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Table 1. Sample dates and codes for biological and chemical parameters.

Date	Code	pH, Alk & Dis. Metals	Acidity & Sed. Metals	Total Aq. Metals	Algae	Surber	Ekman
June 95	Sum95	x				density only	
May96	Sum96	x			x	x	x
Sept96	Fall96	x	x		x	x	x
Dec96	Wn96	x	x		x	x	x
Mar97	Sp97	x	x	x	x	x	x
June97	Sum97	x	x	x	x	x	x
Sept97	Fall97	x	x	x	x	x	x
an98	Wn97	x	x	x	x	x	x
Mar98	Sp98	x	x	x	x	x	x
June98	Sum98	x	x	x	x	x	x
Sept98	Fall98	x	x	x	x	x	x
Feb99	Wn98	x	x	x	x	x	x
Jun99	Sum99	x	x	x	x	x	x

Table 2. Mean relative abundance of epilithic species for the study.

Species ID	Site 44	Site 46	Site 60	Sit 61	Site 65	Site 67	Wolf Crk
Achnanthes minutis.	0.1057	0.0850	0.1223	0.1299	0.2335	0.4110	0.0456
Eunotia minor	0.0191	0.0258	0.1353	0.0398	0.0558	0.0842	0.0000
Nitzschia dissipata	0.0118	0.0030	0.0014	0.0072	0.0066	0.0076	0.0956
Phormidium sp.	0.4849	0.3880	0.2382	0.4690	0.2974	0.1650	0.0662
Navicula gregraria	0.0446	0.0056	0.0012	0.0086	0.0060	0.0073	0.1148
Navicula lanceolata	0.0186	0.0122	0.0013	0.0092	0.0007	0.0078	0.1079
Nitz. frust. v. pup	0.0015	0.0004	0.0006	0.0031	0.0019	0.0003	0.0645
Anomoenies vitrea	0.0200	0.2212	0.2653	0.0224	0.1933	0.0856	0.0012
Eunotia exigua	0.0348	0.0181	0.0570	0.0356	0.0237	0.0469	0.0004
Shannon diversity	2.4052	2.3733	2.2895	2.4033	2.2918	2.3427	3.0944

Table 3. Mean relative abundance of epipelic taxa (> 5%) for the study.

Species ID	Site 44	Site 46	Site 60	Site 61	Site 65	Site 67	Wolf Crk
Achnanthes minutis.	0.1037	0.0754	0.0381	0.1753	0.0989	0.1977	0.0433
Amphora perpusilla	0.0000	0.0000	0.0000	0.0015	0.0000	0.0000	0.0617
Eunotia minor	0.0186	0.0481	0.1140	0.0330	0.0338	0.1251	0.0004
Gomphonema parvulum	0.0542	0.0257	0.0071	0.0385	0.0110	0.0146	0.0076
Phormidium sp.	0.4524	0.3657	0.3035	0.2621	0.2639	0.2007	0.1141
Navicula gregaria	0.0028	0.0055	0.0000	0.0038	0.0177	0.0087	0.1351
Navicula lanceolata	0.0021	0.0007	0.0000	0.0015	0.0022	0.0024	0.0845
Achnan. childanos	0.0061	0.0013	0.0005	0.0584	0.0002	0.0020	0.0005
Anomoeonis vitrea	0.0106	0.0927	0.2691	0.0030	0.1747	0.0972	0.0002
Eunotia exigua	0.0554	0.0951	0.1553	0.0517	0.1309	0.0892	0.0005
Shannon diversity	2.5749	2.6310	2.0603	2.9621	2.7635	2.7922	3.4180

Table 4 Percentage Similarity Matrix for sites based on epilithc algae (dates pooled).

	44	46	60	61	65	67	WC
44	100.0						
46	67.1	100.0					
60	50.7	69.9	100.0				
61	85.5	67.8	56.1	100.0			
65	58.0	73.3	71.9	63.1	100.0		
67	48.1	49.6	58.6	52.2	66.4	100.0	
WC	27.8	20.6	15.6	22.9	18.0	21.7	100.0

Table 5 Percentage Similarity Matrix for sites based on epipelic alage (sample dates pooled).

	44	46	60	61	65	67	Wolf Creek
44	100.0						
46	71.0	100.0					
60	50.5	66.9	100.0				
61	68.1	61.7	46.4	100.0			
65	61.2	70.7	72.5	60.3	100.0		
67	52.9	65.8	62.0	60.2	67.1	100.0	
WC	27.5	26.6	21.1	29.2	31.2	28.3	100.0

Table. 6 Percent similarity of epilithic algae on samples dates to the average composition of the control sites, 61 and Wolf Creek.

