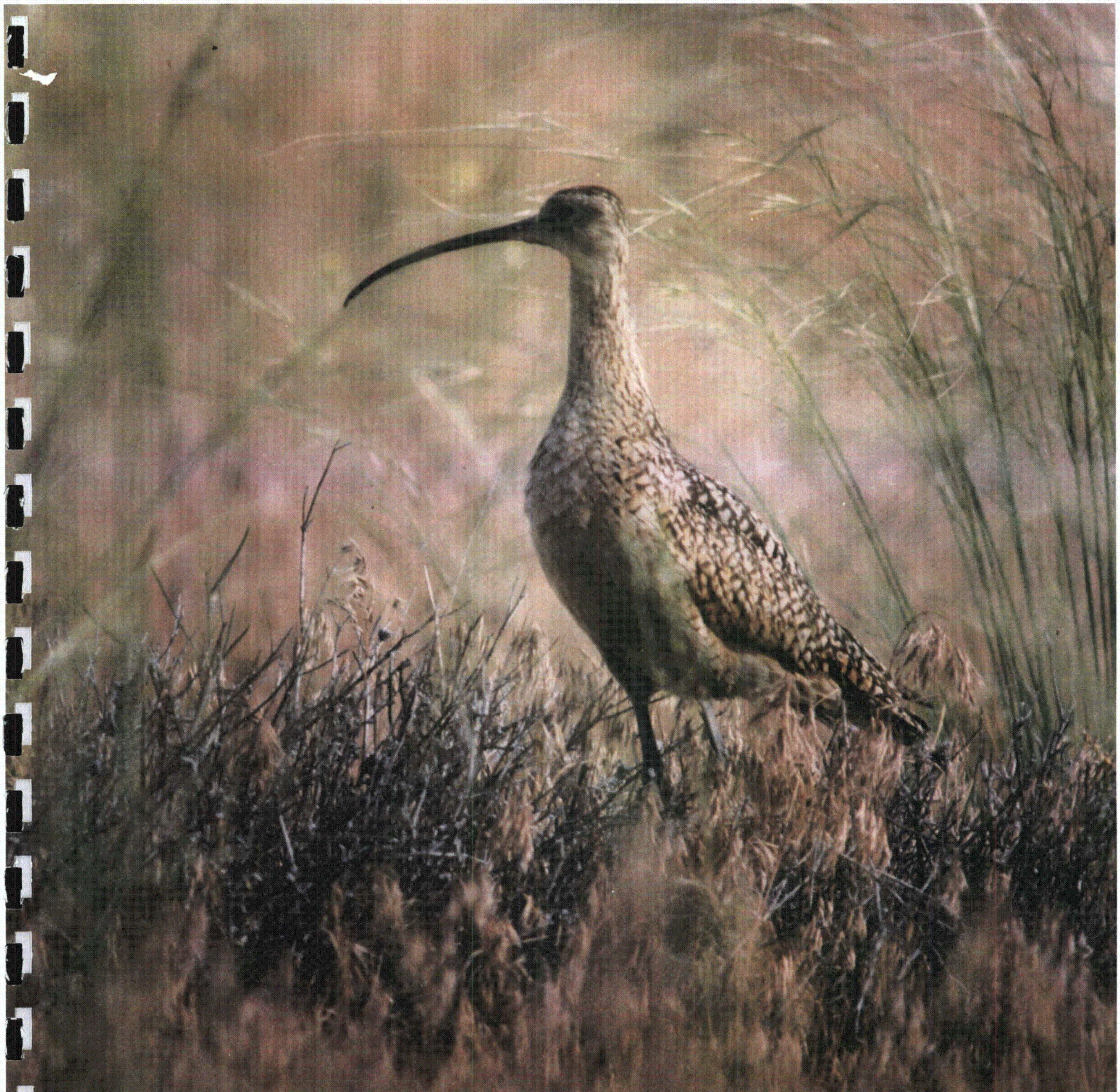

Operational Ecological Monitoring Program For Nuclear Plant 2—1986 Annual Report

Prepared By Environmental Programs Department

WASHINGTON PUBLIC POWER
SUPPLY SYSTEM

870444

OPERATIONAL ECOLOGICAL

MONITORING PROGRAM

FOR

WNP-2

ANNUAL REPORT 1986

Washington Public Power Supply System
Environmental Programs
3000 George Washington Way
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EXECUTIVE SUMMARY

Based upon two years of operational data, there is no indication that WNP-2 is affecting either the density or biomass of benthic macro-invertebrates which reside more than 42.7 meters (140 feet) downstream from the discharge or at the edge of the mixing zone.

The Energy Facility Site Evaluation Council (EFSEC) gave formal approval to change the analytical method for measuring periphyton biomass from the historical total organic matter method to a total carbon method which utilizes a surface carbon analyzer. As in previous years, periphyton biomass was generally high in the winter and low in the spring indicating no apparent changes resulting from the operation of WNP-2.

For nearly all the sampling periods, significant interstation differences could not be detected among any of the water quality parameters measured. All measurements taken, with the exception of the pH values recorded at all stations including the control on May 13, 1986, were within the water quality standards for Class A waters both above and below the mixing zone. It appears that during 1986, WNP-2 cooling water had little effect upon Columbia River water quality.

Intake structure fouling surveys conducted in April and October of 1986 revealed no impingement of fish on the intake screens. Fouling of the screens was comparable to that observed in previous years' surveys.

Inspections of the tower makeup (TMU) pump pit, the circulating water pumphouse and the main condenser water boxes were conducted in 1986 to reveal the presence of Corbicula. Live Corbicula were located in the TMU Pumphouse Sump and one relic shell was retrieved from the condenser middle water box. It appears that the biofouling program now in place at WNP-2 is adequately controlling the Corbicula population.

Trace metal analysis of soil and vegetation samples collected in 1986 were in most cases within the ranges reported in previous studies. Soil copper concentrations were measured at levels exceeding the ranges recorded in preoperational studies at five stations, while nickel concentrations exceeded preoperational data ranges at three stations.

Herbacious cover, density, and phytomass continued to show signs of recovery from the 1984 range fire at most stations. Station G03, which is closest to the cooling tower, continues to exhibit visible signs of disturbance. Although this station did not burn in the 1984 range fire, herbacious cover continues to decline.

The results of the animal monitoring studies within the study areas surrounding WNP-2 compare similarly to previous years, indicating stable avian, deer, and rabbit populations. Studies performed through 1986 do not reveal any impact from the operation of WNP-2.

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).

Project Team

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FIGURES

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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.

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 (Battelle 1976, 1977, 1978, 1979a and 1979b). From August 1978 through March 1980 the aquatic studies were performed by Beak Consultants, Inc. (Beak 1980). In 1982 the Supply System analyzed the 1974-1980 aquatic data and presented the results and a recommended operational monitoring program to EFSEC (WPPSS 1982). The operational program was accepted with minor modifications and initiated in March 1983. Because of operational conditions, the plant did not consistently discharge liquid effluents until the Fall of 1984. Figures 1-1 and 1-2 present summaries of electrical generation and monthly discharges for 1986.

Terrestrial monitoring was initiated in 1974 and was conducted by BNW until 1979 (Battelle 1976b, 1977b, 1979b, 1979c). Beak Consultants, Inc. performed the vegetation monitoring program from 1980-1982 (Beak 1981, 1982a, 1982b). Since 1983 Supply System scientists have been responsible for the vegetation aspects of the program (Northstrom et. al. 1984; WPPSS 1985, 1986). During 1981 the animal studies program was taken over by Supply System scientists and results were reported annually (Schleder 1982, 1983, 1984; WPPSS 1985, 1986). The first comprehensive operational environmental report was prepared by Supply System scientists in 1984 (WPPSS 1985).

This report presents the results of the Ecological Monitoring Program (EMP) for the period January 1986 through December 1986.

1.2 THE SITE

The WNP-2 plant site is located 19 km (12 miles) north of Richland, Washington in Benton County (Figure 1-3). The Supply System has leased 441 hectares (1089 acres) from the U.S. Department of Energy's Hanford Site for WNP-2.

WNP-2 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. The plant communities within the region are described as shrub-steppe communities consisting of various layers of perennial grasses overlayed by a discontinuous layer of shrubs. In general, moisture relations do not support arborescent species except along streambanks. Approximately 5 km (3.25 miles) to the east, the site is bounded by the Columbia River. In August of 1984 a range fire destroyed much of the shrub cover which occupied the site and temporarily modified the shrub-steppe associations which were formerly present.

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 370 meters (1200 feet) wide at a river elevation of 105 meters (345 feet) above sea level and ranges to 7.3 meters (24 feet) 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). These fluctuations cause large areas of river bottom to be alternately exposed and covered. 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 to 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, measured at the USGS stream-quality station located at river mile 388.1 near the Vernita bridge, was 44,900 cfs, while average and maximum flows in 1986 were 109,500 cfs and 197,000 cfs, respectively (Figure 1-4).

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

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Table 1-1. Summary of Field Sampling Periods for the 1986 WNP-2 Ecological Monitoring Program

Task	J	F	M	A	M	J	J	A	S	O	N	D
	(Month Sampled)											
Aquatic Ecology												
Benthic Macrofauna[1]			X			X			X			X
Periphyton												
Gradient[1]	X		X	X		X	X		X	X		X
Core[1]			X			X			X			X
Water Quality	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.

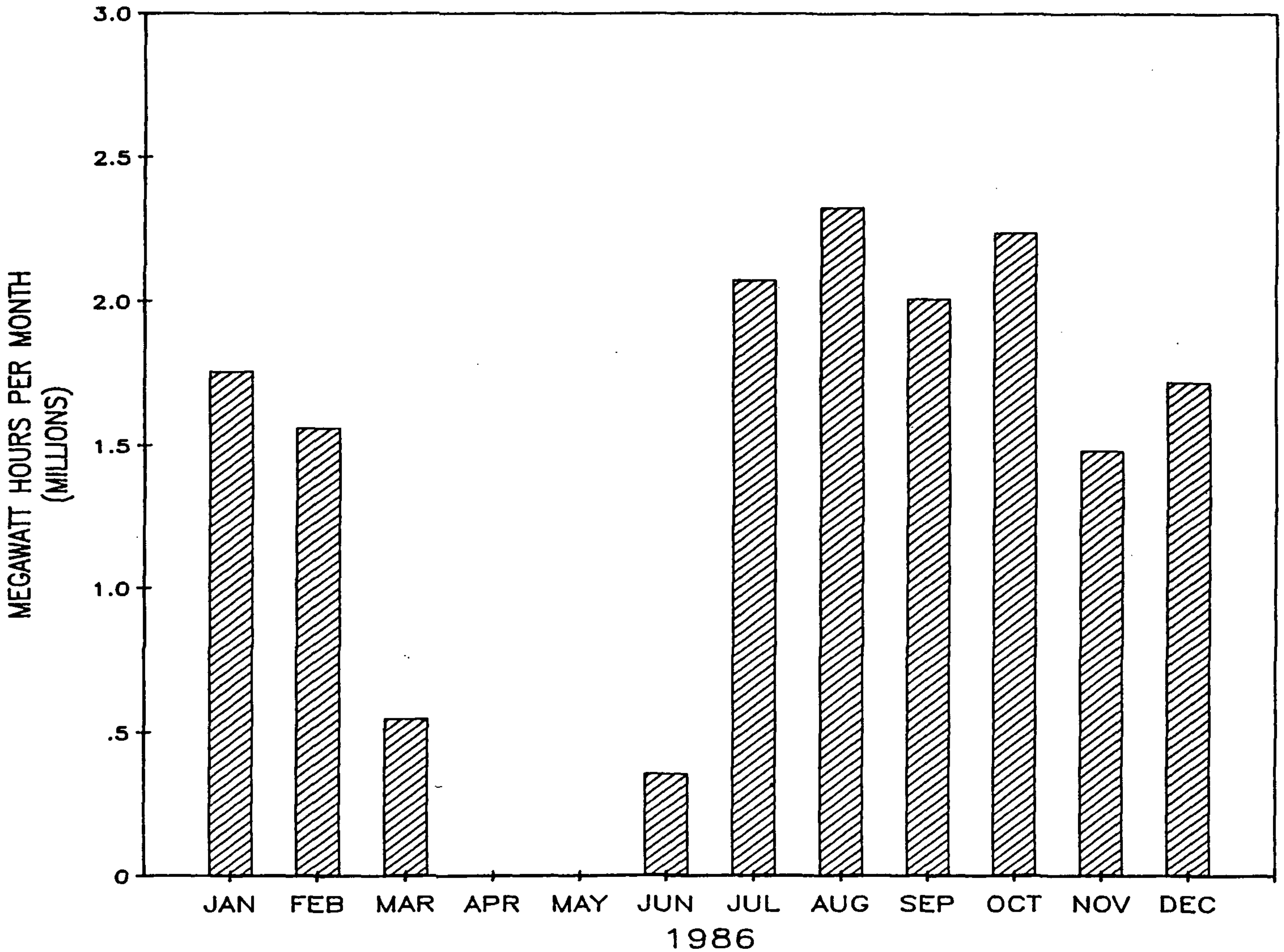

Figure 1-1. WNP-2 Gross Thermal Production for 1986

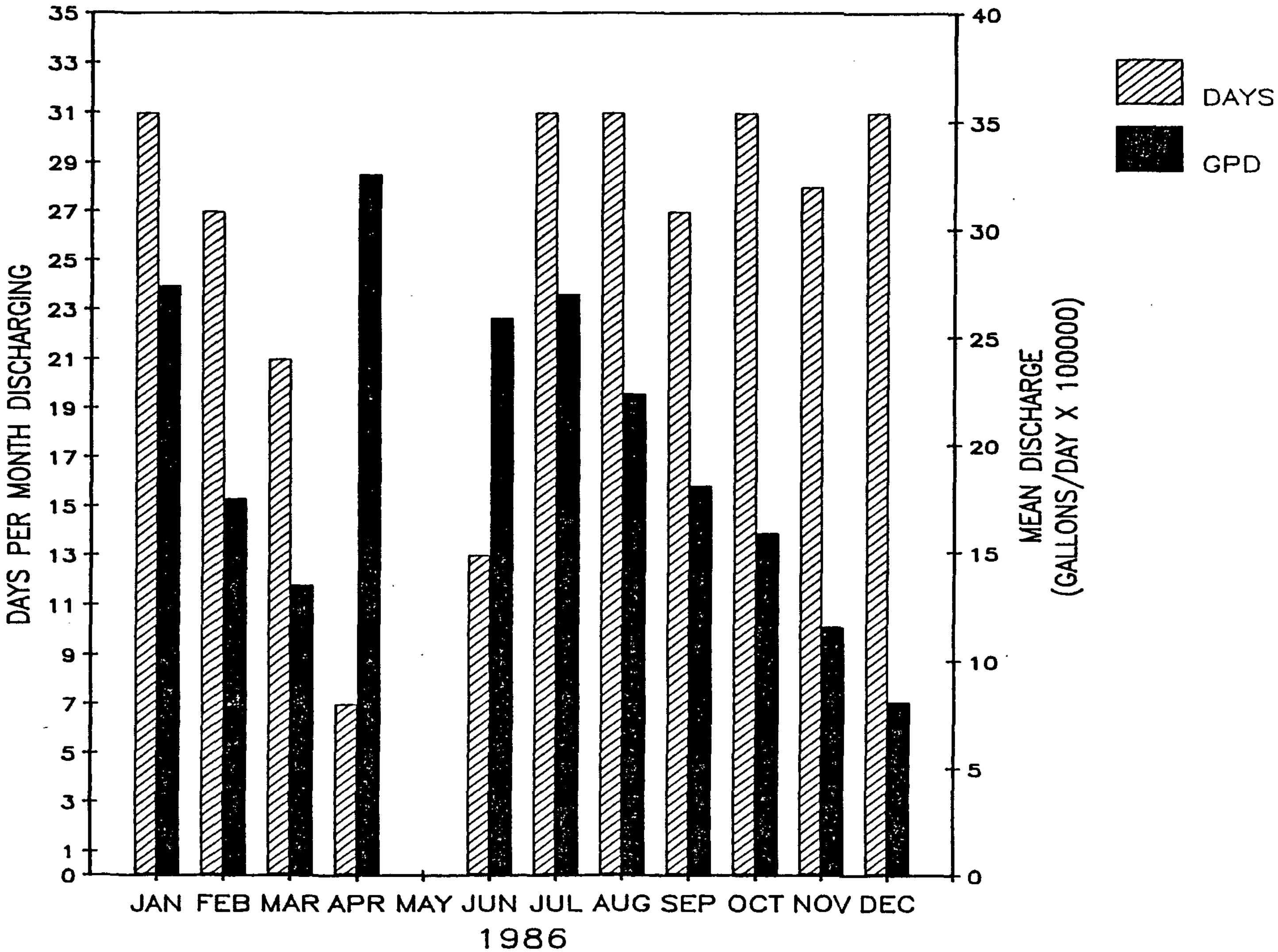

Figure 1-2. WNP-2 Days Per Month Discharging and Mean Monthly Discharge

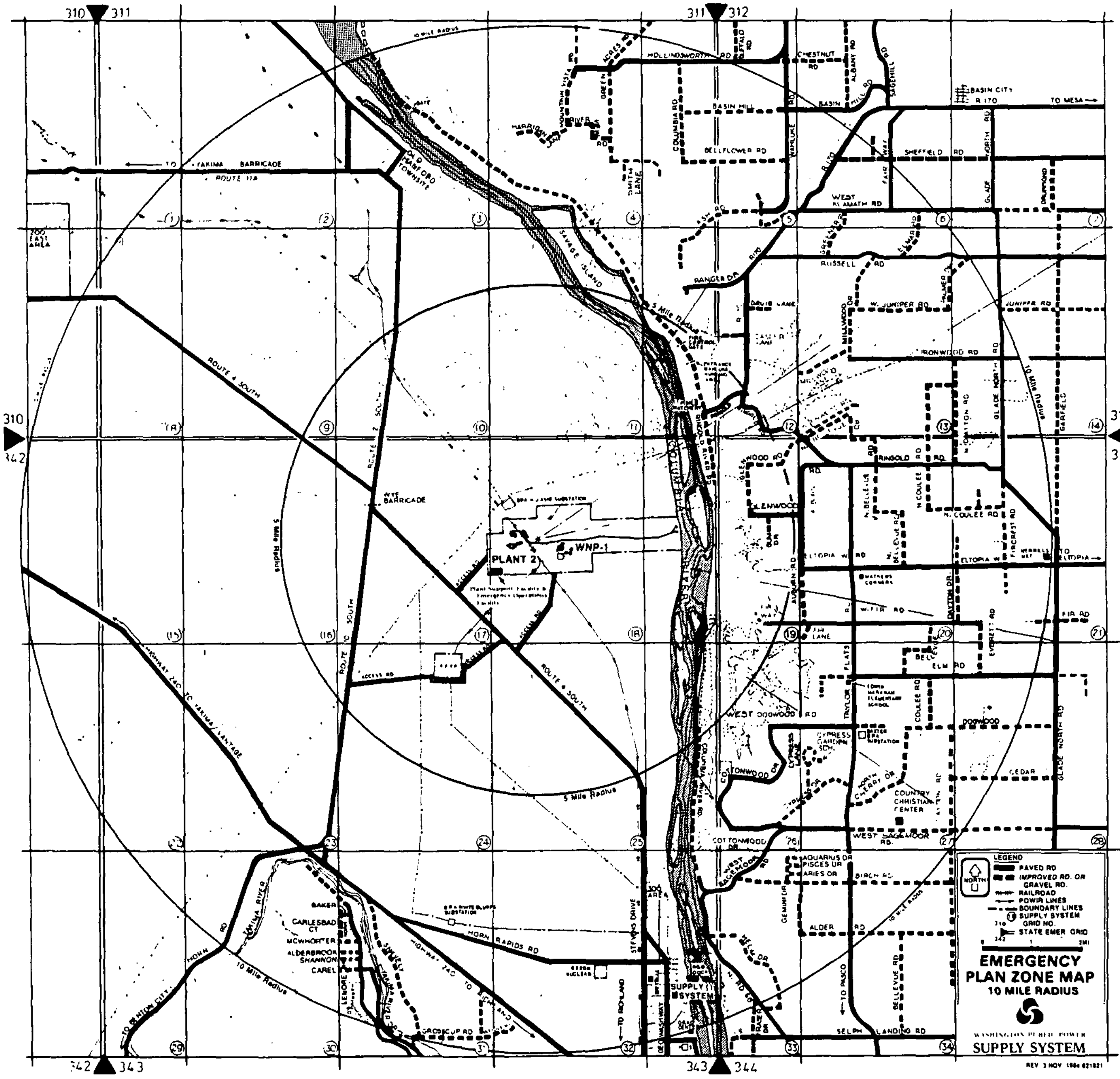

Figure 1-3. WNP-2 Location Map

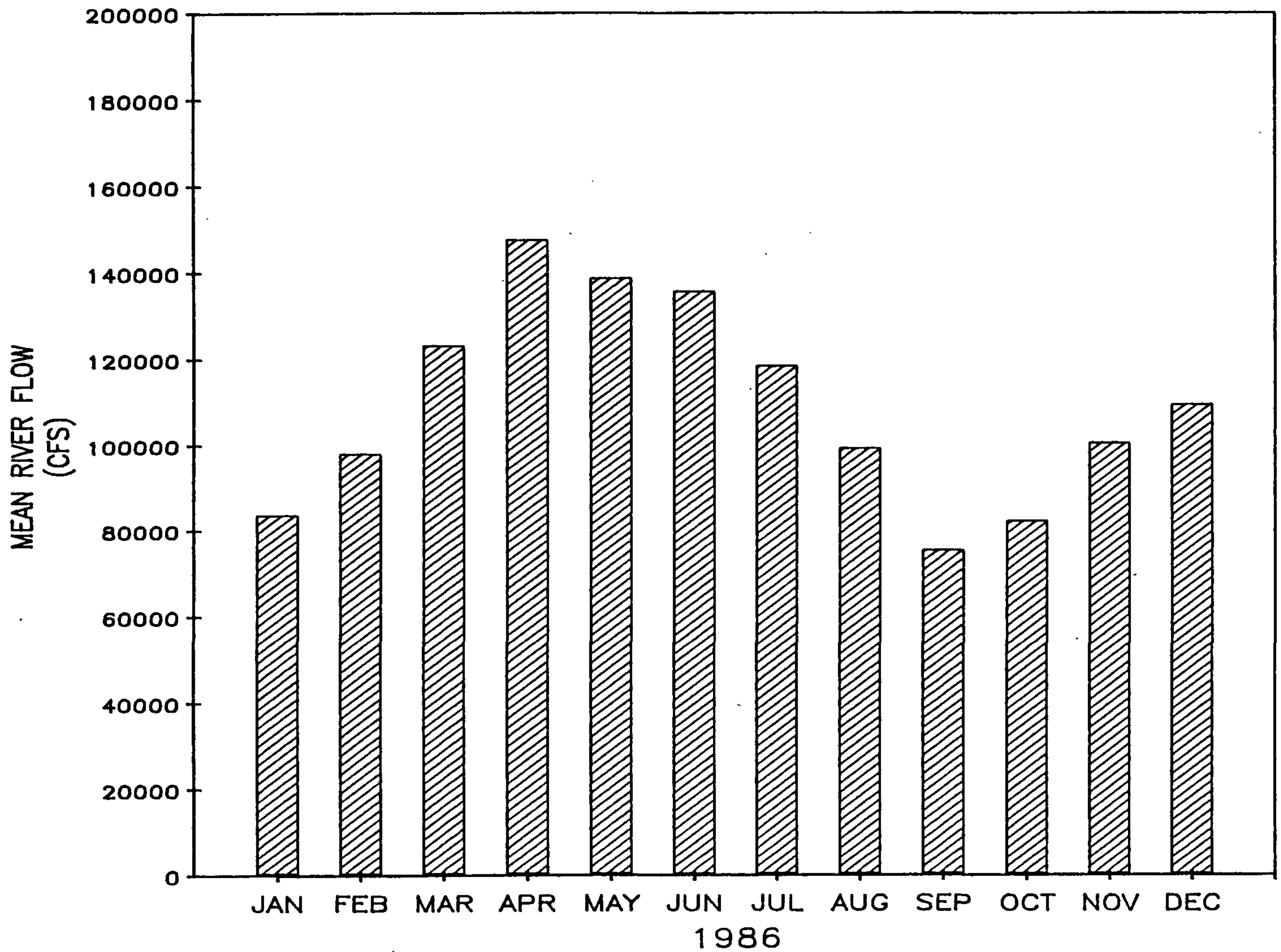

Figure 1-4. Columbia River Mean Monthly Flow for 1986

2.0 BENTHIC MACROFAUNA

2.1 INTRODUCTION

Because of their limited mobility and extreme chemical sensitivity, benthic macrofauna are among the most useful biological indicator organisms found in the Columbia River (EPA 1973). Benthos populations have been measured in the Columbia River's Hanford Reach from 1974 to the present. This study was designed to detect changes within the benthic community which may result from operation of WNP-2. This report covers the period September 1985 to September 1986.

2.2 MATERIALS AND METHODS

Artificial substrates have been used to collect benthos since studies were initiated in 1974. While details of equipment and methods have changed from time-to-time, methods used during the period of this report have been unchanged since 1983 when the preoperational studies began. This method incorporates a nickel-chrome plated wire basket (Figure 2-1) covering 412.9 cm^2 (64 in^2) of the river bottom. Each basket sampler contained 14 smooth river rocks measuring between 5.08 cm and 7.62 cm (2 to 3 inches) in diameter. Eight stations (Figures 2-2 and 2-3) were sampled with 3 replicates placed at each station). The baskets were retrieved by SCUBA divers quarterly. The target incubation period was 91 days. During this reporting period, sample soak times ranged from 90 to 93 (Table 2-1) days while in 1985 they ranged from 85 to 96 days. Each basket was carefully placed in a 600-micron mesh bag before it was returned to the surface.

Samples were iced and transported to the environmental 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 into the taxonomic categories of Table 2-2 (Pennak, 1978;

Merritt, 1978; and Ward, 1959). Samples were then enumerated and weighed (wet blotted) to 0.1 mg. A quality assurance evaluation was performed on 10% of the samples. Detailed procedures are incorporated into the Environmental Programs Instruction Manual (EPI 13-2.2 and EPI 13-2.4).

Data summaries include density and biomass calculations for individual taxa. Statistical analyses include Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT).

To standardize taxonomic classifications (i.e., Lithoglyphus/Fluminicola and Lanx/Fisherola) the EPA Bio-Storet Master List of Aquatic Organisms was used (Weber, 1983).

2.3 RESULTS AND DISCUSSION

The 1986 benthos sample year includes fall quarter 1985 as well as winter, spring, and summer quarters of 1986. The total number and mass of all taxa identified was 78,980 and 432 grams respectively (Table 2-2). Fewer organisms were collected during the period of this report than in either of the previous two. The density measured at each station is graphically presented in Figures 2-4 through 2-7 while biomass data is presented in Figures 2-8 through 2-11. Summer quarter biomass and density data is presented for the preceeding two years in Figures 2-12 through 2-15.

Within the 1986 sample year the highest density of organisms occurred in the summer quarter (Table 2-3) with the fall quarter only slightly lower. The reverse was observed for biomass. The highest density was observed during the summer quarter of each of the three most recent sample years. Biomass was also highest during the summer quarter for the first two years of the study. During the period of this report, however, biomass was higher in the fall than in the summer. Total density for all stations and seasons combined decreased 61% from that measured in 1985 and 44% from 1984. Total biomass in 1986 decreased 32% and 4% from 1985 and 1984 respectively (WPPSS 1985, 1986). Hydropsychidae larvae accounted for 57% of organisms counted in 1986, representing a relative increase over 1985 and 1984. Chironomidae larvae and pupae measured 15% and 5% respectively of 1986 total density. This was a 50% decrease from 1985 and 1984 levels. Of the total biomass measured in 1986, Hydropsychidae larvae, Fluminicola, and Fisherola accounted for 63%, 19%, and 6% respectively. The ranking and percentages were very similar for all three years.

The variability between stations is dramatically influenced by location, depth, bottom topography, and current velocity. Station 1 is the upstream control station but is the deepest (approximately 4.6 meters) and is located in an area with large (5-10 m^3) outcroppings of Ringold formation strata. Changes in river discharge cause water velocities at the samplers to vary greatly (SCUBA diver observations). Station 8 is the furthest station downstream but is located out of the plume centerline and is the shallowest (approximately 2.4 meters deep) of all stations. Station 8 is located behind a jutting point of land which reduces the current to the slowest among all stations. The bottom composition is very similar at all stations, except station 1, and consists of 5-20 cm (2-8 in) of alluvial rocks cemented into a fairly flat bottom. Stations 7E, 7M, 7W and 11E, 11M, 11W are very similar to one another in velocity and depth. The river bottom slopes from the west to the east with a maximum drop of 0.61 meters per 30.5 meters. The centerline slope between 7M and 11M is less than 0.31 meters in 61 meters.

Table 2-4 summarizes the results of one way ANOVAS on the data by seaon. The seasons which demonstrated a significant difference in Table 2-4 were summarized using Duncan's Multiple Range Test in Table 2-5. From the two control locations, stations 1 and 8, it is clear that the reduction in density and biomass during 1986 relative to previous years was a wide spread phenomenon not related to the operation of WNP-2. Additionally, the reduction was present during the spring when the plant wasn't operating. Although the reason for this is not clear, it is speculated that it was the result of a long and unusually cold winter. This thesis is supported by the fact that the fall data, which was actually collected in 1985, was not unusual when compared to both the preoperational and first year of operational data.

Tables 2-6, 2-7, and 2-8 identify stations that differed significantly in biomass and density from the others. The only consistent pattern which emerges from an inspection of the data is that Stations 1 and 8 are different. This observation is consistent with all previous data and results from the fact that they are ecologically different as described earlier. At the present time there is no indication that WNP-2 is affecting either density or biomass of benthic macroinvertebrates which reside more than 42.7 meters (140 feet) downstream of the discharge or at the edge of the mixing zone.

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Table 2-1. Benthic Macrofauna Program Sampling Periods

Period	Date	Number of Days Exposed
Fall 1985	September 4 to December 3	90
Winter 1986	December 3 to March 4	91
Spring 1986	March 4 to June 2	90
Summer 1986	June 2 to September 3	93

Table 2-2. Total Weight and Count of All Organisms Collected from September 1985 to September 1986

Taxa Lifestage	Number	Grams
Caddisfly-Hydropsychidae, Larvae	45241	272.0
Midges-Chironomidae, Larvae	12045	3.9
Midges-Chironomidae, Pupae	4176	2.0
Snail-Fluminicola, Adult	4009	82.4
Mayfly-Baetidae, Nympth	3132	1.6
Blackfly-Baetidae, Nymph	2555	5.5
Snail-Parapholyx	1271	10.0
Snail-Fisherola	1092	28.3
Caddisfly-Leptoceridae, Larvae	1030	2.2
Caddisfly-Hydroptilidae, Larvae	933	0.3
Caddisfly-Hydropsychidae, Pupae	901	12.4
Caddisfly-Psychomyiidae, Larvae	764	0.7
Mayfly-Ephemerellidae, Nymph	441	1.2
Blackfly-Simulidae, Pupae	383	0.9
Oligochaeta	373	*
Mollusc-Unidentifiable Remains	101	0.2
Mayfly-Heptageniidae, Nymph	90	*
Mites	69	*
Moth-Pyralidae, Larvae	56	0.2
Midges-Chironomidae, Adult	49	*
Snail-Lymnaea	43	3.5
Clam-Bivalvia	42	0.9
Caddisfly-Glossosomatidae, Larvae	40	0.1
Caddisfly-Hydroptilidae, Pupae	35	*
Snail-Physa	31	1.7
Mayfly-Tricorythidae, Nymph	24	*
Mayfly-General, Nymph	24	0.1
Caddisfly-Glossosomatidae, Pupae	7	*
Blackfly-Simulidae, Adult	7	*
Flatworm	4	*
Caddisfly-Psychomyiidae, Pupae	4	*
Water Flea, Daphnia	2	*
Scuds/Shrimps	2	*
Leech	2	*
Caddisfly-Leptoceridae, Pupae	1	*
Caddisfly-Hydropsychidae, Adult	1	*
Unidentified	-	2.2
Roundworm-Nematoda	-	-
TOTAL	78,980	432.3

(*) = Less than 0.1 grams

Table 2-3. Density and Biomass of Benthic Macrofauna by Sample Quarter and Station for 1986, 1985, and 1984

Season/Station	Density(1) Mean	Density(1) Std. Dev.	Biomass(2) Mean	Biomass(2) Std. Dev.
Fall 85	29395	8738	225	60
Station 1	27062	5997	175	33
Station 7W	32923	2819	284	26
Station 7M	31559	3809	291	58
Station 7E	22218	3530	245	52
Station 11W	36427	10550	242	54
Station 11M	21515	8532	174	66
Station 11E	21838	4530	210	37
Station 8	41618	2730	177	12
Winter 86	1746	711	9	7
Station 1	993	189	3	0
Station 7W	2228	420	17	7
Station 7M	2422	1311	18	6
Station 7E	1784	854	9	5
Station 11W	300	644	6	2
Station 11M	2147	259	10	6
Station 11E	1566	211	6	2
Station 8	1526	279	4	1
Spring 86	7276	3495	62	33
Station 1	3601	806	27	12
Station 7W	9236	2211	96	36
Station 7M	6975	833	72	23
Station 7E	3488	1697	35	12
Station 11W	9502	1999	71	16
Station 11M	7355	5580	47	47
Station 11E	5934	1443	81	39
Station 8	12118	1079	65	17
Summer 86	41287	10423	141	76
Station 1	35708	14169	49	38
Station 7W	49215	14762	223	91
Station 7M	44678	13554	158	46
Station 7E	39026	2987	190	45
Station 11W	36766	5000	128	114
Station 11M	50628	12897	172	17
Station 11E	34401	2402	138	45
Station 8	39874	6285	66	38

(1) Number of organisms/m^2
(2) Weight of organisms/m^2

Table 2-3. (Continued)

Season/Station	Density(1) Mean	Std. Dev.	Biomass(2) Mean	Std. Dev.
Fall 84	54825	19202	241	117
Station 1	52574	14566	146	33
Station 7W	40246	867	186	18
Station 7M	57522	13782	337	217
Station 7E	37565	3518	163	30
Station 11W	68720	14318	285	162
Station 11M	52234	2572	269	46
Station 11E	41941	9188	288	120
Station 8	87798	23774	256	129
Winter 85	2707	1188	19	19
Station 1	1074	386	4	2
Station 7W	3585	1357	40	24
Station 7M	2236	403	10	4
Station 7E	3609	706	35	20
Station 11W	3149	349	35	5
Station 11M	1405	396	4	2
Station 11E	3108	1308	35	26
Station 8	3488	945	6	1
Spring 85	17410	6006	142	64
Station 1	16793	4599	143	77
Station 7W	14871	2080	186	28
Station 7M	13264	1858	93	41
Station 7E	12804	1303	192	115
Station 11W	21951	4127	186	60
Station 11M	15727	2943	87	11
Station 11E	14976	731	135	52
Station 8	28894	6943	105	22
Summer 85	129790	44975	237	107
Station 1	131200	33349	181	119
Station 7W	134933	13475	287	60
Station 7M	160183	60110	300	190
Station 7E	97765	29928	196	43
Station 11W	135793	11121	310	69
Station 11M	192762	34885	322	34
Station 11E	119719	23395	205	72
Station 8	76067(3)	7786(3)	102(3)	8(3)

(1)Number of organisms/m^2
(2)Weight of organisms/m^2
(3)Estimated from 2 replicates

Table 2-3. (Continued)

Season/Station	Density(1) Mean	Std. Dev.	Biomass(2) Mean	Std. Dev.
Fall 83	35874	12644	154	55
Station 1	49602	16499	171	67
Station 7W	40593	11881	190	58
Station 7M	26359	2651	137	26
Station 7E	25754	6064	142	46
Station 11W	37275	10145	146	21
Station 11M	29015	9656	153	55
Station 11E	28144	8810	199	91
Station 8	50248	5374	98	45
Winter 84	3477	1965	33	38
Station 1	1171	301	4	1
Station 7W	3157	916	25	15
Station 7M	2922	921	13	4
Station 7E	4473	740	111	26
Station 11W	3245	298	16	13
Station 11M	1493	287	7	3
Station 11E	4142	1070	70	27
Station 8	7209	1768	15	4
Spring 84	17871	8442	75	38
Station 1	9058	5286	33	27
Station 7W	23033	4340	111	27
Station 7M	17051	1763	63	17
Station 7E	10302	1249	96	68
Station 11W	22759	2186	94	24
Station 11M	15129	5230	47	20
Station 11E	12546	2174	78	38
Station 8	33093	7121	75	26
Summer 84	88001	23163	200	60
Station 1	83155	19122	120	40
Station 7W	77052	22079	220	18
Station 7M	105378	26778	292	17
Station 7E	67565	23862	197	44
Station 11W	73152	6927	174	27
Station 11M	99367	35462	247	39
Station 11E	96086	28556	163	31
Station 8	95440	11595	186	56

(1)Number of organisms/m^2
(2)Weight of organisms/m^2

Table 2-4. Summary of One-Way ANOVA of Station Density or Biomass Versus Season

Period	Density		Biomass	
	F	P(F)	F	P(F)
Fall 85	4.641	0.0053 (1)	3.333	0.0218
Winter 86	1.786	0.1592	4.539	0.0058
Spring 86	4.476	0.0062	2.069	0.1083
Summer 86	1.082	0.4184	2.835	0.0400

(1)Probabilities which imply that significant differences exist between stations are underlined (Alpha=0.05).

TABLE 2-5. Summary of Duncan's Multiple Range Test on Seasons with Significant Between-Station Density or Biomass Differences (Alpha=0.05)1

Density								
Fall 85	11M	11E	7E	1	7M	7W	11W	8
Spring 86	7E	1	11E	7M	11M	7W	11W	8
Biomass								
Fall 85	11M	1	8	11E	11W	7E	7W	7M
Winter 86	1	8	11E	11W	7E	11M	7W	7M
Summer 86	1	8	11W	11E	7M	11M	7E	7W

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

Table 2-6. Summary of One-Way ANOVA for Selected Taxa Comparing Stations (Alpha=0.05)

	Density F	P(F)	Biomass F	P(F)
Hydropsychidae larvae				
Fall 85	3.899	0.0115	3.557	0.0169
Winter 86	3.156	0.0270	2.619	0.0525
Spring 86	2.503	0.0610	1.768	0.1632
Summer 86	1.377	0.2803	1.786	0.1594
Hydropsychidae All (1)				
Fall 85	3.896	0.0115	2.548	0.0170
Winter 86	3.156	0.0270	0.393	0.8066
Spring 86	2.065	0.1088	1.529	0.2315
Summer 86	1.345	0.2931	1.701	0.1790
Chironomidae larvae				
Fall 85	2.336	0.0758	1.597	0.2069
Winter 86	1.201	0.3566	1.129	0.3933
Spring 86	5.853	0.0017	5.601	0.0021
Summer 86	2.582	0.0551	2.139	0.0986
Chironomidae pupae				
Fall 85	0.633	0.7228	0.689	0.6802
Winter 86	1.108	0.4045	0.713	0.6626
Spring 86	5.317	0.0027	5.326	0.0027
Summer 86	2.014	0.1167	1.722	0.1740
Chironomidae All (1)				
Fall 85	2.234	0.0868	1.281	0.4826
Winter 86	1.155	0.3799	4.200	0.1336
Spring 86	6.505	0.0010	0.976	0.5628
Summer 86	2.513	0.0601	2.037	0.1130
Fluminicola				
Fall 85	18.176	0.0000	11.752	0.0000
Winter 86	2.100	0.1038	2.766	0.0436
Spring 86	3.759	0.0134	3.419	0.0198
Summer 86	2.678	0.0487	2.744	0.0448
Mollusca All (2)				
Fall 85	22.412	0.0000	19.546	0.0000
Winter 86	2.152	0.1104	1.335	0.3450
Spring 86	2.995	0.0353	2.587	0.0579
Summer 86	2.670	0.0492	1.818	0.1615

(1)All life stages combined. (2)All mollusc combined.

TABLE 2-7. Summary of Duncan's Multiple Range Test on Taxa with Significant Between-Station Density Differences (Alpha=0.05)[1,2]

Hydropsychidae Larvae								
Fall 85	11E	7E	11M	1	7W	7M	11W	8
Winter 86	1	11M	7E	11E	11W	8	7W	7M
Hydropsychidae (All)								
Fall 85	11E	7E	11M	1	7W	7M	11W	8
Winter 86	1	11M	7E	11E	11W	8	7W	7M
Chironomidae Larvae								
Spring 86	7E	1	11E	7M	11M	7W	11W	8
Chironomidae Pupae								
Spring 86	7E	1	7W	11E	11W	7M	11M	8
Chironomidae (ALL)								
Spring 86	7E	1	11E	7M	7W	11M	11W	8
Summer 86	11E	11W	7W	7E	8	7M	11M	1
Fluminicola								
Fall 85	1	8	11M	7M	11W	7E	11E	7W
Spring 86	1	7E	8	11M	11W	7M	7W	11E
Summer 86	1	8	11M	11W	7E	7M	11E	7W
Mollusca								
Fall 85	1	11M	8	7M	11W	7W	11E	7E
Spring 86	1	11M	7E	8	11W	7M	7W	11E
Summer 86	1	11M	11W	8	7M	11E	7E	2

(1) Stations are listed by increasing density from left to right.
(2) Seasons not shown have had no significant differences.
(3) All life stages combined.

TABLE 2-8. Summary of Duncan's Multiple Range Test on Taxa with Significant Between-Station Biomass Differences (Alpha=0.05)1,2

Hydropsychidae Larvae								
Fall 85	11E	7E	8	11M	1	7W	11W	7M
Hydropsychidae (All)3								
Fall 85	11E	7E	8	11M	1	7W	11W	7M
Chironomidae Larvae								
Spring 86	7E	1	11E	7M	11M	7W	11W	8
Chironmidae Pupae								
Spring 86	7E	1	7W	11E	7M	11W	11M	8
Fluminicola								
Fall 85	1	8	11M	7M	11W	7W	7E	11E
Winter 86	1	8	11E	11W	11M	7E	7M	7W
Spring 86	1	7E	11M	8	11W	7M	7W	11E
Summer 86	1	8	11W	7M	7E	11M	11E	7W
Mollusca (All)3								
Fall 85	1	11M	8	11W	7M	7W	11E	7E

(1) Stations are listed by increasing biomass from left to right.
(2) Seasons not shown have had no significant differences.
(3) All lifestages combined.

Figure 2-1. Sampler Used to Collect Benthic Macrofauna in Columbia River.

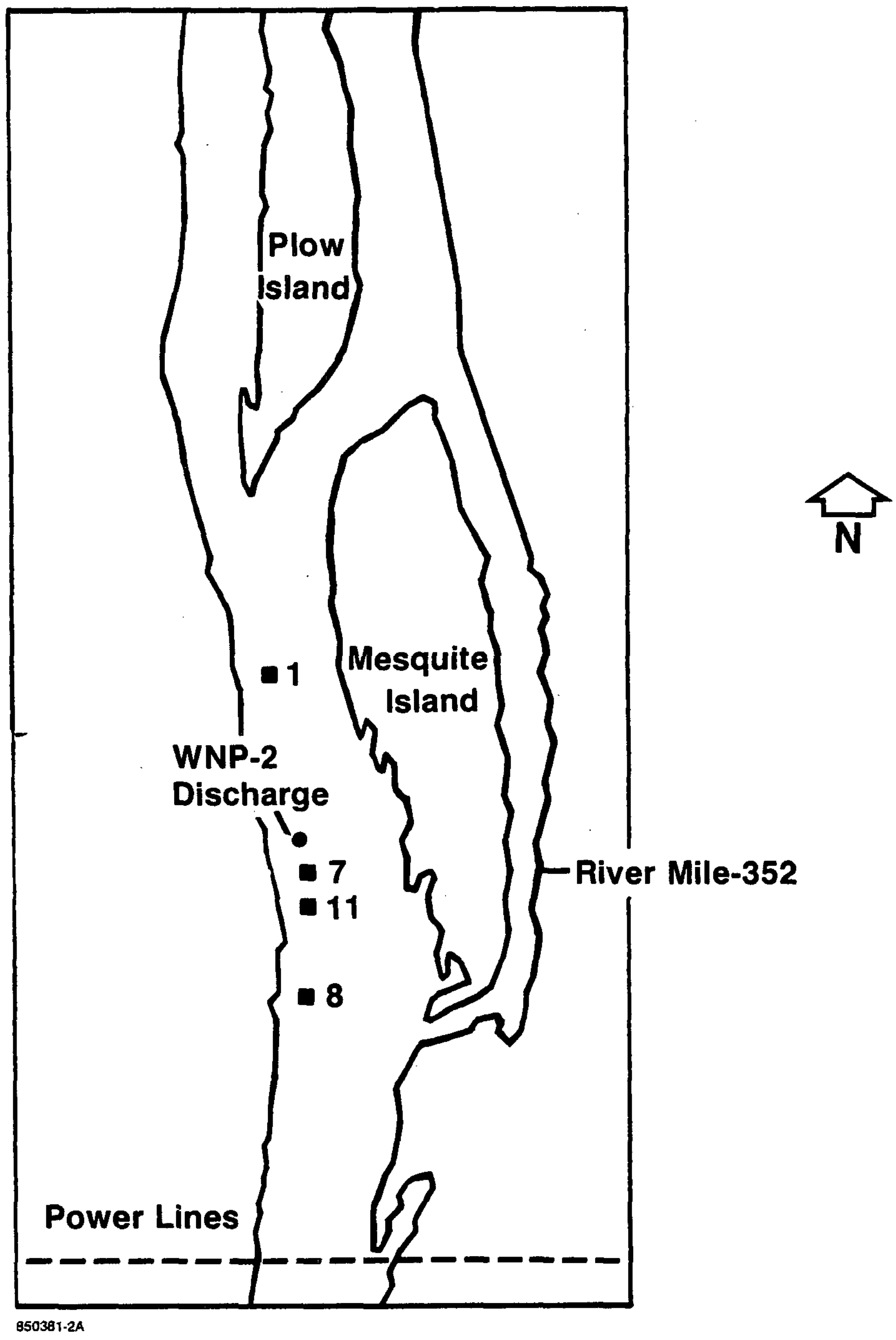

Figure 2-2. Location of Sampling Stations in the Columbia River

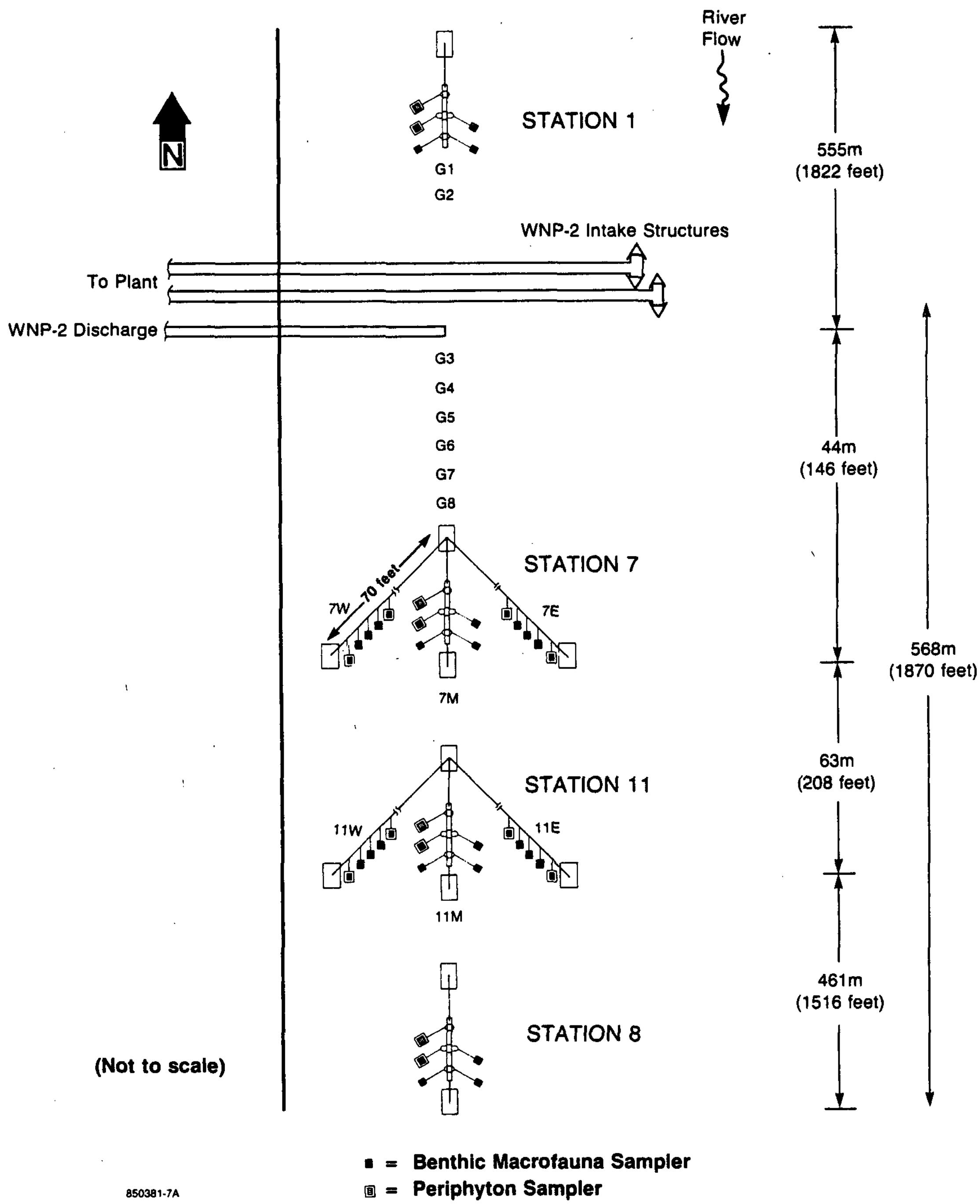

Figure 2-3. Diagrammatic Representation of the Aquatic Sampling Stations in the Columbia River

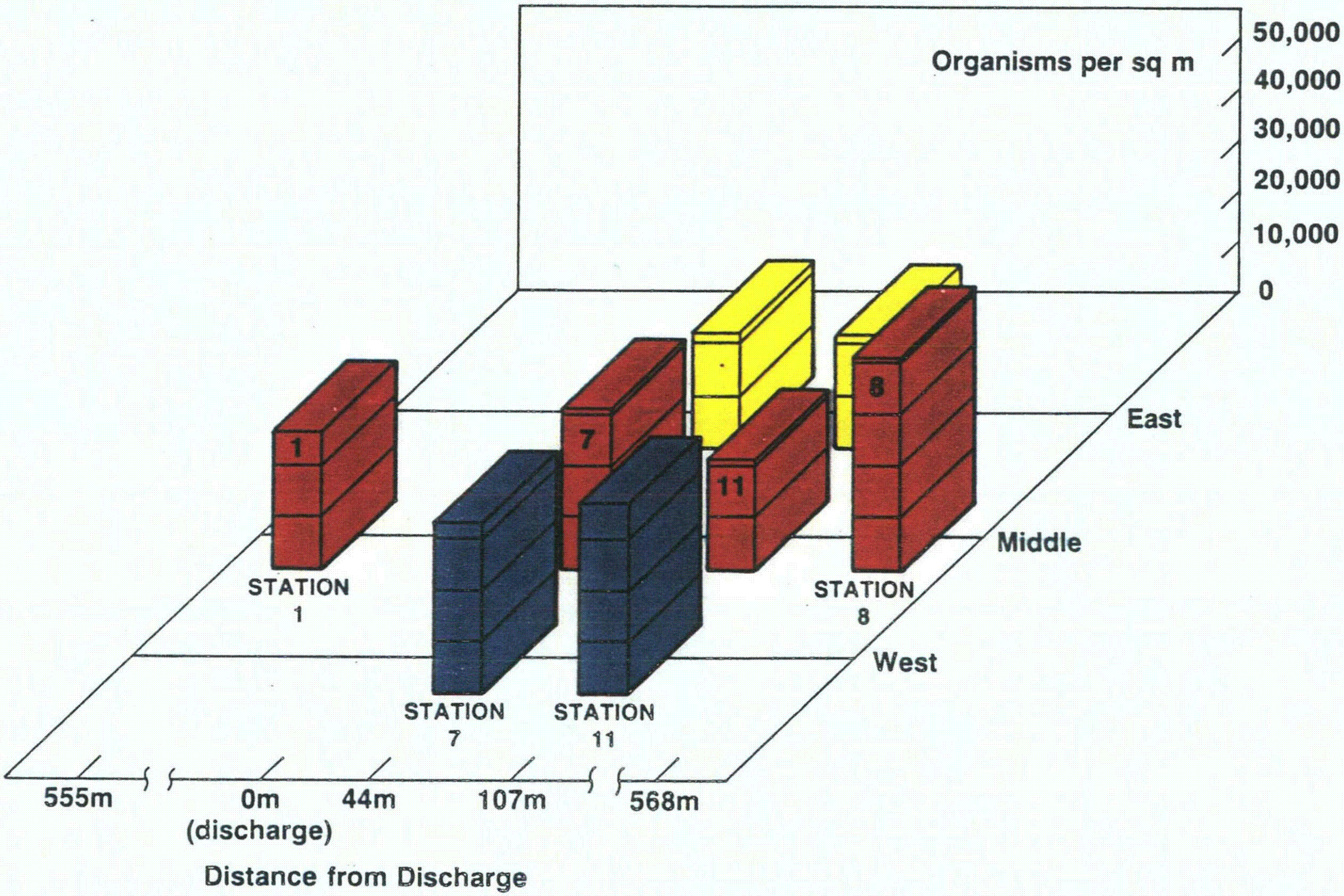

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Figure 2-4. Benthos Total Density-Fall Quarter, 1985

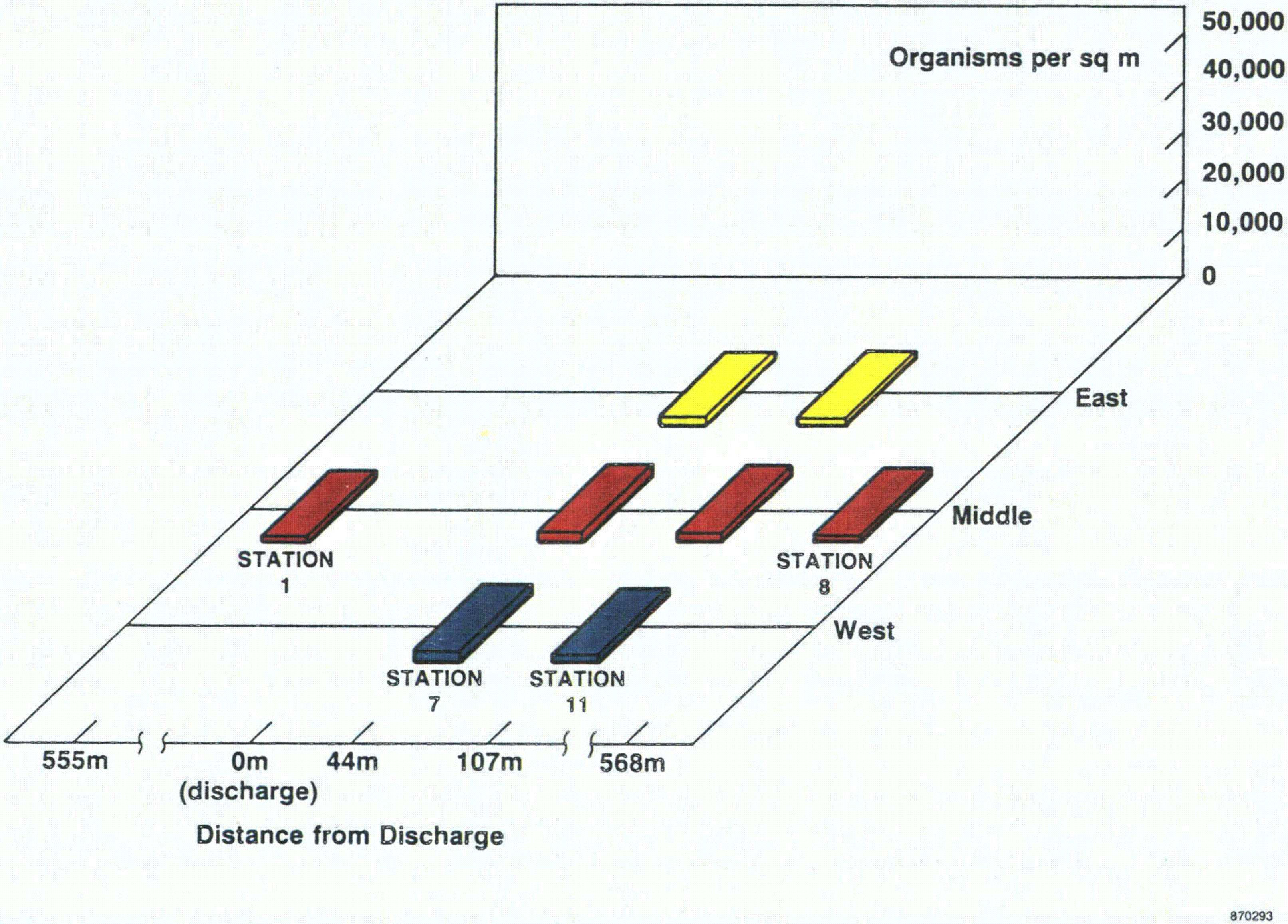

Figure 2-5. Benthos Total Density-Winter Quarter, 1986

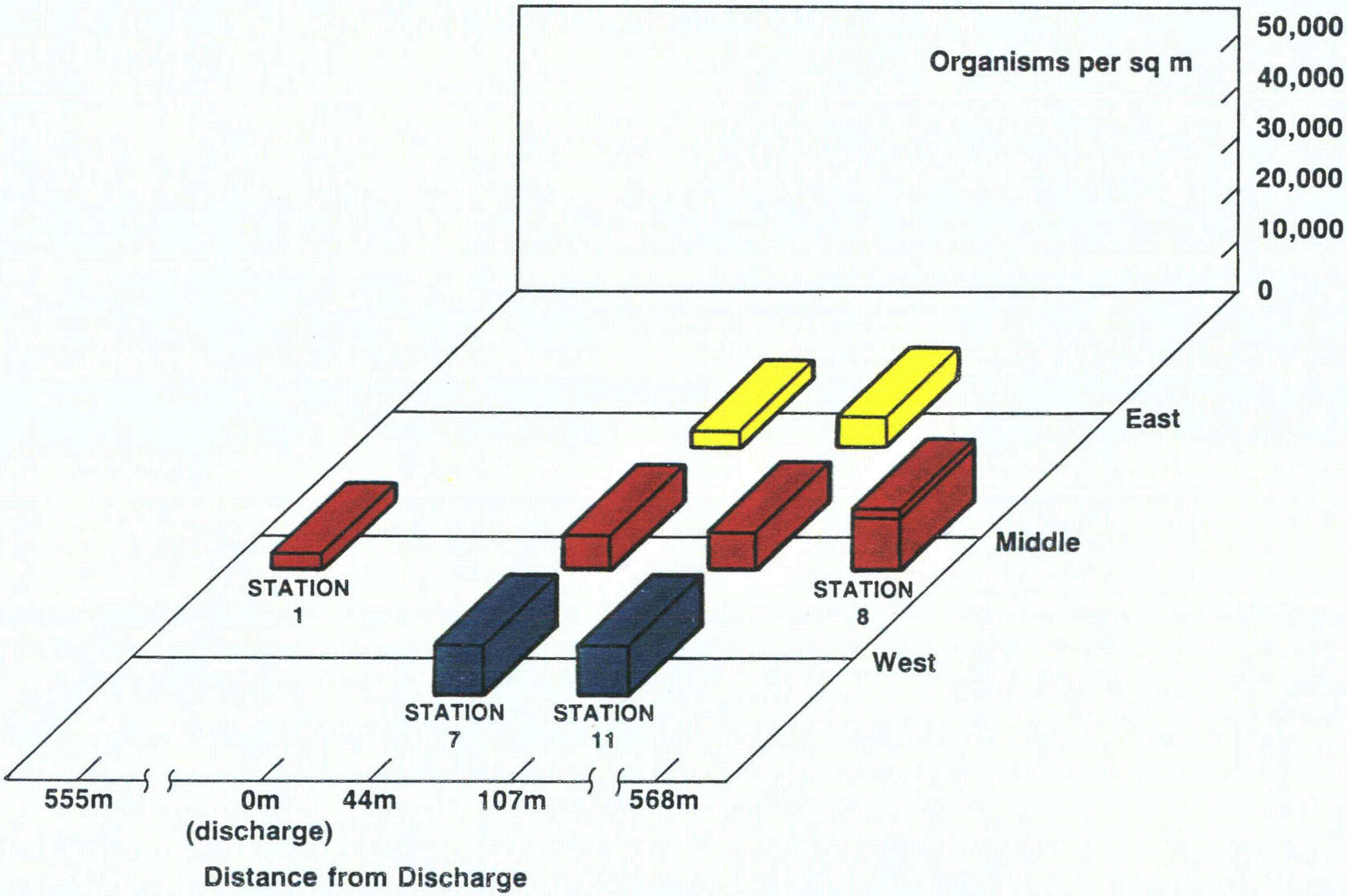

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Figure 2-6. Benthos Total Density - Spring Quarter, 1986

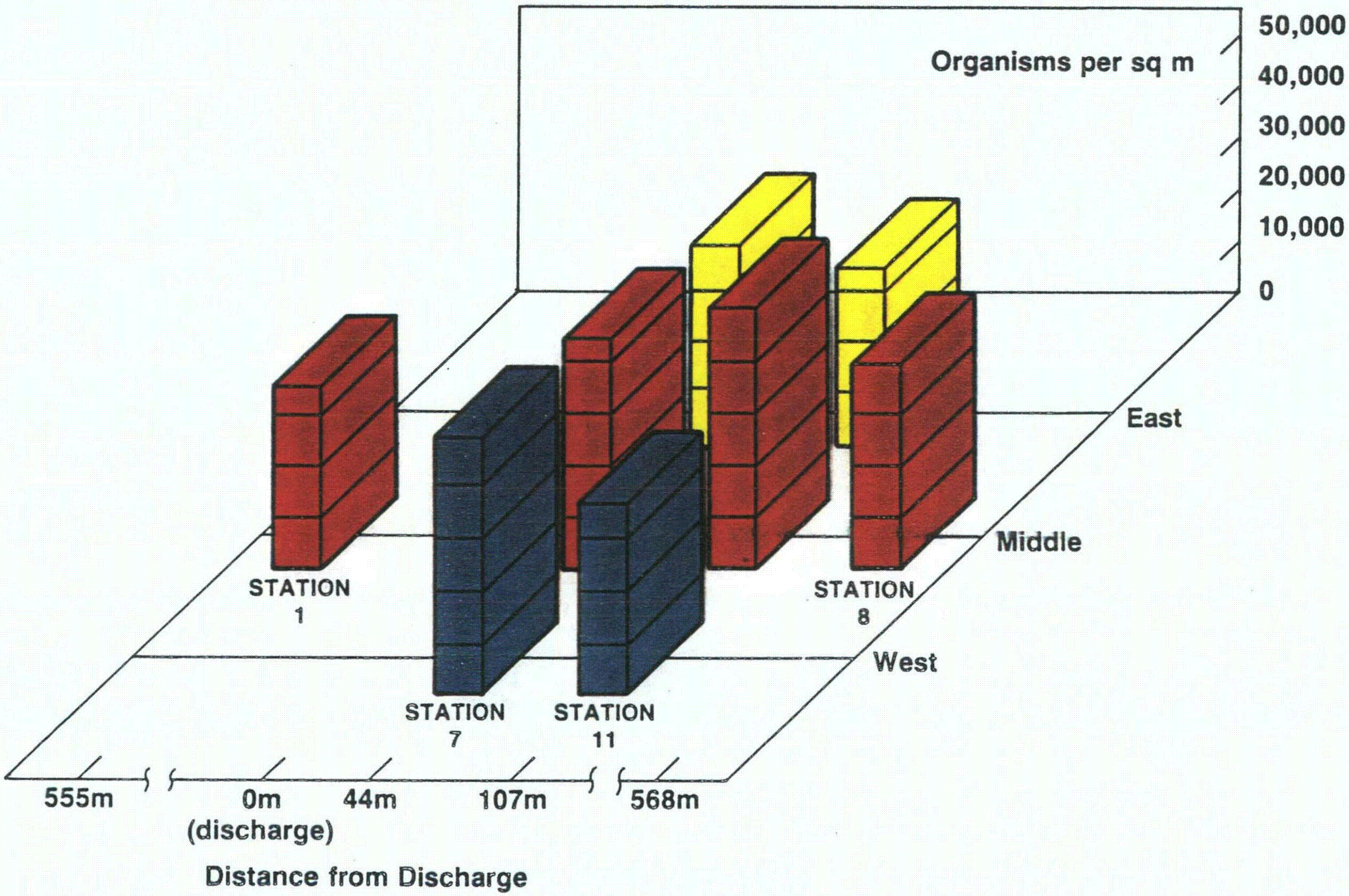

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Figure 2-7. Benthos Total Density-Spring Quarter, 1986

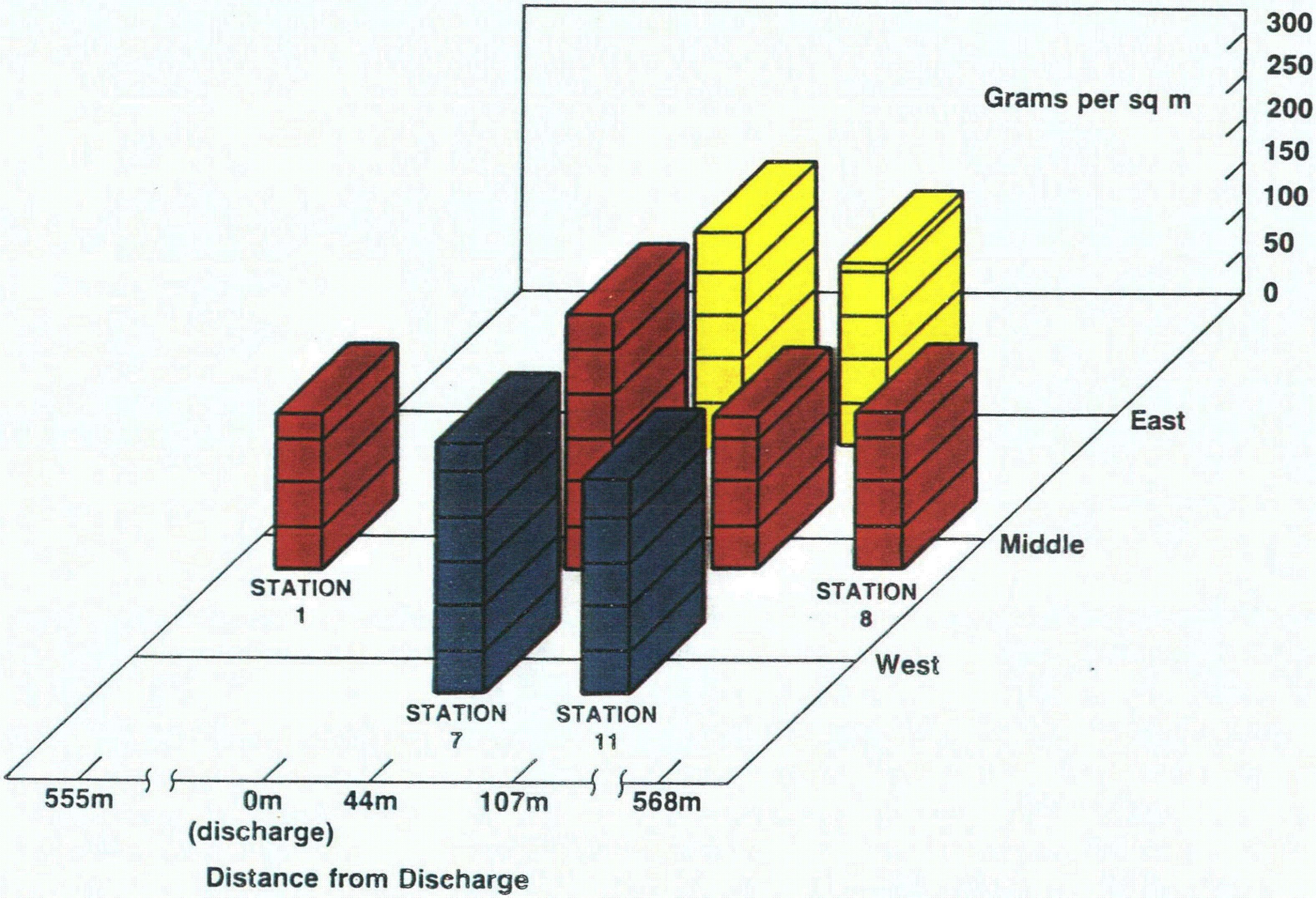

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Figure 2-8. Benthos Total Biomass-Fall Quarter, 1985

