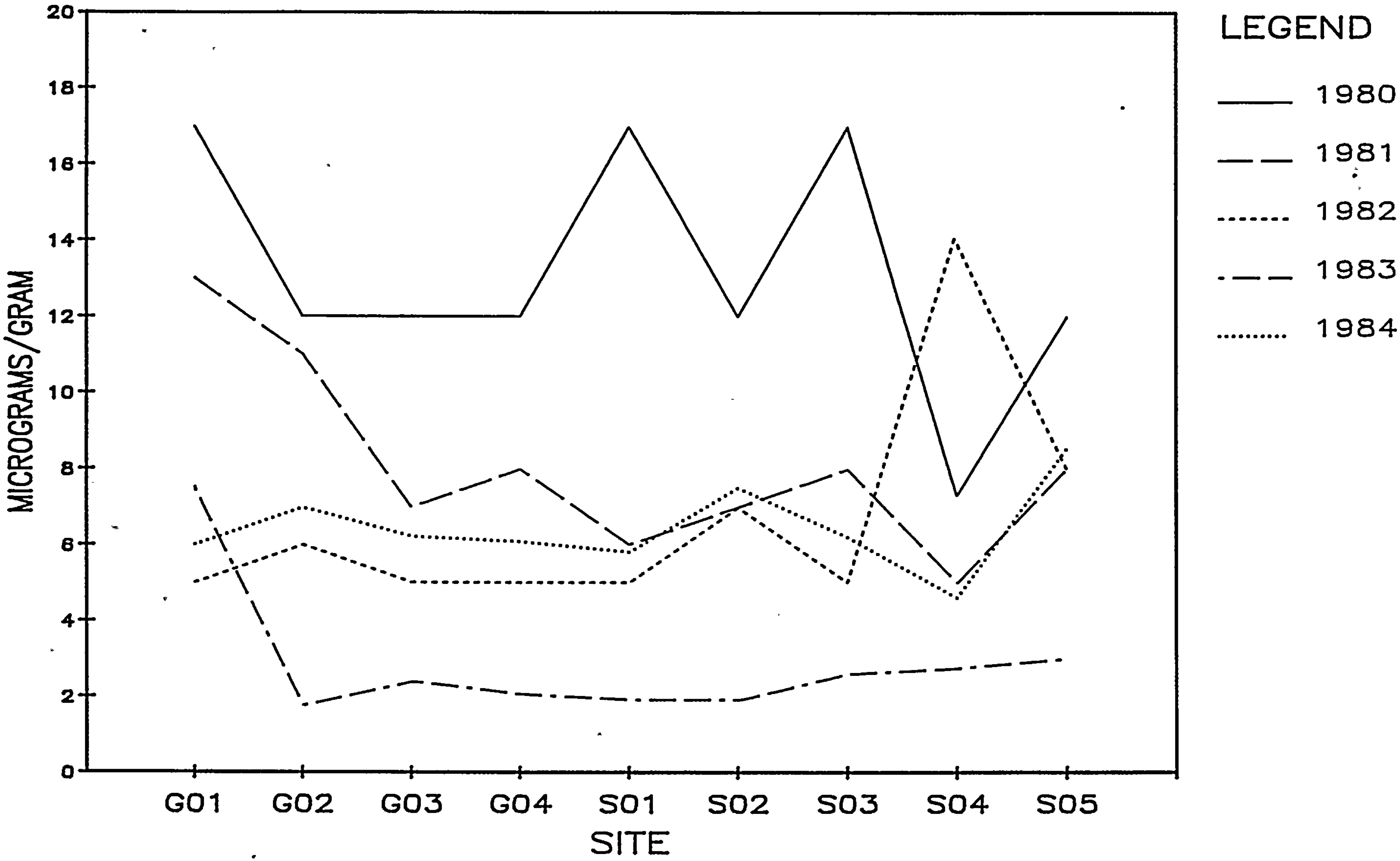


FIGURE 7-33

SOIL LEAD
1980 THROUGH 1984
G01–G04, S01–S05

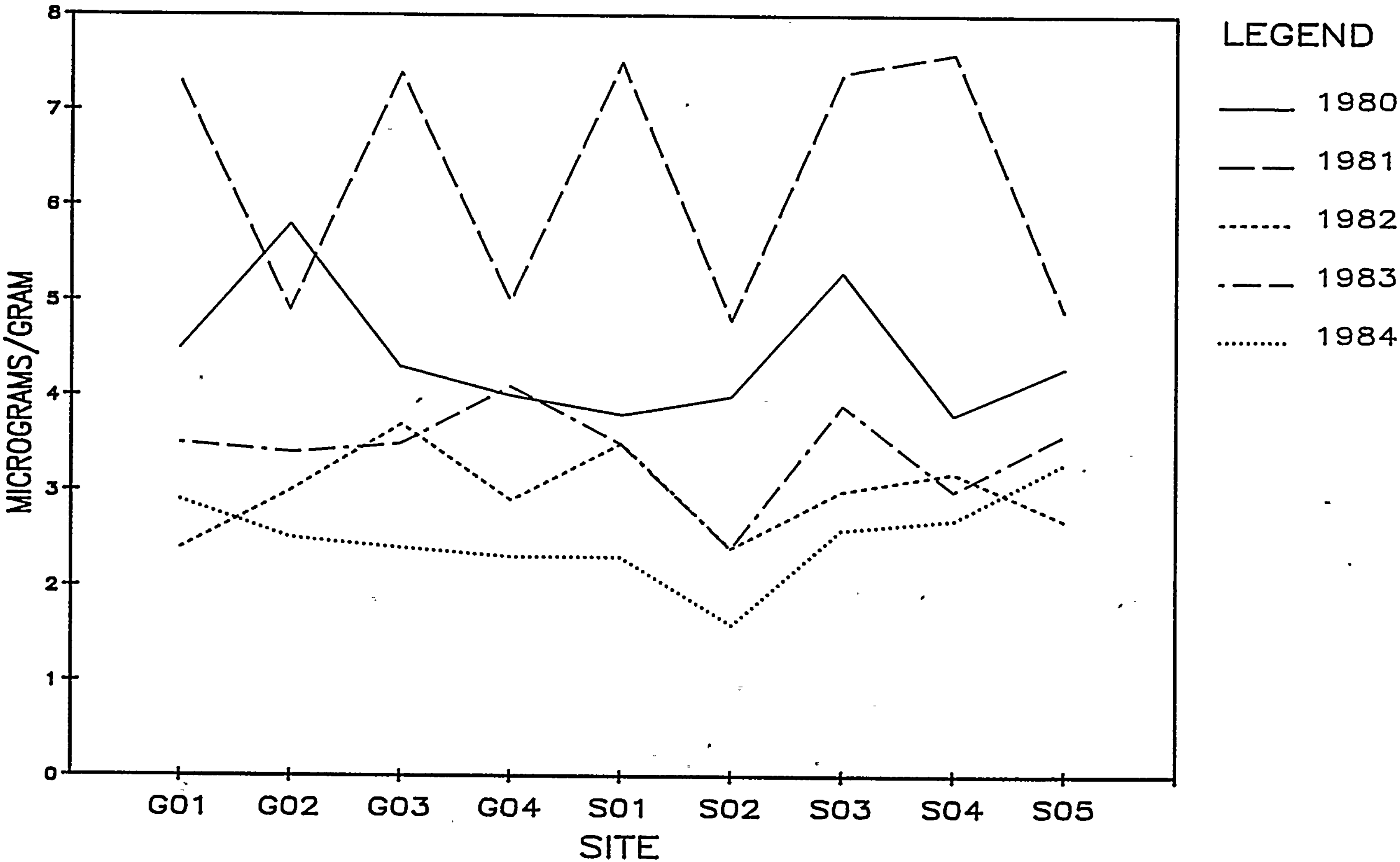


FIGURE 7-34

SOIL COPPER
1980 THROUGH 1984
G01—G04, S01—S05

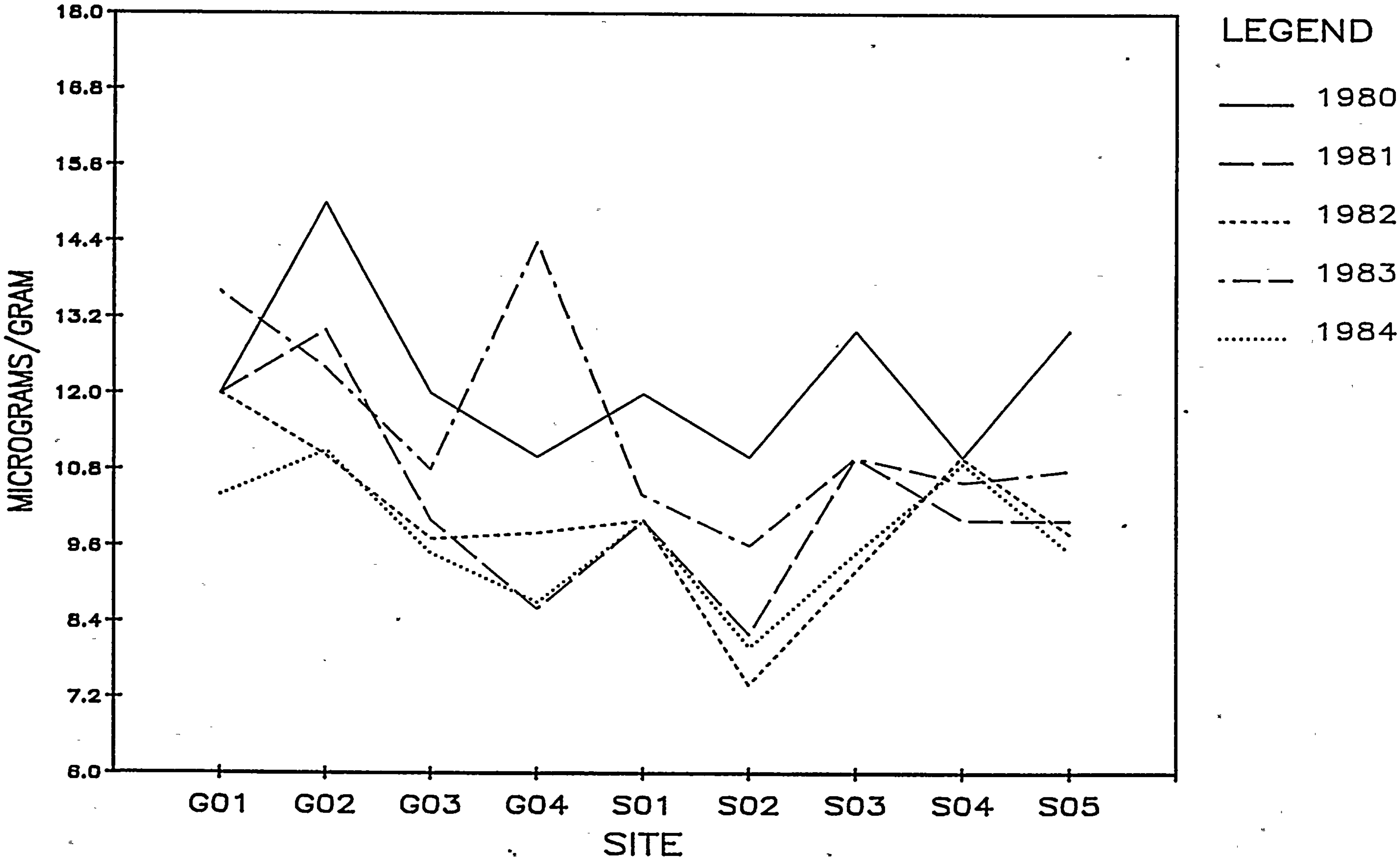


FIGURE 7-35

SOIL CHROMIUM 1980 THROUGH 1984 G01–G04, S01–S05

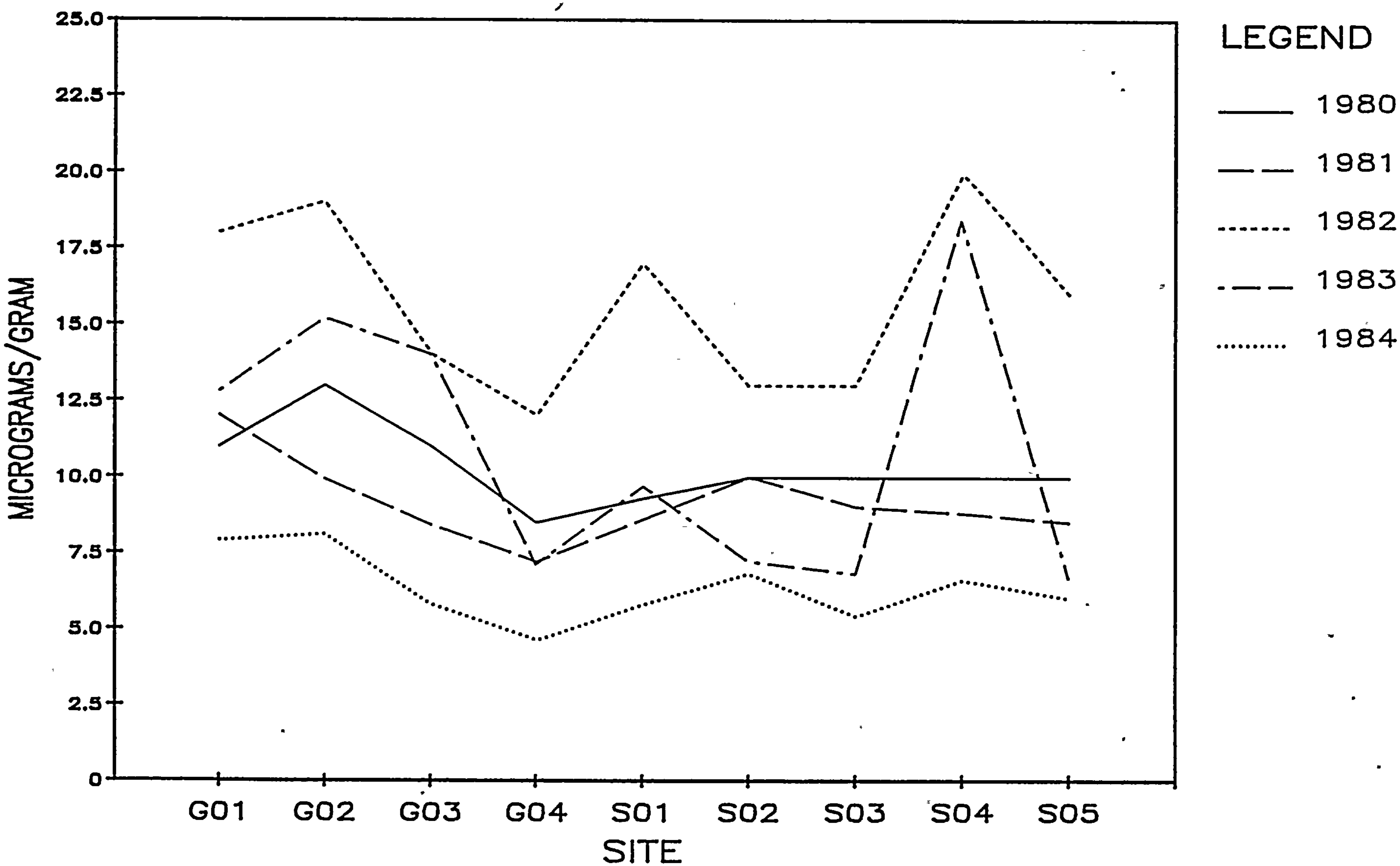


FIGURE 7-36

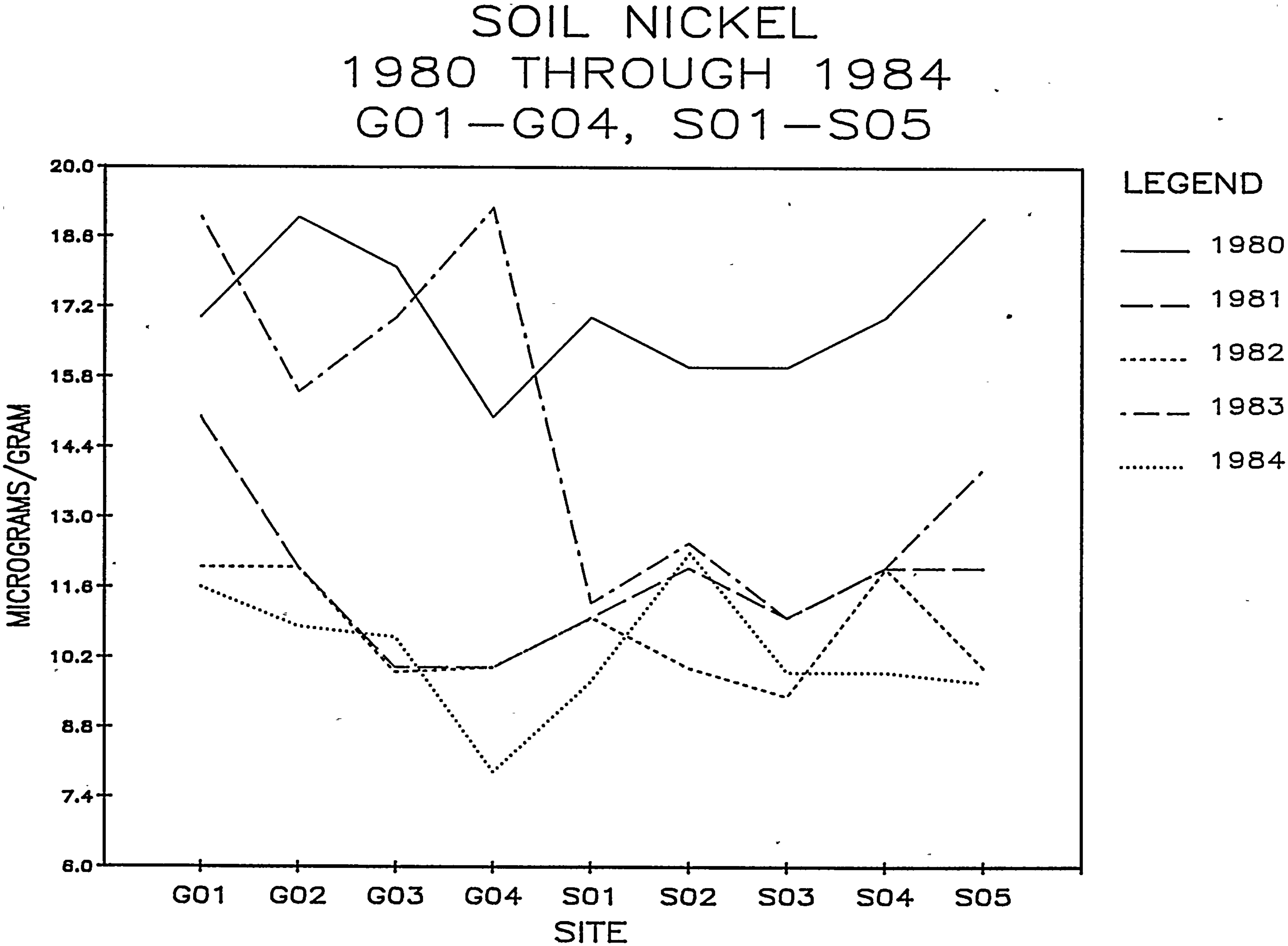

SOIL NICKEL
1980 THROUGH 1984
G01—G04, S01—S05
20.0
18.6
17.2
15.8
14.4
13.0
11.6
10.2
8.8
7.4
6.0
MICROGRAMS/GRAM
G01
G02
G03
G04
S01
S02
S03
S04
S05
SITE
LEGEND
1980
1981
1982
1983
1984

FIGURE 7-37

SOIL SODIUM
1980 THROUGH 1984
G01–G04, S01–S05

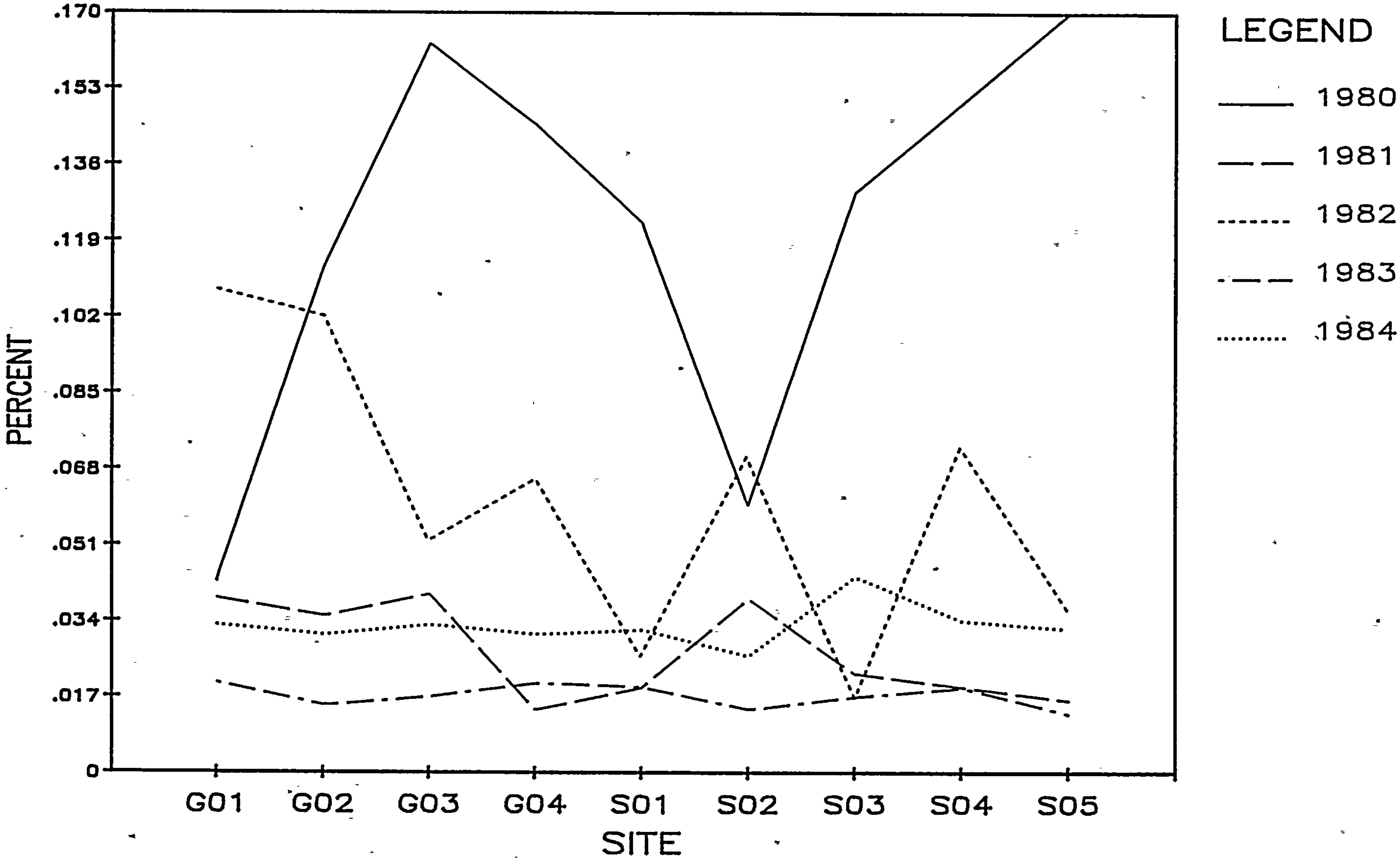


FIGURE 7-38

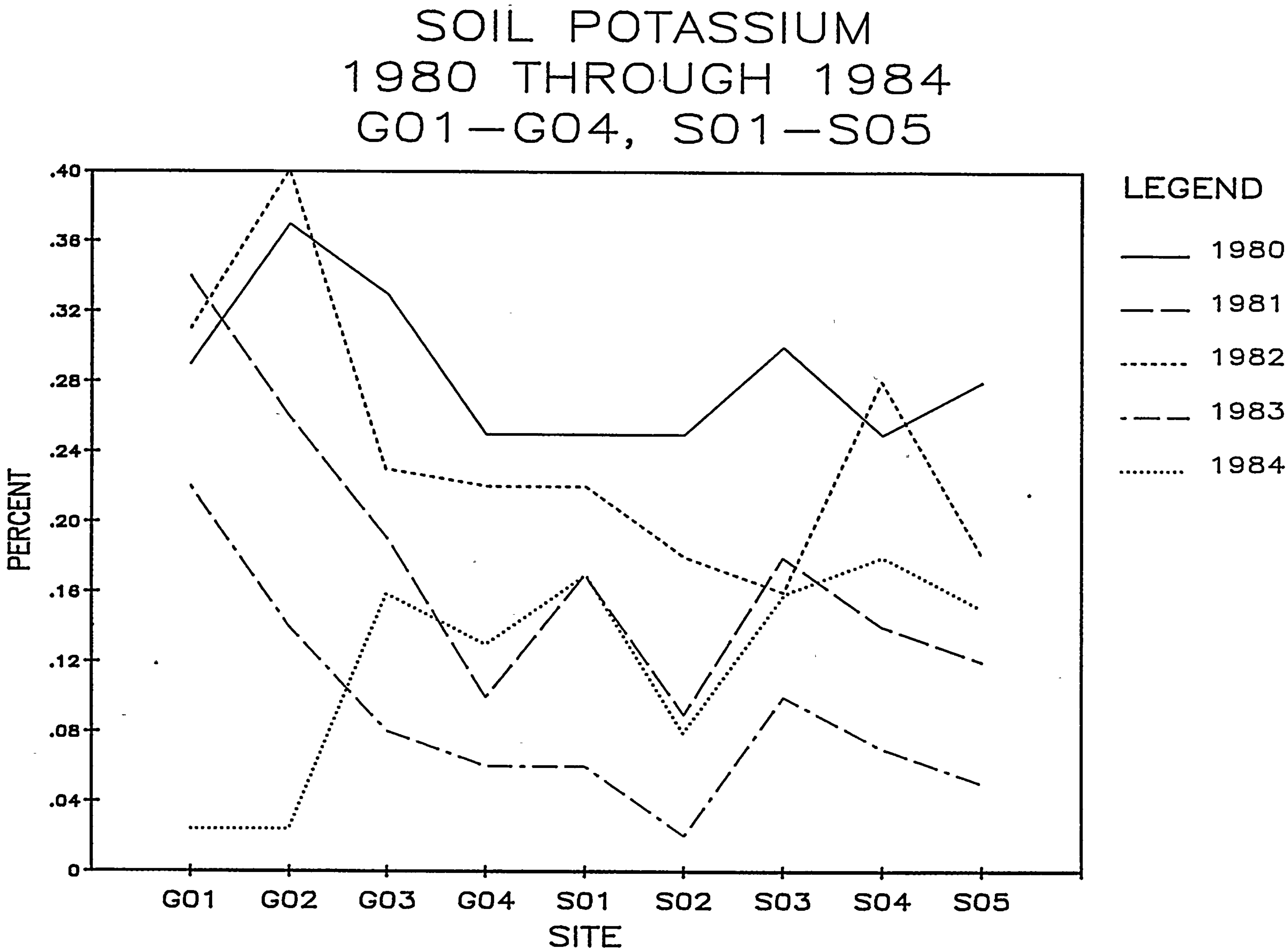

SOIL POTASSIUM
1980 THROUGH 1984
G01—G04, S01—S05
.40
.36
.32
.28
.24
.20
.16
.12
.08
.04
0
PERCENT
G01
G02
G03
G04
S01
S02
S03
S04
S05
SITE
LEGEND
1980
1981
1982
1983
1984