Site 60 Sample Date	Composite Site 61	Composite Wolf Creek
96 summer	24.1	2.7
96 fall	34.0	14.8
96 winter	23.6	3.1
97 spring	36.7	11.5
97 summer	32.6	11.5
97 fall	37.9	14.8
97 winter	31.5	14.8
98 spring	32.6	12.0
98 summer	57.9	21.8
98 fall	48.9	16.3
98 winter	42.6	13.6
98 summer	58.5	19.0

Table 7. Mean relative abundance of dominant macroinvertebrates in riffles for each site over the course of the study. For taxa greater than 5%.

Label	Site 44	Site 60	Site 61	Site 65	Wolf Crk	Site 46
Species ID						
Leptotarsus	0.0550	0.0000	0.0015	0.0000	0.0000	0.0000
Hexatoma	0.0461	0.0000	0.0722	0.0000	0.0030	0.0092
Tipula	0.2644	0.0000	0.0412	0.0417	0.0026	0.3746
Simulium	0.0000	0.0857	0.0423	0.0250	0.0032	0.0278
Rhyacophila	0.0000	0.0000	0.0500	0.0000	0.0000	0.0000
Hydropsyche	0.0976	0.5820	0.1150	0.1750	0.1301	0.2656
Cheumatopsyche	0.0070	0.0493	0.0029	0.0667	0.0151	0.0071
Potamyia	0.0516	0.0004	0.0283	0.0250	0.0007	0.0185
Oecetis	0.0222	0.0000	0.0000	0.1250	0.0000	0.0000
Orthocladius	0.0000	0.0000	0.0025	0.0000	0.1032	0.0222
Limnophyes	0.0000	0.0000	0.0000	0.1250	0.0000	0.0014
Tanypodinae early	0.0000	0.0000	0.0000	0.0625	0.0000	0.0000
Ephemerella	0.0000	0.0000	0.0550	0.0000	0.0058	0.0000
Caenis	0.0000	0.0000	0.0086	0.0000	0.0635	0.0000
Stenonema	0.0000	0.0000	0.0126	0.0000	0.0500	0.0000
Isonychia	0.0000	0.0000	0.0000	0.0000	0.1035	0.0000
Leuctra	0.0000	0.0000	0.0866	0.0000	0.0020	0.0000
Lanthus	0.0000	0.0000	0.0341	0.0500	0.0002	0.0000
Caliopteryx	0.0000	0.0000	0.0000	0.0625	0.0000	0.0000

Run: PERCENT SIMILARITY FOR RIFFLE INVERT SAMPLES POOLED BY DATE

Data: SLIPPERY ROCK CREEK SURBER SUMMER 1996-SUMMER 1999

Table 8 . Percentage Similarity Matrix

Panel 1 of 1.

	44	60	61	65	WC	46
44	100.0					
60	13.7	100.0				
61	28.5	25.8	100.0			
65	19.3	28.1	27.7	100.0		
WC	16.5	21.4	24.8	16.8	100.0	
46	47.5	35.6	29.9	29.6	23.5	100.0

Table 9 Mean relative abudance of dominant invertebrates in pools at each sites over the study. For taxa greater than 5%.

Label	Site 44	Site 61	Site 67	Wolf Crk	Site 46	Site 60
Species ID						
Early chironomid	0.0000	0.0000	0.1221	0.0000	0.0000	0.0000
Tabanus	0.0064	0.0911	0.0000	0.0003	0.2321	0.0000
Crysops	0.0375	0.0000	0.0000	0.0000	0.0417	0.0831
Hydropsyche	0.0000	0.0000	0.0066	0.0006	0.0238	0.0831
Cheumatopsyche	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000
Potamyia	0.0000	0.0000	0.0000	0.0000	0.0000	0.0831
Phryganea	0.0000	0.0000	0.1250	0.0000	0.0000	0.0000
Sialis	0.0377	0.0000	0.0105	0.0006	0.0476	0.2503
Brillia	0.0000	0.0000	0.0000	0.0000	0.0833	0.0000
Prodiamesa	0.1414	0.0142	0.0000	0.0000	0.0000	0.0000
Conchapelopia	0.0032	0.0486	0.0000	0.0000	0.0000	0.0000
Clinotanypus	0.0000	0.0024	0.0798	0.0000	0.0000	0.1672
Rheopelopia	0.0055	0.0000	0.0000	0.0000	0.0000	0.0841
Macropelopia	0.0032	0.1030	0.0000	0.0000	0.0000	0.0000
Polypedilium	0.0000	0.0703	0.0000	0.0000	0.0000	0.0000
Poly. fallax grp	0.0556	0.0000	0.0000	0.0000	0.0000	0.0000
Chironomus	0.0000	0.0024	0.0208	0.2284	0.0000	0.0000
Pentaneura	0.0000	0.0052	0.1314	0.0000	0.0000	0.0000
Litobrancha	0.0000	0.0486	0.0312	0.0003	0.0000	0.0000
Progomphus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0831
Cordulegaster	0.0124	0.0245	0.0000	0.0000	0.0793	0.0000
Parapoynx	0.0000	0.0000	0.0000	0.0000	0.0000	0.1662
Oligochaeta	0.0580	0.0508	0.0855	0.5901	0.1112	0.0000