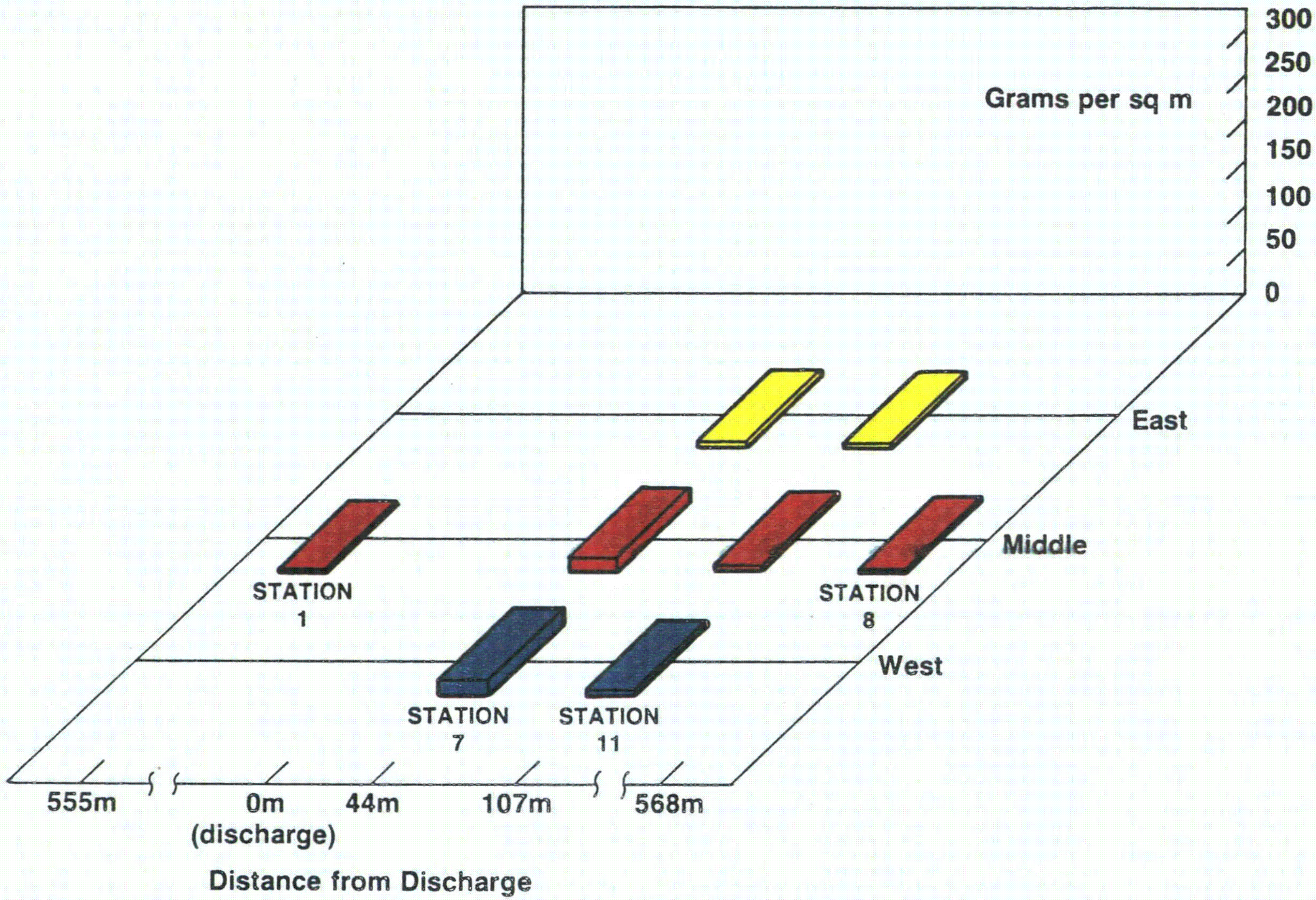

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Figure 2-9. Benthos Total Biomass-Winter Quarter, 1986

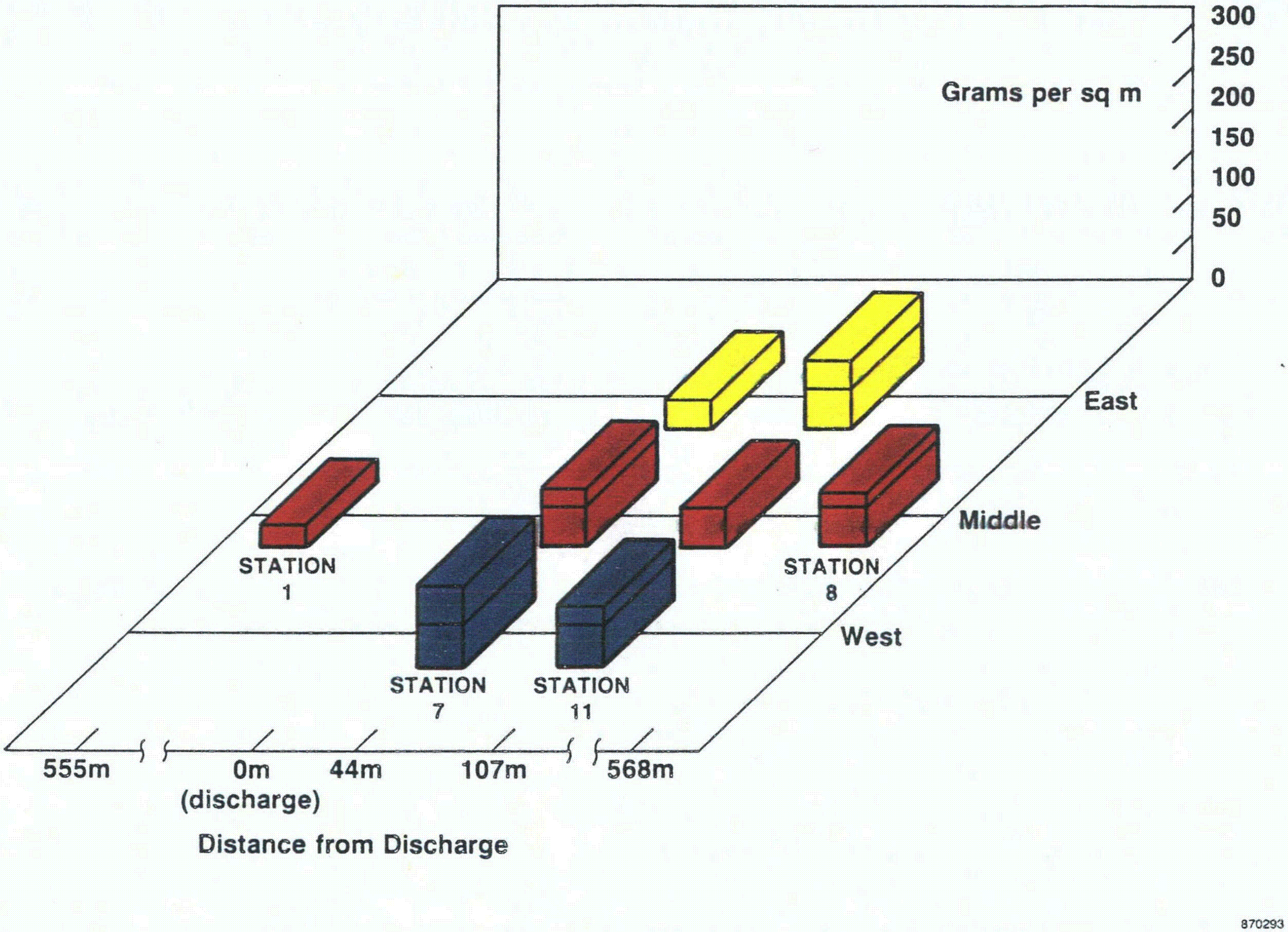

Figure 2-10. Benthos Total Biomass-Spring Quarter, 1986

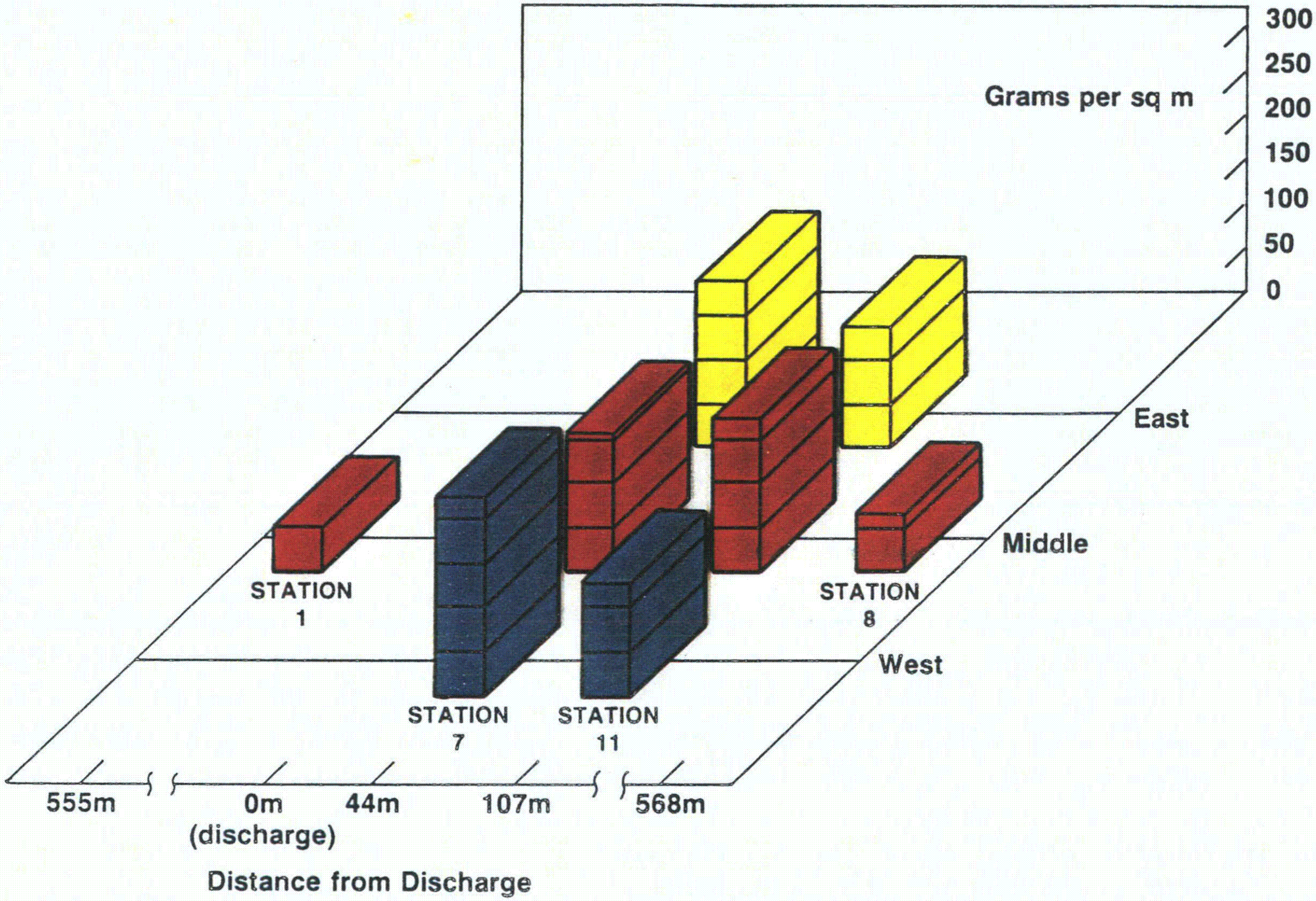

Figure 2-11. Benthos Total Biomass-Summer Quarter, 1986

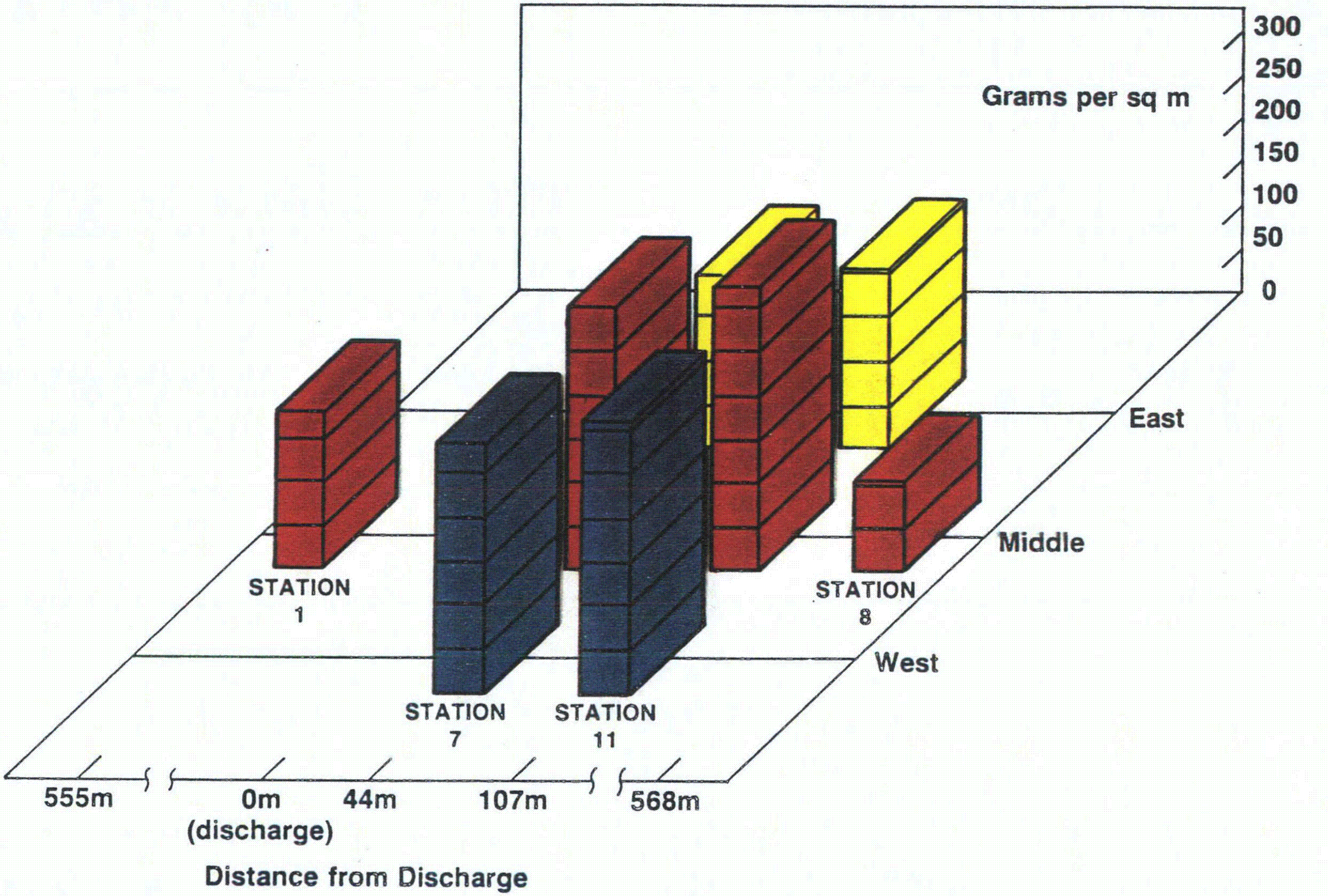

Figure 2-12. Benthos Total Biomass-Summer Quarter, 1985

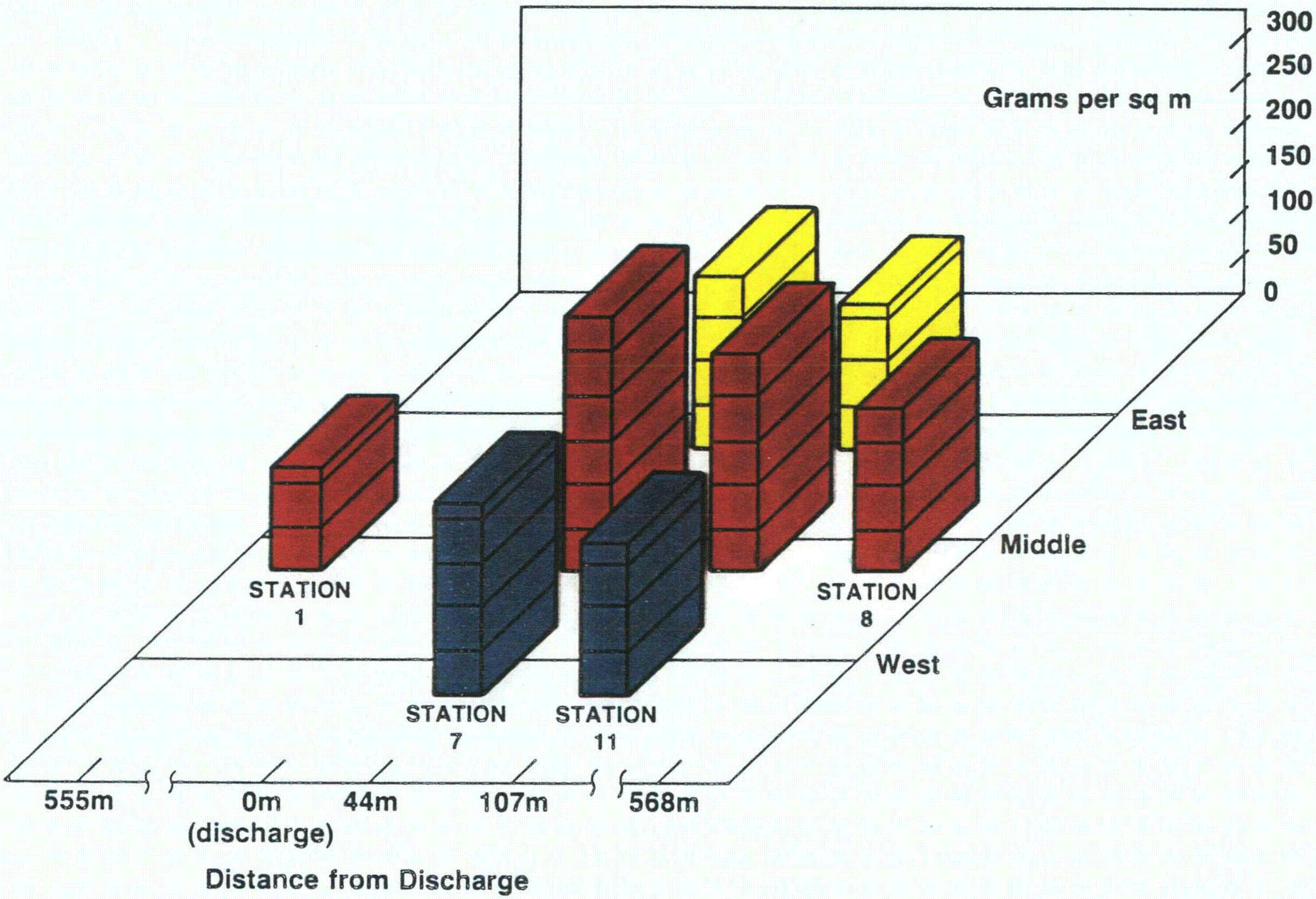

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Figure 2-13. Benthos Total Biomass-Summer Quarter, 1984

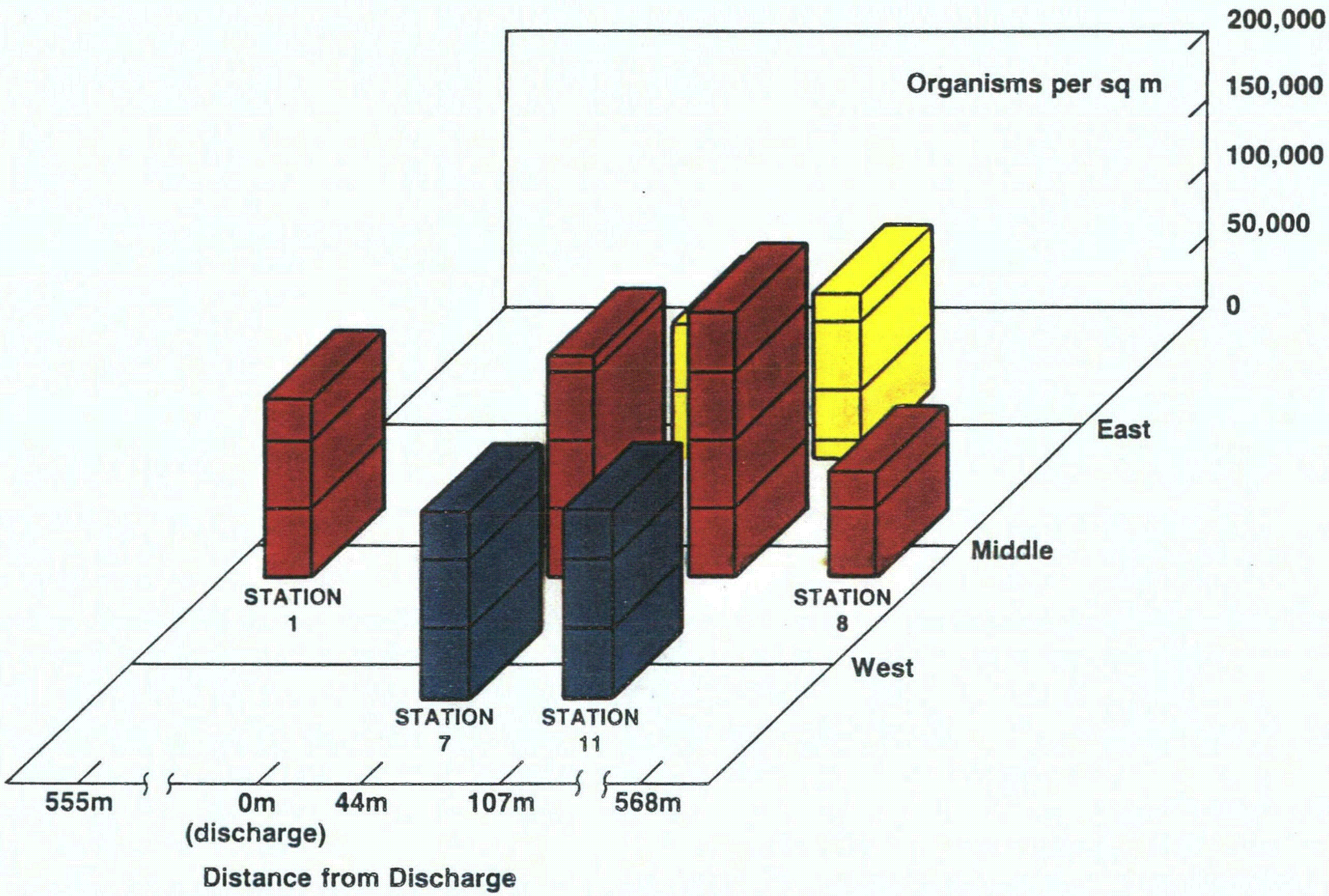

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Figure 2-14. Benthos Total Density-Summer Quarter, 1985

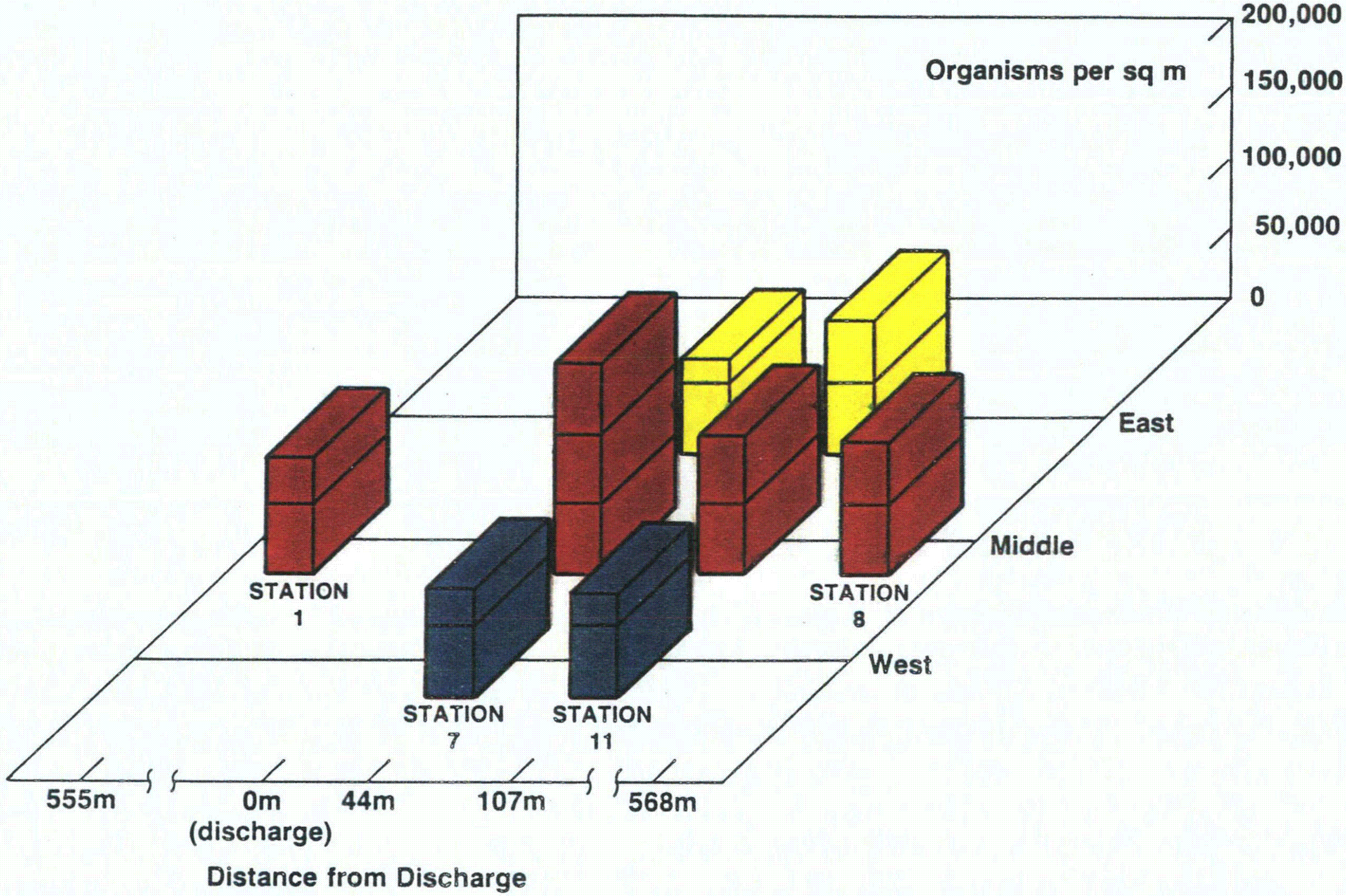

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Figure 2-15. Benthos Total Density-Summer Quarter, 1984

3.0 PERIPHYTON

3.1 INTRODUCTION

Periphyton can be useful biological indicators of water quality because they form a vital link in the aquatic food chain and are sensitive to thermal and chemical discharges (APHA, 1985). Because periphyton are 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 were sampled near WNP-2 from 1977 to 1980 in studies that preceded those reported on in this section.

During preoperational sampling, diatoms dominated the benthic microflora in the Columbia River near WNP-2 due to favorable environmental conditions, including cool water temperatures (Patrick, 1969). Elevated temperatures from power plant discharge could change this balance causing increased periphyton biomass, reduced species diversity, or changed species composition (e.g. Patrick, 1969; Cairns, 1956; Owens, 1971; Coutant and Owens, 1970). However, a study of the thermal tolerance of Columbia River periphyton indicated that an increase of as much as 10°C above ambient river temperature significantly changed (increased) biomass only during a short period in winter, with the domination of diatoms persisting (Owens, 1971). Total residual chlorine concentrations of near 0.1 ppm, as in the discharge, can also affect periphyton by reducing growth (Brungs, 1976), but dilution of discharge water in the mixing zone rapidly lowers the concentration to levels that should not be harmful. Mixing also quickly reduces elevated temperatures (WPPSS, 1986).

Periphyton sampling performed during 1986 represents the second full year of operational studies and includes data collected between December 1985 and December 1986. On April 14, 1986, the Energy Facility Site Evaluation Council gave approval to change the analytical method for measuring periphyton biomass from the historical total organic matter method to the total carbon (T.C.) method which utilizes a surface carbon analyzer. Only results obtained using the total carbon technique are reported on in this section.

3.2 MATERIALS AND METHODS

Periphyton samples were collected from the Columbia River in the vicinity of WNP-2 from December 1985 to December 1986. Two groups of stations were sampled. Eight stations used in earlier preoperational studies (core program) were sampled on a quarterly basis (Table 3-1). They are situated such that one is 555-meters upstream of the WNP-2 discharge port, six others are spaced over the length and breadth of the discharge plume, and another is 568-meters 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 in March 1983 and are located close to the discharge port. During 1985, a new station G4A, was established between stations G3 and G4 as a result of concerns that station G4, which is on top of an anchor, may be atypical. These are referred to as the gradient program and are situated at 6.1-meter intervals along the discharge plume center-line, beginning at the discharge port and extending downstream 30.5-meters (Figure 3-1). These stations are 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. Gradient samples were collected every six weeks. 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 which were set out and retrieved by SCUBA divers (Figure 3-2). Two replicate diatometers were located at each station. Two slides from each diatometer were picked free of insects, air dried, and total carbon was directly read out from the surface carbon determinator. For more information on the T.C. method, see Davis (1986).

To provide information on the effects of benthic macrofauna on periphyton biomass, an additional two slides from each diatometer were left as is (not picked), and analyzed using the same procedure as for the picked slides.

3.3 Results and Discussion

Mean periphyton biomass at core program stations ranged from 0.17 g T.C. per square meter at station 7E during the spring to 2.29 g T.C. per square meter at station 8 during the winter (Table 3-2). A three-way analysis of variance (ANOVA) was performed on operational data collected during 1985 and 1986. Year, season and station effects were found to be statistically significant. Higher order interactions (2-way, 3-way) could not be completed due to missing station values (broken slides, samplers found upside down). A one-way ANOVA was performed on each season's data to determine if there were any significant between station differences in biomass (the hypothesis of a homogeneous density was rejected at the 0.05 level). A Duncan's Multiple Range Test (DMRT) was performed on each data set to determine which stations are different (Table 3-3). Station 1 consistently ranked lowest in biomass while stations 8 and 7E frequently ranked high. Station 11W ranked high in total biomass during winter and spring sampling periods. A DMRT comparing seasons (stations combined) indicated that all sampling periods were significantly different from one-another. Total biomass was lowest in the spring and highest in the winter. Fall and summer periods fell between these two extremes, with above average and below average values, respectively (Figure 3-3).

Mean periphyton biomass at gradient program stations ranged from 0.03 g T.C. per square meter at station G4A during the early winter to 1.00 g T.C. per square meter at station G5 during the late winter (Table 3-2, Figure 3-4). All periods exhibited significant between-station differences when analyzed with a one-way ANOVA at the 0.05 level. Results of the Duncan's Multiple Range Tests on these data are presented in Table 3-4. A DMRT comparing seasons (stations combined) showed that all periods, with the exception of early winter and late spring, were significantly different from one-another. As with the core program, a three-way analysis of variance could not be completed due to missing station values. Stations G1 and G2 consistently produced below average biomass. This result is consistent with the findings of previous years.

Core and gradient program data for 1986 is in agreement with previous studies conducted at WNP-2 (Beak, 1980; Wolf et. al., 1976; WPPSS, 1985 and 1986). Seasonal trends, including station and season differences, were similar for both the preoperational and operational periods. Figures 3-5 to 3-10 include data collected by Supply System personnel from April 1983 through December 1985. Peaks in biomass production during winter sampling periods, as seen during 1985 and 1986, are consistent with the findings of the earlier studies. These studies determined that shading of the river bottom by dense plankton populations and other suspended materials during increased river-flow periods (March through September), was a major factor in limiting periphyton growth (Beak, 1980; Wolf et. a., 1976). Lower plankton populations during winter resulted in more light being available for periphyton production. Table 3-5 provides information on Columbia River flow rates, temperature, and turbidity from spring 1983 through fall 1986. The aforementioned peaks in biomass during 1985 and 1986 winter periods were associated with low turbidity measurements. In contrast, low biomass production during spring periods were generally associated with higher turbidity measurements and somewhat to increased flow rates. Higher turbidity may also help to explain why biomass production during the winter sampling period for 1984 was well below that of both the summer and fall periods. It is also interesting to note that nearly all of the biomass produced during the winter periods of 1985 and 1986 was from the middle of January to the first of March. Early winter production (December through mid January) was very limited, even though flow rate and turbidity were virtually the same for the two periods. Photoperiod and/or the amount or kind of light intensity (periods of low overcast conditions are common during late fall and early winter periods) may be the determining factor here.

A general description of core sampling stations by location, depth, bottom topography, and current velocity is presented in section 2.0 - Benthic Macrofauna. These observations provide additional information when attempting to explain station differences within seasons. Station 1, being the deepest, generally has the lowest biomass, while station 8, the shallowest, usually ranks highest. All other stations, being basically the same for the aforementioned parameters, tend to have similar biomass production. This same general trend holds true for gradient program stations. Stations G1 and G2, located at core program station 1, were consistently lower in biomass than the other gradient stations, which are more typical of core program stations 7 (E, W, M) and 11 (E, W, M).

It is obvious that several factors can affect periphyton biomass production. Among these, light availability appears to play a major role. When using biomass measurements to determine the effect of the operation of WNP-2 on the periphyton community, one must minimize the influence that these factors have. Because of the great variability in climatic conditions, year and season comparisons are not very useful for this task. Comparing stations within a given season is probably the best method. Any plant induced changes in biomass would be most apparent at gradient program stations G3 and G4A. As in previous years, these stations consistently produced average results, indicating negligible impact from WNP-2's discharge.

The effect of benthic macrofauna (infestation, grazing, etc.) on periphyton production is demonstrated in Tables 3-6 and 3-7. During fall and summer periods, benthic macrofauna account for 53 percent and 67 percent of the total biomass measured, respectively. These results indicate that sample exposure time during peak production months may be too long. Additionally, these results lend support to the conclusion that WNP-2's discharge has no significant effect on Columbia River periphyton. Gradient program stations G3 and G4A were again consistently typical of the gradient stations and showed no tendency toward unusual readings.

3.4 BIBLIOGRAPHY

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Table 3-1. Periphyton Core and Gradient Program Sample Periods

Program	Sampling Period[1]	Period Name
Core	December 2, 1985 - March 5, 1986	Winter
	March 5 - June 2, 1986	Spring
	June 2 - September 2, 1986	Summer
	September 2 - December 2, 1986	Fall
Gradient	December 2, 1985 - January 22, 1986	Early Winter
	January 22, 1986 - March 3, 1986	Late Winter
	March 3 - April 15, 1986	Early Spring
	April 15 - June 4, 1986	Late Spring
	June 4 - July 16, 1986	Early Summer
	July 16 - September 5, 1986	Late Summer
	September 5 - October 15, 1986	Early Fall
	October 15 - December 2, 1986	Late Fall

[1] Actual time for sample collection frequently took several days. As a result, an individual sample may have been collected 1-2 days before or after the listed date.

Table 3-2. Mean Periphyton Biomass (g/m^2) by Season, Station and Subprogram as Determined by Total Carbon Technique.

A) Core Program

Season	Station 1	7W	7M	7E	11W	11M	11E	8	Average
Winter	1.02	1.41	1.79	1.86	2.07	1.05	1.69	2.29	1.65
Spring	0.32	0.25	0.26	0.17	0.59	0.25	0.19	0.51	0.32
Summer	0.60	0.76	0.81	0.78	0.75	0.74	0.71	0.76	0.74
Fall	0.90	1.30	-	1.51	1.23	1.75	1.48	1.49	1.38
Average	0.76	0.93	0.95	1.08	1.16	0.95	1.02	1.26	1.02

B) Gradient Program

Season	Station G1	G2	G3	G4A	G4	G5	G6	G7	G8	Average
Early Winter	0.07	0.05	0.05	0.03	0.04	0.09	0.07	0.07	0.11	0.06
Late Winter	0.51	0.67	0.67	0.60	0.85	1.00	0.49	0.97	0.73	0.72
Early Spring	0.36	0.15	0.49	0.32	0.14	0.56	0.26	0.40	0.33	0.33
Late Spring	0.08	0.06	0.09	0.09	0.09	0.07	0.14	0.07	0.20	0.10
Early Summer	0.30	0.21	0.28	0.22	0.17	0.18	-	0.18	0.19	0.22
Late Summer	0.41	0.36	0.43	0.61	-	0.67	0.63	0.61	0.68	0.55
Early Fall	0.54	0.61	0.74	0.78	0.90	0.85	0.88	0.65	0.95	0.77
Late Fall	0.47	0.29	0.51	0.56	0.57	0.48	0.29	0.40	0.30	0.43
Average	0.34	0.30	0.41	0.40	0.39	0.49	0.39	0.42	0.44	0.40

Table 3-3. Significant Station Differences in the 1986 Periphyton Core Program as Determined by Duncan's Multiple Range Test(1)

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

(1) Stations are ranked from low to high. The bars identify groups with means which do not differ significantly at the 0.05 level.

Table 3-4. Significant Station Differences in the 1986 Periphyton Gradient Program as Determined by Duncan's Multiple Range Test

Start Date									
Dec 2	4A	4	3	2	6	7	1	5	8
January 22	6	1	4A	3	2	8	4	7	5
March 3	4	2	6	4A	8	1	7	3	5
April 15	2	5	7	1	3	4	4A	6	8
June 4[1]	4	5	7	8	2	4A	3	1	
July 16[1]	2	1	3	7	4A	6	5	8	
Sep 5	1	2	7	3	4A	5	6	4	8
Oct 15	6	2	8	7	1	5	3	4A	4

(1)All stations are not presented due to breakage of slides.

Table 3-5 Columbia River Average Monthly Flow Rates, Temperature, and Turbidity Measurements from April, 1983 through December, 1986.

Month	Flow Rate (CFS)	Temperature (°C)	Turbidity (NTU)
April/83	156,000	7.2	2.7
May	187,000	10.2	2.0
June	172,000	14.6	5.3
July	148,000	17.2	1.2
August	122,000	19.1	0.9
Sept.	96,000	18.0	0.9
Oct.	83,000	14.3	0.9
Nov.	54,000	11.4	0.8
Dec.	110,000	7.6	0.8
Jan./84	114,000	3.0	1.7
Feb.	153,000	3.0	1.1
Mar.	125,000	4.1	4.8
April	137,000	7.0	1.8
May	137,000	10.8	1.5
June	151,000	13.7	1.7
July	124,000	16.2	1.2
August	116,000	19.1	1.0
Sept.	89,000	18.8	0.9
Oct.	79,000	16.3	1.1
Nov.	95,000	10.2	1.1
Dec.	130,000	5.0	0.6
Jan./85	150,000	2.7	0.6
Feb.	145,000	1.9	0.7
Mar.	118,000	2.5	1.0
April	95,000	8.1	1.0
May	135,000	9.8	1.5
June	110,000	15.9	1.1
July	80,000	19.4	1.0
August	65,000	19.1	0.8
Sept.	65,000	17.9	0.8
Oct.	110,000	14.4	0.7
Nov.	112,000	6.0	0.8

Table 3-5. (Cont'd)

Dec.	130,000	3.2	0.8
Jan./86	85,000	1.0	0.6
Feb.	98,000	2.0	0.5
Mar.	124,000	4.5	0.8
April	150,000	6.0	2.9
May	140,000	9.5	1.2
June	135,000	14.0	4.0
July	120,000	17.0	1.2
August	100,000	20.0	1.4
Sept.	78,000	19.0	1.2
Oct.	82,000	16.0	1.0
Nov.	100,000	11.2	0.8
Dec.	110,000	7.0	0.7

Table 3-6. Mean Periphyton Biomass (g/m^2) by Season, Station, and Subprogram For Non-Picked Slides as Determined by Total Carbon Technique

A) Core Program

	Station								
Season	1	7W	7M	7E	11W	11M	11E	8	Average
Winter	1.00	1.51	2.18	1.73	1.99	1.25	1.80	2.41	1.73
Spring	0.30	0.35	0.23	0.21	0.47	0.29	0.22	0.87	0.37
Summer	2.62	2.22	2.07	2.23	0.95	3.02	2.33	2.25	2.21
Fall	2.39	3.28	-	3.29	2.71	3.19	2.91	2.69	2.92
Average	1.58	1.84	1.49	1.87	1.53	1.94	1.82	2.06	1.77

B) Gradient Program

	Station									
Season	G1	G2	G3	G4A	G4	G5	G6	G7	G8	Average
Early Winter	0.08	0.04	0.09	0.04	0.03	0.06	0.06	0.08	0.10	0.06
Late Winter	0.54	0.57	0.78	0.67	1.04	0.96	0.50	0.90	0.94	0.77
Early Spring	0.30	0.15	0.49	0.40	0.12	0.48	0.33	0.38	0.29	0.33
Late Spring	0.10	0.14	0.14	0.08	0.05	0.10	0.11	0.08	0.30	0.12
Early Summer	0.28	0.38	0.40	0.29	0.50	0.36	-	0.60	0.48	0.41
Late Summer	1.27	1.54	1.80	2.44	-	1.50	1.78	2.02	2.69	1.88
Early Fall	0.95	1.56	1.17	1.67	1.10	1.49	2.18	1.87	2.38	1.60
Late Fall	0.53	0.46	0.53	0.49	0.62	0.45	0.32	0.38	0.38	0.46
Average	0.51	0.61	0.68	0.76	0.49	0.68	0.75	0.79	0.95	0.70

Table 3-7. Mean Periphyton Biomass (g/m^2) by Season, and Subprogram For Picked (CARPK) and Non-Picked (CARBN) Slides as Determined by Total Carbon Technique.

A) Core Program

Season	CARPK	CARBN
Winter	1.65	1.73
Spring	0.32	0.37
Summer	0.74	2.21
Fall	1.38	2.92
Average	1.02	1.77

B) Gradient Program

Season	CARPK	CARBN
Early Winter	0.06	0.06
Late Winter	0.72	0.77
Early Spring	0.33	0.33
Late Spring	0.10	0.12
Early Summer	0.22	0.41
Late Summer	0.55	1.88
Early Fall	0.77	1.60
Late Fall	0.43	0.46
Average	0.40	0.70

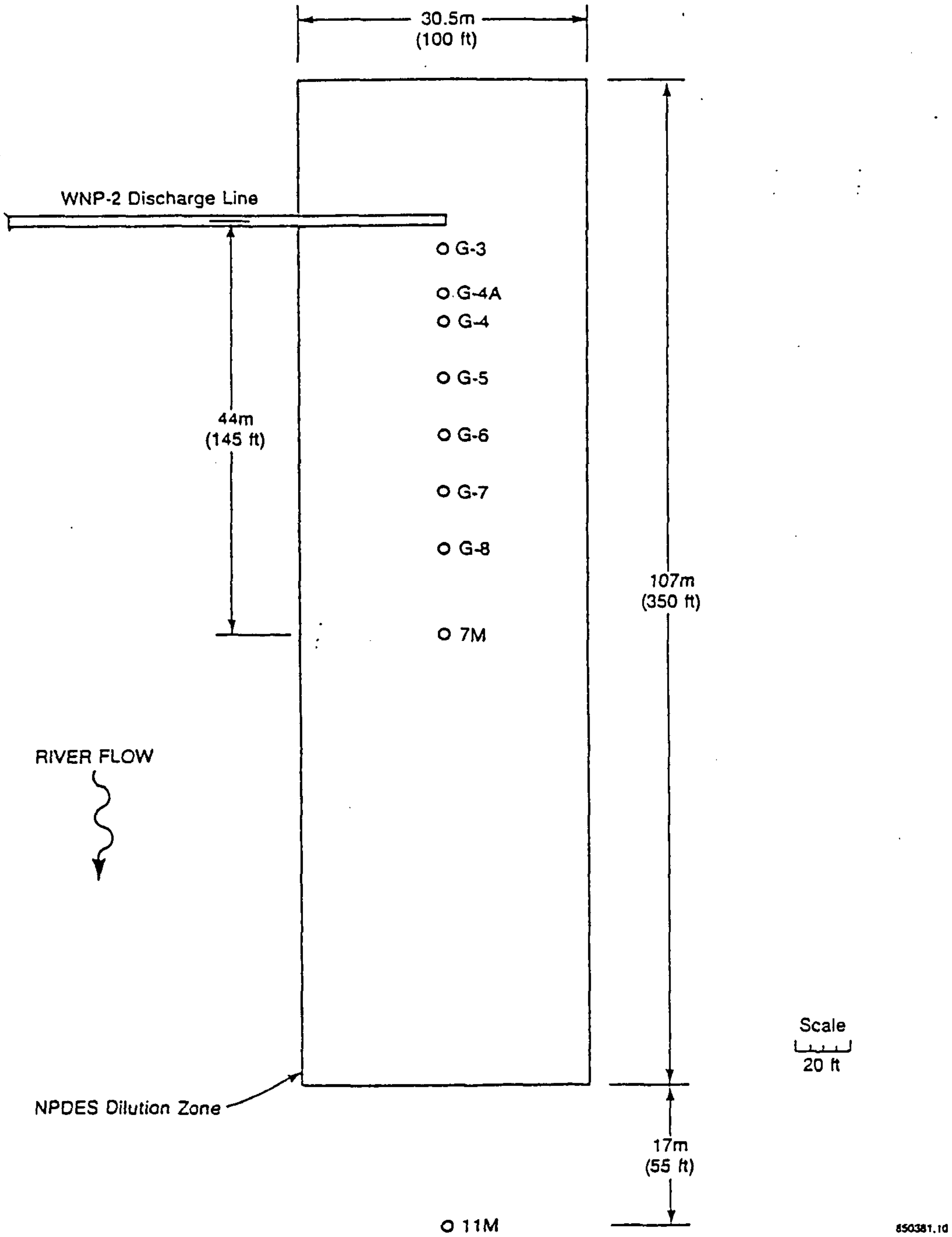

Figure 3-1. Mixing Zone Sampling Stations

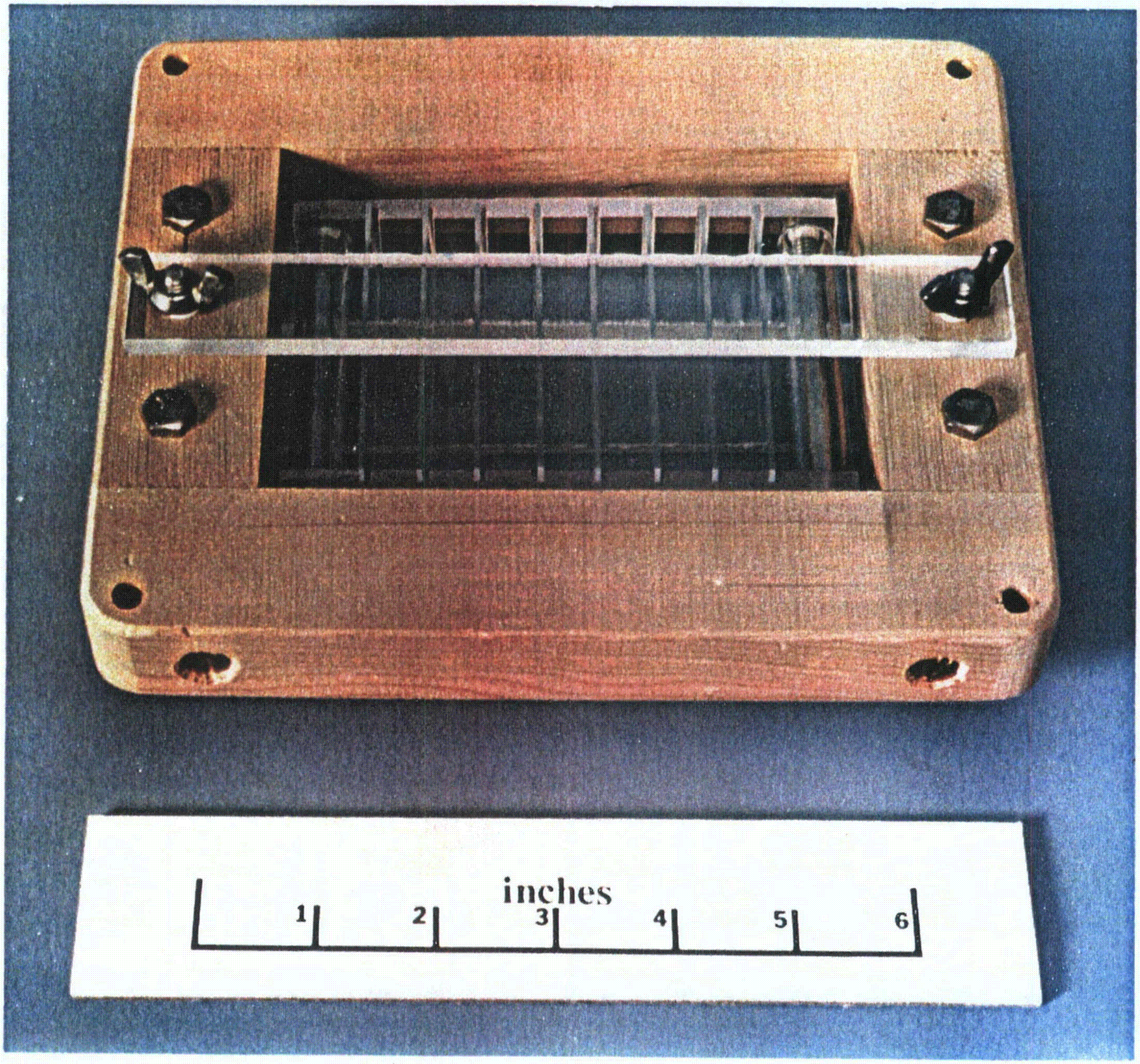

Figure 3-2. Glass slide diatometer used in Plant 2 periphyton program

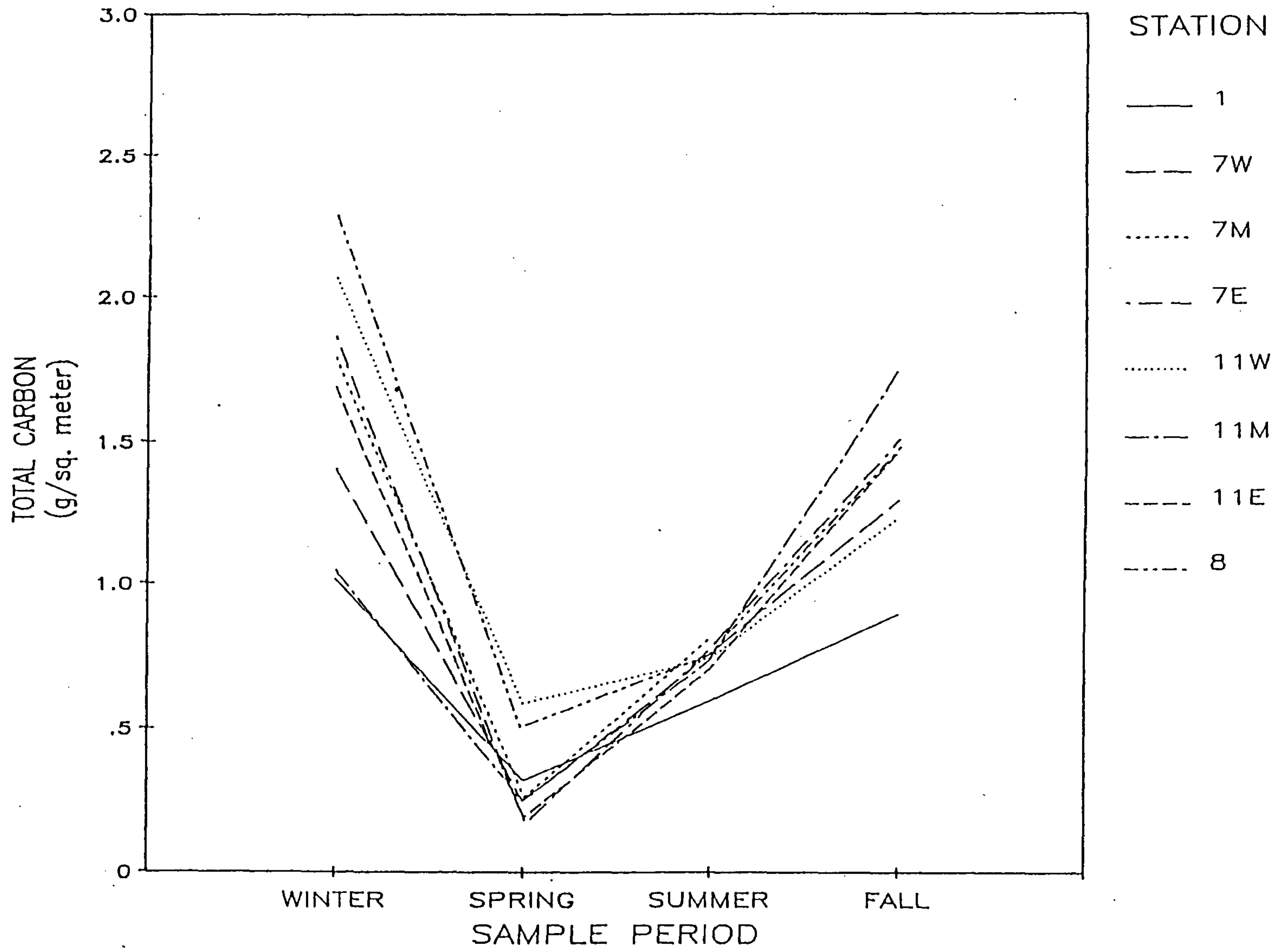

Figure 3-3. Core Program Total Carbon During 1986

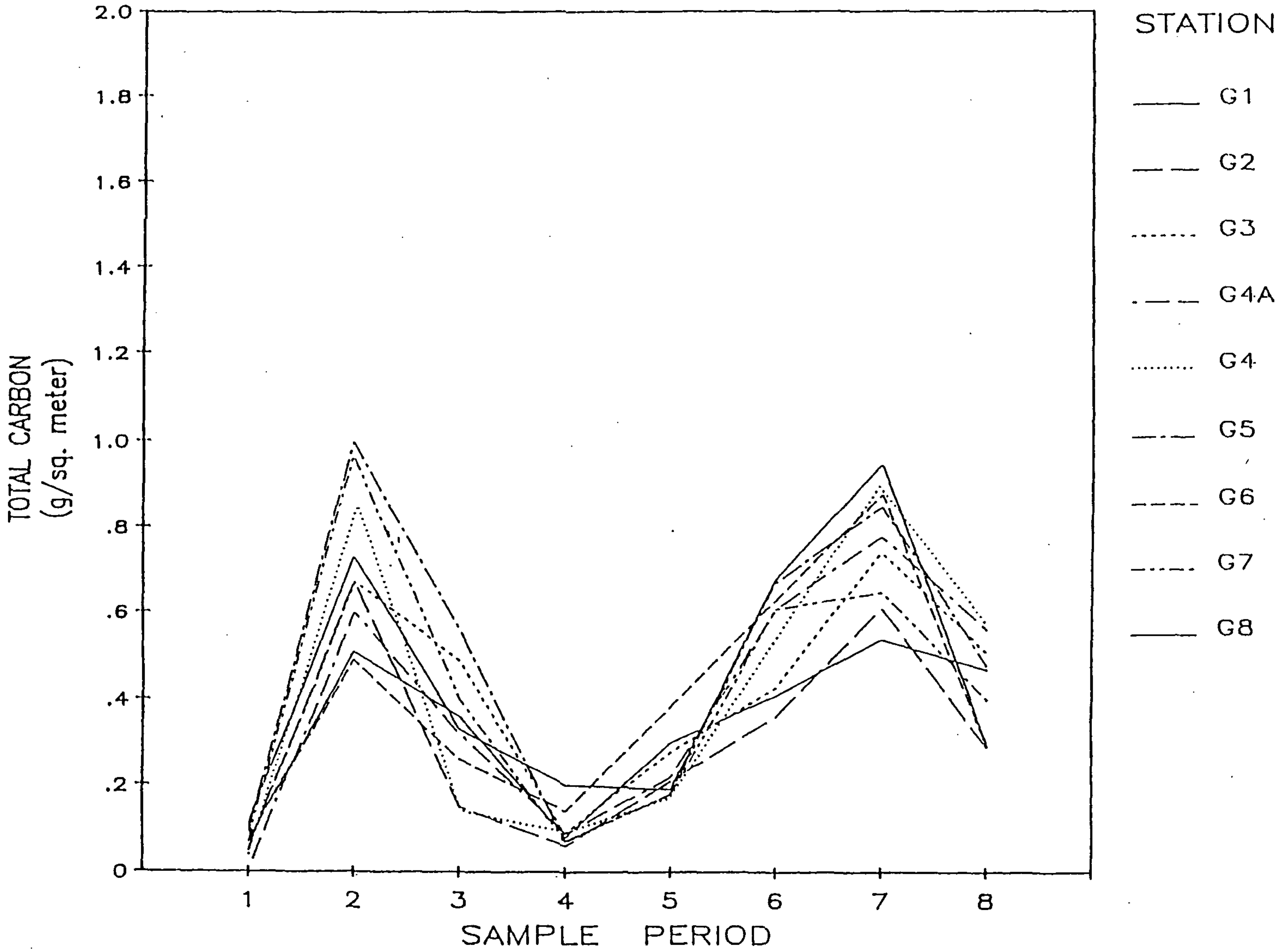

Figure 3-4. Gradient Program Total Carbon During 1986

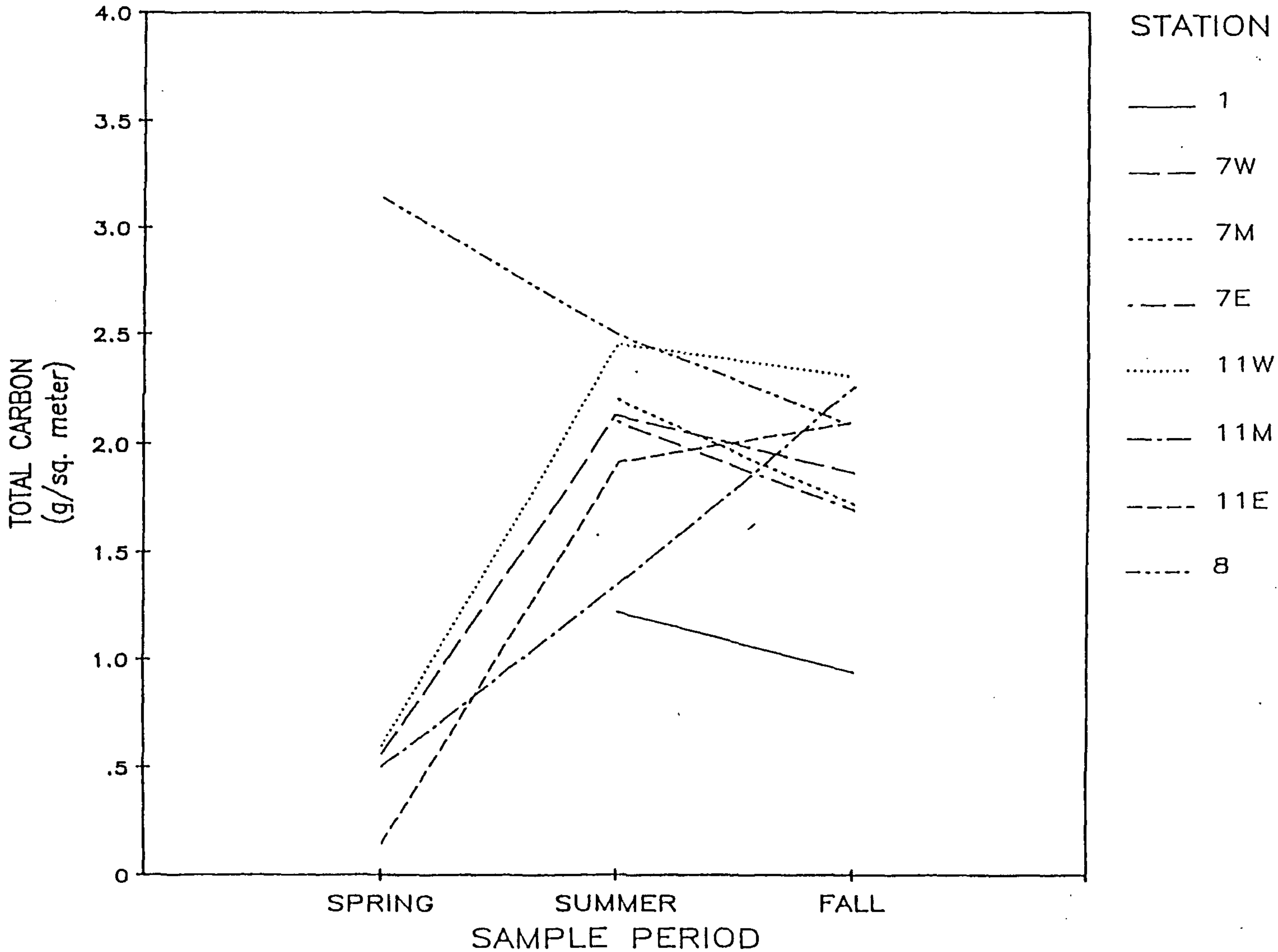

Figure 3-5. Core Program Total Organic Matter During 1983.

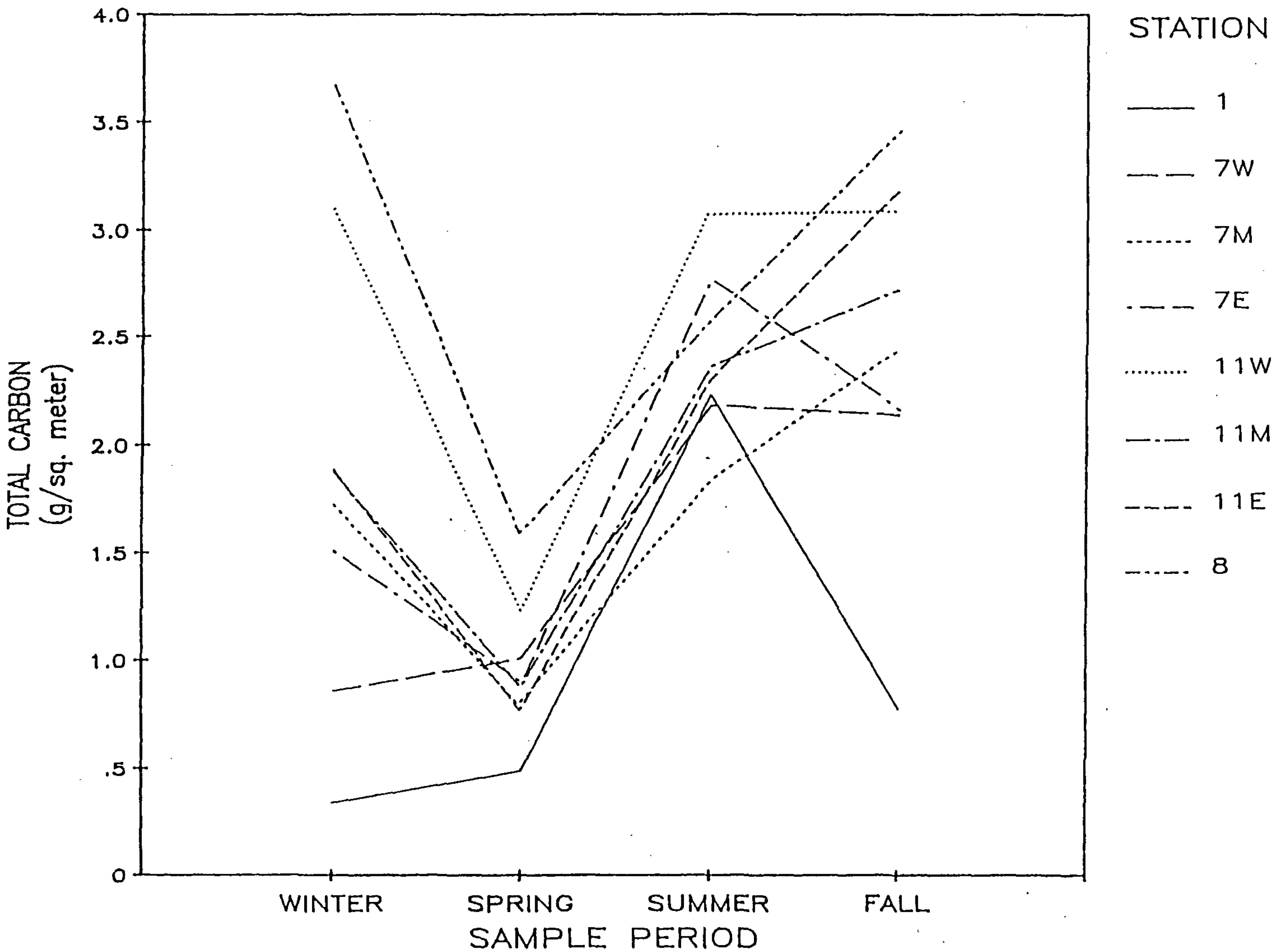

Figure 3-6. Core Program Total Organic Matter During 1984.

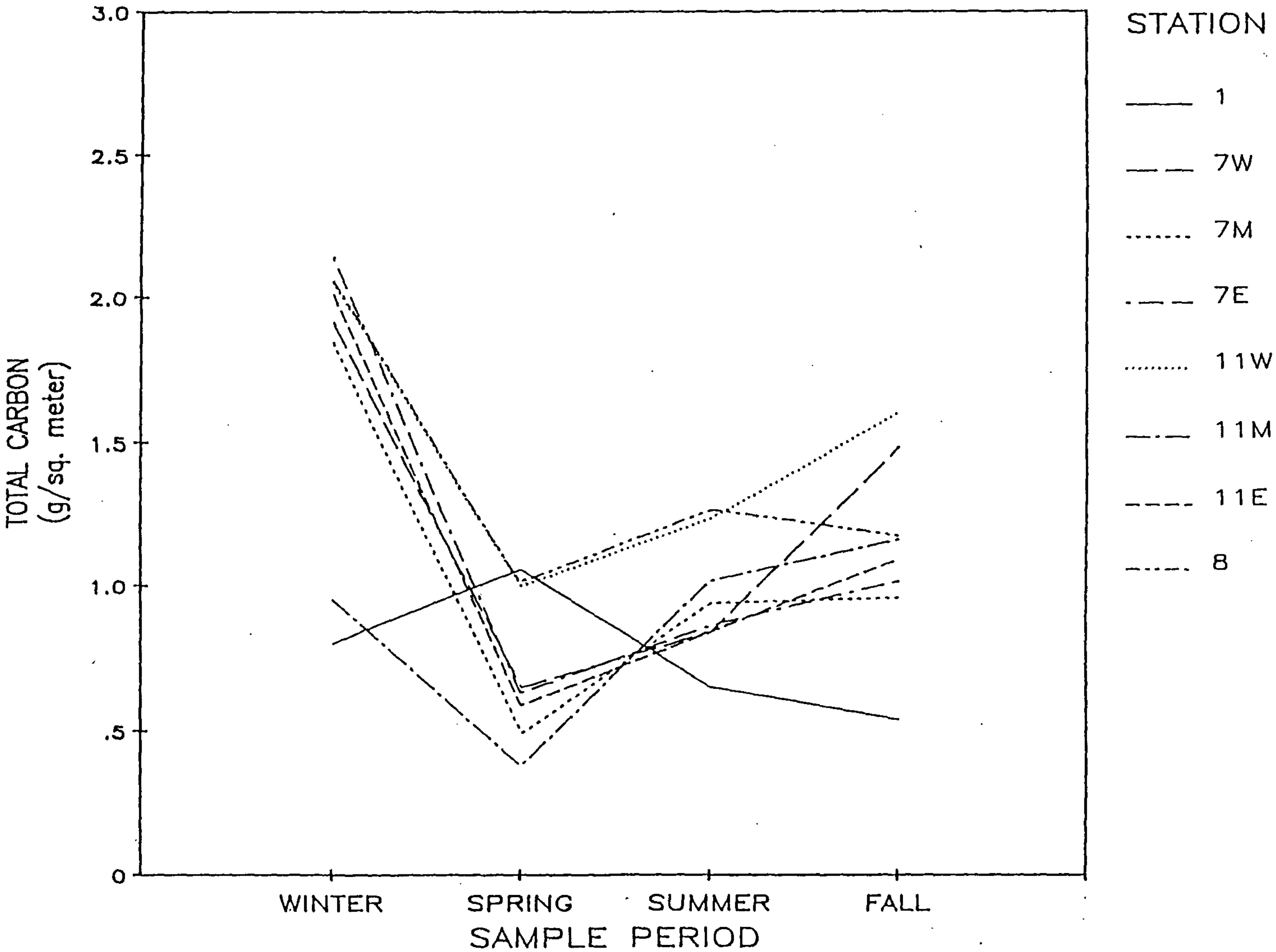

Figure 3-7. Core Program Total Carbon During 1985.