FIGURE 7-39

SOIL CALCIUM
1980 THROUGH 1984
G01—G04, S01—S05

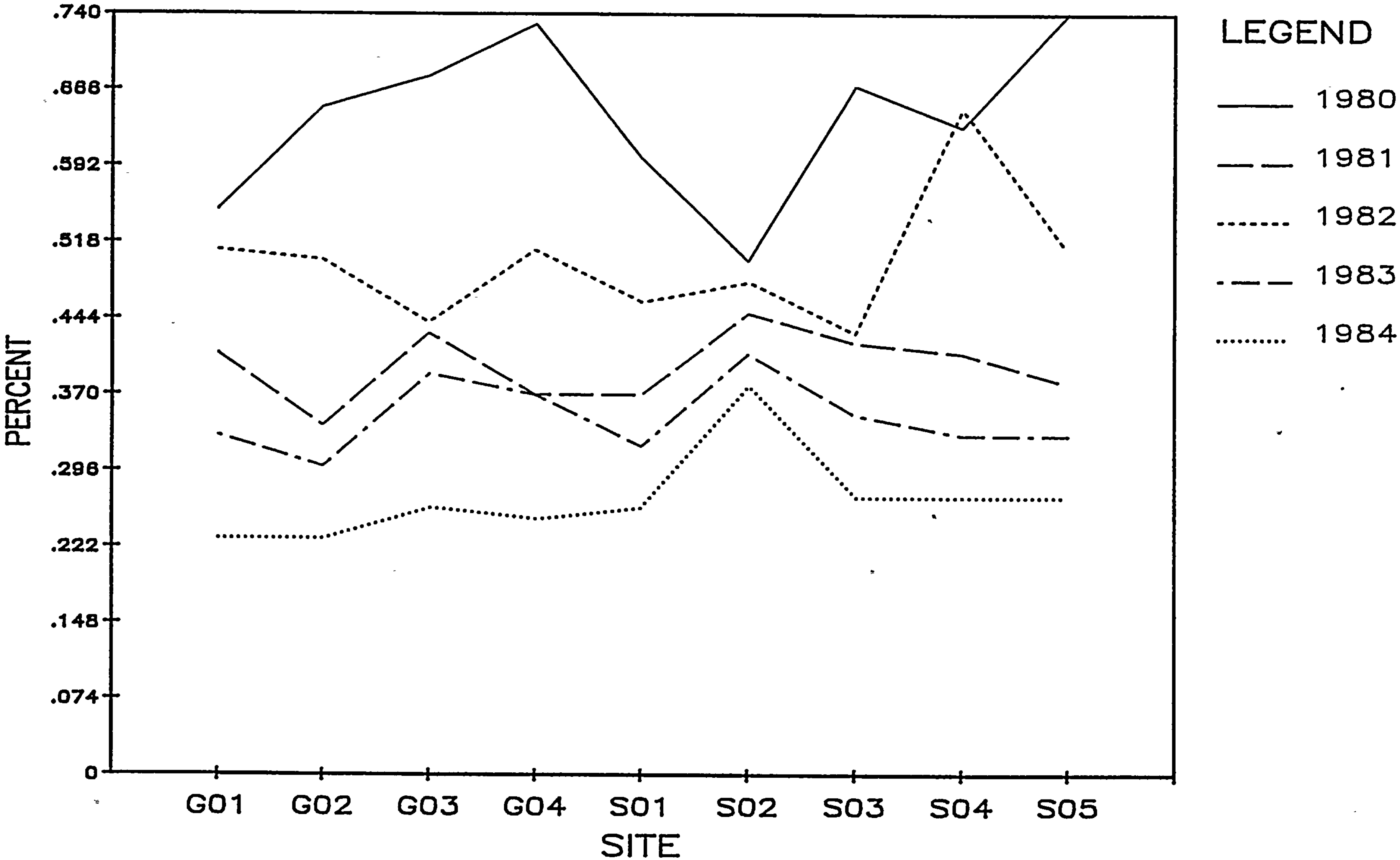


FIGURE 7-40

SOIL FLUORIDE
1980 THROUGH 1984
G01–G04, S01–S05

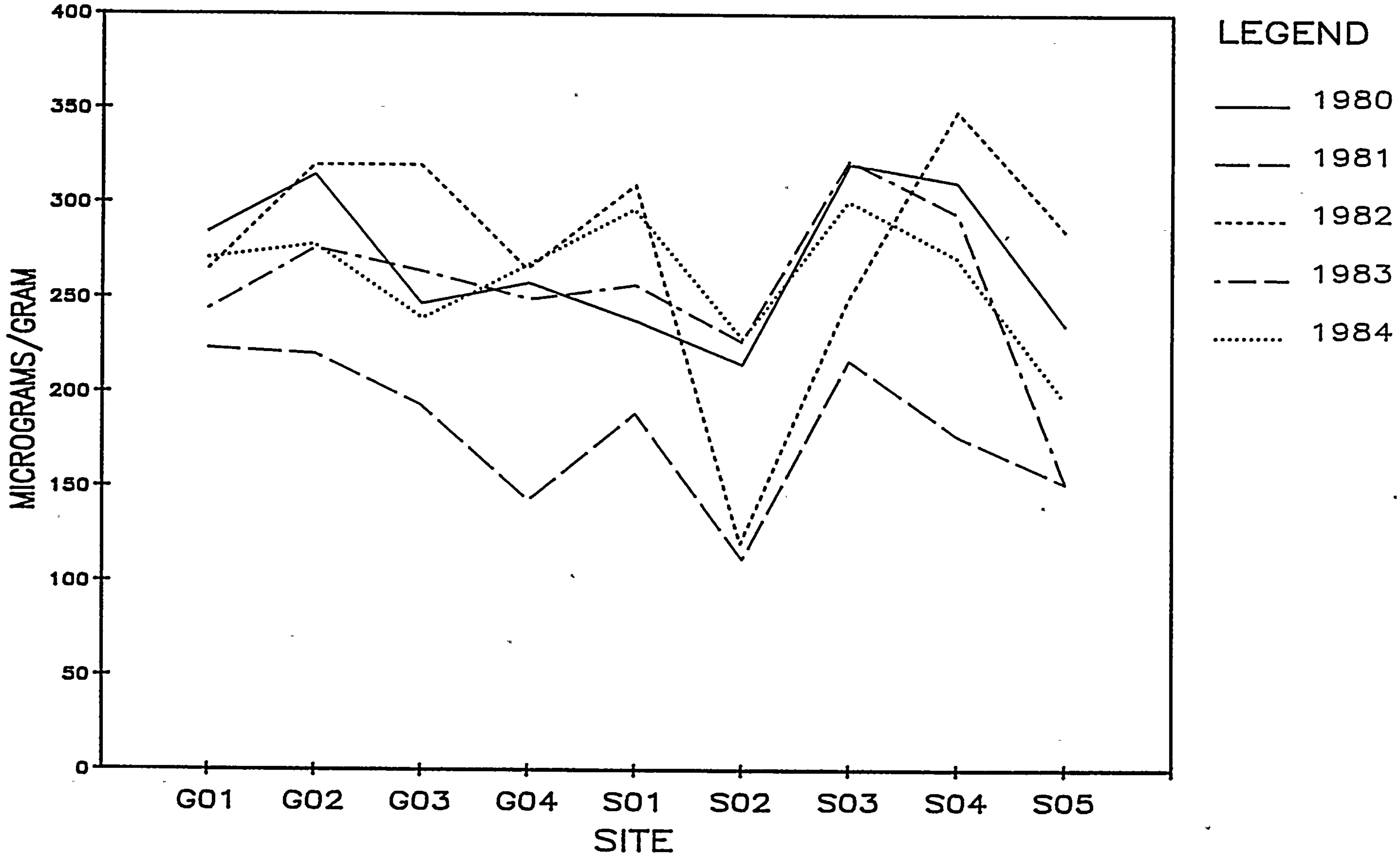


FIGURE 7-41

SOIL BICARBONATE
1980 THROUGH 1984
G01–G04, S01–S05

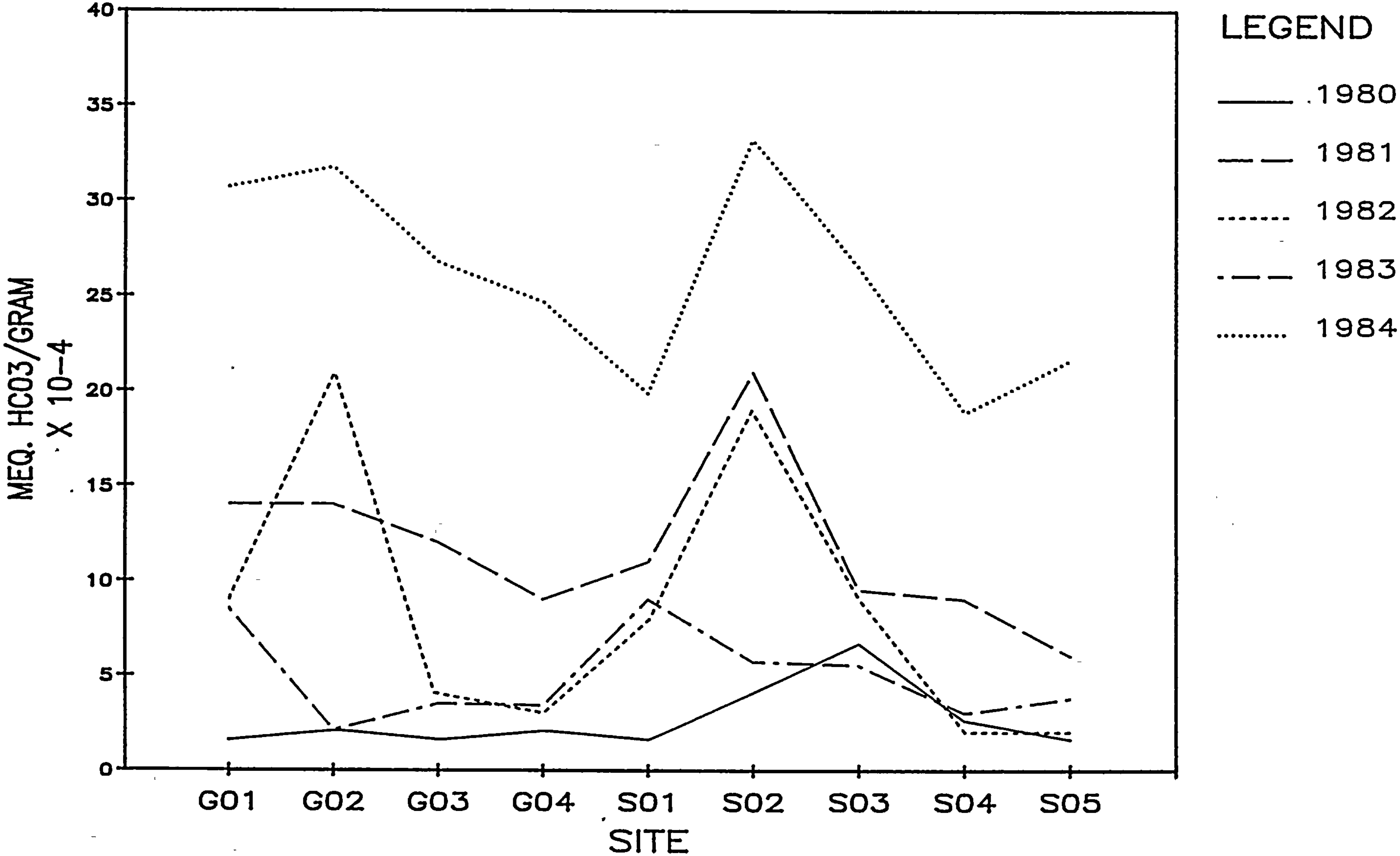


FIGURE 7-42

SOIL pH
1980 THROUGH 1984
SITES G01—G04, S01—S05

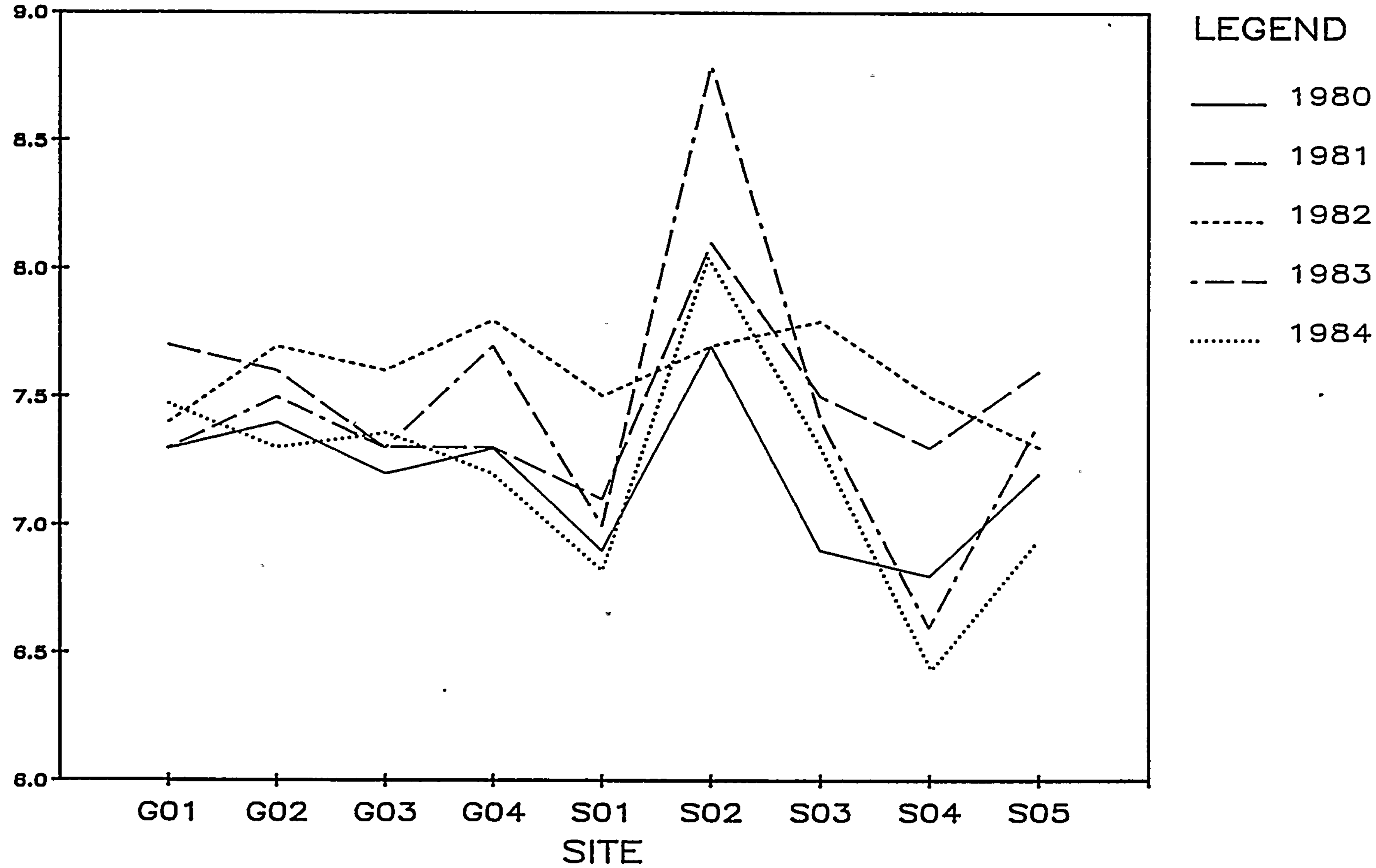


FIGURE 7-43

SOIL SULFATE
1980 THROUGH 1984
SITES G01–G04, S01–S05

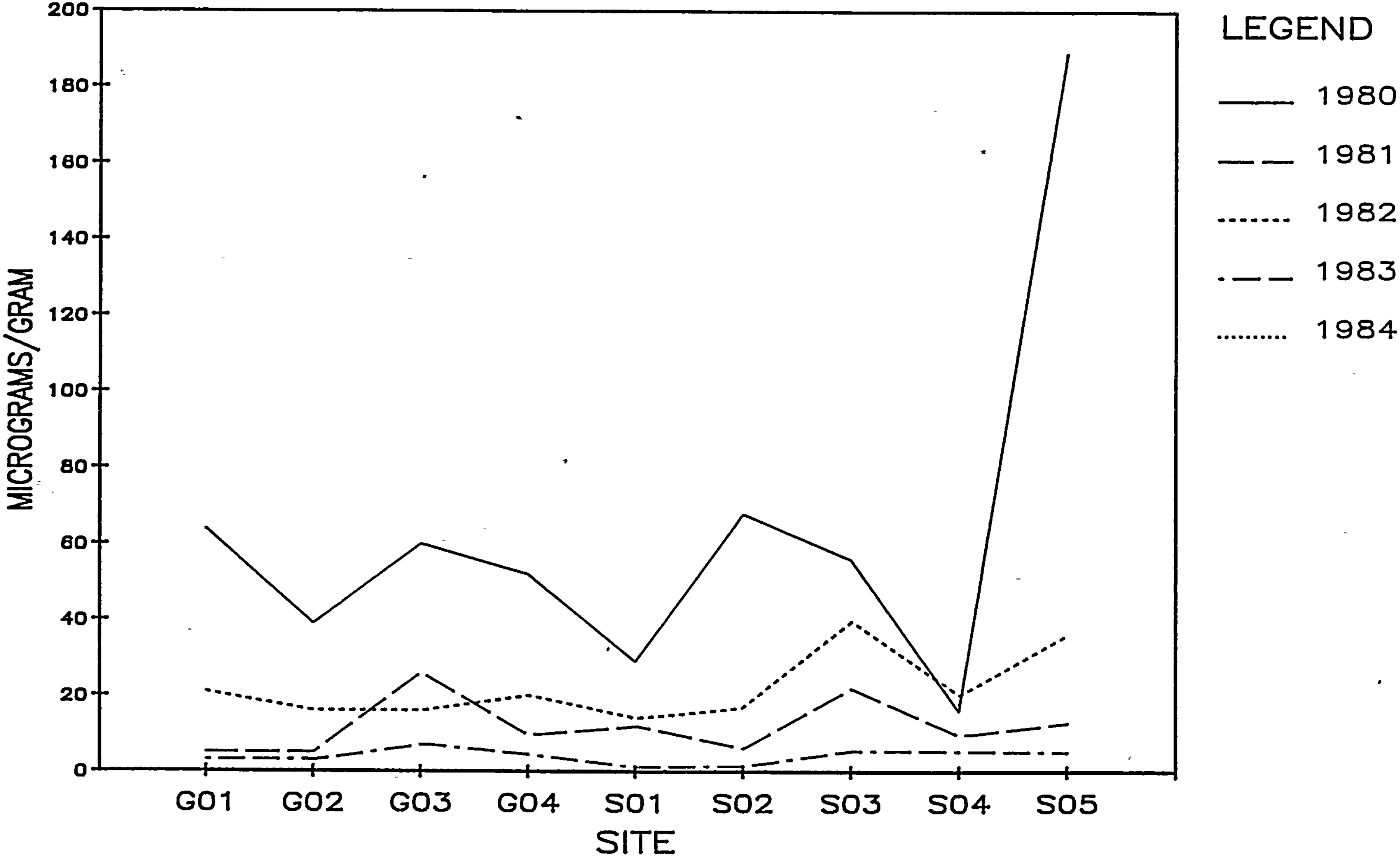


FIGURE 7-44

SOIL ZINC
1980 THROUGH 1984
G01–G04, S01–S05

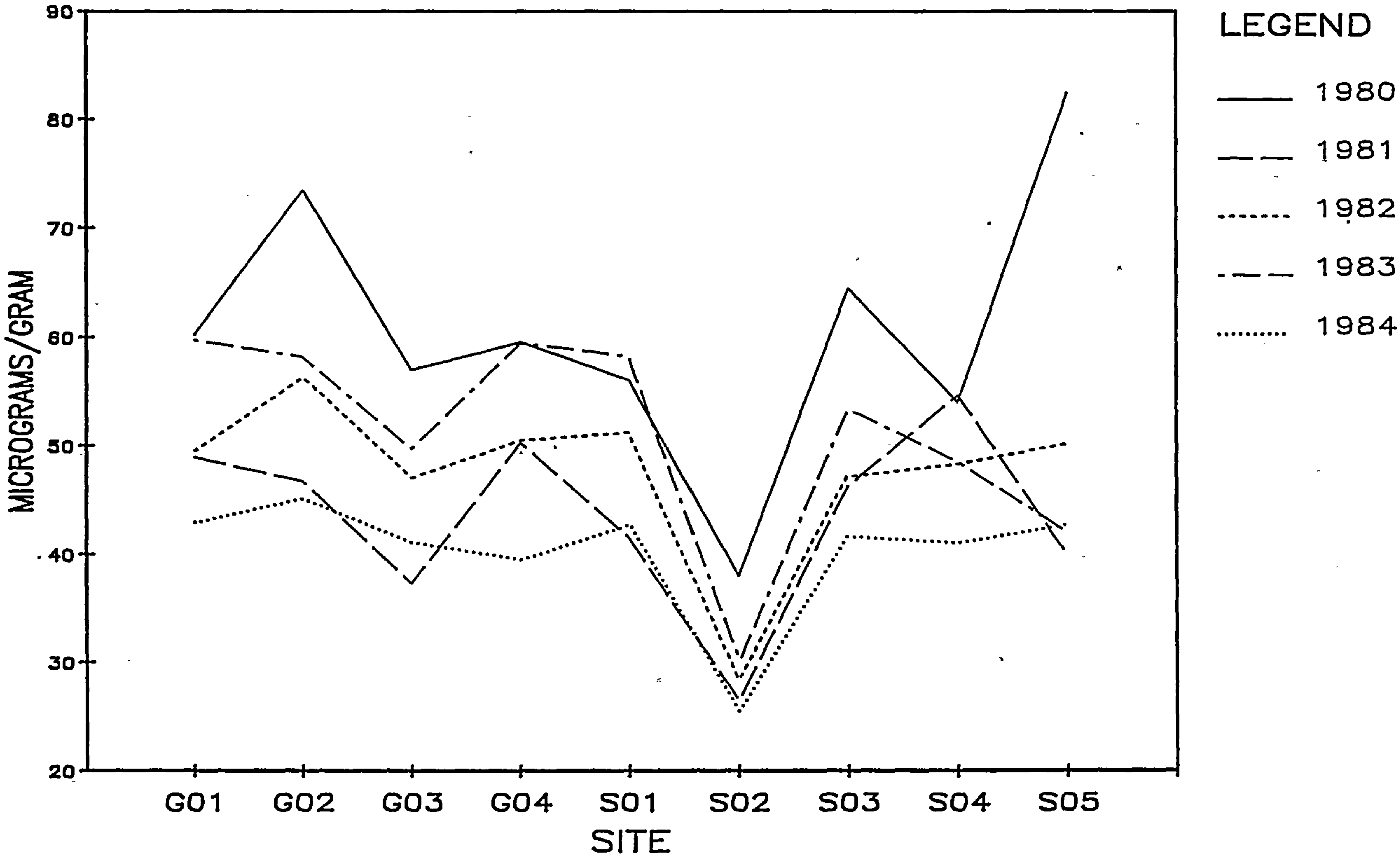


FIGURE 7-45

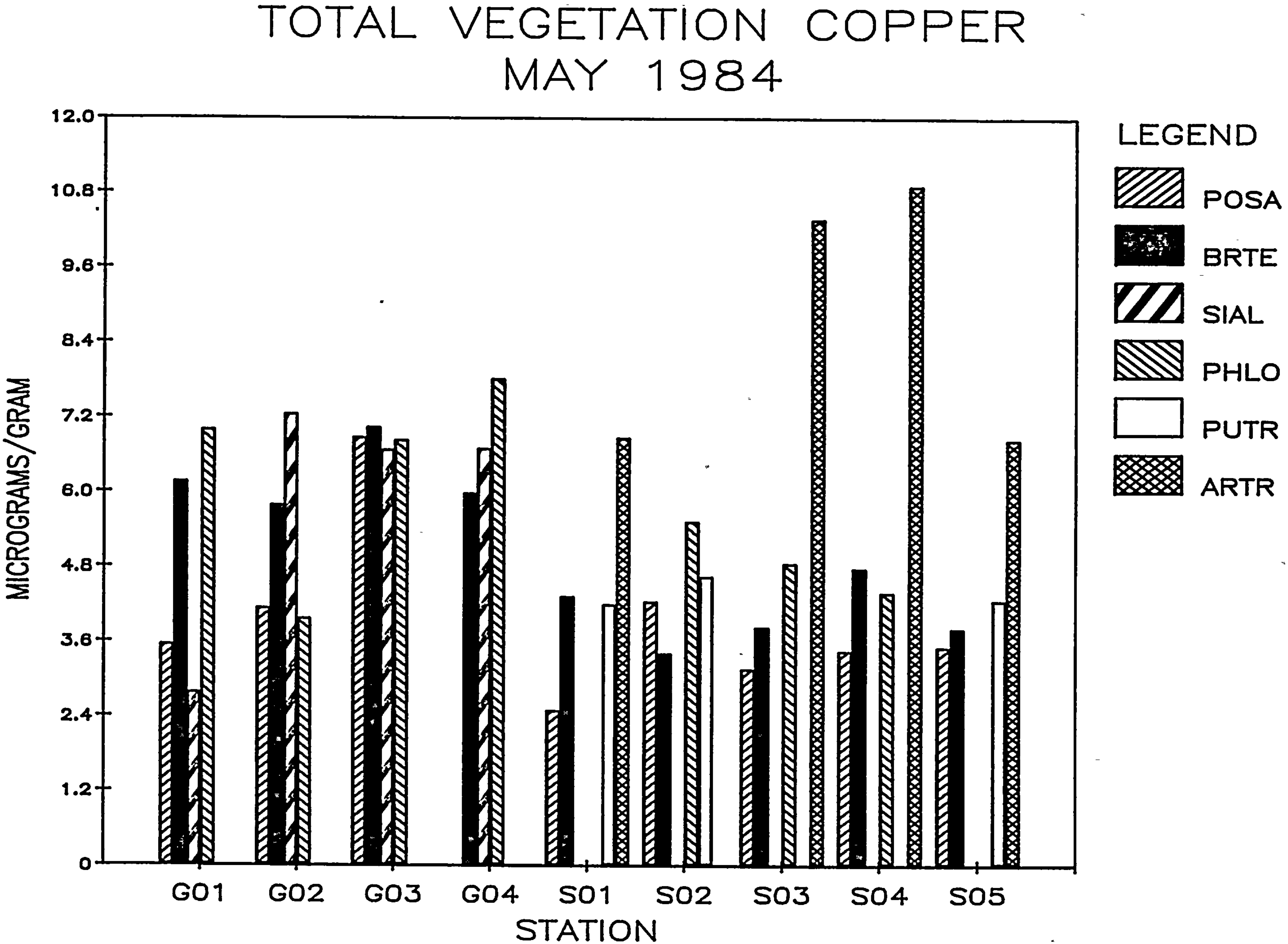

TOTAL VEGETATION COPPER
MAY 1984
MICROGRAMS/GRAM
12.0
10.8
9.6
8.4
7.2
6.0
4.8
3.6
2.4
1.2
0
G01
G02
G03
G04
S01
S02
S03
S04
S05
STATION
LEGEND
POSA
BRTE
SIAL
PHLO
PUTR
ARTR