TABLE. 10 PERCENT SIMILARITY FOR INVERTS IN POOL SAMPLES POOLED BY DATE

	44	61	67	WOLF CRK	46	60
44	100.0					
61	24.8	100.0				
67	13.0	13.5	100.0			
WC	8.2	7.5	13.1	100.0		
46	17.5	22.8	18.9	11.7	100.0	
60	8.1	0.2	9.7	0.1	11.3	100.0

Table 11 Changes in aluminum, iron, manganese and zinc concentration on AMD precipate coated sandstone and limestone rocks, after 4 weeks in the reference stream, Wolf Creek.

Metal	Change in concentration (mg/cm^2)		Percent change from initial concentration	
	Sandstone	Limestone	Sandstone	Limestone
Al	-4.98×10^{-3}	-8.80×10^{-3}	-18.7	-48.3
Fe	-1.06×10^{-1}	-1.25×10^{-1}	-40.8	-43.3
Mn	-1.51×10^{-4}	2.10×10^{-3}	-3.8	52.3
Zn	3.14×10^{-3}	-7.72×10^{-3}	140.6	-18.8

Table Concentrations of metals in tissue of Hydropsychid caddisflies collected in Wolf Creek and at Site 60 in July 1997 and 1998. Standards for Al and Zn in New York are included as a reference. Values are ppm dry weight.

Site and date	Al	Fe	Mn	Zn
Wolf Crk 1997	2,275	5,135	2,105	301
Wolf Crk 1998	1,495	5,625	2,090	161
Site 60 1997	529	6,655	760	380
Site 60 1998	525	16,420	1,190	238
Standards for New York	5000	NA	NA	250

Figure Captions

Fig. 1. Map of the hadwaters of Slippery Rock Creek indicating the location of sample sites, passive treatment systems for acid mine drainage discharges, and the area of land reclamation. Wolf Creek is approximately 30 km west of the headwaters and not on the map..

Fig. 2. Median pH at the sample stations ± 1 SD.

Fig. 3. Temporal changes in pH at sites on the main stem. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 4. Temporal changes in pH at triburtaries and the reference sites. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 5. Mean alkalinity at the sample stations ± 1 SD.

Fig. 6. Temporal changes in alkalinity at sites on the main stem. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 7. Temporal changes in alkalinity at triburtaries and the reference sites. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 8. Mean acidity at the sample stations ± 1 SD.

Fig. 9. Temporal changes in acidity at sites on the main stem. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 10. Temporal changes in acidity at triburtaries and the reference sites. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 11. Mean dissolved iron at the sample stations ± 1 SD.

Fig. 12. Mean total aqueous iron at the sample stations ± SD.

Fig. 13. Mean dissolved manganese at the sample stations ± 1 SD.

Fig. 14. Mean total aqueous manganese at the sample stations ± SD.

Fig. 15. Mean dissolved aluminum at the sample stations ± 1 SD.

Fig. 16. Mean total aqueous aluminum at the sample stations ± SD.

Fig. 17. Mean dissolved silicon at the sample stations $\pm$ 1 SD.

Fig. 18. Mean total aqueous silicon at the sample stations $\pm$ SD.

Fig. 19. Mean dissolved lead at the sample stations $\pm$ 1 SD.

Fig. 20. Mean total aqueous lead at the sample stations $\pm$ SD.

Fig. 21. Mean dissolved zinc at the sample stations $\pm$ 1 SD.

Fig. 22. Mean total aqueous zinc at the sample stations $\pm$ SD.

Fig. 23. Mean dissolved cobalt at the sample stations $\pm$ 1 SD.

Fig. 24. Mean total aqueous cobalt at the sample stations $\pm$ SD.

Fig. 25. Mean dissolved nickel at the sample stations $\pm$ 1 SD.

Fig. 26. Mean total aqueous nickel at the sample stations $\pm$ SD.

Fig. 27. Mean dissolved cadmium at the sample stations $\pm$ 1 SD.

Fig. 28. Mean total aqueous cadmium at the sample stations $\pm$ SD.

Fig. 29. Mean dissolved copper at the sample stations $\pm$ 1 SD.

Fig. 30. Mean total aqueous copper at the sample stations $\pm$ SD.

Fig. 31. Mean dissolved chromium at the sample stations $\pm$ 1 SD.

Fig. 32. Mean total aqueous chromium at the sample stations $\pm$ SD.