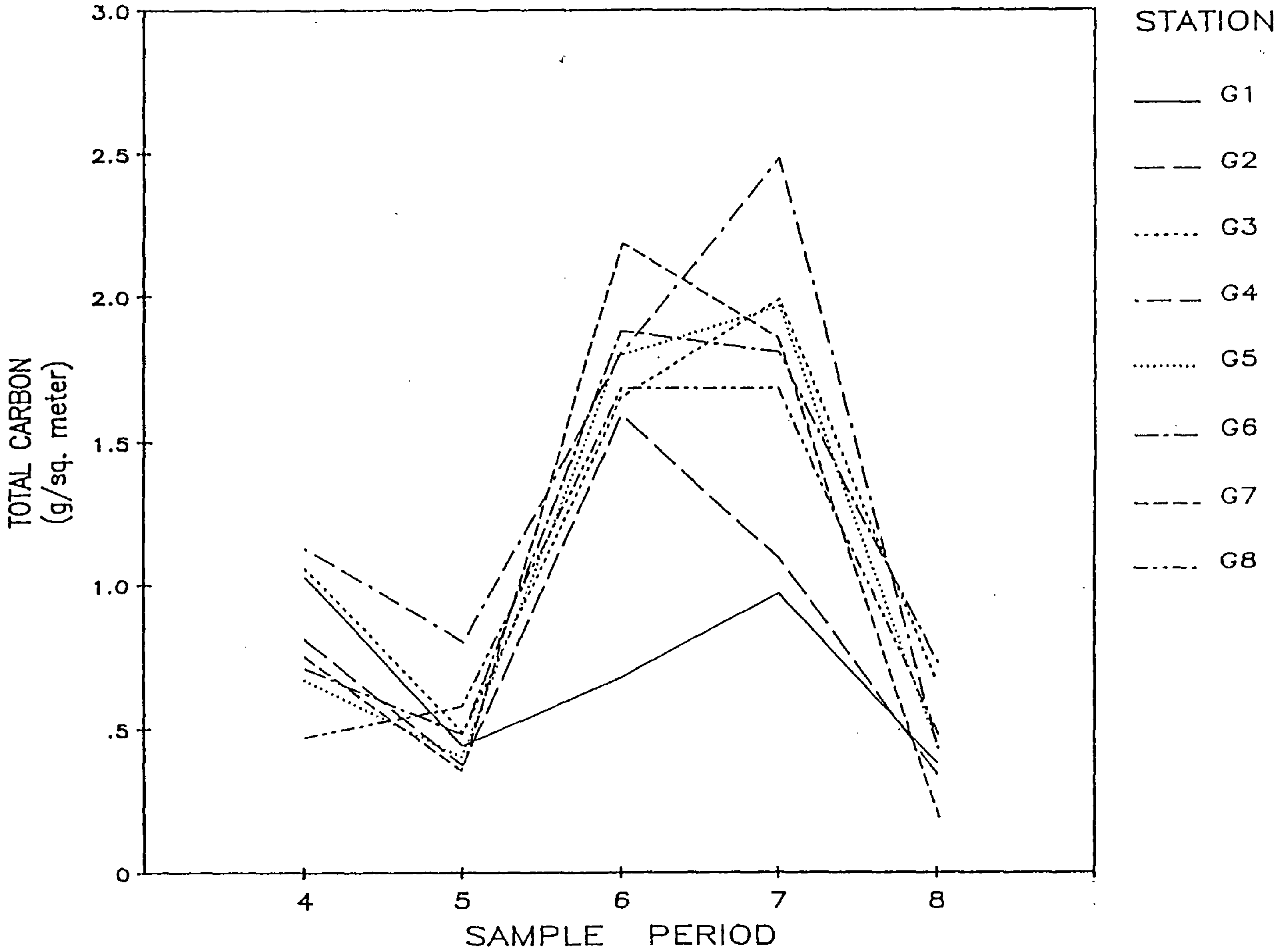

Figure 3-8. Gradient Program Total Organic Matter During 1983.

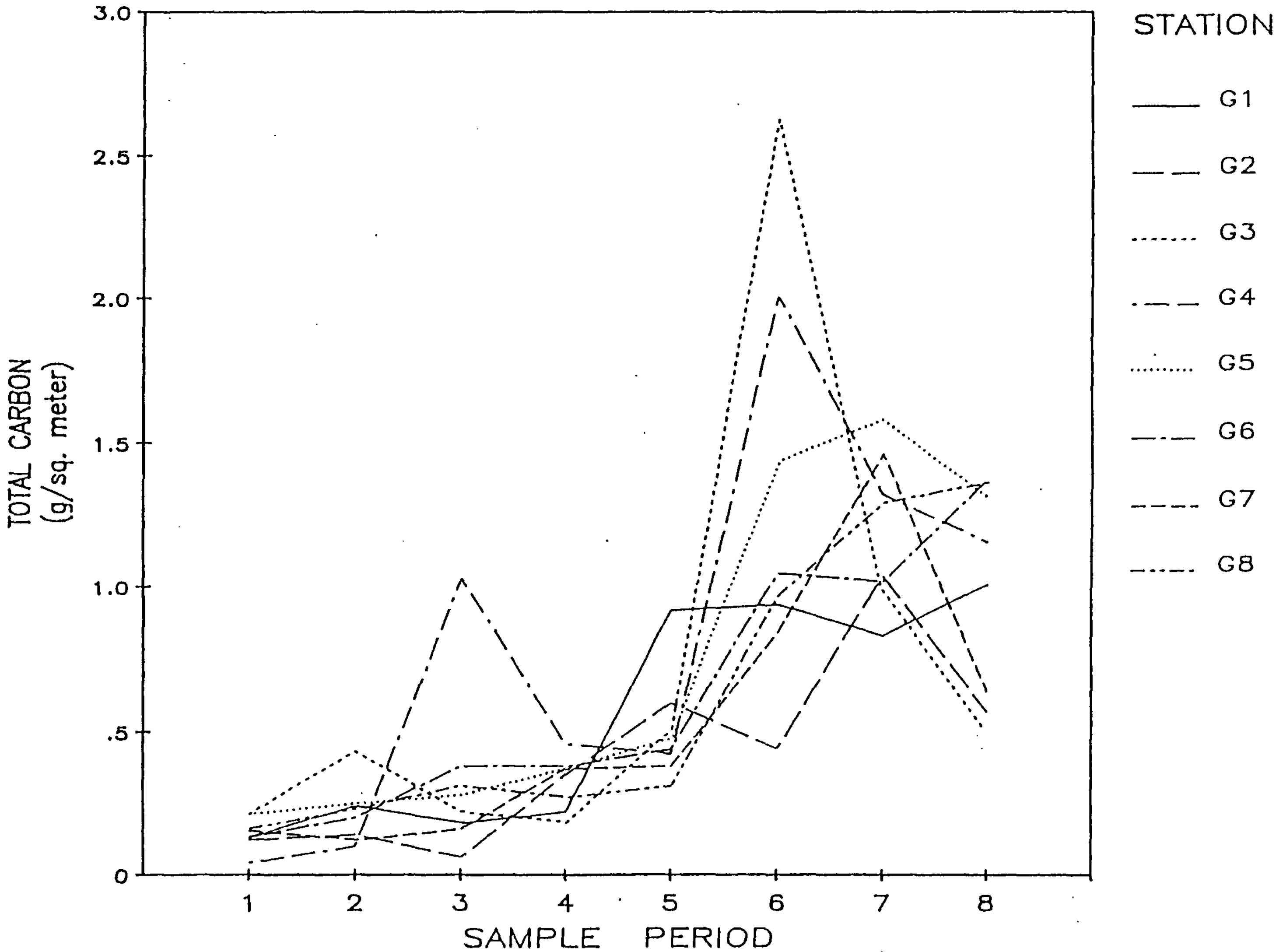

Figure 3-9. Gradient Program Total Organic Matter During 1984.

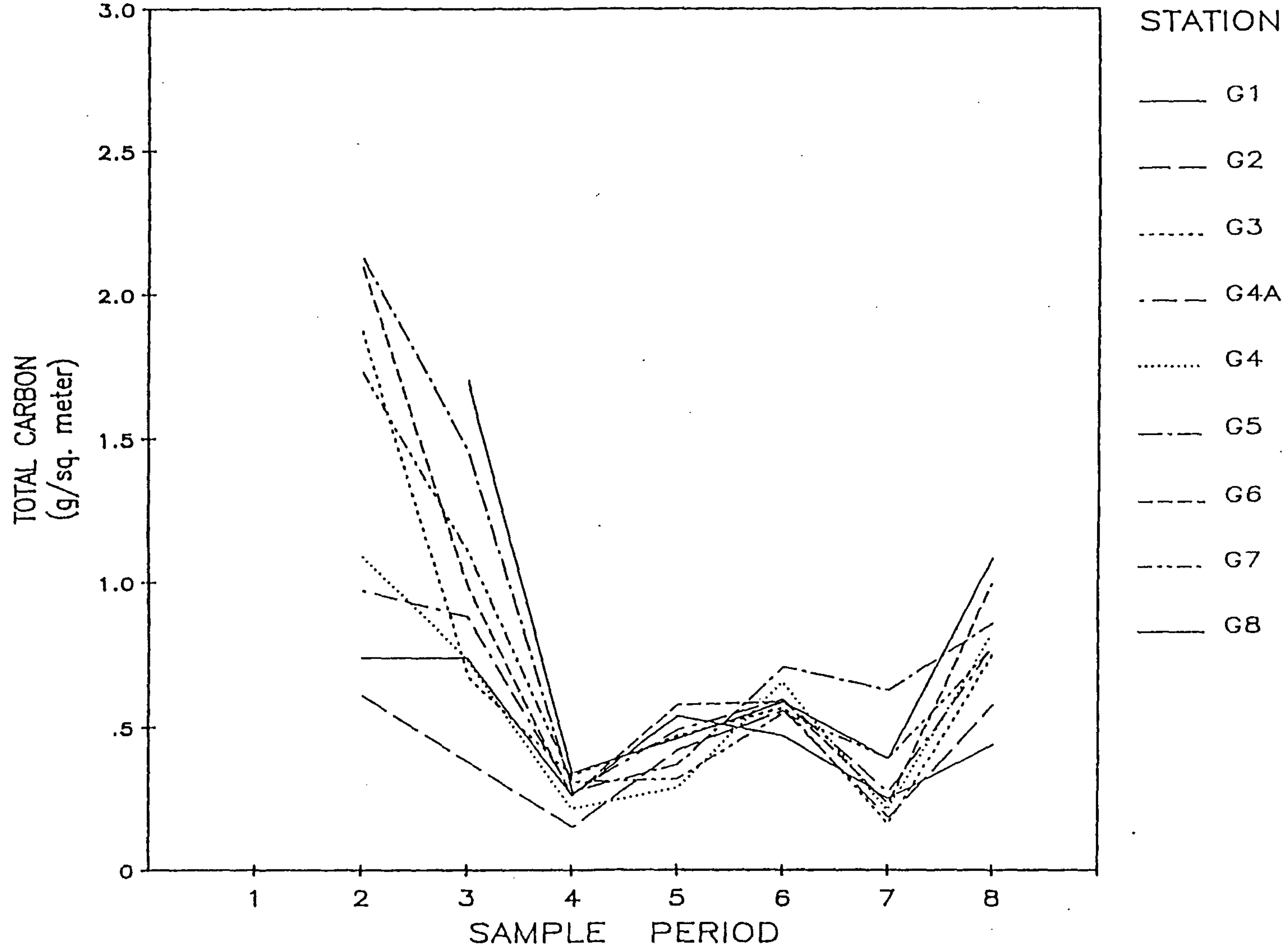

Figure 3-10. Gradient Program Total Carbon During 1985.

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.

4.2 MATERIALS AND METHODS

Columbia River surface water was sampled monthly from January 1986 through December 1986. 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 Pollutant Discharge Elimination System (NPDES) permit. Station 8 is approximately 568 meters (1800 feet) downstream from the discharge which is well outside of the mixing zone.

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.

4.2.1 Sample Collection

Columbia River samples were collected by boat approximately 91.4 meters (300 feet) from the Benton County shore. Temperature, dissolved oxygen, and pH 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 System's Environmental Programs Laboratory. 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, conductivity, sulfate, total phosphorus, orthophosphorus, ammonia-nitrogen, nitrate-nitrogen, total residual chlorine, 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.

4.2.2 Field Equipment and Measurements

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 monthly 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 monthly and results were compared to the field probe.

Conductivity measurements were made with an IBM Model EC105-1A meter. Prior to each sample date, measurements of conductivity standards were performed.

pH measurements were made with an IBM Model EC105-2A portable pH meter. Prior to each use the instrument was calibrated using pH standards of 4.0, 7.0, and 10.0. If necessary the probes were adjusted to within 0.1 unit of the standards.

4.2.3 Laboratory Measurements

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 the U.S. Environmental Protection Agency (USEPA 1983). Analyses were performed per USEPA (1983) approved methods (Table 4-2).

4.3 RESULTS

4.3.1 Temperature

Columbia River temperatures varied seasonally with a minimum temperature of 1.0°C at all stations on January 9th and a maximum of 20.0°C at all stations on August 12 (Table 4-3). No interstation differences were recorded at any station during 1986. River temperatures measured in 1986 are presented graphically in Figure 4-1.

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 9.4 mg/l in September and October to 14.0 mg/l in April. The mean DO concentrations ranged from 11.5 mg/l at Stations 7 and 11 to 11.6 mg/l at Stations 1 and 8. The largest interstation difference in DO occurred between Station 7 (12.8 mg/l) and Station 8 (13.5 mg/l) in May.

DO concentrations were inversely related to river temperature as would be expected from solubility laws. DO levels were never below the 8 mg/l water quality standard for Class A waters (WDOE), indicating good water quality with respect to dissolved oxygen throughout the year. Dissolved oxygen measurements are presented graphically in Figure 4-2.

4.3.3 pH and Alkalinity

Columbia River mean pH values ranged from 8.10 at Station 1 to 8.18 at Station 8 (Table 4-4). pH varied with a measured minimum of 7.65 at Station 7 in October to a maximum of 8.62 at Station 7 in May. The variation in pH between sample stations is small. The largest difference of 0.50 standard units occurred between Station 7 (pH 7.65) and Station 8 (pH 8.15) in October.

The pH water quality standard for Class A waters is from 6.5 to 8.5 (WDOE 1977). This was exceeded at all stations on May 13th (8.57 - 8.62). pH measurements, presented graphically in Figure 4-3, generally agree with historical data for the Columbia River (Silker 1964).

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 50.0 to 70.0 mg/l as calcium carbonate (Table 4-4). The greatest interstation differences occurred in May where 55 mg/l was measured at the control station while the downstream measurements were 62.5, 70.0 and 65.0 mg/l respectively. The alkalinity measurements are presented graphically in Figure 4-4.

4.3.4 Conductivity

Conductivity is a measure of the ionic content of a solution. Columbia River conductivity measurements ranged from 120.7 us/cm at 25°C at Station 8 in June to 168.3 us/cm at 25°C at Station 11 in September (Table 4-5). Station mean conductivities ranged from 143.6 us/cm at

25°C at Station 8 to 145.0 us/cm at 25°C at Station 7. The largest difference in conductivity (i.e. 4.0 us/cm) occurred between Station 1 (133.2 us/cm) and Station 11 (137.2 us/cm) on August 12, 1986. The conductivity results are very comparable to those reported in earlier studies of the Columbia River (Silker 1964). The measurements are presented graphically in Figure 4-5.

4.3.5 Total Residual Chlorine (TRC)

Total residual chlorine measurements for all stations from January 1986 through December 1986 were less than the measured detection limit of 2 ug/l (Table 4-6). The IBM chlorine analyzer has a detection limit of 2 ug/l, however, the TRC measurements were reported as 0 since the Columbia River consistently exhibits a demand for total residual chlorine of greater than 20 ug/l.

4.3.6 Total Copper, Total Zinc, Total Iron and Total Nickel

Columbia River mean total copper values ranged from 1.0 ug/l at Station 8 to 3.9 ug/l at Station 7 (Table 4-5). Individual copper measurements ranged from 0.3 ug/l to 35.8 ug/l. The largest interstation difference in copper (34.7 ug/l) occurred between Station 11 (1.1 ug/l) and Station 7 (35.8 ug/l) in November. Our copper results show good agreement with earlier studies. In 1962, Silker (1964) 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 (1972). They reported a mean copper concentration of 1.4 ug/l. Florence and Batley (1977) 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. The Hanford reach of the Columbia River would generally be in that category.

Mean total zinc measurements ranged from 7.8 ug/l at Station 8, to 9.2 ug/l at Station 1 (Table 4-7). Individual zinc measurements ranged from 5.0 ug/l at all stations to 15.0 ug/l at Stations 7. Generally, the highest zinc measurements were recorded during the winter months. The greatest inter-station difference (7.0 ug/l) occurred between Station 1 (12.0 ug/l) and all other stations (5.0 ug/l) in July. This is probably the result of a contaminated sample container. 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 (1964) and Cushing and Rancitelli (1972).

Columbia River mean iron concentrations ranged from 66.5 ug/l at Station 7 to 71.8 ug/l at Station 1 (Table 4-7). The greatest inter-station difference in concentration of 83 ug/l, occurred between Station 7 (22.0 ug/l) and Station 11 (105 ug/l) in July.

Mean total nickel concentrations were generally low, ranging from 0.1 ug/l to 1.0 ug/l (Table 4-8). Nickel concentrations showed little variation through time or between sample locations. Total copper, zinc, iron and nickel measurements are presented graphically in Figures 4-6, 4-7, 4-8 and 4-9.

4.3.7 Hardness

Hardness indicates the quantity of divalent metallic cations present in the system, principally calcium and magnesium ions. Hardness ranged from 52.0 to 75.5 mg/l as calcium carbonate (Table 4-8). Mean hardness values ranged from 64.0 mg/l at Station 11 to 64.8 mg/l at Station 1. The hardness measurements are presented graphically in Figure 4-10.

4.3.8 Oil and Grease

Analytical problems in the oil and grease procedures prevented the aquisition of reliable data between January and June of 1986. These problems were resolved with procedural modifications and the addition of external quality control samples. Data is reported herein only for the period July through December 1986. During this period, oil and grease values ranged from less than 0.5 mg/l to 1.0 mg/l. Mean values are not reported since many of the data points were below the detection limit of 0.5 mg/l. The oil and grease measurements are presented graphically in Figure 4-11 and summarized in Table 4-9.

4.3.9 Ammonia-Nitrogen and Nitrate-Nitrogen

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 0.01 to 0.04 mg-N/l (Table 4-9). Mean ammonia concentrations ranged, from .009 mg-N/l at Stations 7 and 8 to 0.011 mg-N/l at Stations 1 and 11. Nitrate concentrations ranged from a low of 0.03 mg-N/l at Station 7 in January to a high of 0.82 at Station 1 in December. Mean station concentrations were similar ranging from 0.41 mg-N/l at Stations 8 and 11 to 0.46 at Station 1. The nitrate measurements are summarized in Table 4-10. The ammonia and nitrate measurements are presented graphically in Figures 4-12 and 4-13.

4.3.10 Total Phosphorus and Orthophosphorus

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 0.01 to 0.05 mg-P/l with mean values from 0.02 to 0.03 mg-P/l (Table 4-10). Orthophosphate concentrations followed a similar pattern and ranged from 0.01 to 0.02 mg-P/l (Table 4-11). Mean concentrations were 0.01 for all sample locations. No seasonal or spatial trends were obvious for either total or orthophosphorus. Total phosphorus and orthophosphorus measurements are presented graphically in Figures 4-14 and 4-15.

4.3.11 Sulfate

Mean sulfate concentrations ranged from 17.4 mg/l at Station 1 to 18.3 mg/l at Station 11 (Table 4-11). Individual sulfate measurements ranged from 7.5 to 88.0 mg/l. Generally, sulfate concentrations between stations were similar, with the largest difference, 8.0 mg/l, occurring in May between Stations 1 and 7. Sulfuric acid is added at WNP-2 to control circulating water pH and a by-product is sulfate. Based on the river measurements, WNP-2 discharges are not appreciably altering river sulfate concentrations. Total sulfate measurements are presented graphically in Figure 4-16.

4.3.12 Total Dissolved Solids, Total Suspended Solids and Turbidity

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 72.0 mg/l at Station 1 to 79.3 mg/l at Station 8 (Table 4-12). There were no consistent differences in TDS concentrations between stations or through time.

Total suspended solids (TSS) or total nonfilterable residue is the material retained on a standard glass fiber filter after filtration of a well-mixed sample. TSS concentrations were generally low and varied from 0.5 to 8.5 mg/l (Table 4-12). Mean TSS concentrations ranged from 3.3 mg/l at Stations 7 to 11 to 3.5 mg/l at Station 8.

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 0.42 nephelometric turbidity units (NTU) to 4.30 NTU (Table 4-6). The largest difference of 0.70 NTU occurred in June between station 1 (4.30 NTU) and Station 11 (3.60 NTU). Total dissolved solids, total suspended solids and turbidity data are presented graphically in Figures 4-17, 4-18 and 4-19.

4.4 DISCUSSION

For nearly all sampling periods, significant interstation differences could not be detected among any of the measured parameters. However, a few exceptions are noteworthy. On November 11 a total copper concentration of 35.8 ug/l was measured at station 7 below the discharge. This sample was reanalyzed with the same results. This is the highest interstation difference for copper recorded during the Ecological Monitoring Program. On December 9, a total copper concentration of 7.9 ug/l was recorded at station 11 below the mixing zone. On the latter date, the remaining stations including the control (station 1) ranged from 1.2 to 1.5 ug/l. It has been observed by the sampling staff that the discharge plume is not uniform in velocity in that it appears to exit the discharge port in surges, which is visually apparent from a trail of bubbles around the sampling buoy. This explains the marked differences sometimes observed in the concentrations of replicate samples taken at nearly the same time and place.

Overall, it appears that with respect to all the measured parameters sampled under the operating conditions prevailing during 1986, WNP-2 cooling water discharge had little effect upon Columbia River water quality. Environmental programs staff were careful to assure that the plant was discharging during all sampling periods. All measurements taken, with the exception of the pH values recorded at all stations, including the upstream control on May 13, 1986, were within the water quality standards for class A waters both above and below the mixing zone.

4.5 BIBLIOGRAPHY

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TABLE 4-1. Summary of Water Quality Parameters, Stations, and Sampling Frequencies, 1986

Parameter	Stations 1	7	11	8
Quantity (flow)	-	-	-	-
Temperature	M	M	M	M
Dissolved Oxygen	M	M	M	M
pH	M	M	M	M
Turbidity	M	M	M	M
Total Alkalinity	M	M	M	M
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
Ortho Phosphorus	M	M	M	M
Total Phosphorus	M	M	M	M
Oil and Grease	M	M	M	M
Chlorine, Total Residual	M	M	M	M
Hardness	M	M	M	M

Symbols Key

M = Monthly
- 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. Summary of Temperature and Dissolved Oxygen Measurements for 1986

Sample Date	Temperature (Degrees C)				Dissolved Oxygen (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86	1.0	1.0	1.0	1.0	13.7	13.6	13.6	13.6
02/20/86	2.0	2.0	2.0	2.0	13.0	13.0	13.2	13.0
03/20/86	4.5	4.5	4.5	4.5	13.0	13.0	13.1	13.0
04/08/86	6.0	6.0	6.0	6.0	14.0	13.8	14.0	13.8
05/13/86	9.5	9.5	9.5	9.5	13.2	12.8	13.5	13.2
06/10/86	14.0	14.0	14.0	14.0	11.9	11.9	11.8	11.7
07/08/86	17.0	17.0	17.0	17.0	10.4	10.3	10.2	10.2
08/12/86	20.0	20.0	20.0	20.0	9.7	9.7	9.7	9.7
09/09/86	19.0	19.0	19.0	19.0	9.4	9.4	9.6	9.4
10/07/86	16.0	16.0	16.0	16.0	9.4	9.4	9.6	9.5
11/11/86	11.2	11.2	11.2	11.2	10.2	10.0	9.9	9.9
12/09/86	7.0	7.0	7.0	7.0	10.8	10.6	10.4	10.5
Mean	10.6	10.6	10.6	10.6	11.6	11.5	11.6	11.5
Std	6.32	6.32	6.32	6.32	1.68	1.65	1.73	1.68
Max	20.0	20.0	20.0	20.0	14.0	13.8	14.0	13.8
Min	1.0	1.0	1.0	1.0	9.4	9.4	9.6	9.4

Table 4-4. Summary of pH and Alkalinity Measurements for 1986

Sample Date	pH 1	pH 7	pH 8	pH 11	Total Alkalinity (mg/l) 1	Total Alkalinity (mg/l) 7	Total Alkalinity (mg/l) 8	Total Alkalinity (mg/l) 11
01/09/86	7.87	8.06	8.06	8.06	60.0	60.0	60.0	58.5
02/20/86	7.98	8.18	8.15	7.98	62.0	63.0	62.0	61.5
03/20/86	7.95	7.98	8.00	7.83	55.0	60.0	57.5	60.0
04/08/86	7.99	8.00	8.12	8.05	52.5	52.5	52.5	52.5
05/13/86	8.57	8.62	8.57	8.57	55.0	62.5	70.0	65.0
06/10/86	7.83	7.86	7.84	7.88	50.0	50.0	5.0	50.0
07/08/86	8.49	8.55	8.55	8.52	50.0	50.0	55.0	55.0
08/12/86	8.20	8.20	8.23	8.21	52.5	52.5	55.0	55.0
09/09/86	8.24	8.38	8.43	8.37	52.5	52.5	55.0	55.0
10/07/86	8.05	7.65	8.15	8.07	50.0	52.5	55.0	52.5
11/11/86	8.00	7.99	8.04	8.08	50.0	55.0	55.0	55.0
12/09/86	7.97	8.05	8.03	8.05	55.0	55.0	55.0	55.0
Mean	8.10	8.13	8.18	8.14	53.5	55.3	56.8	55.8
Std	0.22	0.27	0.22	0.22	3.92	4.68	4.97	4.41
Max	8.57	8.62	8.57	8.57	62.0	63.0	70.0	65.0
Min	7.83	7.65	7.84	7.83	50.0	50.0	50.0	50.0

Table 4-5. Summary of Conductivity and Total Copper Measurements for 1986

Sample Date	Conductivity at 25C (umho/cm)				Copper (ug/l)			
	1	7	8	11	1	7	8	11
01/09/86	150.6	151.0	150.5	150.9	1.4	1.4	1.1	1.0
02/20/86	147.9	148.8	148.7	150.6	0.9	1.0	0.8	1.3
03/20/86	153.8	154.2	153.9	154.4	0.6	0.3	0.8	0.6
04/08/86	147.5	147.1	146.9	147.3	1.7	0.4	1.4	0.7
05/13/86	149.8	148.7	149.4	149.9	0.9	1.0	1.0	1.4
06/10/86	123.6	120.8	120.7	120.9	1.5	1.4	1.1	1.1
07/08/86	128.3	128.5	128.6	131.8	4.5	1.1	0.6	1.7
08/12/86	133.2	133.7	134.0	137.2	1.2	1.0	0.3	1.8
09/09/86	165.8	166.2	165.3	168.3	0.9	1.5	0.9	1.8
10/07/86	136.6	136.7	136.5	137.3	1.5	1.0	0.9	1.1
11/11/86	143.0	142.9	142.2	143.4	4.0	35.8	1.5	1.1
12/09/86	147.5	147.7	146.9	148.3	1.3	1.2	1.5	7.9
Mean	144.0	143.9	143.6	145.0	1.7	3.9	1.0	1.8
Std	11.27	11.74	11.55	11.60	1.18	9.62	0.35	1.88
Max	165.8	166.2	165.3	168.3	4.5	35.8	1.5	7.9
Min	123.6	120.8	120.7	120.9	0.6	0.3	0.3	0.6

Table 4-6. Summary of Turbidity and Total Residual Chlorine Measurements for 1986

Sample Date	Turbidity (NTU)				Total Residual Chlorine (ug/l)			
	1	7	8	11	1	7	8	11
01/09/86	0.64	0.72	0.58	0.62	0	0	0	0
02/20/86	0.48	0.50	0.42	0.48	0	0	0	0
03/20/86	0.75	0.80	0.77	0.65	0	0	0	0
04/08/86	3.20	3.20	2.90	2.40	Maintenance Outage			
05/13/86	1.40	1.10	1.10	1.10	0	0	0	0
06/10/86	4.30	3.80	4.20	3.60	0	0	0	0
07/08/86	0.90	1.40	1.10	1.30	0	0	0	0
08/12/86	1.30	1.40	1.40	1.30	0	0	0	0
09/09/86	1.20	1.10	1.20	1.20	No Data			
10/07/86	1.00	1.00	1.00	1.00	0	0	0	0
11/11/86	0.82	0.90	0.80	0.82	0	0	0	0
12/09/86	0.65	0.70	0.72	0.73	0	0	0	0
Mean	1.39	1.39	1.35	1.27	0	0	0	0
Std	1.11	0.99	1.05	0.85	0	0	0	0
Max	4.30	3.80	4.20	3.60	0	0	0	0
Min	0.48	0.50	0.42	0.48	0	0	0	0

Table 4-7. *Summary of Total Zinc and Iron Measurements for 1986*

Sample Date	Zinc (ug/l) 1	7	8	11	Iron (ug/l) 1	7	8	11
01/09/86	14.0	12.0	12.0	11.0	27.0	36.0	19.0	27.0
02/20/86	10.0	10.0	9.0	8.0	12.0	14.0	16.0	18.0
03/20/86	8.0	7.0	8.0	9.0	40.0	45.0	38.0	37.0
04/08/86	13.0	15.0	11.0	12.0	101.0	98.0	100.0	111.0
05/13/86	9.0	8.0	6.0	6.0	60.0	57.0	67.0	42.0
06/10/86	5.0	6.0	6.0	6.0	298.0	263.0	259.0	261.0
07/08/86	12.0	5.0	5.0	5.0	31.0	22.0	47.0	105.0
08/12/86	10.0	9.0	7.0	9.0	70.0	70.0	71.0	69.0
09/09/86	7.0	5.0	7.0	5.0	58.0	48.0	41.0	37.0
10/07/86	8.0	8.0	8.0	7.0	58.0	48.0	50.0	48.0
11/11/86	5.0	6.0	7.0	6.0	71.0	61.0	68.0	66.0
12/09/86	9.0	8.0	8.0	13.0	36.0	36.0	34.0	35.0
Mean	9.2	8.3	7.8	8.1	71.8	66.5	67.5	71.3
Std	2.73	2.83	1.95	2.63	71.93	62.90	62.03	67.0
Max	14.0	15.0	12.0	13.0	298.0	263.0	259.0	261.0
Min	5.0	5.0	5.0	5.0	12.0	14.0	16.0	18.0

Table 4-8. Summary of Total Nickel and Hardness Measurements for 1986

Sample Date	Nickel (ug/l)				Total Hardness (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86	0.2	0.2	0.3	0.1	70.0	70.0	70.0	71.5
02/20/86	0.1	0.1	1.0	0.1	70.5	70.2	61.0	59.8
03/20/86	0.1	0.3	0.2	0.1	71.0	72.5	69.5	70.0
04/08/86	0.1	0.1	1.0	0.2	65.0	66.5	67.5	65.5
05/13/86	0.1	0.2	0.5	0.1	75.5	72.0	75.0	73.0
06/10/86	0.3	0.3	0.3	0.2	56.0	54.0	59.0	52.0
07/08/86	0.5	0.1	0.2	0.1	58.0	58.0	60.0	60.0
08/12/86	0.8	0.4	0.1	0.2	65.0	64.0	64.0	65.0
09/09/86	0.1	0.1	0.3	0.2	60.0	61.0	60.0	61.0
10/07/86	0.2	0.4	0.4	0.2	60.0	60.0	60.0	61.0
11/11/86	0.1	0.5	0.2	0.1	61.0	62.5	64.0	63.0
12/09/86	0.3	0.2	0.1	0.1	65.0	65.0	66.0	66.0
Mean	0.2	0.2	0.4	0.1	64.8	64.6	64.7	64.0
Std	0.21	0.13	0.30	0.06	5.75	5.60	4.83	5.61
Max	0.8	0.5	1.0	0.2	75.5	72.5	75.0	73.0
Min	0.1	0.1	0.1	0.1	56.0	54.0	59.0	52.0

Table 4-9. Summary of Oil and Grease, and Ammonia Measurements for 1986

Sample Date	Oil and Grease (mg/l)				Ammonia (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86					0.010	0.010	0.010	0.010
02/20/86					0.010	0.010	0.010	0.010
03/20/86					0.010	0.010	0.010	0.010
04/08/86					0.010	0.010	0.010	0.010
05/13/86					0.010	0.010	0.010	0.010
06/10/86					0.012	0.012	0.014	0.013
07/08/86	0.75	1.0	0.5	0.5	0.010	0.010	0.010	0.010
08/12/86	0.5	0.5	0.5	0.5	0.010	0.010	0.010	0.010
09/09/86	0.5	0.5	0.5	0.5	0.010	0.010	0.010	0.010
10/07/86	0.5	0.9	0.5	0.6	0.010	0.010	0.010	0.010
11/11/86	0.5	0.5	0.5	0.5	0.030	0.020	0.030	0.040
12/09/86	0.5	0.5	0.62	0.5	0.030	0.020	0.020	0.020
Mean					0.011	0.009	0.009	0.011
Std					0.009	0.006	0.008	0.010
Max					0.030	0.020	0.030	0.040
Min					0.010	0.010	0.010	0.010

Table 4-10. Summary of Nitrate and Total Phosphorus Measurements for 1986

Sample Date	Nitrate (mg/l)				Total Phosphorus (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86	0.06	0.03	0.05	0.04	0.01	0.01	0.01	0.01
02/20/86	0.23	0.23	0.24	0.24	0.02	0.02	0.03	0.03
03/20/86	0.33	0.20	0.27	0.21	0.02	0.02	0.02	0.03
04/08/86	0.48	0.56	0.46	0.53	0.02	0.02	0.01	0.02
05/13/86	0.31	0.31	0.27	0.27	0.01	0.01	0.01	0.01
06/10/86	0.73	0.69	0.62	0.62	0.04	0.02	0.02	0.02
07/08/86	0.54	0.43	0.39	0.38	0.01	0.01	0.01	0.03
08/12/86	0.30	0.20	0.22	0.23	0.01	0.02	0.02	0.02
09/09/86	0.22	0.19	0.21	0.19	0.02	0.02	0.02	0.02
10/07/86	0.80	0.73	0.76	0.77	0.01	0.02	0.04	0.04
11/11/86	0.66	0.64	0.66	0.63	0.02	0.02	0.02	0.02
12/09/86	0.82	0.80	0.78	0.77	0.03	0.05	0.03	0.04
Mean	0.46	0.42	0.41	0.41	0.02	0.02	0.02	0.03
Std	0.24	0.25	0.23	0.24	0.01	0.01	0.01	0.01
Max	0.82	0.80	0.78	0.77	0.04	0.05	0.04	0.04
Min	0.06	0.03	0.05	0.04	0.01	0.01	0.01	0.01

Table 4-11. Summary of Orthophosphate and Sulfate Measurements for 1986

Sample Date	Ortho Phosphate (mg/l)				Sulfate (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86	0.01	0.01	0.01	0.01	12.7	12.3	12.3	12.7
02/20/86	0.02	0.02	0.02	0.02	14.2	13.5	13.8	14.5
03/20/86	0.02	0.02	0.02	0.02	12.4	12.8	12.8	12.8
04/08/86	0.02	0.02	0.02	0.02	15.0	17.0	14.0	15.0
05/13/86	0.01	0.01	0.01	0.01	80.0	88.0	86.0	86.0
06/10/86	0.01	0.01	0.01	0.01	12.0	12.0	11.0	12.0
07/08/86	0.01	0.01	0.01	0.01	10.5	10.0	10.0	11.3
08/12/86	0.01	0.01	0.01	0.01	9.5	7.5	11.0	10.0
09/09/86	0.01	0.01	0.01	0.01	10.0	10.0	10.1	10.2
10/07/86	0.01	0.01	0.01	0.01	11.0	11.5	11.5	11.5
11/11/86	0.02	0.02	0.02	0.02	10.5	10.5	10.5	10.5
12/09/86	0.02	0.02	0.02	0.02	11.5	12.0	12.0	12.5
Mean	0.01	0.01	0.01	0.01	17.4	18.1	17.9	18.3
Std	0.01	0.01	0.01	0.01	18.9	21.2	20.6	20.5
Max	0.02	0.02	0.02	0.02	80.0	88.0	86.0	86.0
Min	0.01	0.01	0.01	0.01	9.5	7.5	10.0	10.0

Table 4-12. Summary of Total Dissolved and Total Suspended Solids Measurements for 1986

Sample Date	Total Dissolved Solids (mg/l)				Total Suspended Solids (mg/l)			
	1	7	8	11	1	7	8	11
01/09/86	52.0	63.0	66.0	62.0	0.5	0.5	0.5	0.5
02/20/86	66.0	60.0	63.0	63.0	0.9	0.6	0.5	0.5
03/20/86	90.0	91.0	88.0	79.0	2.2	1.8	2.2	2.8
04/08/86	86.0	90.0	93.0	91.0	1.4	1.8	2.2	3.8
05/13/86	70.0	69.0	71.0	70.0	6.9	7.1	8.5	7.9
06/10/86	65.0	57.0	62.0	57.0	7.2	7.2	7.8	7.4
07/08/86	63.0	62.0	68.0	64.0	6.4	5.6	6.1	5.9
08/12/86	82.0	82.0	152.0	88.0	5.1	5.9	5.9	2.2
09/09/86	54.0	51.0	52.0	59.0	3.2	2.1	2.6	2.1
10/07/86	70.0	70.0	67.0	70.0	3.0	3.3	3.2	3.2
11/11/86	82.0	85.0	86.0	84.0	2.2	2.0	1.3	2.1
12/09/86	84.0	85.0	84.0	85.0	1.4	1.4	1.3	1.3
Mean	72.0	72.1	79.3	72.7	3.4	3.3	3.5	3.3
Std	12.1	13.3	24.9	11.6	2.3	2.4	2.8	2.4
Max	90.0	91.0	152.0	91.0	7.2	7.2	8.5	7.9
Min	52.0	51.0	52.0	57.0	0.5	0.5	0.5	0.5

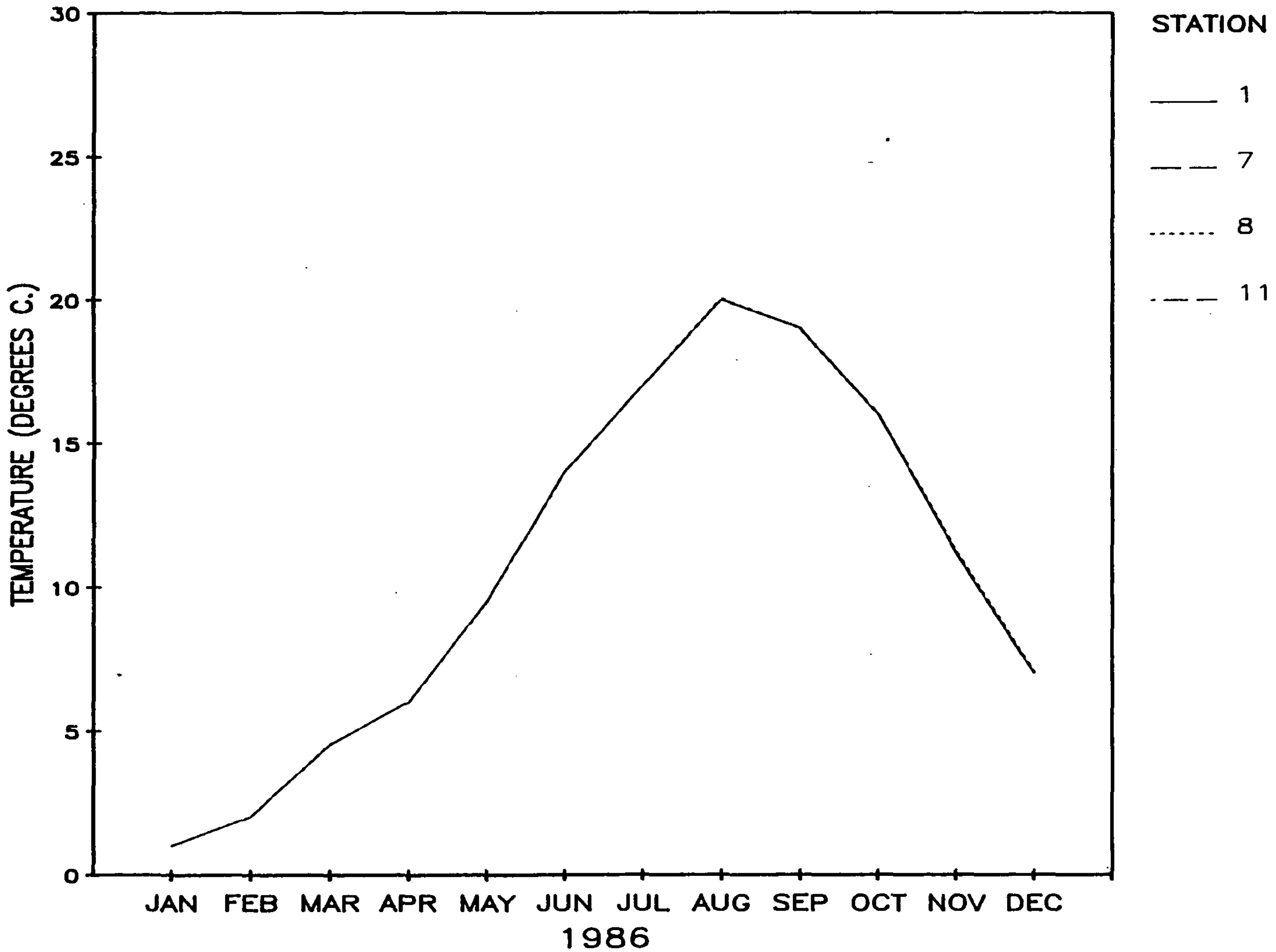

Figure 4-1. Columbia River Temperature Measurements at Four Stations During 1986

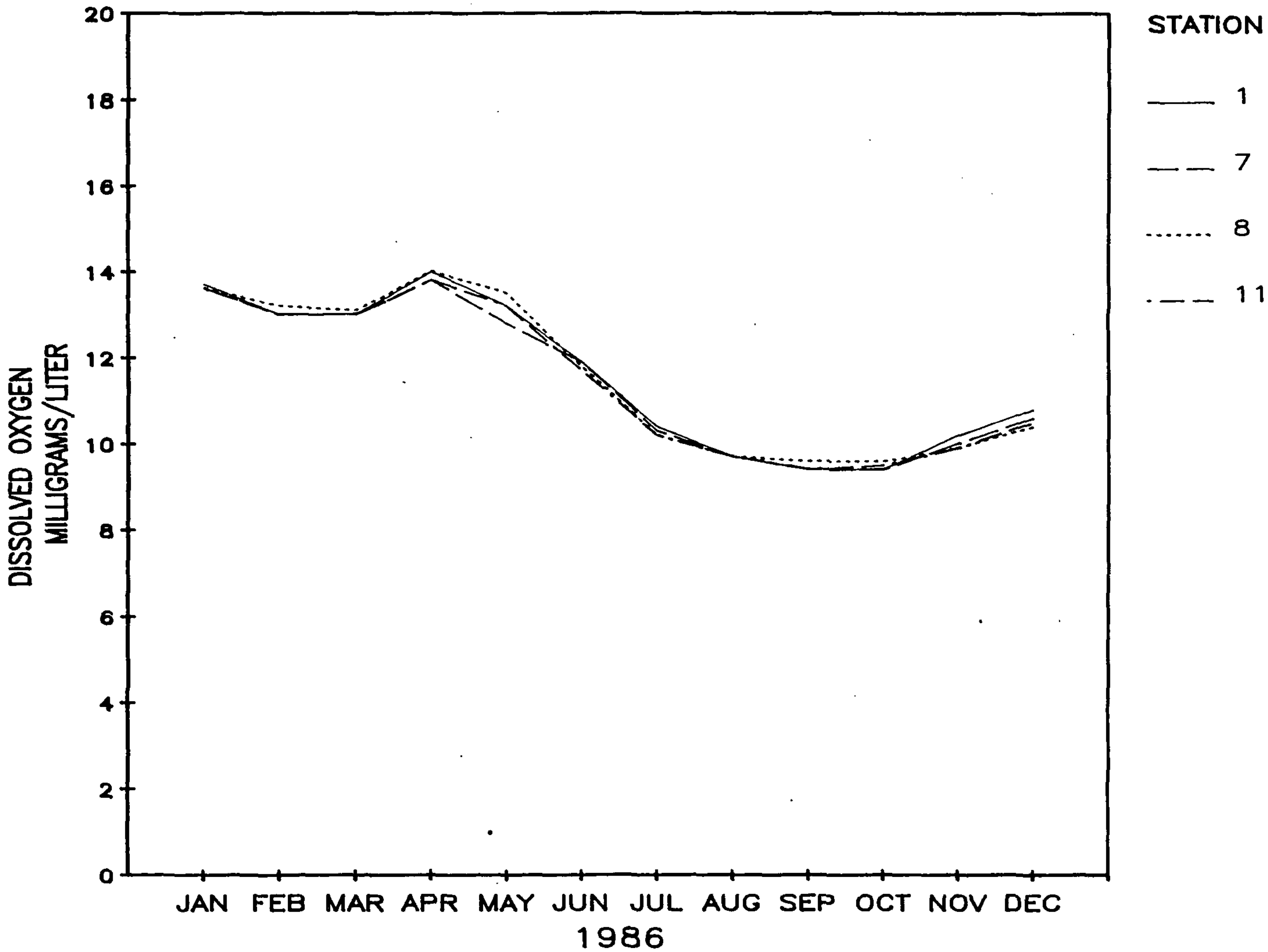

Figure 4-2. Columbia River Dissolved Oxygen Measurements at Four Stations During 1986

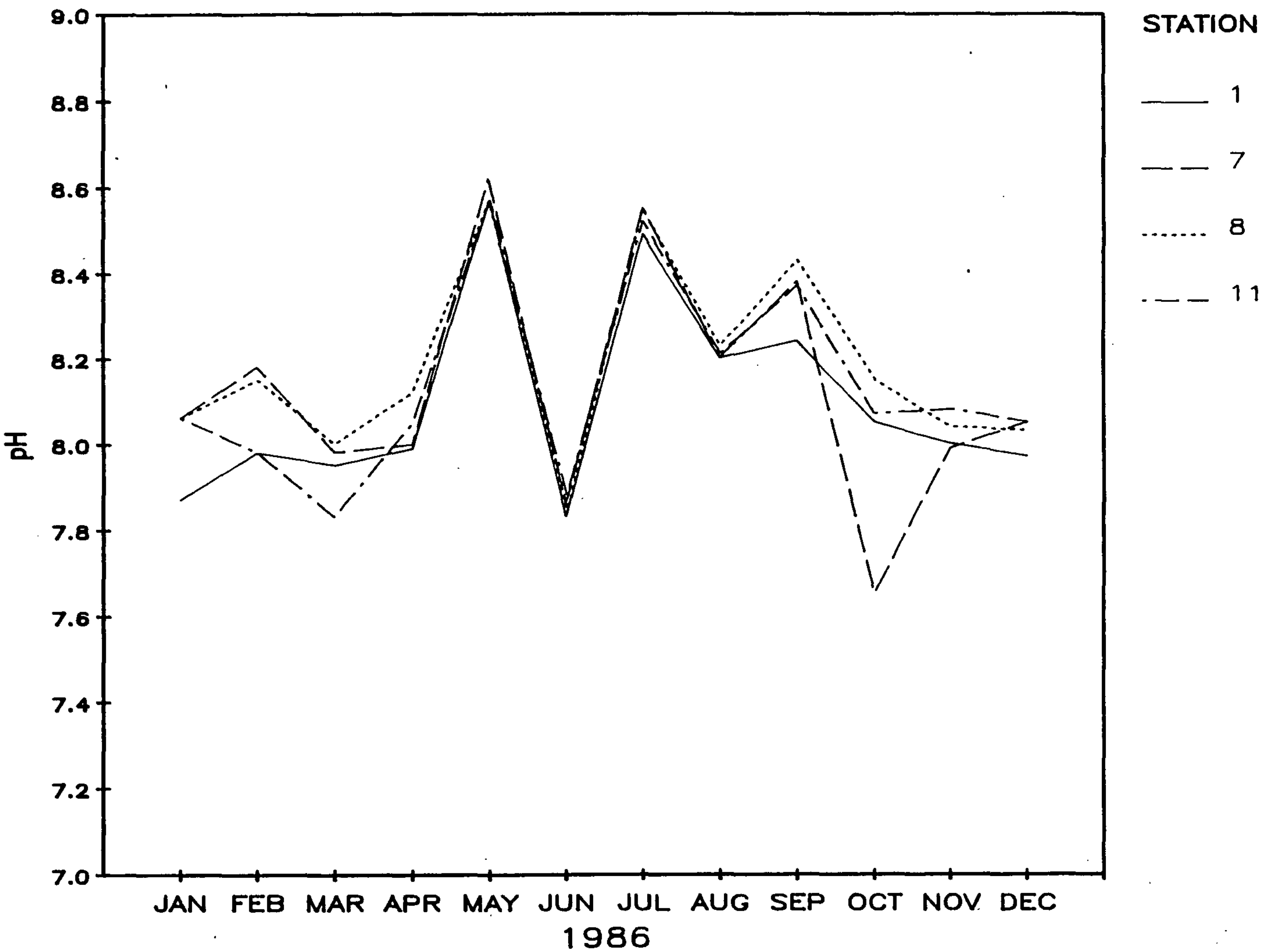

Figure 4-3. Columbia River pH Measurements at Four Stations During 1986

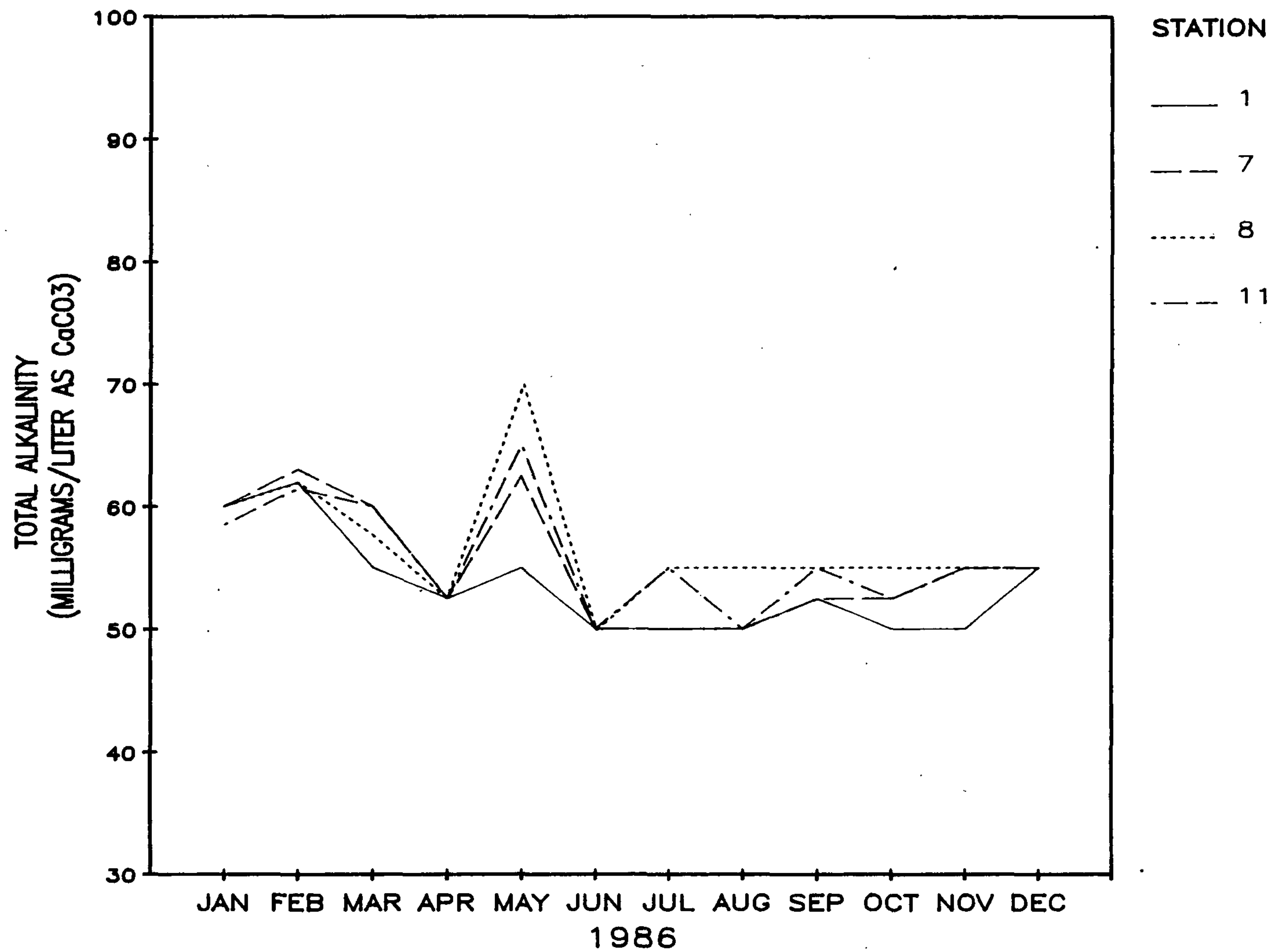

Figure 4-4. Columbia River Total Alkalinity Measurements at Four Stations During 1986

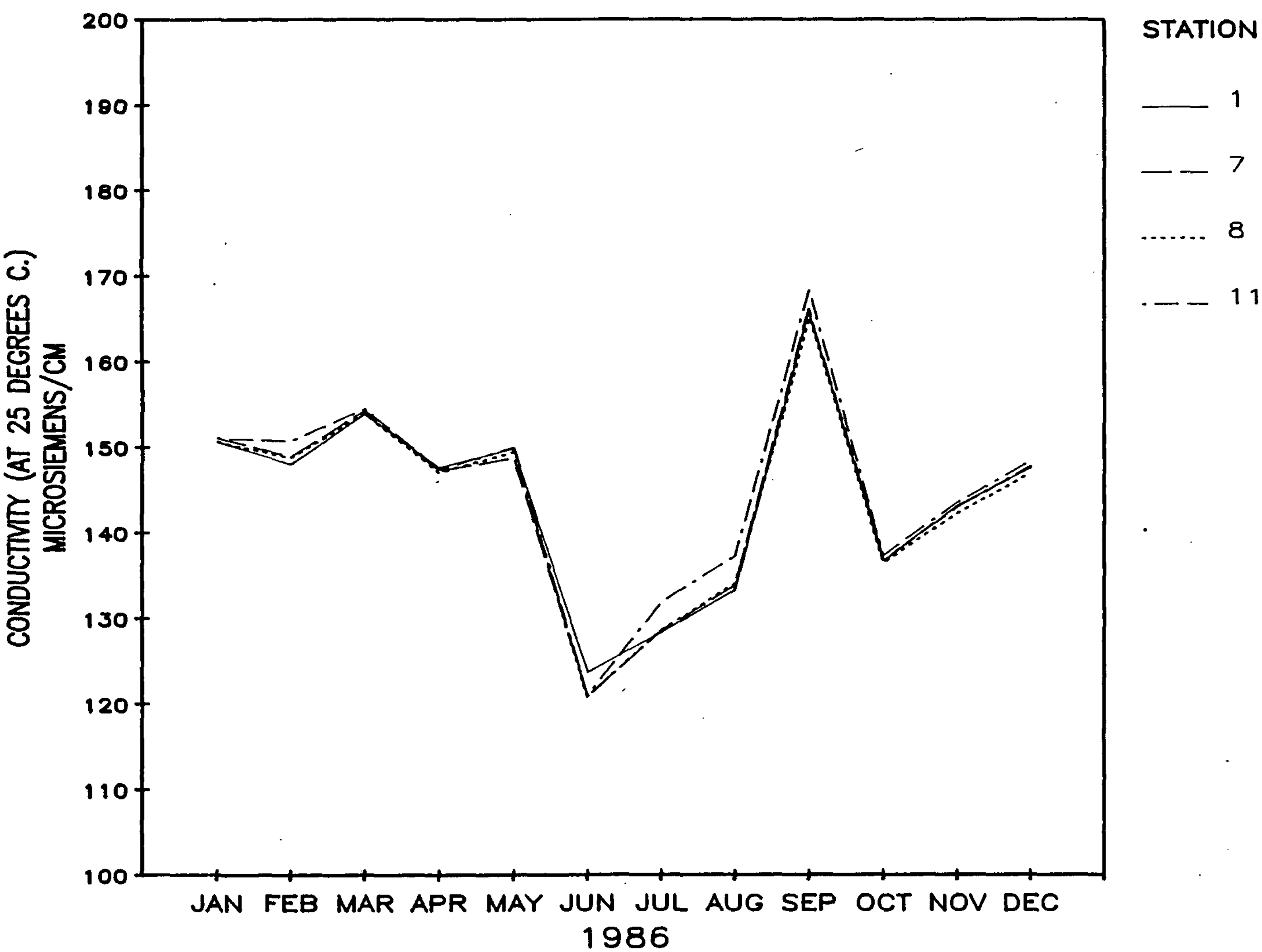

Figure 4-5. Columbia River Conductivity Measurements at Four Stations During 1986

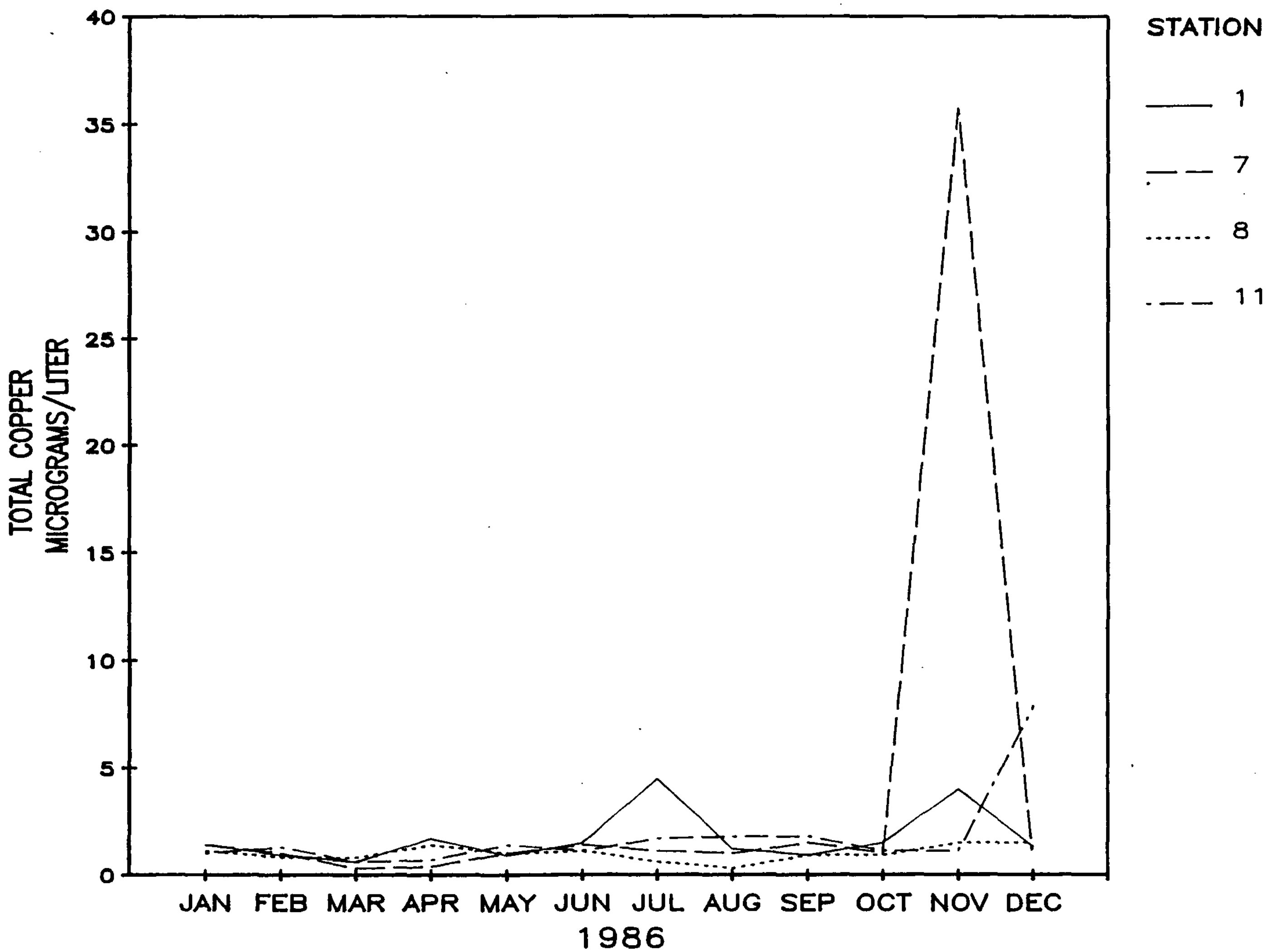

Figure 4-6. Columbia River Total Copper Measurements at Four Stations During 1986

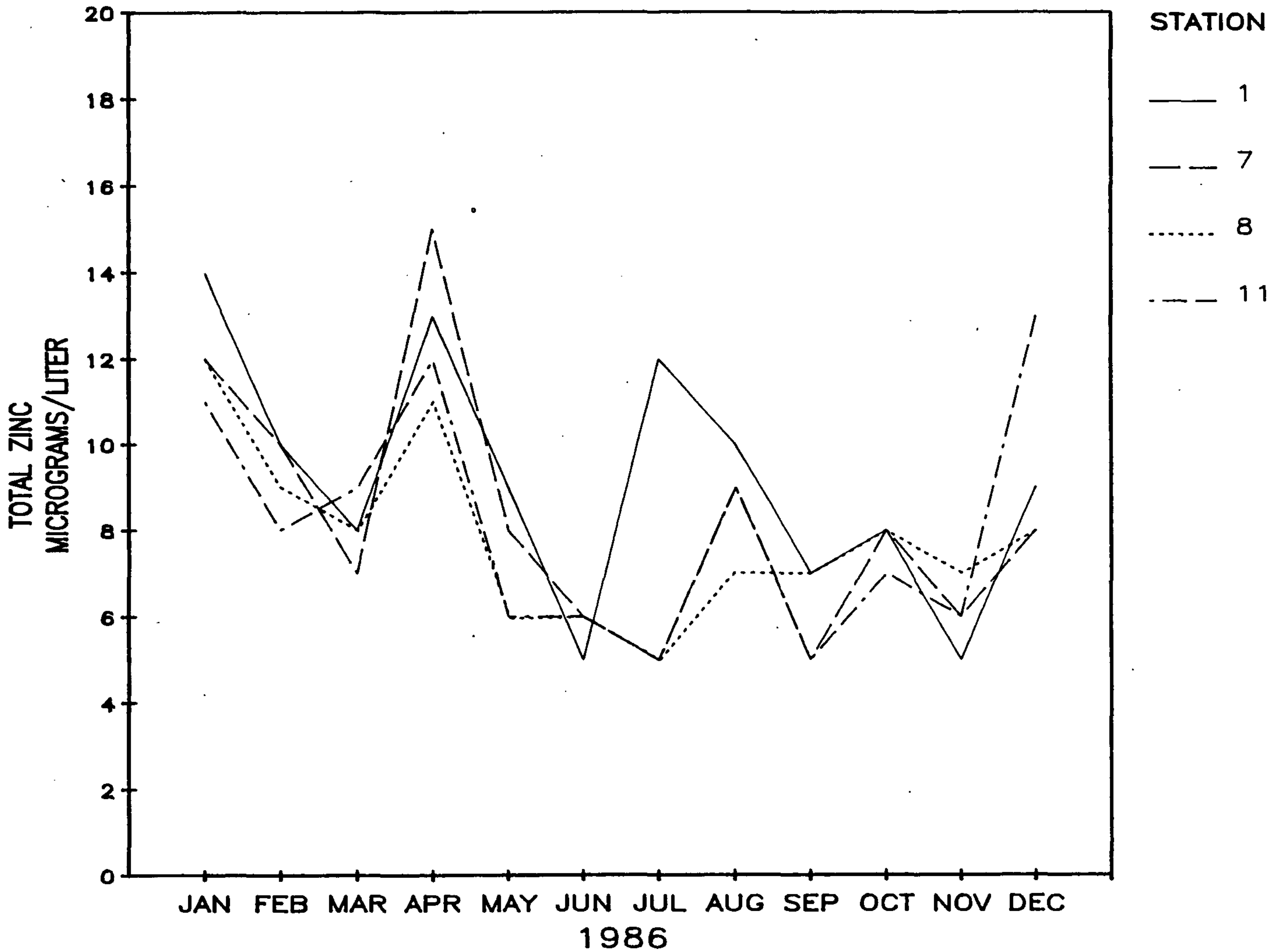

Figure 4-7. Columbia River Total Zinc Measurements at Four Stations During 1986

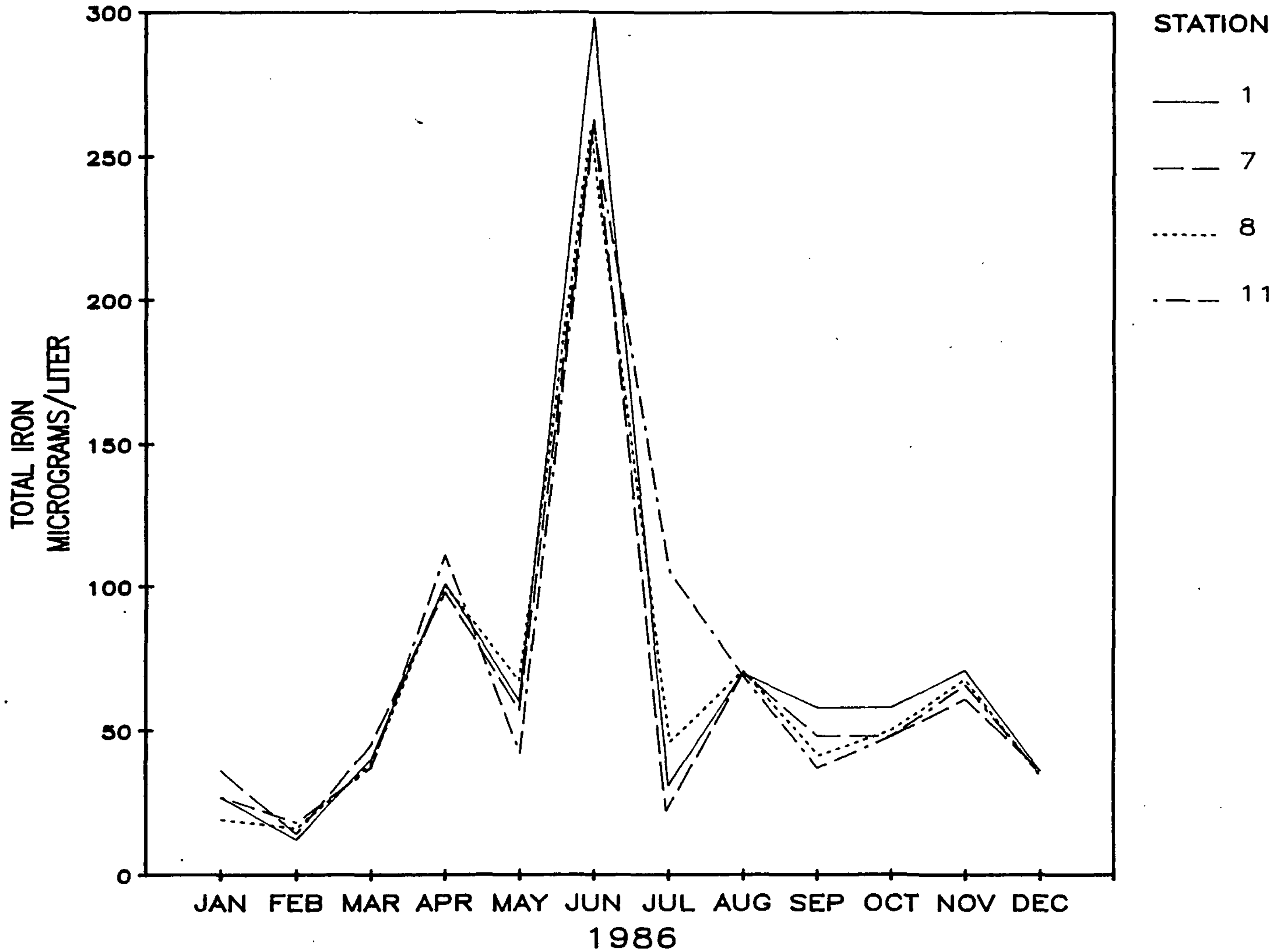

Figure 4-8. Columbia River Total Iron Measurements at Four Stations During 1986

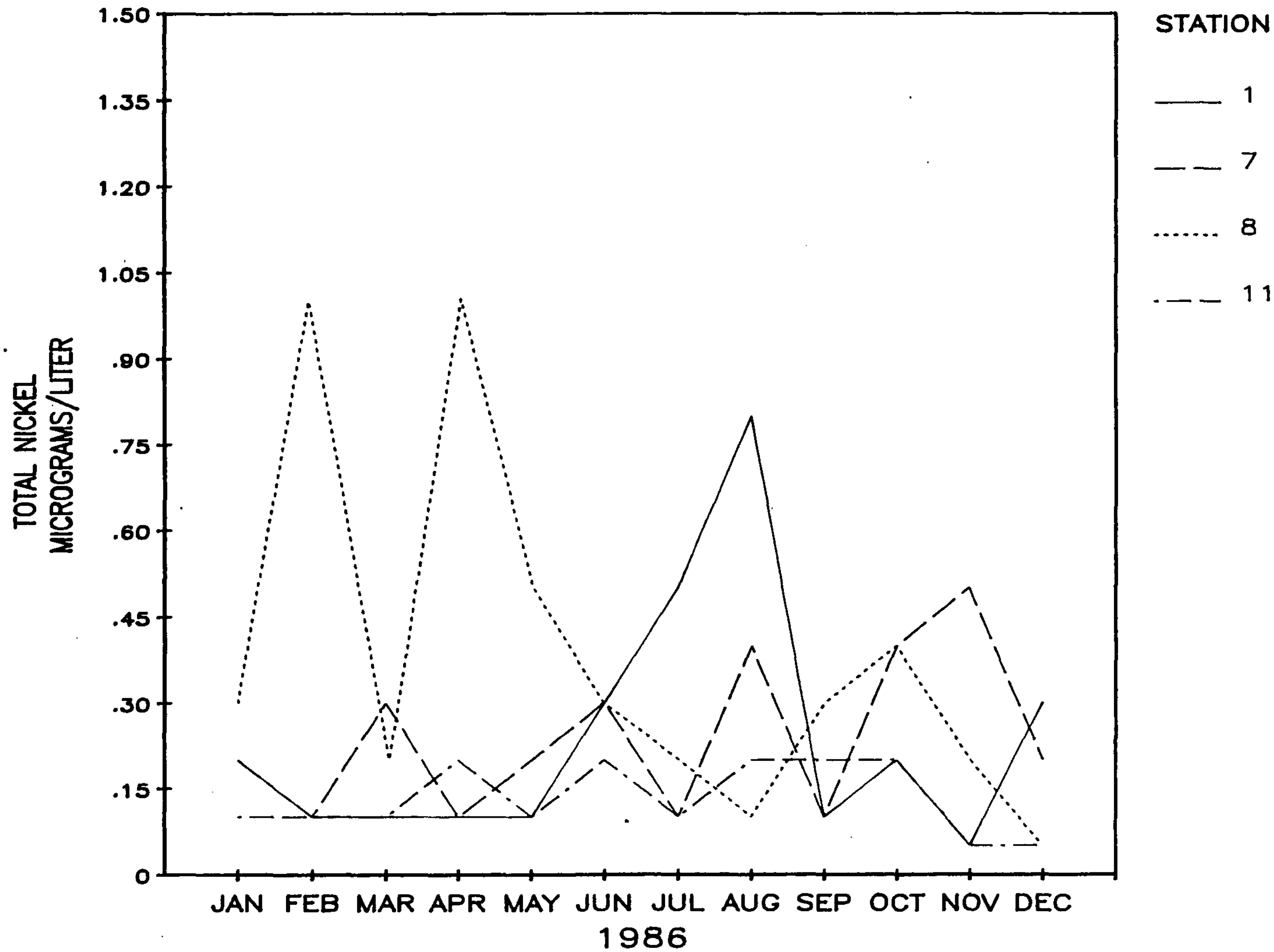

Figure 4-9. Columbia River Total Nickel Measurements at Four Stations During 1986