FIGURE 7-[illegible]6

TOTAL VEGETATION SULFATE
MAY 1984

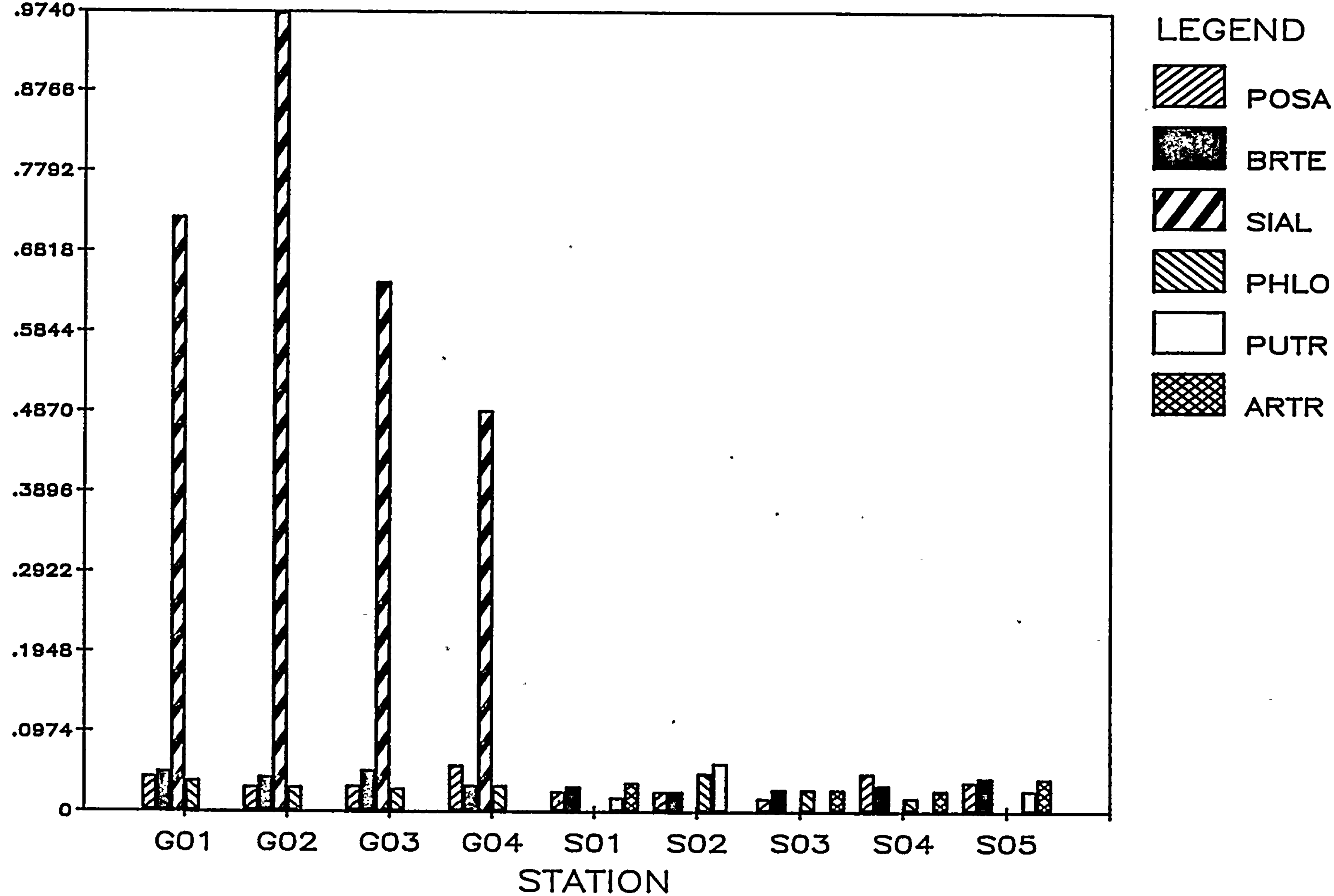


FIGURE 7-47

TOTAL VEGETATION CHLORIDE
MAY 1984

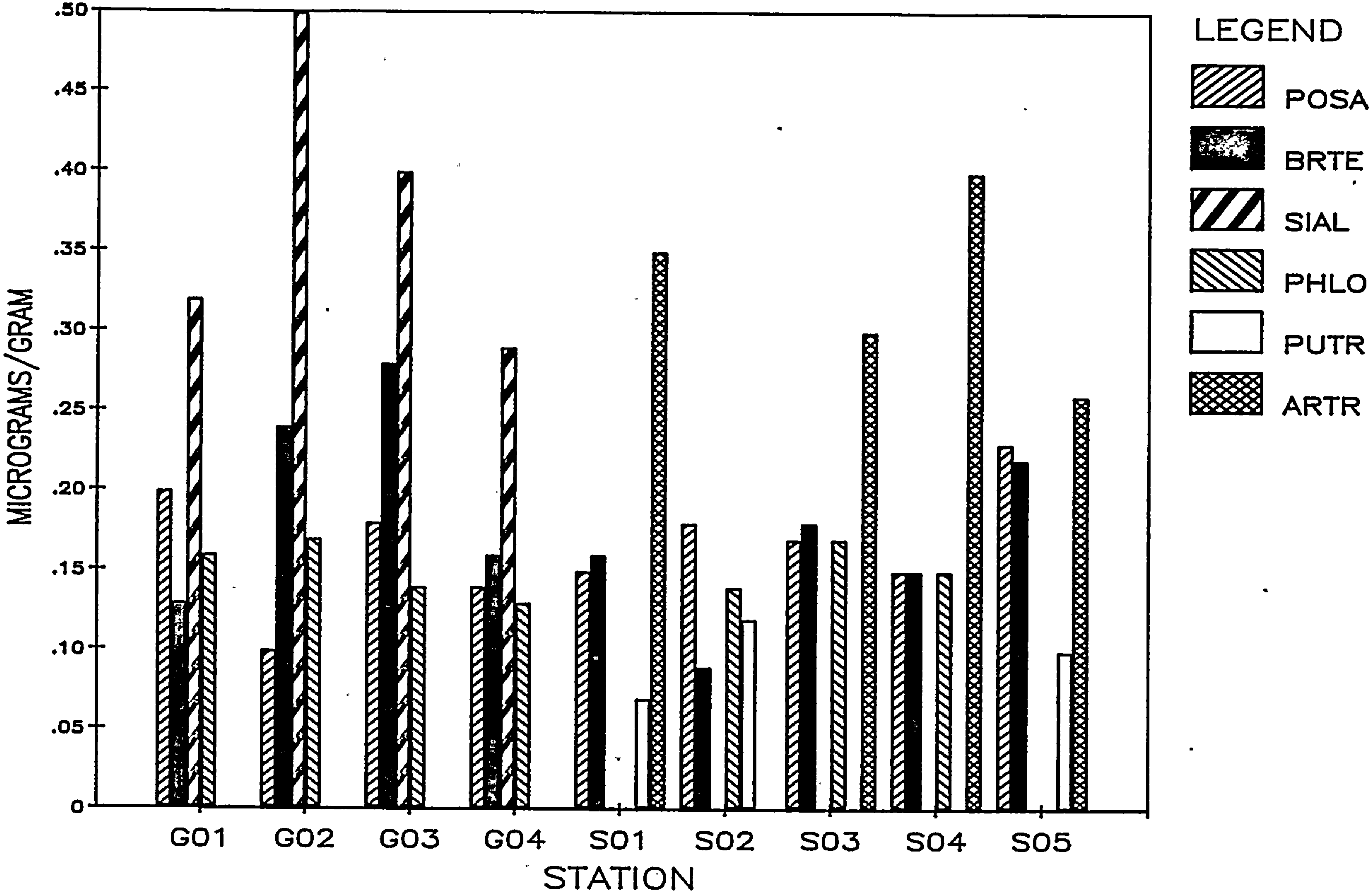


FIGURE 7-48

COPPER CONCENTRATIONS IN BROMUS TECTORUM 1980 THROUGH 1984 SITES G01–G04, S01–S05

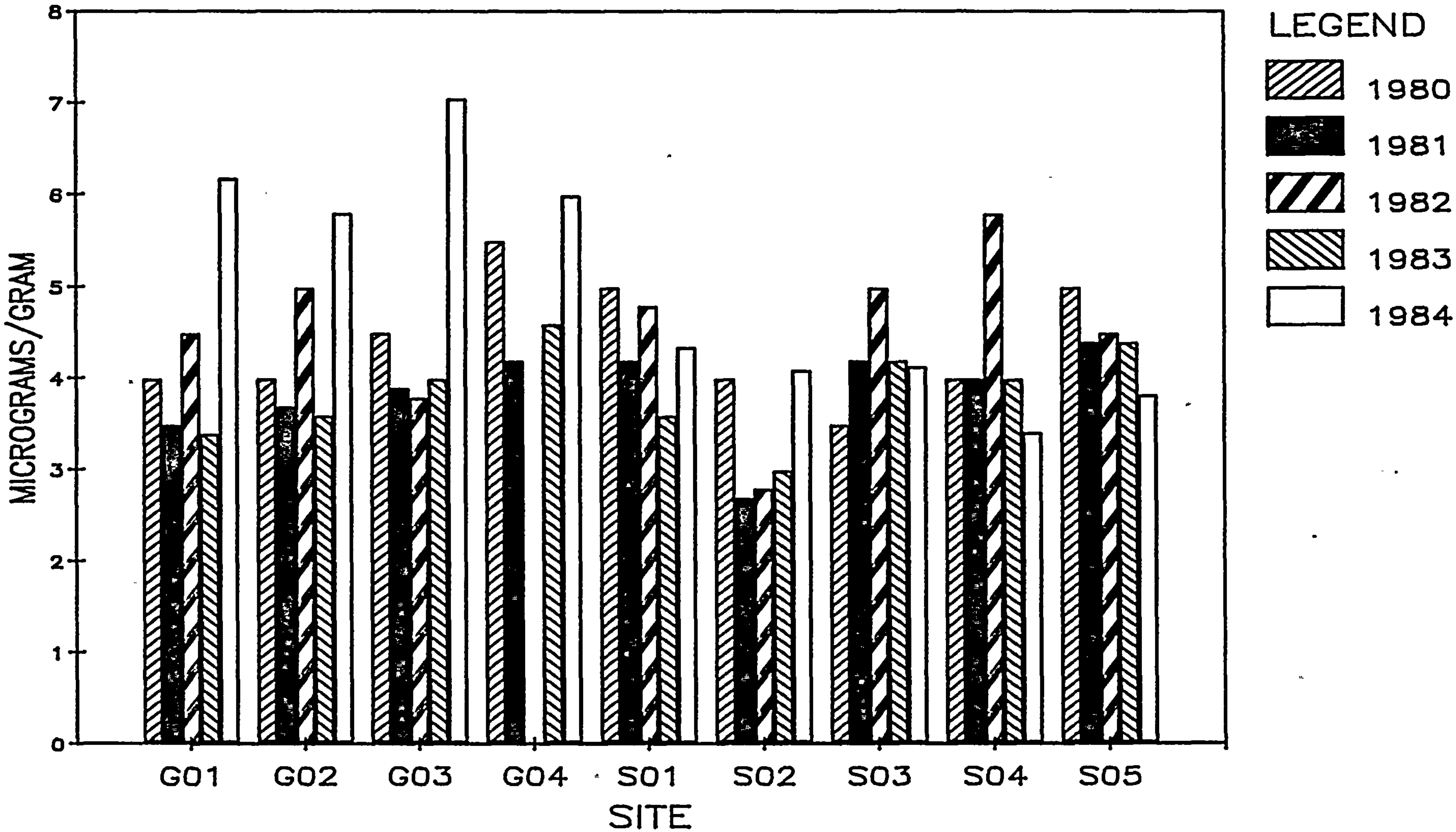


FIGURE 7-49

CHLORIDE CONCENTRATIONS IN BROMUS TECTORUM 1980 THROUGH 1984 SITES G01—G04, S01—S05

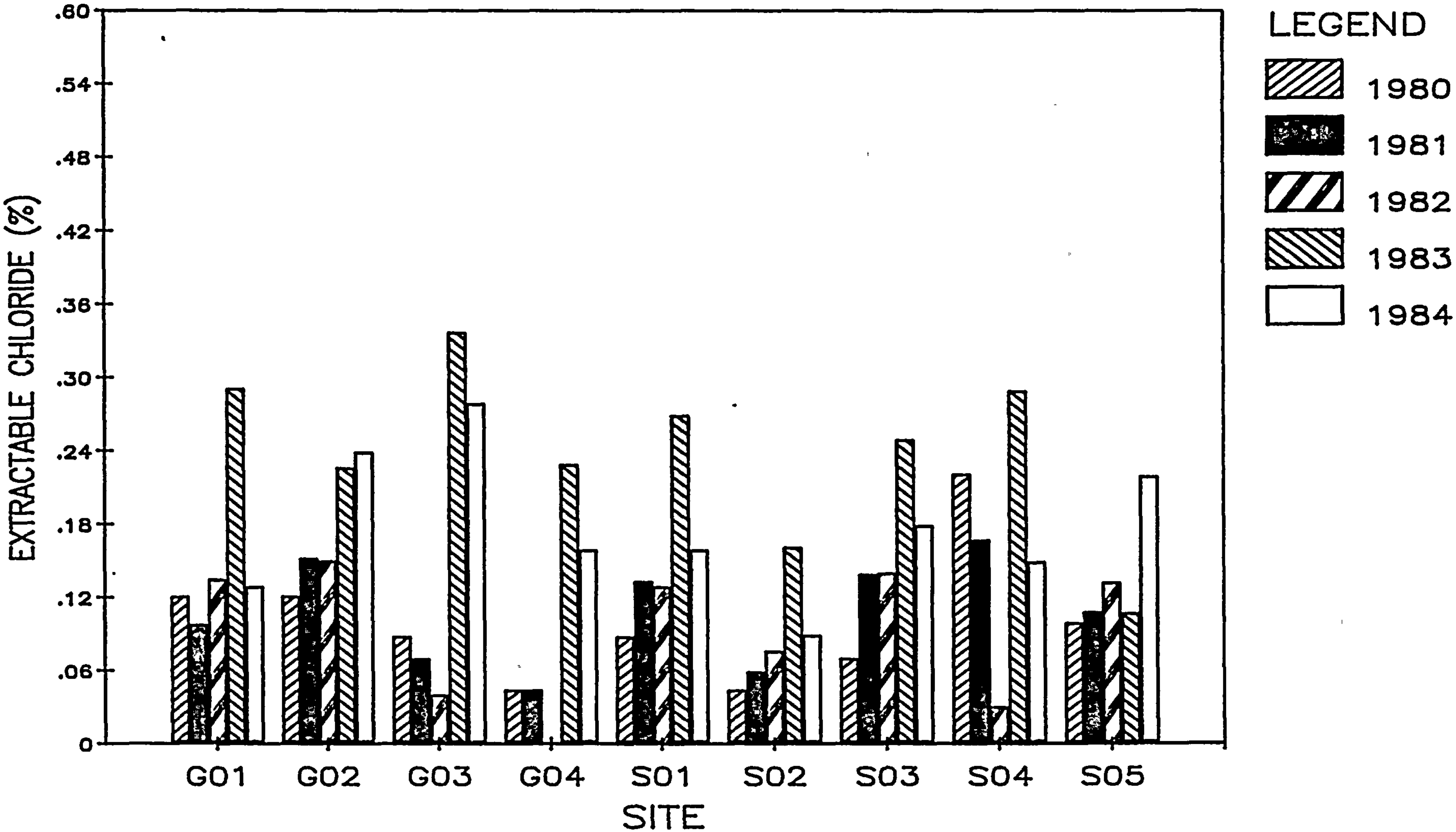


FIGURE 50

CHLORIDE CONCENTRATIONS IN POA SANDBERGII 1980 THROUGH 1984 SITES G01–G04, S01–S05

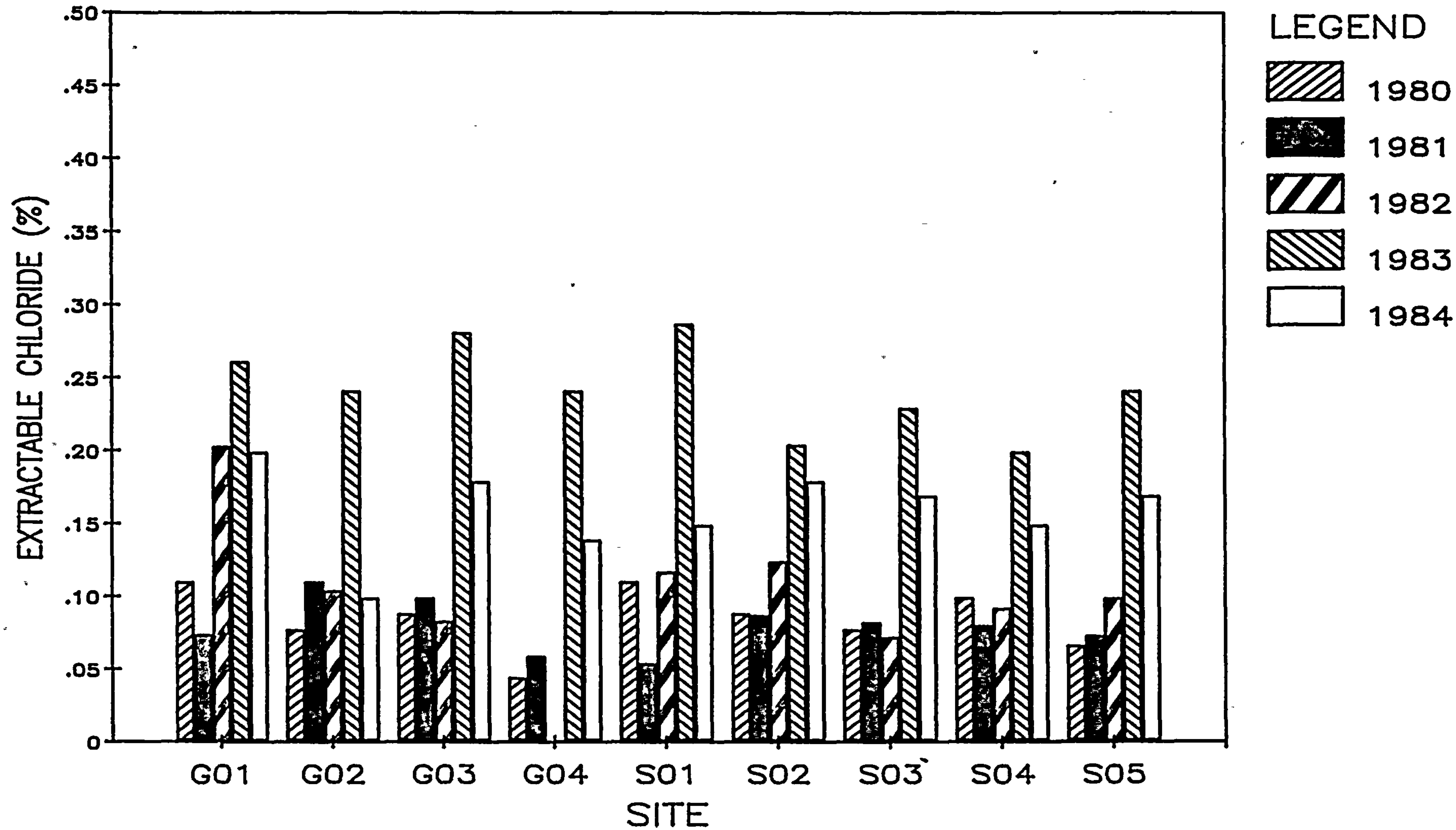
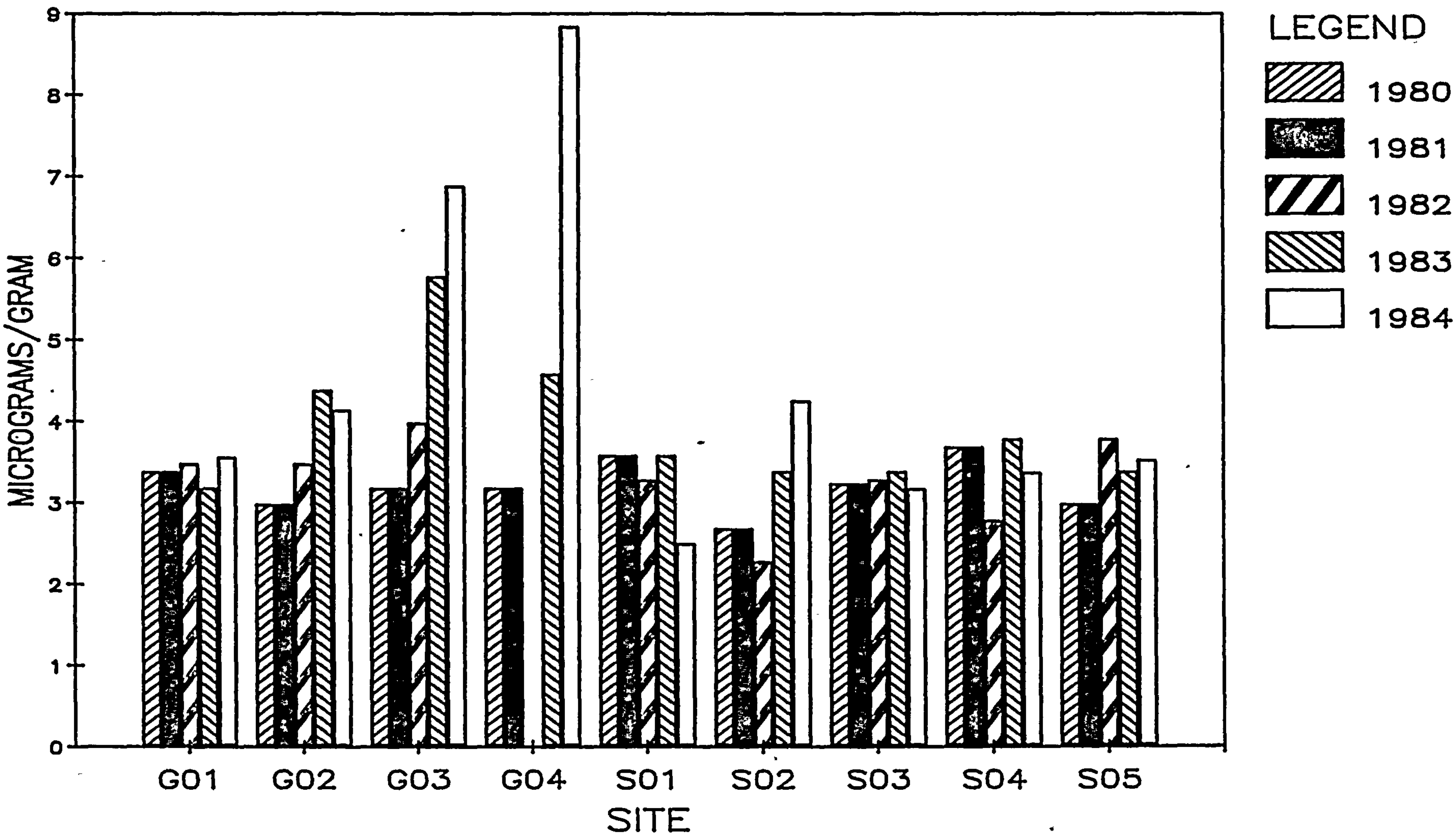


FIGURE 7-5

COPPER CONCENTRATIONS IN POA SANDBERGII 1980 THROUGH 1984 SITES G01-G04, S01-S05



8.0 TERRESTRIAL - ANIMAL

8.1 INTRODUCTION

The habitat found in the vicinity of WNP-1 and WNP-2 supports avian, deer and rabbit communities that may be affected by plant construction and operation. Direct effects such as physical disturbance and noise as well as indirect effects through changes in the abundance of food items, are potentially related to plant construction and operation activities. The objectives of the bird, deer, and rabbit census programs are to document the presence or absence of plant related impacts and to define the temporal and spatial limits of nature population changes in these communities prior to WNP-1 and WNP-2 operation. These surveys fulfill requirements imposed by the Energy Facility site Evaluation Council Resolution Nos. 194 and 195 dated May 26, 1981.

8.2 MATERIALS AND METHODS

Birds

The 1984 spring and fall surveys of bird communities were conducted May 17, 18, 22-25 and October 9 - 12, 16 and 17. The surveys were conducted on four, 20-acre plots (Figure 8.1). Two plots are north and two are south of the WNP-1 and WNP-2 sites. The plots are located in two different biomes, riparian (river), and shrub steppe. All the surveys were started at sunrise. By rotating which plot (and biome) we started with each day, each plot was surveyed at different times of the morning.

The investigator traveled approximately the same route each day within each plot. The starting and ending time, distance walked, and weather were noted. Each bird encountered within the plot was noted as well as those birds observed within one kilometer of the plot.

Deer and Rabbit

The 1984 census was conducted within 150, 25m^2 circular plots. The spring and fall counts were performed during the May 17 - 24 and October 9 - 11 time periods, respectively. The sample areas are located in bitterbrush-sagebrush,

riparian, and burned habitats both north and south of the WNP-1 and WNP-2 site. There are 25 circular plots for each of the six different sample areas (Figure 8.1). The pellet-group/pellets-count technique is used as an index to calculate deer and rabbit population size based on the density of fecal pellet groups/pellets, the desposition period, and regional defecation rate. The investigator proceeds to the monitoring location; the date, time, and weather conditions are noted. The plots are searched for pellets by placing the looped end of a 2.825 meter rope over a nail on the stake that is in the center of each plot. Using the 1 meter and 2 meter marks on the rope, the investigator searches around the stake at each of these intervals and the edge of the plot. The pellet groups are recorded and then removed from the plot. Rabbit pellets are counted individually.

Using the total number of deer and rabbit pellet groups/pellets found in each plot during the semi-annual census, the mean density of deer or rabbits can be calculated per square kilometer for each sample area. The deer and rabbit density for each sample area was calculated by using the formula:

$$\text{Number of deer or rabbits} = \frac{\dfrac{\text{Total number of pellets}^{(a)} \text{ or pellet goups}^{(b)}}{(\text{Number of plots})\ (\text{Size of plot, m}^2)}}{(\text{Days between sample collections})(\text{Pellets}^{(a)} \text{ or pellet groups}^{(b)})} \times 10^{6}$$

(a) = 530 rabbit pellets per individual per day (8-1)

(b) = 13 deer pellet groups per individual per day (8-8)

8.3 RESULTS AND DISCUSSION

Birds

Tables 8.1 and 8.2 present the 1984 spring and fall data, which includes the number of bird species sighted and their frequencies within and outside the plots. Twenty-four different species were observed within the south riparian during the spring survey and five species were observed outside the plot. During the fall survey the south riparian again had the largest number of

species, fifteen within the plot and three outside. Of the four plots the south riparian continues to be the most productive in sighting. Total species sighted during the four years are listed below.

Number of Species

Year	Spring	Fall
1984	29	15
1983	35	21
1982	41	24
1981	32	26

The weekend of August 11 and 12 a range fire, started by lightening north of Prosser, Washington burned approximately 300,000 acres. The vast majority of range land burned was on the Hanford Reservation and within this burned area were the three northern samples plots, north shrub, north grass, and north riparian. Our northern sample plots were destroyed by the fire, and high winds following the fire caused severe drifting of sand which obliterated most circular plot areas that were still visible after the fire (Figures 8.2 and 8.3). As a result of the fire, EFSEC allowed the Supply System to terminate sampling in the three northern areas. (EFSEC Resolution No. 223 October 29, 1984) The fall sample data only reflects the southern plots for both bird, deer and rabbit surveys.

The number of sightings was used to calculated density per acre. However, to calculate density, only low-flying and perching birds were counted. Because of their transient behavior, flocks that were noted as passing through the plots were not included in the density calculations. Tables 8.3 and 8.4 show the spring and fall density figures.

Spring and fall percent composition data are shown on Tables 8.5 and 8.6, respectively. Percentages are figured on those birds appearing within the sample plots.

Red-winged blackbirds, western meadowlarks, white-crowned sparrow, and California Quail comprised 64.2 percent of the birds observed in 1984 (Table 8.7). Waterfowl and shorebirds observed were: duck, geese, gulls, loons, Killdeer, herons and curlews. Only three species of raptors were observed in 1984: loggerhead shrike, red-tailed hawk, and marsh hawk. The game birds observed during the survey include Canada goose, greenwing teal, mallard duck, morning dove, and ring-necked pheasant. Table 8.8 lists all bird species observed during the 1981 through 1984 surveys.

During the 1984 surveys, a total of 39 different species was recorded as compared to 43 during the 1983 and 48 in the 1982 surveys. Twenty-five species recorded in 1984 were also recorded in 1981-1983 studies. Species not recorded in all years were generally low in abundance. Yellow-head blackbirds and Audubon's warblers which were first sighted in the 1983 survey, were sighted again in the 1984 survey. A yellow warbler was seen for the first time in the 1984 survey, all three species were sighted in the riparian areas. In general the seasonal trends in total sightings and species numbers observed in the 1981 census were evident in the 1982 and 1983 census. Due to the range fire and a cold spring, the 1984 species number and counts were below that of the previous studies. Temperatures for May and October 1984, the two census months were both the coldest on record (8-15). The range fire which limited the census to the south plot areas accounts for the low species count in the fall census. May 1984 was the coldest May on record with an average daily temperature of 56°F. Bird activity is undoubtedly lower in cold weather and may account for the lower species count. The following table presents the 1981-1984 temperatures for May sample dates which illustrates this point.

	High Daily Temperature				Low Daily Temperature			
Year	N	$\overline{X}$	SD	R	N	$\overline{X}$	SD	R
1981	6	79.0	3.5	74-84,	6	48.2	5.9	39-54
1982	6	80.2	8.9	65-88,	6	49.3	5.7	42-56
1983	6	86.7	8.9	73-94,	6	54.7	6.7	49-65
1984	6	68.3	5.2	62-76,	6	41.2	3.5	38-47

N = Sample days

$\overline{X}$ = Mean

SD = Standard Deviation

R = Range

Deer and Rabbits

Deer and rabbit densities per sample area for the spring and fall 1984 surveys are presented in Tables 8.9 and 8.10, respectively. The number of deer and rabbit pellet groups per plot for the spring and fall surveys are presented in Tables 8.11 and 8.12, respectively.

Deer densities (deer/km^2) were highest in the south shrub and north riparian sample areas for the spring census periods (Table 8.9). All other sample areas had relatively low density values. The south shrub area had the highest densities for the four years reported and the 1982 density values were higher than in 1981, 1983, and 1984 (Table 8.9). It appears that deer densities near WNP-1 and WNP-2 are low compared to other areas sampled both inside and outside Washington state (8-2; 8-5; 8-9; 8-14).

The highest rabbit densities (rabbit/km^2) were in the north and south shrub areas for all sampling periods in 1981 - 1984 (Table 8.10). The north riparian and south grass had relatively low density values, all remaining plots showed no signs of rabbit pellets. The results of this study are in good agreement with those reported by others (8-3; 8-4; 8-7).

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TABLE 8.1
BIRD SPRING SURVEY 1984

North Riparian

Species List	On Plot * 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Total
American robin														
Bank swallow					2	5	7			10				10
Barn swallow										2				2
Black-billed magpie	2	2	2		1		7	1	2	4		3		10
Brewer's blackbird														
Brown-head cowbird														
Bullock's oriole														
California quail														
Canada goose										3				3
Common raven														
Eastern kingbird														
Foster tern										3			1	4
Great blue heron										2		1		3
Green wing teal		1					1							
Herring gull														
Horned lark			1		1		2					1	3	4
Killdeer	4	5	3	3		1	16	4	7	3		4		18
Lark sparrow														
Loggardhead shrike														
Long-billed curlew	1						1			2			1	3
Mallard				2			2		8	1				9
Mourning dove								1		2				3
Red-tail hawk														
Red-winged blackbird	17	20	17	17	9	13	93		17	18	15	3	7	60
Ring-necked pheasant	1					1	2							
Sage Sparrow														
Savannah sparrow	1	1		1			3							
Savs phebe														
Western kingbird														
Western meadow lark	8	5	4	3	4	1	25	7	12	9	10	5		43
White-crown sparrow	2						2							
Yellow warbler														
Yellowhead blackbird														
Unidentified blackbird				6	2		8	4			4	9	20	37
Unidentified gull	1					1	2	6		8		3	7	24
Unidentified hawk														
Unidentified sparrow	2	1					3		3		3			6
Unidentified swallow				3			3			3	7	1		11
Unidentified tern														
Unidentified species														
Total Sightings							·177							250
Number of Species							16							17

South Riparian

Species List	On Plot 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Total
American robin						2	2							
Bank swallow				4		1	5				2	5		7
Barn swallow				3			3							
Black-billed magpie	5	5	2	3	2	2	19		2	3	1			6
Brewer's blackbird		2	1				3							
Brown-head cowbird	2	1	1	1			5							
Bullock's oriole	1	3	2	2	4	3	15			8				8
California quail			2				2							
Canada goose								15	10	9	4	13		51
Common raven														
Eastern kingbird			2	5	1	2	10					1	1	2
Foster tern	1	1					2			6			2	8
Great blue heron								1	1			2	1	5
Green wing teal														
Herring gull		1					1							
Horned lark			1		1		2							
Killdeer														
Lark sparrow					2		2							
Loggardhead shrike														
Long-billed curlew												1		1
Mallard											1	1		2
Mourning dove	2			1			3			1		1		2
Red-tail hawk	1						1							
Red-winged blackbird	6	3	1	20	3	4	37	3	3	5	12	1	1	25
Ring-necked pheasant					1		1							
Sage Sparrow		1					1							
Savannah sparrow				1			1							
Savs phebe		1					1							
Western kingbird	3	3	5		3	1	15	3	1	1				5
Western meadow lark	3	2	4	1	2	2	14	3	3	1	11	1	3	22
White-crown sparrow		1					1							
Yellow warbler				1			1							
Yellowhead blackbird													1	1
Unidentified blackbird	9	7		1	3		18	3	5	7		7	3	25
Unidentified gull	3	1		3		1	8	13	9	26	11	11	3	73
Unidentified hawk										2				2
Unidentified sparrow	1	1		1			3	1				7		8
Unidentified swallow	2	1			1		4	5		3				8
Unidentified tern									1	3		1		5
Unidentified species		2					2		1					1
Total Sightings							182							267
Number of Species							29							21

* Dates of Surveys

1 - May 17, 1984 3 - May 22, 1984 5 - May 24, 1984

2 - May 18, 1984 4 - May 23, 1984 6 - May 25, 1984

TABLE 8.1 (Cont'd)
BIRD SPRING SURVEY 1984

Species List	North Shrub On Plot * 1	2	3	4	5	6	Total	North Shrub Off Plot 1	2	3	4	5	6	Total	South Shrub On Plot 1	2	3	4	5	6	Total	South Shrub Off Plot 1	2	3	4	5	6	Total
American robin																												
Bank swallow															2						2	4						4
Barn swallow																												
Black-billed magpie												1		1					1		1	1	2	3	3			9
Brewer's blackbird																												
Brown-head cowbird																												
Bullock's oriole																												
California quail																	1				1	1		1	2			4
Canada goose																												
Common raven												2		2										1				1
Eastern kingbird																												
Foster tern																												
Great blue heron																												
Green wing teal																												
Herring gull																												
Horned lark									1					1												1		1
Killdeer																				1	1							
Lark sparrow																												
Loggardhead shrike		1		1			2			2	1	1	1	5									1		1			2
Long-billed curlew																								1			1	2
Mallard																										2		2
Morning dove								2	1					3	2						2							
Red-tail hawk																												
Red-winged blackbird																				1	1		2					2
Ring-necked pheasant																						1			1			2
Sage sparrow	3	3		1	2	1	10	1	2					3														
Savannah sparrow																												
Says phebe																												
Western kingbird																2					2		1					1
Western meadow lark	2	2	1	1	1	4	11	9	7	5	4	7	6	38	4	5	4	2	1	4	20	6	11	5	6	5	6	39
White-crown sparrow			1				1																					
Yellow warbler																												
Yellowhead blackbird																												
Unidentified blackbird																						6	5		5			16
Unidentified gull																				3	3		4	4		2	6	16
Unidentified hawk																												
Unidentified sparrow				1		1	2				2	1	2	5	1			1		1	3				3	1		4
Unidentified swallow																												
Unidentified tern																								2				2
Unidentified species																												
Total Sightings							26							58							34							107
Number of Species							5							8							6							16

* Dates of Surveys
1 - May 17, 1984   3 - May 22, 1984   5 - May 24, 1984
2 - May 18, 1984   4 - May 23, 1984   6 - May 25, 1984

TABLF 8.2
HANFORD BIRD SURVEY: October 9 - 17, 1984

	South Riparian														South Shrub													
	On Plot							Off Plot							On Plot							Off Plot						
Species	* 1	2	3	4	5	6	Total	1	2	3	4	5	6	Totals	1	2	3	4	5	6	Total	1	2	3	4	5	6	Totals
Audubon's warbler	3						3																					
Blackbilled magpie	3	1		1	3	3	11				4		2	6	1						1	1					1	2
Brewer's blackbird					1		1																					
California quail	30		9			22	61																					
Canada goose											25	50	12	87								2				50		52
Common loon													1	1														
Great blue heron				1	4		5	1			2	2	1	6								1				1		2
Killdeer								5	2		10			17								6	10					16
Loggerhead shrike				1		2	3																					
Mallard								115	12	17	17		50	211														
Marsh hawk	1			1	1	1	4									1					1	2		1				3
Oregon junco	1	1					2																					
Ped-shafted flicker		2		2			4																					
Red-winged blackbird	1			2			3																20					20
Ring-necked pheasant	3		3	3			9					1		1					1		1							
Savannah sparrow			1		1	1	3			1		1		2	2	1		1			4							
Song sparrow						3	3																					
Western meadowlark	8				2	1	11		2			3		5	1	3	2	1	4	2	13	5	2	6	3	5	3	24
White-crowned sparrow	25	4	17	11	20		77		2		3			5						1	1							
Unidentified blackbird																												
Unidentified gull	2			3			5	9	5	3	5	8	5	35				2			2			2	5	4	3	14
Unidentified sparrow	7	4		2		1	14		3	1	28		2	34	2	3	2	4		1	12	9	6	30	2	1	3	51
Unidentified species															2						2	7						7
Total Sightings							219							410							37							196
Number of Species							17							12							9							12

* Dates of Surveys
1 - October 9, 1984
2 - October 10, 1984
3 - October 11, 1984
4 - October 12, 1984
5 - October 16, 1984
6 - October 17, 1984

TABLE 8.3

BIRD SPRING SURVEY DENSITIES: May 17 - 25, 1984

Species	N[a] North Shrub	N/A[b]	N North Riparian	N/A
Bank swallow			7	.35
Black-billed magpie			7	.35
Green wing teal			1	.05
Horned lark			2	.1
Killdeer			16	.8
Loggerdhead shrike	2	.1		
Long-billed curlew			1	.05
Mallard duck			2	.1
Red-wing black bird			93	4.65
Ring-necked pheasant			2	.1
Sage sparrow	10	.5		
Savannah sparrow			3	.15
Western meadow lark	11	.55	25	1.25
White-crown sparrow	1	.05	2	.1

[a]N = Number of birds observed
[b]N/A = Number of birds per acre

TABLE 8.3 (Cont'd)