Fig. 33. Mean dissolved calcium at the sample stations $\pm$ 1 SD.

Fig. 34. Mean total aqueous calcium at the sample stations $\pm$ SD.

Fig. 35. Mean dissolved magnesium at the sample stations $\pm$ 1 SD.

Fig. 36. Mean total aqueous magnesium at the sample stations $\pm$ SD.

Fig. 37. No figure

Fig. 38. Concentration of iron in the clay fraction of sediment.

Fig. 39. Concentration of manganese in the clay fraction of sediment.

Fig. 40. Concentration of aluminum in the clay fraction of sediment.

Fig. 41. Concentration of silicon in the clay fraction of sediment.

Fig. 42. Concentration of lead in the clay fraction of sediment.

Fig. 43. Concentration of zinc in the clay fraction of sediment.

Fig. 44. Concentration of cobalt in the clay fraction of sediment.

Fig. 45. Concentration of cadmium in the clay fraction of sediment.

Fig. 46. Concentration of nickel in the clay fraction of sediment.

Fig. 47. Concentration of copper in the clay fraction of sediment.

Fig. 48. Concentration of chromium in the clay fraction of sediment.

Fig. 49. Concentration ofcalcium in the clay fraction of sediment.

Fig. 50. Concentration of magnesium in the clay fraction of sediment.

Fig. 51. Epilithic algal density at the sample sites. Arrows denote when a treatment system was build directly upstream of a site.

Fig. 52. Epipelic algal density at the sample sites. Arrows denote when a treatment system was build directly upstream of a site.

Fig 53. Shannon diversity index for epilithic algae. Arrows denote when a treatment system was build directly upstream of a site.

Fig 54. Shannon diversity index for epipelic algae. Arrows denote when a treatment system was build directly upstream of a site.

Fig 55. DCA ordination of samples for epilithic algae. Code for samples are year/season/site number.

Fig.56. DCA ordination of epilithic algae species. Taxa names are abreviated. See species list in Appendix for complete names.

Fig 57. DCA ordination of samples for epipelic algae. Code for samples are year/season/site number.

Fig.58. DCA ordination of epipelic algae species. Taxa names are abreviated. See species list in Appendix for complete names.

Fig 59. Macroinvertebrate density in riffles for Sites 44, 46, and 65. Values are mean +1 SD (n=3). Arrows denote treatment systems built upstreamof a site.

Fig 60. Macroinvertebrate density in riffles for Sites 60, 61 (reference), and Wolf Creek (reference). Values are mean +1 SD (n=3). Arrows denote treatment systems built upstreamof a site.

Fig. 61. Macroinvertebrate richness (number of taxa) in riffles for Sites 44, 46, and 65. Arrows denote treatment systems built upstreamof a site.

Fig. 62. Macroinvertebrate richness (number of taxa) in riffles for Sites 60, 61 (reference), and Wolf Creek. Arrows denote treatment systems built upstreamof a site.