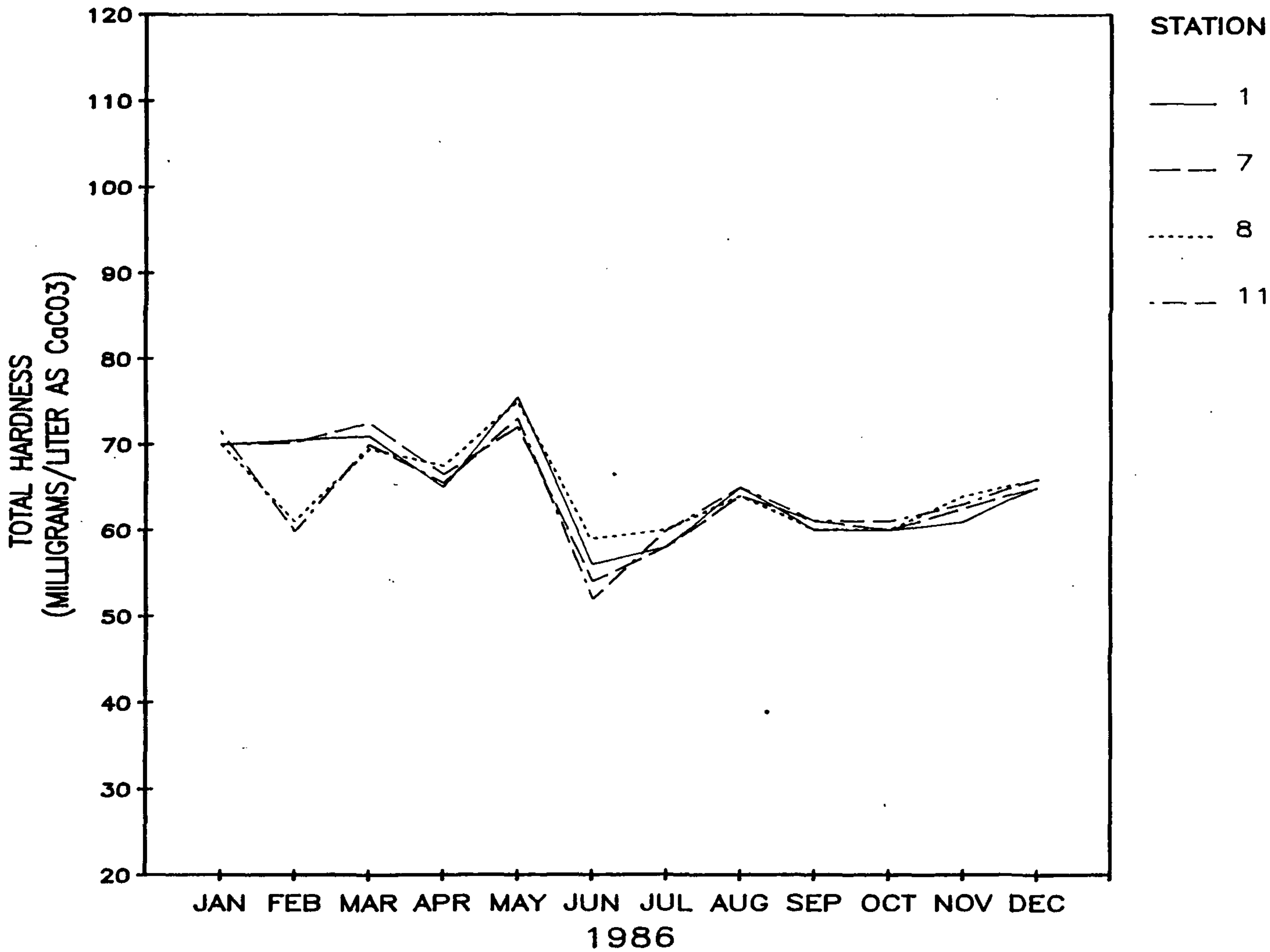

Figure 4-10. Columbia River Total Hardness Measurements at Four Stations During 1986

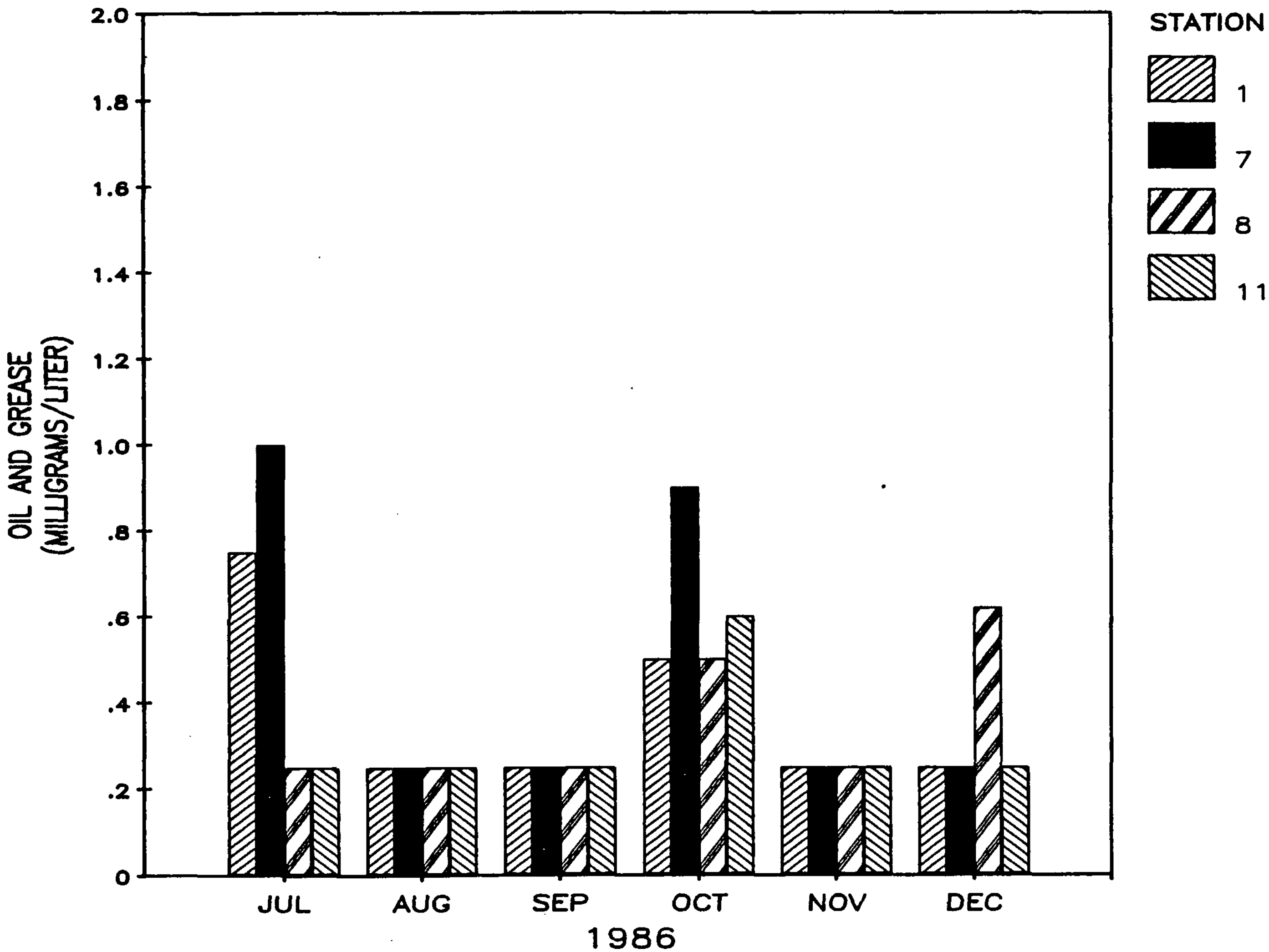

Figure 4-11. Columbia River Oil and Grease Measurements at Four Stations During 1986

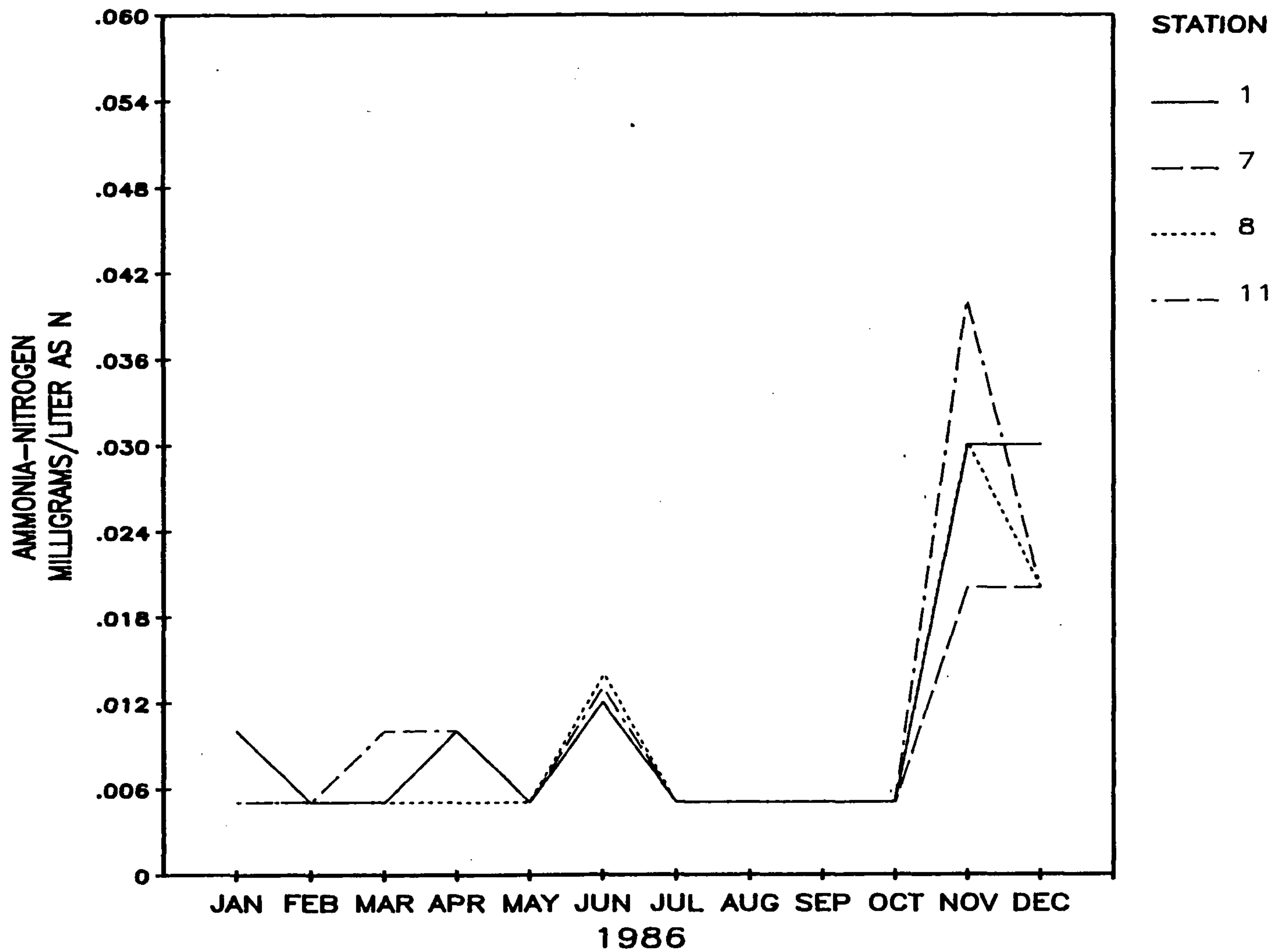

Figure 4-12. Columbia River Ammonia Nitrogen Measurements at Four Stations During 1986

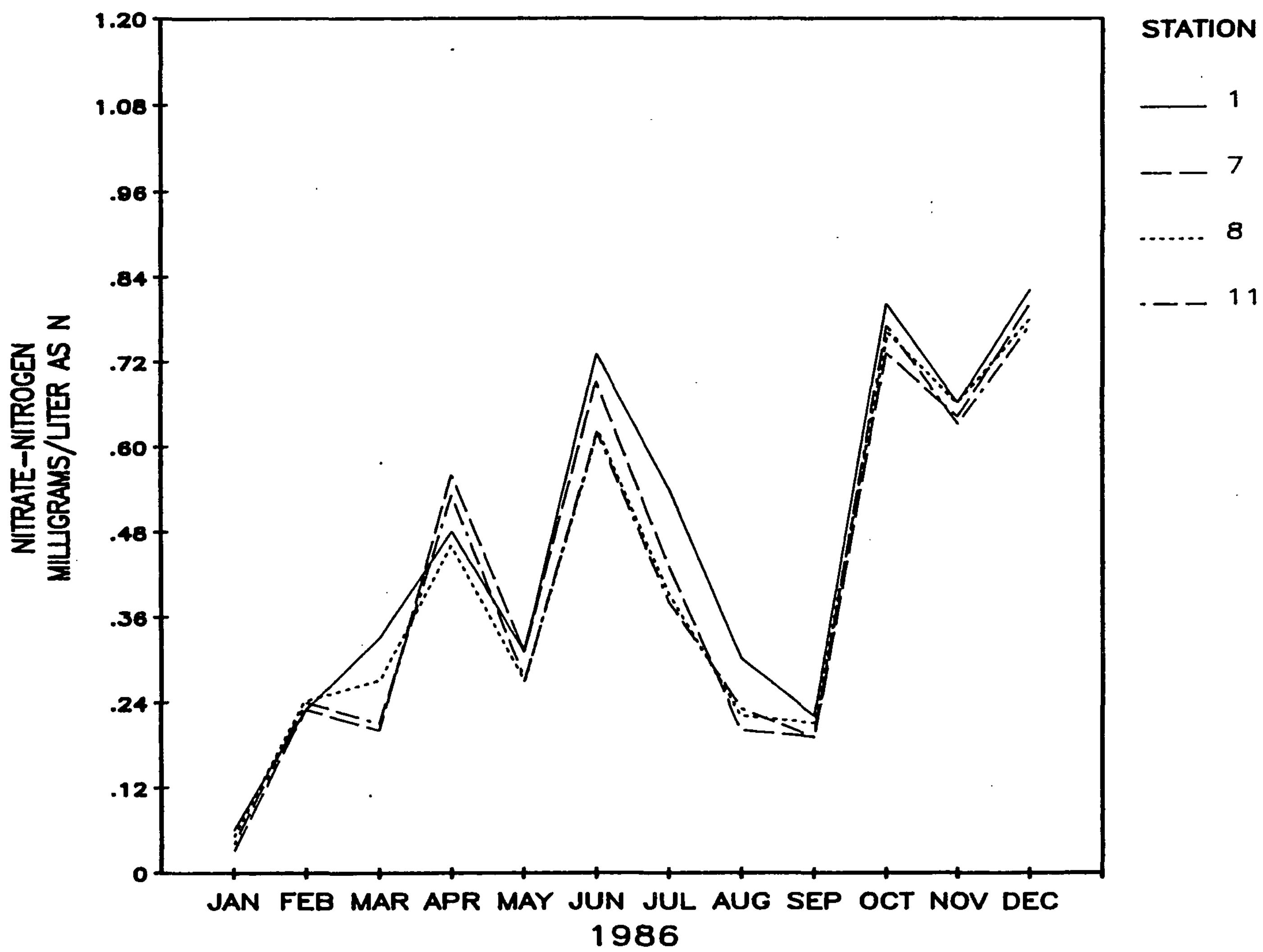

Figure 4-13. Columbia River Nitrate-Nitrogen Measurements at Four Stations During 1986

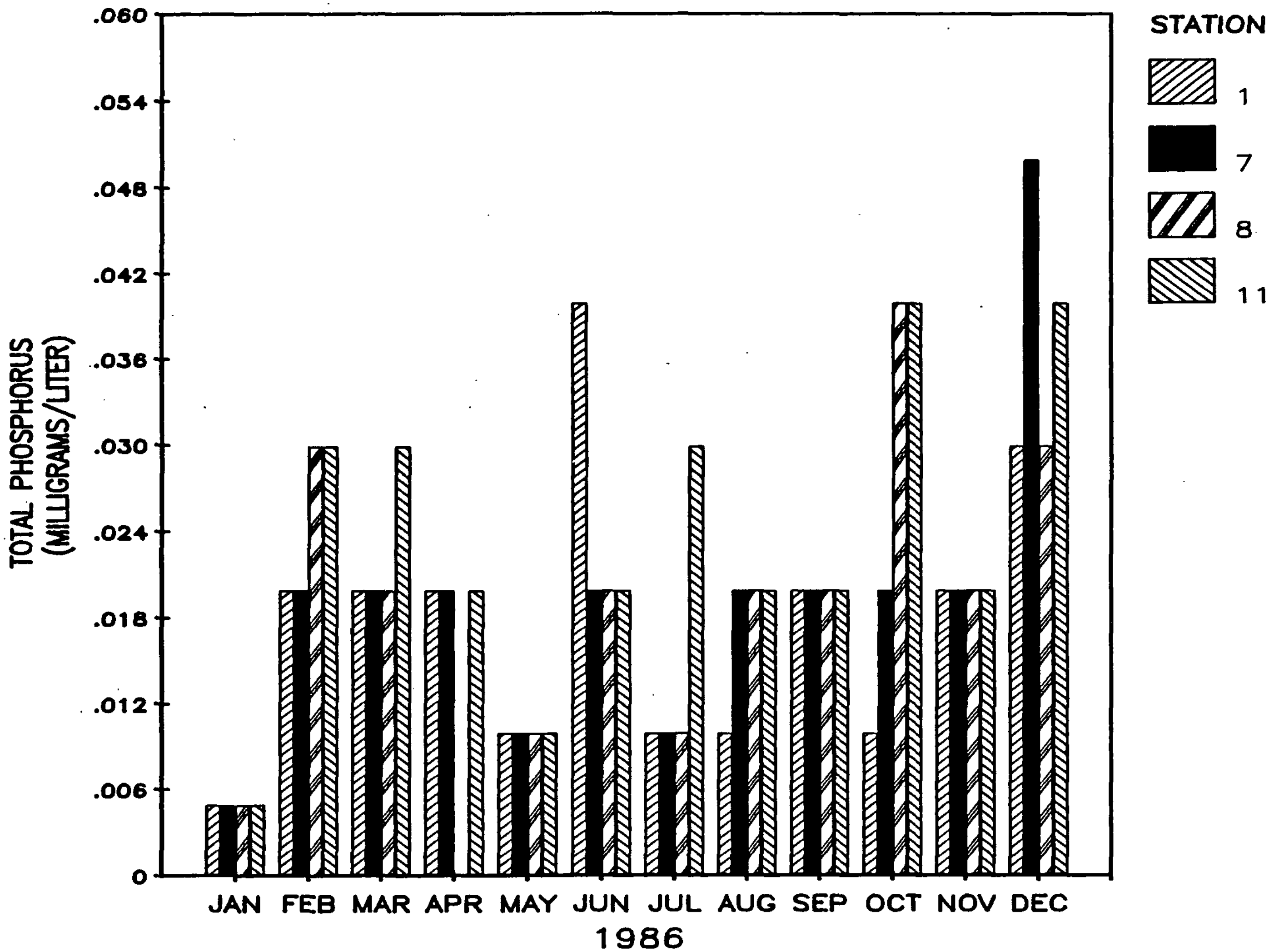

Figure 4-14. Columbia River Total Phorphorus Measurements at Four Stations During 1986

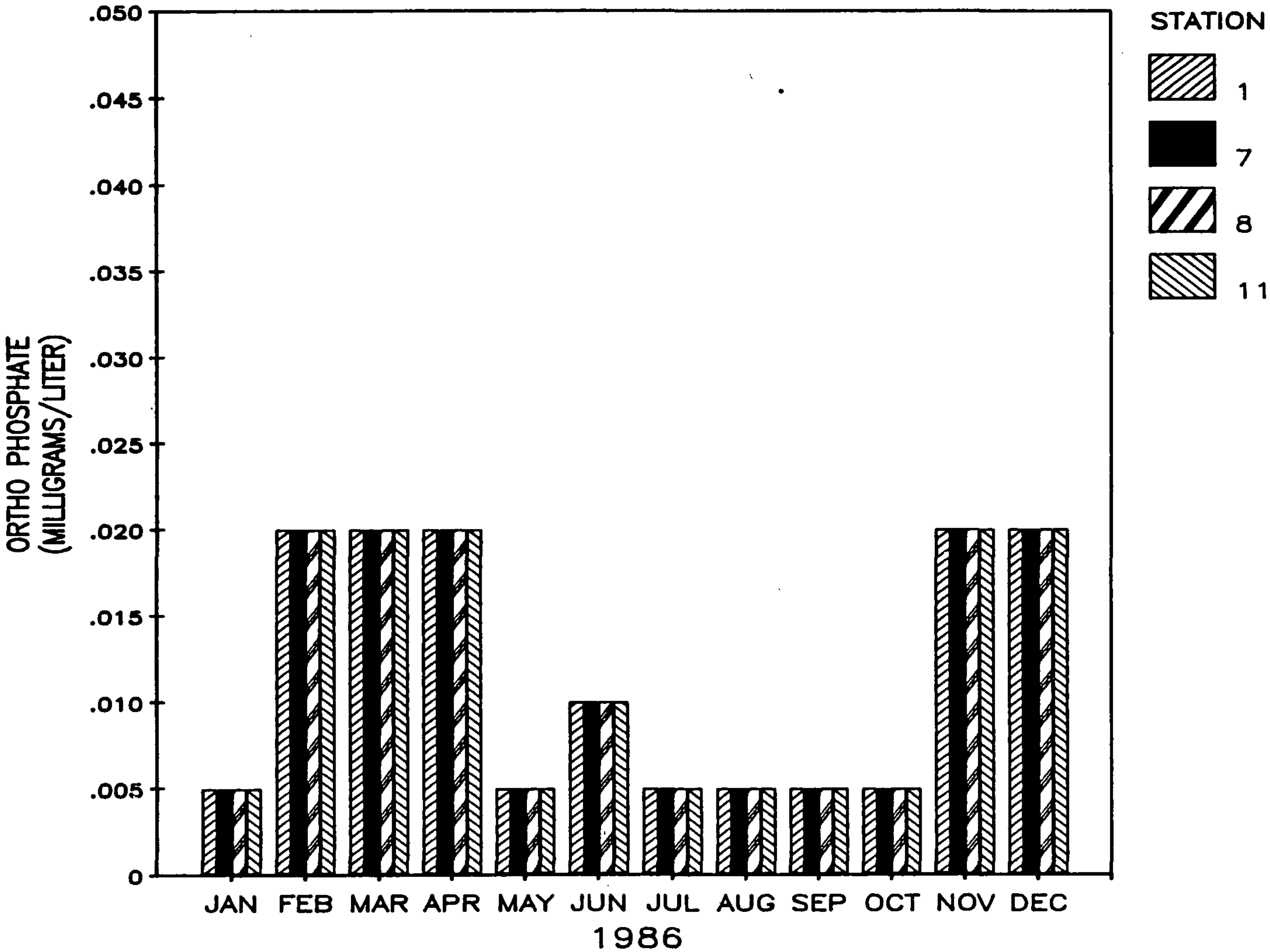

Figure 4-15. Columbia River Ortho Phosphate Measurements at Four Stations During 1986

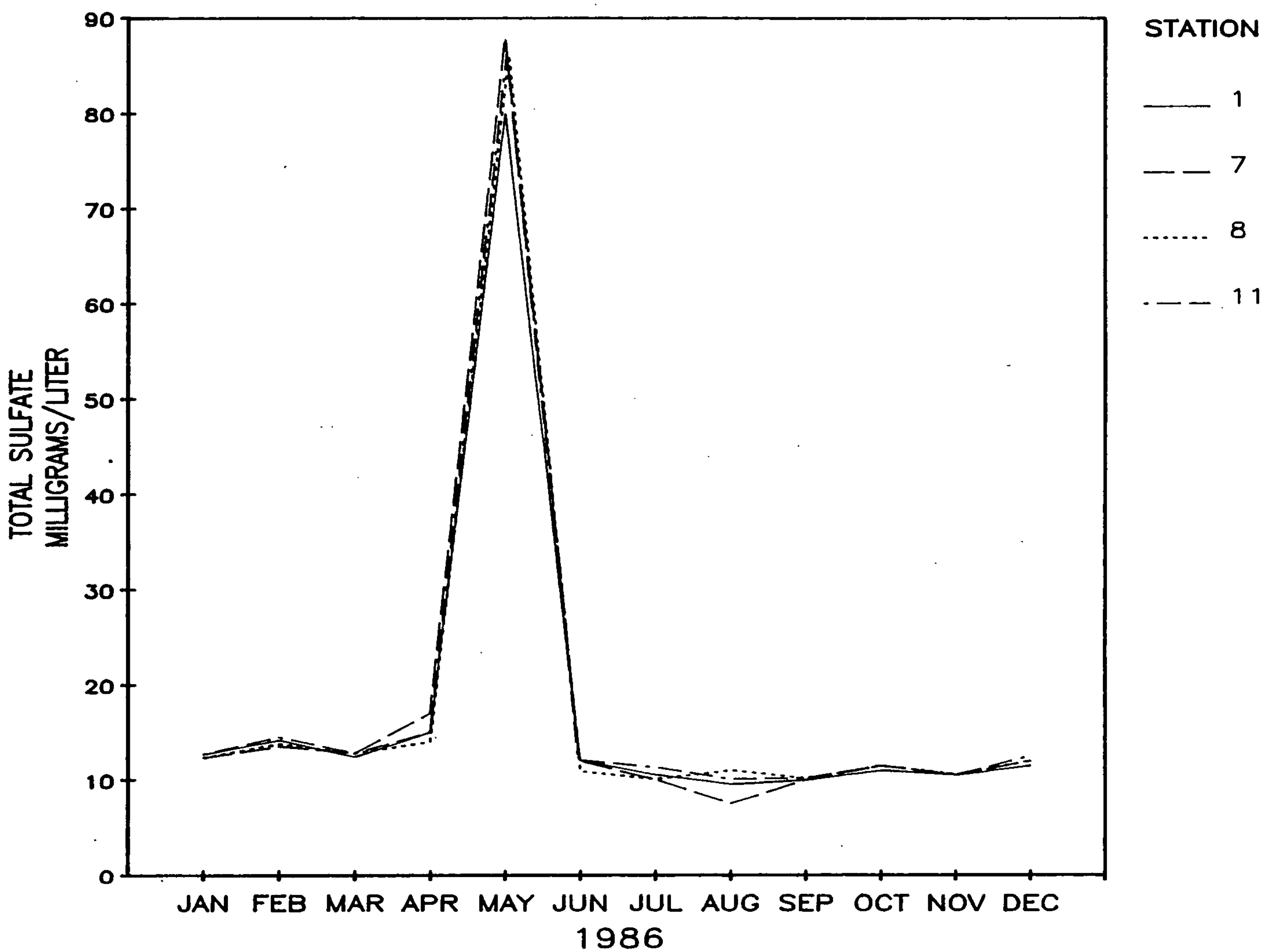

Figure 4-16. Columbia River Total Sulfate Measurements at Four Stations During 1986

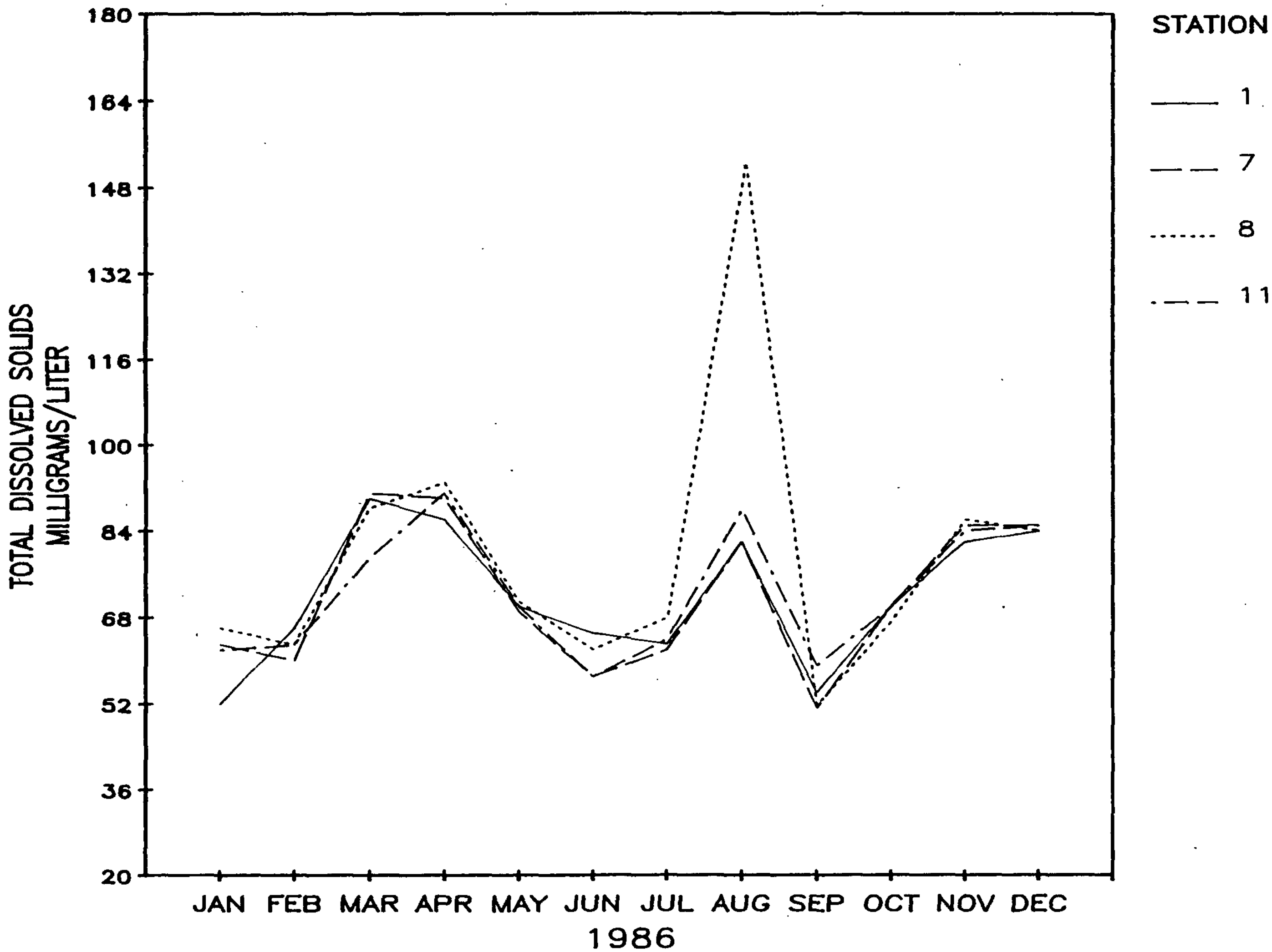

Figure 4-17. Columbia River Total Dissolved Solids Measurements at Four Stations During 1986

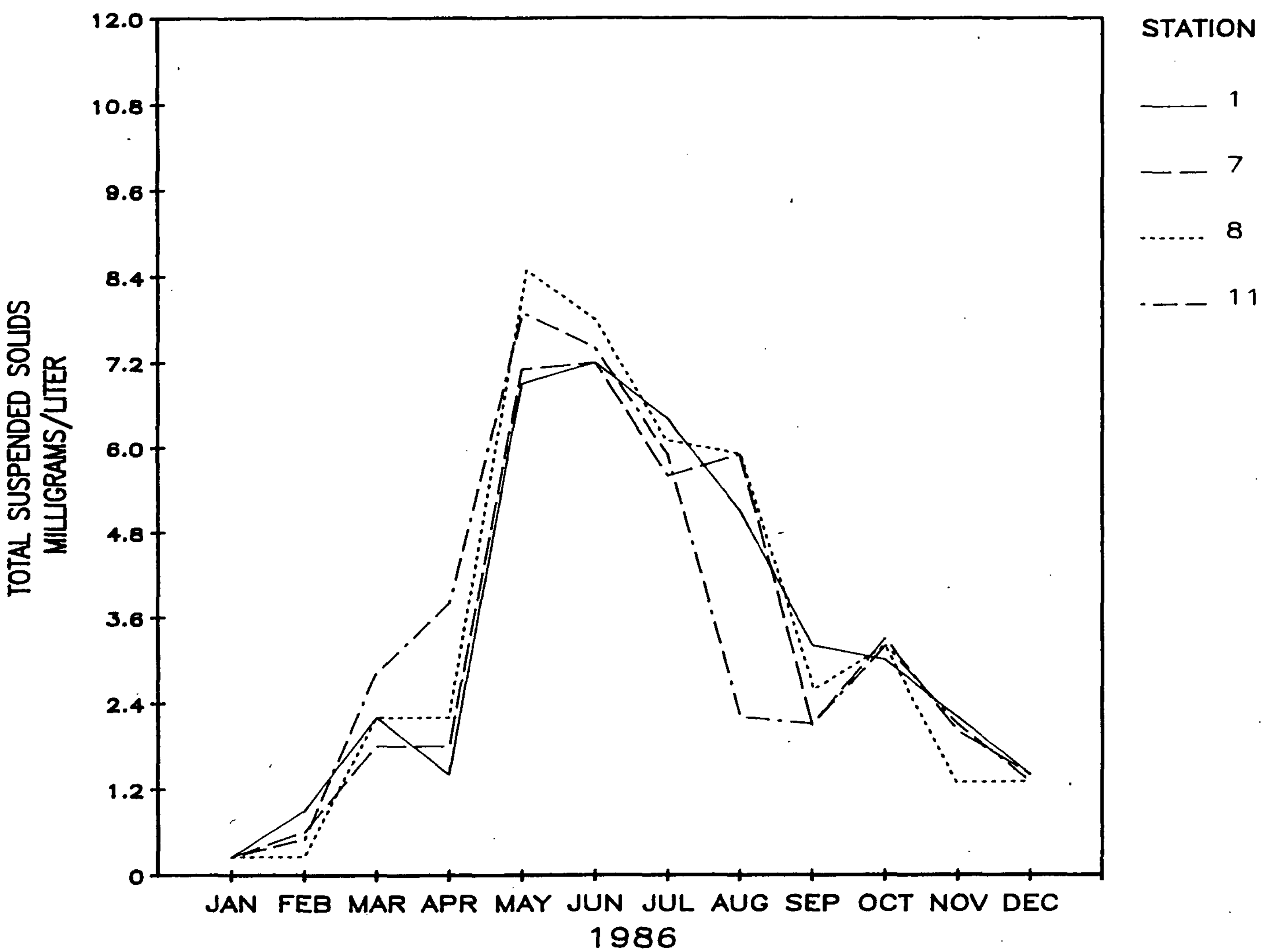

Figure 4-18. Columbia River Total Suspended Solids Measurements at Four Stations During 1986

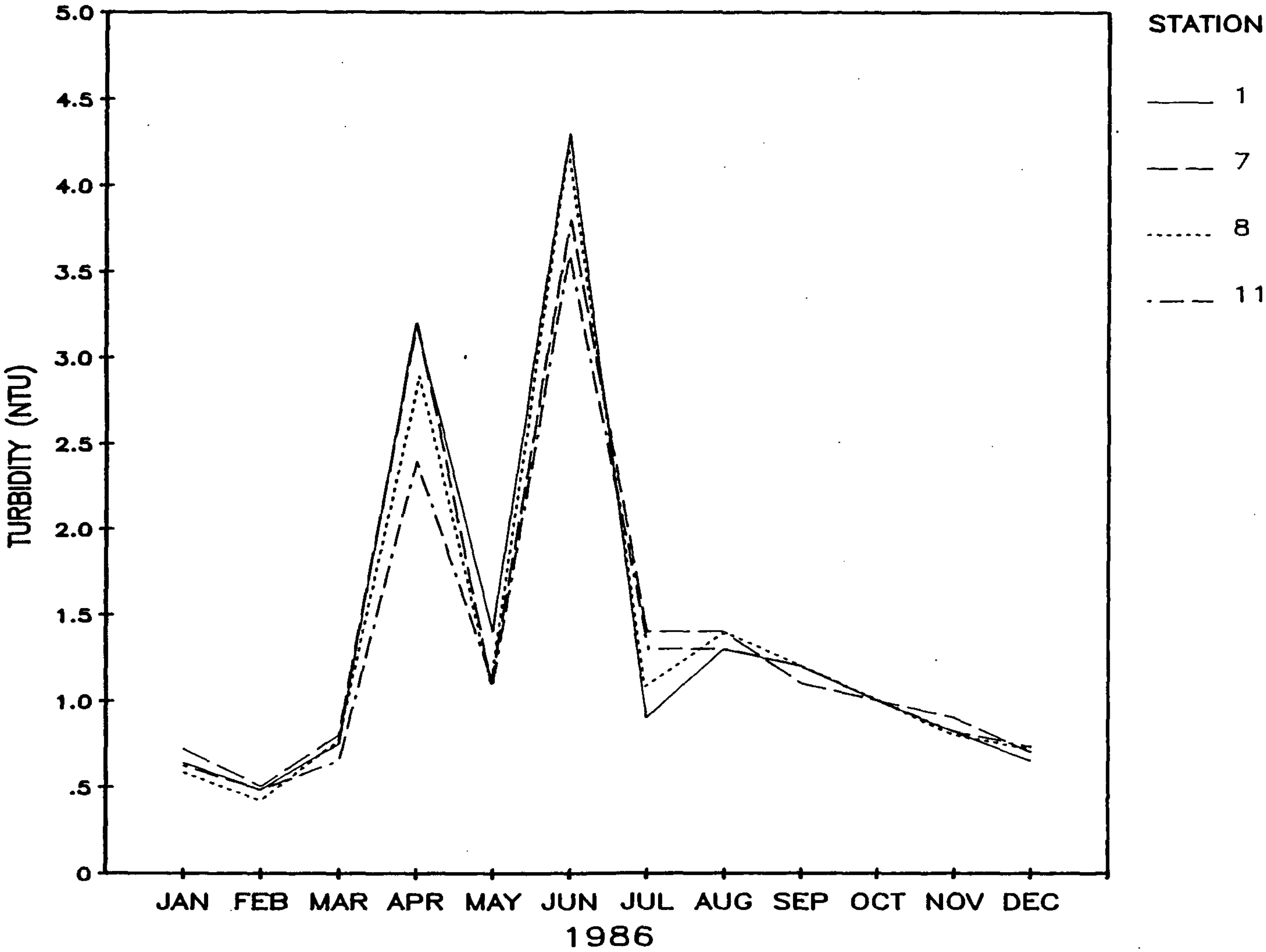

Figure 4-19. Columbia River Turbidity Measurements at Four Stations During 1986

5.0 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) in length. Water is removed through four perforated pipe sections (2 each per intake structure) each 2 m (6.5 ft) in length with 0.95 cm (3/8 in) circular holes. A 91 cm (36 in) diameter perforated internal sleeve is used to equalize flow. Abnormal flow conditions may result in 47,300 to 94,600 liters per minute (lpm) (12,500 to 25,000 gpm) being removed from one intake structure, with the respective modeled (Washington Public Power Supply System, 1977) entrance velocities of 0.20 to 0.34 mps (0.50 and 1.1 fps). Under normal operating conditions 47,300 lpm (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 velocities measured near the perforated pipes ranged between 1.22 and 1.53 mps (4 to 5 fps).

5.2 METHODS AND MATERIALS

Historical studies were conducted between 1978 and 1979 (Beak Consultants, 1980; Mudge et. al., 1981) using SCUBA divers. Routinely, divers inspect and report any fish impingement on or interaction with the intake structure, the need for maintenance, unusual conditions such as accumulation of submerged debris and plugging of water entrance orifices by periphyton. Video tape record logs of intake fouling are made in the fall at four stations (two per intake), each measuring approximately 400 cm^2 (64 in^2) in size. In 1986 the monthly (March through November) survey period was reduced to a semiannual inspection of the screen fouling and riverbed stability.

5.3 RESULTS AND DISCUSSION

Surveys were conducted in April and October. At no time were any fish observed impinged on the intake screens. Fouling on the intakes was comparable with past years and the riverbed appeared stable.

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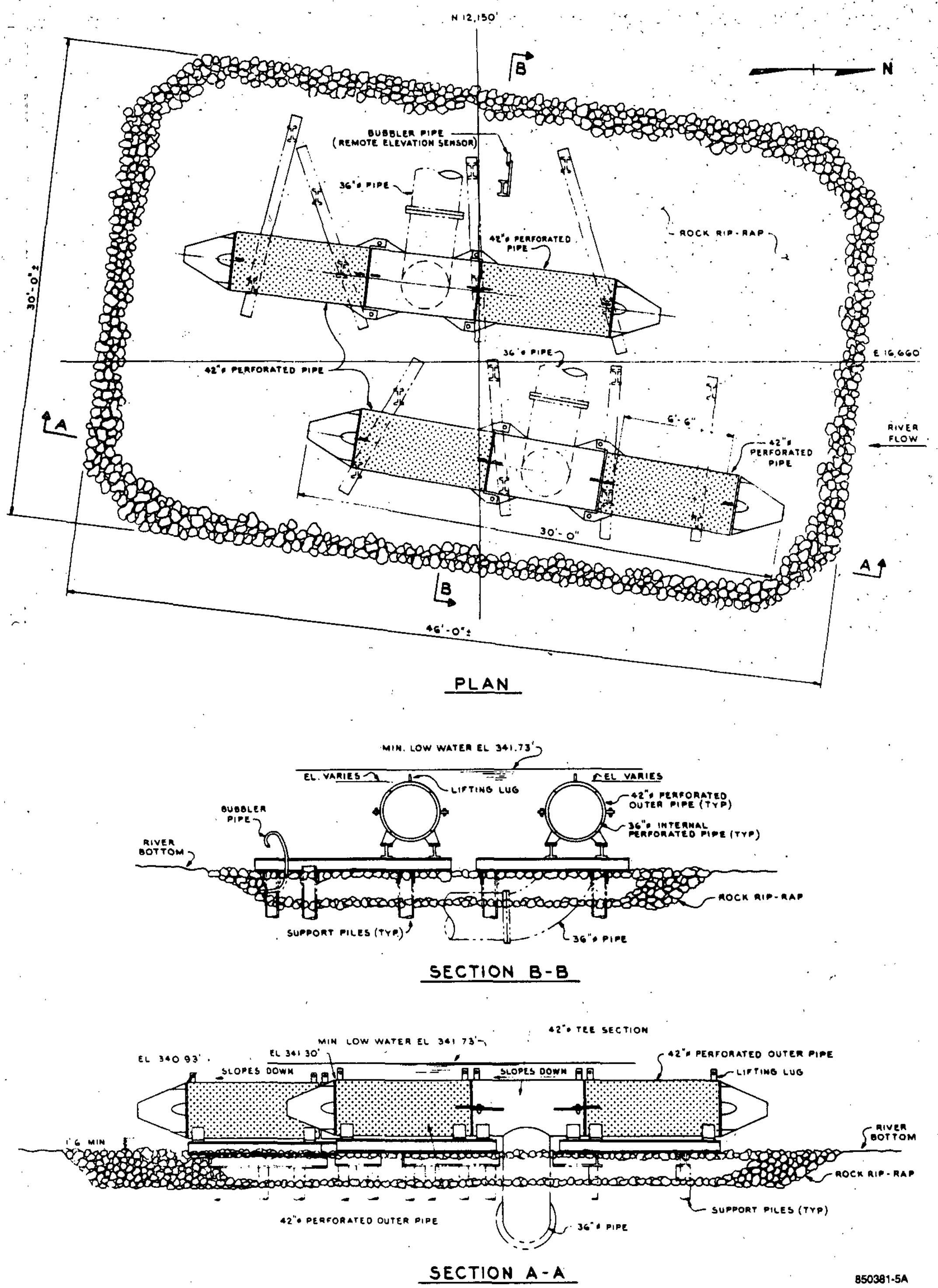

Figure 5-1. Vertical and Cross Sectional Views of WNP-2 Intake Structure

6.0 CORBICULA CLAM SURVEYS

6.1 RESULTS AND DISCUSSION

Corbicula are clams which have caused water flow problems at electrical generating plants. Relic shells have reduced cooling water flow rates in safety related systems necessitating plant shutdowns in the southeast. To assure that these indigenous clams are not a threat to WNP-2's integrity, inspections of the tower make up (TMU) pump pit, the circulating water pump house and the main condenser water boxes are conducted at least once per year. Live clams were located in the TMU and one relic shell was retrieved from the condenser middle water box. WNP-2's normal biofouling treatment program appears to be controlling the clam population and thus Corbicula did not pose a problem to the operation of WNP-2 during 1986.

7.0 COOLING TOWER DRIFT STUDIES

7.1 INTRODUCTION

The purpose of the cooling tower drift 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. This study provides post-operational data for comparisons with pre-operational data and meets the requirements of Washington State Energy Facility Site Evaluation Council (EFSEC) Resolution 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 city center. 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°C and a January mean minimum temperature of -4°C. Annual rainfall averages 20 cm with less than 25% falling between April and October (Phillips 1972).

Sampling was conducted at each of nine permanent stations, four grassland stations G01-G04, and five shrub stations S01-S05. Figure 7-1 shows the location of each station. The orientation of the various components including transects and productivity plots within each community are depicted in Figure 7-2. Stations G01, G02, and G03 are extensively disturbed grassland areas dominated by annual forbs and grasses located within close proximity to the plant. Two of the stations, G01 and G02, were burned in a 1984 range fire. Station G03 was not burned in the range fire. 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. Station G04, located approximately 3 km 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.

Stations 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, a number of annual and perennial forbs and Bromus tectorum (cheat grass). Most of the dominant shrubs at station S01 were destroyed in the 1984 fire. Station S03, however, was not burned. Station S05 lies approximately 8 km southeast of WNP-2. The station was a mixed shrub community, however, a fire in 1981 destroyed most of the shrubs reducing the cover to less than 1%. Stations S02 and S04 lie 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. The area supports 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 sandbergii, 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. The shrub cover, however, was reduced to zero at both the S02 and S04 sampling plots in the 1984 fire.

Given the low precipitation level of the region, operation of the cooling towers may increase the concentration of some components of the cooling water matrix in the local 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 may be determined by monitoring such parameters as productivity, vegetation cover and frequency, and soil chemistry over time and comparing the data with preoperational 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 analyses. 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 7-3 and 7-4 (Droppo et. al. 1976). It is evident that if all the salt were to be confined to the soil profile, values as high as 7,200 kg 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.

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 7-2). Canopy cover was estimated for each species occurring within a microplot using Daubenmire's (1968) 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.

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 7-2). 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 laboratory, opened, and placed in a drying oven at 50°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.

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 7-2). 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.

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 7-2). 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 stations, five 500-ml soil samples were 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°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 (1965). 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 (USEPA 1983). Mercury was analyzed by cold vapor atomic absorption spectroscopy according to USEPA (1983). Samples for copper, cadmium, lead, nickel and chromium were analyzed by graphite furnace atomic absorption spectroscopy according to USEPA (1983). Fluoride samples were analyzed by specific ion electrode utilizing a sodium carbonate fusion analysis developed at AM Test Laboratories Inc., Seattle, Washington (Appendix). Aliquots of soil for trace metal analyses were digested according to Procedures for Handling and Chemical Analysis of Sediment and Water Samples (Plumb 1981). Preservation times and conditions, when utilized, were according to USEPA (1983).

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°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 (1981). Sulfate was analyzed by nephalometry and chloride by mercuric chloride titration according to USEPA (1983). Copper was analyzed by graphite furnace atomic spectroscopy according to USEPA (1983).

7.3 RESULTS AND DISCUSSION

During the 1986 season, 59 plant taxa were observed in the study area. These are presented in Table 7-2. Table 7-3 lists by year the species of vascular plants observed during field activities from 1975-1986.

7.3.1 Herbaceous Cover

Herbaceous cover data for 1986 are summarized in Tables 7-4 and 7-5. Figures 7-5, 7-6, 7-7 and 7-8 provide a comparison with the data of previous years.

On August 11th and 12th of 1984 a fire burned approximately 300,000 acres of rangeland within the Columbia Basin, most of which was on the Hanford Reservation. The fire destroyed most of the vegetation on Stations G01, G02, S01, S02 and S04 and exerted a marked effect on the herbaceous and shrub cover produced during the 1985 and 1986 seasons.

Total herbaceous cover averaged 50.61% in the study area. At grassland sites average herbaceous cover was 55.36% and at shrub sites it was 43.75%. *Poa sandbergii* dominated the herbaceous vegetation in the study area, accounting for 12.44% of total herbaceous cover. This is up markedly from 1985 (7.41%) where the herbaceous vegetation was dominated by *Bromus tectorum* (10.12% in 1985 vs. 9.25% in 1986).

Annual grasses averaged 9.53%, down from the 10.27% observed in 1985. The dominant annual grass observed at all stations was *Bromus tectorum*. *Festuca octoflora* was present at stations S04 (2.40%) and S02 (0.10%) up from the 1.35% observed at station S04 in 1985.

Mean herbaceous cover increased markedly in 1986 from 1985 (50.61% vs. 32.45%). Although the annual precipitation was higher in 1986 than in 1985 (18.0 vs. 12.9 cm) it is likely that the stations are still recovering from the 1984 fire.

Perennial grasses averaged 13.98% or 27.60% of the total in comparison to 8.86% and 27.30% in 1985. Poa sandbergii was the most abundant perennial grass at all stations except G03 and S05 where it did not occur. As in 1985, perennial grasses were absent at station G03. The dominant perennial grass at station S05 was Agropyron spicatum.

Annual forb cover averaged 22.64% as opposed to 11.91% in 1985 and still lower in 1984, 1983 and 1982. The most abundant annual forbs were Draba verna (7.60%), Salsola kali (1.92%), Plantago pategonica (2.08%), Microsteris gracilis (0.91%), and Sisymbrium altissimum (1.90%).

Perennial forb cover for 1986 averaged 4.45% which is a marked increase from the 1.41% measured in 1985. The dominant species include Cymopteris terebinthinus (0.67%), Oenothera pallida (0.58%) and Balsamorhiza careyana (0.49%).

Species frequency increased in 1986 at all stations except G03. Station S02 had the greatest number of species present (23) while station G03 had the fewest (10). Species frequencies for 1986 are presented in Table 7-6.

7.3.2 Herbaceous Phytomass

Mean production of herbaceous phytomass in 1986 was 61.2 g/m^2 dry weight. Production varied widely among stations, from 24.3 g/m^2 at station S05 to 176.5 g/m^2 at station S04 (Figure 7-9). In 1986, shrubland stations averaged higher herbaceous phytomass than grassland stations (74.5 vs. 44.6).

Mean herbaceous phytomass production at grassland stations and at shrub stations for 1986 is shown graphically in Figure 7-10 and summarized in Table 7-7. In previous years, the grassland stations have shown considerably more variability from year to year than did the shrub stations, however, this was not evident in 1986. Table 7-8 presents mean phytomass values for each station in each year since 1975. Mean herbaceous phytomass and percent herbaceous cover for each station from 1980 through 1986 are presented graphically in Figures 7-11 through 7-19.

7.3.3 Shrub Cover and Density

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.

During the 1984 August range fire all viable shrubs were completely destroyed at stations S02 and S04, while the only individuals surviving at station S01, were isolated clumps of low growing *Eriogonum niveum*. Shrub density at station S03 decreased slightly from that observed in 1985. Station S05, which was burned in 1981, also showed a slight decrease in density from 1985. Table 7-9 summarizes shrub density for 1986.

Shrub cover values continue to reflect recovery from the August 1984 fire. Total shrub cover was reduced to zero in 1985 at stations S01, S02 and S04 while a slight increase was observed at stations S03 (7.05 vs. 6.69) and S05 (2.18 vs. 1.61). In 1986, shrub cover was still zero at stations S02 and S04, while only a few juvenile specimens of *Eriogonum niveum* were observed at S01. Shrub cover declined slightly at station S03 (7.05 vs. 6.60) but continued to recover from the 1981 fire at station S05 (4.09% vs. 2.18%). Table 7-10 summarizes shrub cover data for 1986. Figure 7-20 presents the mean shrub cover values measured from 1975 through 1986. Shrub cover and density at the five sample stations in 1986 are shown in Figure 7-21. Figure 7-22 shows the values for shrub density at each station for 1980 through 1986.

7.3.4 Soil Chemistry

The results of the 1986 soil chemical analyses are presented in Table 7-11 and are shown graphically in Figures 7-23 through 7-39.

Soil pH ranged from 6.81 to 7.94 in 1986 which is well within the ranges experienced in preoperational studies (Figure 7-23). At station G03 pH declined for the second straight year from 7.35 in 1984, 7.12 in 1985 to 6.97 in 1986. No other trends were apparent to date.

Soil conductivity ranged from 13.6 microsiemens/cm at station S05 to 50.8 at station G04. The large increases in conductivity noted between 1984 and 1985 at stations G02, G03 and G04 were not evident in 1986. Conductivities at stations S03 and S05 have declined since 1984. Overall, soil conductivities have remained relatively constant since 1980 (Figure 7-24).

Soil sulfate ranged from 0.88 ug/gm at station S05 to 7.96 ug/gm at station G04. Concentrations at all sites were low and within the ranges measured during preoperational studies (Figure 7-25).

Chloride concentrations ranged from 4.48 ug/gm at station G02 to 5.92 at stations S04 and G03 which are at the lower end of the range observed in preoperational studies (Figure 7-26).

Soil bicarbonate ranged from .0006 meq/gm at stations S04 and S05 to .0025 at station G02. As in previous years, no carbonate was present in any of the samples analyzed (Figure 7-27).

Soil copper concentrations were measured at levels exceeding the ranges recorded in preoperational studies at stations G02, G04, S01, S02 and S04. However, at station G03, which is closest to the cooling towers, the concentrations were near the median of previously recorded values. The range was 10.62 ug/gm at station G03 to 17.06 at station S04 (Figure 7-28).

Concentrations of soil lead ranged from 1.37 ug/gm at station G03 to 4.54 at station G01. These values are at the lower end of preoperational data ranges (Figure 7-29).

Concentrations of nickel have increased over the past three years at stations G01, G02, G04 and S01. Values recorded for station G01 (23.43 ug/gm), G04 (21.53) and S02 (19.08) were the highest recorded since the study began in 1980 (Figure 7-30).

Cadmium concentrations ranged from .03 ug/gm at station S02 to .07 at station G02 (Figure 7-31). These were among the lowest values recorded since 1980.

Mercury concentrations were low as in previous years, and ranged from .002 to .007 ug/gm (Figure 7-32).

Zinc concentrations ranged from 37.52 ug/gm at station S02 to 56.61 ug/gm at station S04. Concentrations recorded at station S02 are consistently lower than at all other stations. The values recorded during 1986 were within the ranges recorded in previous years (Figure 7-33).

Chromium concentrations ranged from 7.32 ug/gm at station G04 to 13.10 at station G01. Concentrations at all stations were near the means of previously recorded data (Figure 7-34).

Sodium concentrations declined slightly over the past years at all sampling stations. Concentrations measured in 1986 were the lowest recorded at all stations except S05 since 1980 (Figure 7-35).

Potassium concentrations ranged from .052% at station S02 to 0.187% at station G01. Values recorded at all stations tended to cluster around the means of previous preoperational and operational data (Figure 7-36).

At most stations, calcium and magnesium concentrations were near the means of previous years data. Station G02 experienced a marked increase in calcium concentration between 1985 (.27%) and 1986 (.57%) (Figures 7-37 and 7-38).

Fluoride concentrations ranged from 167 to 218 ug/gm. These are well within the concentration ranges recorded in previous years (Figure 7-39).

7.3.5 Vegetation Chemistry

The results of the 1986 vegetation chemical analyses are presented in Table 7-12 and shown graphically in Figures 7-40 through 7-60.

Copper concentrations in *Sisymbrium altissimum* (Figure 7-40) were similar to those observed in previous years at all stations except G04 where a concentration of 15.98 ug/gm was measured in 1986. This is approximately three times the mean copper concentration observed at that station in previous years. In *Poa sandbergii* (Figure 7-41) copper concentrations were near the means recorded in previous years at stations G01, G03, S01, S03 and S04 but were elevated markedly at stations G02, G04, S02 and S05. In *Artemesia tridentata* (Figure 7-42) and *Purshia tridentata* (Figure 43) concentrations measured in 1986 were similar to those recorded in previous years. In *Phlox longifolia* (Figure 7-44), copper concentrations were elevated slightly at station

S01 and markedly at station S03. Bromus tectorum (Figure 7-45) has exhibited increases in copper concentrations in 1985 and in 1986 at stations G01, G03, S01, S03 and S05 while the remaining stations exhibited concentrations similar to those recorded in previous years. The increase which occurred at station G03 is the most dramatic. Total copper concentrations for all species at each station during 1986 is presented in Figure 7-46.

Chloride concentrations in all six of the species examined in 1986 were similar to those observed in previous years, although Poa sandbergii exhibited a marked increase in chloride concentration at station G02. Sisymbrium altissimum and Artemisia tridentata, as in previous years, exhibit the highest chloride concentrations of all the species examined (Figures 7-47 through 7-53).

Sulfate concentrations in Sisymbrium altissimum, Phlox longifolia, Purshia tridentata and Artemisia tridentata clustered near the mean of values recorded during preoperational studies. Bromus tectorum and Poa sandbergii both showed a marked increase in sulfate concentrations at station G02 (Figures 7-54 through 7-60).

7.3.6 SUMMARY AND CONCLUSIONS

7.3.6.1 Herbaceous Cover

Overall herbaceous cover continues to recover from the range fire of 1984. Average cover increased from 32.45% in 1985 to 50.60% in 1986. On a site-to-site basis, stations G01, G02 and G04 showed a modest increase in herbaceous cover while station G03 showed a decline in cover for the third straight year. Stations S01, S02, S03 and S04 also increased in cover between 1985 and 1986, however station S05 showed a decline for the third straight year. Station G03 continues to show visible signs of continual disturbance. Although this station did not burn during the 1984 fire, there is no evidence of any recolonization of shrub species while herbaceous cover continues to decline. The vegetation is dominated by weedy annuals including *Sisymbrium altissimum*, *Franseria acanthicarpa*, *Holosteum umbellatum* and *Salsola kali*.

7.3.6.2 Herbaceous Phytomass

Phytomass production also continued to show signs of recovery from the fire at most stations. Station G02, G03, S01, S02 and S04 increased markedly. Station G01, one of the burned stations, showed a decline in phytomass for the third straight year. Station G04 and S03 experienced slight declines in phytomass production over 1985.

7.3.6.3 Shrub Cover and Density

The fire of 1984 completely destroyed all shrubs at stations S01, S02 and S04. The remaining stations, S03 and S05, both showed slight decreases in density. Shrub cover declined slightly at station S03 but increased moderately at station S05. A few juvenile shrub seedlings were noted in the vicinity of the burned stations in 1985 and 1986.

7.3.6.4 Soil and Vegetation Chemistry

Trace metal analyses of soil and vegetation samples collected in the study areas during May of 1986 gave results which were in most cases within the ranges reported in previous studies. A decrease in pH for the second straight year was evident at station G03. Soil copper concentrations were measured at levels exceeding the ranges recorded in preoperational studies at five stations. Nickel concentrations also exceeded preoperational data ranges at three stations and increased over the past three years at four stations.

Bromus tectorum exhibited increases in copper concentrations over the last two years at five stations particularly at site G03 which is closest to the cooling towers. At station G04 a copper concentration of 15.98 ug/gm was measured in Sisymbrium altissimum which is approximately three times the concentration reported at that station in previous years. Poa sandbergii exhibited markedly elevated copper concentrations at four stations. No other trends were apparent.

The objective of this study was to quantify levels of copper, sulfate and chloride in vegetation as well as copper, nickel, zinc, lead, cadmium, chromium, mercury, magnesium, calcium, sodium, potassium, sulfate, chloride, fluoride, bicarbonate, conductivity and pH in soils. When the study began in 1980 the sampling protocol was designed by Battelle Northwest to reveal the concentrations of basic soil and vegetation chemical parameters at various sampling sites near WNP-1, 2 and 4. The sites selected were not based upon predicted isopleths of salt drift deposition from the operation of WNP-2 cooling towers, nor was the intensity of the sampling designed to be sufficient for any statistical analysis of spatial relationships or time trends.

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Table 7-1. Estimates of Salt Deposition Rates Versus Distance From Cooling Towers

Distance from Tower (miles)	Salt Deposition (lb/acre yr): Equal Direction Frequency	Salt Deposition (lb/acre yr): 9%(1) from Single Direction	Salt Deposition (lb/acre yr): 20% (1) from Single Direction
0 to 0.22	nil	nil	nil
0.22 to 0.28	271.0	390.0	867.0
0.28 to 0.33	166.0	239.0	531.0
0.33 to 0.6	0.4	0.6	1.3
0.6 to 3	0.7	1.0	2.2
3	0.7	1.0	2.2

(1) 16-point compass presumed. Maximum wind direction frequency observed at WNP-2 site was 9%. Measurement elevation was 23 ft.

(2) 16-point compass presumed. Maximum wind direction frequency observed at HMS site was 20%. Measurement elevation was 400 ft.