BIRD SPRING SURVEY DENSITIES: May 17 - 25, 1984

Species	N[a] South Shrub	N/A	N South Riparian	N/A
American robin			2	.1
Bank swallow	2	.1	5	.25
Barn swallow			3	.15
Black-billed magpie	1	.05	19	.95
Brewer's blackbird			3	.15
Brownhead cowbird			5	.25
Bullock's oriole			15	.75
California quail	1	.05	2	.1
Eastern kingbird			10	.5
Foster tern			2	.1
Herring gull			1	.05
Horned lark			2	.1
Killdeer	1	.05		
Lark sparrow			2	.1
Morning dove			3	.15
Red-tail hawk			1	.0[illegible]
Red-winged blackbird	1	.05	37	1.85
Ring-necked pheasant			1	.05
Sage sparrow			1	.05
Savannah sparrow			1	.05
Says phoebe			1	.05
Western kingbird	2	.1	15	.75
Western meadowlark	20	1.	14	.70
White-crowned sparrow			1	.05
Yellow warbler			1	.05

[a]N = Number of birds observed

[b]N/A = Number of birds per acre

TABLE 8.4

BIRD FALL SURVEY DENSITIES: October 9 - 17, 1984

Species	N[a] North Shrub	N/A[b]	N North Riparian	N/A
Audubon's warbler			3	.15
Black-billed magpie	1	.05	11	.55
Brewer's blackbird			1	.05
California quail			61	3.05
Great blue heron			5	.25
Loggerhead shrike			3	1.5
Marsh hawk	1	.05	4	.2
Oregon junco			2	.1
Red-shafted flicker			4	.2
Red-wing blackbird			3	.15
Ring-necked pheasant	1	.05	9	.45
Savannah sparrow	4	.2	3	.15
Song sparrow			3	.15
Western meadowlark	13	.65	11	.55
White-crowned sparrow	1	.05	77	3.85

(a)N = Number of birds observed

(b)N/A = Number of birds per acre

TABLE 8.5

BIRD SPRING SURVEY PERCENTAGES: May 17 - 25, 1984

Species	#Sightings North Shrub	Percent Composition	#Sightings Within North Riparian	Percent Composition
Bank swallow			7	4.3
Black-billed magpie			7	4.4
Green winged teal			1	.6
Horned lark			2	1.2
Killdeer			16	9.9
Loggardhead shrike	2	8.3		
Long-billed curlew			1	.6
Mallard			2	1.2
Red-winged blackbird			93	57.7
Ring-necked pheasant			2	1.2
Sage sparrow	10	41.6	3	1.8
Western meadow lark	11	45.8	25	15.5
White-crowned sparrow	1	4.1	2	1.2
Total Sightings	24		161	

TABLE 8.5 (Cont'd)

BIRD SPRING SURVEY PERCENTAGES: May 17 - 25, 1984

Species	#Sightings South Shrub	Percent Composition	#Sightings Within South Riparian	Percent Composition
American robin			2	1.3
Bank swallow	2	7.1	5	3.4
Barn swallow			3	2.0
Black-billed magpie	1	3.5	19	12.9
Brewing blackbird			3	2.0
Brownhead cow bird			5	3.4
Bullock's oriole			15	10.2
California quail	1	3.5	2	1.3
Eastern kingbird			10	6.8
Foster tern			2	1.3
Herring gull			1	.6
Horned lark			2	1.3
Killdeer	1	3.5		
Lark sparrow			2	1.3
Morning dove			3	2.0
Re[illegible]ail hawk			1	.6
Red-winged blackbird	1	3.5	37	25.1
Ring-necked pheasant			1	.6
Sage sparrow			1	.6
Savannah sparrow			1	.6
Says phoebe			1	.6
Western kingbird	2	7.1	15	10.2
Western meadowlark	20	71.4	14	9.5
White-crowned sparrow			1	.6
Yellow warbler			1	.6
Total Sightings	28		147	

TABLE 8.6

BIRD FALL SURVEY PERCENTAGES: October 9 - 17, 1984

Species	#Sightings North Shrub	Percent Composition	#Sightings Within North Riparian	Percent Composition
Audubon's warbler			3	1.5
Black-billed magpie	1	4.7	11	5.5
Brewer's blackbird			1	.5
California quail			61	30.5
Great blue heron			5	2.5
Loggerhead shrike			3	1.5
Marsh hawk	1	4.7	4	2.0
Oregon junco			2	1.0
Red-shafted flicker			4	2.0
Red-winged blackbird			3	1.5
Ring-necked pheasant	1	4.7	9	4.5
Savannah sparrow	4	19.	3	1.5
Song sparrow			3	1.5
Western meadowlark	13	61.9	11	5.5
White-crowned sparrow	1	4.7	77	38.5
Total Sightings	21		200	

TABLE 8.7

LIST OF TEN (10) MOST SIGHTED BIRDS AND PERCENT COMPOSITION FOR 1984

	Species	Sighted	*Percent Composition
1.	Reg-winged blackbird	134	23.1
2.	Western meadowlark	94	16.2
3.	White-crowned sparrow	81	13.9
4.	California quail	64	11.0
5.	Black-billed magpie	39	6.7
6.	Killdeer	17	2.9
7.	Western kingbird	17	2.9
8.	Bullock's oriole	15	2.5
9.	Bank swallow	14	2.4
10.	Ring-necked pheasant	13	2.2
			83.8

*Percentages are derived from total identified birds sighted inside the plots for 1984.

*Total birds sighted within plots 580.

TABLE 8.8

BIRD SPECIES LIST

	Identified	Spring 1981-1984	Fall 1981-1984	Previous Studies*
1.	American coot	X	X	
2.	American goldfinch	X		
3.	American kestrel	X	X	X
4.	American robin	X	X	
5.	Audubon's warbler		X	
6.	Bald eagle		X	
7.	Bank swallow	X		
8.	Barn swallow	X	X	X
9.	Black-billed magpie	X	X	X
10.	Blue-wing teal	X		
11.	Brewer's blackbird	X		
12.	Brownhead cowbird	X		
13.	Bullock's oriole	X		
14.	Burrowing owl		X	X
15.	California quail	X	X	
16.	Canada goose	X	X	
17.	Cinnamon teal	X		
18.	Cliff swallow	X		X
19.	Common crow	X	X	
20.	Common loon	X	X	
21.	Common merganser	X		
22.	Common nighthawk	X		X
23.	Common raven	X	X	X
24.	Common tern	X		
25.	Eared grebe		X	
26.	Eastern kingbird	X		
27.	Ferruginous hawk			X

TABLE 8.8 (Cont'd)

BIRD SPECIES LIST

	Identified	Spring 1981-1984	Fall 1981-1984	Previous Studies*
28.	Foster tern	X		
29.	Golden eagle			X
30.	Great blue heron	X	X	
31.	Green-wing teal	X		
32.	Herring gull	X		
33.	Horned lark	X	X	X
34.	Killdeer	X	X	X
35.	Lark sparrow	X		
36.	Loggerhead shrike	X	X	X
37.	Long-billed curlew	X		X
38.	Mallard	X	X	
39.	Marsh hawk (harrier)	X	X	X
40.	Morning dove	X		X
41.	Oregon junco		X	X
42.	Prairie falcon			X
43.	Red-headed duck	X		
44.	Red-shafted flicker		X	X
45.	Red-tailed hawk	X	X	X
46.	Red-wing blackbird	X	X	
47.	Ring-necked pheasant	X	X	
48.	Rock dove (domestic pigeon)	X		
49.	Rough-legged hawk		X	X
50.	Sage sparrow	X	X	X
51.	Savannah sparrow	X	X	X
52.	Say's phoebe	X		
53.	Song sparrow	X		
54.	Spotted sandpiper	X		
55.	Starling	X	X	X

TABLE 8.8 (Cont'd)

BIRD SPECIES LIST

	Identified	Spring 1981-1984	Fall 1981-1984	Previous Studies*
56.	Swainson's hawk		X	
57.	Tree sparrow	X	X	
58.	Water pipit		X	
59.	Western kingbird	X		
60.	Western meadowlark	X	X	X
61.	Western sandpiper		X	
62.	Western gull	X		
63.	Whistling swan		X	
64.	White-crowned sparrow	X	X	X
65.	Wilson's warbler	X		
66.	Yellow warbler	X		
67.	Yellow head blackbird	X		

*Previous studies were performed for the Washington Public Power Supply System by Battelle Pacific Northwest Laboratories (8-10 through 8-13).

TABLE 8.9

DEER PELLET CENSUS: DENSITIES

SPRING 1984

Sample area	Total Pellet Group				Densities (No. of Deer/km^2)			
	1981	1982	1983	1984	1981	1982	1983	1984
North Shrub	--*	3	0	2	--	1.74	0	1.01
South Shrub	--	137	35	25	--	77.31	19.3	14.0
North Riparian	--	11	27	28	--	6.26	14.9	14.9
South Riparian	--	3	5	5	--	1.83	2.7	2.6
North Grass	--	3	4	0	--	1.82	2.1	0
South Grass	--	6	14	27	--	3.63	7.49	14.7

*Plots initially cleared of pellets.

TABLE 8.9 (Cont'd)

DEER PELLET CENSUS: DENSITIES

FALL 1984

Sample area	Total Pellet Group				Densities (No. of Deer/km^2)			
	1981	1982	1983	1984	1981	1982	1983	1984
North Shrub	4	8	1	--*	2.91	7.57	0.89	--
South Shrub	35	79	40	28	28.53	72.56	35.6	23.6
North Riparian	17	18	19	--	12.92	17.44	16.7	--
South Riparian	1	2	6	7	0.76	2.21	5.3	6.1
North Grass	1	1	4	--	0.76	1.13	3.5	--
South Grass	1	6	10	7	0.78	6.65	9.1	5.9

*North plots were not sampled because of range fire on August 11-12, 1984.

TABLE 8.10

RABBIT PELLET CENSUS: DENSITIES

SPRING 1984

Sample area	Total Pellet Group				Densities (No. of Rabbit/km^2)			
	1981	1982	1983	1984	1981	1982	1983	1984
North Shrub	--*	2,795	1,361	1,035	--	31.80	18.1	13.8
South Shrub	--	1,441	1,393	924	--	19.90	18.8	12.7
North Riparian	--	299	641	468	--	4.17	8.68	6.3
South Riparian	--	0	23	0	--	0	.30	0
North Grass	--	0	0	0	--	0	0	0
South Grass	--	0	0	41	--	0	0	.5

*Plots initially cleared of pellets.

TABLE 8.10 (Cont'd)

RABBIT PELLET CENSUS: DENSITIES

FALL 1984

Sample area	Total Pellet Group				Densities (No. of Rabbit/km^2)			
	1981	1982	1983	1984	1981	1982	1983	1984
North Shrub	4,680	2,743	1,549	--*	83.60	63.69	33.8	--*
South Shrub	720	2,717	886	1,337	14.39	61.21	19.1	26.6
North Riparian	120	433	740	--	2.24	10.29	15.9	--
South Riparian	0	0	2	23	0	0	.44	.49
North Grass	120	0	0	--	2.32	0		--
South Grass	0	0	0	2	0	0	0	.004

*North plots were not sampled because of range fire on August 11-12, 1984.

TABLE 8.11

DEER PELLET CENSUS 1984: Number of Pellet Groups

SPRING SURVEY: May 17 - 24, 1984

Plot No.	North Shrub May 23	South Shrub May 18	North Riparian May 24	South Riparian May 21	North Grass May 17	South Grass May 17
1	1	1	0	0	0	1
2	0	1	1	1	0	2
3	0	0	1	3	0	0
4	0	0	0	0	0	1
5	0	2	0	0	0	1
6	0	2	0	0	0	1
7	0	1	0	0	0	1
8	0	3	0	0	0	4
9	0	0	0	0	0	2
10	0	0	0	0	0	2
11	0	1	0	0	0	1
12	0	0	1	0	0	0
13	0	1	0	0	0	4
14	0	2	1	0	0	1
15	0	0	5	0	0	2
16	0	1	2	0	0	0
17	0	0	1	0	0	0
18	0	0	1	0	0	0
19	0	2	0	0	0	0
20	0	1	9	0	0	1
21	1	1	3	0	0	0
22	0	1	1	0	0	1
23	0	2	0	0	0	0
24	0	1	1	0	0	1
25	0	2	1	1	0	1
Total Pellet Groups	2	25	28	5	0	27

TABLE 8.11 (Cont'd)

DEER PELLET CENSUS 1984: Number of Pellet Groups

FALL SURVEY: October 9 - 11, 1984

Plot No.	South Shrub Oct 11	South Riparian Oct 9	South Grass Oct 10
1	2	0	0
2	1	1	0
3	1	1	0
4	2	0	0
5	0	0	0
6	1	0	0
7	1	0	0
8	3	0	1
9	1	0	0
10	1	0	0
11	0	2	0
12	1	0	0
13	2	1	1
14	3	0	0
15	2	0	0
16	1	1	0
17	1	0	0
18	0	0	0
19	1	0	0
20	2	0	2
21	0	0	0
22	1	0	1
23	0	0	1
24	1	0	1
25	0	1	0
Total Pellet Groups	28	7	7

North

TABLE 8.12

RABBIT PELLET CENSUS 1984: Number of Pellets

SPRING SURVEY: May 17 - 24, 1984

Plot No.	North Shrub May 23	South Shrub May 18	North Riparian May 24	South Riparian May 21	North Grass May 17	South Grass May 17
1	4	109	58	0	0	0
2	49	42	0	0	0	0
3	19	0	240	0	0	0
4	26	0	143	0	0	0
5	55	25	0	0	0	0
6	58	172	0	0	0	17
7	65	37	0	0	0	9
8	35	137	0	0	0	0
9	62	78	0	0	0	0
10	70	51	0	0	0	0
11	12	16	0	0	0	0
12	9	8	18	0	0	3
13	62	89	0	0	0	0
14	71	113	0	0	0	0
15	13	0	0	0	0	0
16	137	0	0	0	0	12
17	34	0	0	0	0	0
18	49	9	0	0	0	0
19	26	5	0	0	0	0
20	34	12	3	0	0	0
21	8	14	6	0	0	0
22	58	7	0	0	0	0
23	18	0	0	0	0	0
24	20	0	0	0	0	0
25	41	0	0	0	0	0
Total Pellet Groups	1,035	924	468	0	0	41

TABLE 8.12 (Cont'd)

RABBIT PELLET CENSUS 1984: Number of Pellets

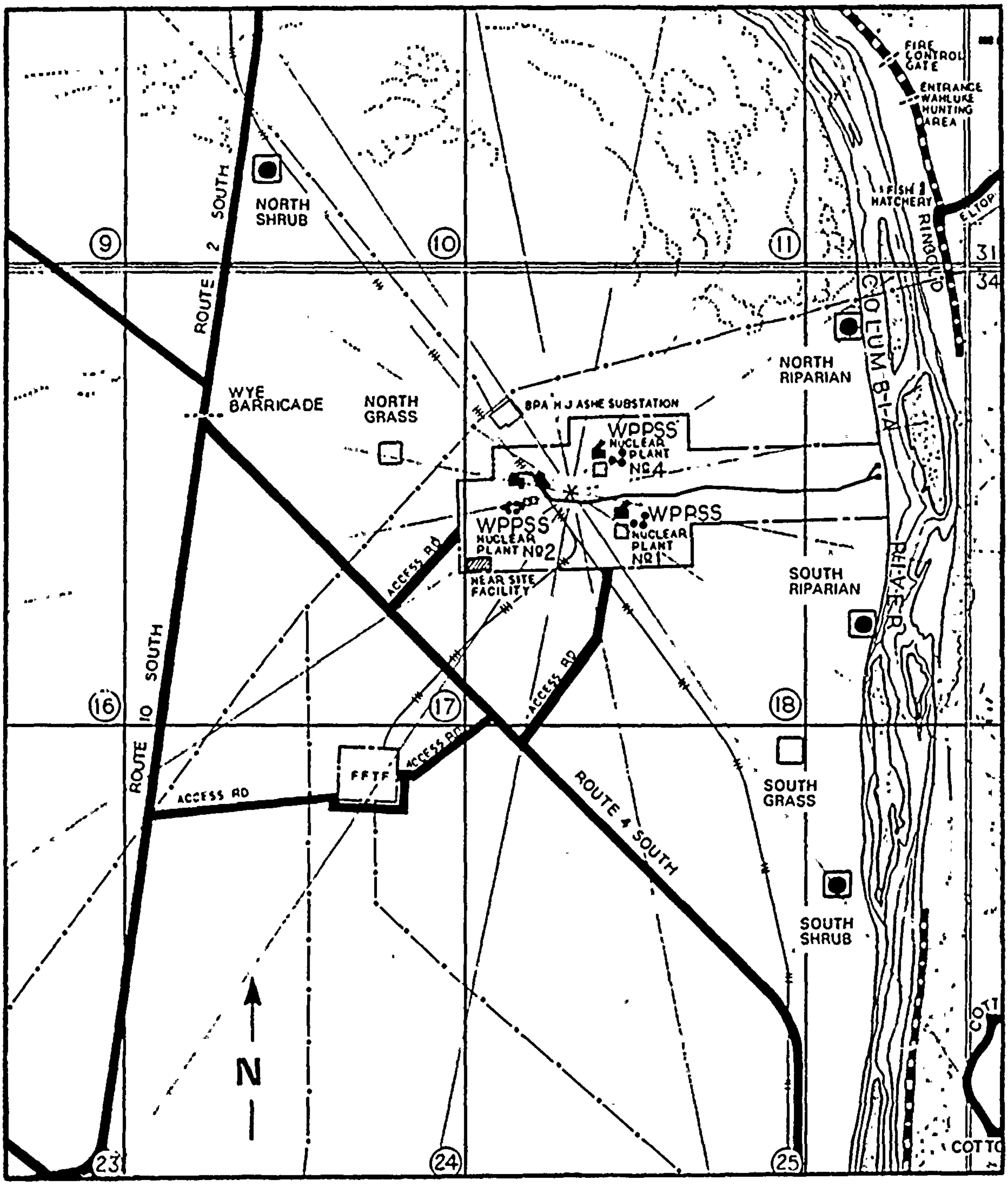
FALL SURVEY: October 9 - 11, 1984

Plot No.*	South Shrub October 11	South Riparian	South Grass October 10
1	95	0	0
2	62	0	0
3	41	23	0
4	41	0	0
5	18	0	0
6	82	0	0
7	8	0	2
8	12	0	0
9	40	0	0
10	16	0	0
11	17	0	0
12	60	0	0
13	83	0	0
14	147	0	0
15	21	0	0
16	17	0	0
17	44	0	0
18	52	0	0
19	45	0	0
20	27	0	0
21	58	0	0
22	45	0	0
23	126	0	0
24	89	0	0
25	91	0	0
Total Pellets	1,337	2[illegible]	2

North plots were not sampled because of range fire on August 11, 1984.

FIGURE 8.1

Deer, Rabbit and Bird Plots in the Vicinity of WNP-1 and WNP-2



DEER RABBIT SAMPLE PLOTS

DEER RABBIT SAMPLE PLOTS AND BIRD CENSUS PLOTS

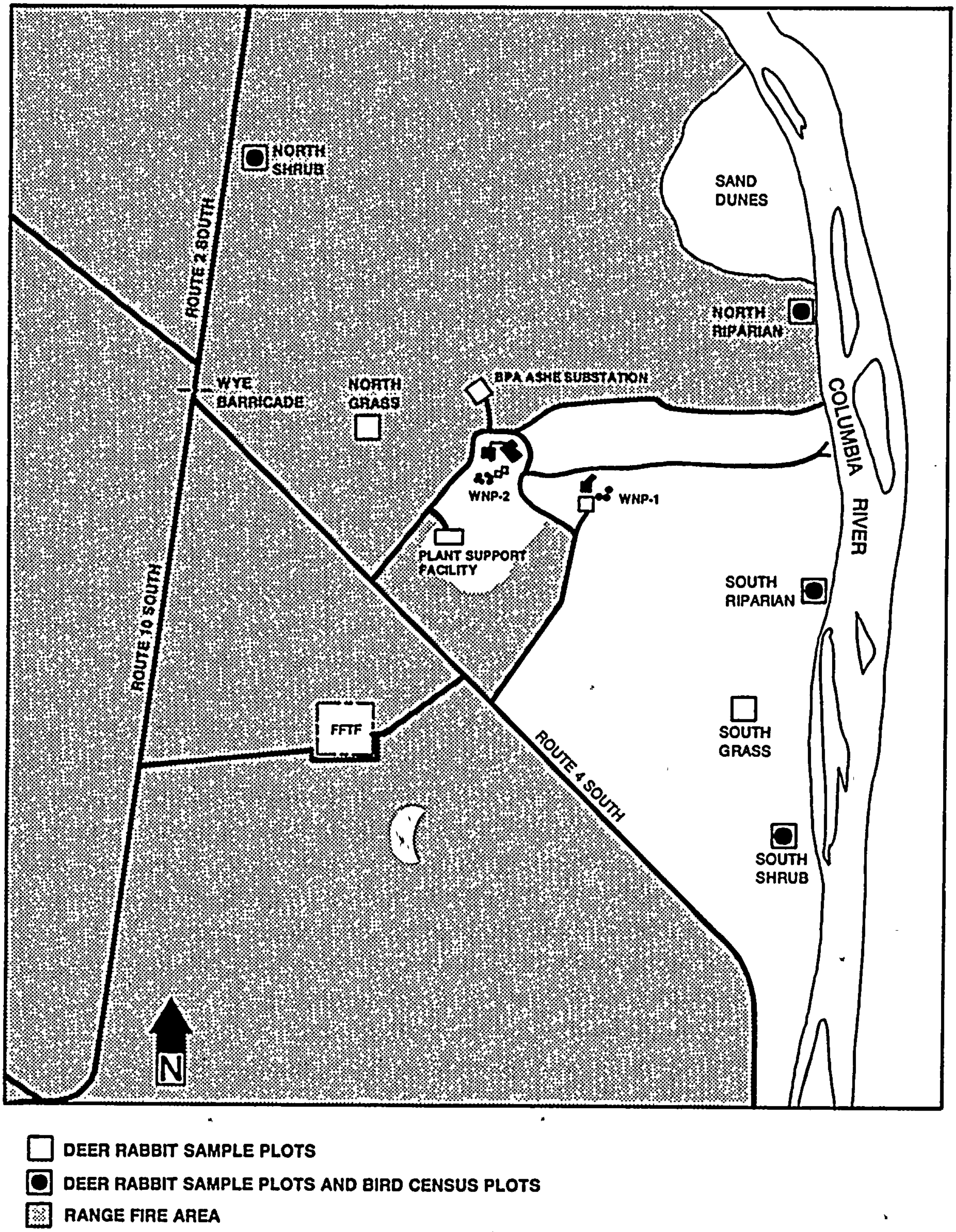


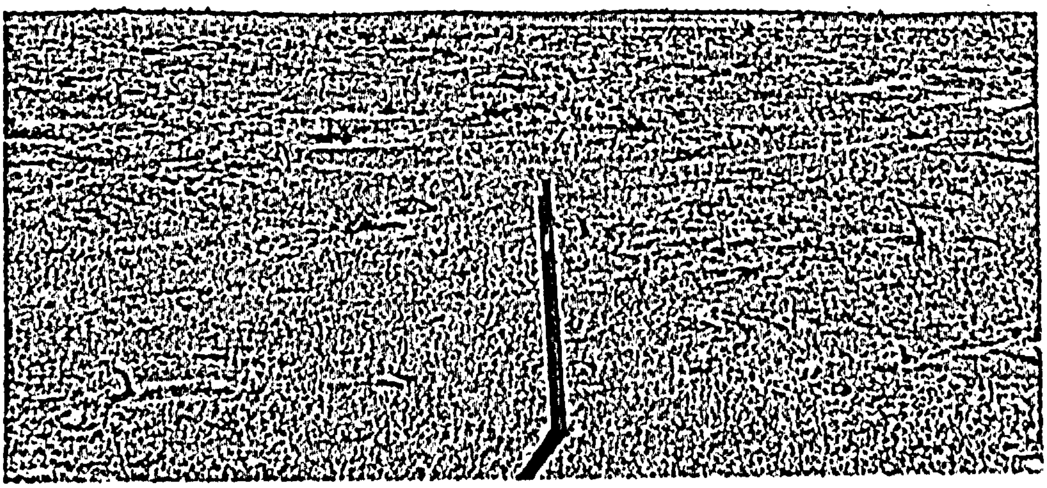
FIGURE 8.2
Deer, Rabbit and Bird Plots in the Vicinity of WNP-1 and WNP-2

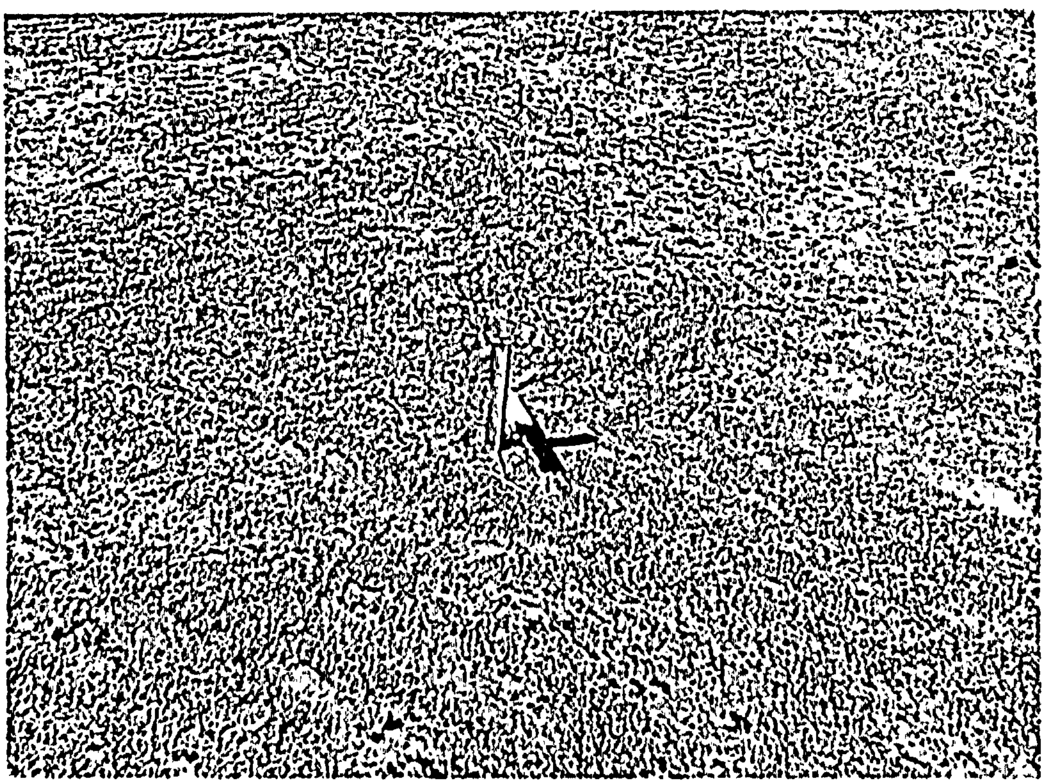
850040

FIGURE 8.3

NORTH SHRUB CENSUS PLOT
August 22, 1984

The north shrub area is representative of the three northern census areas burned in the August 11-12 range fire.





9.0 FISH BIOASSAY

9.1 INTRODUCTION

The purpose of the WNP-2 static bioassays is to evaluate the effect of the cooling tower blowdown effluent on Columbia River salmonids. The National Pollutant Discharge Elimination System Waste Discharge Permit (NPDES) Number WA-002515-1 for WNP-2 requires the performance of bioassays during plant operation. Specifically, General Conditions Section G26 of the permit states: "The permittee shall control wastewater discharge to achieve 80 percent survival of salmonid test organisms in a 65 percent concentration of composite wastewater for a 96-hour period. Toxicity tests shall be conducted and the results reported by the permittee on a schedule and format approved by the Council. Survival rates of less than 80 percent shall be investigated and reported to the Council." Ninety-six hour static bioassays will be performed over a one year period. The bioassays will be initiated when the plant reaches at least 75 percent load (i.e., 850 MW), which is consistent with the requirements of EFSEC Resolution No. 214.

9.2 METHODS AND MATERIALS

The bioassays generally adhered to the procedures set forth by the Washington State Department of Ecology (9-1). Specific methodology is provided in Environmental Programs Instruction, EPI 13-2.11 entitled "WNP-2 Aquatic Bioassays" (9-2).

In 1984 Chinook salmon parr were used in the bioassays. The size of the fish is presented in Table 9-1. The Washington Department of Fisheries provided the salmon from the Ringold Hatchery (River Mile 355). Fish were acclimatized, in a 2006-liter capacity holding tank, for at least two weeks prior to testing. A commercial fish food (i.e., Oregon Moist) was utilized, with food size and feeding rates as used at the Ringold Hatchery. Fish were not fed for 48 hours prior to the start of, or during acute (i.e., 96 hours) bioassays.

Fish acclimatization and control aquaria water was drawn from the Columbia River via the Supply System Nuclear Unit 2 (i.e., WNP-2) river water pumphouse.

Static tests were conducted in 132.5 liter capacity glass aquaria containing a volume of approximately 113.6 liters. The bioassay system (Figure 9-1) consisted of twelve aquaria placed in one water bath (temperature modifying) table. The water bath table maintained aquaria water temperature within + 1.2°C of river temperature during the test. Six different concentrations were tested in duplicate. The six concentrations represented the following percentage of WNP-2 cooling tower blowdown water: 0, 30, 60, 65, 80 and 100. One test was performed October 22-26, 1984. Test water was taken directly from the WNP-2 cooling towers and distributed to the aquaria on October 18, 1984.

At the beginning of the test 10 fish were distributed in a stratified random manner to the aquaria. The loading factor was approximately 1.8 grams per liter. Aeration was used in order to maintain adequate dissolved oxygen (DO) concentrations in the test solutions. Checks for dead fish were made at least twice daily. Dead fish were removed when observed.

Fork lengths and wet weights were determined by anesthetizing and measuring representative fish before the test and all survivors at the end of the test. All fish surviving the tests were released to the Columbia River.

Daily during the bioassay, temperature, DO, pH and conductivity were measured in each aquaria. Grab samples collected daily from each aquaria were analyzed for total copper, total nickel, total iron, total zinc, total cadmium, total lead, total mercury and total chromium.

At the beginning and end of the bioassay grab water samples were collected from a control, high, medium and low concentration aquaria and analyzed for hardness, alkalinity, chloride, total sodium, total potassium, total calcium, total magnesium, orthophosphorus, sulfate, and ammonia. In the same aquaria at the beginning of the bioassay total residual chlorine analyses were performed.

Water samples were collected, stored and analyzed per USEPA (9-3). Instrumentation and quality control were the same as described in Section 4.0.

9.3 RESULTS AND DISCUSSION

No fish mortalities were observed at any concentration for the acute bioassay performed October 22-26, 1984. Our results are in good agreement with those reported for the Trojan Nuclear Plant, which is located downstream on the Columbia River at River Mile 72.5 (9-4) and the Centralia Power Station on the Skookumchuck River (9-5). It is interesting that there were no mortalities considering the high concentration of some metals in the cooling tower water (e.g., copper, Table 9-4; zinc, Table 9-5 and iron, Table 9-7). Possible explanations for no mortality are: (1) the majority of the metal is in the particulate form which is non-toxic, (2) the high hardness of the cooling tower water (i.e., 330 mg/l; Table 9-3) reduces the toxic effect and/or (3) the corrosion inhibitor (calgon 1245, approximately 85-90 mg/l; per verbal communication with R. Kyle) added to the cooling tower water binds the toxic metal forms. Chemical speciation work planned for the Spring 1985 bioassay should provide information on the chemical form of the metal as related to toxicity.