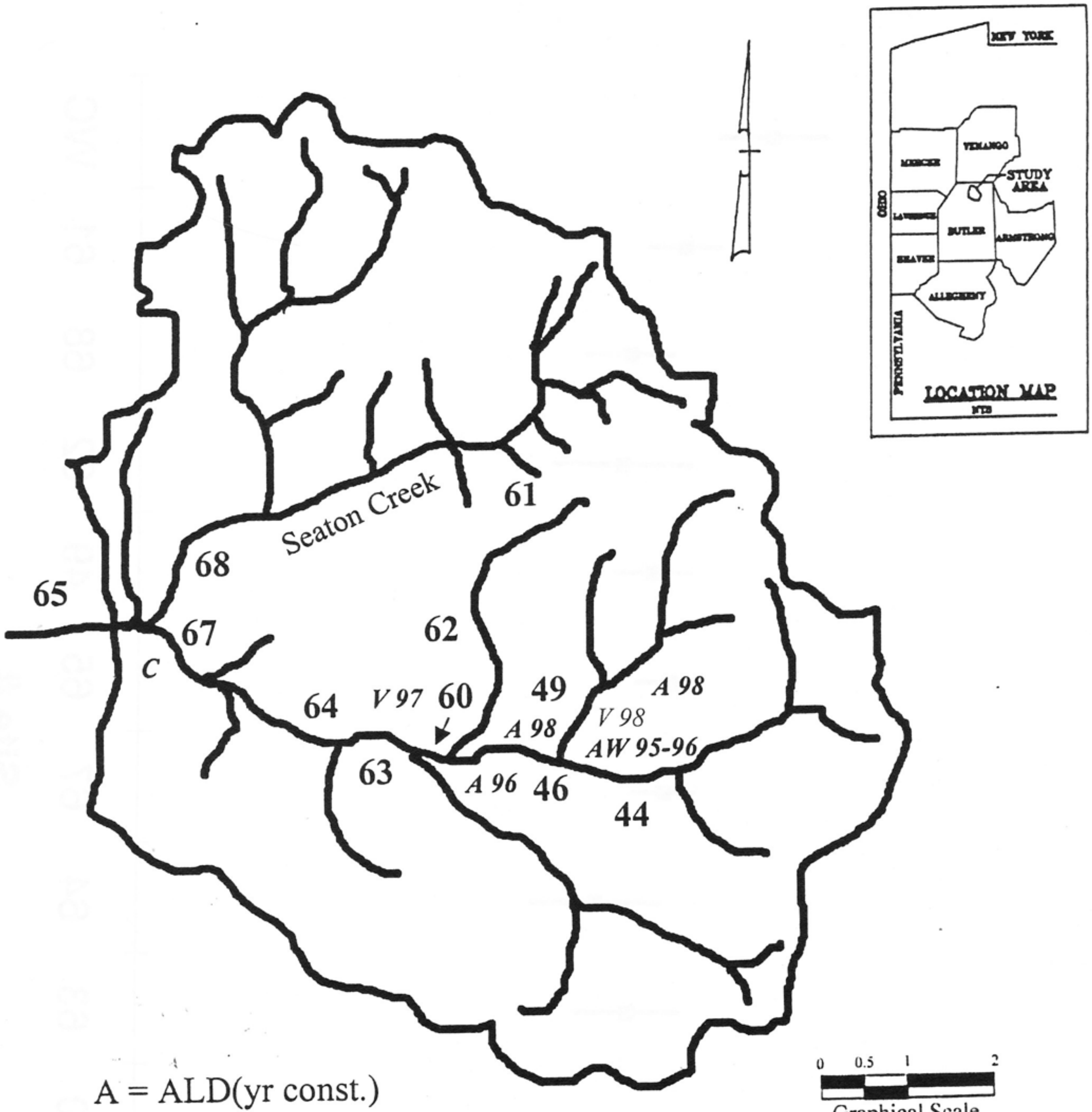
Fig 63. DCA ordination of samples for macroinvertebrates in riffles. Code for samples are year/season/site number.

Fig 64. DCA ordination of macroinvertebrates species in riffles. Taxa names are abreviated. See species list in Appendix for complete names.

Fig. 65. Macroinvertebrate density in pools. Values are mean +1 SD (n=3). Arrows denote treatment systems built upstreamof a site.

Fig. 66. Macroinvertebrate richness (number of taxa) in pools. Arrows denote treatment systems built upstreamof a site.

Fig. 67. Changes in leaf pack dry mass for packs placed at Sites 44, 46, 64, and Wolf Creek (reference) in October of 1997 and 1998.



A = ALD(yr const.)
W= Wetland (yr const.)
V = Vertical Flow (yr const.)
C = Coal refuse removal (yr const.)