Table 7-2. Vascular Plants Observed During 1986 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 leucophaea (Dougl.) Pays.	Gray 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 7-2 (cont.). Vascular Plants Observed During 1986 Field Work

	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 (Pursh) Spreng.	Chocolate lily
LOASACEAE	Blazing-star Family
Mentzelia albicaulis Dougl.	White-stemmed mentzelia
MALVACEAE	Mallow Family
Sphaeralcea munroana (Dougl.) Spach	White-stemmed globe-mallow
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 dasystachyum (Hoak.) Scribn.	Thick-spiked 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

Table 7-2 (cont.). Vascular Plants Observed During 1986 Field Work

	Common Name
Poa sandbergii Vasey	Sandberg's bluegrass
Poa scabrella (Thurb.) Benth. ex Vasey	
Sitanion hystrix (Nutt.) Smith	Bottlebrush squirreltail
Stipa comata Trin & Rupr.	Needle-and-thread
POLEMONIACEAE	Phlox Family
Gilia minutiflora Benth.	Gilia
Gilia sinuata Dougl.	Shy gilia
Microsteris gracilis (Hook.) Greene var. *humilior* (Hook.) Cronq.	Pink microsteris
Phlox longifolia	Long-leaf phlox
POLYGONACEAE	Buckwheat Family
Eriogonum niveum Dougl.	Snow buckwheat
Rumex venosus Pursh	Wild begonia
RANUNCULACEAE	Buttercup Family
Delphinium nuttallianum Pritz. ex Walpers	Larkspur
ROSACEAE	Rose Family
Purshia tridentata (Pursh) DC.	Antelope bitterbursh
SANTALACEAE	Sandalwood Family
Comandra umbellata (L.) Nutt.	Bastard toad-flax
SAXIFRAGACEAE	
Ribes aureum Pursh	Golden current
SCROPHULARIACEAE	Figwort Family
Penstemon acuminatus Dougl.	Sand-dune penstemon
VALERIANACEAE	Valerian Family
Plectritis macrocera T&G	Longhorn plectritis

Table 7-3. Vascular Plants Observed During 1975 - 1986 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Annual Grasses												
Bromus tectorum	X	X	X	X	X	X	X	X	X	X	X	X
Festuca octoflora	X					X	X	X	X	X	X	X
Festuca sp.		X		X								
Perennial Grasses												
Agropyron cristatum							X	X	X	X	X	X
Agropyron dasystachyum				X			X	X	X	X	X	X
Agropyron spicatum						X	X	X	X	X	X	X
Koeleria cristata				X		X	X	X	X	X	X	X
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X	X	X
Poa sandbergii							X	X	X	X	X	X
Poa Scabrella							X	X	X	X		X
Sitanion hystrix						X		X	X	X	X	X
Stipa comata		X		X	X	X	X	X	X	X	X	X
Stipa thurberiana					X							

Table 7-3 (cont.). Vascular Plants Observed During 1975 - 1986 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Annual Forbs												
Franseria acanthicarpa	X		X	X	X			X	X	X	X	X
Amsinckia lycopsoides	X	X	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	X	X
Cryptantha circumscissa	X	X	X	X	X	X	X	X	X	X	X	X
Descurainia pinnata	X	X	X	X	X	X	X	X	X	X	X	X
Draba verna	X	X		X	X	X	X	X	X	X	X	X
Epilobium paniculatum	X	X	X	X	X							
Erysimum asperum							X	X	X	X	X	X
Gilia minutiflora					X				X		X	X
Gilia sinuata						X		X	X	X	X	X
Holosteum umbellatum	X	X		X	X	X	X	X	X	X	X	X
Lagophylla ramosissima						X						
Layia glandulosa			X		X			X	X	X	X	X
Mentzelia albicaulis			X		X			X	X	X	X	X
Microsteris gracilis	X	X	X	X	X	X	X	X	X	X	X	X
Phacelia hastata							X	X	X	X	X	X
Phacelia linearis				X		X	X	X	X	X	X	X
Phacelia sp.		X										
Plantago patagonica	X	X		X	X	X	X	X	X	X	X	X
Plectritis macrocera		X							X		X	X

Table 7-3 (cont.). Vascular Plants Observed During 1975 - 1986 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Polemonium micranthum	X			X								
Salsola kali	X	X	X	X	X	X	X	X	X	X	X	X
Sisymbrium altissimum	X	X	X	X	X	X	X	X	X	X	X	X
Tragopogon dubius				X			X	X	X	X	X	X
Perennial Forbs												
Achillea millefolium	X	X	X			X	X	X	X	X	X	X
Antennaria dimorpha						X	X	X	X	X	X	X
Arenaria franklinii var. *franklinii*						X	X	X	X	X	X	X
Aster canescens		X			X				X	X	X	X
Astragalus lyallii			X									
Astragalus purshii	X	X				X	X	X	X	X	X	X
Astragalus sclerocarpus						X	X	X	X	X	X	X
Astragalus sp.				X								
Balsamorhiza careyanna	X	X		X	X	X	X	X	X	X	X	X
Brodiaea douglasii	X	X		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	X	X
Crepis atrabarba		X	X	X	X	X	X	X	X	X	X	X
Cryptantha leucophaea						X	X	X	X		X	X

Table 7-3 (cont.). Vascular Plants Observed During 1975 - 1986 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Cymopterus terebinthinus	X			X		X	X	X	X	X	X	X
Delphinium nuttallianum				X					X	X	X	X
Erigeron divergens							X					
Fritillaria pudica									X	X	X	X
Lomatium macrocarpum	X		X		X	X	X	X	X	X	X	X
Lomatium sp.				X								
Oenothera pallida	X	X	X	X	X	X	X	X	X	X	X	X
Penstemon acuminatus							X	X	X	X	X	X
Penstemon sp.						X						
Phlox longifolia	X	X	X	X	X	X	X	X	X	X	X	X
Psoralea lanceolata	X	X	X	X	X		X	X	X	X	X	X
Rumex venosus				X		X	X	X	X	X	X	X
Sphaeralcea munroana								X	X		X	X
Shrubs, subshrubs, cacti												
Artemisia tridentata	X	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus nauseosus	X	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus viscidiflorus	X	X	X	X		X	X	X	X	X	X	X
Eriogonum niveum	X	X	X	X	X	X	X	X	X	X	X	X
Leptodactylon pungens									X	X		
Opuntia polyacantha	X			X		X	X	X	X	X	X	X
Purshia tridentata	X	X	X	X	X	X	X	X	X	X	X	X
Ribes aureum											X	X

Table 7-4. Herbaceous Cover for Nine Sampling Sites - 1986

	G01	G02	G03	G04	S01	S02	S03	S04	S05	Average
Annual Grasses										
Bromus tectorum	9.40	4.65	13.25	7.35	17.45	1.85	7.20	9.05	13.05	9.25
Festuca octoflora						0.10		2.40		0.28
Total Annual Grass Cover	9.40	4.65	13.25	7.35	17.45	1.95	7.20	11.45	13.05	9.53
Perennial Grasses										
Agropyron spicatum						0.65			1.25	0.21
Oryzopis hymenoides				2.85		0.05				0.32
Poa sandbergii	19.85	38.65		14.65	2.20	9.55	17.25	9.65		12.44
Poa scabrella						0.05				0.01
Stipa comata				8.50		0.45			0.05	1.00
Total Perennial Grass Cover	19.85	38.65		26.00	2.20	10.75	17.25	9.85	1.30	13.98
Annual Forbs										
Amsinckia lycopsoides	0.05	0.05	0.35			0.70	0.10	0.05	1.90	0.36
Cryptantha pterocarya								0.55		0.06
Cryptantha circumscissa	0.10	0.55		0.10	0.95	0.10		0.10	0.15	0.23
Descurainia pinnata	0.30	0.25			2.90	0.50		2.25	0.10	0.70
Draba verna	15.45	19.55	3.40	2.75	2.20	2.40	16.95	1.70	3.60	7.60
Franseria acanthicarpa			3.70	0.75	2.70	1.35	0.05	0.70	3.15	1.40
Gilia sinuata					0.30	0.15			0.15	0.07
Holosteum umbellatum	2.30	2.55	2.85	0.85	1.00	1.60	4.20		1.15	1.83
Layia glandulosa	0.05	0.05								0.01
Mentzelia albicaulis			0.15	0.10	5.85	5.85		0.75	0.65	1.48
Microsteris gracilis	2.00	4.50	10.05	0.05	1.70		2.30	1.00	0.85	2.49
Phacelia linearis		0.05		0.05	0.10	1.95				0.24
Plantago pategonica	0.20	0.05		1.95		0.10	12.55		3.85	2.08
Salsola kali	0.60	0.20	3.4	1.80	6.45	1.75	0.90	1.80	0.35	1.92
Sisymbrium altissimum	5.95	4.8	1.55	0.25	1.25	0.20	0.75	1.35	0.80	1.90
Tragopogon dubius	0.65	1.55		0.05			0.30			0.28
Total Annual Forb Cover	27.65	34.15	25.45	8.70	25.4	16.65	38.10	10.25	16.70	22.65
Perennial Forbs										
Achillea millefolium				0.05		0.30		0.85		0.13
Aster canescens	0.30	0.30		0.80				0.70	0.90	0.33
Astragalus sclerocarpus								3.00		0.33
Balsamorhiza careyana								4.05	0.35	0.49
Brodiaea douglasii							0.05			0.01
Crepis atrabarba										
Cymopteris terebinthinus	0.30	0.85				4.85				0.67
Fritillaria pudica								0.05		0.01
Oenothera pallida	0.65	0.80	0.05	0.40	0.90	0.15	1.75	0.50		0.01
Phlox longifolia				1.30			0.50			0.58
Rumex venosus	1.20				0.25	0.05				1.70
Total Perennial Forb Cover	1.80	1 95	0.05	2.55	1.15	5.35	2.30	9.15	1.25	4.45
TOTAL HERBACEOUS COVER	58.70	79.40	38.75	44.60	46.20	34.70	64.85	40.70	32.30	50.61

Table 7-5. Mean Herbaceous Cover - 1975-1986

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

Table 7-5 (cont.). Mean Herbaceous Cover - 1975-1986

Class	Year	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
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	564.60	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
PG	1984	1.85	8.80	11.55	8.55	0.40	6.23	1.20	4.45		25.00	10.22	6.87
AF	1984	12.35	8.10	11.10	4.00	13.40	9.79	20.65	9.70	19.45	7.95	14.44	11.86
PF	1984	0.30	4.00	0.75	6.55	0.65	2.45	0.70	0.20	1.10	1.25	0.81	1.72
All	1984	56.00	53.65	62.75	55.40	50.95	55.75	83.40	85.65	81.40	43.80	73.56	63.67

Table 7-5 (cont.). Mean Herbaceous Cover - 1975-1986

Class	Year	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
AG	1985	2.10	2.15	14.60	4.95	27.05	10.17	8.00	8.10	18.30	7.25	10.41	10.28
PG	1985	1.05	4.70	17.85	2.40	1.85	5.57	9.20	17.95	0.00	13.90	10.26	7.66
AF	1985	0.70	1.35	9.40	2.30	4.75	3.70	18.20	8.15	7.55	3.05	9.24	6.16
PF	1985	0.00	1.35	1.15	3.00	0.25	1.15	0.80	0.10	2.35	0.90	1.04	1.10
All	1985	3.85	9.55	43.00	12.65	33.90	20.59	36.20	34.30	28.20	25.10	30.95	25.19
AG	1986	17.45	1.95	7.20	11.45	13.05	10.22	9.40	4.65	13.25	7.35	8.66	9.53
PG	1986	2.20	10.75	17.25	9.85	1.30	8.27	19.85	38.65	0.00	26.00	21.13	13.98
AF	1986	25.40	16.65	38.10	10.25	16.70	21.42	27.65	34.15	25.45	8.70	23.99	22.56
PF	1986	1.15	5.35	2.30	9.15	1.25	3.84	1.80	1.95	0.05	2.55	1.59	2.84
All	1986	46.20	34.70	64.85	40.70	32.30	43.75	58.70	79.40	38.75	44.60	55.36	48.91

Table 7-6. Mean Frequency Values (%) by Species for Each Sampling Site - 1986

	G01	G02	G03	G04	S01	S02	S03	S04	S05
Annual Grasses									
Bromus tectorum	96	96	100	74	96	44	100	82	94
Festuca octoflora						4		66	
Perennial Grasses									
Agropyron spicatum						6			2
Oryzopis hymenoides				16		2			
Poa sandbergii	88	100		90	20	38	98	42	
Poa scabrella						2			
Stipa comata				52		8			2
Annual Forbs									
Amsinckia lycopsoides	2	2	4			18	4	2	28
Cryptantha circumscissa	4	12		4	28	4		4	6
Cryptantha pterocarya								22	
Descurainia pinnata	12	10			58	20		60	4
Draba verna	98	98	76	70	68	28	100	68	94
Franseria acanthicarpa			78	30	50	26	2	28	48
Gilia sinuata					2	6			6
Holosteum umbellatum	92	82	84	34	40	24	88		36
Layia glandulosa	2	2							
Mentzelia albicaulis			6	4	60	62		30	16
Microsteris gracilis	60	90	100	2	38		72	30	24
Phacelia linearis		2		2	4	38			
Plantago pategonica	8	2		38		4	84		54
Salsola kali	24	8	78	44	92	40	36	52	14
Sisymbrium altissimum	88	82	42	10	10	8	10	34	12
Tragopogon dubius	26	42		2			12		
Perennial Forbs									
Achillea millefolium				2		2		24	
Aster canescens	2	2		22				28	36
Astragalus sclerocarpus								16	4
Balsamorhiza careyana								10	
Brodiaea douglasii							2		
Crepis atrabarba									
Cymopteris terebinthinus	2	6				24			
Fritillaria pudica								2	
Oenothera pallida	26	32	2	6	26	6	40	20	
Phlox longifolia				22			10		
Rumex venosus	8				10	2			
TOTAL SPECIES PER SITE	17	17	10	19	15	23	14	19	17

Table 7-7. Mean Herbaceous Phytomass for 1986

Date	Site	Plot	Wt.(g)	Wt./ Sq. Meter
5/14/86	G01	20-6	6.25	62.50
	G01	3-14	3.87	38.70
	G01	10-3	2.17	21.70
	G01	9-18	4.80	48.00
	G01	2-19	8.10	81.00
		AVG	5.04	50.38
		STD	2.02	20.24
5/14/86	G02	21-6	4.15	41.50
	G02	10-4	7.23	72.30
	G02	4-18	4.13	41.30
	G02	2-9	7.24	72.40
	G02	24-9	8.00	80.00
		AVG	6.15	61.50
		STD	1.66	16.65
5/15/86	G03	13-14	2.12	21.20
	G03	2-9	4.73	47.30
	G03	1-11	2.28	22.80
	G03	21-7	5.31	53.10
	G03	11-7	1.35	13.50
		AVG	3.16	31.58
		STD	1.56	15.63
5/09/86	G04	2-16	1.74	17.40
	G04	15-3	1.66	16.60
	G04	13-19	3.55	35.50
	G04	14-6	2.07	20.70
	G04	9-18	8.53	85.30
		AVG	3.51	35.10
		STD	2.60	26.01

Mean G01-G04 44.64 Grams/sq. meter

Mean S01-S05 74.55 Grams/sq. meter

Date	Site	Plot	Wt.(g)	Wt./ Sq. Meter
5/15/86	S01	6-18	5.16	51.60
	S01	11-5	1.97	19.70
	S01	1-8	3.34	33.40
	S01	5-16	1.84	18.40
	S01	9-3	5.11	51.10
		AVG	3.48	34.84
		STD	1.45	14.47
5/07/86	S02	3-9	3.89	38.90
	S02	5-23	1.93	19.30
	S02	19-6	44.06	440.60
	S02	18-4	5.13	51.30
	S02	12-2	0.89	8.90
		AVG	11.18	111.80
		STD	16.51	165.06
5/16/86	S03	7-3	1.30	13.00
	S03	16-20	3.68	36.80
	S03	19-5	2.62	26.20
		AVG	2.53	25.33
		STD	0.97	9.74
5/5/86	S04	5-21	0.72	7.20
	S04	18-9	2.14	21.40
	S04	1-7	3.17	31.70
	S04	20-7	75.18	751.80
		AVG	17.65	176.50
		STD	28.84	288.41
5/16/86	S05	1-8	4.97	49.70
	S05	3-6	1.88	18.80
	S05	5-18	0.73	7.30
	S05	6-7	2.67	26.70
	S05	19-3	1.89	18.90
		AVG	2.43	24.28
		STD	1.41	14.14

Table 7-8. Comparison of Herbaceous Phytomass for 1975 - 1986

	Mean Dry Weight (g/m^2)											
SITE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
G01	359	108	21	166	64	160	200	90	77	94	70	50
G02	302	258	11	162	37	68	255	60	137	116	27	61
G03	-	-	-	-	-	53	261	62	64	133	12	32
G04	-	-	-	-	-	79	159	113	82	67	37	35
S01	126	137	4	173	21	36	180	98	171	104	5	35
S02	144	98	7	128	28	63	115	24	232	57	1	112
S03	88	177	7	115	16	43	31	22	54	95	27	25
S04	-	-	-	-	-	78	52	39	68	93	11	176
S05	-	-	-	-	-	71	81	184	136	43	61	42

Table 7-9. Summary of Shrub Density for 1986

Site	Species*	1	2	3	4	Total	S/Ha	S/a
S01	ARTR	2	0	4	1	7	70	28
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	1	1	1	0	3	30	12
	ERNI	18	8	5	14	45	450	182
						55	550	222
S02	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	0	0	0	0	0
						0	0	0
S03	ARTR	15	8	10	10	43	430	175
	CHNA	2	3	1	4	10	100	18
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	1	0	0	0	0
						53	530	183
	ERNI	1	1	0	0	2	20	8
	OPPO	2	0	0	2	2	20	8
						57	570	199
S04	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	0	0	0	0	0
						0	0	0
S05	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	1	2	20	8
	CHVI	0	0	0	1	1	10	4
	PUTR	1	2	4	0	7	70	28
						10	100	40
	ERNI	68	25	3	1	97	970	392
	OPPO	16	10	22	7	35	550	223
						162	1620	656

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

Table 7-10. Summary of Shrub Cover (%) at Five Stations for 1986

SHRUBS	S01	S02	S03	S04	S05	X
Artemisia tridentata	-	-	5.40	-	-	1.08
Chrysothamnus nauseosus	-	-	1.20	-	.32	0.30
Chrysothamnus viscidiflorus	-	-	-	-	0.22	0.04
Purshia tridentata	-	-	-	-	-	-
TOTAL SHRUB COVER	0.00	0.00	6.60	0.00	0.54	1.43
SUBSHRUB						
Eriogonum niveum	0.21	-	-	-	3.08	0.69
CACTUS						
Opuntia polyacantha	-	-	-	-	0.47	0.09
TOTAL COVER	0.21	0.00	6.60	0.00	4.09	2.18

Table 7-11. Summary of Soil Chemistry for 1986

	G01	G02	G03	G04	S01	S02	S03	S04	S05
pH (1:2 soil to water)	7.17	7.18	6.97	7.01	6.81	7.94	7.29	7.22	7.02
Conductivity (1:2 soil to water) umhos/cm	37.8	28.1	25.8	50.8	21.0	26.1	13.7	24.2	13.6
Sulfate ug/gm	4.88	3.04	5.44	7.96	2.84	2.80	2.16	2.84	0.88
Chloride ug/gm	4.80	4.48	5.92	4.56	4.56	5.76	4.80	5.92	4.56
Copper ug/gm	14.29	16.90	10.62	13.87	14.45	14.34	12.86	17.06	10.72
Lead ug/gm	4.54	1.66	1.37	2.39	1.81	1.77	1.70	1.99	1.83
Cadmium ug/gm	0.05	0.07	0.04	0.06	0.06	0.03	0.05	0.05	0.04
Chromium ug/gm	13.10	11.01	8.01	7.32	9.52	10.22	8.72	10.69	7.65
Nickel ug/gm	23.43	15.16	12.41	21.53	16.76	19.08	10.88	11.80	11.10
Zinc ug/gm	54.01	51.19	43.95	51.60	50.47	37.52	56.35	56.61	56.22
Sodium %	0.018	0.020	0.013	0.013	0.017	0.008	0.018	0.017	0.017
Potassium %	0.187	0.143	0.096	0.080	0.099	0.052	0.095	0.122	0.092
Calcium %	0.32	0.57	0.34	0.34	0.35	0.44	0.37	0.36	0.34
Mercury ug/gm	0.007	0.005	0.002	0.003	0.006	0.004	0.003	0.005	0.004
Fluoride ug/gm	207	189	204	184	201	174	167	186	218
Bicarbonate (meq/HCO_3/gm)	0.0021	0.0025	0.0015	0.0014	0.0007	0.0024	0.0010	0.0006	0.0006
Magnesium %	0.49	0.50	0.41	0.38	0.45	0.35	0.42	0.43	0.40

Table 7-12. Summary of Vegetation Chemistry for 1986

	Site	POSA(1)	BRTE(1)	SIAL(1)	PHLO(1)	PUTR(1)	ARTR(1)
Copper (ug/g)	G01	2.49	4.07	5.23	4.92		
	G02	8.25	4.68	4.10	4.50		
	G03	4.90	14.62	7.89		8.52	
	G04	7.79	10.12	15.98	6.38		
	S01	3.38	6.75	3.08	8.28		
	S02	9.12	4.50		3.06	4.74	
	S03	4.02	5.53		12.04		6.80
	S04	5.07	6.18	6.32	7.44		
	S05	5.40	6.30			4.00	6.38
Extractable Sulfate (%)	G01	0.000	0.068	0.596	0.000		
	G02	0.170	0.294	0.793	0.000		
	G03	0.000	0.026	0.822		0.000	
	G04	0.000	0.078	0.524	0.000		
	S01	0.000	0.019	0.564	0.096		
	S02	0.037	0.176		0.018	0.000	
	S03	0.026	0.094		0.026		0.000
	S04	0.000	0.000	0.671	0.036		
	S05	0.000	0.079			0.000	0.050
Extractable Chloride (%)	G01	0.13	0.28	0.75	0.16		
	G02	0.47	0.16	0.49	0.14		
	G03	0.33	0.15	0.45		0.17	
	G04	0.15	0.15	0.51	0.14		
	S01	0.13	0.10	0.31	0.19		
	S02	0.14	0.12		0.13	0.19	
	S03	0.17	0.17		0.16		0.85
	S04	0.14	0.40	0.53	0.11		
	S05	0.19	0.15			0.09	0.85

(1) POSA = *Poa Sandbergii*
BRTE = *Bromus tectorum*
SIAL = *Sisymbrium altissimum*
PHLO = *Phlox longifolia*
PUTR = *Purshia tridentata*
ARTR = *Artemisia tridentata*

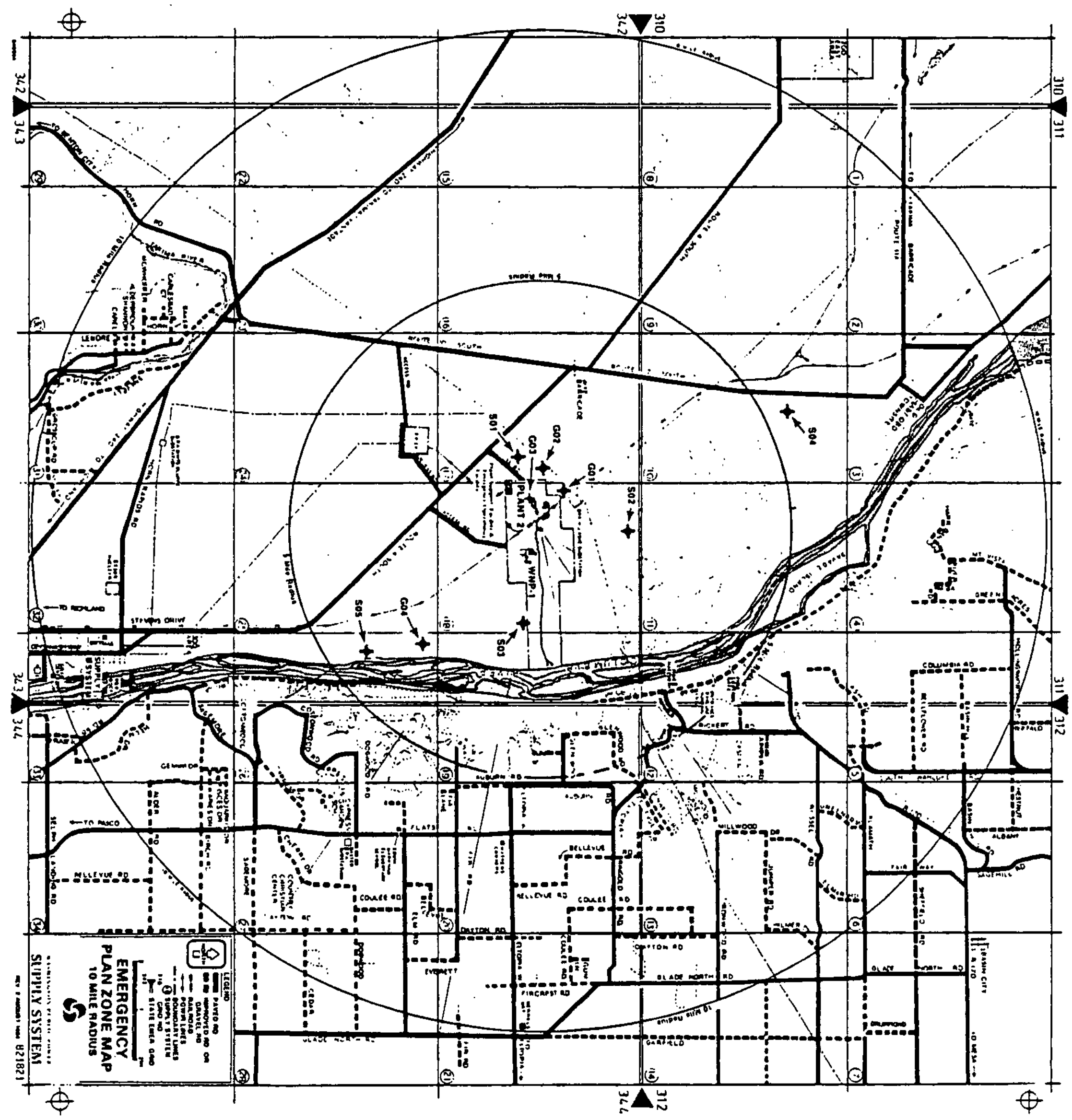


Figure 7-1. Soil and Vegetation Sampling Location Map

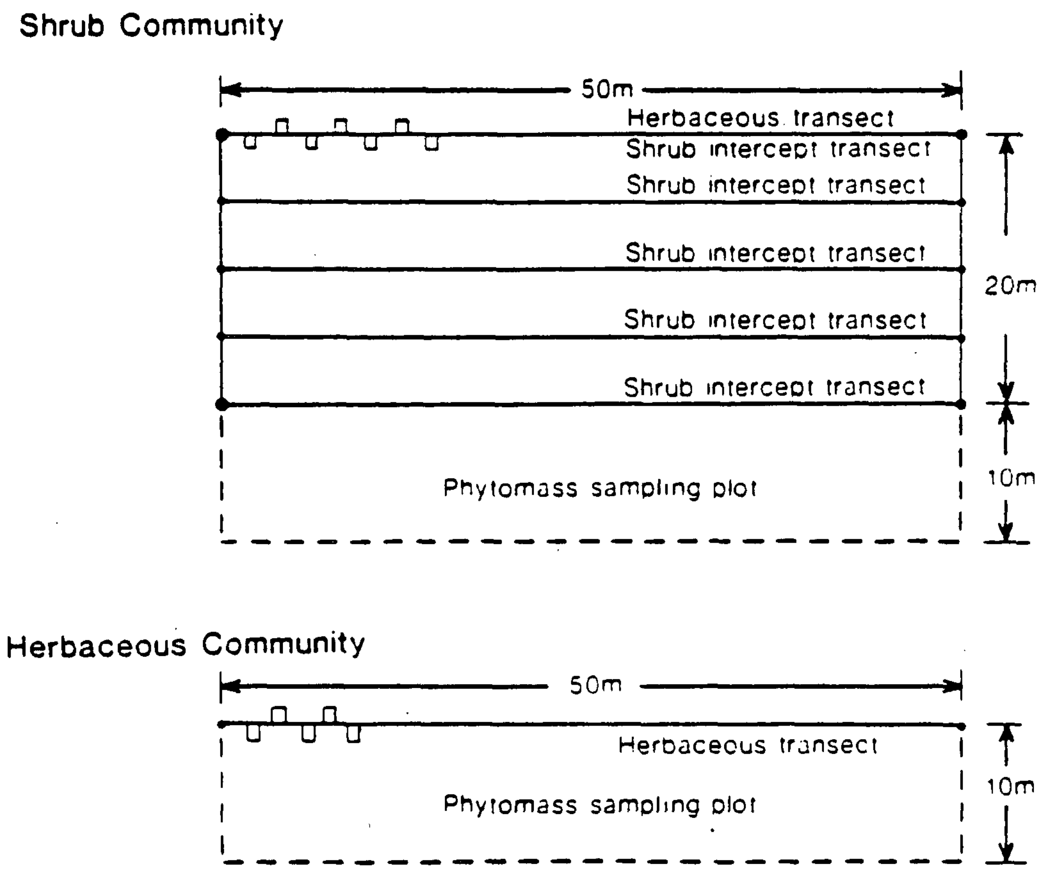


Figure 7-2. Layout of Vegetation and Soil Sampling Plots

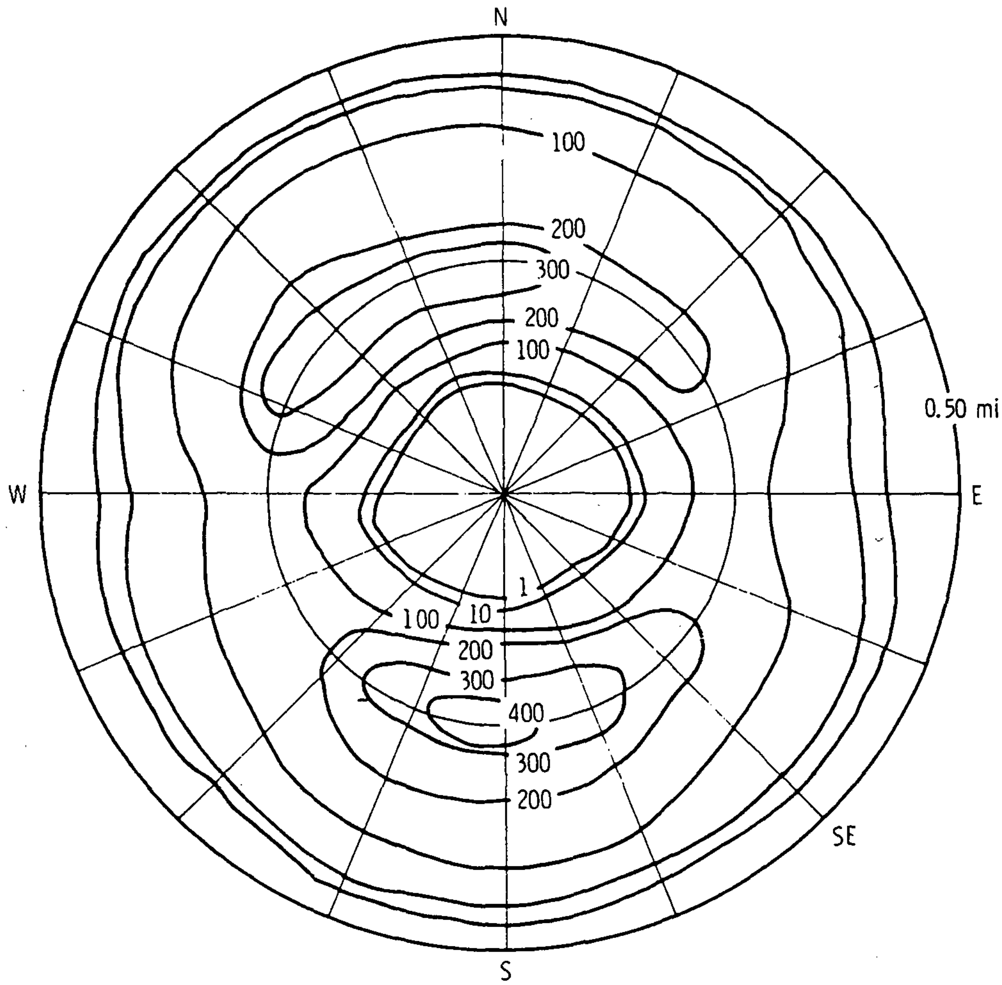


Figure 7-3. Predicted Isopleth of Salt Draft Deposition from WNP-2 Mechanical Draft Cooling Towers

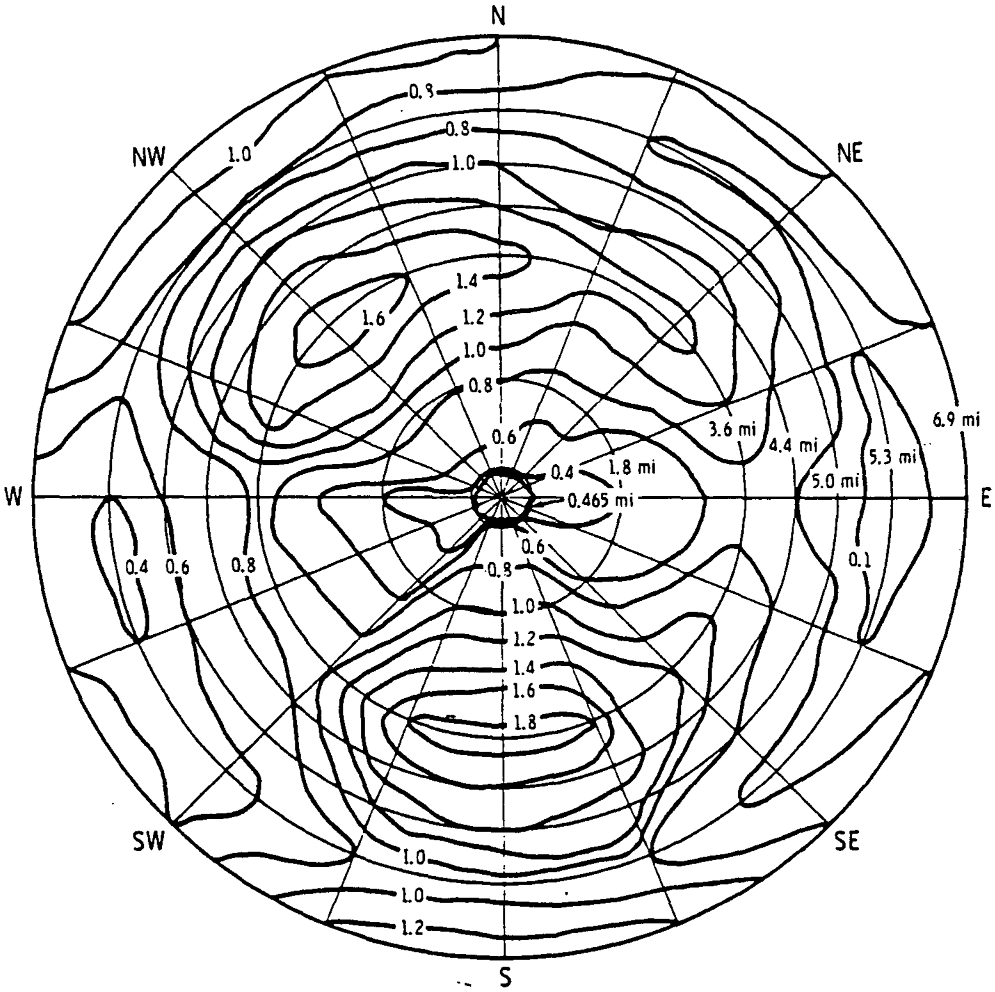


Figure 7-4. Predicted Isopleth of Salt Draft Deposition from WNP-2 Mechanical Draft Cooling Towers

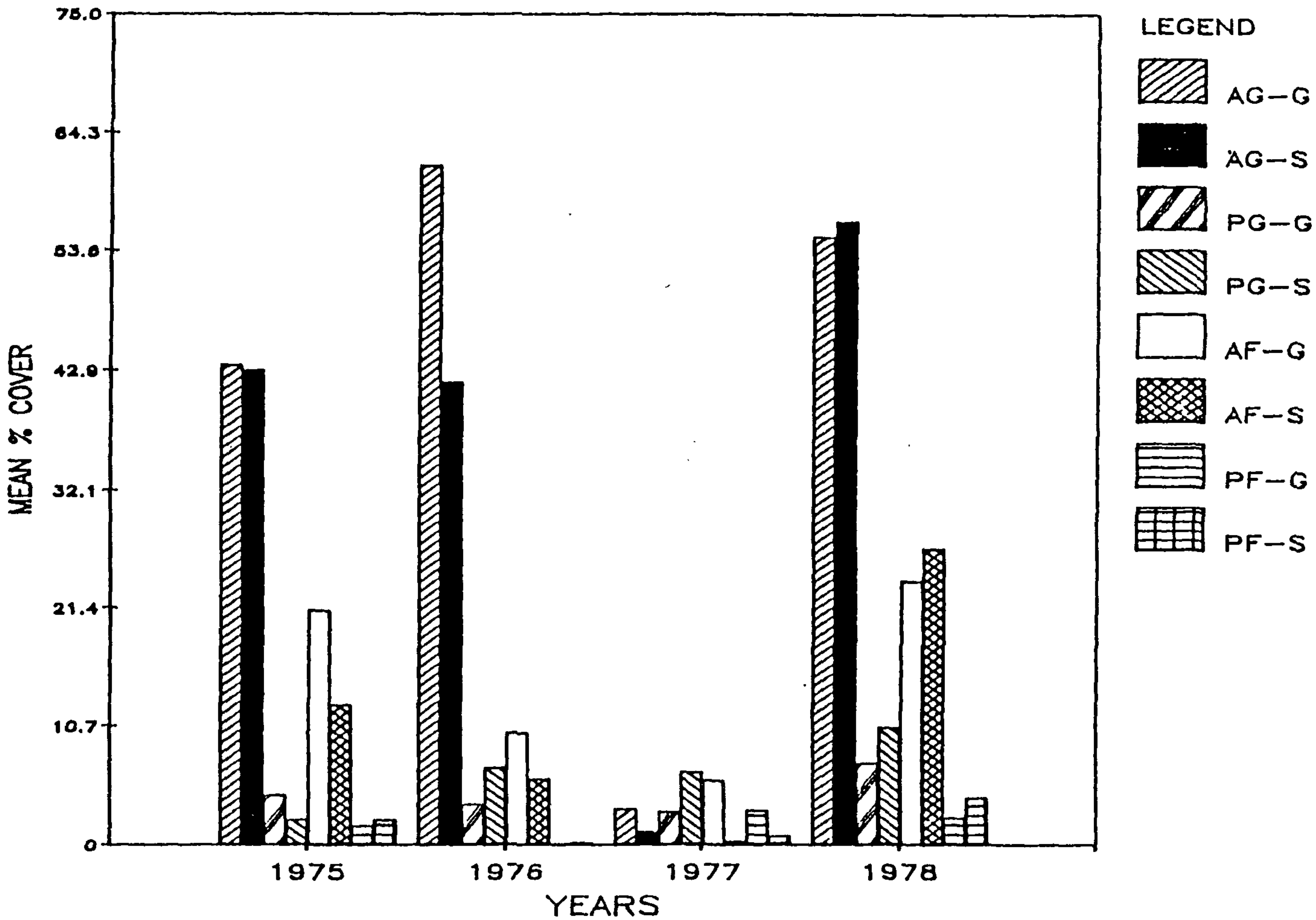


Figure 7-5. Mean Herbaceous Cover - 1975 - 1978

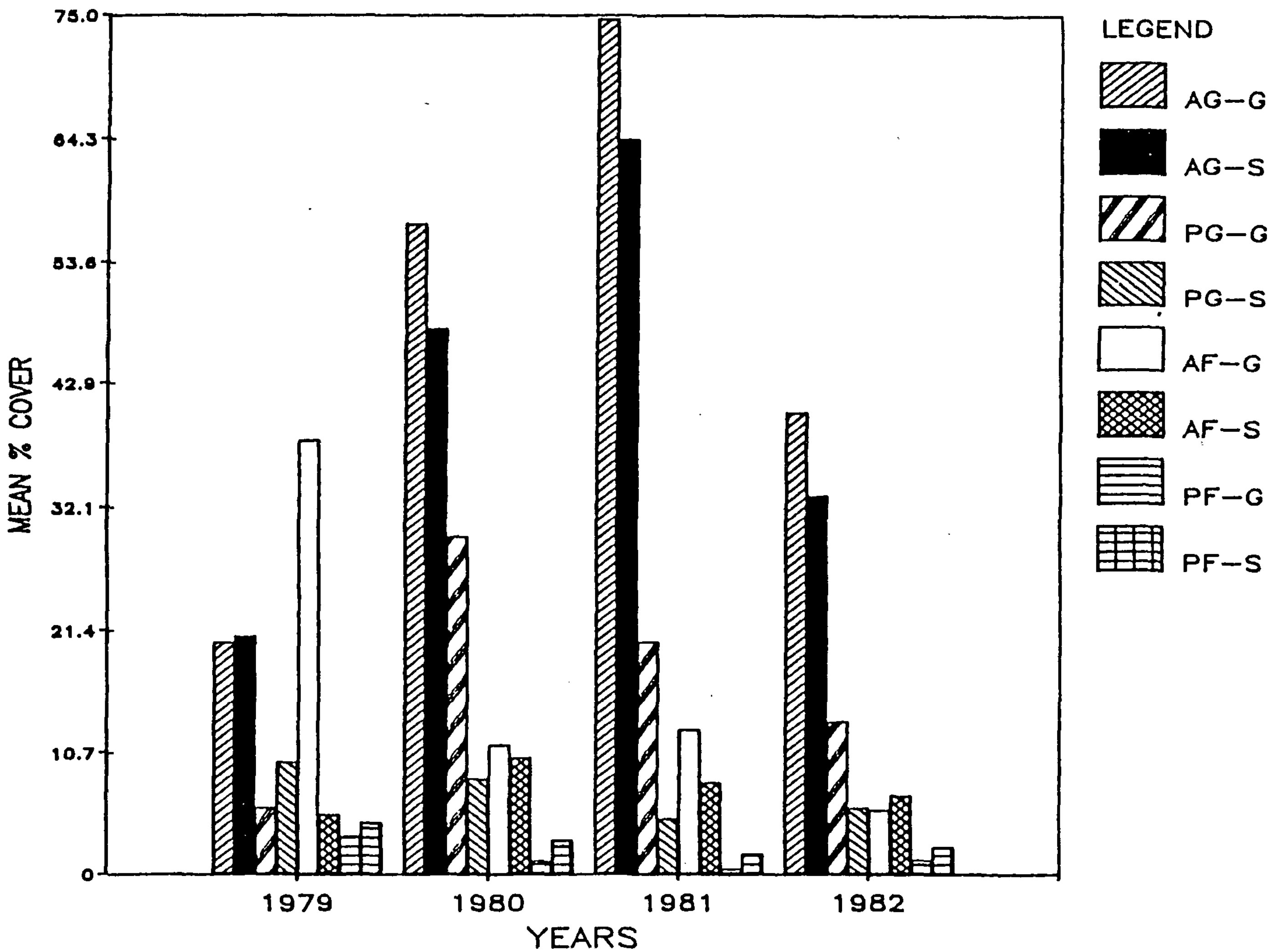


Figure 7-6. Mean Herbaceous Cover - 1979 - 1982

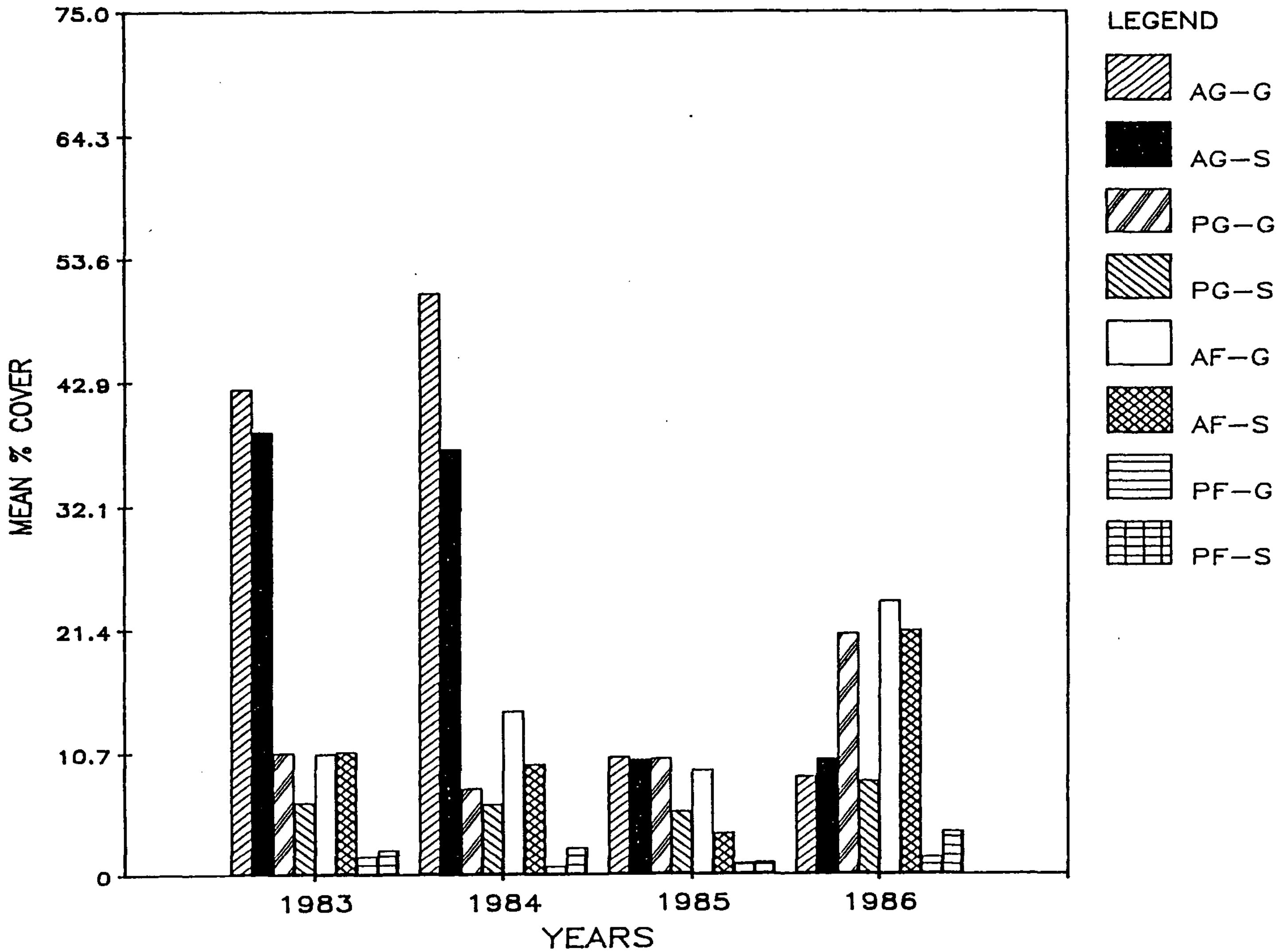


Figure 7-7. Mean Herbaceous Cover - 1983 - 1986

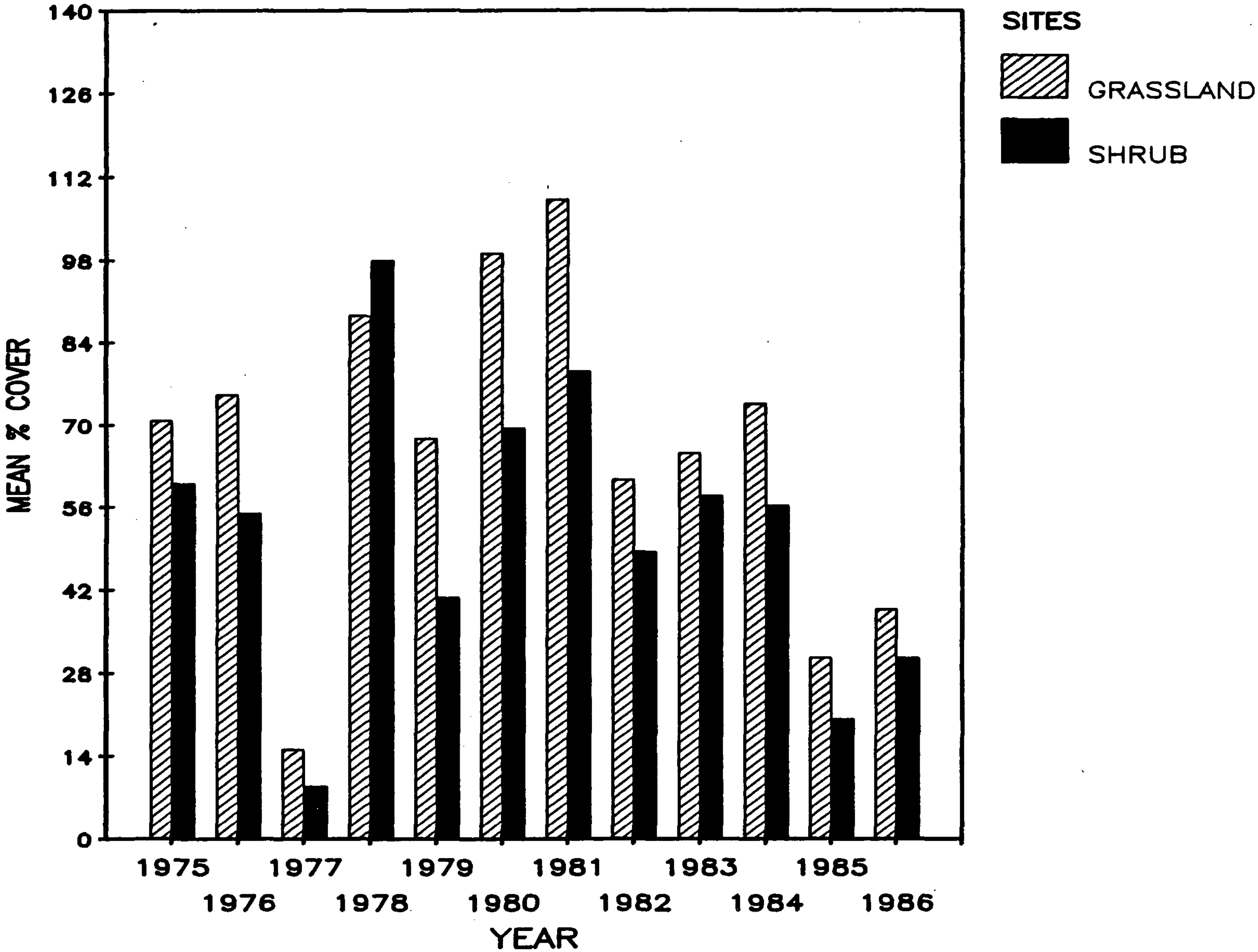


Figure 7-8. Mean Herbaceous Cover - Grassland and Shrub Sites for 1975 - 1986

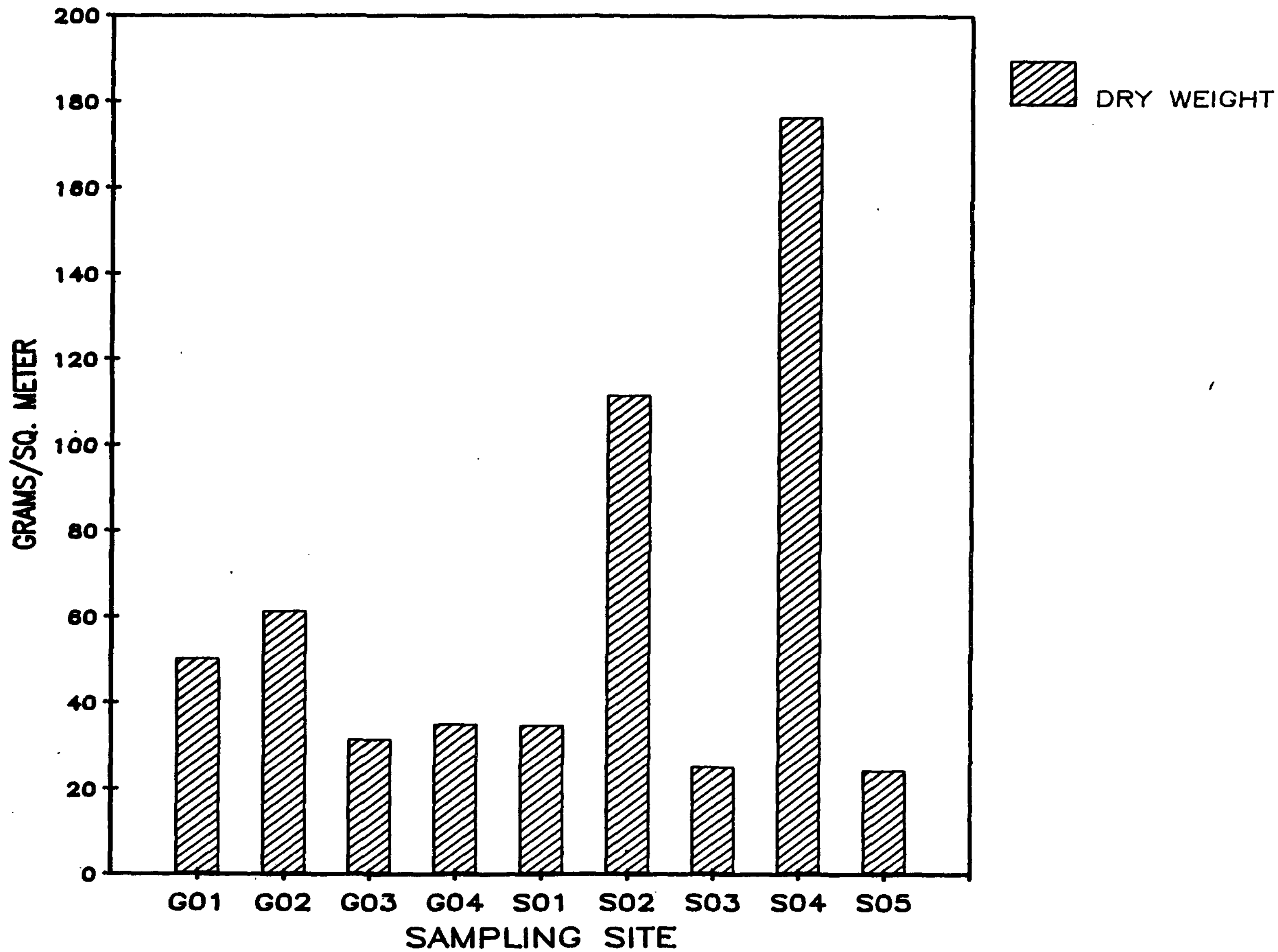


Figure 7-9. Mean Herbaceous Phytomass for May 1986

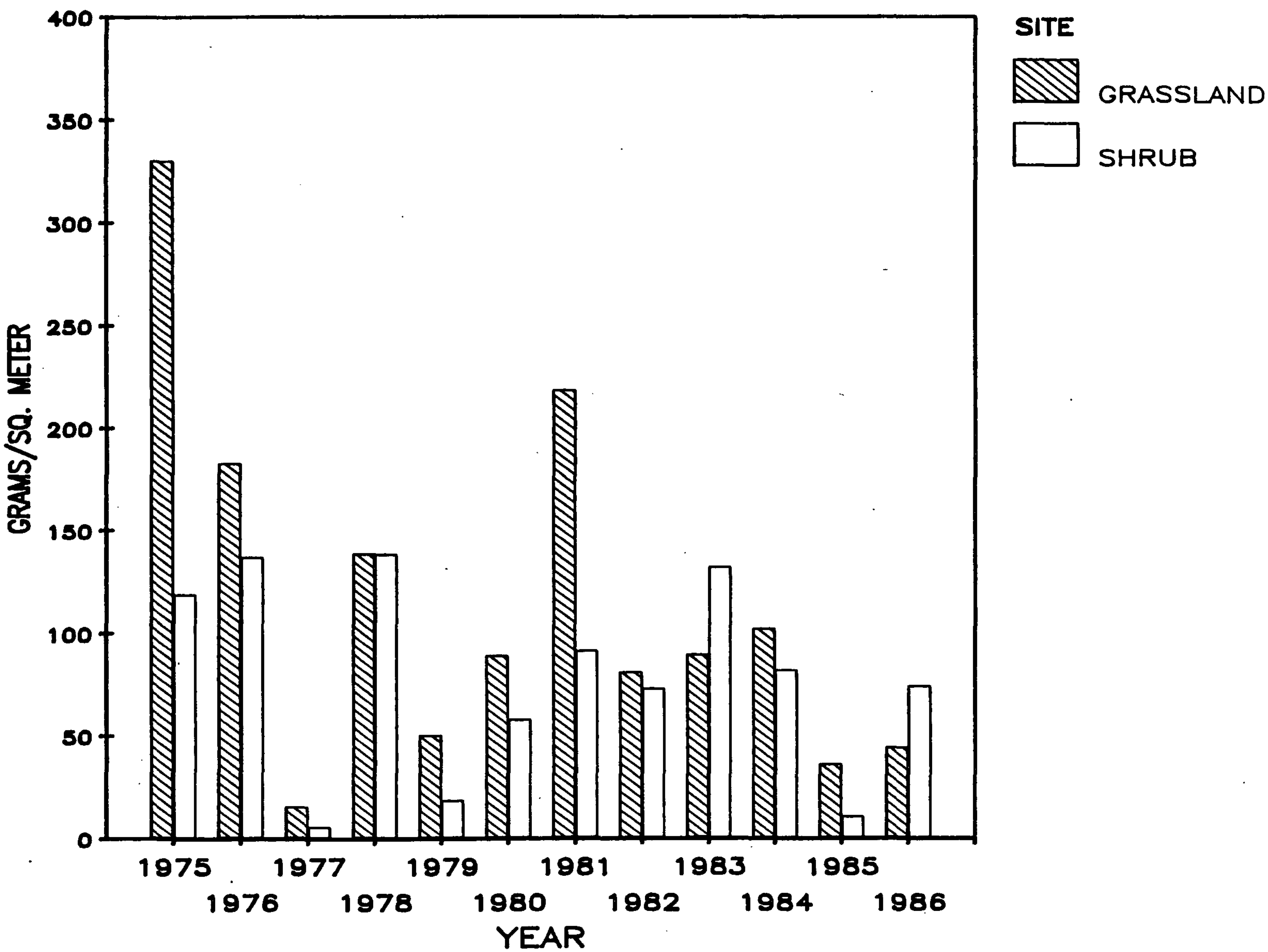


Figure 7-10. Mean Herbaceous Phytomass at Grassland and Shrub Sites for 1975 - 1986