A review of the basic water quality parameters (Table 9-2) shows that temperature, pH and DO between aquaria and the river were very similar. Conductivity in the highest (100%) concentration of discharge water was approximately five times higher than in the control aquaria; the hardness measurements (Table 9-3) show a similar relationship. According to WNP-2 personnel, the cooling tower water used for the bioassay was at five cycles of concentration and collected when the plant was at approximately 73 percent thermal load. Sulfate, chloride and orthophosphate values were highest in the aquaria with the greatest percentage of discharge water (Table 9-3). The addition of chlorine, sulfuric acid and a corrosion inhibitor (Calgon 1245) to the cooling tower water probably explains the increases. Ammonia-nitrogen values increased in all tanks to similar values (0.56 - 0.61mg/l) by the end of the test. This undoubtedly was attributable to performance of a static bioassay. Total residual chlorine values in all aquaria at the beginning of the test were low (1-13 μg/l: Table 9-3).

Tables 9-4 through 9-15 present the results of metal analyses in each aquaria for each day of the test. The metal concentrations in river water during our bioassay were comparable to those previously reported for the Columbia River near WNP-2 (9-6 through 9-8). Copper, zinc, iron, mercury and potassium concentrations in the 100 percent discharge water aquaria were consistently much higher than would be estimated by simply concentrating river water by factor of 5. The higher levels may be attributable to a number of factors such as residual within the plant pipes and the products.of pipe corrosion. Mercury levels in the 100 percent discharge water aquaria are high compared to the river but the actual concentrations are still low. Mercury is not added to the WNP-2 discharge via chemical treatment processes. In contrast, lead, and cadmium concentrations were at levels close to ambient. Nickel, calcium, magnesium and sodium levels were close to the expected five cycles of concentration produced by the cooling towers.

9.4 REFERENCES

9-1 General Procedure for Static - Bioassay to Evaluate Industrial Effluent Toxicity, 1980 4p, Washington State Department of Ecology, Olympia Environmental Laboratory.

9-2 WNP-2 Aquatic Bioassays, 1983. Washington Public Power Supply System Environmental Programs Instruction 13-2.11, 13p.

9-3 EPA Methods for Chemical Analysis of Water and Wastes. 1983 EPA 600/4-79-020.

9-4 Beak Consultants Incorporated and Portland General Electric Company, 1979. Operational ecological monitoring program for the Trojan Nuclear Plant. Annual report for 1977.

9-5 Mulvihill, E.L. and R.L. Kruger. 1976. Copper in a closed cycle power plant cooling system and its relation to the aquatic environment. Copper Development Association Inc., New York, 9 p.

9-6 Washington Public Power Supply System, 1982. Supply System Nuclear Projects Nos. 1 and 4 Environmental Report, Docket Nos. 50-460 and 50-513, Section 2.4.

9-7 Cushing, C.E., and L.A. Rancitelli. 1972. Trace element analyses of Columbia River water and phytoplankton. Northwest Science 46(2): 115-121.

9-8 Silker, W.B.: 1964. Variations in elemental concentrations in the Columbia River. Limnol. Oceanogr. 9, 540-545.

TABLE 9-1

FISH SIZE, WNP-2 BIOASSAY, OCTOBER 22-26, 1984

		Length, mm				Weight, g			
Location	Date	n	Average	Standard Deviation	Range	n	Average	Standard Deviation	Range
Holding Tank	10/08/84	20	108.9	13.4	81-129	20	15.4	5.1	5.6-24.7
Holding Tank	10/22/84	20	122.2	7.2	110-135	20	20.2	4.0	15.0-28.3
Control Tanks 4, 9	10/26/84	20	119.8	7.0	104-131	20	19.6	6.6	11.6-44.6
100% Discharge Water Tanks 5, 11	10/26/84	20	123.6	9.2	111-149	20	20.4	4.9	14.9-36.6

TABLE 9-2

BASIC WATER QUALITY PARAMETER COMPARISON, OCTOBER 22-26, 1984

		Temperature, °C			Dissolved Oxygen, mg/l			Conductivity µmhos, cm			pH Standard Units		
Location - Tank	n	X̄	S.D.	R	X̄	S.D.	R	X̄	S.D.	R	Median	S.D.	R
Control - 4	5	14.3	0.3	13.9 - 14.6	8.7	0.3	8.5 - 9.15	117	5	111 - 124	7.72	0.12	7.64 - 7.94
100% Discharge - 5	5	14.3	0.3	13.9 - 14.6	8.8	0.5	8.1 - 9.2	596	6	590 - 600	7.76	0.07	7.64 - 7.80
Holding Tank - 13	5	13.9	0.1	13.7 - 14.0	8.5	0.2	8.2 - 8.8	107	4	102 - 111	7.78	0.07	7.73 - 7.91
River - 14	5	13.1	0.2	12.9 - 13.4	10.4	0.4	10.0 - 11.0	104	2	103 - 107	8.12	0.12	8.06 - 8.37

X̄ = Mean
SD = Standard Deviation
R = Range

TABLE 9-3

WNP-2 BIOASSAY: CHEMISTRY DATA

Cooling Tower Blowdown Water (Percent)	Total Residual Chlorine+	Sulfate*		Chloride*		Alkalinity*		Hardness*		Orthophosphate*		Ammonia-Nitrogen*	
	1	1	2	1	2	1	2	1	2	1	2	1	2
0	1	12	11	0.9	0.9	55.4	60.0	64	64	.03	0.10	<.01	.56
30	5	107	98	6.2	5.8	60.6	65.6	144	145	.47	.59	.06	.56
65	12	185	181	11.9	11.0	67.2	73.4	246	235	.99	1.08	.09	.61
100	13	273	251	18.4	17.7	72.6	76.0	330	333	1.20	1.25	.4	.58
River	1	12	11	1.2	.12	55.8	58.0	64	65	.02	.03	<.01	<.01

1 - Beginning of test.

2 - End of test.

* - mg/l

+ - µg/l

TABLE 9-4

TOTAL COPPER CONCENTRATIONS WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Copper, µg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	457	446	457	451	453	5	446-457
2	50	352	347	354	343	349	5	343-354
3	30	210	206	209	209	209	2	206-210
4	0	1.9	1.5	2.0	2.6	2	0.5	1.5-2.6
5	100	697	696	710	714	704	9	696-714
6	80	557	558	559	557	558	1	557-559
7	65	437	447	446	453	446	7	437-453
8	30	208	206	213	215	211	4	206-215
9	0	0.6	1.5	1.5	1.6	1.3	0.5	0.6-1.6
10	50	331	348	336	332	337	8	331-348
11	100	681	696	701	696	694	9	681-701
12	80	543	558	554	552	552	6	543-558
13	Holding Tank		1.1					
14	River	2.9		0.6	0.5	1.3	1.4	0.5-2.9

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-5

TOTAL ZINC CONCENTRATIONS WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Zn, μg/l Day 1	2	3	4	X̄	S.D.	R
1	65	401	360	-	-	381	29	360-401
2	50	339	267	312	262	295	37	262-339
3	30	234	266	-	327	276	47	234-327
4	0	86	67	57	44	64	18	44-86
5	100	504	500	501	502	502	2	500-504
6	80	412	412	410	413	412	1	410-413
7	65	364	366	391	-	374	15	364-391
8	30	172	274	324	266	259	63	172-324
9	0	73	-	251	201	175	92	73-251
10	50	273	327	390	387	344	56	273-390
11	100	588	622	-	665	625	39	588-665
12	80	406	473	510	545	484	59	406-545
13	Holding Tank		37					
14	River	2		7	6	5	3	2-7

X̄ = Mean
S.D. = Standard Deviation
R = Range
\- = Contaminated Sample

TABLE 9-6

TOTAL MERCURY CONCENTRATIONS FOR WNP-2 BIOASSAY
Total Mercury, $\mu g/l$

Tank Number	Percent Discharge Concentration	Day 1	Day 2	Day 3	Day 4	$\bar{X}$	S.D.	R
1	65	.28	.33	.38	.69	.42	.18	.28 - .69
2	50	.22	.31	.31	.21	.26	.06	.21 - .31
3	30	.08	.03	.06	.03	.05	.02	.03 - .08
4	0	.02	.08	.06	.03	.05	.03	.02 - .08
5	100	.43	.42	.53	.55	.48	.07	.42 - .55
6	80	.25	.08	.22	.06	.15	.10	.06 - .25
7	65	.16	.32	.13	.03	.16	.12	.03 - .32
8	30	.32	<.02	.08	.18	.15	.13	<.02 - .06
9	0	.05	.06	<.02	<.02	.04	.02	<.02 - .06
10	50	.05	.09	.13	.03	.08	.04	.03 - .13
11	100	.08	.17	.10	.06	.10	.05	.08 - .17
12	80	.08	.17	.22	.11	.15	.06	.08 - .22
13	Holding Tank		.08					
14	River	<.02		<.02	<.02	<.02		<.02

$\bar{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-7

TOTAL IRON CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Iron, μg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	178	255	431	268	283	106	178 - 431
2	50	133	238	336	212	230	84	133 - 336
3	30	90	184	169	173	154	43	90 - 184
4	0	28	60	54	34	44	15	28 - 60
5	100	248	344	565	572	432	162	248 - 572
6	80	216	235	372	352	294	80	216 - 372
7	65	161	206	290	366	256	91	161 - 366
8	30	87	202	229	217	184	65	87 - 229
9	0	19	44	23	30	29	11	19 - 44
10	50	181	228	145	189	186	34	145 - 228
11	100	245	476	569	537	457	146	245 - 569
12	80	185	379	486	492	386	143	185 - 492
13	Holding Tank		62					
14	River	6		53	73	44	34	6 - 73

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-8

TOTAL LEAD CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Lead, µg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	3	4	4	4	4	1	3 - 4
2	50	4	5	6	6	5	1	4 - 6
3	30	3	5	4	3	4	1	3 - 5
4	0	1	3	3	1	2	1	1 - 3
5	100	6	4	7	8	6	2	4 - 8
6	80	8	6	6	9	7	2	6 - 9
7	65	6	5	6	5	6	1	5 - 6
8	30	5	5	4	4	5	1	4 - 5
9	0	<1	4	2	1	2	1	<1 - 4
10	50	4	6	6	4	5	1	4 - 6
11	100	11	8	9	8	9	1	8 - 11
12	80	5	6	7	7	6	1	5 - 7
13	Holding Tank		4					
14	River	3		4	3	3	1	3 - 4

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-9

TOTAL NICKEL CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Nickel, µg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	3	3	3	3	3	0	3
2	50	2	2	2	2	2	0	2
3	30	1	1	1	1	1	0	1
4	0	<1	<1	<1	<1	<1	0	<1
5	100	4	4	5	5	5	1	4 - 5
6	80	3	3	3	4	3	1	3 - 4
7	65	3	3	3	3	3	0	3
8	30	1	1	2	1	1	1	1 - 2
9	0	<1	<1	<1	1	1	0	<1 - 1
10	50	2	2	2	2	2	0	1 - 1
11	100	4	4	5	4	4	1	4 - 5
12	80	3	3	3	3	3	0	3
13	Holding Tank		<1					
14	River	<1		<1	<1	<1	0	<1

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-10

TOTAL CADMIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Cadmium, µg/l Day 1	2	3	4	X̄	S.D.	R
1	65	.2	.2	.2	.4	.3	.1	.2 - .4
2	50	.2	.2	.2	.2	.2	0	.2
3	30	.2	.2	.3	.3	.3	.1	.2 - .3
4	0	.4	.3	.2	.3	.3	.1	.1 - .4
5	100	.3	.5	.4	.4	.4	.1	.3 - .5
6	80	.2	.4	.2	.3	.3	.1	.2 - .4
7	65	.3	.2	.3	.2	.3	.1	.2 - .3
8	30	.3	.2	.3	.3	.3	.1	.2 - .3
9	0	.2	.2	.2	.2	.2	0	.2
10	50	.3	.3	.2	.3	.3	.1	.2 - .3
11	100	.2	.4	.3	.3	.3	.1	.2 - .4
12	80	.3	.3	.4	.3	.3	.1	.3 - .4
13	Holding Tank		.2					
14	River	<.1		.2	.3	.2	.1	<.1 - .3

X̄ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-11

TOTAL CHROMIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Chromium, μg/l Day 1	2	3	4	$\bar{X}$	S.D.	R
1	65	1.0	1.0	1.4	1.0	1.1	0.2	1.0 - 1.4
2	50	0.7	0.8	0.9	0.8	0.8	0.1	0.7 - 0.9
3	30	0.5	0.5	0.4	0.4	0.5	0.1	0.4 - 0.5
4	0	<0.1	<0.1	<0.1	<0.1	<0.1	0	<0.1
5	100	1.4	1.6	1.2	1.8	1.5	0.3	1.2 - 1.8
6	80	1.1	0.8	1.3	1.3	1.1	0.2	0.8 - 1.3
7	65	0.7	0.9	0.8	0.9	0.8	0.1	0.7 - 0.9
8	30	0.5	0.6	0.3	0.2	0.4	0.2	0.2 - 0.6
9	0	<0.1	<0.1	0.1	<0.1	<0.1	0	<0.1 - 0.1
10	50	0.8	0.9	0.7	0.6	0.8	0.1	0.7 - 0.9
11	100	1.5	1.5	1.9	1.4	1.6	0.2	1.4 - 1.9
12	80	0.7	1.0	1.4	1.1	1.1	0.3	0.7 - 1.4
13	Holding Tank		<0.1					
14	River	<0.1		0.1	<0.1	<0.1	0.1	<0.1 - 0.1

$\bar{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-12

TOTAL CALCIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Calcium, mg/l Day 1	2	3	4	X̄	S.D.	R
1	65	73	75	73	76	74	2	73 - 76
2	50	63	63	63	63	63	0	63
3	30	48	47	47	47	47	1	47 - 48
4	0	22	22	24	23	23	1	22 - 24
5	100	100	101	100	98	100	1	98 - 101
6	80	85	84	84	85	85	1	84 - 85
7	65	72	73	75	72	73	1	72 - 75
8	30	47	46	47	48	47	1	46 - 48
9	0	23	23	23	22	23	1	22 - 23
10	50	61	62	61	62	62	1	61 - 62
11	100	98	98	101	99	99	1	98 - 101
12	80	84	84	83	85	84	1	83 - 85
13	Holding Tank		23					
14	River	22		23	23	23	1	22 - 23

X̄ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-13

TOTAL MAGNESIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Magnesium, mg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	15.2	15.0	15.2	15.4	15.2	0.2	15.0 - 15.4
2	50	12.7	12.9	12.7	12.8	12.8	0.1	12.7 - 12.9
3	30	9.2	9.2	9.3	9.2	9.2	0.1	9.2 - 9.3
4	0	3.8	3.9	4.0	3.9	3.9	0.1	3.8 - 4.0
5	100	20.7	20.9	20.5	20.5	20.7	0.2	20.5 - 20.9
6	80	17.5	17.4	17.5	17.8	17.6	0.2	17.4 - 17.8
7	65	14.9	15.1	15.2	14.9	15.0	0.2	14.9 - 15.2
8	30	9.3	9.1	9.2	9.3	9.2	0.1	9.1 - 9.3
9	0	3.9	4.0	3.9	3.9	3.9	0.1	3.9 - 4.0
10	50	12.5	12.5	12.4	12.5	12.5	0.1	12.4 - 12.5
11	100	20.3	20.5	20.9	20.4	20.5	0.3	20.3 - 20.9
12	80	17.4	17.7	17.5	17.5	17.5	0.1	17.4 - 17.7
13	Holding Tank		3.9					
14	River	3.9		3.9	4.0	3.9	0.1	3.9 - 4.0

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-14

TOTAL SODIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Sodium, mg/l Day 1	2	3	4	$\bar{X}$	S.D.	R
1	65	17	17	17	18	17	1	17 - 18
2	50	15	15	15	15	15	0	15
3	30	15	12	11	11	12	2	11 - 15
4	0	6	7	6	7	7	1	6 - 7
5	100	22	23	23	22	23	1	22 - 23
6	80	19	20	20	20	20	1	19 - 20
7	65	16	17	17	17	17	1	16 - 17
8	30	11	11	12	11	11	1	11 - 12
9	0	7	7	6	6	7	1	6 - 7
10	50	14	14	14	15	14	1	14 - 15
11	100	22	22	22	23	22	1	22 - 23
12	80	19	19	19	19	19	0	19
13	Holding Tank		6					
14	River	7		6	6	6	1	6 - 7

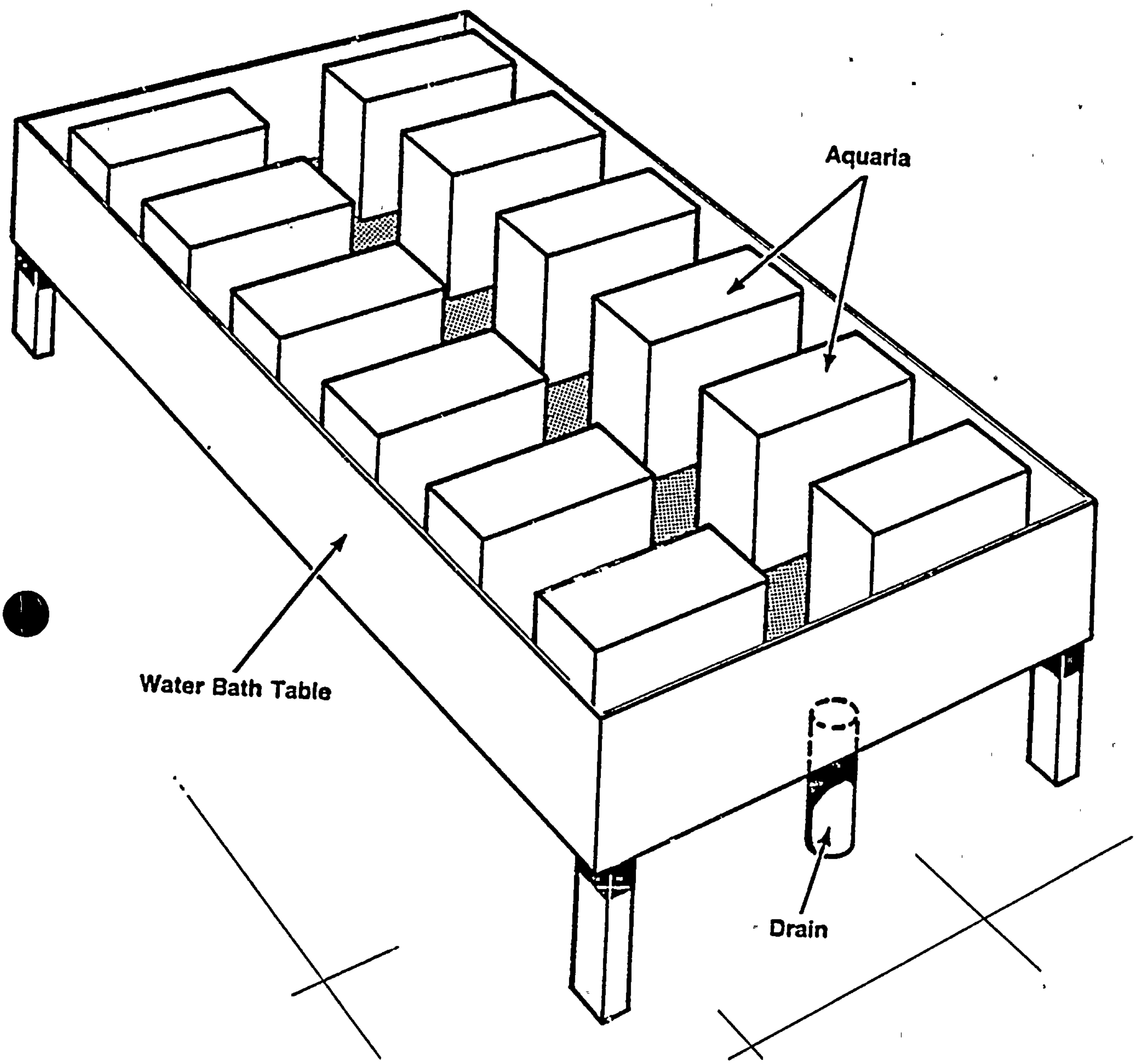
$\bar{X}$ = Mean
S.D. = Standard Deviation
R = Range

TABLE 9-15

TOTAL POTASSIUM CONCENTRATIONS FOR WNP-2 BIOASSAY

Tank Number	Percent Discharge Concentration	Total Potassium, mg/l Day 1	2	3	4	$\overline{X}$	S.D.	R
1	65	13.3	11.9	12.7	12.6	12.6	0.6	11.9 - 13.3
2	50	9.5	9.6	10.6	10.4	10.0	0.6	9.5 - 10.6
3	30	7.0	6.5	6.5	6.2	6.6	0.3	6.2 - 7.0
4	0	1.2	1.3	1.6	1.5	1.4	0.2	1.2 - 1.6
5	100	18.6	20.1	19.9	19.1	19.4	0.7	18.6 - 20.1
6	80	16.0	14.6	14.5	15.7	15.2	0.8	14.5 - 16.0
7	65	11.8	12.0	13.5	11.9	12.3	0.8	11.8 - 13.5
8	30	6.7	6.8	6.2	6.9	6.7	0.3	6.2 - 6.9
9	0	1.2	1.4	1.6	1.2	1.4	0.2	1.2 - 1.6
10	50	9.3	9.8	10.6	10.0	9.9	0.5	9.3 - 10.6
11	100	17.6	20.0	19.9	18.5	19.0	1.2	17.6 - 20.0
12	80	14.6	14.4	15.4	14.4	14.7	0.5	14.4 - 15.4
13	Holding Tank		1.2					
14	River	1.2		1.3	1.1	1.2	0.1	1.1 - 1.3

$\overline{X}$ = Mean
S.D. = Standard Deviation
R = Range



ONE STATIC BIOASSAY SYSTEM
Figure 9-1

APPENDIX A

TABLE A-1

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-NOV 83	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	30145.83	60.77	10641.43	161.12	94.42	64.10
SEPT-NOV 83	1	MIDGES-CHIRONOMIDAE, LARVAE	16752.17	33.77	11465.87	2.11	1.24	1.99
SEPT-NOV 83	1	BLACKFLY-SIMULIDAE, LARVAE	1194.87	2.41	562.97	2.68	1.57	1.42
SEPT-NOV 83	1	MAYFLY-EPHEMERELLIDAE, NYMPH	500.53	1.01	266.77	.10	.06	.07
SEPT-NOV 83	1	CADDISFLY-LEPTOCERIDAE, LARVAE	242.23	.49	272.95	.79	.47	.76
SEPT-NOV 83	1	CADDISFLY-HYDROPTILIDAE, LARVAE	201.80	.41	77.85	.03	.02	.02
SEPT-NOV 83	1	MIDGES-CHIRONOMIDAE, PUPAE	177.60	.36	77.85	.08	.05	.04
SEPT-NOV 83	1	MAYFLY, NYMPH	129.17	.26	223.72	.02	.01	.04
SEPT-NOV 83	1	SNAIL-FLUMINICOLA	56.50	.11	77.85	1.09	.64	.96
SEPT-NOV 83	1	BLACKFLY-SIMULIDAE, PUPAE	56.50	.11	14.03	.20	.12	.05
SEPT-NOV 83	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	40.33	.08	13.97	.02	.01	.02
SEPT-NOV 83	1	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	32.30	.07	37.02	.09	.05	.11
SEPT-NOV 83	1	SNAIL-PARAPHOLYX	24.23	.05	41.97	1.08	.63	1.87
SEPT-NOV 83	1	CLAMS	8.07	.02	13.97	.00	.00	.00
SEPT-NOV 83	1	BLACKFLY-SIMULIDAE, ADULT	8.07	.02	13.97	0.0	0.0	0.0
SEPT-NOV 83	1	MOTH-PYRALIDAE, LARVAE	8.07	.02	13.97	.01	.01	.02
SEPT-NOV 83	1	MAYFLY-BAETIDAE, NYMPH	8.07	.02	13.97	.01	.01	.02
SEPT-NOV 83	1	MAYFLY-TRICOR., NYMPH	8.07	.02	13.97	0.0	0.0	0.0
SEPT-NOV 83	1	OLIGOCHAETE	8.07	.02	13.97	.00	.00	.00
SEPT-NOV 83	1	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
SEPT-NOV 83	1	UNIDENTIFIED	.	.	.	1.21	.71	1.09
SEPT-NOV 83	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	25221.07	62.13	5321.01	147.90	77.64	54.12
SEPT-NOV 83	7W	MIDGES-CHIRONOMIDAE, LARVAE	10422.67	25.68	7251.33	.77	.40	.36
SEPT-NOV 83	7W	BLACKFLY-SIMULIDAE, LARVAE	2099.03	5.17	375.46	3.41	1.79	.77
SEPT-NOV 83	7W	SNAIL-FLUMINICOLA	1550.07	3.82	887.95	32.58	17.10	18.73
SEPT-NOV 83	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	314.87	.78	261.97	.04	.02	.02
SEPT-NOV 83	7W	MIDGES-CHIRONOMIDAE, PUPAE	298.70	.74	37.02	.08	.04	.00
SEPT-NOV 83	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	193.77	.48	83.89	.44	.23	.15
SEPT-NOV 83	7W	MAYFLY, NYMPH	104.97	.26	181.81	.01	.00	.02
SEPT-NOV 83	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	104.97	.26	36.97	.01	.01	.00
SEPT-NOV 83	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	88.80	.22	37.02	.03	.02	.01
SEPT-NOV 83	7W	BLACKFLY-SIMULIDAE, PUPAE	64.60	.16	55.95	.26	.14	.24
SEPT-NOV 83	7W	MAYFLY-BAETIDAE, NYMPH	40.37	.10	50.43	.00	.00	.00
SEPT-NOV 83	7W	CLAMS	24.23	.06	41.97	.01	.01	.03
SEPT-NOV 83	7W	SNAIL-PARAPHOLYX	16.13	.04	27.94	.00	.00	.01
SEPT-NOV 83	7W	SNAIL-FISHEROLA	16.13	.04	13.97	.88	.46	.81
SEPT-NOV 83	7W	MITES-GENERAL	16.13	.04	27.94	.00	.00	.00
SEPT-NOV 83	7W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.02	13.97	.00	.00	.00
SEPT-NOV 83	7W	MAYFLY-TRICOR., NYMPH	8.07	.02	13.97	.00	.00	.00
SEPT-NOV 83	7W	UNIDENTIFIED	.	.	.	4.06	2.13	2.38
SEPT-NOV 83	7W	ROUND-WORM	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-NOV 83	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	15767.23	59.82	1867.76	121.65	88.81	20.23
SEPT-NOV 83	7M	MIDGES-CHIRONOMIDAE, LARVAE	8105.63	30.75	3233.52	.33	.24	.23
SEPT-NOV 83	7M	BLACKFLY-SIMULIDAE, LARVAE	1582.37	6.00	724.27	2.27	1.66	2.10
SEPT-NOV 83	7M	SNAIL-FLUMINICOLA	193.77	.74	105.54	6.14	4.48	4.08
SEPT-NOV 83	7M	BLACKFLY-SIMULIDAE, PUPAE	137.23	.52	133.38	.57	.42	.62
SEPT-NOV 83	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	129.20	.49	60.95	.01	.01	.01
SEPT-NOV 83	7M	MIDGES-CHIRONOMIDAE, PUPAE	113.03	.43	13.97	.03	.02	.02
SEPT-NOV 83	7M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	72.67	.28	48.45	.04	.03	.04
SEPT-NOV 83	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	56.53	.21	50.43	.00	.00	.00
SEPT-NOV 83	7M	SNAIL-FISHEROLA	56.50	.21	60.95	1.93	1.41	1.93
SEPT-NOV 83	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	40.37	.15	28.00	.10	.07	.08
SEPT-NOV 83	7M	CADDISFLY-HYDROPTILIDAE, PUPAE	40.37	.15	69.92	.00	.00	.01
SEPT-NOV 83	7M	BLACKFLY-SIMULIDAE, ADULT	24.23	.09	41.97	0.0	0.0	0.0
SEPT-NOV 83	7M	CLAMS	8.07	.03	13.97	0.0	0.0	0.0
SEPT-NOV 83	7M	MOTH-PYRALIDAE, LARVAE	8.07	.03	13.97	.02	.01	.03
SEPT-NOV 83	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	8.07	.03	13.97	.05	.04	.09
SEPT-NOV 83	7M	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.03	13.97	.00	.00	.01
SEPT-NOV 83	7M	MAYFLY-BAETIDAE, NYMPH	8.07	.03	13.97	.00	.00	.00
SEPT-NOV 83	7M	UNIDENTIFIED	.	.	.	3.82	2.79	1.55
SEPT-NOV 83	7M	ROUND-WORM	.	.	.	.	.	.
SEPT-NOV 83	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	15541.20	60.35	3772.82	99.61	70.04	73.[illegible]
SEPT-NOV 83	7E	MIDGES-CHIRONOMIDAE, LARVAE	5481.80	21.29	3682.11	.96	.67	.84
SEPT-NOV 83	7E	BLACKFLY-SIMULIDAE, LARVAE	2252.43	8.75	548.57	4.36	3.07	1.65
SEPT-NOV 83	7E	SNAIL-FLUMINICOLA	1332.10	5.17	1642.53	28.45	20.00	35.33
SEPT-NOV 83	7E	MIDGES-CHIRONOMIDAE, PUPAE	209.90	.82	119.43	.11	.08	.09
SEPT-NOV 83	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	193.77	.75	222.00	.02	.02	.03
SEPT-NOV 83	7E	BLACKFLY-SIMULIDAE, PUPAE	161.47	.63	175.21	1.16	.82	1.64
SEPT-NOV 83	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	137.23	.53	109.22	.32	.22	.25
SEPT-NOV 83	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	104.97	.41	36.97	.04	.03	.02
SEPT-NOV 83	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	96.90	.38	24.20	.01	.01	.01
SEPT-NOV 83	7E	SNAIL-FISHEROLA	72.67	.28	48.45	4.76	3.34	3.26
SEPT-NOV 83	7E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	64.57	.25	91.68	.27	.19	.33
SEPT-NOV 83	7E	MAYFLY-BAETIDAE, NYMPH	48.43	.19	41.97	.02	.02	.02
SEPT-NOV 83	7E	CLAMS	24.20	.09	24.20	.01	.01	.01
SEPT-NOV 83	7E	MOTH-PYRALIDAE, LARVAE	16.13	.06	13.97	.03	.02	.06
SEPT-NOV 83	7E	MIDGES-CHIRONOMIDAE, ADULT	8.07	.03	13.97	0.0	0.0	0.0
SEPT-NOV 83	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	8.07	.03	13.97	.11	.08	.19
SEPT-NOV 83	7E	UNIDENTIFIED	.	.	.	1.97	1.38	.89
SEPT-NOV 83	7E	ROUND-WORM	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-NOV 83	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	25156.50	67.49	3681.60	122.02	83.77	19.34
SEPT-NOV 83	11W	MIDGES-CHIRONOMIDAE, LARVAE	7952.23	21.33	6216.23	.64	.44	.64
SEPT-NOV 83	11W	BLACKFLY-SIMULIDAE, LARVAE	1784.20	4.79	454.65	1.88	1.29	1.78
SEPT-NOV 83	11W	SNAIL-FLUMINICOLA	678.17	1.82	644.92	14.25	9.78	12.50
SEPT-NOV 83	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	435.93	1.17	482.59	.09	.06	.10
SEPT-NOV 83	11W	SNAIL-PARAPHOLYX	363.30	.97	629.25	2.15	1.48	3.73
SEPT-NOV 83	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	185.70	.50	37.02	.36	.24	.15
SEPT-NOV 83	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	177.60	.48	100.81	.02	.01	.01
SEPT-NOV 83	11W	MIDGES-CHIRONOMIDAE, PUPAE	161.47	.43	137.76	1.12	.77	1.85
SEPT-NOV 83	11W	BLACKFLY-SIMULIDAE, PUPAE	104.93	.28	50.43	.46	.32	.28
SEPT-NOV 83	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	104.93	.28	161.25	.02	.02	.03
SEPT-NOV 83	11W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	56.50	.15	60.95	.16	.11	.23
SEPT-NOV 83	11W	MAYFLY-BAETIDAE, NYMPH	32.30	.09	37.02	.01	.01	.02
SEPT-NOV 83	11W	MAYFLY-TRICOR., NYMPH	32.30	.09	37.02	.01	.01	.02
SEPT-NOV 83	11W	SNAIL-FISHEROLA	24.23	.07	41.97	1.08	.74	1.87
SEPT-NOV 83	11W	CLAMS	8.07	.02	13.97	.00	.00	.01
SEPT-NOV 83	11W	BLACKFLY-SIMULIDAE, ADULT	8.07	.02	13.97	0.0	0.0	0.0
SEPT-NOV 83	11W	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.02	13.97	.01	.01	.02
SEPT-NOV 83	11W	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
SEPT-NOV 83	11W	UNIDENTIFIED	.	.	.	1.37	.94	.52
SEPT-NOV 83	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	19957.27	68.78	3681.45	136.08	89.08	48.14
SEPT-NOV 83	11M	MIDGES-CHIRONOMIDAE, LARVAE	5360.70	18.48	4029.16	.33	.22	.20
SEPT-NOV 83	11M	BLACKFLY-SIMULIDAE, LARVAE	2292.83	7.90	870.69	4.44	2.91	2.18
SEPT-NOV 83	11M	SNAIL-FLUMINICOLA	274.47	.95	217.07	8.72	5.71	7.10
SEPT-NOV 83	11M	MIDGES-CHIRONOMIDAE, PUPAE	258.33	.89	195.78	.07	.05	.06
SEPT-NOV 83	11M	MAYFLY, NYMPH	250.27	.86	433.47	.02	.01	.04
SEPT-NOV 83	11M	BLACKFLY-SIMULIDAE, PUPAE	169.53	.58	105.60	.65	.43	.46
SEPT-NOV 83	11M	MAYFLY-EPHEMERELLIDAE, NYMPH	153.40	.53	100.81	.01	.01	.01
SEPT-NOV 83	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	113.03	.39	137.70	.03	.02	.02
SEPT-NOV 83	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	72.67	.25	72.65	.01	.01	.01
SEPT-NOV 83	11M	MOTH-PYRALIDAE, LARVAE	40.37	.14	37.01	.15	.10	.15
SEPT-NOV 83	11M	SNAIL-FISHEROLA	16.13	.06	27.94	.05	.03	.09
SEPT-NOV 83	11M	MOLLUSC	16.13	.06	27.94	.63	.41	1.09
SEPT-NOV 83	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	16.13	.06	27.94	.01	.01	.02
SEPT-NOV 83	11M	MAYFLY-BAETIDAE, NYMPH	16.13	.06	27.94	.00	.00	.00
SEPT-NOV 83	11M	BLACKFLY-SIMULIDAE, ADULT	8.07	.03	13.97	.03	.02	.06
SEPT-NOV 83	11M	UNIDENTIFIED	.	.	.	1.51	.99	1.02
SEPT-NOV 83	11M	ROUND-WORM	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-NOV 83	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	20199.50	71.77	1543.03	135.33	67.89	4.09
SEPT-NOV 83	11E	SNAIL-FLUMINICOLA	3374.63	11.99	1941.30	54.13	27.15	29.54
SEPT-NOV 83	11E	MIDGES-CHIRONOMIDAE, LARVAE	1994.13	7.09	434.18	.23	.11	.12
SEPT-NOV 83	11E	BLACKFLY-SIMULIDAE, LARVAE	1525.87	5.42	325.83	2.89	1.45	.44
SEPT-NOV 83	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	298.70	1.06	121.91	.03	.02	.01
SEPT-NOV 83	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	226.07	.80	133.37	.56	.28	.39
SEPT-NOV 83	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	96.90	.34	24.20	.01	.01	.00
SEPT-NOV 83	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	80.73	.29	28.00	.05	.02	.01
SEPT-NOV 83	11E	SNAIL-FISHEROLA	72.67	.26	48.45	3.32	1.66	2.41
SEPT-NOV 83	11E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	72.67	.26	48.45	.11	.06	.14
SEPT-NOV 83	11E	MIDGES-CHIRONOMIDAE, PUPAE	64.60	.23	14.03	.03	.01	.00
SEPT-NOV 83	11E	BLACKFLY-SIMULIDAE, PUPAE	64.60	.23	37.02	.26	.13	.14
SEPT-NOV 83	11E	CLAMS	32.30	.11	55.95	.01	.01	.03
SEPT-NOV 83	11E	MAYFLY-BAETIDAE, NYMPH	32.30	.11	37.02	.01	.01	.01
SEPT-NOV 83	11E	MOTH-PYRALIDAE, NYMPH	8.07	.03	13.97	.10	.05	.18
SEPT-NOV 83	11E	UNIDENTIFIED	.	.	.	2.27	1.14	.87
SEPT-NOV 83	11E	ROUND-WORM	.	.	.	.	.	.
SEPT-NOV 83	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	24510.63	48.78	8601.96	89.50	91.70	45.99
SEPT-NOV 83	8	MIDGES-CHIRONOMIDAE, LARVAE	20909.93	41.61	6033.74	1.64	1.68	1.22
SEPT-NOV 83	8	CADDISFLY-HYDROPTILIDAE, LARVAE	1913.37	3.81	1055.48	.25	.25	.1[illegible]
SEPT-NOV 83	8	BLACKFLY-SIMULIDAE, LARVAE	1598.50	3.18	1075.25	2.20	2.25	1.7[illegible]
SEPT-NOV 83	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	573.20	1.14	553.54	.27	.28	.43
SEPT-NOV 83	8	MAYFLY-EPHEMERELLIDAE, NYMPH	258.37	.51	50.43	.03	.03	.00
SEPT-NOV 83	8	CADDISFLY-LEPTOCERIDAE, LARVAE	209.90	.42	208.85	.47	.48	.47
SEPT-NOV 83	8	MIDGES-CHIRONOMIDAE, PUPAE	137.23	.27	85.09	.04	.04	.03
SEPT-NOV 83	8	BLACKFLY-SIMULIDAE, PUPAE	72.67	.14	105.60	.29	.30	.41
SEPT-NOV 83	8	MOTH-PYRALIDAE, LARVAE	24.20	.05	24.20	.10	.10	.11
SEPT-NOV 83	8	SNAIL-FLUMINICOLA	16.13	.03	13.97	.32	.33	.33
SEPT-NOV 83	8	SNAIL-PARAPHOLYX	8.07	.02	13.97	.21	.22	.36
SEPT-NOV 83	8	SNAIL-FISHEROLA	8.07	.02	13.97	.32	.33	.56
SEPT-NOV 83	8	MAYFLY-TRICOR., NYMPH	8.07	.02	13.97	.00	.00	.00
SEPT-NOV 83	8	UNIDENTIFIED	.	.	.	1.96	2.01	.53
SEPT-NOV 83	8	ROUND-WORM	.	.	.	.	.	.
DEC-FEB 84	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	347.13	29.65	178.53	1.64	41.45	.11
DEC-FEB 84	1	MIDGES-CHIRONOMIDAE, LARVAE	322.93	27.59	85.04	.20	5.07	.07
DEC-FEB 84	1	BLACKFLY-SIMULIDAE, LARVAE	201.83	17.24	60.95	.96	24.26	.36
DEC-FEB 84	1	MIDGES-CHIRONOMIDAE, PUPAE	137.27	11.73	50.43	.12	2.97	.03
DEC-FEB 84	1	BLACKFLY-SIMULIDAE, PUPAE	96.90	8.28	0.0	.90	22.93	.87
DEC-FEB 84	1	MAYFLY-EPHEMERELLIDAE, NYMPH	24.20	2.07	24.20	.01	.18	.01
DEC-FEB 84	1	MIDGES-CHIRONOMIDAE, ADULT	16.13	1.38	13.97	.02	.41	.01
DEC-FEB 84	1	CADDISFLY-LEPTOCERIDAE, LARVAE	16.13	1.38	27.94	.09	2.29	.16
DEC-FEB 84	1	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.69	13.97	.00	.06	.00
DEC-FEB 84	1	UNIDENTIFIED	.	.	.	.01	.37	.02