Figure 1

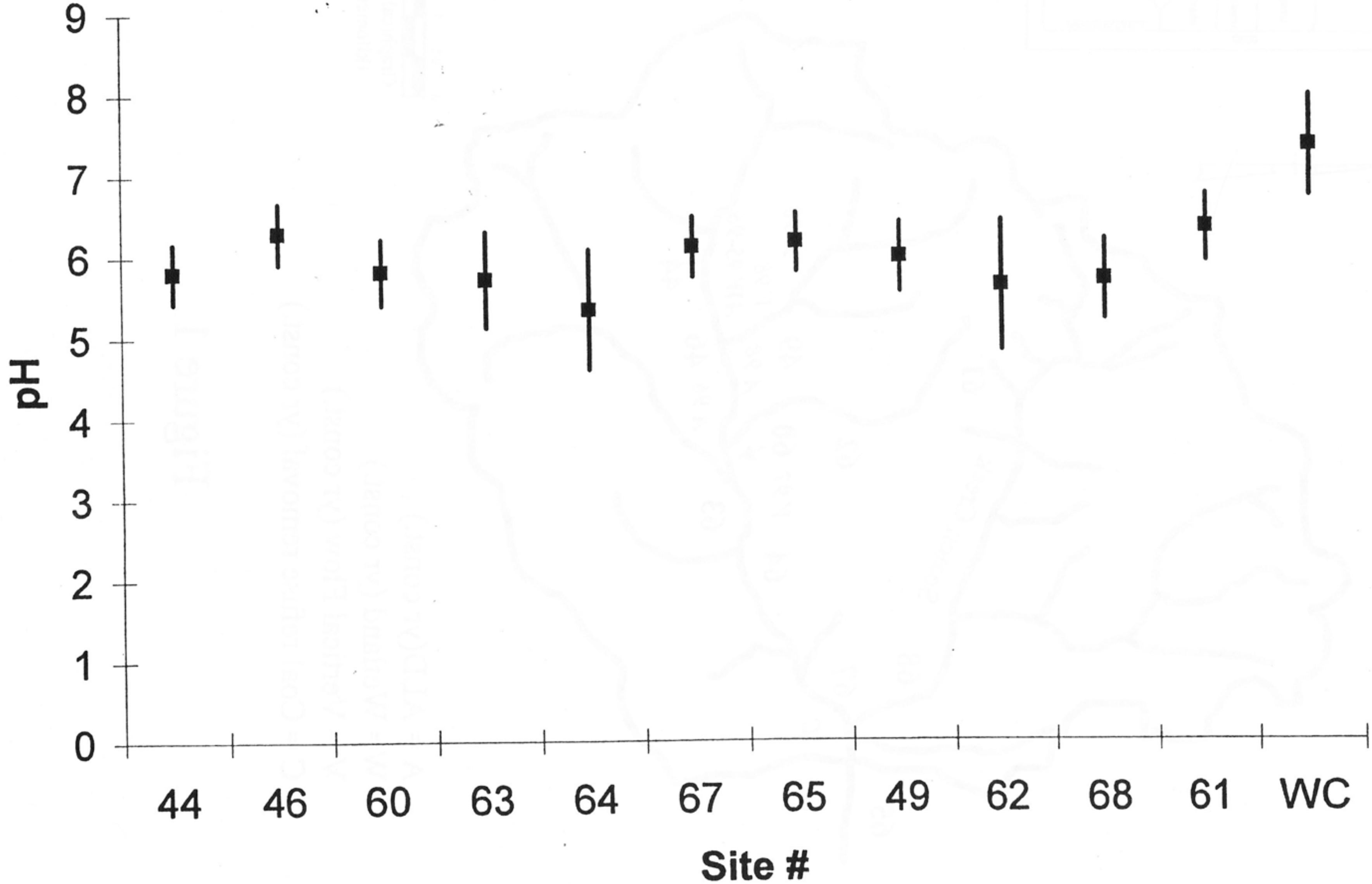


Fig.