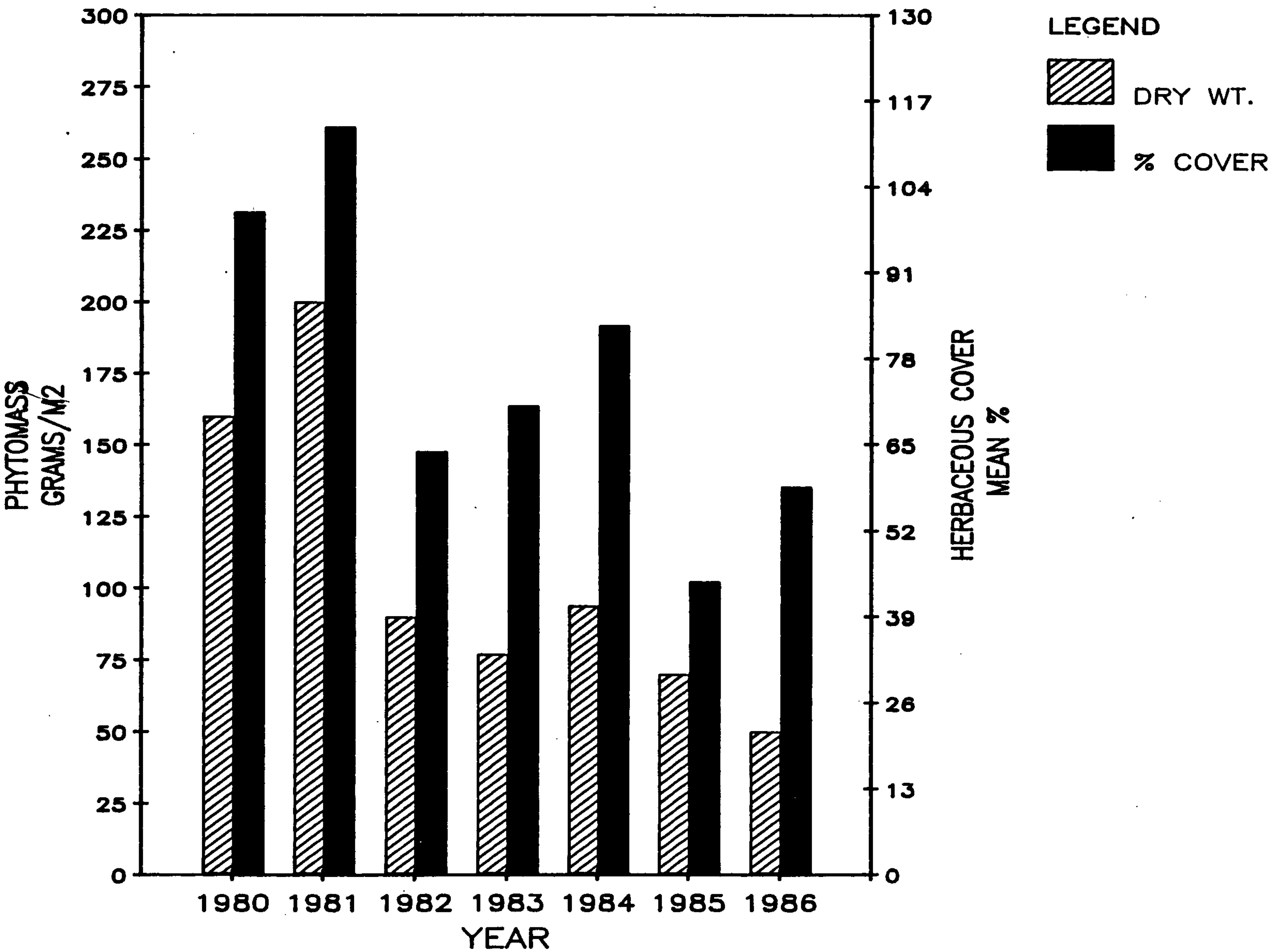


Figure 7-11. Mean Herbaceous Cover and Phytomass for Site G01 for 1980 - 1986

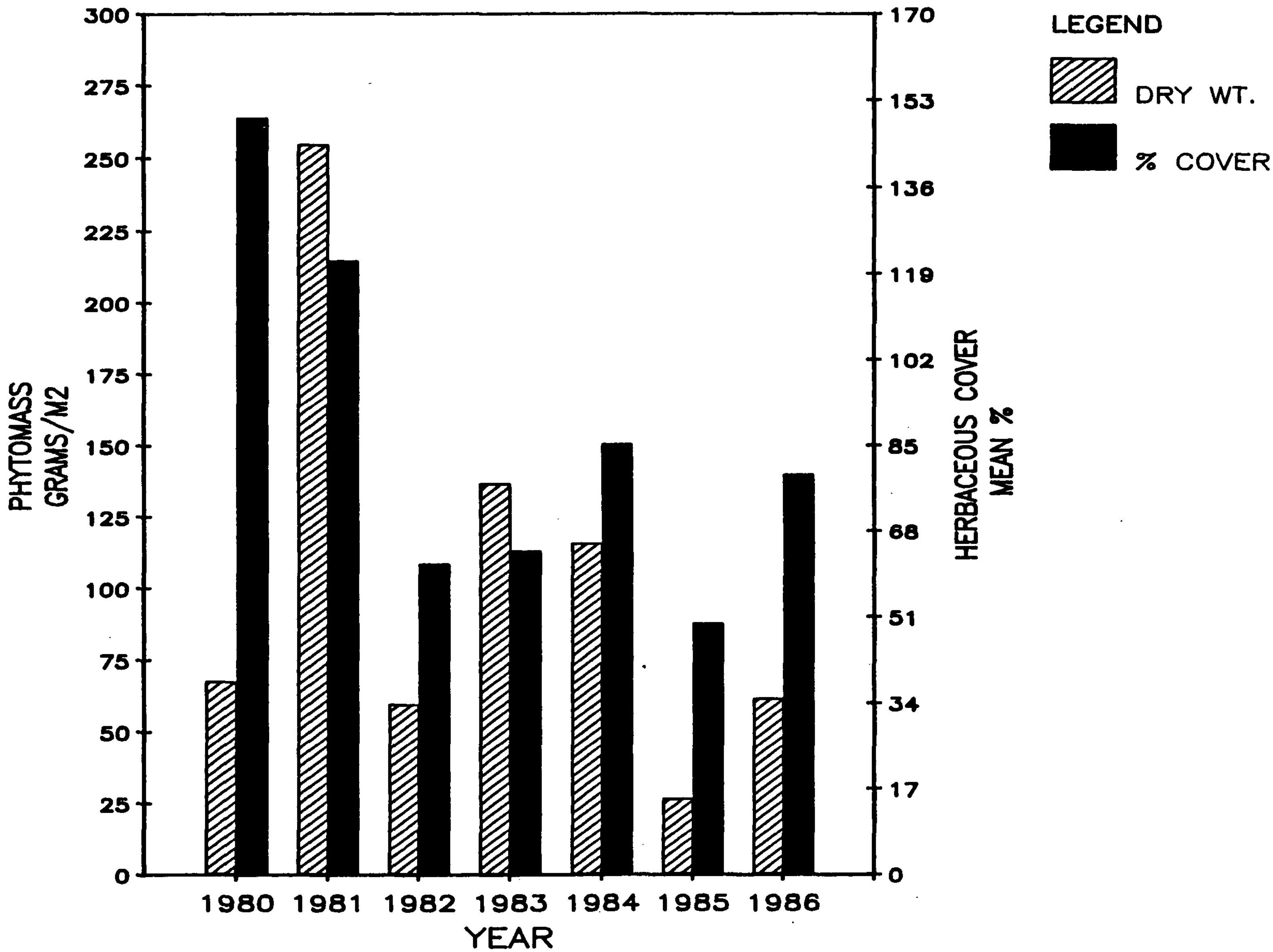


Figure 7-12. Mean Herbaceous Cover and Phytomass for Site G02 for 1980 - 1986

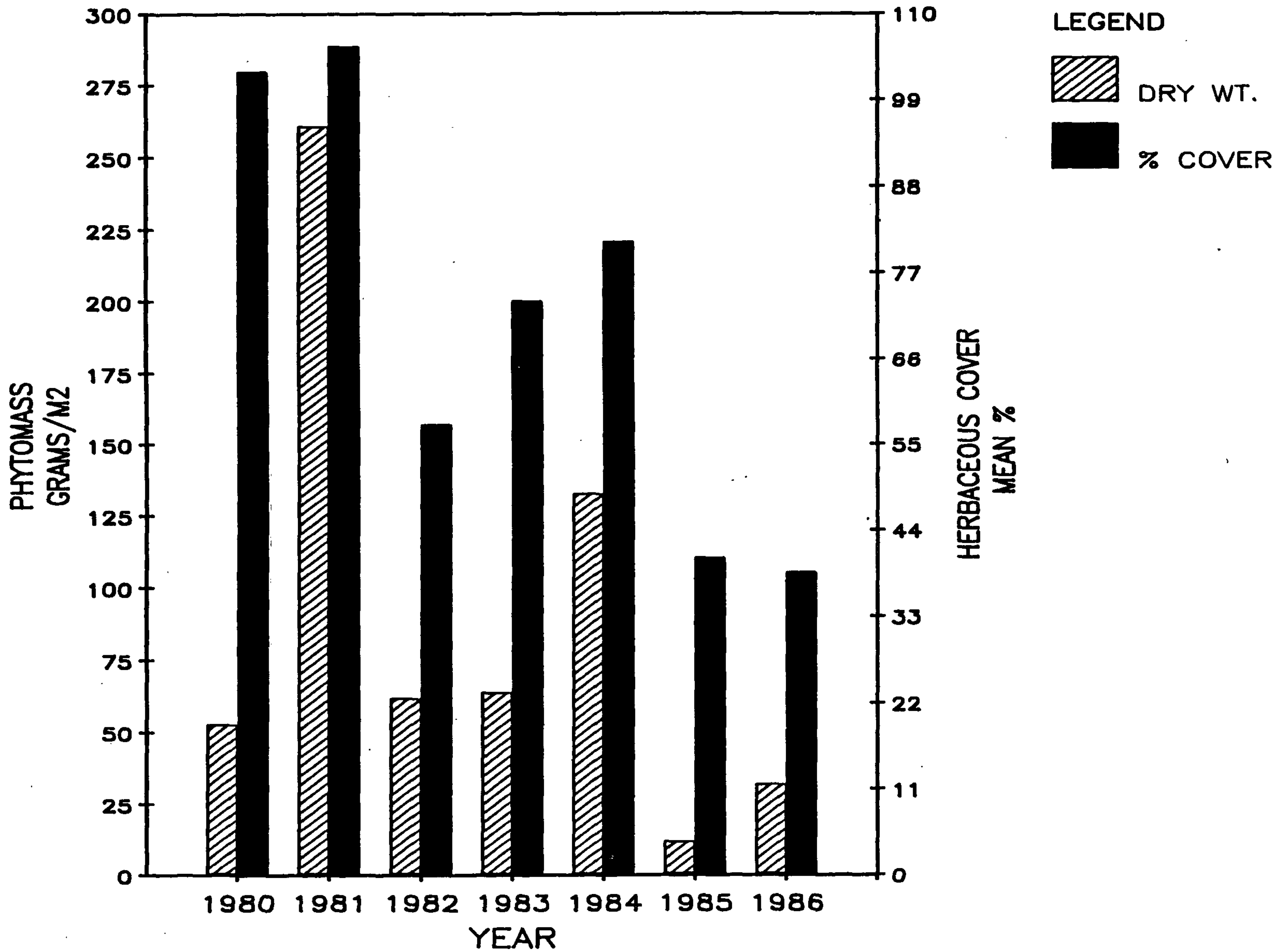


Figure 7-13. Mean Herbaceous Cover and Phytomass for Site G03 for 1980 - 1986

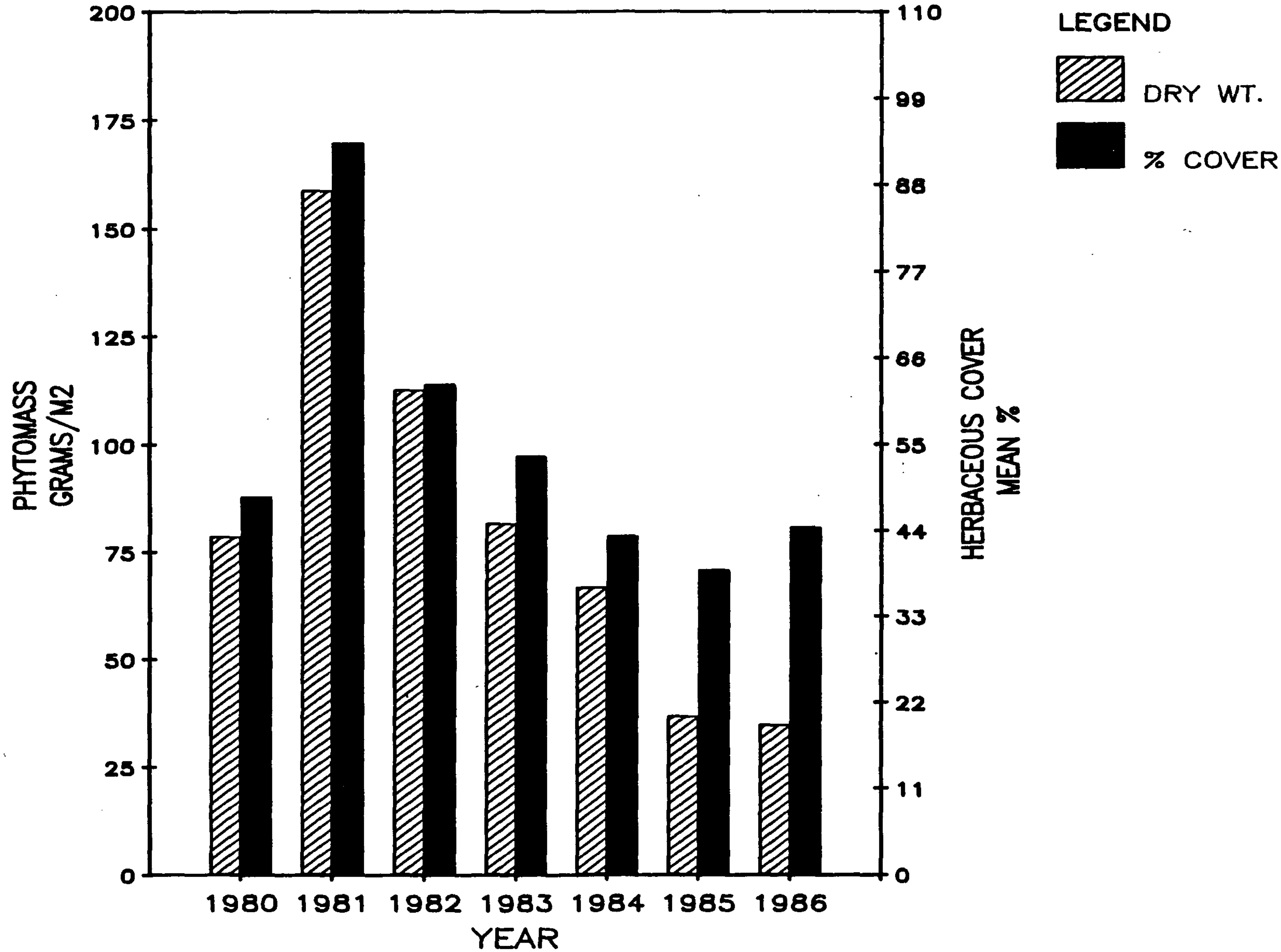


Figure 7-14. Mean Herbaceous Cover and Phytomass for Site G04 for 1980 - 1986

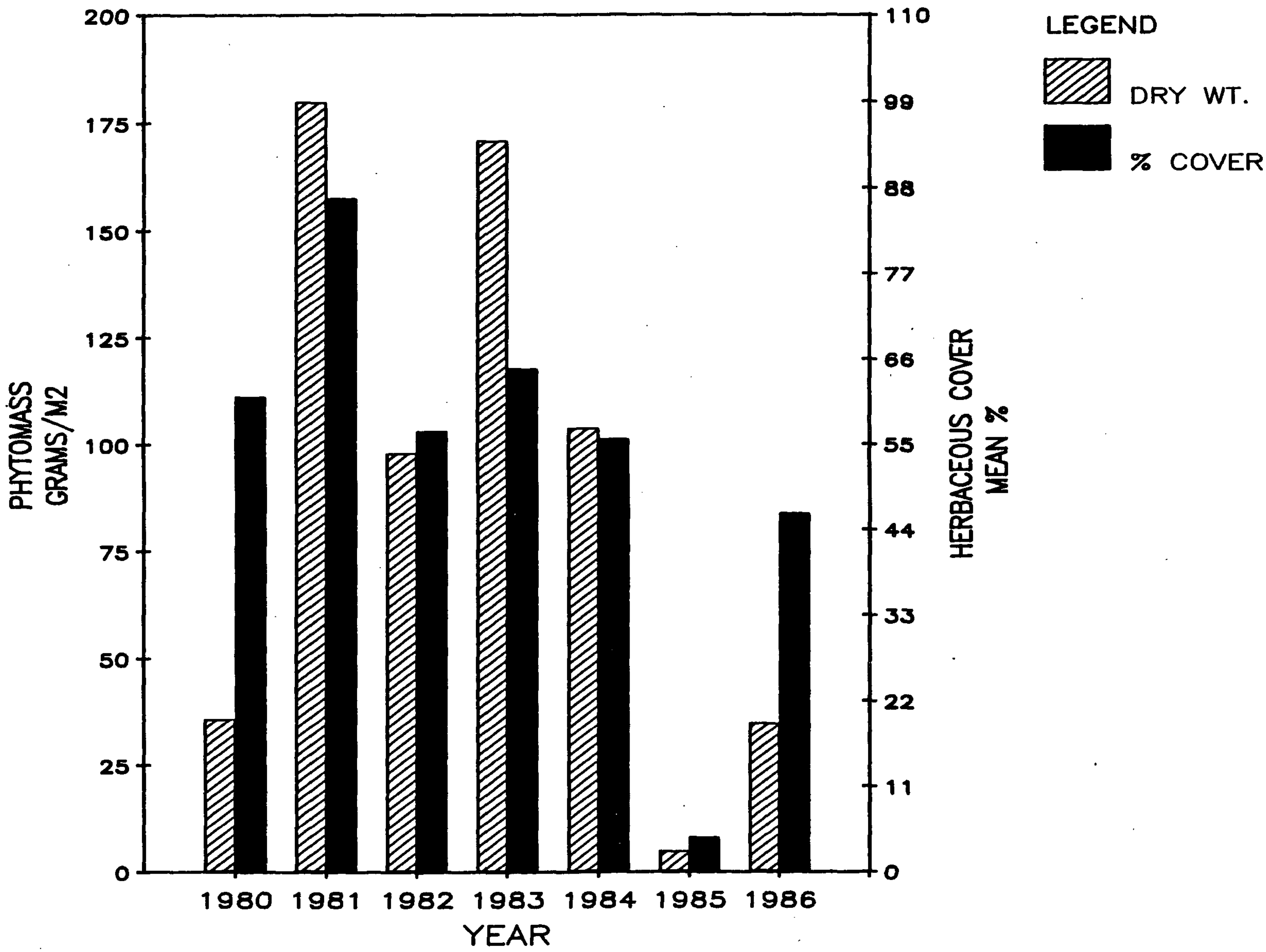


Figure 7-15. Mean Herbaceous Cover and Phytomass for Site S01 for 1980 - 1986

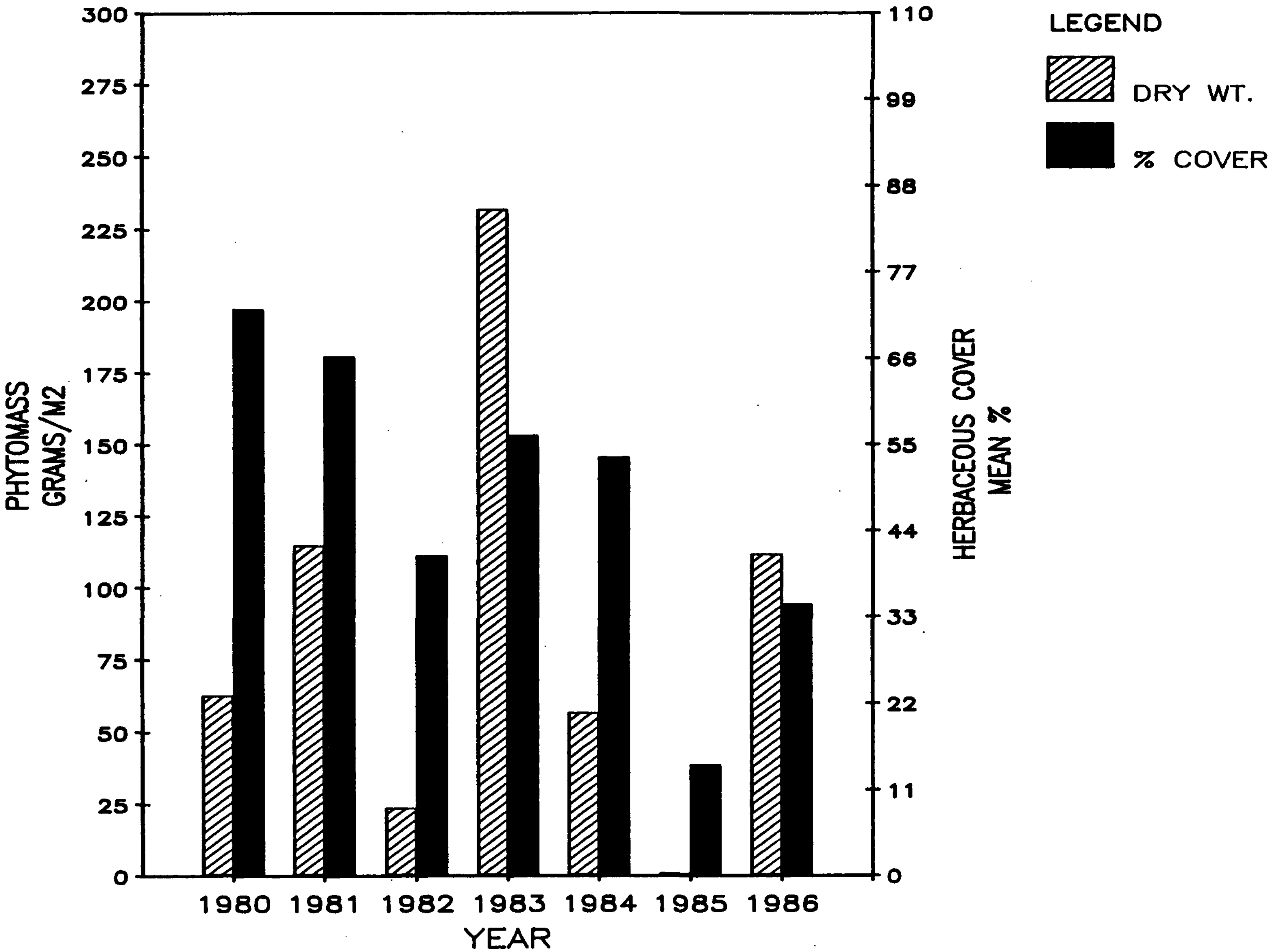


Figure 7-16. Mean Herbaceous Cover and Phytomass for Site S02 for 1980 - 1986

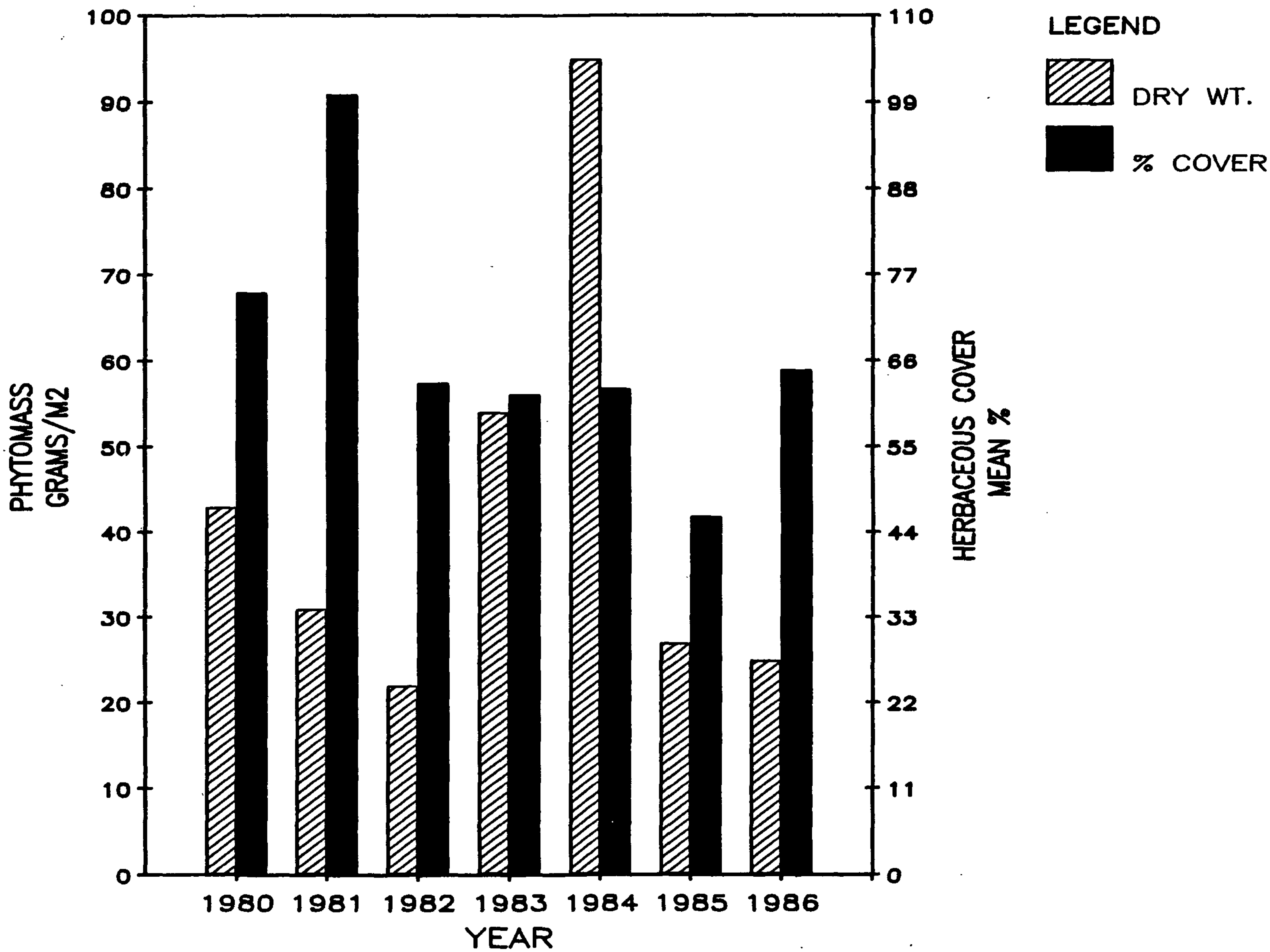


Figure 7-17. Mean Herbaceous Cover and Phytomass for Site S03 for 1980 - 1986

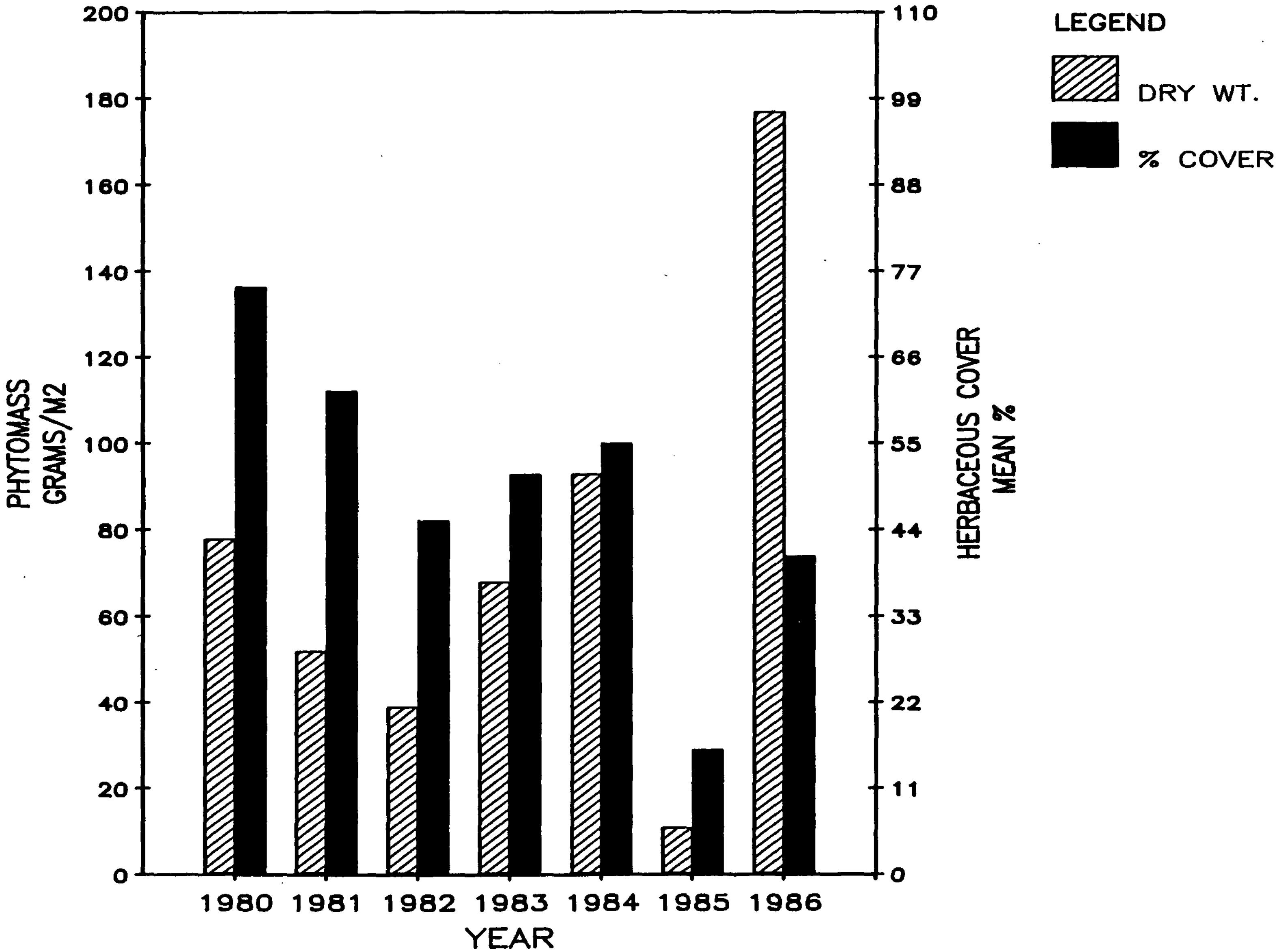


Figure 7-18. Mean Herbaceous Cover and Phytomass for Site S04 for 1980 - 1986

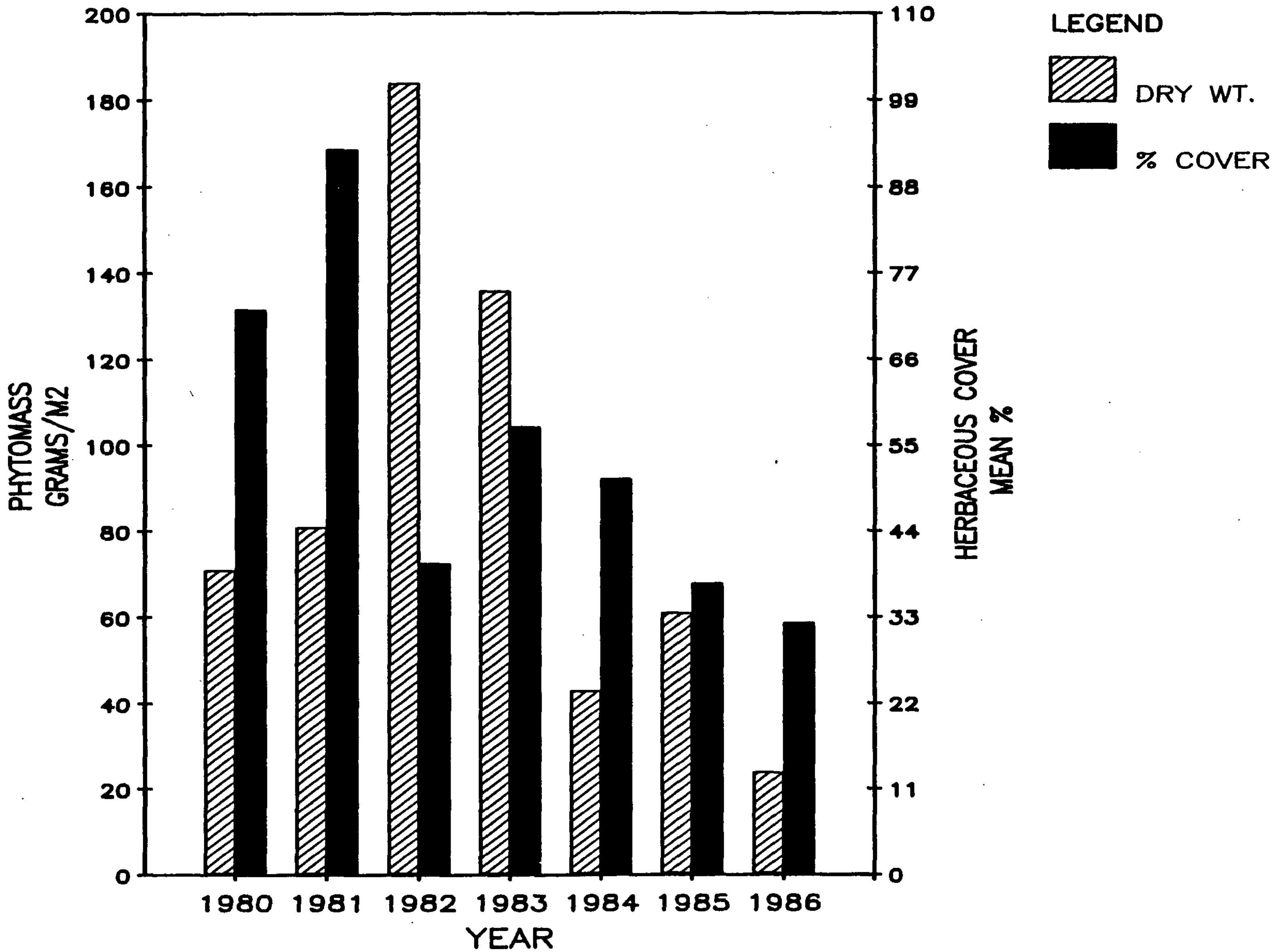


Figure 7-19. Mean Herbaceous Cover and Phytomass for Site S05 for 1980 - 1986

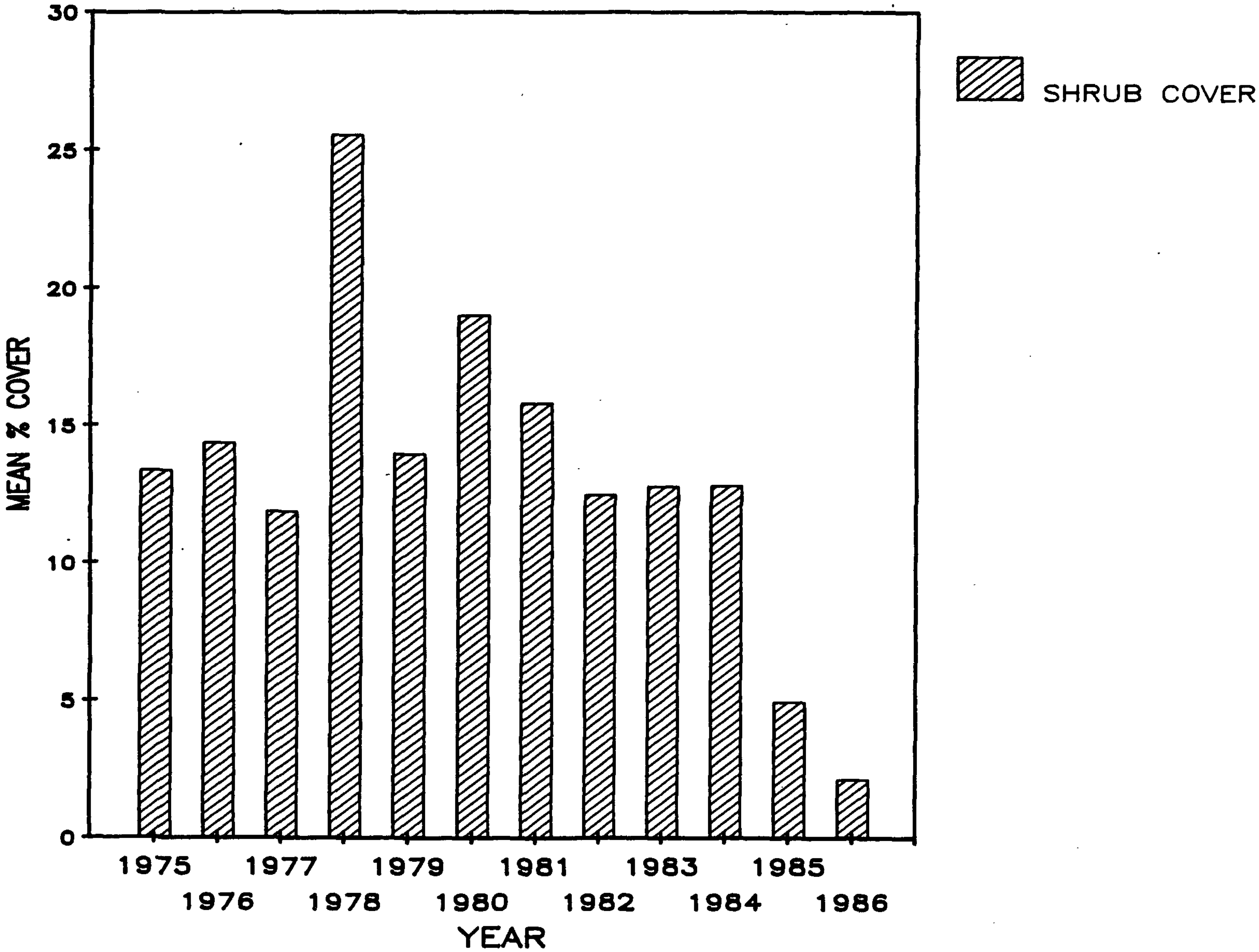


Figure 7-20. Mean Total Shrub Cover for 1975 - 1986

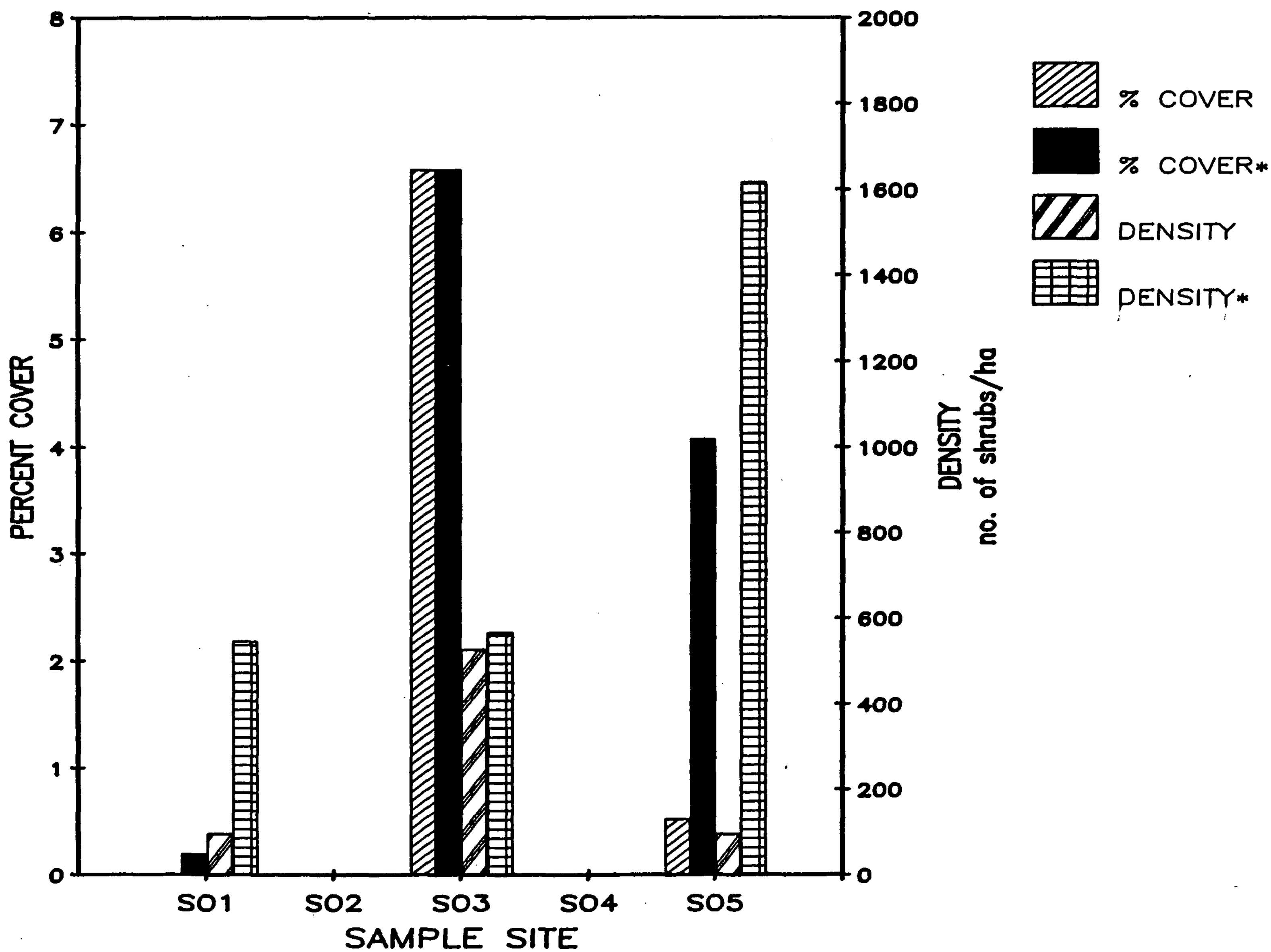


Figure 7-21. Shrub Cover and Shrub Density for May 1986

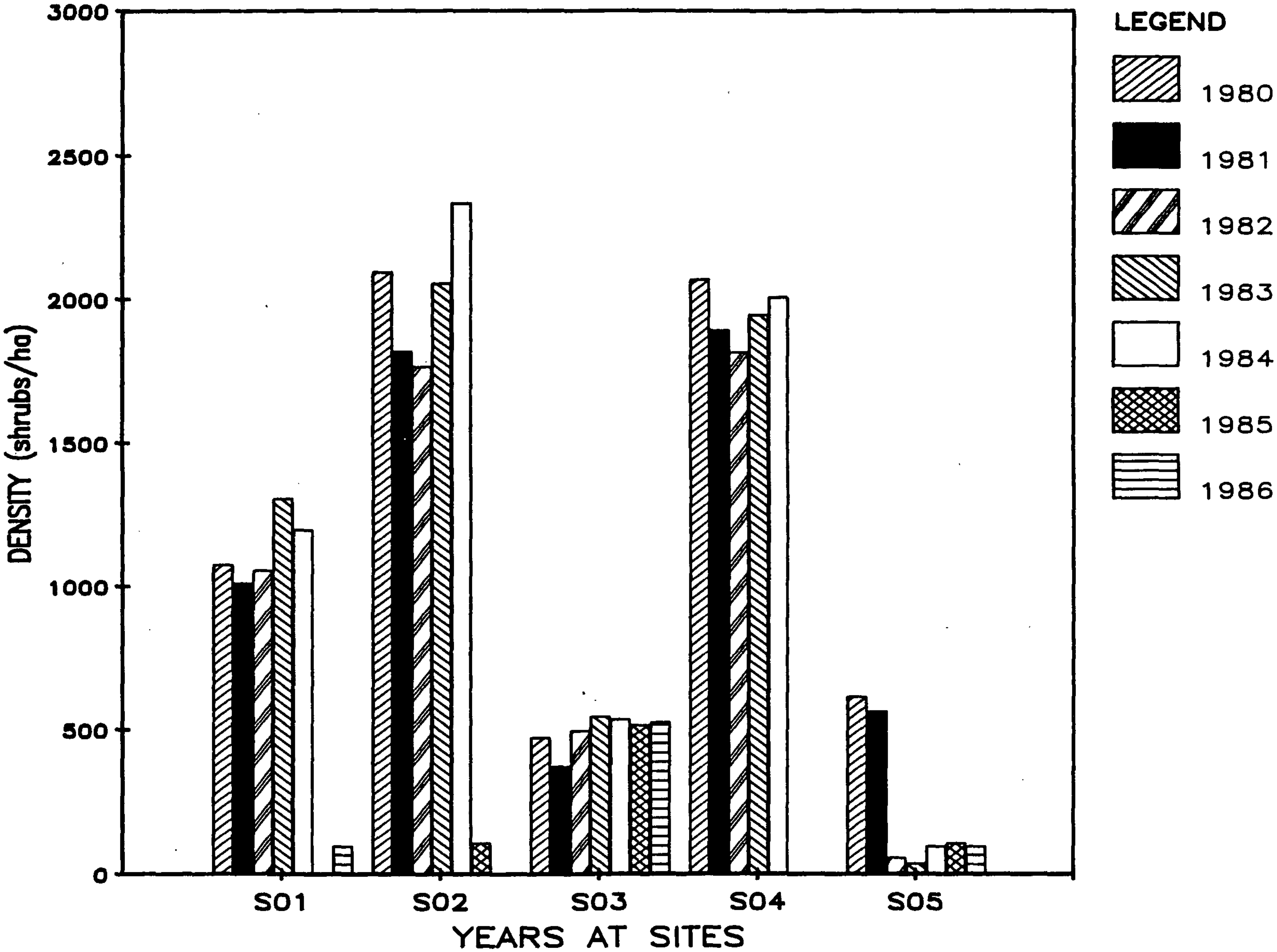


Figure 7-22. Shrub Density at Five Sites for 1980 - 1986

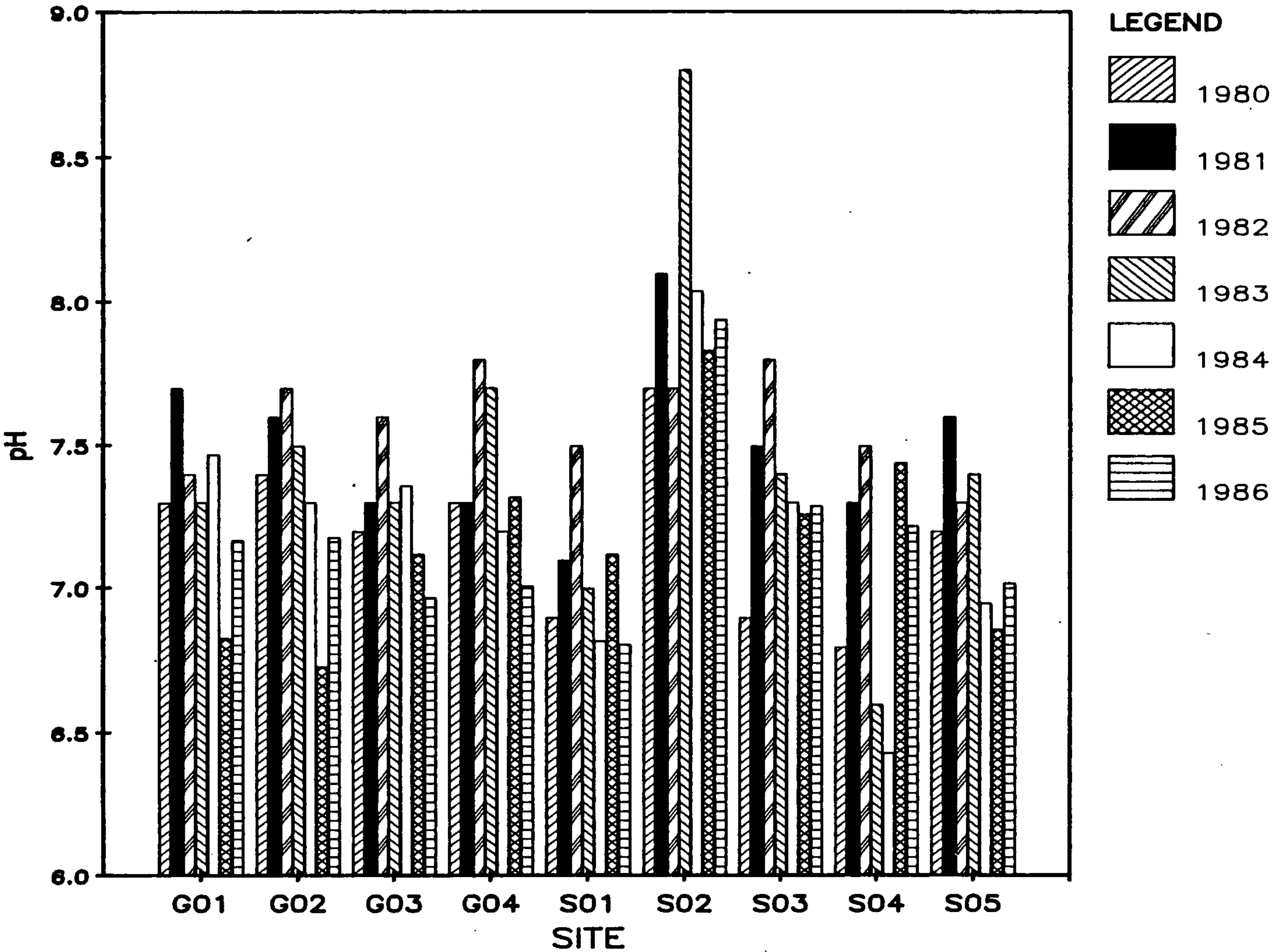


Figure 7-23. Soil pH for 1980 - 1986

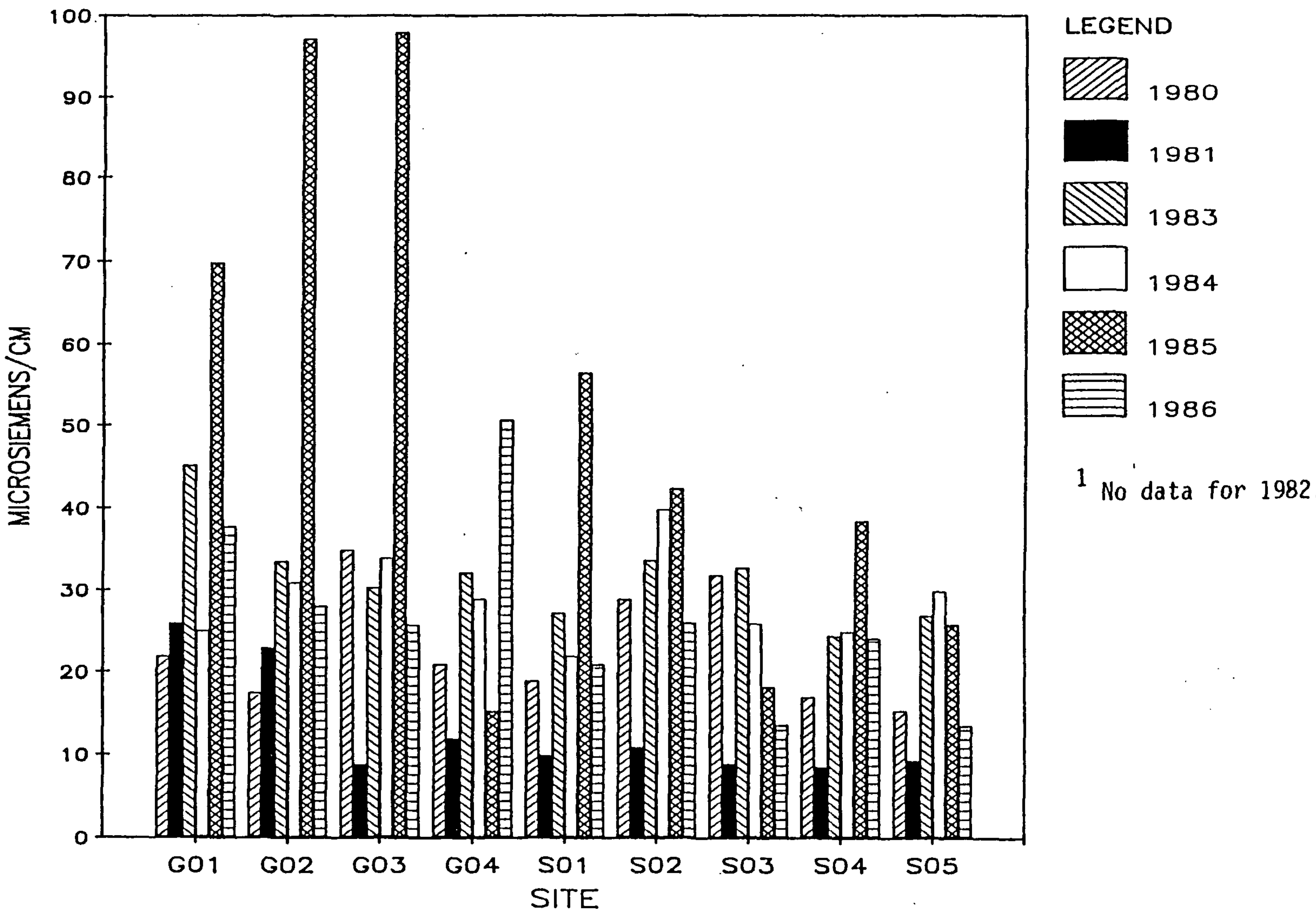


Figure 7-24. Soil Conductivity for 1980 - 1986

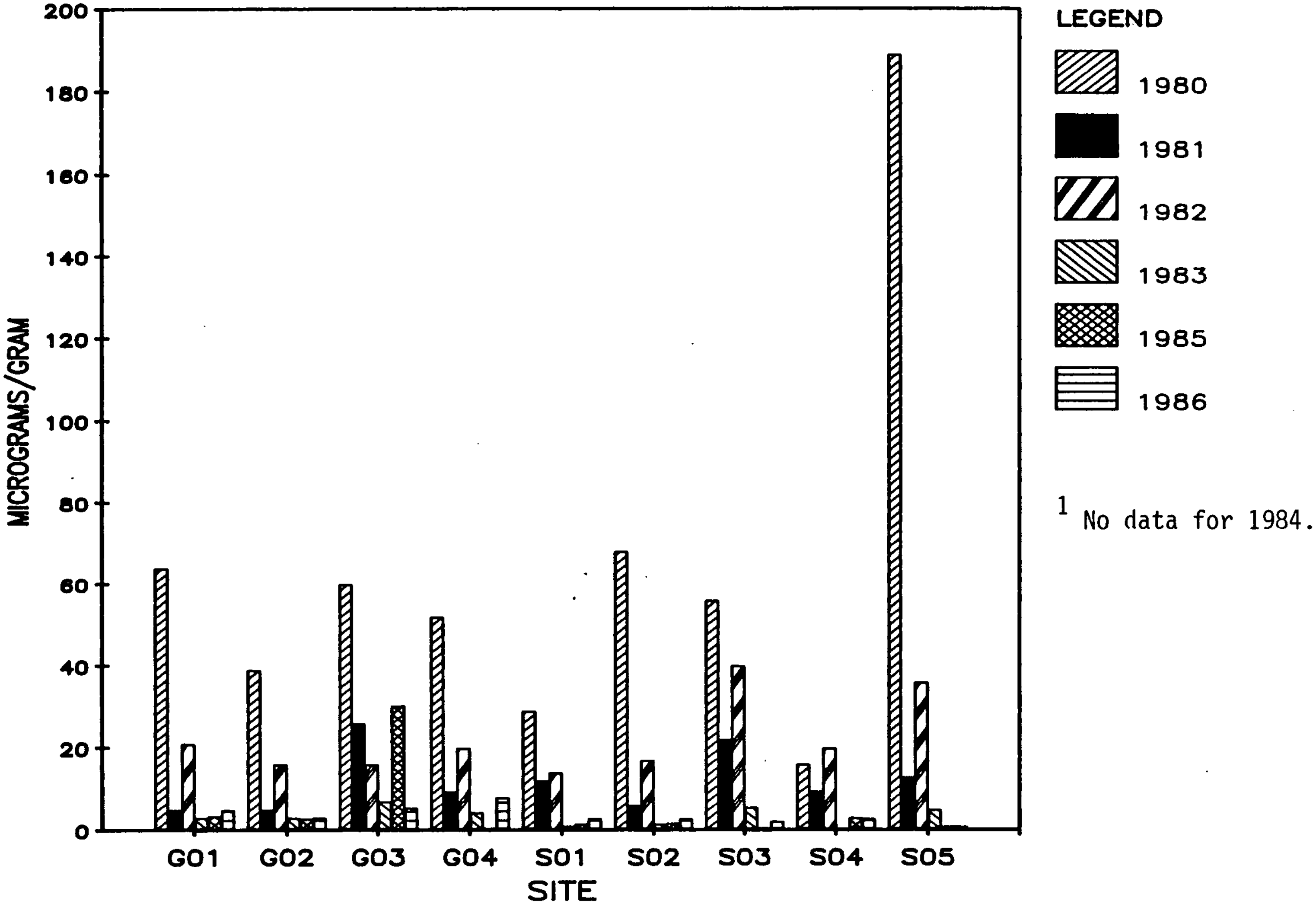


Figure 7-25. Soil Sulfate for 1980 - 1986

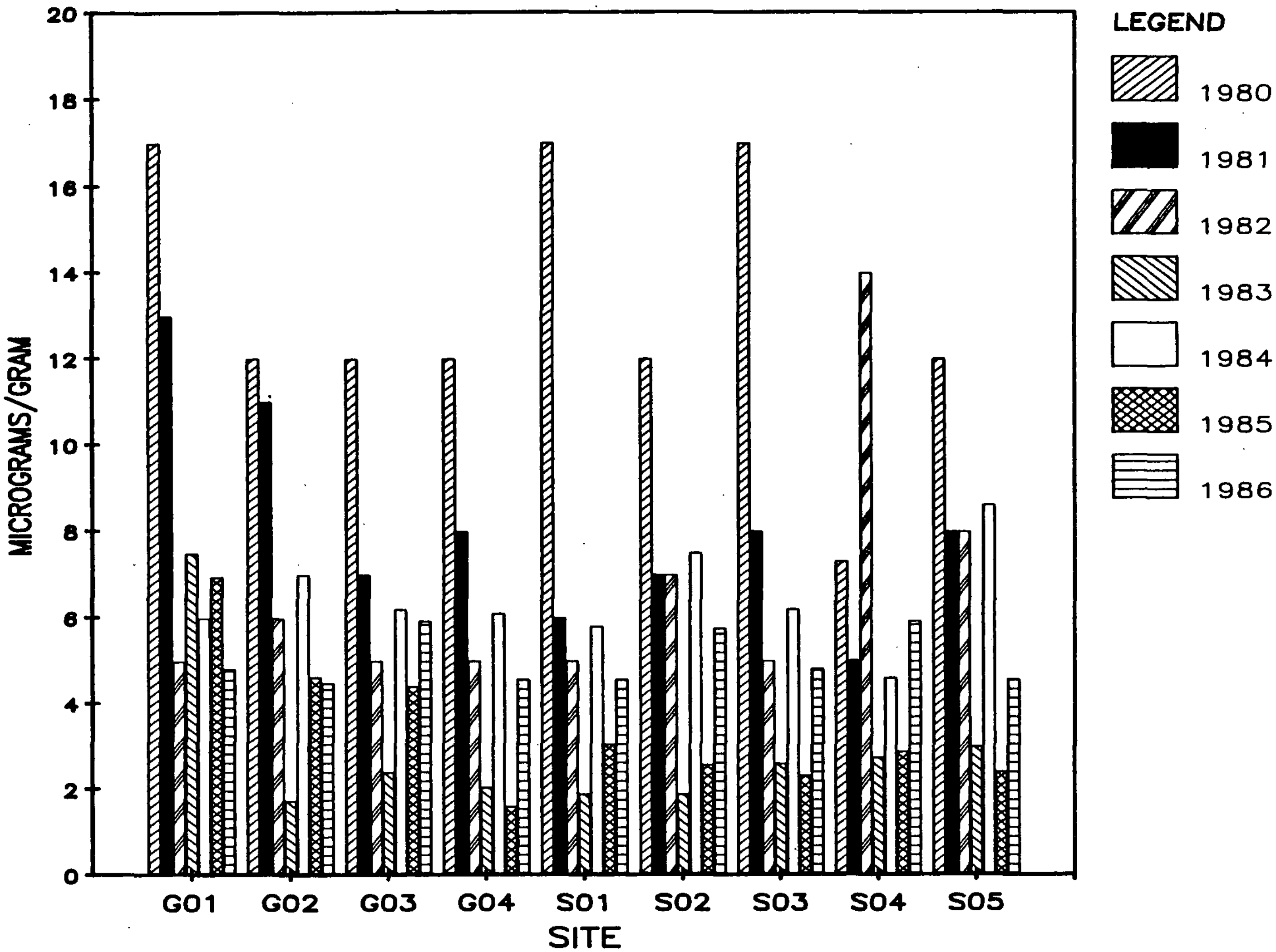


Figure 7-26. Soil Chloride for 1980 - 1986

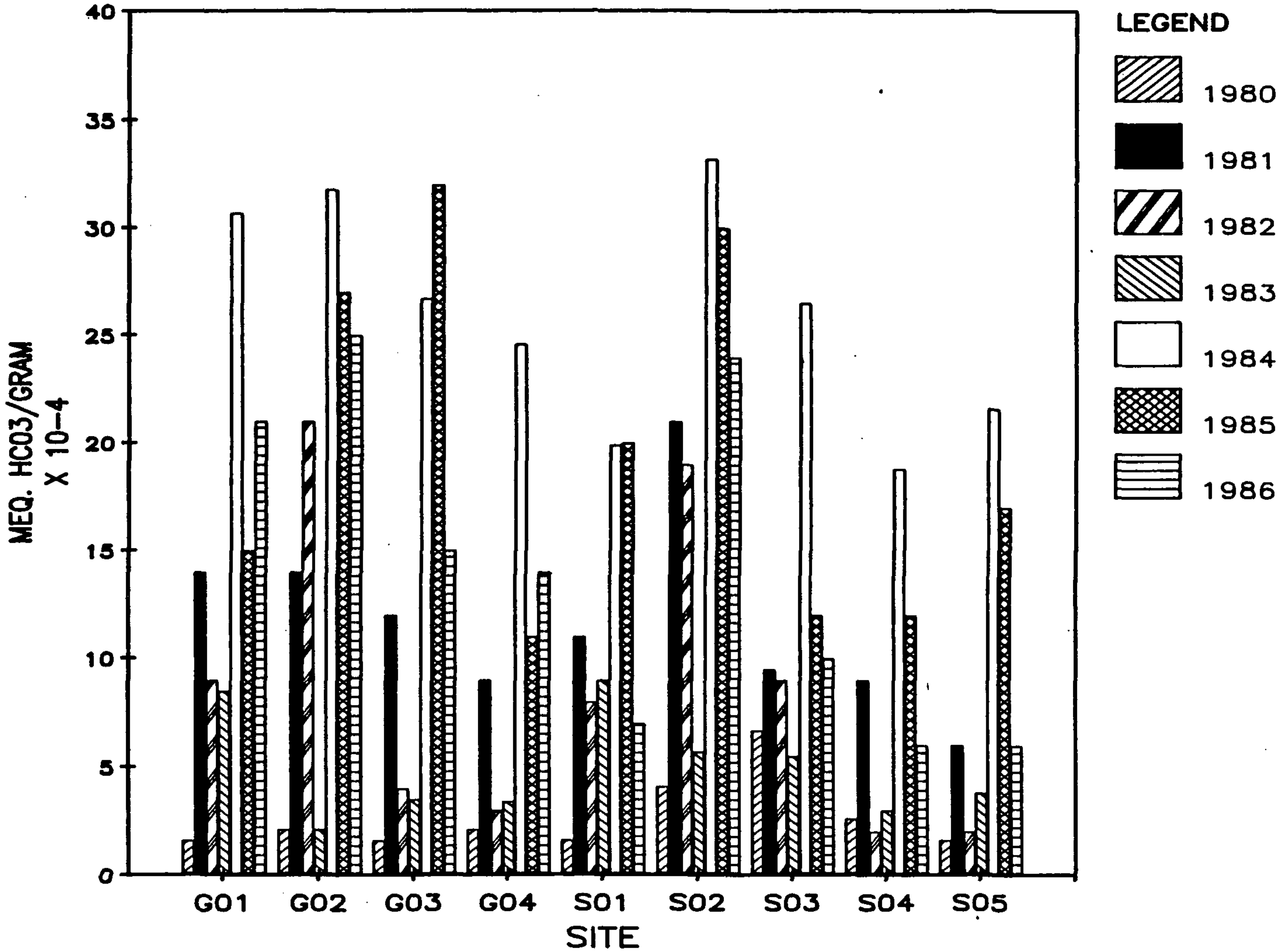


Figure 7-27. Soil Bicarbonates for 1980 - 1986

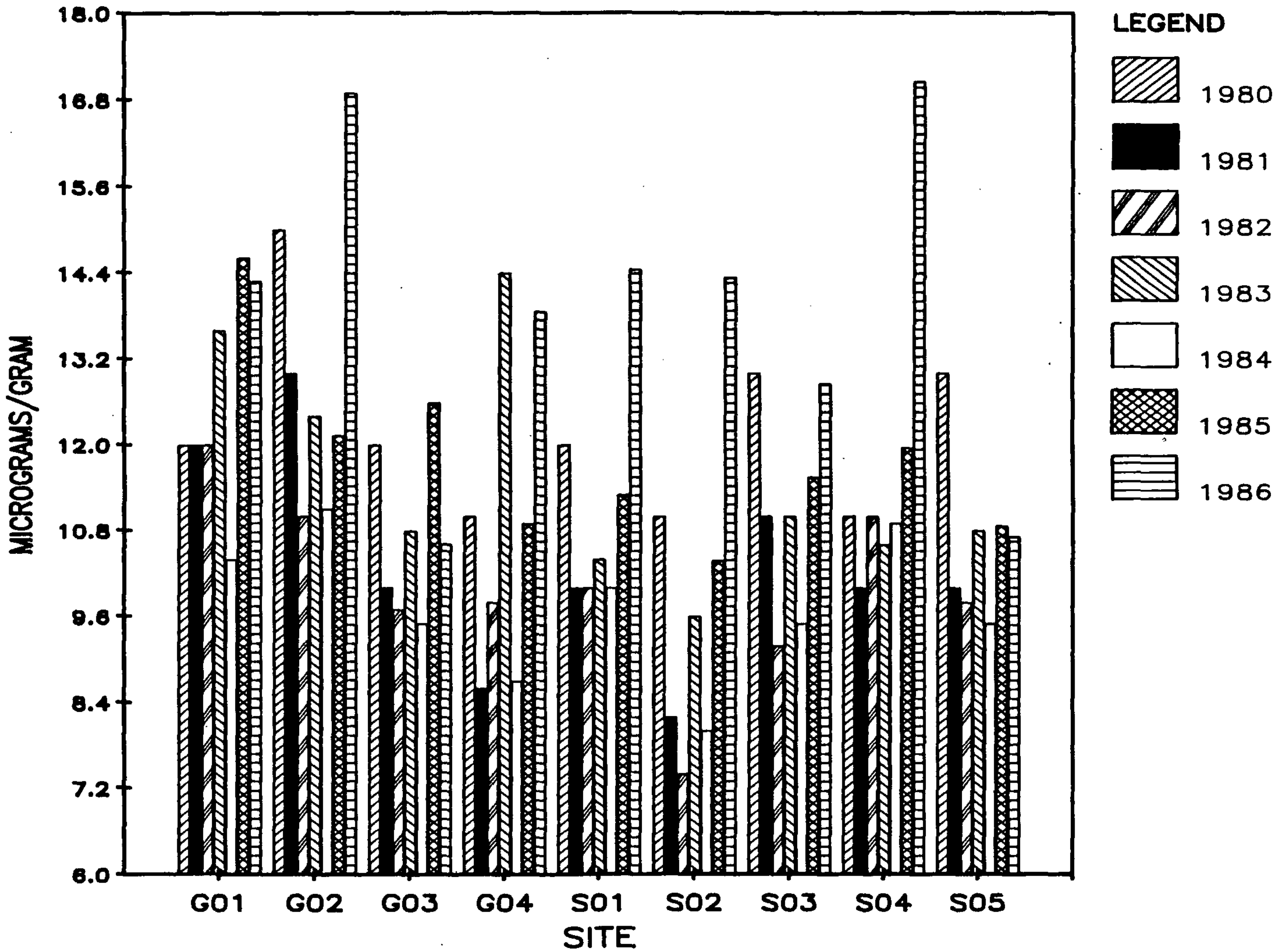


Figure 7-28. Soil Copper for 1980 - 1986

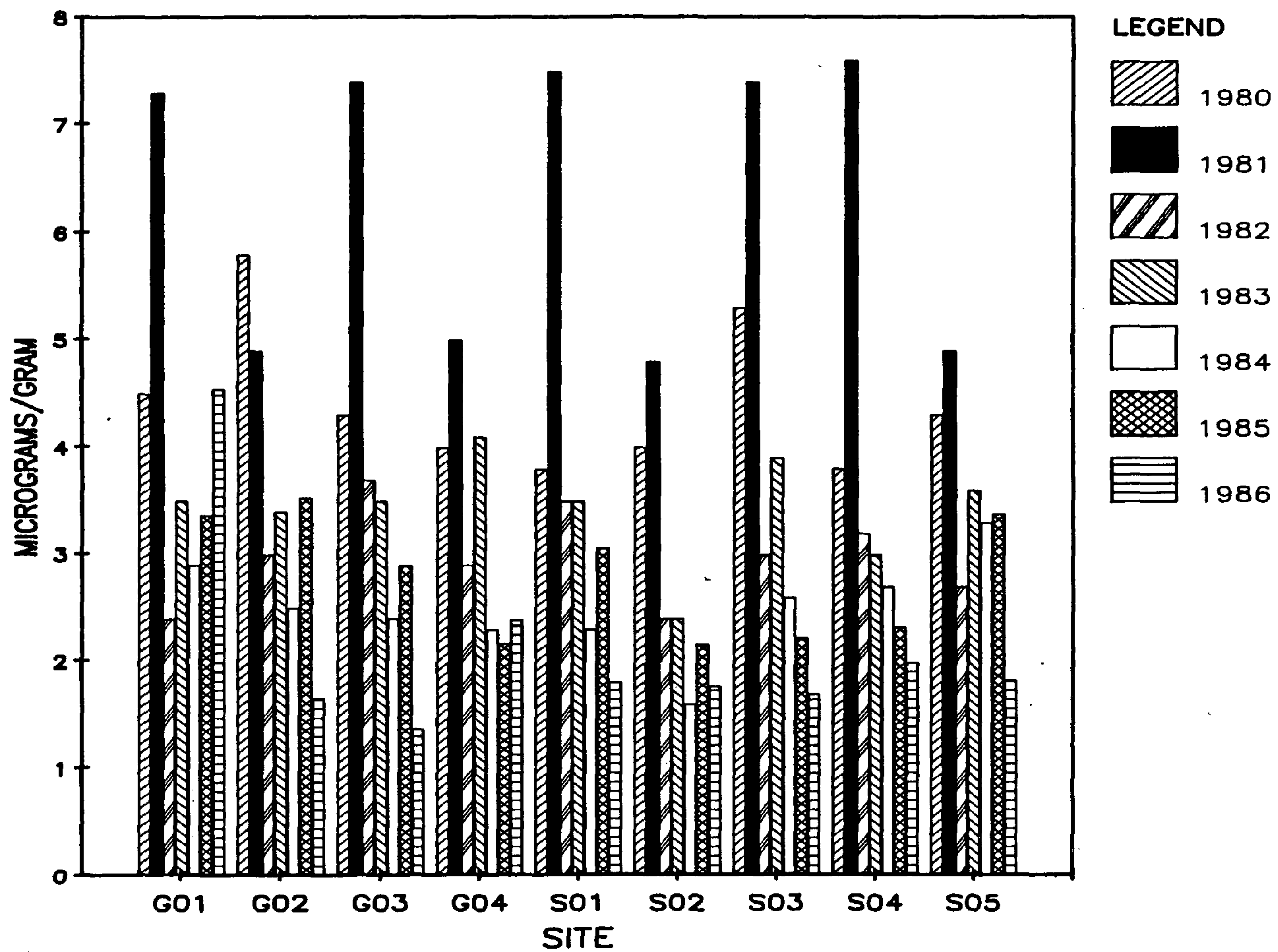


Figure 7-29. Soil Lead for 1980 - 1986

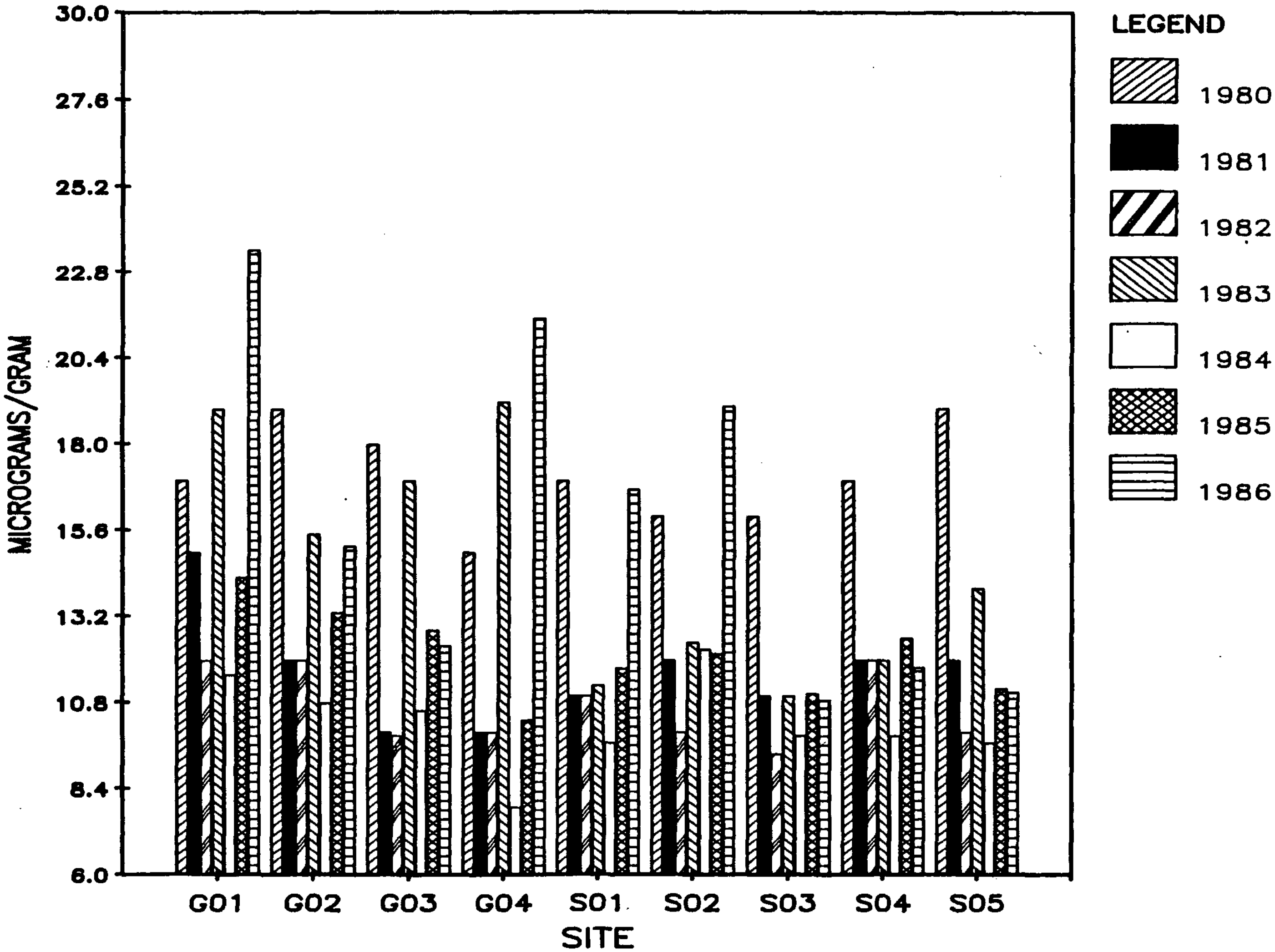


Figure 7-30. Soil Nickel for 1980 - 1986

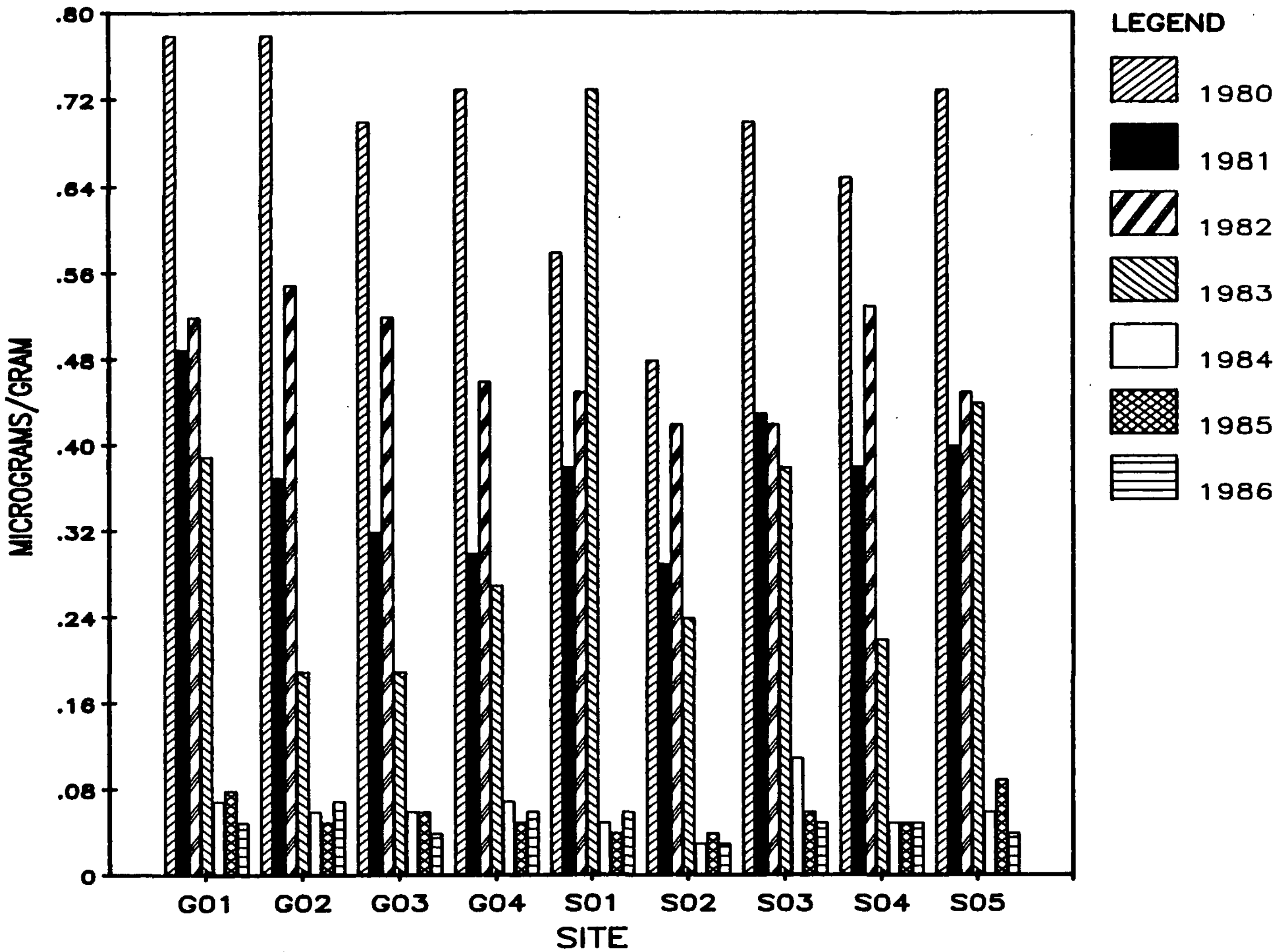
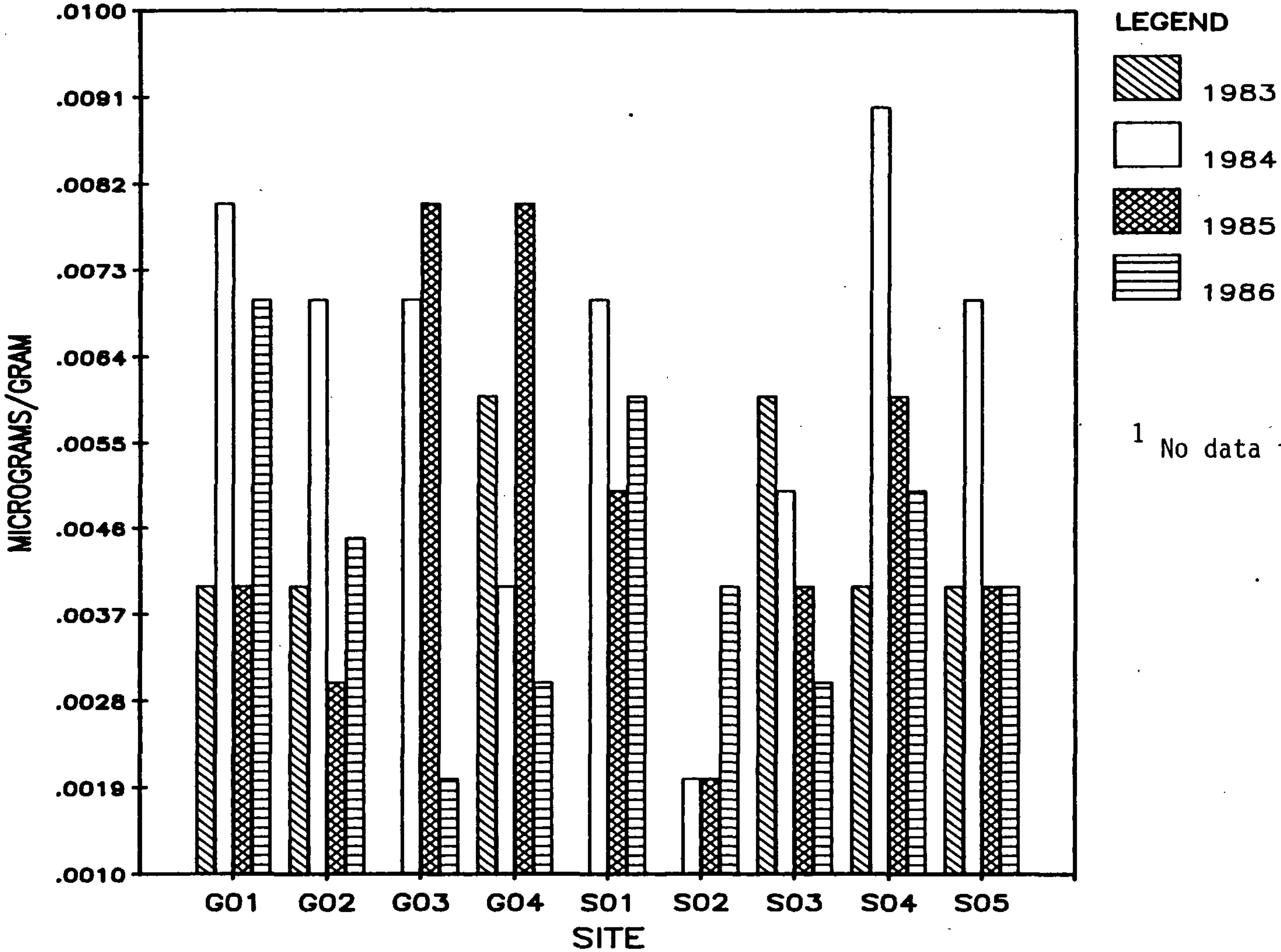