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-FEB 84	7W	MIDGES-CHIRONOMIDAE, LARVAE	1194.87	37.85	387.75	1.67	6.70	.44
DEC-FEB 84	7W	SNAIL-FLUMINICOLA	589.33	18.67	510.53	16.09	64.50	13.16
DEC-FEB 84	7W	BLACKFLY-SIMULIDAE, LARVAE	460.20	14.58	24.20	2.02	8.09	.10
DEC-FEB 84	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	444.03	14.07	208.80	3.74	14.98	2.20
DEC-FEB 84	7W	MIDGES-CHIRONOMIDAE, PUPAE	250.30	7.93	111.89	.32	1.29	.13
DEC-FEB 84	7W	BLACKFLY-SIMULIDAE, PUPAE	72.67	2.30	24.25	.25	.99	.15
DEC-FEB 84	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	56.50	1.79	37.02	.01	.05	.01
DEC-FEB 84	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	40.37	1.28	37.01	.03	.13	.04
DEC-FEB 84	7W	MIDGES-CHIRONOMIDAE, ADULT	16.13	.51	13.97	.01	.04	.02
DEC-FEB 84	7W	SNAIL-FISHEROLA	8.07	.26	13.97	.55	2.20	.95
DEC-FEB 84	7W	MOTH-PYRALIDAE, LARVAE	8.07	.26	13.97	.04	.15	.06
DEC-FEB 84	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	8.07	.26	13.97	.03	.12	.05
DEC-FEB 84	7W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.26	13.97	.07	.29	.13
DEC-FEB 84	7W	UNIDENTIFIED	.	.	.	.12	.47	.02
DEC-FEB 84	7M	MIDGES-CHIRONOMIDAE, LARVAE	1671.20	57.18	825.28	2.06	16.25	1.07
DEC-FEB 84	7M	MIDGES-CHIRONOMIDAE, PUPAE	298.70	10.22	205.97	.62	4.92	.33
DEC-FEB 84	7M	BLACKFLY-SIMULIDAE, LARVAE	282.57	9.67	111.83	1.14	9.01	.45
DEC-FEB 84	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	266.43	9.12	147.32	2.00	15.81	1.40
DEC-FEB 84	7M	BLACKFLY-SIMULIDAE, PUPAE	137.23	4.70	145.97	.58	4.60	.54
DEC-FEB 84	7M	SNAIL-FISHEROLA	64.57	2.21	73.99	4.98	39.29	4.81
DEC-FEB 84	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	48.43	1.66	83.89	.01	.10	.02
DEC-FEB 84	7M	MIDGES-CHIRONOMIDAE, ADULT	40.37	1.38	69.92	.04	.29	.06
DEC-FEB 84	7M	SNAIL-FLUMINICOLA	32.27	1.10	27.94	.97	7.67	.85
DEC-FEB 84	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	24.23	.83	41.97	.01	.08	.02
DEC-FEB 84	7M	FLY-GENERAL, ADULT	16.13	.55	27.94	.19	1.53	.34
DEC-FEB 84	7M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	16.13	.55	13.97	.01	.06	.01
DEC-FEB 84	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	8.07	.28	13.97	.02	.16	.03
DEC-FEB 84	7M	MAYFLY-BAETIDAE, NYMPH	8.07	.28	13.97	.01	.06	.01
DEC-FEB 84	7M	MAYFLY, NYMPH	8.07	.28	13.97	0.0	0.0	0.0
DEC-FEB 84	7M	UNIDENTIFIED	0.0	0.0	.	.02	.15	.02
DEC-FEB 84	7E	SNAIL-FLUMINICOLA	2470.43	55.23	448.57	67.20	60.48	14.80
DEC-FEB 84	7E	MIDGES-CHIRONOMIDAE, LARVAE	758.90	16.97	454.65	.91	.82	.61
DEC-FEB 84	7E	SNAIL-FISHEROLA	468.27	10.47	97.90	32.06	28.85	5.93
DEC-FEB 84	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	347.17	7.76	85.09	7.71	6.94	11.19
DEC-FEB 84	7E	MIDGES-CHIRONOMIDAE, PUPAE	153.40	3.43	60.95	.18	.16	.07
DEC-FEB 84	7E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	96.87	2.17	64.06	.69	.62	.17
DEC-FEB 84	7E	BLACKFLY-SIMULIDAE, LARVAE	56.53	1.26	50.43	.10	.09	.09
DEC-FEB 84	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	40.37	.90	50.43	.16	.15	.22
DEC-FEB 84	7E	MIDGES-CHIRONOMIDAE, ADULT	24.20	.54	24.20	.03	.03	.03
DEC-FEB 84	7E	BLACKFLY-SIMULIDAE, PUPAE	16.13	.36	27.94	.08	.07	.14
DEC-FEB 84	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	16.13	.36	27.94	.00	.00	.00
DEC-FEB 84	7E	SNAIL-PARAPHOLYX	8.07	.18	13.97	.13	.12	.23
DEC-FEB 84	7E	SNAIL-LIMNAE	8.07	.18	13.97	.49	.44	.85
DEC-FEB 84	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.18	13.97	.00	.00	.00
DEC-FEB 84	7E	UNIDENTIFIED	.	.	.	1.35	1.22	1.21

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-FEB 84	11W	MIDGES-CHIRONOMIDAE, LARVAE	1501.63	46.27	151.28	1.92	11.98	.08
DEC-FEB 84	11W	SNAIL-FLUMINICOLA	427.90	13.18	615.22	9.55	59.55	14.27
DEC-FEB 84	11W	MIDGES-CHIRONOMIDAE, PUPAE	403.67	12.44	91.68	.53	3.28	.09
DEC-FEB 84	11W	BLACKFLY-SIMULIDAE, LARVAE	347.13	10.70	178.53	1.53	9.54	1.08
DEC-FEB 84	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	242.20	7.46	87.35	1.03	6.43	.53
DEC-FEB 84	11W	BLACKFLY-SIMULIDAE, PUPAE	226.07	6.97	109.22	.87	5.44	.44
DEC-FEB 84	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	32.27	.99	13.97	.01	.05	.00
DEC-FEB 84	11W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	16.13	.50	13.97	.23	1.40	.21
DEC-FEB 84	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	16.13	.50	27.94	.00	.03	.01
DEC-FEB 84	11W	OLIGOCHAETE	16.13	.50	13.97	.01	.05	.01
DEC-FEB 84	11W	MIDGES-CHIRONOMIDAE, ADULT	8.07	.25	13.97	.01	.05	.01
DEC-FEB 84	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.25	13.97	.01	.07	.02
DEC-FEB 84	11W	UNIDENTIFIED	.	.	.	.34	2.13	.31
DEC-FEB 84	11M	MIDGES-CHIRONOMIDAE, LARVAE	758.90	50.82	283.81	.85	12.15	.31
DEC-FEB 84	11M	BLACKFLY-SIMULIDAE, LARVAE	185.67	12.43	28.00	.68	9.73	.23
DEC-FEB 84	11M	MIDGES-CHIRONOMIDAE, PUPAE	169.53	11.35	48.45	.17	2.42	.07
DEC-FEB 84	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	145.30	9.73	0.0	.57	8.22	.37
DEC-FEB 84	11M	BLACKFLY-SIMULIDAE, PUPAE	72.63	4.86	41.97	.24	3.46	.08
DEC-FEB 84	11M	SNAIL-FLUMINICOLA	56.50	3.78	37.02	2.31	33.11	1.65
DEC-FEB 84	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	56.50	3.78	37.02	.02	.24	.02
DEC-FEB 84	11M	SNAIL-FISHEROLA	16.13	1.08	13.97	2.05	29.35	1.[illegible]
DEC-FEB 84	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	16.13	1.08	13.97	.03	.36	.0[illegible]
DEC-FEB 84	11M	MIDGES-CHIRONOMIDAE, ADULT	8.07	.54	13.97	.01	.15	.02
DEC-FEB 84	11M	OLIGOCHAETE	8.07	.54	13.97	.00	.02	.00
DEC-FEB 84	11M	UNIDENTIFIED	.	.	.	.06	.80	.05
DEC-FEB 84	11E	SNAIL-FLUMINICOLA	2074.83	50.10	872.35	54.35	77.70	27.00
DEC-FEB 84	11E	MIDGES-CHIRONOMIDAE, LARVAE	1194.87	28.85	555.63	1.25	1.78	.70
DEC-FEB 84	11E	MIDGES-CHIRONOMIDAE, PUPAE	266.43	6.43	41.97	.32	.45	.12
DEC-FEB 84	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	258.33	6.24	55.89	1.17	1.67	.61
DEC-FEB 84	11E	SNAIL-FISHEROLA	161.43	3.90	133.38	11.75	16.79	10.79
DEC-FEB 84	11E	BLACKFLY-SIMULIDAE, LARVAE	104.97	2.53	85.09	.42	.61	.37
DEC-FEB 84	11E	BLACKFLY-SIMULIDAE, PUPAE	64.60	1.56	14.03	.23	.32	.04
DEC-FEB 84	11E	MAYFLY, NYMPH	16.13	.39	27.94	.00	.00	.01
DEC-FEB 84	11E	UNIDENTIFIED	0.0	0.0	.	.47	.67	.61

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-FEB 84	8	MIDGES-CHIRONOMIDAE, LARVAE	3616.87	50.17	1676.33	4.65	31.48	1.76
DEC-FEB 84	8	MIDGES-CHIRONOMIDAE, PUPAE	1114.10	15.45	460.16	1.58	10.70	.56
DEC-FEB 84	8	CADDISFLY-HYDROPTILIDAE, LARVAE	880.00	12.21	386.22	.30	2.03	.17
DEC-FEB 84	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	775.03	10.75	303.48	4.20	28.43	2.48
DEC-FEB 84	8	BLACKFLY-SIMULIDAE, LARVAE	387.53	5.38	275.09	1.78	12.05	1.37
DEC-FEB 84	8	BLACKFLY-SIMULIDAE, PUPAE	226.07	3.14	77.89	.86	5.85	.17
DEC-FEB 84	8	MAYFLY-EPHEMERELLIDAE, NYMPH	48.43	.67	83.89	.03	.17	.04
DEC-FEB 84	8	MIDGES-CHIRONOMIDAE, ADULT	40.37	.56	37.01	.04	.28	.04
DEC-FEB 84	8	CADDISFLY-LEPTOCERIDAE, LARVAE	40.37	.56	69.92	.19	1.28	.33
DEC-FEB 84	8	MAYFLY, NYMPH	24.23	.34	41.97	.01	.05	.01
DEC-FEB 84	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	24.20	.34	24.20	.03	.21	.03
DEC-FEB 84	8	SNAIL-FISHEROLA	8.07	.11	13.97	.76	5.17	1.32
DEC-FEB 84	8	BLACKFLY-SIMULIDAE, ADULT	8.07	.11	13.97	.02	.15	.04
DEC-FEB 84	8	MOTH-PYRALIDAE, LARVAE	8.07	.11	13.97	.05	.32	.08
DEC-FEB 84	8	OLIGOCHAETE	8.07	.11	13.97	.00	.01	.00
DEC-FEB 84	8	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
DEC-FEB 84	8	UNIDENTIFIED	.	.	.	.27	1.82	.40
MARCH-MAY 84	1	MIDGES-CHIRONOMIDAE, LARVAE	3092.10	34.14	1825.76	1.46	4.50	1.10
MARCH-MAY 84	1	MIDGES-CHIRONOMIDAE, PUPAE	2761.10	30.48	1594.83	1.63	5.00	1.33
MARCH-MAY 84	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	928.43	10.25	641.83	15.18	46.69	12.58
MARCH-MAY 84	1	BLACKFLY-SIMULIDAE, LARVAE	678.17	7.49	361.70	1.26	3.87	.81
MARCH-MAY 84	1	BLACKFLY-SIMULIDAE, PUPAE	500.53	5.53	100.85	2.17	6.67	1.93
MARCH-MAY 84	1	MAYFLY-EPHEMERELLIDAE, NYMPH	411.73	4.55	358.41	2.39	7.34	2.09
MARCH-MAY 84	1	MAYFLY-BAETIDAE, NYMPH	355.20	3.92	272.21	.13	.40	.09
MARCH-MAY 84	1	SNAIL-FLUMINICOLA	80.73	.89	73.99	4.31	13.24	4.05
MARCH-MAY 84	1	OLIGOCHAETE	48.47	.54	41.97	.00	.01	.00
MARCH-MAY 84	1	MAYFLY, NYMPH	48.43	.53	83.89	.05	.15	.08
MARCH-MAY 84	1	CADDISFLY-HYDROPSYCHIDAE, PUPAE	40.37	.45	37.01	.80	2.46	.71
MARCH-MAY 84	1	MIDGES-CHIRONOMIDAE, ADULT	32.30	.36	37.02	.01	.04	.01
MARCH-MAY 84	1	CADDISFLY-LEPTOCERIDAE, LARVAE	32.30	.36	37.02	.35	1.07	.47
MARCH-MAY 84	1	SNAIL-FISHEROLA	24.23	.27	41.97	1.88	5.78	3.26
MARCH-MAY 84	1	CLAMS	8.07	.09	13.97	.01	.02	.01
MARCH-MAY 84	1	SNAIL-PARAPHOLYX	8.07	.09	13.97	.45	1.37	.77
MARCH-MAY 84	1	MITES-GENERAL	8.07	.09	13.97	.00	.00	.00
MARCH-MAY 84	1	UNIDENTIFIED	.	.	.	.45	1.37	.34

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-MAY 84	7W	MIDGES-CHIRONOMIDAE, LARVAE	8000.67	34.74	1440.52	1.72	1.55	.23
MARCH-MAY 84	7W	MIDGES-CHIRONOMIDAE, PUPAE	5667.50	24.61	2291.71	1.93	1.74	.14
MARCH-MAY 84	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	2131.37	9.25	272.95	26.19	23.62	1.69
MARCH-MAY 84	7W	BLACKFLY-SIMULIDAE, PUPAE	1703.47	7.40	354.59	3.99	3.59	.85
MARCH-MAY 84	7W	SNAIL-FLUMINICOLA	1348.23	5.85	811.42	44.64	40.26	24.70
MARCH-MAY 84	7W	BLACKFLY-SIMULIDAE, LARVAE	1332.07	5.78	545.35	2.76	2.49	1.20
MARCH-MAY 84	7W	MAYFLY-BAETIDAE, NYMPH	1130.27	4.91	517.42	.48	.44	.16
MARCH-MAY 84	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	476.33	2.07	183.41	1.65	1.48	.71
MARCH-MAY 84	7W	MIDGES-CHIRONOMIDAE, ADULT	452.10	1.96	201.71	.11	.10	.05
MARCH-MAY 84	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	209.90	.91	148.02	1.94	1.75	1.32
MARCH-MAY 84	7W	SNAIL-FISHEROLA	137.23	.60	36.97	15.57	14.04	4.23
MARCH-MAY 84	7W	MAYFLY, NYMPH	137.23	.60	237.70	.04	.04	.08
MARCH-MAY 84	7W	MITES-GENERAL	88.83	.39	13.97	.04	.04	.01
MARCH-MAY 84	7W	SNAIL-PARAPHOLYX	48.47	.21	41.97	3.14	2.83	2.73
MARCH-MAY 84	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	48.43	.21	24.25	.02	.02	.02
MARCH-MAY 84	7W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	32.27	.14	27.94	4.61	4.16	6.77
MARCH-MAY 84	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	24.20	.11	24.20	.05	.04	.05
MARCH-MAY 84	7W	SNAIL-PHYSA	16.13	.07	13.97	1.06	.95	1.26
MARCH-MAY 84	7W	BLACKFLY-SIMULIDAE, ADULT	16.13	.07	27.94	.03	.02	.04
MARCH-MAY 84	7W	MOTH-PYRALIDAE, LARVAE	16.13	.07	13.97	.00	.00	.00
MARCH-MAY 84	7W	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.04	13.97	.00	.00	.0[illegible]
MARCH-MAY 84	7W	CADDISFLY-GLOSSOSOMATIDAE, PUPAE	8.07	.04	13.97	.02	.02	.[illegible]
MARCH-MAY 84	7W	UNIDENTIFIED	.	.	.	.88	.79	.72
MARCH-MAY 84	7M	MIDGES-CHIRONOMIDAE, LARVAE	5336.47	31.30	2659.84	1.76	2.79	.87
MARCH-MAY 84	7M	MIDGES-CHIRONOMIDAE, PUPAE	3996.27	23.44	1587.65	1.85	2.94	.86
MARCH-MAY 84	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	2099.07	12.31	561.47	26.83	42.56	16.27
MARCH-MAY 84	7M	BLACKFLY-SIMULIDAE, LARVAE	1768.07	10.37	2349.33	4.16	6.60	5.77
MARCH-MAY 84	7M	BLACKFLY-SIMULIDAE, PUPAE	1743.87	10.23	2852.73	5.11	8.10	8.48
MARCH-MAY 84	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	742.73	4.36	448.10	1.57	2.49	.60
MARCH-MAY 84	7M	MAYFLY-BAETIDAE, NYMPH	621.63	3.65	511.70	.43	.68	.34
MARCH-MAY 84	7M	MIDGES-CHIRONOMIDAE, ADULT	201.83	1.18	69.92	.04	.07	.03
MARCH-MAY 84	7M	SNAIL-FLUMINICOLA	169.53	.99	151.24	4.30	6.82	3.72
MARCH-MAY 84	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	137.23	.80	124.28	2.89	4.58	2.66
MARCH-MAY 84	7M	SNAIL-FISHEROLA	129.17	.76	100.85	12.23	19.40	11.37
MARCH-MAY 84	7M	MITES-GENERAL	40.37	.24	37.01	.02	.03	.02
MARCH-MAY 84	7M	SNAIL-PARAPHOLYX	16.13	.09	27.94	1.11	1.76	1.93
MARCH-MAY 84	7M	BLACKFLY-SIMULIDAE, ADULT	16.13	.09	27.94	.02	.02	.03
MARCH-MAY 84	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	16.13	.09	27.94	.12	.20	.21
MARCH-MAY 84	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	16.13	.09	27.94	.00	.00	.00
MARCH-MAY 84	7M	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
MARCH-MAY 84	7M	UNIDENTIFIED	.	.	.	.60	.95	.50

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-MAY 84	7E	MIDGES-CHIRONOMIDAE, LARVAE	3633.00	35.27	547.51	1.12	1.16	.33
MARCH-MAY 84	7E	MIDGES-CHIRONOMIDAE, PUPAE	2446.20	23.75	233.55	1.16	1.21	.09
MARCH-MAY 84	7E	SNAIL-FLUMINICOLA	1097.97	10.66	937.21	38.93	40.43	27.04
MARCH-MAY 84	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	863.87	8.39	386.26	11.17	11.60	2.88
MARCH-MAY 84	7E	MAYFLY-BAETIDAE, NYMPH	863.83	8.39	412.69	.32	.33	.20
MARCH-MAY 84	7E	SNAIL-FISHEROLA	322.93	3.13	292.95	38.25	39.73	36.75
MARCH-MAY 84	7E	BLACKFLY-SIMULIDAE, LARVAE	306.80	2.98	322.55	.58	.60	.54
MARCH-MAY 84	7E	MIDGES-CHIRONOMIDAE, ADULT	226.07	2.19	133.37	.05	.05	.03
MARCH-MAY 84	7E	BLACKFLY-SIMULIDAE, PUPAE	226.07	2.19	157.55	.69	.71	.35
MARCH-MAY 84	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	145.30	1.41	24.20	.49	.51	.31
MARCH-MAY 84	7E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	88.80	.86	50.42	.57	.60	.39
MARCH-MAY 84	7E	SNAIL-PARAPHOLYX	48.43	.47	64.08	2.51	2.61	3.53
MARCH-MAY 84	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	16.13	.16	27.94	.16	.17	.28
MARCH-MAY 84	7E	CLAMS	8.07	.08	13.97	0.0	0.0	0.0
MARCH-MAY 84	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.08	13.97	.00	.00	.00
MARCH-MAY 84	7E	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
MARCH-MAY 84	7E	UNIDENTIFIED	.	.	.	.28	.30	.05
MARCH-MAY 84	11W	MIDGES-CHIRONOMIDAE, LARVAE	6870.43	30.19	1089.99	2.69	2.88	.35
MARCH-MAY 84	11W	MIDGES-CHIRONOMIDAE, PUPAE	6603.97	29.02	1434.58	3.29	3.52	1.11
MARCH-MAY 84	11W	MAYFLY-BAETIDAE, NYMPH	2607.67	11.46	480.94	1.65	1.77	.58
MARCH-MAY 84	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	2131.33	9.36	365.72	29.02	31.02	5.47
MARCH-MAY 84	11W	SNAIL-FLUMINICOLA	1509.70	6.63	778.19	40.53	43.31	23.11
MARCH-MAY 84	11W	MIDGES-CHIRONOMIDAE, ADULT	678.20	2.98	209.75	.21	.22	.07
MARCH-MAY 84	11W	BLACKFLY-SIMULIDAE, LARVAE	637.83	2.80	369.97	1.49	1.59	.89
MARCH-MAY 84	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	500.57	2.20	69.92	1.93	2.06	.26
MARCH-MAY 84	11W	BLACKFLY-SIMULIDAE, PUPAE	492.47	2.16	230.21	1.16	1.24	.59
MARCH-MAY 84	11W	OLIGOCHAETE	177.63	.78	69.92	.01	.01	.01
MARCH-MAY 84	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	169.53	.74	87.31	.08	.09	.04
MARCH-MAY 84	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	129.17	.57	13.97	1.12	1.20	.18
MARCH-MAY 84	11W	SNAIL-FISHEROLA	88.80	.39	50.42	8.47	9.05	5.03
MARCH-MAY 84	11W	MITES-GENERAL	48.43	.21	41.97	.02	.02	.01
MARCH-MAY 84	11W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	40.37	.18	50.43	.54	.58	.65
MARCH-MAY 84	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	24.20	.11	24.20	.06	.06	.06
MARCH-MAY 84	11W	SNAIL-PARAPHOLYX	16.13	.07	13.97	.79	.84	1.21
MARCH-MAY 84	11W	CLAMS	8.07	.04	13.97	.01	.01	.02
MARCH-MAY 84	11W	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.04	13.97	.00	.00	.01
MARCH-MAY 84	11W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.04	13.97	.00	.00	.00
MARCH-MAY 84	11W	CADDISFLY-GENERAL, ADULT	8.07	.04	13.97	.29	.31	.50
MARCH-MAY 84	11W	UNIDENTIFIED	.	.	.	.21	.22	.17