Figure 7-31. Soil Cadmium for 1980 - 1986



1 No data for 1980 - 1982.

Figure 7-32. Soil Mercury for 1983 - 1986

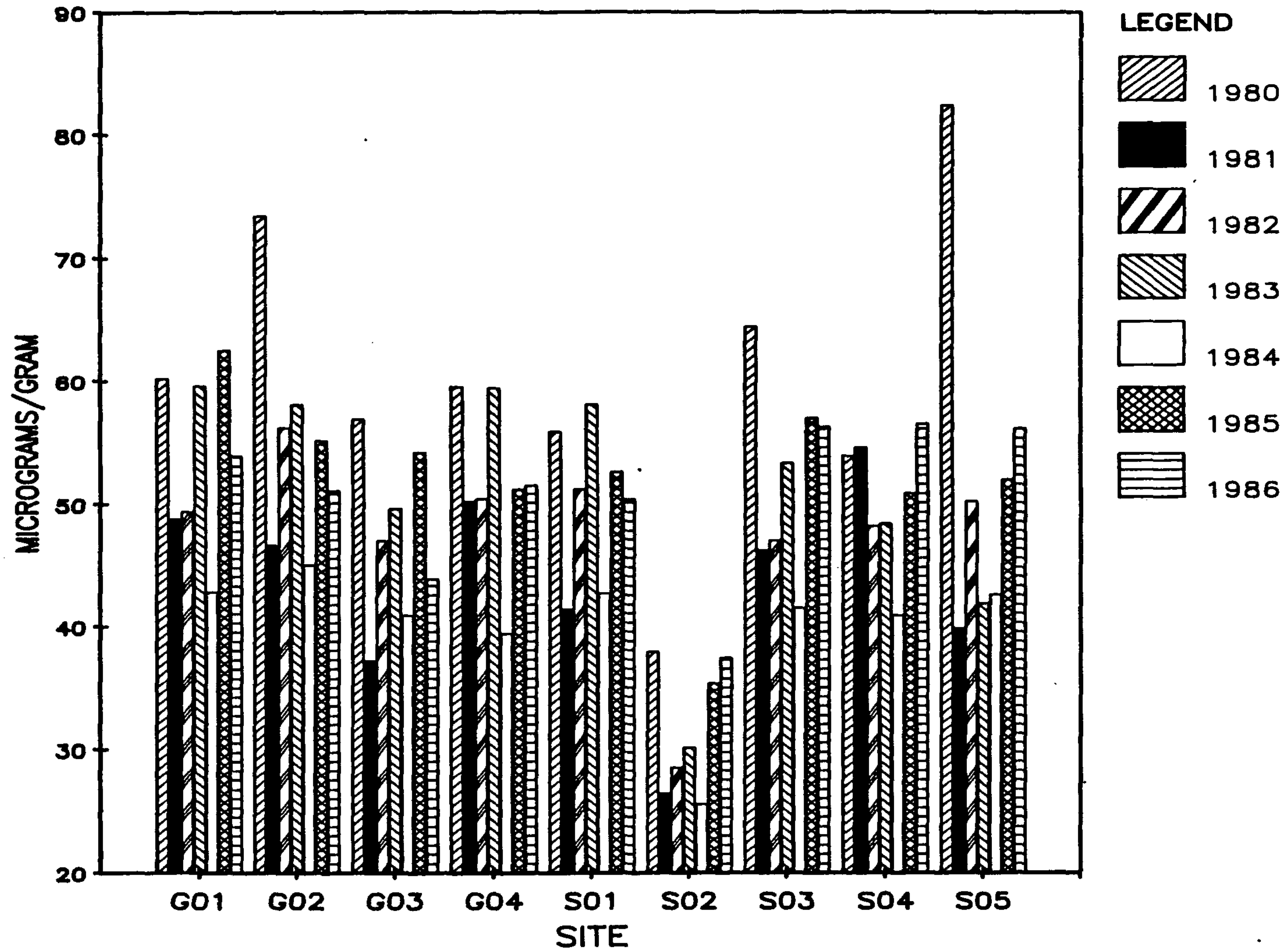


Figure 7-33. Soil Zinc for 1980 - 1986

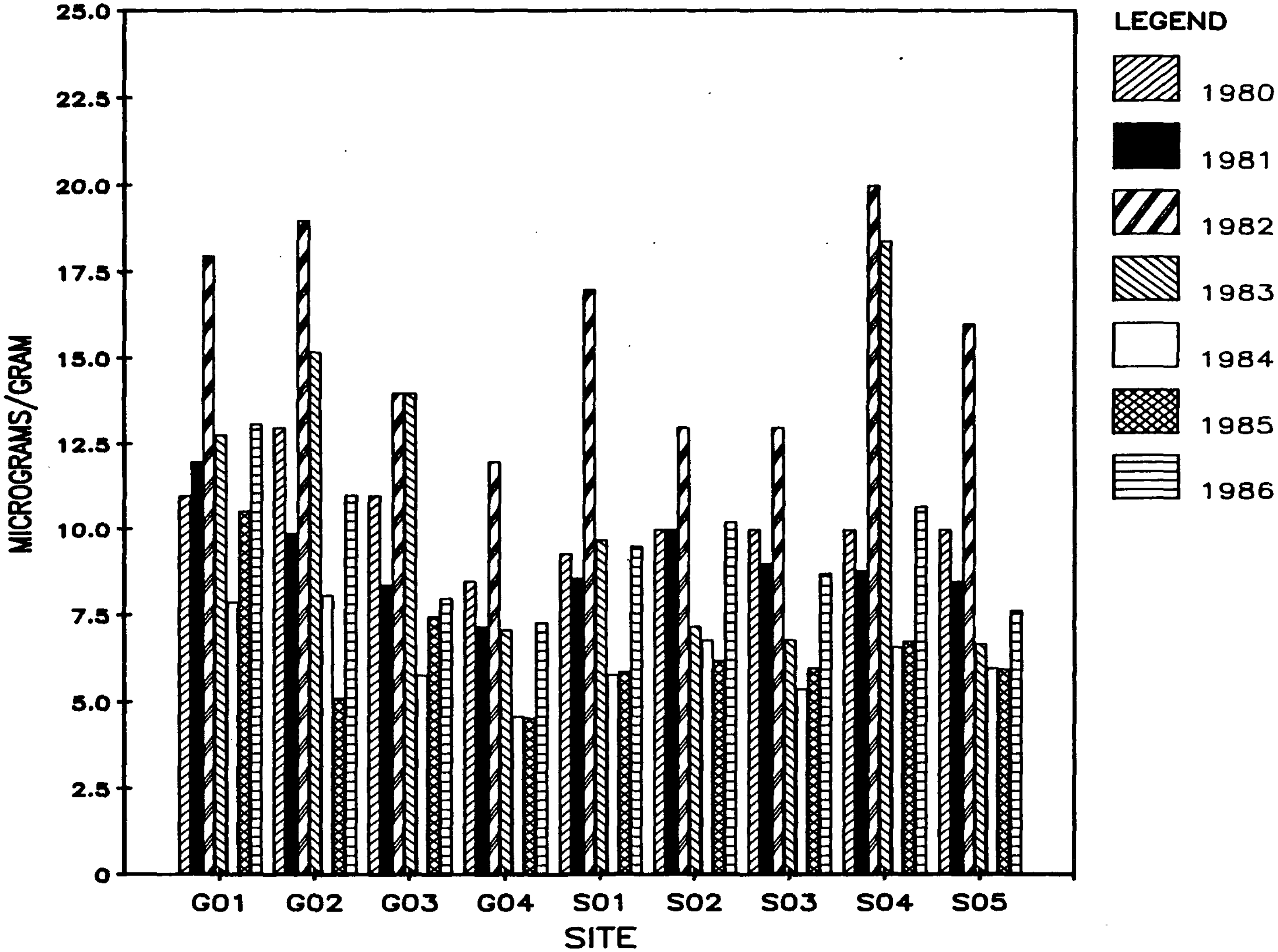


Figure 7-34. Soil Chromium for 1980 - 1986

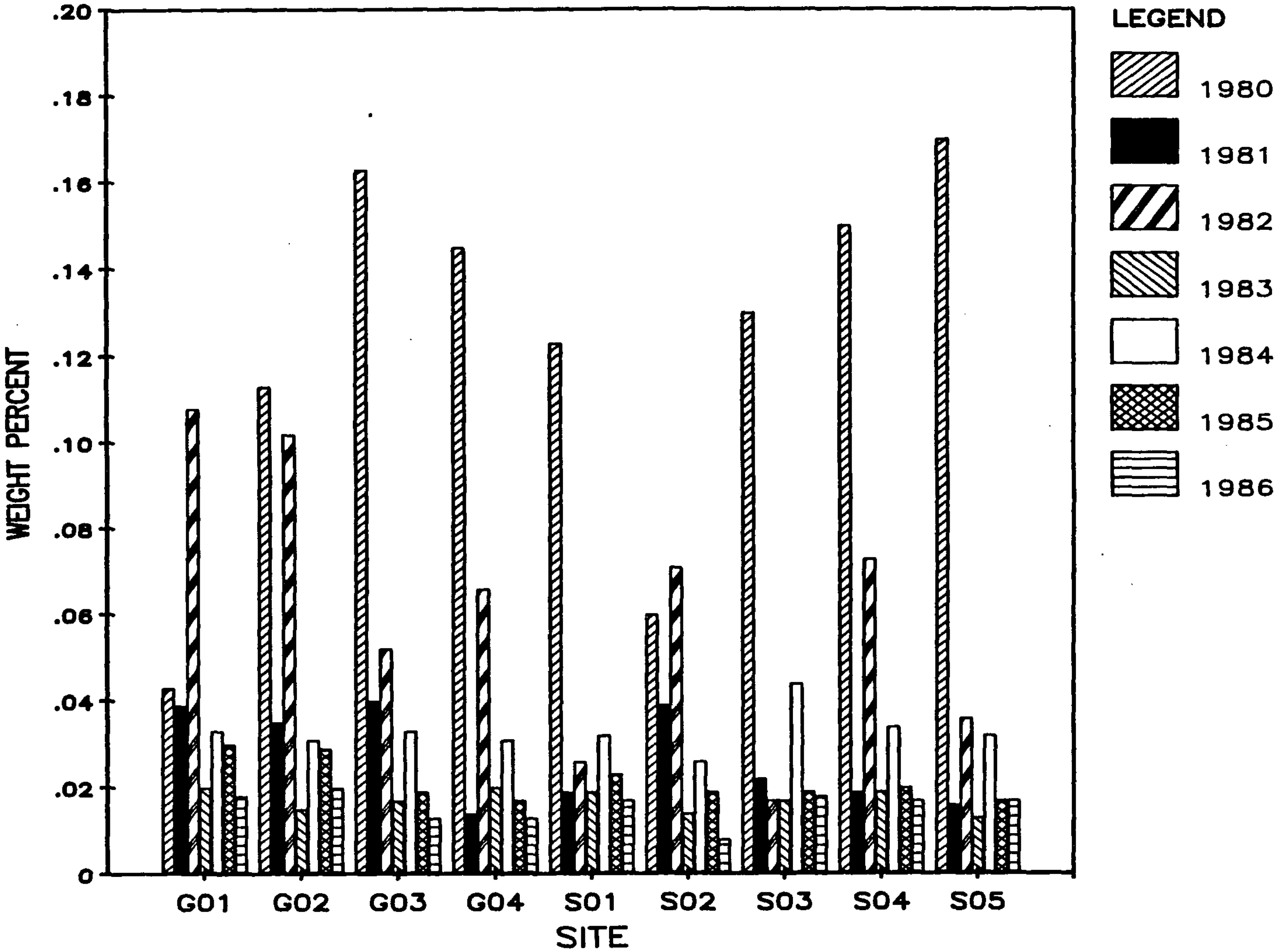


Figure 7-35. Soil Sodium for 1980 - 1986

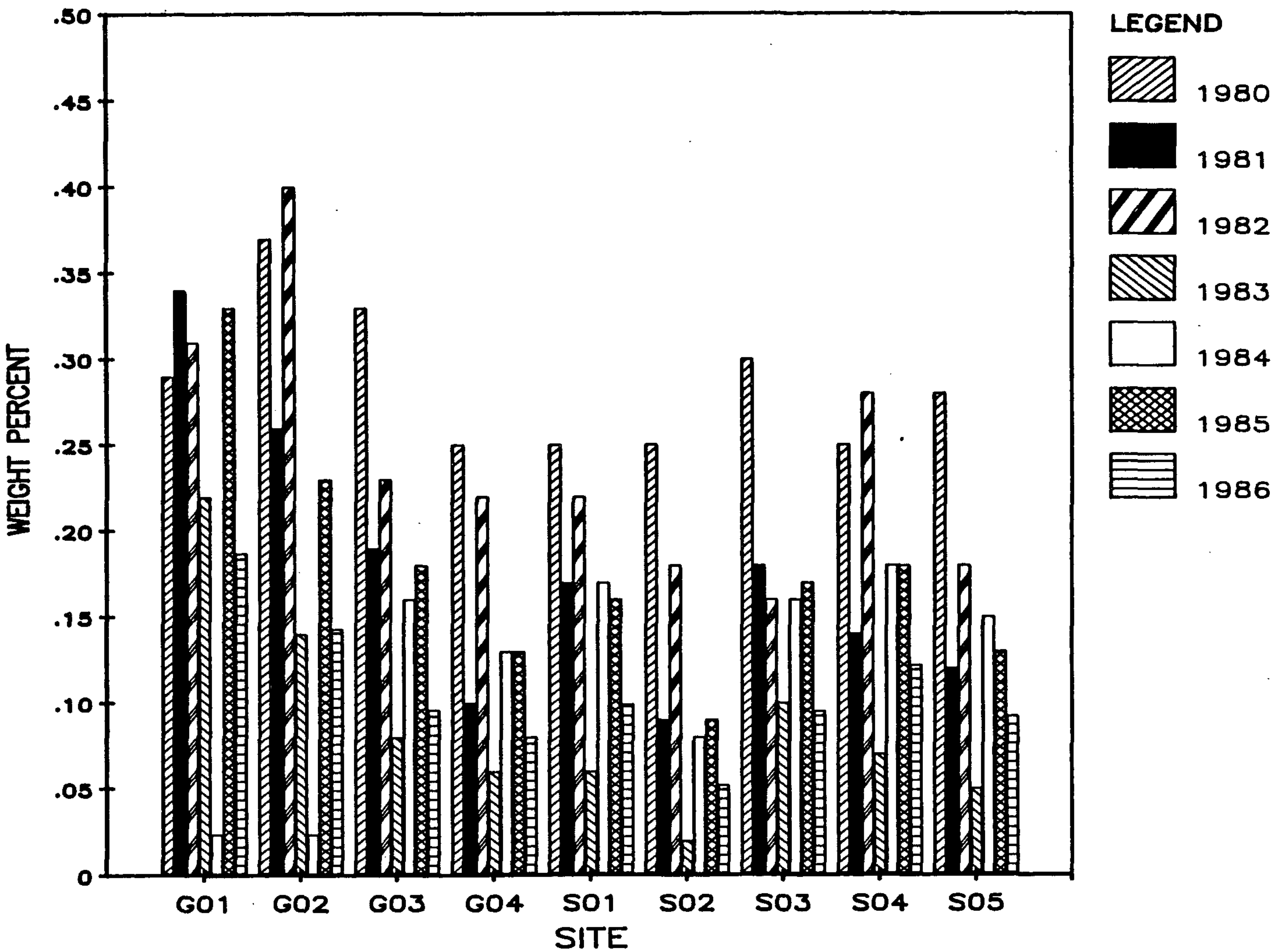


Figure 7-36. Soil Potassium for 1980 - 1986

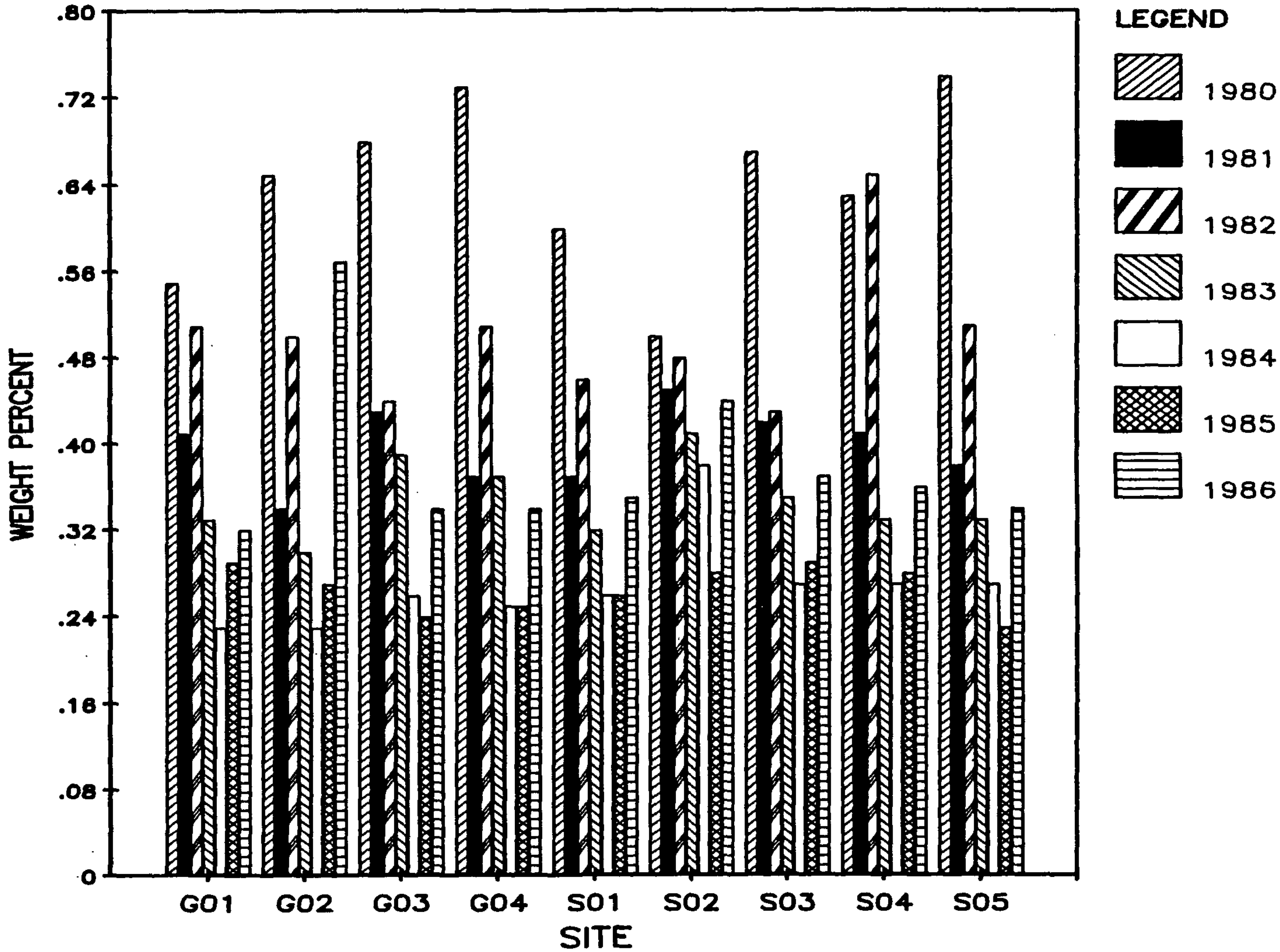


Figure 7-37. Soil Calcium for 1980 - 1986

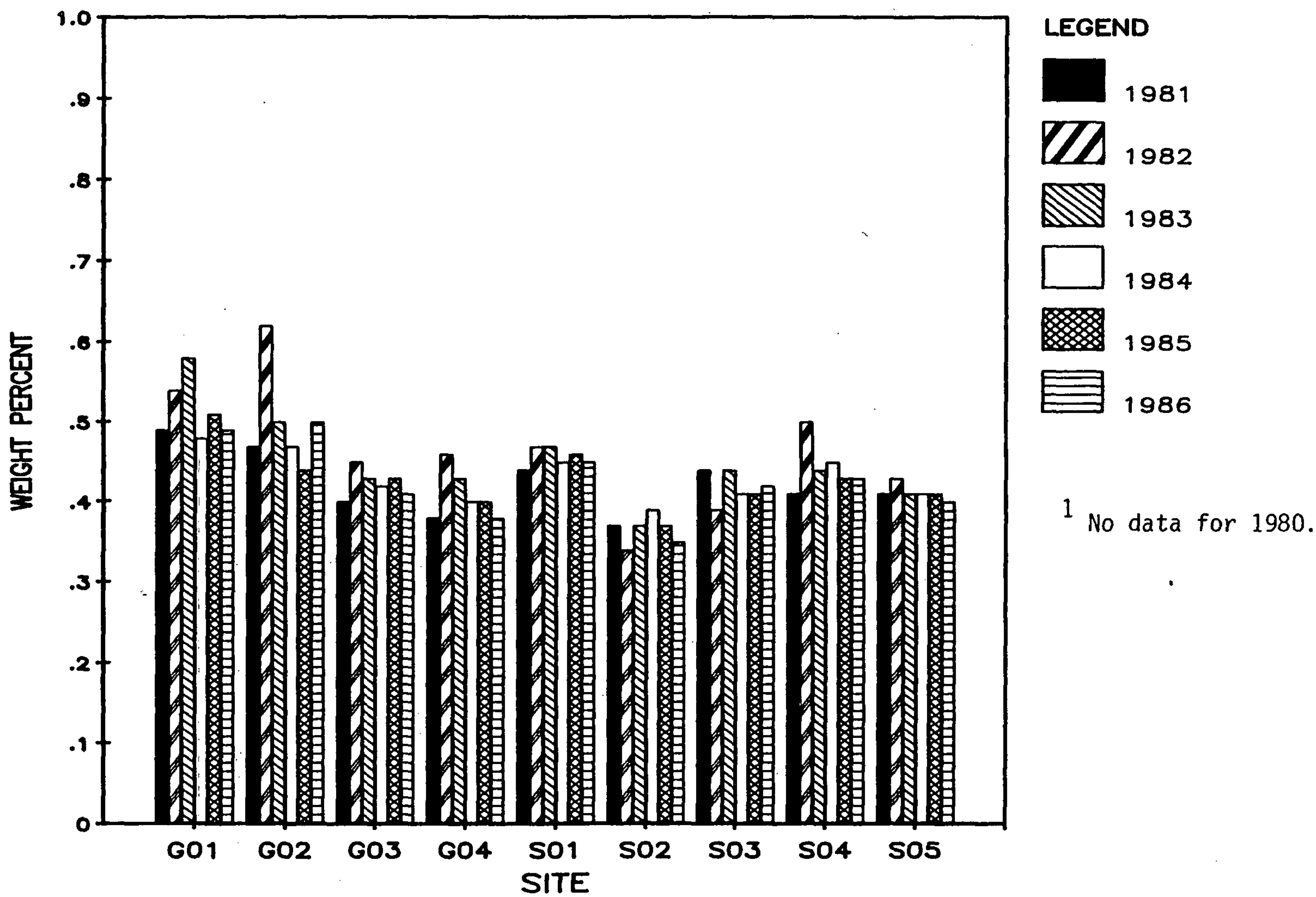


Figure 7-38. Soil Magnesium for 1980 - 1986

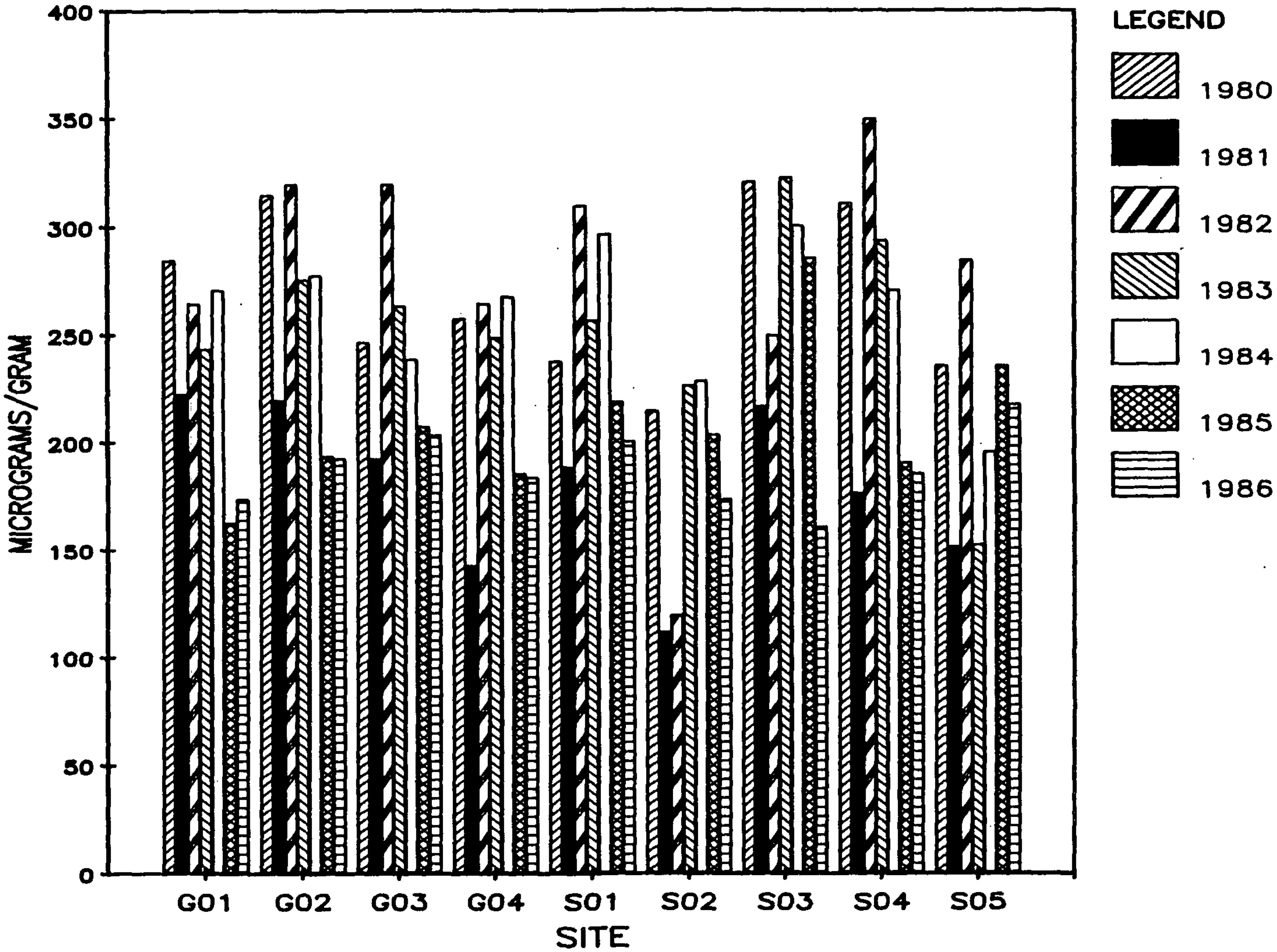


Figure 7-39. Soil Fluoride for 1980 - 1986

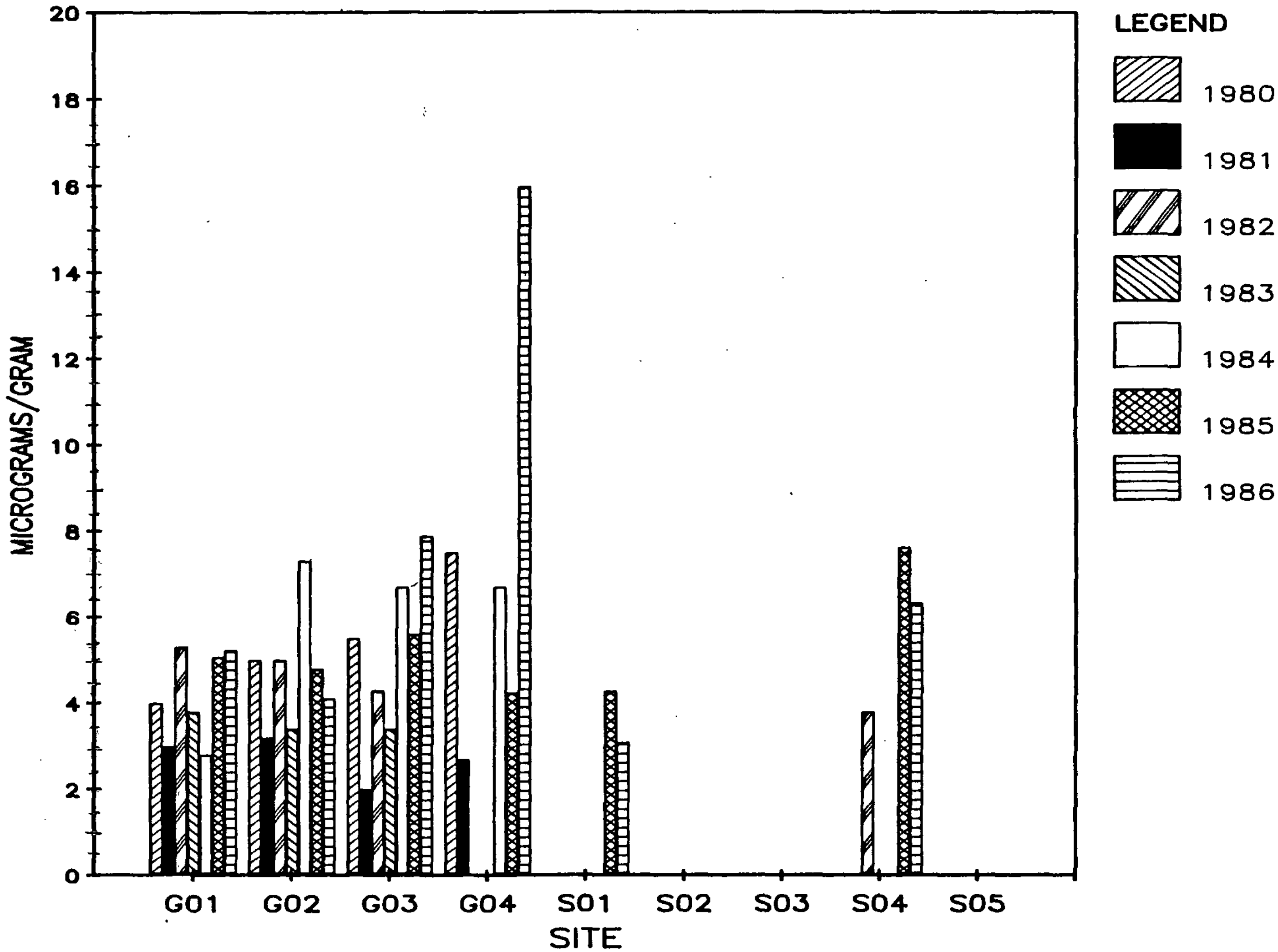


Figure 7-40. Copper concentration (μg/g) in <u>Sisymbrium</u> <u>Altissimum</u> by site for 1980 - 1986

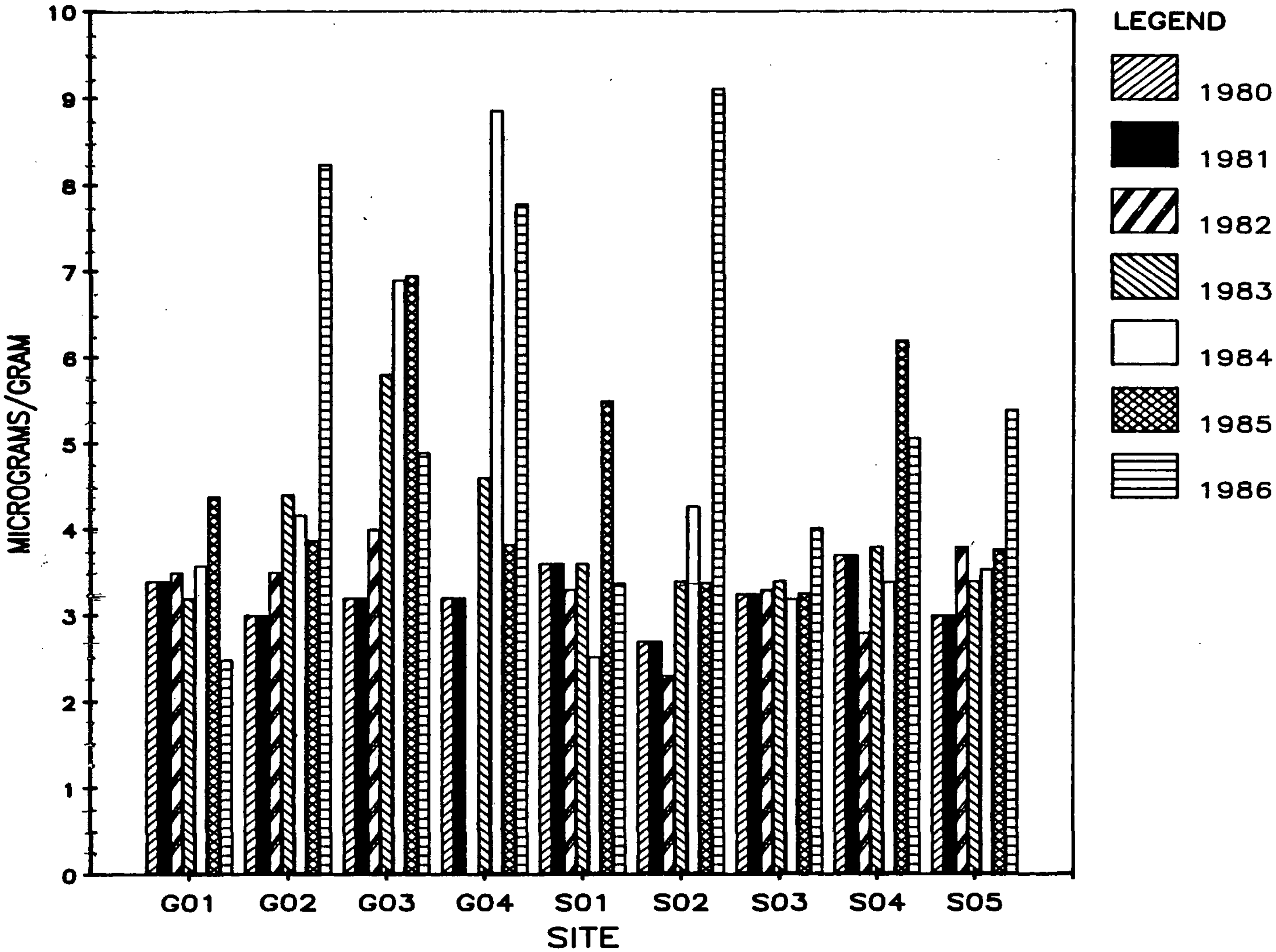


Figure 7-41. Copper Concentration (μg/g) in Poa Sandbergiiby by Site for 1980 - 1986

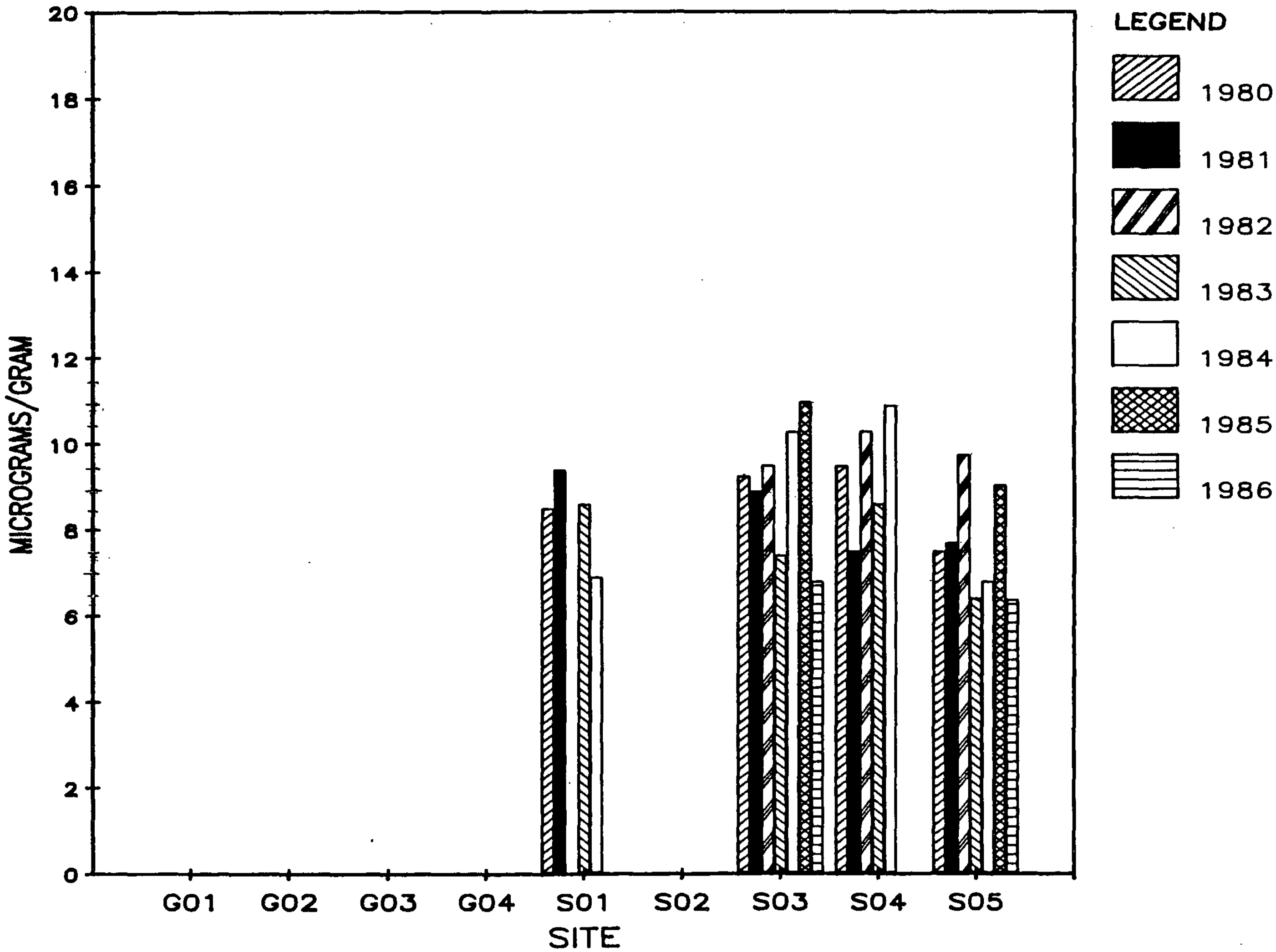


Figure 7-42. Copper Concentration (μg/g) in Artemisia Tridentata by Site for 1980 - 1986

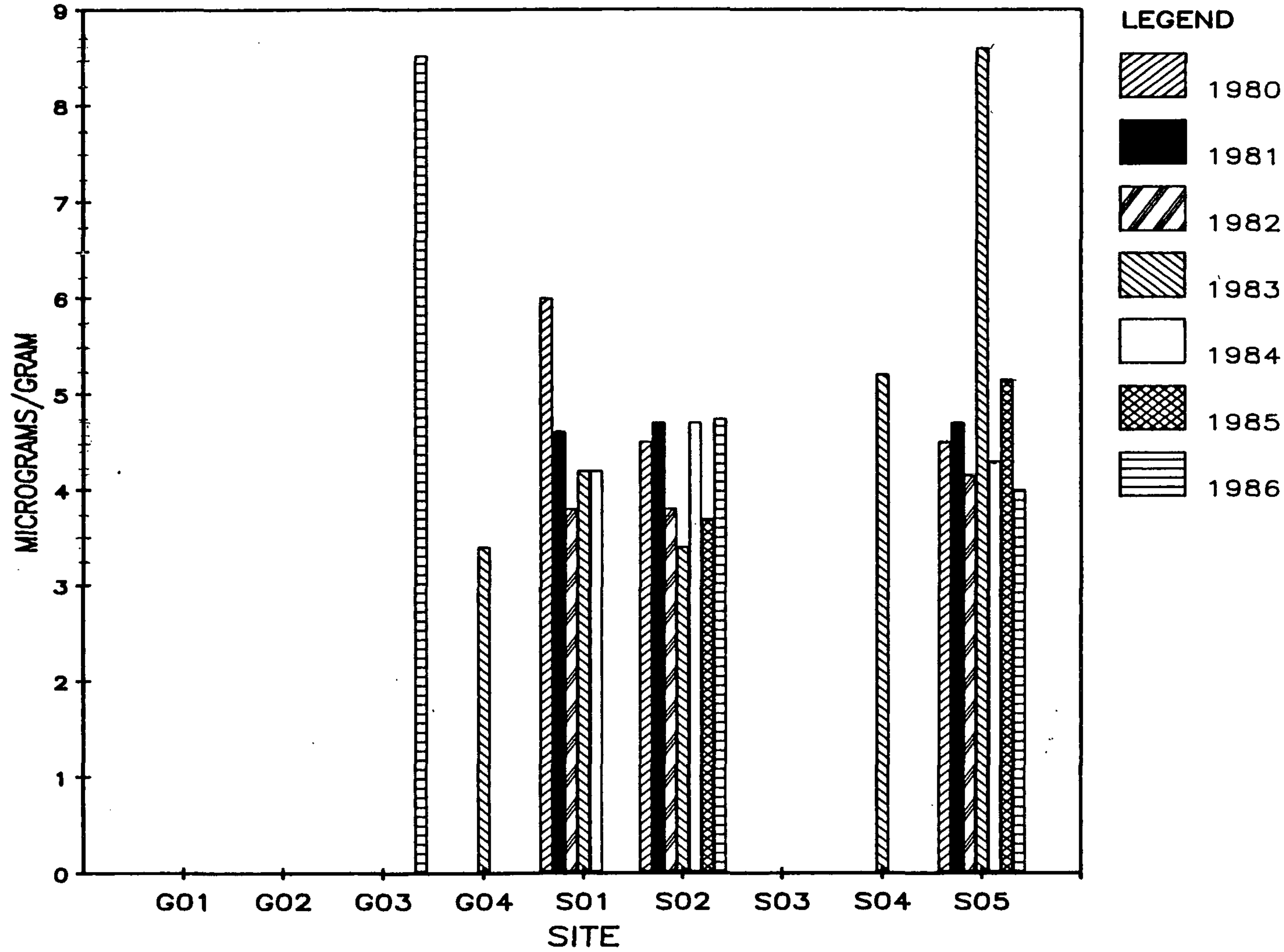


Figure 7-43. Copper Concentration (μg/g) in <u>Purshia</u> <u>Tridentata</u> by Site for 1980 - 1986

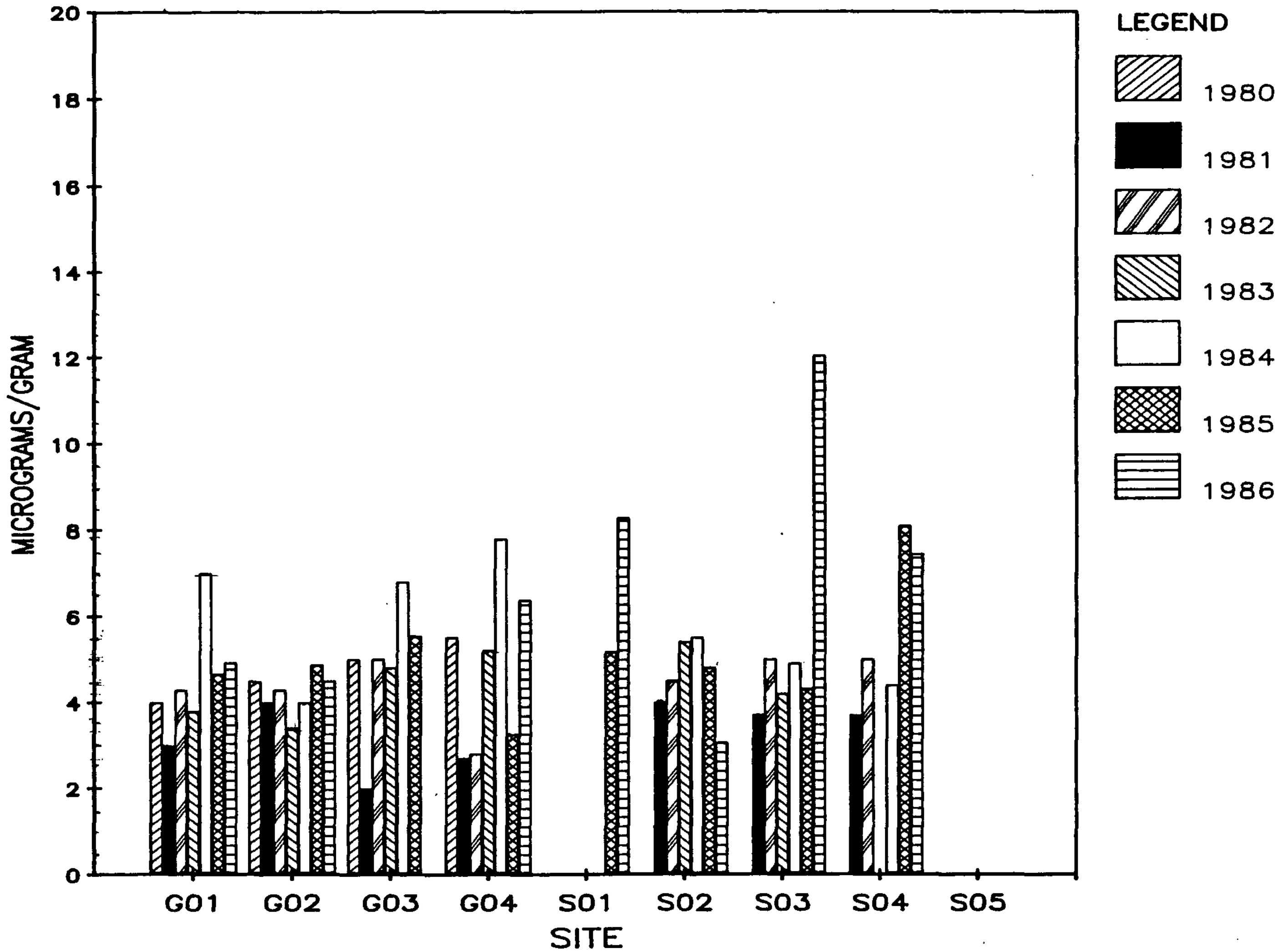


Figure 7-44. Copper Concentration (μg/g) in Phlox Longifolia by Site for 1980 - 1986

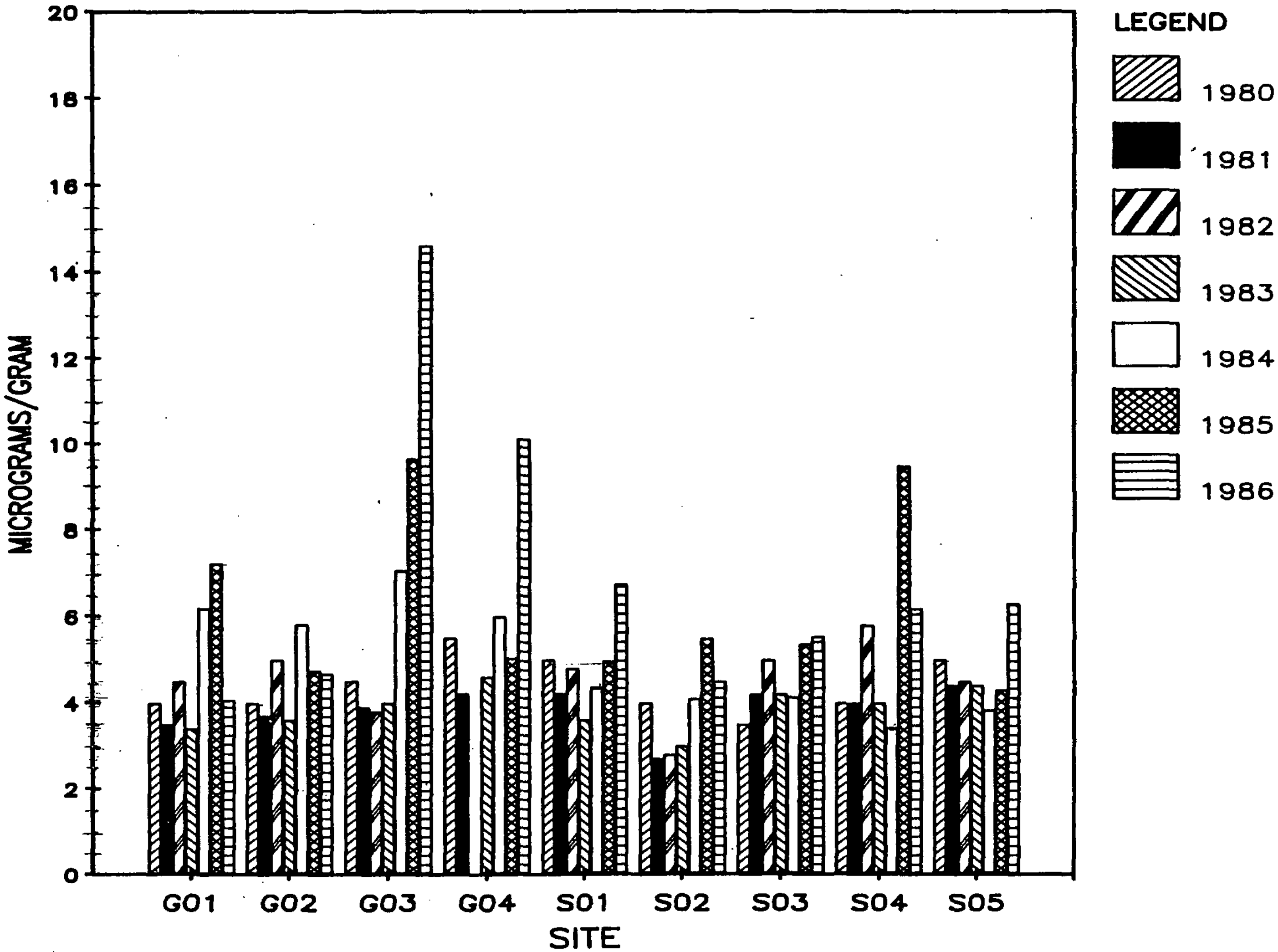


Figure 7-45. Copper Concentration (µg/g) in Bromus Tectorum by Site for 1980 - 1986

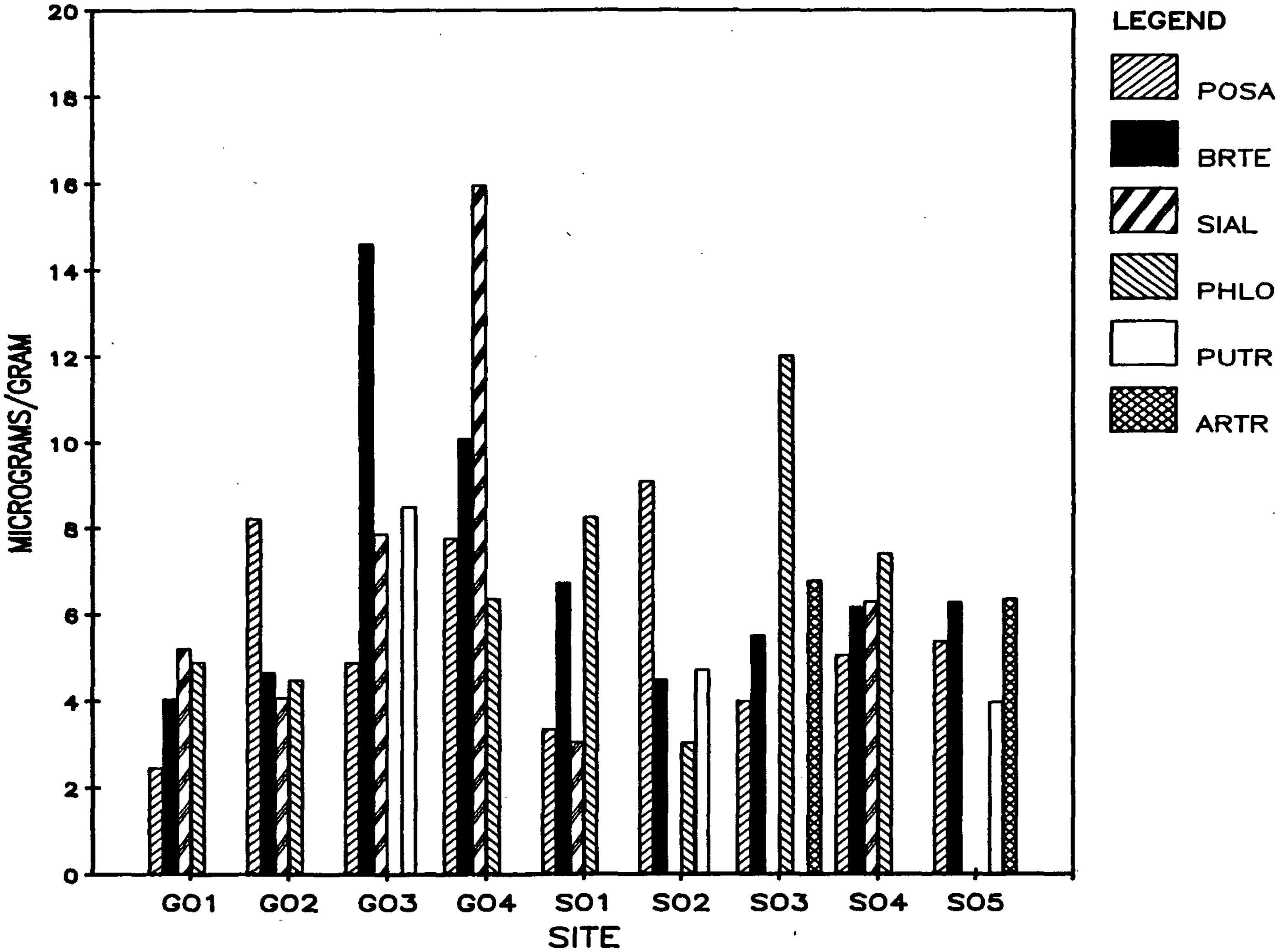


Figure 7-46. Total Vegetation Copper for May 1986

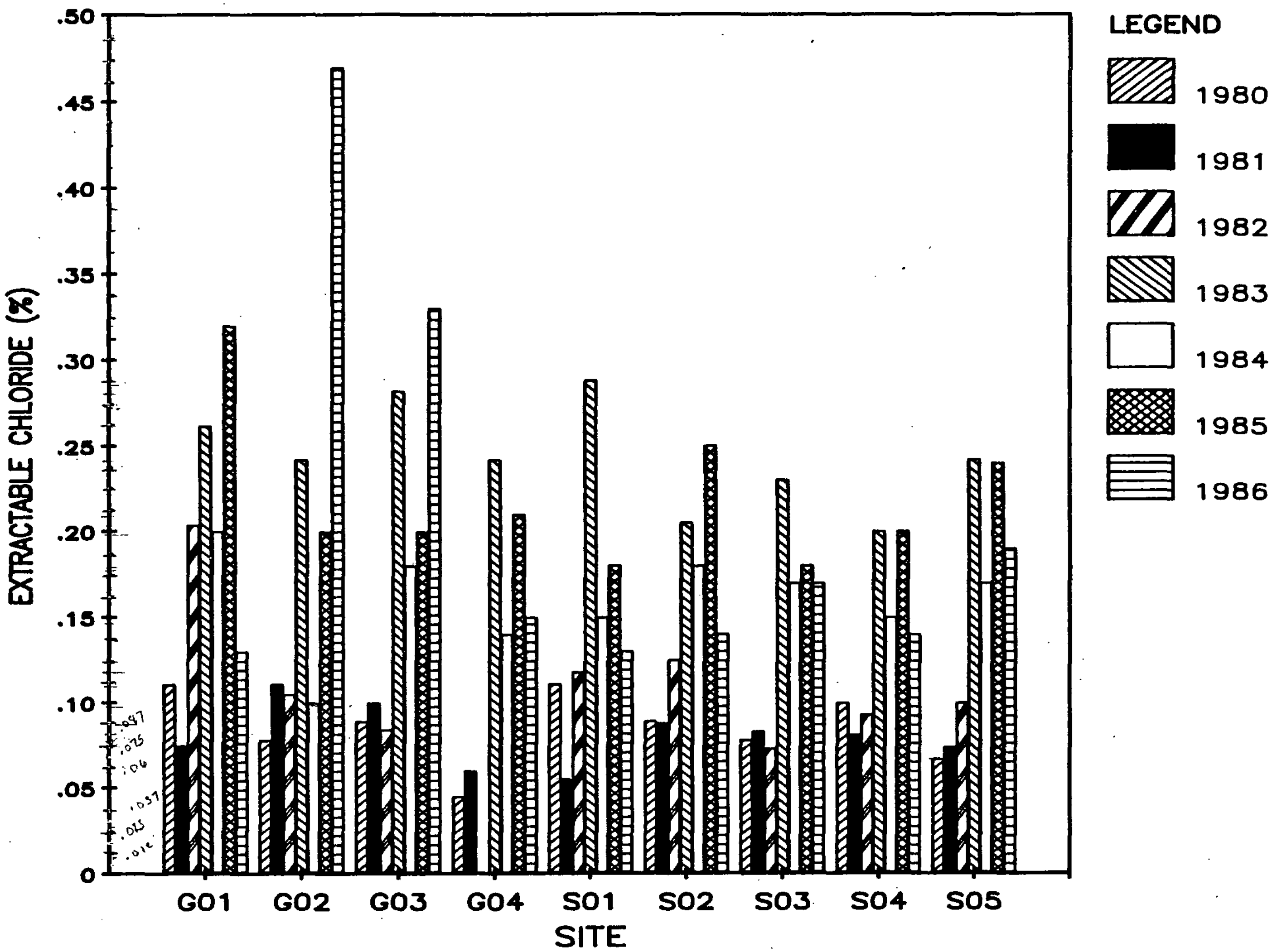


Figure 7-47. Chloride Concentration (%) in <u>Poa Sandbergii</u> by Site for 1980 - 1986

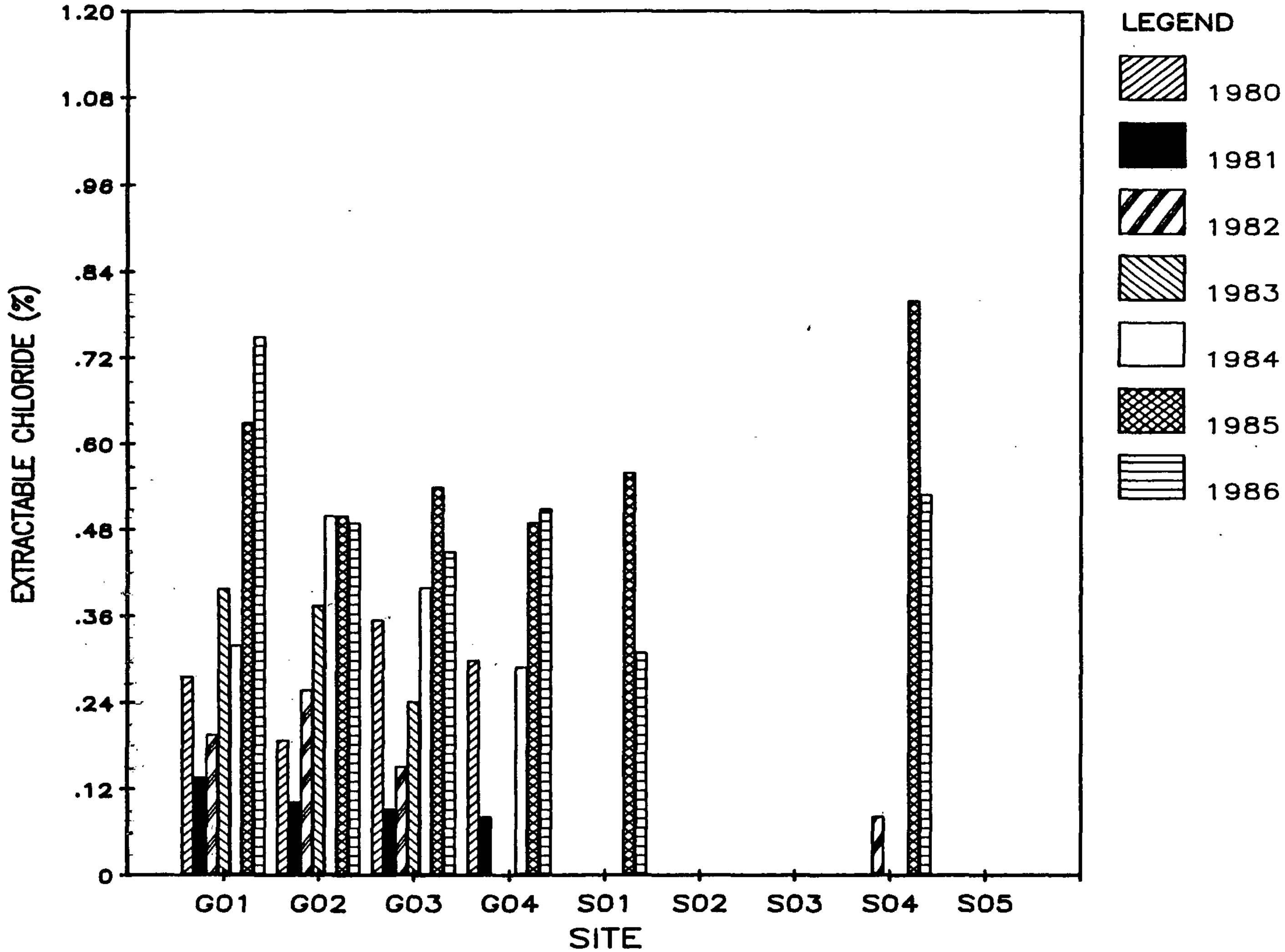


Figure 7-48. Chloride Concentration (%) in <u>Sisymbrium</u> <u>Altissimum</u> by Site for 1980 - 1986

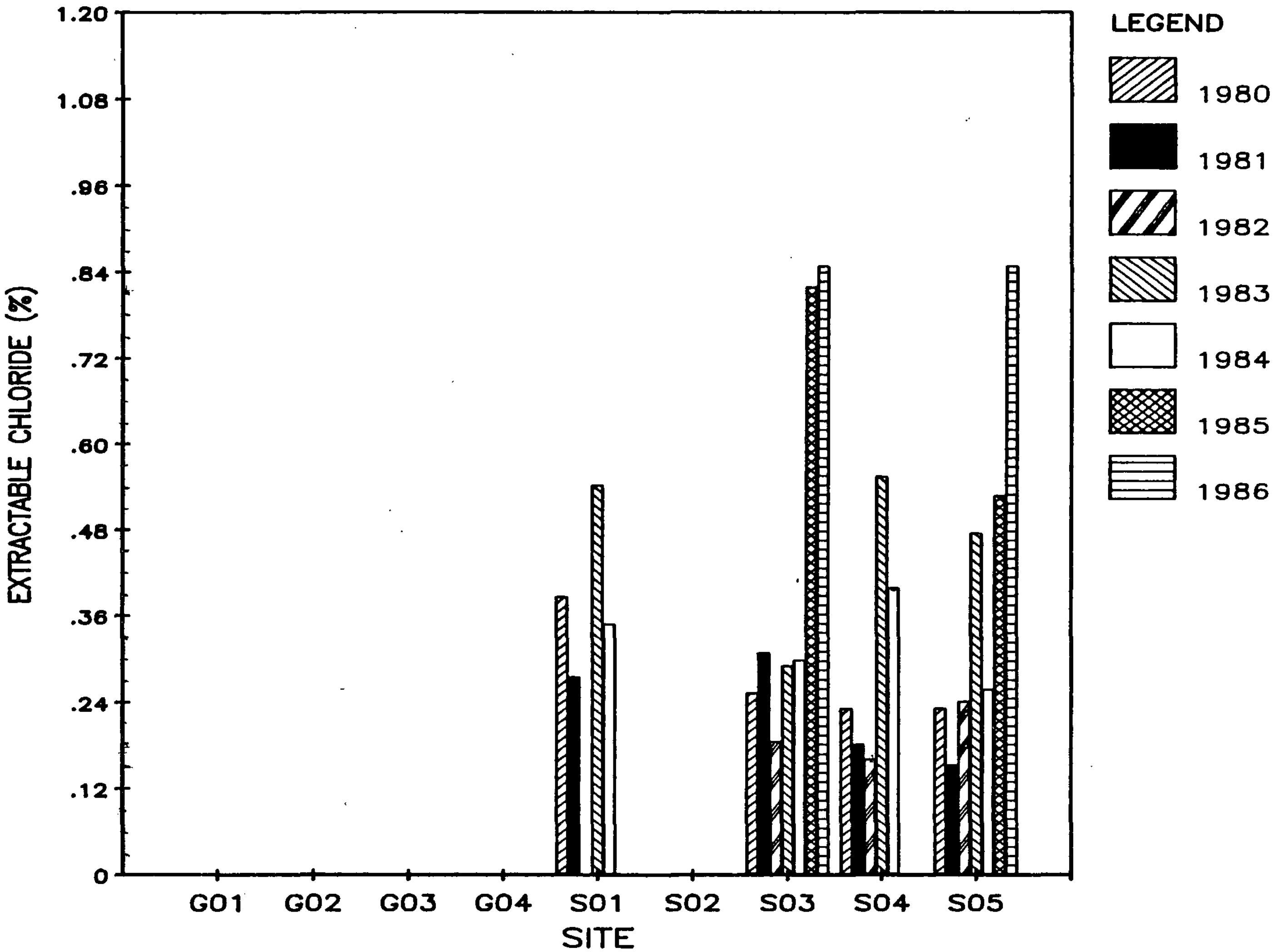


Figure 7-49. Chloride Concentration (%) in Artemisia Tridentata by Site for 1980 - 1986

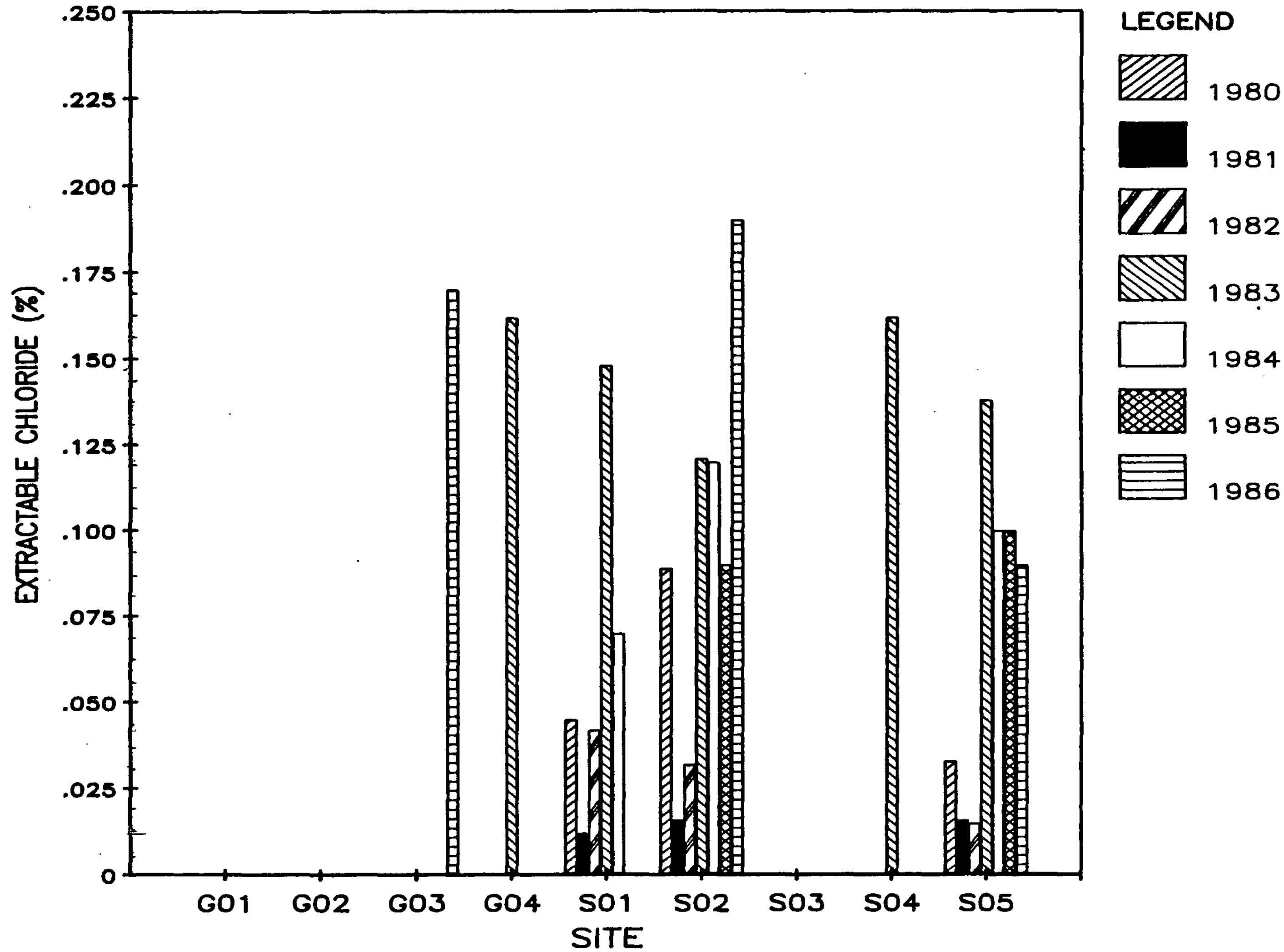


Figure 7-50. Chloride Concentration (%) in <u>Purshia Tridentata</u> by Site for 1980 - 1986

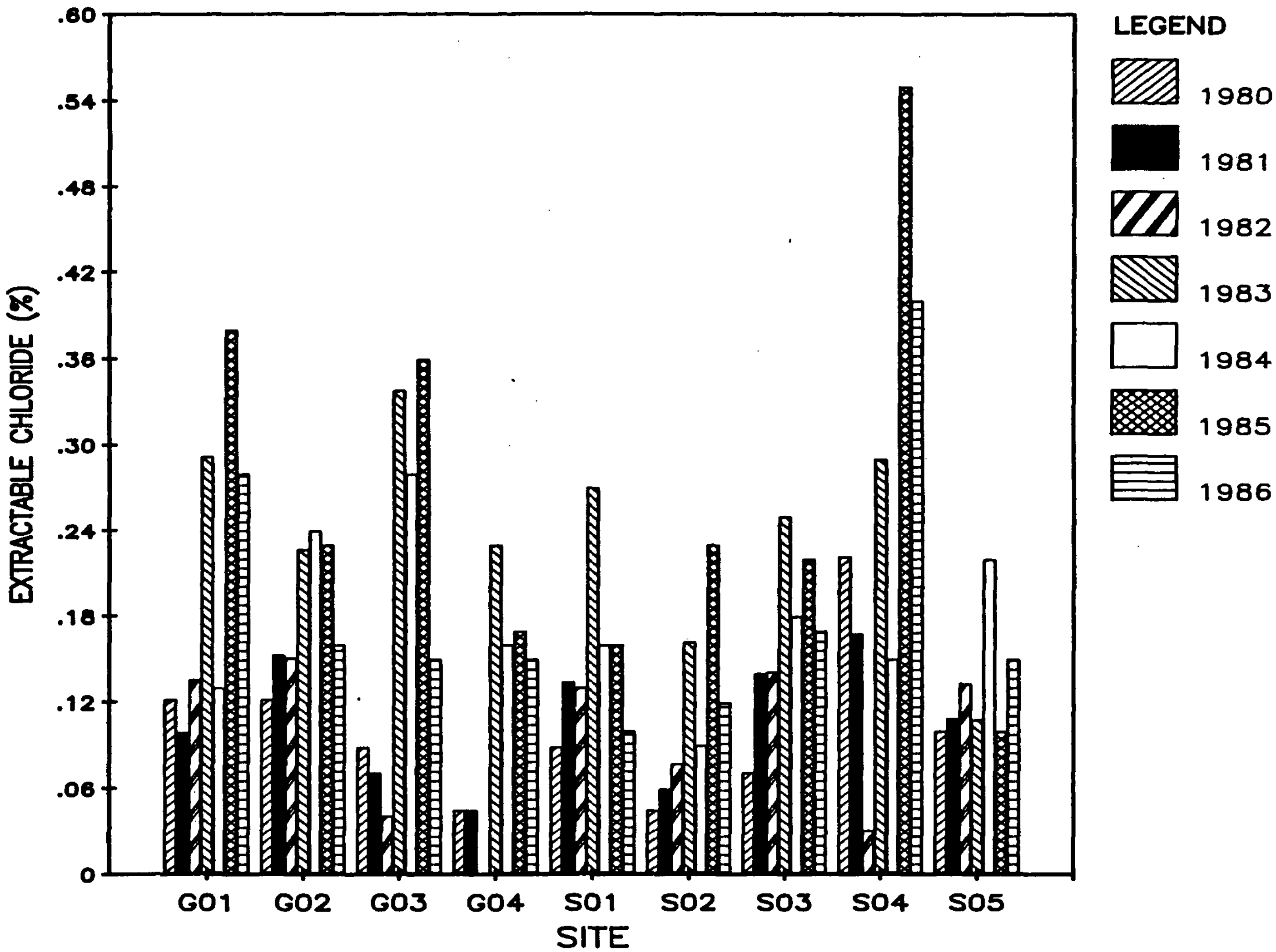


Figure 7-51. Chloride Concentration (%) in <u>Bromus</u> <u>Tectorum</u> by Site for 1980 - 1986

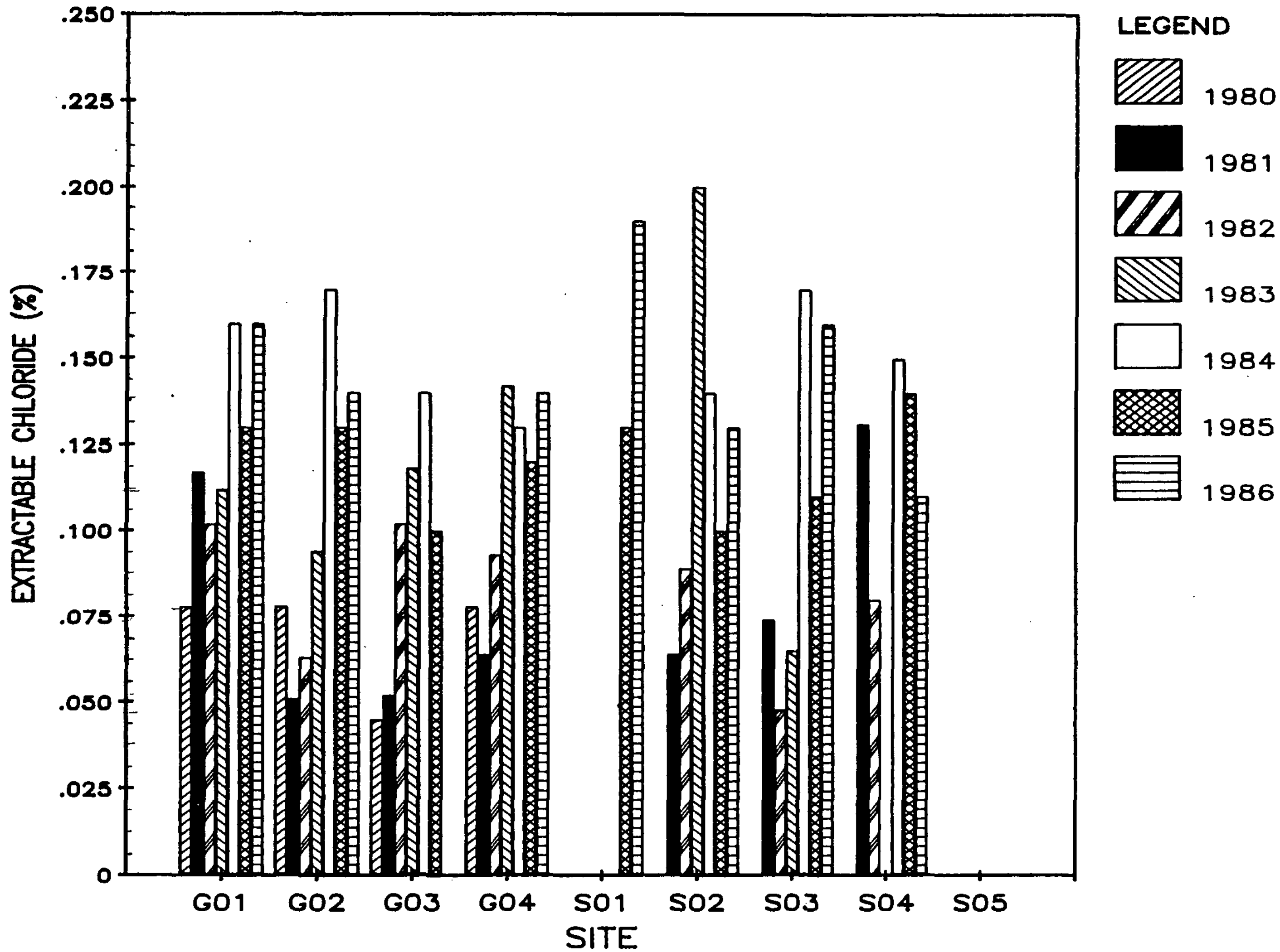


Figure 7-52. Chloride Concentration (%) in Phlox Longifolia by Site for 1980 - 1986

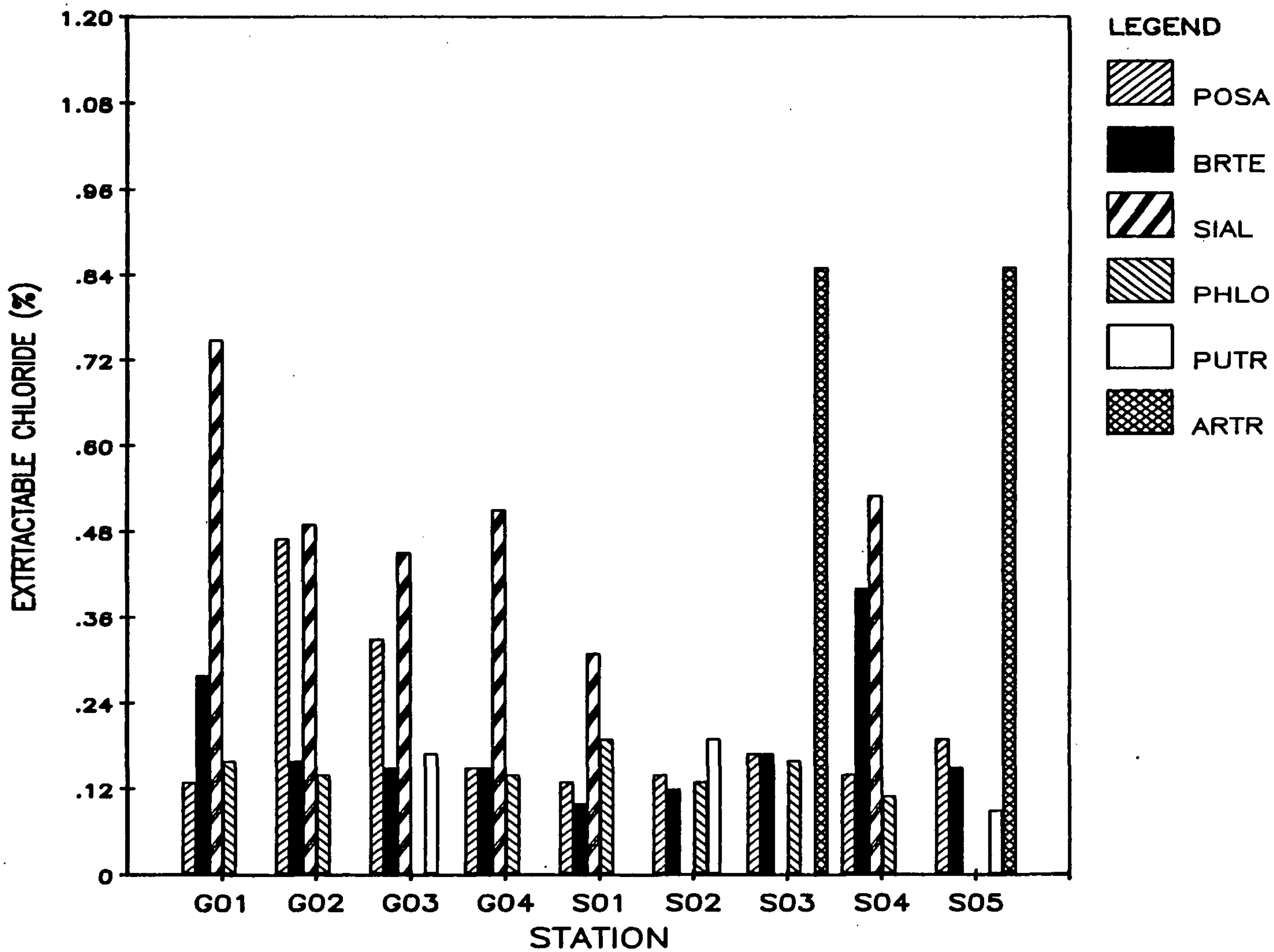


Figure 7-53. Total Vegetation Chloride for May 1986

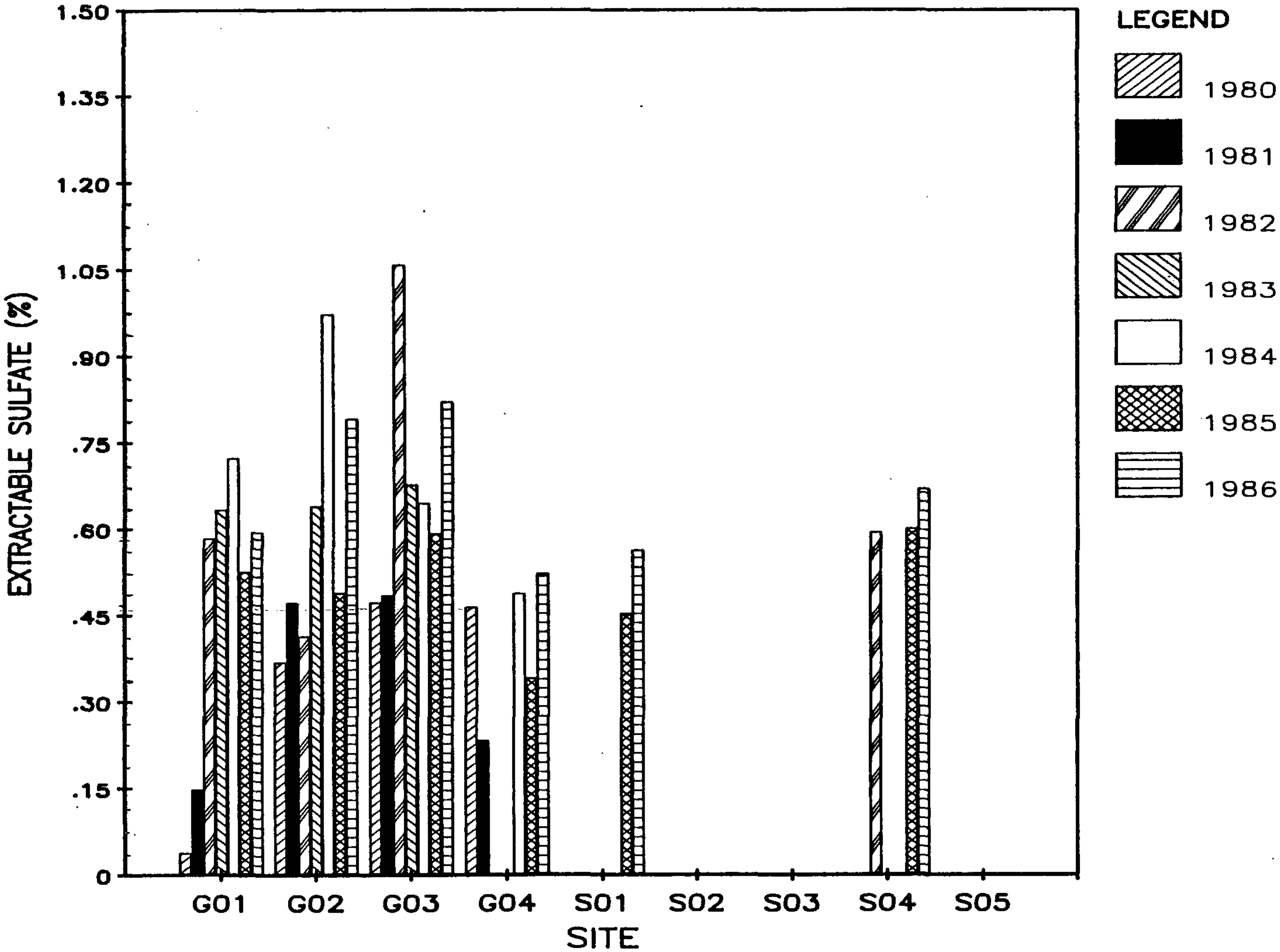


Figure 7-54. Sulfate Concentration (%) in Sisymbrium Altissimum by Site for 1980 - 1986

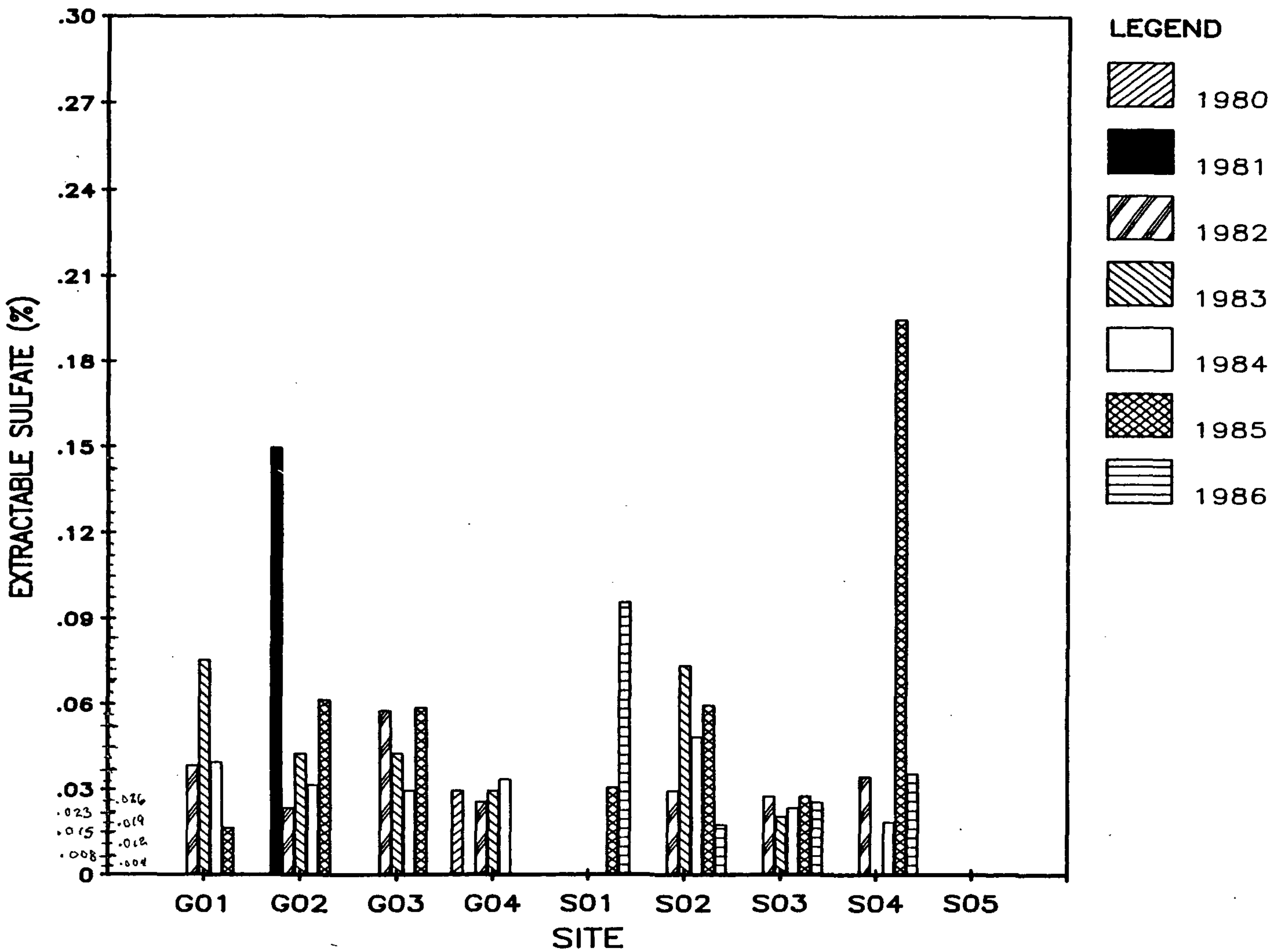


Figure 7-55. Sulfate Concentration (%) in Phlox Longifolia by Site for 1980 - 1986

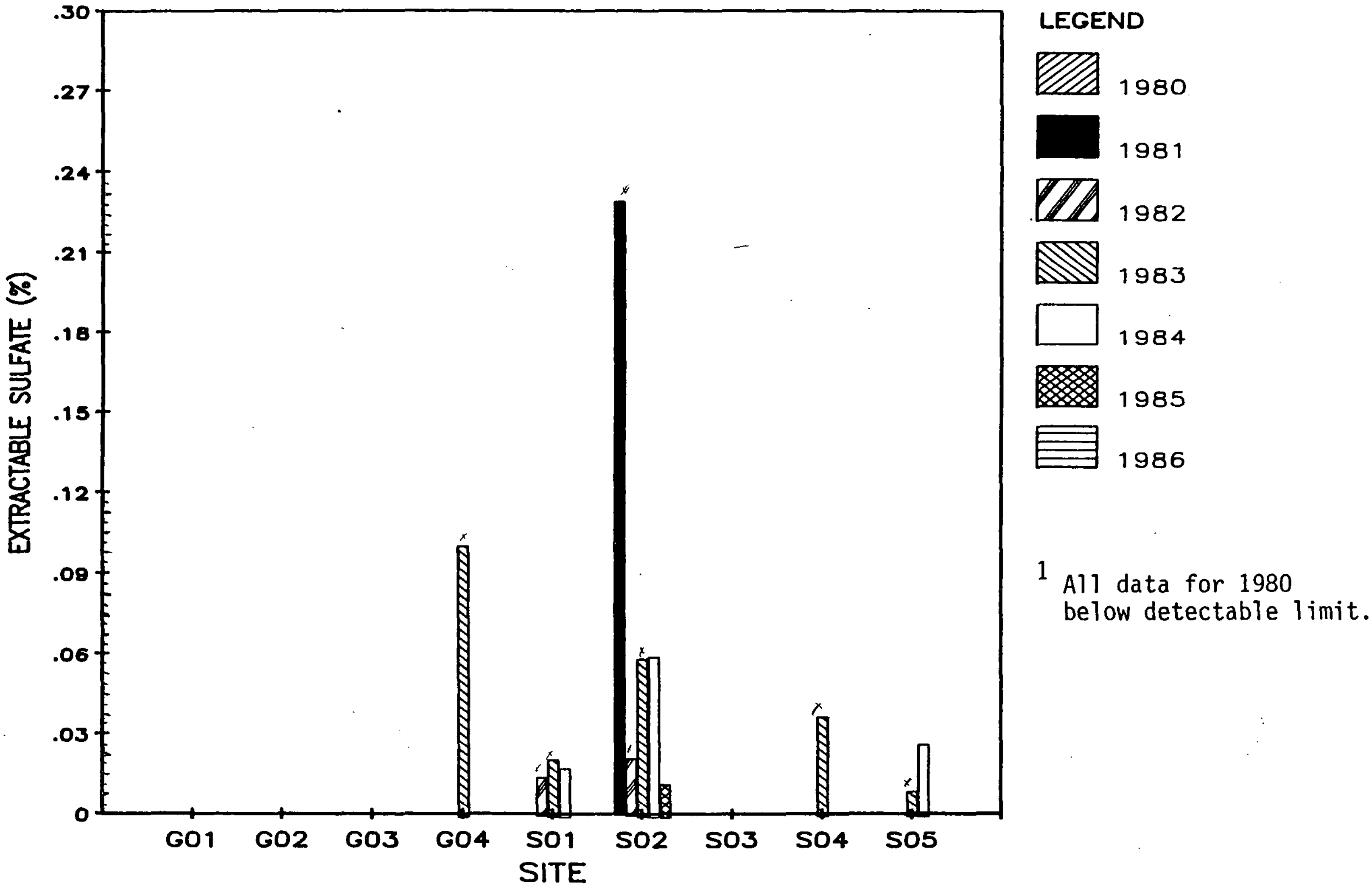


Figure 7-56. Sulfate Concentration (%) in Purshia Tridentata by Site for 1980 - 1986

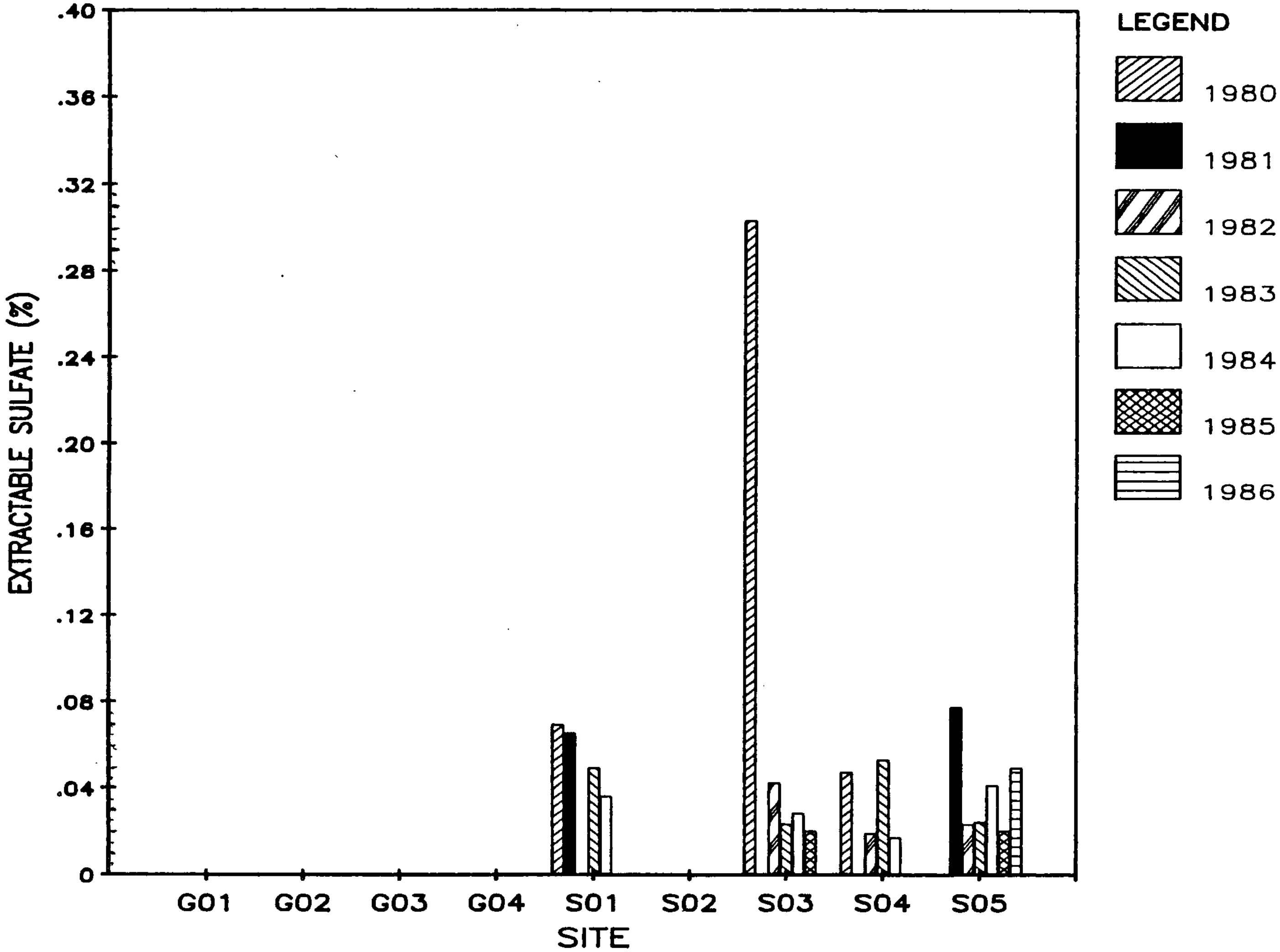


Figure 7-57. Sulfate Concentration (%) in Artemisia Tridentata by Site for 1980 - 1986

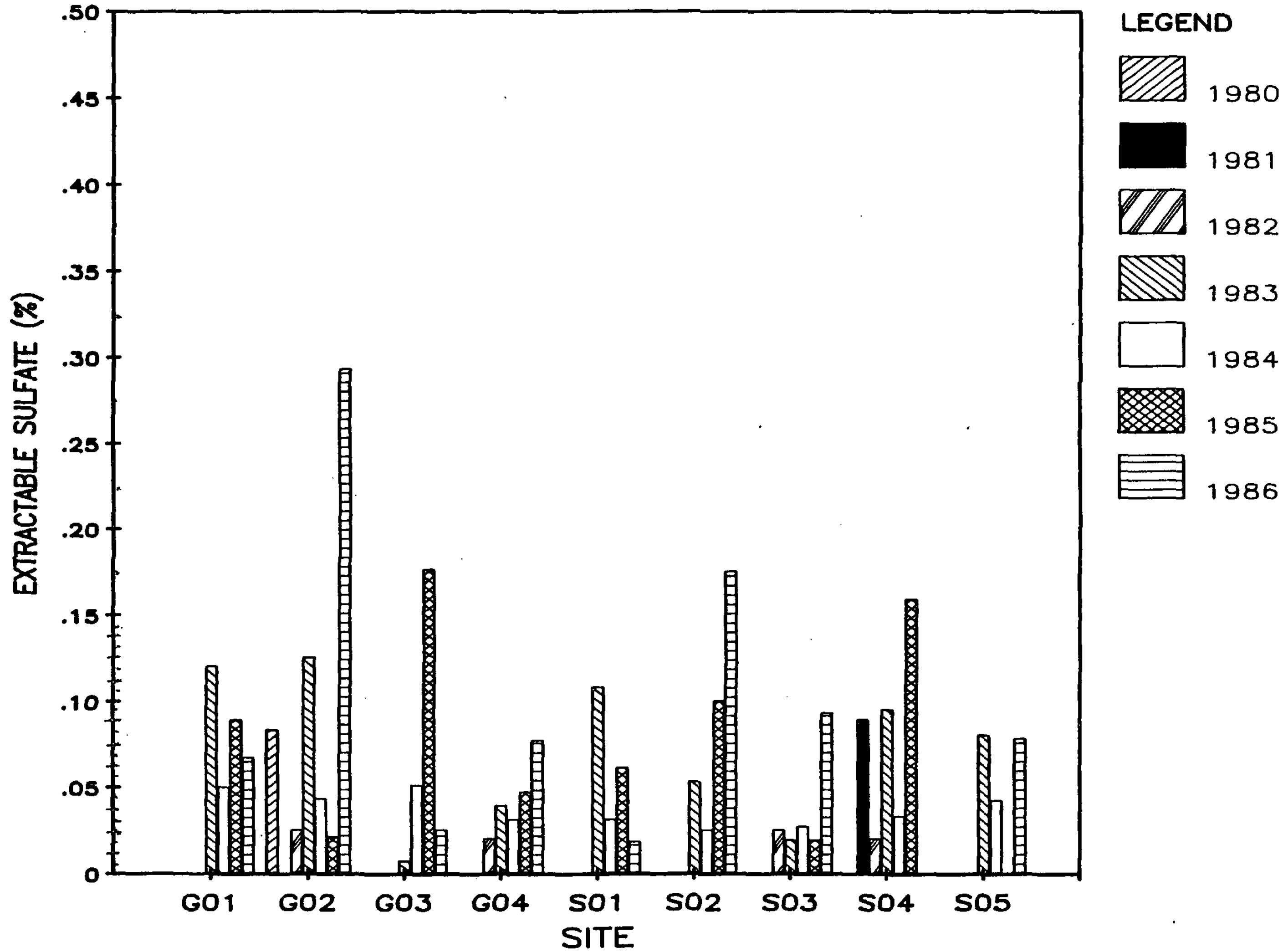


Figure 7-58. Sulfate Concentration (%) in <u>Bromus Tectorum</u> by Site for 1980 - 1986

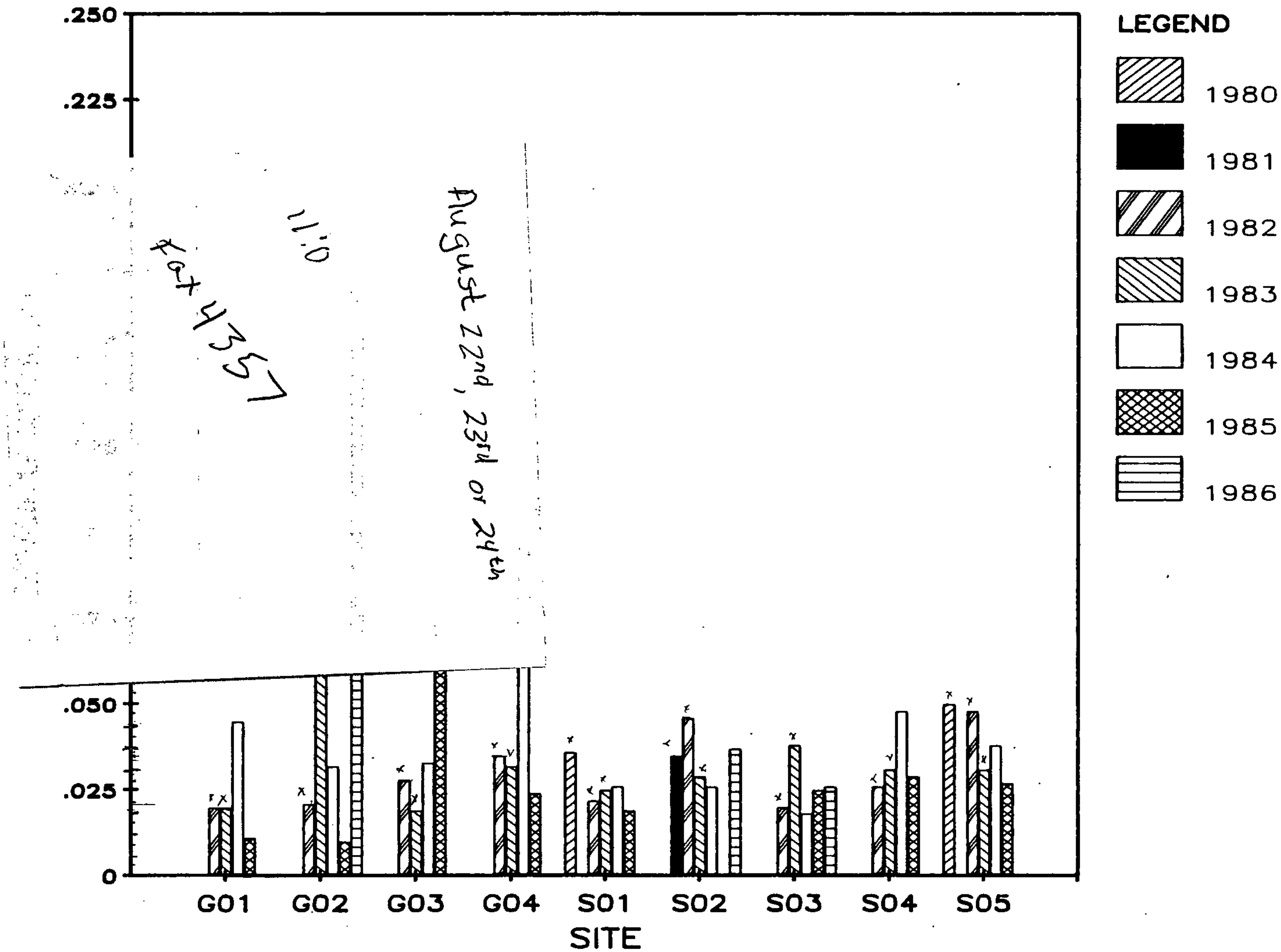


Figure 7-59. Sulfate Concentration (%) in Poa Sandburgii by Site for 1980 - 1986

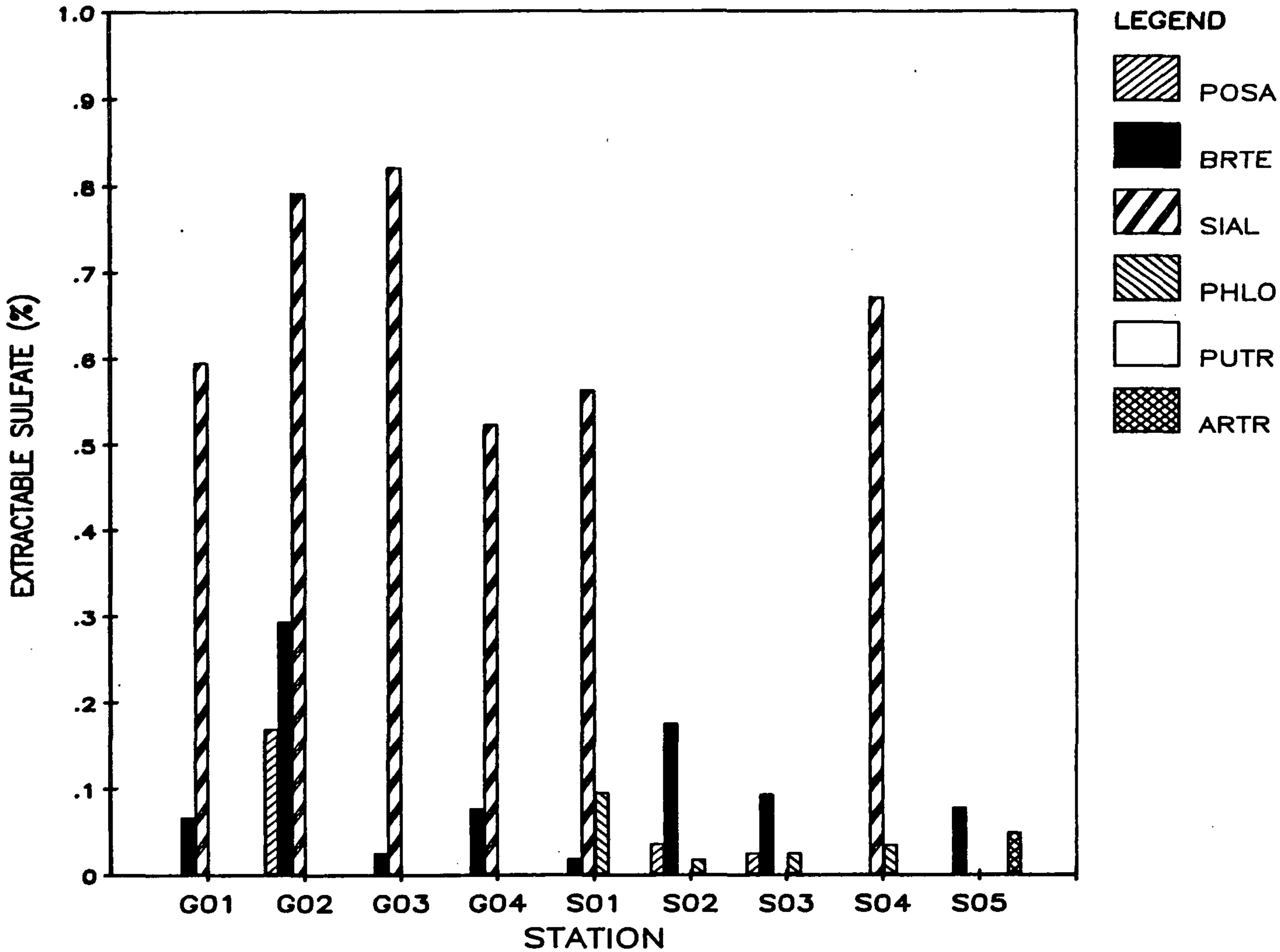


Figure 7-60. Total Vegetation Sulfate for May 1986

8.0 ANIMAL STUDIES

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 disturbances and noise as well as indirect effects brought about through changes in the abundance of food, 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 natural population changes in these communities during WNP-2 operation. These surveys fulfill requirements imposed by the Energy Facility Site Evaluation Council Resolution Nos. 194 and 195 dated May 26, 1981.

As a result of an August 1984 range fire, EFSEC allowed the Supply System to terminate sampling in the three plots which were disturbed by the fire (EFSEC Resolution No. 223 dated October 29, 1985). The 1986 survey program was limited to three plots in the southeast quadrant.

8.2 MATERIALS AND METHODS

8.2.1 Birds

The 1986 spring and fall surveys of bird communities were conducted May 15, 16, 22, 23, 29, 30 and October 8-10, 15-17. The surveys were conducted on two 20-acre plots located south of the WNP-1 and WNP-2 sites (Figure 8-1). 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) was surveyed first each day, each plot was observed 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 recorded. Each bird encountered within the plot was recorded, as well as those birds observed within one kilometer of the plot.

8.2.2 Deer and Rabbits

The 1986 census was conducted within 75 circular 25-m^2 plots. The spring and fall counts were performed during the June 5, 6 and October 8, 9, 15-17 time periods, respectively. The sample areas are located in bitterbrush-sagebrush, riparian, and burned habitats south of the WNP-1 and WNP-2 sites. There are 25 circular plots for each of the three different sample areas (Figure 8-1). The pellet-group/pellet-count technique (Bennett et. al. 1940) was used as an index for calculating deer and rabbit population size based on the density of fecal pellet groups or fecal pellets, the deposition period and regional defecation rate. The investigator proceeded to the monitoring location where the date, time, and weather conditions were recorded. The plots were searched for pellets by placing the looped end of a 2.8 meter rope over a nail on a stake that was in the center of each plot. Using the 1 meter and 2 meter marks on the rope, the investigator searched around the stake at each of these intervals and at the edge of the plot. The pellet groups were recorded and then removed from the plot. Rabbit pellets are counted individually.

Using the total number of deer and rabbit pellet groups or 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 formulas:

$$\text{Number of rabbits} = \frac{\left(\frac{a}{b}\right) \times 10^6}{(c \times d)}$$

a = number of pellets

b = size of plot

c = days between sample collection

d = deposition rate/day (530 pellets/day/rabbit)

$$\text{Number of deer} = \frac{\left(\frac{a}{b}\right) \times 10^6}{(c \times d)}$$

a = pellet groups

b = size of plot

c = days between sample collection

d = deposition rate (13 pellet groups/day deer)

8.3 RESULTS AND DISCUSSION

8.3.1 Birds

Tables 8-1 and 8-2 present the 1986 spring and fall data, which includes the number of bird species sighted and their frequencies within and outside the plots. Twenty-two different species were observed within the south riparian biome during the spring survey and ten species were observed within the south shrub biome. During the fall survey the south riparian biome again had the largest number of species with nineteen within the plot and twelve outside. The total number of species sighted during the previous five years are listed in Table 8-3.

The number of sightings was used to calculate density per acre. However, when calculating density, only low-flying and perching birds were counted in the calculations. Because of their transient behavior, flocks that were noted as passing through the plots were not included in the density calculations. Tables 8-4 and 8-5 show the spring and fall density figures. Spring and fall percent composition data are presented in Tables 8-6 and 8-7, respectively. Percentages were calculated utilizing only those birds appearing within the sample plots.

Western meadow larks, brown-headed cow birds, red-winged black birds, and white-crowned sparrows comprised 56.9 percent of the birds observed in 1986 (Table 8-7). Waterfowl and shorebirds observed were: ducks, geese, gulls, loons, killdeer, herons and curlews. Five species of raptors were observed in 1986: loggerhead shrike, red-tailed hawk, marsh hawk or northern harrier, common night hawk, and rough-legged hawk. The game birds observed during the survey include the Canada goose, mallard duck, California quail, morning dove, and ring-necked pheasant. Table 8-9 lists all bird species observed during the 1981 through 1986 surveys.

During the 1986 surveys, a total of 36 different species were recorded, compared to 39, 42, 43, and 48 during the 1982 through 1985 surveys. Twenty-five of the species recorded during 1986 were also recorded during the 1981-1985 studies. Species not recorded in all years were generally low in abundance. Two species sighted for the first time in 1986 were the black-crowned night heron and mountain chickadee. These were seen in the south riparian biome. In general, the seasonal trends in total sightings and species numbers observed in the 1981 census were evident in the 1982 - 1986 censuses.

8.3.2 Deer and Rabbits

The number of deer and rabbit pellet groups per plot recorded during the spring and fall surveys from 1981 through 1986 are presented in Tables 8-10 through 8-13, respectively. Deer and rabbit densities per sample area recorded during the spring and fall 1986 surveys are presented in Tables 8-14 through 8-17, respectively.

Deer densities (deer/km^2) were highest in the south shrub and south riparian sample biomes during the spring and fall census periods (Tables 8-10 and 8-11). The south grass biomes had relatively low density values. The south shrub biome had the highest densities recorded during the five year sampling period while the 1982 density values were the highest observed during the five years (Tables 8-10 and 8-11). It appears that deer densities near WNP-1 and WNP-2 are low compared to other areas sampled both inside and outside Washington state (Bennett et. al. 1940, Eberhardt et. al. 1956, Pickens 1976, Zeigler 1978).

The highest rabbit densities (rabbits/km^2) were observed in the south shrub biome during the 1981-1986 sampling periods (Tables 8-12 and 8-13). The south riparian and south grass biome had relatively low density values. The results of this study are in good agreement with those reported by others (Beak 1979, Cochran et. al. 1961, Larrison 1970).

The results of the animal monitoring studies within the study areas surrounding WNP-2 compare similarly to previous years indicating stable avian, deer and rabbit populations. Studies performed through 1986 do not reveal any impact from the operation of WNP-2.

8.4 BIBLIOGRAPHY

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Table 8-1. Spring Bird Survey
May 15-30, 1986

SPRING SURVEY 1986

South Riparian

	On Plot							Off Plot						
Species	(1) 1	2	3	4	5	6	Total	1	2	3	4	5	6	Totals
Bank swallow	1		2	3			6			1	3	2		33
Barn swallow		1					1							
Black-billed magpie	1	2		1	2		6							
Black crown night heron					1		1							
Brown-head cowbird	10	7	10	16	4	10	57		6		3	5	5	19
Bullocks oriole	3		4	3	3	2	15				3			3
California gull						1	1					1		1
Canada goose									11		9	11	4	35
Common loon						1	1					1	1	2
Common night hawk						1	1							
Eastern kingbird			2	2	4	4	12							
Foster tern									3			1	5	9
Great blue heron	4						4						2	2
Herring gull					1		1							
Long-billed curlew														
Mallard											2		7	9
Morning dove	4	2			1		7							
Red-tailed hawk				1			1							
Red-winged blackbird	12	8	7	6	4	4	41	1	4	2				7
Sage sparrow		1	1	2	1		5							
Western kingbird	5	2	2	3	3	1	16				1			1
Western meadowlark	6	7	3	5	5	2	28	2	9	4	3	3		21
Unidentified blackbird														
Unidentified gull	5						5	11	17	7	22	58	24	139
Unidentified sparrow									1					1
Unidentified species													2	2
Unidentified swallow									1					1
	Total Sightings						209	Total Species						286

South Shrub

	On Plot							Off Plot						
Species	1	2	3	4	5	6	Total	1	2	3	4	5	6	Totals
Bank swallow								1						1
Barn swallow														
Black-billed magpie											2			2
Black crown night heron														
Brown-head cowbird									2			2	1	5
Bullocks oriole														
California gull														
Canada goose														
Common loon														
Common night hawk												7		7
Eastern kingbird														
Foster tern														
Great blue heron														
Herring gull									5		1			6
Long-billed curlew											1			1
Mallard									1					1
Morning dove														
Red-tailed hawk														
Red-winged blackbird	1				1		2	2	1	3		4		10
Sage sparrow														
Western kingbird														
Western meadowlark	11	5	5	6	5	2	34	3	7	9	6	7		32
Unidentified blackbird								4				3		7
Unidentified gull	1		2		1		4	6	3	7	11	8	4	39
Unidentified sparrow														
Unidentified species														
Unidentified swallow														
	Total Sightings						41	Total Sightings						113
	Total Species						10							

Total Species 22

(1) Dates of Surveys
1 - May 15, 1986 3 - May 22, 1986 5 - May 29, 1986
2 - May 16, 1986 4 - May 23, 1986 6 - May 30, 1986

Table 8-2. Fall Bird Survey
October 8-17, 1986

FALL SURVEY 1986

South Riparian

Species List	On Plot (1) 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Total
Audubon's warbler								3						3
Black-billed magpie	2			1	1		4				1	2		3
California quail								1						1
Canada goose								25		25	10	40		100
Common merganizer									2					2
Common raven				1			1	1				1		1
Great blue heron	3		2		1		6		2	1	1			4
Killdeer	3	1		1			5			1		2		3
Loggerhead shrike	1			2	1	1	5							
Mallard								10	4	15	65	9	25	128
Marsh hawks (Harrier)														
Morning dove					1		1							
Mt. Chickadee				2	2		4							
Oregon junco		5				5	10		8					8
Red-shafted flicker		2	1	1	4	1	9					2		2
Ring-necked pheasant	1	1		4			6			2				2
Rough legged hawk					1		1							
Savannah sparrow	3	3	4	3	3	1	17							
Song sparrow														
Western meadow lark	1	7	2	19	1	5	35	5	18	3	1	1	2	30
White-crown sparrow		5	6	8	7	5	31							
Unidentified gull				1	1	2	4		3		2	7	10	22
Unidentified sparrow	2		4		1	1	8	3	2	6		4	2	17
	Total Species						147	Total Sightings						326

South Riparian

Species List	On Plot 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Total
Audubon's warbler														
Black-billed magpie	1						1					2		2
California quail			1				1							
Canada goose								6	25					31
Common merganizer								4			1			5
Common raven														
Great blue heron											2			2
Killdeer											1			1
Loggerhead shrike														
Mallard														
Marsh hawks (Harrier)		1					1							
Morning dove														
Mt. Chickadee														
Oregon junco					2		2				5			5
Red-shafted flicker	1					1	2	1			1	1	1	4
Ring-necked pheasant														
Rough legged hawk														
Savannah sparrow														
Song sparrow	2						2	1						1
Western meadow lark	3	4	2	1	4	3	17	4	6			6	5	21
White-crown sparrow		3				4	7							
Unidentified gull		2	3		1	1	7	3	15	15	1	12	15	61
Unidentified sparrow			1	2	2	1	6	4	10	10		3	3	30
	Total Species						46	Total Sightings						163

(1) Dates of Surveys
1 - October 8, 1986   3 - October 10, 1986   5 - October 16, 1986
2 - October 9, 1986   4 - October 15, 1986   6 - October 17, 1986

Table 8-3. Total Number of Bird Species Sighted 1981 Through 1986

Year	Spring	Fall
1986	23	20
1985	35	20
1984	29	15
1983	35	21
1982	41	24
1981	32	26

Table 8-4. Spring Bird Survey Densities for 1986

Species	N(1) South Shrub	N/A(2)	N(1) South Riparian	N/A(2)
Bank swallow			6	.30
Barn swallow	1	.05	1	.05
Black-billed magpie			6	.30
Black-crowned night heron			1	.05
Brown-headed cowbird			57	2.85
Bullock's oriole			15	.75
California gull			1	.05
Common loon			1	.05
Common night hawk			1	.05
Eastern kingbird			12	.6
Great blue heron			4	.2
Herring gull			1	.05
Morning dove			7	.35
Red-tailed hawk			1	.05
Red-winged blackbird	2	.1	41	2.05
Sage sparrow			5	.25
Western kingbird			16	.8
Western meadow lark	34	1.7	28	1.4

(1)N = Number of birds observed

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

Table 8-5. Fall Bird Densities for 1986

Species	N(1) South Shrub	N/A(2)	N(1) South Riparian	N/A (2)
Black-billed magpie	1	.05	4	.2
California gull	1	.05		
Common raven			1	.05
Great blue heron			6	.3
Killdeer			5	.25
Loggerhead shrike			5	.25
Marsh hawk	1	.05		
Morning dove	1	.05	1	.05
Mt. chickadee			4	.2
Oregon junco	2	.1	10	.5
Red-shafted flicker	2	.1	9	.45
Ring-necked pheasant			6	.3
Rough-legged hawk			1	.05
Savannha sparrow			17	.85
Song sparrow	2	.1		
Western meadow lark	17	.85	35	1.75
White-crowned sparrow	7	.35	31	1.55

(1)N = Number of birds observed

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

Table 8-6. Spring Bird Survey Percentages for 1986

Species	#Sightings South Shrub	Percent Composition	#Sightings Within South Riparian	Percent Composition
Bank swallow			6	2.9
Barn swallow	1	2.7	1	0.49
Black-billed magpie			6	2.9
Black-crowned night heron			1	0.49
Brown-headed cowbird			57	27.9
Bullock's oriole			15	7.3
California gull			1	0.49
Common loon			1	0.49
Common night hawk			1	0.49
Eastern kingbird			12	5.8
Great blue heron			4	1.9
Herring gull			1	0.49
Morning dove			7	3.4
Red-tailed hawk			1	0.49
Red-winged blackbird	2	5.4	41	20.0
Sage sparrow			5	2.4
Western kingbird			16	7.8
Western meadowlark	34	91.8	28	13.7
Total Sightings	37		204	

Table 8-7. Fall Bird Survey Percentages for 1986

Species	#Sightings South Shrub	Percent Composition	#Sightings Within South Riparian	Percent Composition
Black-billed magpie	1	3.0	4	2.9
California gull	1	3.0		
Common raven			1	.74
Great blue heron			6	4.4
Killdeer			5	3.7
Loggerhead shrike			5	3.7
Marsh hawk	1	3.0		
Morning dove			1	.74
Mt. chickadee			4	2.9
Oregon junco	2	6.0	10	7.4
Red-shafted flicker	2	6.0	9	6.6
Ring-necked pheasant			6	4.4
Rough-legged hawk			1	.74
Savannha sparrow			17	12.5
Song sparrow	2	6.0		
Western meadow lark	17	51.1	35	25.9
White-crowned sparrow	7	21.2	31	22.9
Total Sightings	33		135	

Table 8-8. List of Ten (10) Most Sighted Birds and Their Percent Compositions for 1986

	Species	Sighted [1]	Percent Composition [2]
1.	Western meadow larks	114	25.7
2.	Brown-headed cowbird	57	12.8
3.	Red-winged blackbird	43	9.7
4.	White-crowned sparrow	38	8.5
5.	Savannha sparrow	17	3.8
6.	Western kingbird	16	3.6
7.	Bullock's oriole	15	3.3
8.	Oregon junco	12	2.7
9.	Red-shafted flicker	11	2.4
10.	Great blue heron	10	2.2
			74.7

(1) Total birds sighted within plots-443.

(2) Percentages are derived from total identified birds sighted inside the plots for 1986.

Table 8-9. Summary of Bird Species Observed from 1981 through 1986

	Identified	Spring 1981-1986	Fall 1981-1986	Previous Studies(1)
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.	Black-crowned night heron	X		
11.	Blue-winged teal	X		
12.	Brewer's blackbird	X		
13.	Brown-headed cowbird	X		
14.	Bullock's oriole	X		
15.	Burrowing owl		X	X
16.	California quail	X	X	
17.	Canada goose	X	X	
18.	Cinnamon teal	X		
19.	Cliff swallow	X		X
20.	Common crow	X	X	
21.	Common loon	X	X	
22.	Common merganser	X		
23.	Common nighthawk	X		X
24.	Common raven	X	X	X
25.	Common tern	X		
26.	Eared grebe		X	
27.	Eastern kingbird	X		
28.	Ferruginous hawk			X

Table 8-9. (Cont'd)

	Identified	Spring 1981-1986	Fall 1981-1986	Previous Studies(1)
29.	Foster tern	X		
30.	Golden eagle			X
31.	Great blue heron	X	X	
32.	Green-winged teal	X		
33.	Herring gull	X		
34.	Horned lark	X	X	X
35.	Killdeer	X	X	X
36.	Lark sparrow	X		
37.	Loggerhead shrike	X	X	X
38.	Long-billed curlew	X		X
39.	Mallard	X	X	
40.	Marsh hawk (harrier)	X	X	X
41.	Morning dove	X		X
42.	Mountain chickadee		X	
43.	Oregon junco		X	X
44.	Prairie falcon			X
45.	Red-headed duck	X		
46.	Red-shafted flicker		X	X
47.	Red-tailed hawk	X	X	X
48.	Red-winged blackbird	X	X	
49.	Ring-necked pheasant	X	X	
50.	Rock dove (domestic pigeon)	X		
51.	Rough-legged hawk		X	X
52.	Sage sparrow	X	X	X
53.	Savannah sparrow	X	X	X
54.	Say's phoebe	X		
55.	Song sparrow	X		
56.	Spotted sandpiper	X		
57.	Starling	X	X	X

Table 8-9. (Cont'd)

	Identified	Spring 1981-1986	Fall 1981-1986	Previous Studies(1)
58.	Swainson's hawk		X	
59.	Traill's flycatcher	X		
60.	Tree sparrow	X	X	
61.	Water pipit		X	
62.	Western kingbird	X		
63.	Western meadowlark	X	X	X
64.	Western sandpiper		X	
65.	Western gull	X		
66.	Whistling swan		X	
67.	White-crowned sparrow	X	X	X
68.	Wilson's warbler	X		
69.	Yellow warbler	X		
70.	Yellow-headed blackbird	X		

(1) Previous studies were performed for the Washington Public Power Supply System by Battelle Pacific Northwest Laboratories (Battelle, 1976, 1977, 1979a, 1979b).

Table 8-10. Summary of the Spring Deer Pellet Censuses; from 1981 through 1986

Sample area	Total Pellet Group						Densities (No. of Deer/km^2)					
	1981	1982	1983	1984	1985	1986	1981	1982	1983	1984	1985	1986
North Shrub	--[1]	3	0	2	--[2]	--	--	1.74	0	1.01	--	--
South Shrub	--	137	35	25	15	34	--	77.31	19.3	14.0	8.8	19.1
North Riparian	--	11	27	28	--	--	--	6.26	14.9	14.9	--	--
South Riparian	--	3	5	5	15	25	--	1.83	2.7	2.6	8.5	13.6
North Grass	--	3	4	0	--	--	--	1.82	2.1	0	--	--
South Grass	--	6	14	27	17	8	--	3.63	7.49	14.7	9.5	4.3

[1]Plots initially cleared of pellets.

[2]North plots were not sampled because of range fire (EFSEC Resolution No. 223, October 29, 1984).

Table 8-11. Summary of the Fall Deer Pellet Censuses: from 1981 through 1986

Sample area	Total Pellet Group						Densities (No. of Deer/km^2)					
	1981	1982	1983	1984	1985	1986	1981	1982	1983	1984	1985	1986
North Shrub	4	8	1	- [1]	--	--	2.91	7.57	0.89	--	--	--
South Shrub	35	79	40	28	8	33	28.53	72.56	35.6	23.6	5.7	30.7
North Riparian	17	18	19	--	--	--	12.92	17.44	16.7	--	--	--
South Riparian	1	2	6	7	9	27	0.76	2.21	5.3	6.1	6.6	27.2
North Grass	1	1	4	--	-	--	0.76	1.13	3.5	-	--	--
South Grass	1	6	10	7	3	11	0.78	6.65	9.1	5.9	2.3	10.8

[1] North plots were not sampled because of range fire on August 11-12, 1984. (EFSEC Resolution No. 223, October 1984)

Table 8-12. Summary of the Spring Rabbit Pellet Censuses: from 1981 through 1986

Sample area	Total Pellets						Densities (No. of Rabbits/km^2)					
	1981	1982	1983	1984	1985	1986	1981	1982	1983	1984	1985	1986
North Shrub	--[1]	2,795	1,361	1,035	-[2]	--	--	31.80	18.1	13.8	--	--
South Shrub	--	1,441	1,393	924	886	960	--	19.90	18.8	12.7	12.7	13.2
North Riparian	--	299	641	468	--	--	--	4.17	8.68	6.3	--	--
South Riparian	--	0	23	0	0	2	--	0	.30	0	0	.026
North Grass	--	0	0	0	--	--	--	0	0	0	--	--
South Grass	--	0	0	41	0	0	--	0	0	.5	0	0

[1] Plots initially cleared of pellets.

[2] North plots were not sampled because of range fire on August 11-12, 1984. (EFSEC Resolution No. 223, October 1984)

Table 8-13. Summary of the Fall Rabbit Pellet Censuses: from 1981 through 1986

Sample area	Total Pellets						Densities (No. of Rabbits/km^2)					
	1981	1982	1983	1984	1985	1986	1981	1982	1983	1984	1985	1986
North Shrub	4,680	2,743	1,549	--(1)	--	--	83.60	63.69	33.8	--(1)	--	--
South Shrub	720	2,717	886	1,337	590	940	14.39	61.21	19.1	26.6	12.7	21.4
North Riparian	120	433	740	--	--	--	2.24	10.29	15.9	--	--	--
South Riparian	0	0	2	23	3	1	0	0	.04	.49	.05	.024
North Grass	120	0	0	-	-	--	2.32	0		--	--	--
South Grass	0	0	0	2	0	0	0	0	0	.04	0	0

(1)North plots were not sampled because of range fire on August 11-12, 1984. (EFSEC Resolution No. 223, October 1984)

Table 8-14. Summary of the Spring Deer Pellet Census for 1986:

Plot No.[1]	South Shrub June 5, 6	South Riparian June 5	South Grass June 6
1	3	0	0
2	0	0	0
3	5	1	0
4	0	0	0
5	2	0	0
6	0	0	0
7	2	0	0
8	2	0	0
9	0	0	0
10	1	0	2
11	0	2	0
12	1	3	0
13	1	3	1
14	2	4	0
15	2	0	0
16	1	2	1
17	0	4	1
18	1	1	0
19	1	2	0
20	1	0	0
21	4	0	0
22	1	0	1
23	0	1	0
24	2	1	2
25	2	1	0
Total Pellet Groups	34	25	8

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

Table 8-15. Summary of the Fall Deer Pellet Census for 1986:

Plot No.[1]	South Shrub Oct 15-17	South Riparian Oct 10	South Grass Oct 9
1	4	0	0
2	1	0	0
3	2	1	0
4	1	0	0
5	2	0	1
6	0	0	0
7	1	0	1
8	1	0	2
9	1	0	2
10	0	0	2
11	3	1	0
12	0	2	0
13	1	3	0
14	2	6	0
15	2	1	1
16	1	4	1
17	0	0	1
18	1	0	0
19	1	2	0
20	1	0	0
21	3	0	0
22	2	1	1
23	2	2	0
24	1	1	0
25	2	3	0
Total Pellet Groups	33	27	11

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

Table 8-16. Summary of the Spring Rabbit Pellet Census for 1986:

Plot No.[1]	South Shrub June 5, 6	South Riparian June 5	South Grass June 6
1	59	0	0
2	23	0	0
3	126	0	0
4	19	0	0
5	55	0	0
6	49	0	0
7	23	0	0
8	33	0	0
9	89	0	0
10	20	0	0
11	28	0	0
12	20	0	0
13	75	0	0
14	67	0	0
15	79	1	0
16	9	0	0
17	20	0	0
18	3	0	0
19	27	0	0
20	4	0	0
21	96	0	0
22	1	0	0
23	11	0	0
24	6	1	0
25	18	0	0
Total Pellets	960	2	0

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

Table 8-17. Summary of the Fall Rabbit Pellet Census for 1986:

Plot No.[1]	South Shrub Oct 15-17	South Riparian Oct 10	South Grass Oct 9
1	66	0	0
2	44	0	0
3	78	1	0
4	33	0	0
5	42	0	0
6	53	0	0
7	26	0	0
8	31	0	0
9	76	0	0
10	12	0	0
11	25	0	0
12	44	0	0
13	24	0	0
14	38	0	0
15	39	0	0
16	19	0	0
17	37	0	0
18	47	0	0
19	27	0	0
20	23	0	0
21	46	0	0
22	21	0	0
23	34	0	0
24	22	0	0
25	33	0	0
Total Pellets	940	1	0

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

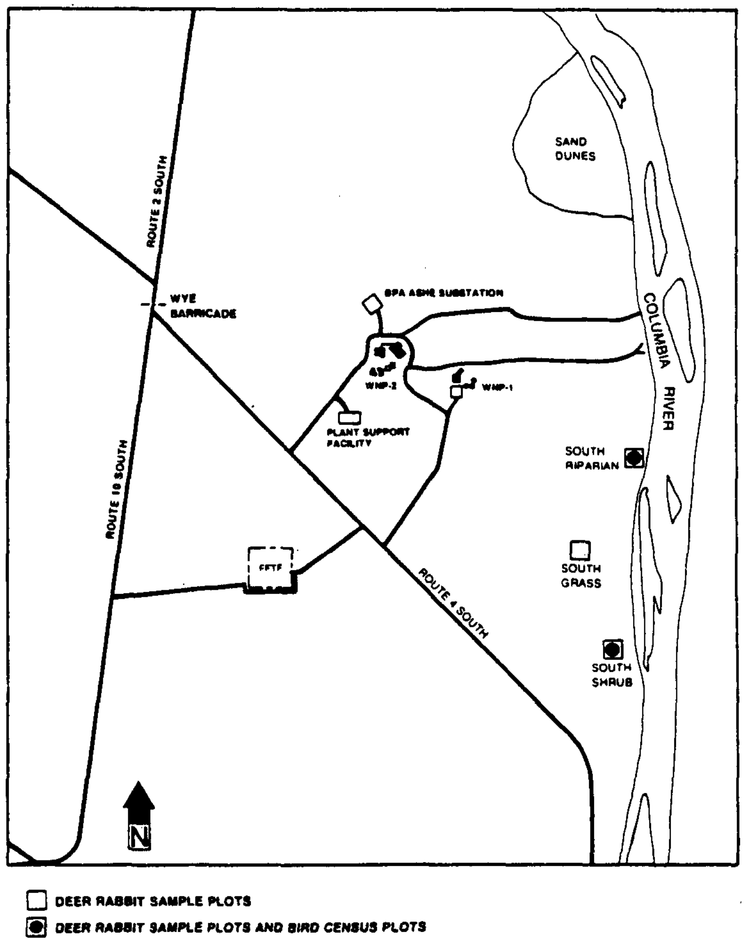

Figure 8-1. Deer, Rabbit, and Bird Plots in the Vicinity of WNP-1 and WNP-2