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-MAY 84	11M	MIDGES-CHIRONOMIDAE, PUPAE	4319.23	28.55	2300.83	1.35	2.85	.94
MARCH-MAY 84	11M	MIDGES-CHIRONOMIDAE, LARVAE	3980.13	26.31	1763.97	.87	1.84	.34
MARCH-MAY 84	11M	BLACKFLY-SIMULIDAE, LARVAE	1873.03	12.38	347.94	3.99	8.41	.86
MARCH-MAY 84	11M	BLACKFLY-SIMULIDAE, PUPAE	1719.63	11.37	753.20	3.66	7.72	1.40
MARCH-MAY 84	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	1081.83	7.15	567.63	20.39	43.02	10.83
MARCH-MAY 84	11M	MAYFLY-BAETIDAE, NYMPH	799.23	5.28	569.54	.28	.60	.14
MARCH-MAY 84	11M	MAYFLY-EPHEMERELLIDAE, NYMPH	339.10	2.24	242.20	1.23	2.60	.69
MARCH-MAY 84	11M	MAYFLY, NYMPH	282.57	1.87	219.74	.12	.25	.07
MARCH-MAY 84	11M	MIDGES-CHIRONOMIDAE, ADULT	282.57	1.87	114.42	.10	.21	.02
MARCH-MAY 84	11M	SNAIL-FLUMINICOLA	137.23	.91	137.70	6.15	12.97	6.59
MARCH-MAY 84	11M	OLIGOCHAETE	113.03	.75	91.71	.02	.04	.01
MARCH-MAY 84	11M	SNAIL-FISHEROLA	72.63	.48	87.31	8.21	17.32	8.14
MARCH-MAY 84	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	48.43	.32	64.08	.41	.87	.65
MARCH-MAY 84	11M	BLACKFLY-SIMULIDAE, ADULT	32.27	.21	27.94	.05	.10	.04
MARCH-MAY 84	11M	CLAMS	8.07	.05	13.97	.00	.01	.00
MARCH-MAY 84	11M	MITES-GENERAL	8.07	.05	13.97	.00	.00	.00
MARCH-MAY 84	11M	MOTH-PYRALIDAE, LARVAE	8.07	.05	13.97	.01	.01	.01
MARCH-MAY 84	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.05	13.97	.01	.01	.01
MARCH-MAY 84	11M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	8.07	.05	13.97	.09	.18	.15
MARCH-MAY 84	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.05	13.97	.01	.02	.01
MARCH-MAY 84	11M	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
MARCH-MAY 84	11M	UNIDENTIFIED	.	.	.	.46	.97	.3[illegible]
MARCH-MAY 84	11E	MIDGES-CHIRONOMIDAE, LARVAE	3649.13	29.09	1601.54	.93	1.19	.58
MARCH-MAY 84	11E	MIDGES-CHIRONOMIDAE, PUPAE	3326.23	26.51	533.03	.99	1.28	.31
MARCH-MAY 84	11E	SNAIL-FLUMINICOLA	1485.50	11.84	1230.29	40.00	51.48	26.13
MARCH-MAY 84	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	984.93	7.85	352.90	14.54	18.72	3.62
MARCH-MAY 84	11E	MAYFLY-BAETIDAE, NYMPH	880.00	7.01	50.42	.32	.42	.07
MARCH-MAY 84	11E	BLACKFLY-SIMULIDAE, LARVAE	710.43	5.66	727.17	1.65	2.13	1.63
MARCH-MAY 84	11E	BLACKFLY-SIMULIDAE, PUPAE	427.90	3.41	225.06	.96	1.24	.42
MARCH-MAY 84	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	250.27	1.99	235.24	.84	1.09	1.14
MARCH-MAY 84	11E	MAYFLY, NYMPH	226.07	1.80	137.70	.09	.12	.08
MARCH-MAY 84	11E	MIDGES-CHIRONOMIDAE, ADULT	209.93	1.67	13.97	.07	.09	.01
MARCH-MAY 84	11E	SNAIL-FISHEROLA	161.47	1.29	137.76	15.53	19.99	12.30
MARCH-MAY 84	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	80.73	.64	85.04	.58	.74	.58
MARCH-MAY 84	11E	OLIGOCHAETE	48.43	.39	48.45	.01	.01	.01
MARCH-MAY 84	11E	MITES-GENERAL	40.37	.32	50.43	.02	.03	.03
MARCH-MAY 84	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	16.13	.13	13.97	.00	.01	.01
MARCH-MAY 84	11E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	16.13	.13	27.94	.31	.40	.54
MARCH-MAY 84	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	16.13	.13	13.97	.02	.02	.02
MARCH-MAY 84	11E	SNAIL-PARAPHOLYX	8.07	.06	13.97	.42	.54	.73
MARCH-MAY 84	11E	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.06	13.97	.01	.02	.03
MARCH-MAY 84	11E	UNIDENTIFIED	.	.	.	.39	.51	.36

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-MAY 84	8	MIDGES-CHIRONOMIDAE, PUPAE	11238.10	33.96	1917.98	7.78	10.34	5.29
MARCH-MAY 84	8	MIDGES-CHIRONOMIDAE, LARVAE	10277.37	31.06	1901.73	5.14	6.83	4.02
MARCH-MAY 84	8	MAYFLY-BAETIDAE, NYMPH	3737.97	11.30	1416.92	3.19	4.24	1.86
MARCH-MAY 84	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	3318.17	10.03	581.78	45.91	60.99	17.85
MARCH-MAY 84	8	OLIGOCHAETE	1081.80	3.27	1437.22	.06	.08	.05
MARCH-MAY 84	8	MAYFLY-EPHEMERELLIDAE, NYMPH	565.13	1.71	256.74	2.24	2.98	1.06
MARCH-MAY 84	8	BLACKFLY-SIMULIDAE, PUPAE	508.63	1.54	366.52	1.42	1.89	1.02
MARCH-MAY 84	8	BLACKFLY-SIMULIDAE, LARVAE	468.27	1.42	322.53	1.16	1.54	.97
MARCH-MAY 84	8	MAYFLY, NYMPH	419.83	1.27	370.77	.20	.26	.20
MARCH-MAY 84	8	MITES-GENERAL	387.53	1.17	169.55	.14	.19	.06
MARCH-MAY 84	8	CADDISFLY-HYDROPTILIDAE, LARVAE	314.83	.95	83.89	.15	.20	.03
MARCH-MAY 84	8	MIDGES-CHIRONOMIDAE, ADULT	217.97	.66	245.81	.08	.10	.09
MARCH-MAY 84	8	CADDISFLY-HYDROPTILIDAE, PUPAE	153.40	.46	77.85	.06	.08	.04
MARCH-MAY 84	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	113.07	.34	69.92	.21	.28	.04
MARCH-MAY 84	8	CADDISFLY-LEPTOCERIDAE, LARVAE	64.57	.20	50.43	.61	.81	.59
MARCH-MAY 84	8	MOTH-PYRALIDAE, LARVAE	48.43	.15	64.08	.28	.38	.46
MARCH-MAY 84	8	CADDISFLY-HYDROPSYCHIDAE, PUPAE	32.30	.10	37.02	.75	.99	1.13
MARCH-MAY 84	8	SNAIL-FISHEROLA	24.23	.07	41.97	1.62	2.15	2.81
MARCH-MAY 84	8	SNAIL-PARAPHOLYX	24.20	.07	24.20	2.29	3.04	2.29
MARCH-MAY 84	8	CLAMS	16.13	.05	27.94	.00	.01	.01
MARCH-MAY 84	8	SNAIL-FLUMINICOLA	16.13	.05	27.94	1.03	1.36	1.78
MARCH-MAY 84	8	MITES-GENERAL, LARVAE	16.13	.05	27.94	.00	.00	.00
MARCH-MAY 84	8	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	16.13	.05	27.94	.04	.05	.06
MARCH-MAY 84	8	BLACKFLY-SIMULIDAE, ADULT	8.07	.02	13.97	.01	.02	.02
MARCH-MAY 84	8	CADDISFLY-PSYCHOMYIIDAE, PUPAE	8.07	.02	13.97	.02	.02	.03
MARCH-MAY 84	8	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.02	13.97	.00	.01	.01
MARCH-MAY 84	8	MAYFLY-TRICOR., NYMPH	8.07	.02	13.97	.00	.01	.01
MARCH-MAY 84	8	ROUND-WORM	0.0	0.0	.	0.0	0.0	.
MARCH-MAY 84	8	UNIDENTIFIED	.	.	.	.87	1.16	.47

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-AUG 84	1	MIDGES-CHIRONOMIDAE, LARVAE	39478.60	47.48	11967.32	4.13	3.44	2.88
JUNE-AUG 84	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	22551.50	27.12	5493.02	96.71	80.73	39.48
JUNE-AUG 84	1	MIDGES-CHIRONOMIDAE, PUPAE	15586.93	18.74	5595.36	4.11	3.43	2.73
JUNE-AUG 84	1	CADDISFLY-LEPTOCERIDAE, LARVAE	2615.77	3.15	1531.64	.39	.32	.18
JUNE-AUG 84	1	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1194.83	1.44	538.52	11.20	9.35	3.23
JUNE-AUG 84	1	SNAIL-FLUMINICOLA	460.17	.55	269.69	1.26	1.05	.91
JUNE-AUG 84	1	OLIGOCHAETE	339.07	.41	483.77	.02	.02	.01
JUNE-AUG 84	1	MAYFLY-BAETIDAE, NYMPH	201.87	.24	133.38	.13	.11	.11
JUNE-AUG 84	1	MIDGES-CHIRONOMIDAE, ADULT	185.70	.22	219.79	.05	.04	.06
JUNE-AUG 84	1	SNAIL-PARAPHOLYX	161.50	.19	133.40	.25	.21	.25
JUNE-AUG 84	1	MITES-GENERAL	113.00	.14	77.85	.04	.04	.03
JUNE-AUG 84	1	SNAIL-FISHEROLA	88.80	.11	85.04	.11	.10	.10
JUNE-AUG 84	1	SNAIL-PHYSA	40.37	.05	69.92	.86	.72	1.49
JUNE-AUG 84	1	CADDISFLY-HYDROPSYCHIDAE, ADULT	40.37	.05	69.92	.32	.27	.56
JUNE-AUG 84	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	32.30	.04	37.02	.05	.04	.04
JUNE-AUG 84	1	CLAMS	8.07	.01	13.97	0.0	0.0	0.0
JUNE-AUG 84	1	SNAIL-LIMNAE	8.07	.01	13.97	.00	.00	.01
JUNE-AUG 84	1	BLACKFLY-SIMULIDAE, LARVAE	8.07	.01	13.97	.03	.02	.05
JUNE-AUG 84	1	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	1	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	1	CADDISFLY-GENERAL, ADULT	8.07	.01	13.97	.06	.05	.11
JUNE-AUG 84	1	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.0[illegible]
JUNE-AUG 84	1	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	1	UNIDENTIFIED	0.0	0.0	.	.07	.06	.06
JUNE-AUG 84	1	ROUND-WORM	.	.	.	.	.	.
JUNE-AUG 84	7W	MIDGES-CHIRONOMIDAE, LARVAE	29031.70	37.68	16520.89	4.40	2.00	3.68
JUNE-AUG 84	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	25713.57	33.37	3283.95	139.89	63.73	11.95
JUNE-AUG 84	7W	MIDGES-CHIRONOMIDAE, PUPAE	13369.43	17.35	4635.11	5.35	2.44	3.86
JUNE-AUG 84	7W	SNAIL-FLUMINICOLA	4238.50	5.50	714.82	51.83	23.61	3.71
JUNE-AUG 84	7W	MAYFLY-BAETIDAE, NYMPH	1420.90	1.84	826.41	.87	.39	.62
JUNE-AUG 84	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	920.37	1.19	380.65	.17	.08	.09
JUNE-AUG 84	7W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	831.53	1.08	455.91	12.06	5.49	6.22
JUNE-AUG 84	7W	SNAIL-FISHEROLA	597.43	.78	605.66	1.93	.88	1.89
JUNE-AUG 84	7W	SNAIL-PARAPHOLYX	597.43	.78	412.69	.81	.37	.59
JUNE-AUG 84	7W	MIDGES-CHIRONOMIDAE, ADULT	80.70	.10	77.85	.02	.01	.01
JUNE-AUG 84	7W	OLIGOCHAETE	48.43	.06	64.08	0.0	0.0	0.0
JUNE-AUG 84	7W	BLACKFLY-SIMULIDAE, LARVAE	40.37	.05	28.00	.07	.03	.08
JUNE-AUG 84	7W	MITES-GENERAL	32.30	.04	37.02	.01	.00	.01
JUNE-AUG 84	7W	SNAIL-PHYSA	24.20	.03	0.0	.71	.32	.36
JUNE-AUG 84	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	24.20	.03	24.20	.02	.01	.02
JUNE-AUG 84	7W	CLAMS	16.13	.02	13.97	.01	.00	.01
JUNE-AUG 84	7W	CADDISFLY-HYDROPTILIDAE, PUPAE	16.13	.02	13.97	.00	.00	.00
JUNE-AUG 84	7W	SNAIL-LIMNAE	8.07	.01	13.97	.02	.01	.04
JUNE-AUG 84	7W	BLACKFLY-SIMULIDAE, PUPAE	8.07	.01	13.97	.01	.01	.02
JUNE-AUG 84	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.01	13.97	.00	.00	.01
JUNE-AUG 84	7W	CADDISFLY-PSYCHOMYIIDAE, PUPAE	8.07	.01	13.97	.00	.00	[illegible]
JUNE-AUG 84	7W	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.0[illegible]
JUNE-AUG 84	7W	MAYFLY-TRICOR., NYMPH	8.07	.01	13.97	.01	.00	.02
JUNE-AUG 84	7W	UNIDENTIFIED	.	.	.	1.30	.59	1.70

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-AUG 84	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	46018.00	43.67	12722.13	247.65	84.87	10.86
JUNE-AUG 84	7M	MIDGES-CHIRONOMIDAE, LARVAE	35522.67	33.71	10352.77	5.79	1.98	2.32
JUNE-AUG 84	7M	MIDGES-CHIRONOMIDAE, PUPAE	17532.60	16.64	3186.77	7.13	2.44	2.03
JUNE-AUG 84	7M	MAYFLY-BAETIDAE, NYMPH	1743.83	1.65	189.12	1.10	.38	.41
JUNE-AUG 84	7M	SNAIL-FLUMINICOLA	1582.37	1.50	716.17	16.01	5.49	6.30
JUNE-AUG 84	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	912.30	.87	133.40	10.53	3.61	3.29
JUNE-AUG 84	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	726.60	.69	366.48	.14	.05	.07
JUNE-AUG 84	7M	SNAIL-FISHEROLA	484.40	.46	206.96	1.42	.49	.47
JUNE-AUG 84	7M	OLIGOCHAETE	306.77	.29	290.99	.01	.00	.00
JUNE-AUG 84	7M	SNAIL-PARAPHOLYX	129.17	.12	97.90	.25	.08	.05
JUNE-AUG 84	7M	MAYFLY, NYMPH	121.10	.08	171.26	.08	.03	.07
JUNE-AUG 84	7M	BLACKFLY-SIMULIDAE, LARVAE	56.50	.05	37.02	.07	.02	.05
JUNE-AUG 84	7M	MOLLUSC	40.37	.04	69.92	.01	.00	.02
JUNE-AUG 84	7M	MITES-GENERAL	40.37	.04	69.92	.01	.00	.02
JUNE-AUG 84	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	40.37	.04	37.01	.01	.00	.01
JUNE-AUG 84	7M	CADDISFLY-HYDROPTILIDAE, PUPAE	40.33	.04	13.97	.01	.00	.00
JUNE-AUG 84	7M	CLAMS	32.30	.03	37.02	.01	.00	.02
JUNE-AUG 84	7M	SNAIL-PHYSA	16.13	.02	13.97	.36	.12	.37
JUNE-AUG 84	7M	SNAIL-LIMNAE	16.13	.02	27.94	.88	.30	1.52
JUNE-AUG 84	7M	MIDGES-CHIRONOMIDAE, ADULT	16.13	.02	13.97	.01	.00	.01
JUNE-AUG 84	7M	BLACKFLY-SIMULIDAE, PUPAE	16.13	.02	27.94	.03	.01	.05
JUNE-AUG 84	7M	CADDISFLY-HYDROPSYCHIDAE, ADULT	8.07	.01	13.97	.08	.03	.13
JUNE-AUG 84	7M	CADDISFLY-PSYCHOMYIIDAE, PUPAE	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	7M	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	7M	UNIDENTIFIED	0.0	0.0	.	.23	.08	.20
JUNE-AUG 84	7M	ROUND-WORM	.	.	.	.	.	.
JUNE-AUG 84	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	17061.63	37.88	14960.15	58.34	44.51	52.40
JUNE-AUG 84	7E	MIDGES-CHIRONOMIDAE, LARVAE	12174.60	27.03	15802.52	1.88	1.43	2.01
JUNE-AUG 84	7E	MIDGES-CHIRONOMIDAE, PUPAE	8396.27	18.64	7525.11	1.99	1.52	2.15
JUNE-AUG 84	7E	SNAIL-FLUMINICOLA	3544.20	7.87	3071.30	56.24	42.92	49.89
JUNE-AUG 84	7E	SNAIL-FISHEROLA	1049.53	2.33	947.16	3.48	2.65	3.04
JUNE-AUG 84	7E	MAYFLY-BAETIDAE, NYMPH	960.73	2.13	1021.95	.54	.41	.54
JUNE-AUG 84	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	863.83	1.92	775.91	.20	.15	.18
JUNE-AUG 84	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	557.07	1.24	557.05	6.05	4.62	6.58
JUNE-AUG 84	7E	SNAIL-PARAPHOLYX	250.27	.56	254.40	.42	.32	.44
JUNE-AUG 84	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	40.37	.09	37.01	.02	.01	.03
JUNE-AUG 84	7E	OLIGOCHAETE	40.37	.09	69.92	.02	.02	.04
JUNE-AUG 84	7E	SNAIL-PHYSA	24.20	.05	24.20	.26	.20	.23
JUNE-AUG 84	7E	CLAMS	16.13	.04	27.94	.33	.25	.57
JUNE-AUG 84	7E	CADDISFLY-PSYCHOMYIIDAE, PUPAE	16.13	.04	13.97	.01	.01	.01
JUNE-AUG 84	7E	SNAIL-LIMNAE	8.07	.02	13.97	.38	.29	.66
JUNE-AUG 84	7E	BLACKFLY-SIMULIDAE, PUPAE	8.07	.02	13.97	.02	.02	.04
JUNE-AUG 84	7E	BLACKFLY-SIMULIDAE, LARVAE	8.07	.02	13.97	.00	.00	.01
JUNE-AUG 84	7E	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.02	13.97	.01	.01	.01
JUNE-AUG 84	7E	MAYFLY-TRICOR., NYMPH	8.07	.02	13.97	.01	.00	.01
JUNE-AUG 84	7E	SCUDS/SHRIMPS	8.07	.02	13.97	.00	.00	.01
JUNE-AUG 84	7E	UNIDENTIFIED	0.0	0.0	0.0	.85	.65	1.47
JUNE-AUG 84	7E	ROUND-WORM	0.0	0.0	.	0.0	0.0	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-AUG 84	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	27556.97	37.67	8447.90	120.60	69.24	45.70
JUNE-AUG 84	11W	MIDGES-CHIRONOMIDAE, LARVAE	25727.00	35.17	1211.90	2.85	1.64	1.35
JUNE-AUG 84	11W	MIDGES-CHIRONOMIDAE, PUPAE	7588.93	10.37	739.93	2.57	1.48	.98
JUNE-AUG 84	11W	SNAIL-FLUMINICOLA	4504.93	6.16	1599.05	32.28	18.53	25.48
JUNE-AUG 84	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	4303.07	5.88	545.02	1.16	.66	.36
JUNE-AUG 84	11W	MAYFLY-BAETIDAE, NYMPH	1194.87	1.63	306.69	.79	.46	.02
JUNE-AUG 84	11W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	823.47	1.13	356.78	8.73	5.01	3.94
JUNE-AUG 84	11W	SNAIL-FISHEROLA	670.10	.92	325.26	2.66	1.53	1.23
JUNE-AUG 84	11W	SNAIL-PARAPHOLYX	217.97	.30	147.32	.47	.27	.35
JUNE-AUG 84	11W	OLIGOCHAETE	161.47	.22	279.67	.00	.00	.00
JUNE-AUG 84	11W	MITES-GENERAL	72.67	.10	24.25	.02	.01	.02
JUNE-AUG 84	11W	CLAMS	48.43	.07	24.25	.01	.00	.01
JUNE-AUG 84	11W	MAYFLY-TRICOR., NYMPH	40.37	.06	37.01	.05	.03	.08
JUNE-AUG 84	11W	SNAIL-PHYSA	32.30	.04	37.02	.56	.32	.84
JUNE-AUG 84	11W	CADDISFLY-HYDROPTILIDAE, PUPAE	32.27	.04	13.97	.01	.01	.01
JUNE-AUG 84	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	32.27	.04	13.97	.01	.00	.00
JUNE-AUG 84	11W	CADDISFLY-HYDROPSYCHIDAE, ADULT	24.23	.03	41.97	.43	.25	.74
JUNE-AUG 84	11W	CADDISFLY-PSYCHOMYIIDAE, PUPAE	24.20	.03	24.20	.02	.01	.02
JUNE-AUG 84	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	24.20	.03	24.20	.02	.01	.03
JUNE-AUG 84	11W	MAYFLY, NYMPH	16.13	.02	27.94	.00	.00	.00
JUNE-AUG 84	11W	MIDGES-CHIRONOMIDAE, ADULT	8.07	.01	13.97	0.0	0.0	0.0
JUNE-AUG 84	11W	BLACKFLY-SIMULIDAE, PUPAE	8.07	.01	13.97	.01	.01	.02
JUNE-AUG 84	11W	BLACKFLY-SIMULIDAE, LARVAE	8.07	.01	13.97	.01	.00	.01
JUNE-AUG 84	11W	CADDISFLY-GENERAL, ADULT	8.07	.01	13.97	.07	.04	.12
JUNE-AUG 84	11W	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.01
JUNE-AUG 84	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.01	.01	.02
JUNE-AUG 84	11W	WATER APHNIA	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	11W	UNIDENTIFIED	0.0	0.0	.	.83	.48	1.38
JUNE-AUG 84	11W	ROUND-WORM	0.0	0.0	.	0.0	0.0	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-AUG 84	11M	MIDGES-CHIRONOMIDAE, LARVAE	48709.13	49.02	29652.06	5.93	2.40	3.89
JUNE-AUG 84	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	36416.13	36.65	3036.49	208.65	84.32	54.47
JUNE-AUG 84	11M	MIDGES-CHIRONOMIDAE, PUPAE	9429.67	9.49	1813.32	5.08	2.05	.60
JUNE-AUG 84	11M	SNAIL-FLUMINICOLA	1307.90	1.32	587.28	20.00	8.08	13.17
JUNE-AUG 84	11M	MAYFLY-BAETIDAE, NYMPH	1211.00	1.22	279.29	.84	.34	.23
JUNE-AUG 84	11M	OLIGOCHAETE	460.17	.46	151.24	.00	.00	0.0
JUNE-AUG 84	11M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	395.60	.40	247.42	4.46	1.80	2.58
JUNE-AUG 84	11M	SNAIL-FISHEROLA	387.53	.39	252.89	1.47	.60	1.20
JUNE-AUG 84	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	379.47	.38	170.13	.12	.05	.09
JUNE-AUG 84	11M	MAYFLY, NYMPH	177.63	.18	170.13	.09	.04	.08
JUNE-AUG 84	11M	SNAIL-PARAPHOLYX	113.03	.11	195.78	.20	.08	.35
JUNE-AUG 84	11M	BLACKFLY-SIMULIDAE, LARVAE	96.87	.10	83.95	.15	.06	.09
JUNE-AUG 84	11M	CADDISFLY-HYDROPTILIDAE, PUPAE	56.50	.06	60.95	.02	.01	.02
JUNE-AUG 84	11M	MIDGES-CHIRONOMIDAE, ADULT	48.43	.05	83.89	.01	.00	.02
JUNE-AUG 84	11M	BLACKFLY-SIMULIDAE, PUPAE	40.33	.04	13.97	.10	.04	.04
JUNE-AUG 84	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	32.27	.03	27.94	.01	.00	.01
JUNE-AUG 84	11M	CLAMS	24.23	.02	41.97	.00	.00	.00
JUNE-AUG 84	11M	MITES-GENERAL	24.20	.02	24.20	.01	.00	.01
JUNE-AUG 84	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	16.13	.02	13.97	.00	.00	.00
JUNE-AUG 84	11M	FLAT-WORM	16.13	.02	27.94	.00	.00	.00
JUNE-AUG 84	11M	CADDISFLY-LEPTOCERIDAE, PUPAE	8.07	.01	13.97	.00	.00	.01
JUNE-AUG 84	11M	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	11M	SCUDS/SHRIMPS	8.07	.01	13.97	.01	.00	.01
JUNE-AUG 84	11M	UNIDENTIFIED	.	.	.	.28	.11	.14
JUNE-AUG 84	11M	ROUND-WORM	.	.	.	.	.	.
JUNE-AUG 84	11E	MIDGES-CHIRONOMIDAE, LARVAE	56190.40	58.48	5540.29	8.93	5.47	2.88
JUNE-AUG 84	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	24435.30	25.43	5230.47	99.57	60.92	30.70
JUNE-AUG 84	11E	MIDGES-CHIRONOMIDAE, PUPAE	9058.27	9.43	428.08	3.19	1.95	1.16
JUNE-AUG 84	11E	SNAIL-FLUMINICOLA	2769.17	2.88	1432.30	41.31	25.28	21.73
JUNE-AUG 84	11E	MAYFLY-BAETIDAE, NYMPH	1332.07	1.39	272.95	.68	.42	.19
JUNE-AUG 84	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	589.37	.61	414.11	.15	.09	.13
JUNE-AUG 84	11E	SNAIL-FISHEROLA	565.13	.59	119.49	2.95	1.80	.56
JUNE-AUG 84	11E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	524.73	.55	121.90	5.58	3.42	1.57
JUNE-AUG 84	11E	OLIGOCHAETE	266.40	.28	419.50	.00	.00	.00
JUNE-AUG 84	11E	SNAIL-PARAPHOLYX	145.33	.15	64.08	.26	.16	.18
JUNE-AUG 84	11E	BLACKFLY-SIMULIDAE, LARVAE	80.73	.08	85.04	.19	.12	.17
JUNE-AUG 84	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	48.40	.05	0.0	.02	.01	.01
JUNE-AUG 84	11E	CADDISFLY-HYDROPTILIDAE, PUPAE	24.23	.03	41.97	.00	.00	.01
JUNE-AUG 84	11E	SNAIL-PHYSA	16.13	.02	27.94	.40	.24	.69
JUNE-AUG 84	11E	MITES-GENERAL	16.13	.02	13.97	.01	.00	.01
JUNE-AUG 84	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	16.13	.02	13.97	.01	.00	.01
JUNE-AUG 84	11E	MAYFLY-TRICOR., NYMPH	8.07	.01	13.97	.01	.00	.01
JUNE-AUG 84	11E	UNIDENTIFIED	.	.	.	.18	.11	.12

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-AUG 84	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	47288.23	49.55	5129.08	147.65	79.33	43.70
JUNE-AUG 84	8	MIDGES-CHIRONOMIDAE, LARVAE	28698.00	30.07	4429.10	2.79	1.50	.99
JUNE-AUG 84	8	MIDGES-CHIRONOMIDAE, PUPAE	10105.13	10.59	1918.28	2.75	1.48	1.48
JUNE-AUG 84	8	CADDISFLY-LEPTOCERIDAE, LARVAE	3156.67	3.31	1346.81	.81	.43	.16
JUNE-AUG 84	8	CADDISFLY-HYDROPSYCHIDAE, PUPAE	2026.40	2.12	1192.02	19.08	10.25	13.83
JUNE-AUG 84	8	SNAIL-FLUMINICOLA	984.93	1.03	77.89	5.09	2.73	1.80
JUNE-AUG 84	8	SNAIL-PARAPHOLYX	920.37	.96	758.61	3.44	1.85	1.89
JUNE-AUG 84	8	CADDISFLY-HYDROPTILIDAE, LARVAE	670.07	.70	146.02	.09	.05	.03
JUNE-AUG 84	8	MITES-GENERAL	371.37	.39	235.24	.11	.06	.05
JUNE-AUG 84	8	CADDISFLY-HYDROPTILIDAE, PUPAE	314.87	.33	297.58	.07	.04	.03
JUNE-AUG 84	8	MAYFLY-BAETIDAE, NYMPH	298.70	.31	261.22	.20	.10	.18
JUNE-AUG 84	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	193.77	.20	105.54	.08	.05	.06
JUNE-AUG 84	8	MIDGES-CHIRONOMIDAE, ADULT	113.03	.12	121.90	.02	.01	.02
JUNE-AUG 84	8	MAYFLY-TRICOR., NYMPH	64.60	.07	60.95	.05	.03	.05
JUNE-AUG 84	8	SNAIL-FISHEROLA	64.57	.07	91.68	.21	.11	.31
JUNE-AUG 84	8	MAYFLY, NYMPH	40.37	.04	69.92	.02	.01	.03
JUNE-AUG 84	8	MAYFLY-HEPTAGENIIDAE, NYMPH	24.23	.03	41.97	.01	.00	.01
JUNE-AUG 84	8	CLAMS	16.13	.02	27.94	.01	.00	.01
JUNE-AUG 84	8	SNAIL-PHYSA	16.13	.02	27.94	.55	.29	.95
JUNE-AUG 84	8	SNAIL-LIMNAE	16.13	.02	27.94	1.14	.61	1.97
JUNE-AUG 84	8	OLIGOCHAETE	16.13	.02	13.97	.01	.00	.01
JUNE-AUG 84	8	BEETLES-ELMIDAE, ADULT	8.07	.01	13.97	.00	.00	.0[illegible]
JUNE-AUG 84	8	BLACKFLY-SIMULIDAE, LARVAE	8.07	.01	13.97	.00	.00	.01
JUNE-AUG 84	8	MOTH-PYRALIDAE, LARVAE	8.07	.01	13.97	.02	.01	.03
JUNE-AUG 84	8	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.01	13.97	.00	.00	.00
JUNE-AUG 84	8	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.01	.01	.02
JUNE-AUG 84	8	UNIDENTIFIED	.	.	.	1.90	1.02	1.62
JUNE-AUG 84	8	ROUND-WORM	.	.	.	.	.	.

APPENDIX B

MEAN HERBACEOUS COVER - 1975-1984

CLASS	YEAR	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
AG	1975	49.90	35.30	43.80			43.00	43.90	43.00			43.45	43.18
PG	1975	0.60	2.00	4.50			2.37	3.70	5.50			4.60	3.26
AF	1975	14.60	11.70	11.70			12.67	29.50	13.00			21.25	16.10
PF	1975	4.30	0.90	1.80			2.33	1.50	2.10			1.80	2.12
all	1975	69.40	49.90	61.80			60.37	78.60	63.60			71.10	64.66
AG	1976	50.70	40.90	34.30			41.97	71.20	51.60			61.40	49.74
PG	1976	0.40	10.50	10.30			7.07	4.40	3.10			3.75	5.74
AF	1976	5.50	5.30	7.20			6.00	11.90	8.50			10.20	7.68
PF	1976	0.00	0.50	0.20			0.23	0.00	0.20			0.10	0.18
all	1976	56.60	57.20	52.00			55.27	87.50	63.40			75.45	63.34
AG	1977	1.35	0.65	1.90			1.30	5.20	1.45			3.33	2.11
PG	1977	0.35	11.30	8.28			6.64	3.25	2.90			3.08	5.22
AF	1977	0.25	0.05	0.90			0.40	2.40	9.35			5.88	2.59
PF	1977	0.55	0.60	1.42			0.86	0.05	6.30			3.18	1.78
all	1977	2.50	12.60	12.50			9.20	10.90	20.00			15.45	11.70
AG	1978	51.00	67.00	51.00			56.33	68.00	42.00			55.00	55.80
PG	1978	3.00	18.00	11.00			10.67	8.00	7.00			7.50	9.40
AF	1978	38.00	10.00	33.00			27.00	23.00	25.00			24.00	25.80
PF	1978	8.00	0.00	5.00			4.33	2.00	3.00			2.50	3.60
all	1978	100.00	95.00	100.00			98.33	101.00	77.00			89.00	94.60
AG	1979	25.00	29.00	9.00			21.00	31.00	10.00			20.50	20.80
PG	1979	1.00	18.00	11.00			10.00	7.00	5.00			6.00	8.40
AF	1979	2.00	4.00	10.00			5.33	43.00	33.00			38.00	18.40
PF	1979	11.00	0.00	3.00			4.67	0.00	7.00			3.50	4.20
all	1979	39.00	51.00	33.00			41.00	81.00	55.00			68.00	51.80
AG	1980	50.40	51.80	24.30	56.20	56.40	47.82	64.30	77.80	73.80	12.30	57.05	51.92
PG	1980	1.00	7.20	23.30	10.90	0.10	8.50	28.30	64.00	0.10	26.60	29.75	17.94
AF	1980	7.60	4.20	22.50	3.40	14.10	10.36	7.30	5.00	28.70	4.90	11.48	10.86
PF	1980	2.20	2.20	4.70	4.60	1.80	3.10	0.40	0.00	0.00	4.60	1.25	2.28
all	1980	61.20	65.40	74.80	75.10	72.40	69.78	100.30	146.80	102.60	48.40	99.53	83.00
AG	1981	74.80	54.60	66.50	49.80	76.20	64.38	77.40	84.00	88.40	48.90	74.68	68.96
PG	1981	0.10	4.70	14.30	5.80	0.00	4.98	19.60	25.90	0.00	36.70	20.55	11.90
AF	1981	5.30	3.50	18.20	1.20	12.50	8.14	15.90	11.90	17.50	5.90	12.80	10.21
PF	1981	0.00	3.20	0.70	4.90	0.50	1.86	0.20	0.00	0.00	1.90	0.53	1.27
all	1981	80.20	66.00	99.70	61.70	89.20	79.36	113.10	121.80	105.90	93.40	108.55	92.33
AG	1982	51.50	25.80	36.60	32.70	20.00	33.32	42.20	45.50	51.00	22.90	40.40	36.47
PG	1982	0.40	6.40	17.90	4.30	0.80	5.96	11.20	11.60	0.10	31.30	13.55	9.33
AF	1982	4.60	4.20	7.50	1.60	17.30	7.04	9.70	4.60	4.60	4.10	5.75	6.47
PF	1982	0.20	4.30	0.70	6.20	1.00	2.48	0.30	0.00	1.30	3.80	1.35	1.98
all	1982	56.70	40.70	62.70	44.80	39.10	48.80	63.40	61.70	57.00	62.10	61.05	54.24
AG	1983	53.80	37.60	33.65	36.75	31.85	38.73	49.50	39.55	62.75	17.55	42.34	40.33
PG	1983	2.15	7.70	14.45	6.40	1.29	6.40	2.10	15.75	0.00	25.50	10.84	8.37
AF	1983	8.20	7.85	12.55	3.45	22.35	10.88	18.70	8.85	8.65	6.65	10.71	10.81
PF	1983	0.70	3.10	1.05	4.40	1.95	2.24	0.65	0.05	2.10	4.00	1.70	2.00
all	1983	64.85	56.25	61.70	51.00	57.44	58.25	70.95	64.20	73.50	53.70	65.59	61.51
AG	1984	41.50	32.75	39.35	36.30	36.50	37.28	60.85	71.30	60.85	9.60	50.65	43.22

MEAN HERBACEOUS COVER - 1975-1984

PG	1984	1.85	8.80	11.55	8.55	0.40	6.23	1.20	4.45		25.00	[illegible]
AF	1984	12.35	8.10	11.10	4.00	13.40	9.79	20.65	9.70	19.45	7.95	14.44
PF	1984	0.30	4.00	0.75	6.55.	0.65	2.45	0.70	0.20	1.10	1.25	0.81
all	1984	56.00	53.65	62.75	55.40	50.95	55.75	83.40	85.65	81.40	43.80	73.56

Shrub Cover Data (Percent), 1984

Site	Transect	ARTR*	PUTR*	CHNA*	CHVI*
S01	1	1.89	10.62	0.0	0.00
	2	2.94	8.78	0.0	0.00
	3	3.56	8.74	0.0	0.00
	4	3.16	12.34	0.0	0.00
	5	7.32	4.34	0.0	0.00
	X̄	3.79	8.96	0.0	0.00
	SE	0.92	1.33	0.0	0.00
S02	1	0.00	16.76	0.0	3.90
	2	0.00	14.1	0.0	0.38
	3	0.00	21.52	0.0	0.00
	4	0.00	23.48	0.0	0.00
	5	0.00	18.26	2.24	2.98
	X̄	0.00	19.92	0.45	1.45
	SE	0.00	1.27	0.45	0.82
S03	1	0.00	0.00	1.04	0.00
	2	8.34	0.00	1.6	0.00
	3	14.9	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00
	5	4.88	0.00	2.62	0.00
	X̄	5.62	0.00	1.05	0.00
	SE	2.80	0.00	0.49	0.00
S04	1	17.56	0.00	0.00	0.00
	2	13.28	0.00	0.00	0.00
	3	21.02	0.00	0.00	0.00
	4	16.46	0.00	0.00	1.46
	5	14.56	0.00	0.00	0.00
	X̄	16.58	0.00	0.00	0.29
	SE	1.33	0.00	0.00	0.29
S05	1	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.96
	5	0.00	0.00	0.00	0.00
	X̄	0.00	0.00	0.00	0.19
	SE	0.00	0.00	0.00	0.19

*ARTR = *Artemisia tridentata*
CHNA = *Chrysothamnus nauseosus*
CHVI = *Chrysothamnus viscidiflorus*
PUTR = *Purshia tridentata*

1984 Shrub Density

Site	Species*	1	2	3	4	Total	S/Ha	S/a
S01	ARTR	9	12	13	20	54	540	219
	CHNA	0	0	0	2	2	20	8
	CHVI	1	0	2	1	4	40	16
	PUTR	15	12	18	15	60	600	243
						120	1,200	486
	ERNI	388	190	160	168	906	9,060	3,668
						1,026	10,260	4,154
S02	ARTR	0	0	0	0	0	0	0
	CHNA	0	1	0	1	2	20	8
	CHVI	4	2	3	0	9	90	36
	PUTR	43	55	50	39	223	2,230	930
						234	2,340	947
S03	ARTR	5	9	15	15	44	440	178
	CHNA	5	1	3	1	10	100	41
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	0	0	0	0	0
						54	540	219
	ERNI	0	0	0	6	6	60	24
	OPPO	0	0	0	2	2	20	8
						62	620	251
S04	ARTR	43	40	53	52	188	1,880	761
	CHNA	0	0	0	0	0	0	0
	CHVI	4	1	0	8	13	130	53
	PUTR	0	0	0	0	0	0	0
						201	2,010	814
S05	ARTR	1	3	2	0	6	60	24
	CHNA	0	1	0	2	3	30	12
	CHVI	0	0	0	1	1	10	4
	PUTR	0	0	0	0	0	0	0
						10	100	40
	ERNI	47	21	2	0	70	700	283
	OPPO	17	8	24	5	54	540	219
						124	1,240	502

*ARTR = *Artemisia tridentata*
CHNA = *Chrysothamnus nauseosus*
CHVI = *Chrysothamnus viscidiflorus*
ERNI = *Eriogonum niveum*
OPPO = *Opuntia polyacantha*
PUTR = *Purshia tridentata*

1984 Phytomass Sample Weights

Site	Plot	Dry Weight (g)
G01	07-06	9.20
	07-05	6.83
	09-01	12.04
	41-10	6.89
	28-00	13.03
	X̄	9.40
G02	01-07	14.36
	48-01	11.54
	40-03	15.39
	20-04	5.67
	25-07	11.25
	X̄	11.64
G03	28-06	7.24
	38-00	20.65
	33-09	12.17
	44-03	10.14
	29-04	16.31
	X̄	13.30
G04	35-01	3.84
	35-10	12.90
	17-04	4.58
	05-02	7.54
	28-00	4.74
	X̄	6.72

Site	Plot	Dry Weight (g)
S01	44-01	20.05
	46-06	4.99
	19-02	6.33
	22-01	3.61
	25-01	17.39
X̄	10.47	
S02	46-01	1.61
	26-00	5.33
	42-10	9.20
	44-07	8.30
	32-01	3.84
	X̄	5.66
S03	16-07	10.52
	24-08	3.83
	03-01	2.32
	30-09	19.41
	28-09	11.66
	X̄	9.55
S04	12-00	7.36
	25-08	7.92
	27-00	4.85
	31-07	14.65
	44-01	11.86
	X̄	9.33
S05	25-06	2.24
	15-04	1.92
	25-01	17.34
	31-07	1.26
	44-01	7.83
	X̄	6.13

SOIL FLUORIDE PROTOCOL

REAGENTS:

1. Na_2CO_3: KNO_3 FLUX (1:1) - Sift together equal weights of Na_2CO_3 and KNO_3 and store in a dry place.
2. Citric Acid 10% (W/V) - Dissolve 100 g Citric Acid in one liter distilled water.
3. T.I.S.A.B. Buffer - Add 57 mls concentrated Acetic Acid, 50g NaCl, 12g sodium citrate dihydrate to 500 mls water. Adjust pH to 5.2 with 6 N NaOH and bring to 100 mls.

PROCEDURE:

NOTE: Samples are dried for 24 hours at 105°C and ground to a fine powder on a Wiley mill.

1. Weigh a 1.00g sample and transfer to a 130 ml nickel crucible.
2. Add 4 grams of the Na_2CO_3: KNO_3 flux and place in muffle furnace at 700°C for 30 minutes.
3. After cooling, add 10 mls of citric acid to the crucible and heat gently until melt dissolves.
4. Bring solution to 100 mls in a volumetric flask and allow to settle.

NOTE: Standards are prepared by adding aqueous NaF to the crucibles and carrying these through the fusion process. A blank must also be carried through each run.

5. Pipette 25.0 mls of standards and samples into 50 ml plastic beakers and adjust pH to 5.5 with 10% citric acid.
6. Add 25.0 mls of TISAB buffer.
7. Using the prepared standards set, the fluoride meter to read in direct concentration and measure samples against these.

Recovery of fluoride in spiked samples as well as NBS River Sediment was 95 - 100%.

Parameters and methods for soil and vegetation sample analyses.

PARAMETER	METHOD	REFERENCE
Soils		
pH	Glass Electrode (1:2 soil to water ratio)	(1) Methods for Soil Analysis, p. 922
Bicarbonate/ Carbonate	Water leach (1:5 soil to water ratio), Acid titration	(1) Methods for Soil Analysis, p. 945
Conductivity	Conductivity cell (1:2 soil to water ratio)	(1) Methods for Soil Analysis, p. 936
Sulfate (soluble)	Water leach (1:5 soil to water ratio), Turbidimetric detection	(1) Methods for Soil Analysis, p. 935 (2) EPA, 375.4
Chloride	Water leach (1:5 soil to water ratio), Mercuric nitrate titration for detection	(1) Methods for Soil Analysis, p. 935 (2) EPA, 325.3
Fluoride (Total)	Fusion, Specific Ion Electrode detection	(2) EPA, 340.2
Mercury	Acid Digestion, Cold Vapor AA detection	(2) EPA, 245.5
Copper, Lead, Cadmium, Chromium, Nickel, Zinc, Sodium, Potassium, Calcium, Magnesium	$HNO_3/HClO_4/HF$ Digestion, AA detection	(2) EPA, 213.1, 220.1, 218.1, 215.1, 239.1, 249.1, 289.1, 273.1, 258.
Vegetation		
Sulfate (Extractable)	Water leach (1:50 vegetation to water ratio), Turbidimetric detection	(2) EPA, 375.4
Chloride (Extractable)	Water leach (1:50 vegetation to water ratio), Mercuric nitrate detection	(2) EPA, 325.3
Copper (Total)	$HNO_3/HClO_4$ digestion, Flame AA detection	(2) EPA, 220.1

STATION : s01
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	98	64.30	3.993
depi	0	0.00	0.000
houm	48	4.65	1.420
loma	4	0.35	0.303
misrh	24	0.60	0.153
phlo	0	0.00	0.000
posa3	84	28.30	3.772
sial	50	2.00	0.500

STATION : s02
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	77.85	2.615
depi	0	0.00	0.000
houm	20	1.25	0.511
misrh	74	3.60	0.674
phlo	0	0.00	0.000
posa3	100	64.05	3.423
sial	0	0.00	0.000

STATION : s03
SAMPLING DATE : 050980

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	73.75	3.197
depi	4	0.10	0.070
houm	96	15.40	2.380
misrh	82	12.65	2.398
phlo	0	0.00	0.000
posa3	4	0.10	0.070
sial	14	0.60	0.316

STATION : s04
SAMPLING DATE : 050680

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
brte	100	12.25	1.731
chvi	2	0.05	0.050
crci	2	0.05	0.050
depi	4	0.10	0.070
houm	18	0.70	0.320
orhy	4	2.00	1.950
phli	2	0.05	0.050
phlo	24	4.45	1.402
plpa	20	1.45	0.802
posa3	88	22.95	2.563
sial	74	2.35	0.400
stco2	16	1.60	0.847

STATION : s01
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	4	0.35	0.303
artr	2	0.05	0.050
brte	100	50.40	4.232
coum	2	0.05	0.050
depi	62	3.70	1.100
eras	4	0.10	0.070
houm	20	1.50	0.580
lasl	2	0.05	0.050
misrh	40	1.75	0.506
oepap	16	0.65	0.318
phlo	6	1.35	0.849
posa3	10	1.00	0.510
sial	0	0.00	0.000

STATION : s02
SAMPLING DATE : 050980

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	8	1.20	0.581
assp	4	1.50	1.050
amly	10	0.25	0.107
brte	92	51.75	4.511
crpt	10	0.25	0.107
cytet	8	0.95	0.510
depi	38	1.95	0.573
sisi	4	0.35	0.303
houm	18	2.15	1.303
lasl	12	0.80	0.425
misrh	18	1.45	0.581
orhy	2	0.05	0.050
phli	40	3.45	1.002
phlo	0	0.00	0.000
posa3	24	5.60	2.311
sial	6	0.15	0.085

STATION : s03
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	16	0.65	0.318
baca	6	0.85	0.751
brte	100	24.25	3.538
crat	4	0.10	0.070
depi	2	0.05	0.050
houm	68	5.15	1.393
lasl	8	0.20	0.097
lara	2	0.05	0.050
misrh	42	2.75	0.910
phlo	34	3.80	1.060
plpa	80	11.65	1.740
posa3	88	23.30	3.012
sial	46	1.65	0.426

STATION : s04
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	8	0.70	0.423
assc2	8	0.45	0.309
baca	10	3.35	1.642
brte	98	39.85	4.945
depi	44	1.35	0.329
feoc2	86	16.25	3.008
misrh	44	1.60	0.427
phli	2	0.05	0.050
phlo	0	0.00	0.000
posa3	28	10.90	3.408
sial	12	0.30	0.116

STATION : s05
SAMPLING DATE : 050680

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	1.80	1.083
agsp	2	0.05	0.050
amly	22	0.55	0.148
brte	100	56.40	4.528
crci	2	0.05	0.050
depi	10	0.50	0.311
eras	2	0.05	0.050
gisi	2	0.05	0.050
houm	54	4.95	1.631
migrh	2	0.05	0.050
phlo	0	0.00	0.000
plpa	48	4.80	1.638
posa3	0	0.00	0.000
sial	60	2.75	0.607

STATION : g01
SAMPLING DATE : 050481

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	77.40	3.339
depi	0	0.00	0.000
drve2	88	4.45	0.715
houm	96	7.10	1.046
loma	2	0.05	0.050
migrh	14	0.35	0.124
phlo	0	0.00	0.000
posa3	76	19.55	3.019
ruve	4	0.10	0.070
sial	66	3.85	0.943

STATION : s02
SAMPLING DATE : 050481

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	84.00	2.150
depi	0	0.00	0.000
drve2	86	4.85	0.957
houm	54	4.50	1.193
misrh	36	1.15	0.329
phlo	0	0.00	0.000
posa3	94	25.85	3.255
sial	20	1.25	0.511

STATION : s03
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	88.40	2.011
depi	4	0.10	0.070
drve2	12	0.55	0.314
houm	88	14.40	2.831
misrh	10	0.25	0.107
phlo	0	0.00	0.000
posa3	0	0.00	0.000
sial	8	2.10	1.443

STATION : s04
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.80	0.751
brte	100	48.85	5.098
depi	2	0.05	0.050
drve2	28	0.70	0.160
houm	56	1.65	0.324
mifo	2	0.05	0.050
oepap	14	0.35	0.124
phlo	6	0.65	0.421
plpa	12	0.80	0.425
posa3	92	18.70	2.936
sial	36	2.60	1.296
stco2	56	18.00	3.588

STATION : s01
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	74.75	3.315
depi	16	0.40	0.131
drve2	64	1.60	0.171
erni	44	6.60	2.103
houm	44	2.10	0.569
misrh	36	0.90	0.171
phlo	0	0.00	0.000
posa3	2	0.05	0.050
sial	2	0.30	0.300

STATION : s02
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	14	2.00	1.081
adsp	8	0.95	0.510
amly	4	0.10	0.070
aspu	2	0.05	0.050
brte	100	54.00	4.675
crci	2	0.05	0.050
cytet	4	0.60	0.420
depi	10	0.25	0.107
drve2	30	1.50	0.510
feoc2	12	0.55	0.314
houm	28	1.20	0.430
mifo	14	0.35	0.124
misrh	8	0.20	0.097
oepap	8	0.45	0.309
orhy	2	1.25	1.250
phli	2	0.05	0.050
phlo	0	0.00	0.000
posa3	24	2.30	0.923
sial	0	0.00	0.000
stco2	2	0.05	0.050

STATION : s03
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
baca	2	0.05	0.050
brte	100	66.50	4.277
coum	2	0.05	0.050
crat	2	0.30	0.300
depi	2	0.05	0.050
drve2	80	2.75	0.464
houm	86	6.30	1.506
misrh	12	0.30	0.116
oppo	2	0.30	0.300
phlo	8	0.20	0.097
plpa	78	5.95	0.898
posa3	74	14.30	2.702
sial	38	2.65	0.913

STATION : s04
SAMPLING DATE : 050581

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	0.85	0.751
assc2	14	1.80	0.889
baca	12	2.20	1.113
brte	100	45.55	4.713
depi	24	0.60	0.153
drve2	4	0.10	0.070
feoc2	90	4.20	0.879
misrh	18	0.45	0.137
phlo	4	0.10	0.070
posa3	14	5.80	2.570

STATION : s05
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.35	0.303
amly	2	0.05	0.050
brte	100	72.20	4.051
depi	0	0.00	0.000
drve2	40	1.00	0.175
erni	8	5.65	2.889
houm	82	3.80	0.659
mifo	4	0.10	0.070
misrh	2	0.05	0.050
oepap	4	0.10	0.070
oppo	6	1.80	1.699
phlo	0	0.00	0.000
plpa	36	2.85	0.948
posa3	0	0.00	0.000
sial	50	4.60	1.339

STATION : s01
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	42.20	3.517
drve2	70	2.00	0.311
houm	98	6.85	1.175
mifo	22	0.55	0.148
misrh	2	0.05	0.050
posa3	80	11.20	2.107
ruve	2	0.30	0.300
saka	8	0.20	0.097
sial	20	0.50	0.143

STATION : s02
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	45.45	3.323
drve2	74	1.85	0.157
houm	60	1.50	0.175
misrh	36	0.90	0.171
posa3	74	11.60	1.511
saka	8	0.20	0.097
sial	2	0.05	0.050

STATION : s03
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.050
brte	100	51.00	3.685
depi	2	0.30	0.300
drve2	20	0.50	0.143
houm	80	2.00	0.143
mifo	28	0.70	0.160
misrh	42	1.05	0.176
oepap	12	1.30	0.581
posa3	2	0.05	0.050
saka	18	0.45	0.137
sial	2	0.05	0.050

STATION : s04
SAMPLING DATE : 051782

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
brte	98	22.85	3.976
depi	2	0.05	0.050
drve2	36	0.90	0.171
houm	66	2.15	0.410
mifo	26	0.65	0.157
oepap	38	3.40	1.004
phlo	10	0.25	0.107
plpa	16	0.65	0.318
posa3	96	15.80	2.124
sial	6	0.15	0.085
stco2	56	15.50	3.210

STATION : s01
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	51.50	3.567
drve2	68	1.70	0.167
houm	54	1.35	0.178
mifo	2	0.05	0.050
misrh	56	1.40	0.177
oepap	6	0.15	0.085
posa3	6	0.40	0.306
sial	2	0.05	0.050

STATION : s02
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	14	1.75	1.048
asda	8	0.20	0.097
amly	2	0.30	0.300
astra	2	0.05	0.050
brte	96	25.55	3.394
crpt	6	0.15	0.085
cytet	8	2.10	1.719
depi	6	0.15	0.085
drve2	26	1.15	0.430
feoc2	8	0.20	0.097
sisi	2	0.05	0.050
houm	26	1.40	0.511
lasl	2	0.05	0.050
meal2	4	0.10	0.070
mifo	6	0.15	0.085
misrh	10	0.25	0.107
oepap	10	0.25	0.107
orhy	4	1.30	1.250
posa3	26	4.50	1.674
sial	2	0.30	0.300
stco2	4	0.35	0.303

STATION : s03
SAMPLING DATE : 051782

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	36.60	4.307
crat	12	0.55	0.314
drve2	88	2.45	0.281
houm	80	3.00	0.525
mifo	18	0.45	0.137
phlo	4	0.10	0.070
plpa	80	2.00	0.143
posa3	92	17.90	1.824

STATION : s04
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
assc2	20	2.45	0.960
baca	8	3.55	2.114
brte	100	30.55	3.747
crpt	2	0.05	0.050
depi	32	0.80	0.167
drve2	2	0.05	0.050
feoc2	82	2.05	0.137
mifo	14	0.35	0.124
misrh	22	0.55	0.148
posa3	26	4.25	1.660

STATION : s05
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.30	0.300
assp	2	0.75	0.750
amly	16	1.60	0.847
brte	98	19.95	2.704
depi	16	1.15	0.511
drve2	48	1.20	0.178
sisi	6	0.15	0.085
houm	90	3.75	0.603
lasl	2	0.05	0.050
meal2	8	0.45	0.309
mifo	20	0.75	0.321
misrh	6	0.15	0.085
oepap	16	0.65	0.318
plpa	34	1.10	0.329
saka	2	0.05	0.050
sial	44	7.30	2.197

STATION : s01
SAMPLING DATE : 050683

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	49.50	2.583
cytet	4	0.35	0.303
depi	2	0.05	0.050
drve2	92	3.25	0.750
houm	100	9.00	0.892
mifo	16	0.40	0.131
misrh	24	0.60	0.153
posa3	54	2.10	0.497
ruve	2	0.30	0.300
saka	70	1.75	0.164
sial	2	0.05	0.050
trdu	4	0.35	0.303

STATION : s02
SAMPLING DATE : 050683

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	39.55	2.739
cytet	2	0.05	0.050
depi	2	0.05	0.050
drve2	94	2.60	0.267
houm	52	1.30	0.178
mifo	26	0.65	0.157
misrh	94	2.85	0.364
posa3	100	15.75	1.735
saka	76	1.90	0.153
sial	6	0.15	0.085

STATION : s03
SAMPLING DATE : 050483

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.30	0.300
brte	100	62.70	3.348
depi	2	0.05	0.050
depi	8	0.45	0.309
drve2	36	0.90	0.171
feoc2	2	0.05	0.050
houm	92	3.30	0.502
mifo	36	0.90	0.171
misrh	70	2.00	0.311
oepap	34	2.10	0.632
saka	60	1.50	0.175
sial	6	0.15	0.085

STATION : s04
SAMPLING DATE : 050483

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.05	0.050
brdo	2	0.05	0.050
brte	100	17.55	3.611
depi	2	0.05	0.050
drve2	76	1.90	0.153
houm	82	2.05	0.137
mifo	30	1.00	0.327
oepap	62	3.55	0.732
phlo	14	0.35	0.124
plpa	18	0.70	0.320
posa3	90	10.95	1.644
saka	44	1.80	0.749
sial	6	0.15	0.085
stco2	64	14.55	2.700

STATION : s01
SAMPLING DATE : 050583

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	53.80	3.769
depi	32	1.05	0.328
drve2	80	2.75	0.464
houm	74	2.35	0.400
mifo	18	0.45	0.137
misrh	82	2.05	0.137
oepap	8	0.70	0.423
posa3	10	2.15	1.113

STATION : s02
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	16	1.15	0.511
agsp	8	0.70	0.423
amly	10	0.25	0.107
brte	98	37.15	4.149
crci	2	0.05	0.050
crpt	4	0.10	0.070
cytet	10	1.45	0.848
depi	50	2.00	0.500
drve2	42	1.30	0.329
eras	2	0.30	0.300
feoc2	18	0.45	0.137
gimi	4	0.10	0.070
gisi	6	0.15	0.085
houm	40	1.25	0.329
lagl	6	0.15	0.085
meal2	6	0.15	0.085
mifo	8	0.20	0.097
migrh	36	1.15	0.329
oepap	4	0.35	0.303
phli	26	0.90	0.325
phlo	6	0.15	0.085
posa3	30	7.10	1.962
stco2	4	0.60	0.420

STATION : s03
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.050
brdo	2	0.05	0.050
brte	100	33.65	4.538
crat	8	0.45	0.309
depi	2	0.05	0.050
drve2	96	2.65	0.262
houm	94	2.60	0.267
mifo	8	0.20	0.097
migrh	70	1.75	0.164
phlo	12	0.55	0.314
plma	2	0.05	0.050
plpa	86	2.65	0.381
posa3	96	14.40	1.841
saka	56	1.90	0.420
sial	34	0.85	0.169
sihy	2	0.05	0.050

STATION : s04
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
assc2	16	1.60	0.847
baca	10	2.65	1.487
brte	100	34.05	4.477
crci	2	0.05	0.050
crpt	2	0.05	0.050
depi	54	1.35	0.178
drve2	28	0.70	0.160
feoc2	88	2.70	0.377
houm	2	0.05	0.050
mifo	38	0.95	0.173
misrh	50	1.25	0.179
oepap	2	0.05	0.050
posa3	28	6.40	2.001

STATION : s05
SAMPLING DATE : 050283

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
assp	2	0.30	0.300
amly	16	0.40	0.131
brte	100	31.85	3.646
crci	12	0.30	0.116
depi	38	1.45	0.429
drve2	94	2.60	0.267
sisi	8	0.20	0.097
houm	100	14.20	1.456
lasl	20	0.50	0.143
meal2	4	0.10	0.070
mifo	56	1.40	0.177
misrh	12	0.30	0.116
oepap	28	1.95	0.636
phli	2	0.05	0.050
plpa	40	1.00	0.175
sial	40	1.25	0.329
stco2	4	1.29	0.327

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STATION : s01
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	2	0.05	0.05
brte	100	60.85	2.54
cytet	6	0.15	0.08
drve2	80	2.00	0.14
houm	100	16.60	1.45
mifo	26	0.65	0.16
misrh	22	0.55	0.15
posa3	48	1.20	0.18
ruve	10	0.50	0.31
saka	26	0.65	0.16
sial	34	0.85	0.17
trdu	12	0.30	0.12

STATION : s02
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	6	0.15	0.08
brte	100	71.30	2.10
cytet	2	0.05	0.05
drve2	100	2.75	0.25
houm	80	4.00	0.70
mifo	36	0.90	0.17
misrh	88	2.20	0.12
posa3	90	4.45	0.90
saka	14	0.35	0.12
sial	16	0.40	0.13

STATION : s03
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.05
brdo	40	1.00	0.17
brte	100	60.85	3.54
depi	4	0.10	0.07
drve2	82	2.05	0.14
houm	100	13.85	1.11
mifo	26	0.65	0.16
misrh	74	1.85	0.16
oepap	4	0.10	0.07
saka	56	1.40	0.18
sial	6	0.15	0.08

STATION : s04
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.05	0.05
brdo	16	0.40	0.13
brte	94	9.60	2.03
drve2	92	2.30	0.10
houm	96	3.65	0.54
mifo	10	0.25	0.11
misrh	2	0.05	0.05
phlo	12	0.80	0.43
plpa	28	0.95	0.33
posa3	88	12.85	1.67
saka	28	0.70	0.16
sial	12	0.30	0.12
stco2	76	12.15	2.19

STATION : s01
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	41.50	3.49
depi	6	0.15	0.08
drve2	72	2.55	0.48
houm	86	7.85	1.10
misrh	68	1.70	0.17
phlo	2	0.30	0.30
posa3	14	1.85	0.70
saka	4	0.10	0.07

STATION : s02
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	10	1.00	0.51
agsp	4	0.60	0.42
assc2	0	0.00	0.00
brte	98	32.45	3.42
crci	4	0.10	0.07
crpt	4	0.10	0.07
cytet	14	3.00	1.99
depi	10	0.25	0.11
drve2	44	1.10	0.18
feoc2	12	0.30	0.12
gisi	4	0.10	0.07
houm	54	4.75	1.21
lagl	2	0.05	0.05
meal2	6	0.15	0.08
mifo	22	0.55	0.15
migrh	26	0.65	0.16
phli	22	0.80	0.32
posa3	48	8.20	1.91
saka	2	0.05	0.05

STATION : s03
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	2	0.05	0.05
brte	100	39.35	4.11
crat	12	0.55	0.31
drve2	96	2.40	0.07
houm	100	3.50	0.48
mifo	16	0.40	0.13
migrh	60	1.50	0.17
phlo	6	0.15	0.08
plpa	86	2.90	0.45
posa3	100	11.55	1.39
saka	28	0.70	0.16
sial	4	0.10	0.07

STATION : s04
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	0.15	0.08
amac	2	0.05	0.05
assc2	4	2.00	1.44
baca	12	4.35	2.40
brdo	2	0.05	0.05
brte	100	33.90	4.00
crci	4	0.10	0.07
crpt	2	0.05	0.05
depi	28	0.70	0.16
drve2	48	1.20	0.18
feoc2	86	2.40	0.29
houm	14	0.35	0.12
mifo	18	0.45	0.14
migrh	62	1.55	0.17
posa3	46	8.55	2.61
trdu	2	0.05	0.05

STATION : s05
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
agsp	2	0.05	0.05
amly	36	1.15	0.33
brte	100	36.50	3.41
crci	12	0.30	0.12
depi	8	0.20	0.10
drve2	96	2.90	0.36
erni	22	1.30	0.51
gisi	2	0.05	0.05
houm	100	3.75	0.54
lagl	12	0.30	0.12
meal2	4	0.10	0.07
mifo	52	1.55	0.33
migrh	36	0.90	0.17
oepap	26	0.65	0.16
oppo	8	1.40	0.85
phli	4	0.10	0.07
plpa	48	1.95	0.50
saka	16	0.40	0.13
sial	32	1.30	0.43
stco2	4	0.35	0.30

OK,