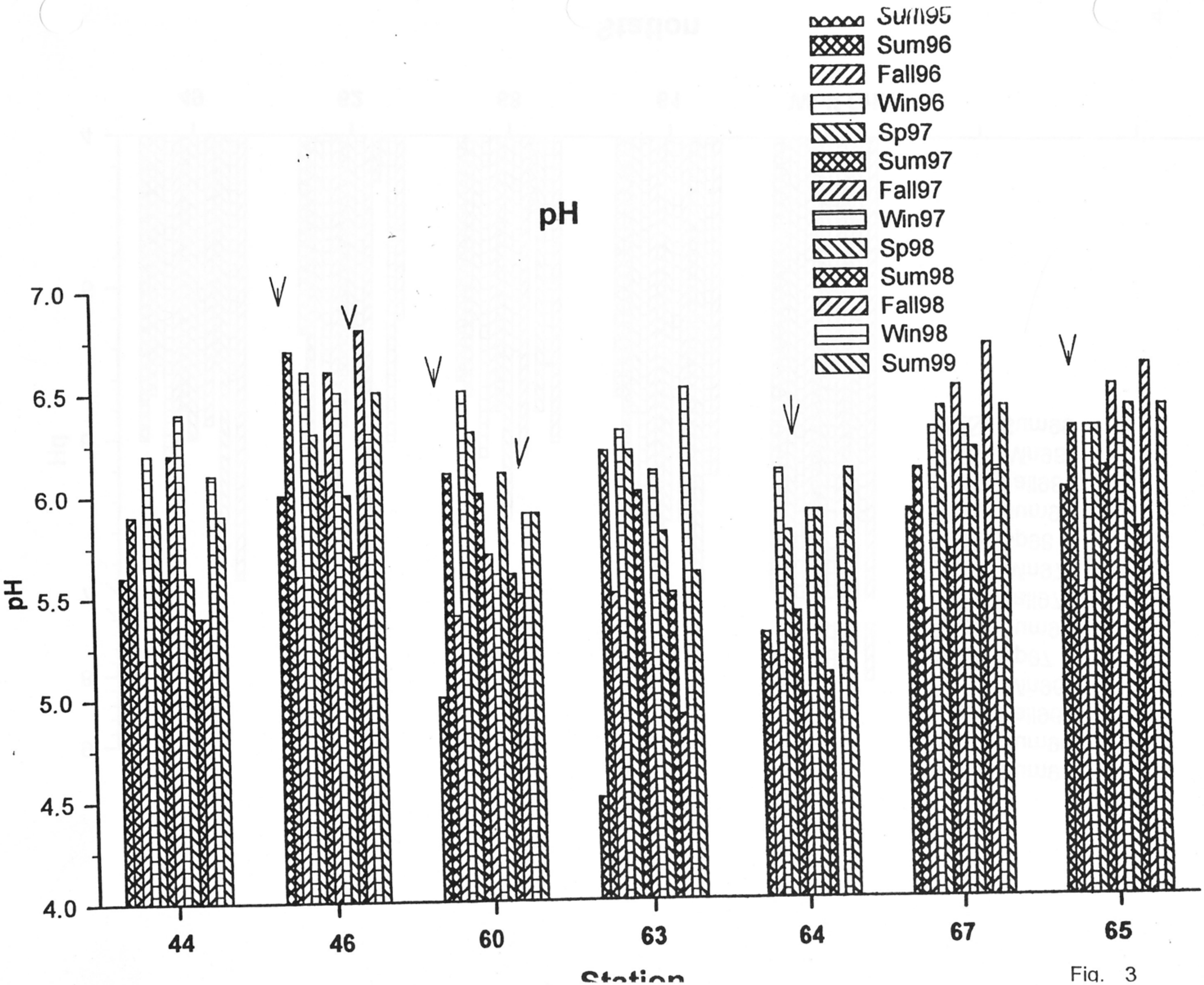
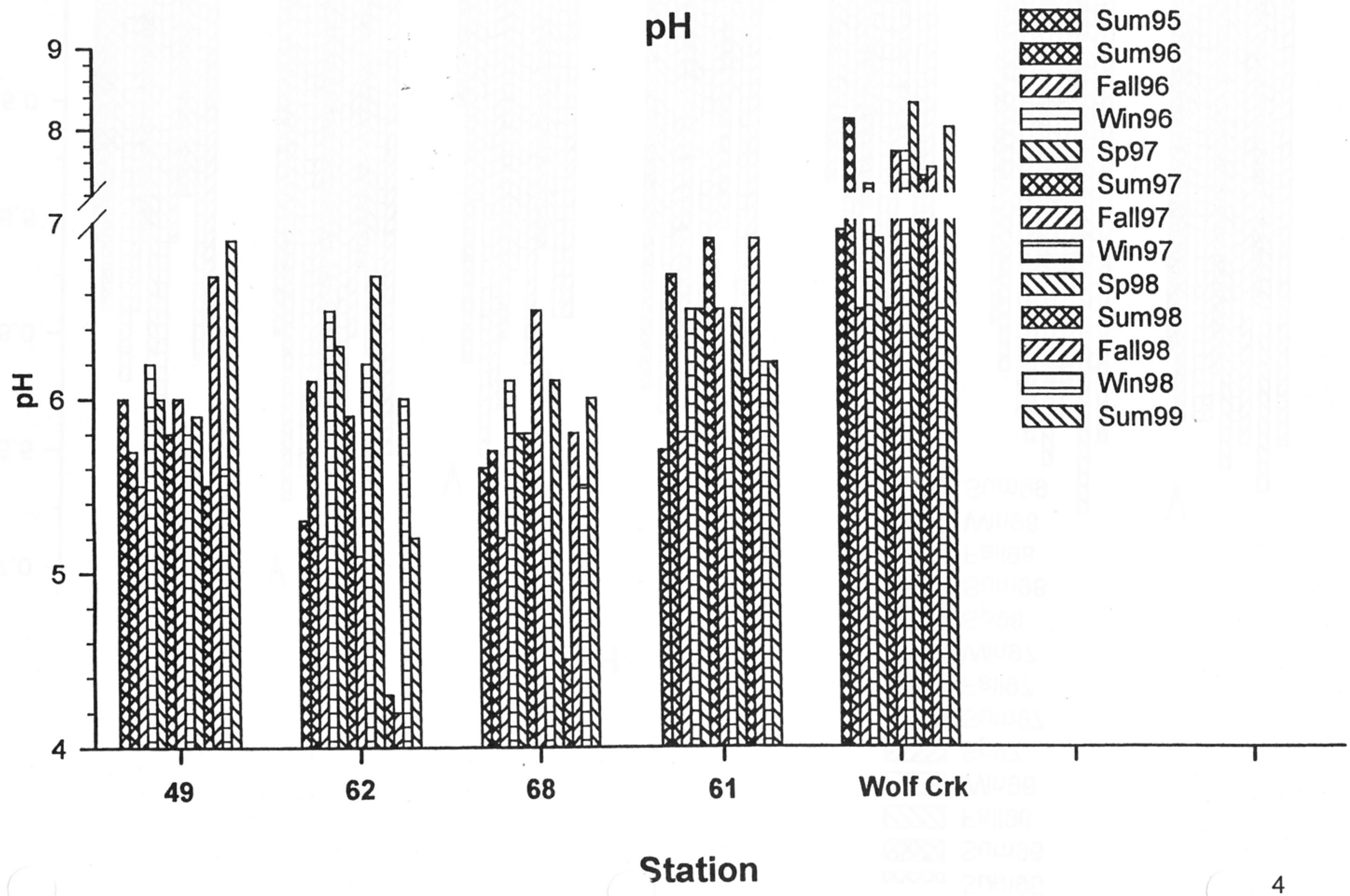
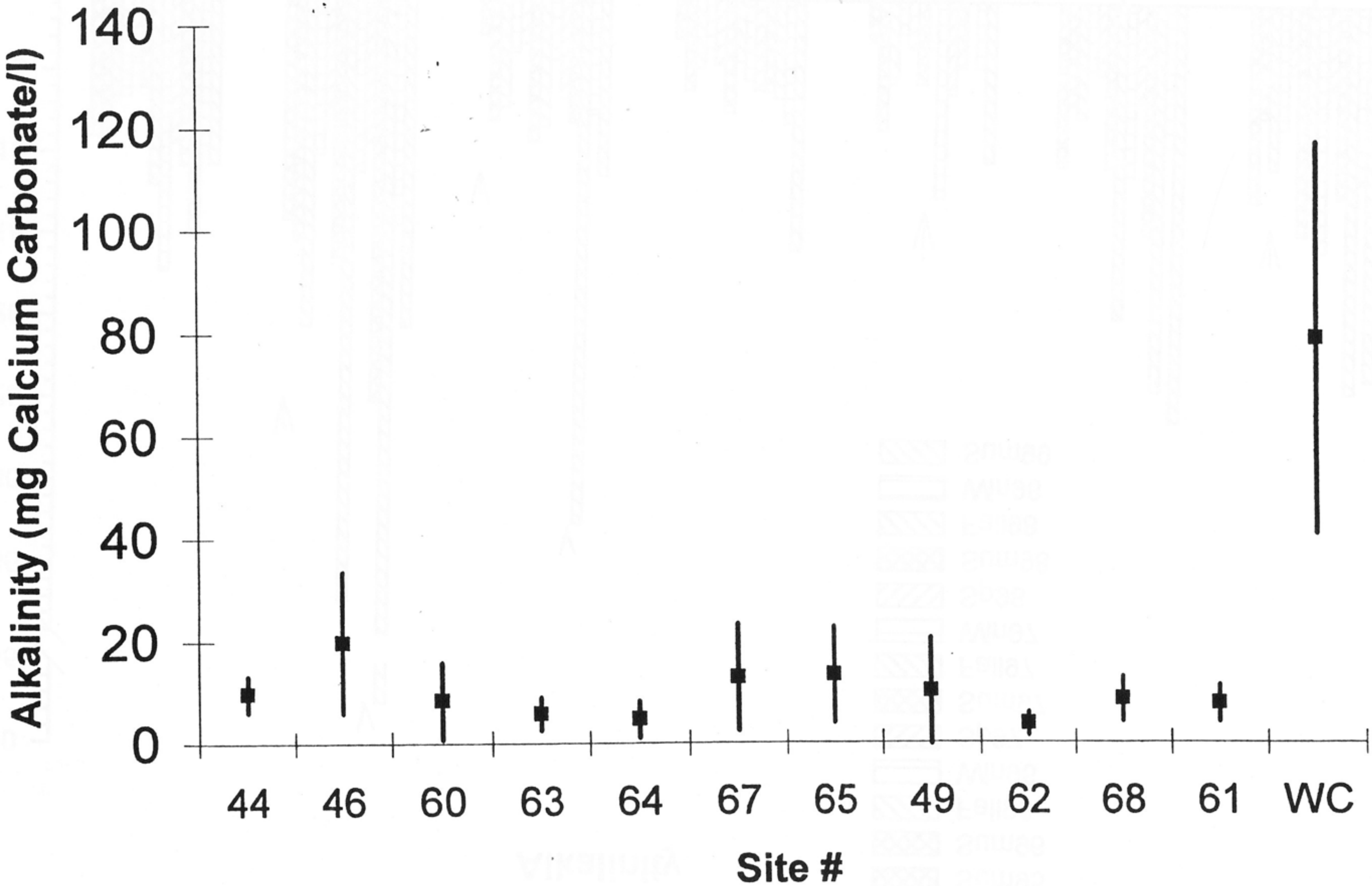

pH
Sum95
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99
7.0
6.5
6.0
5.5
5.0
4.5
4.0
pH
44
46
60
63
64
67
65
Station

Fig. 3


pH
Sum95
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99
pH
9
8
7
6
5
4
49
62
68
61
Wolf Crk
Station



Alkalinity (mg Calcium Carbonate/l)
140
120
100
80
60
40
20
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 5

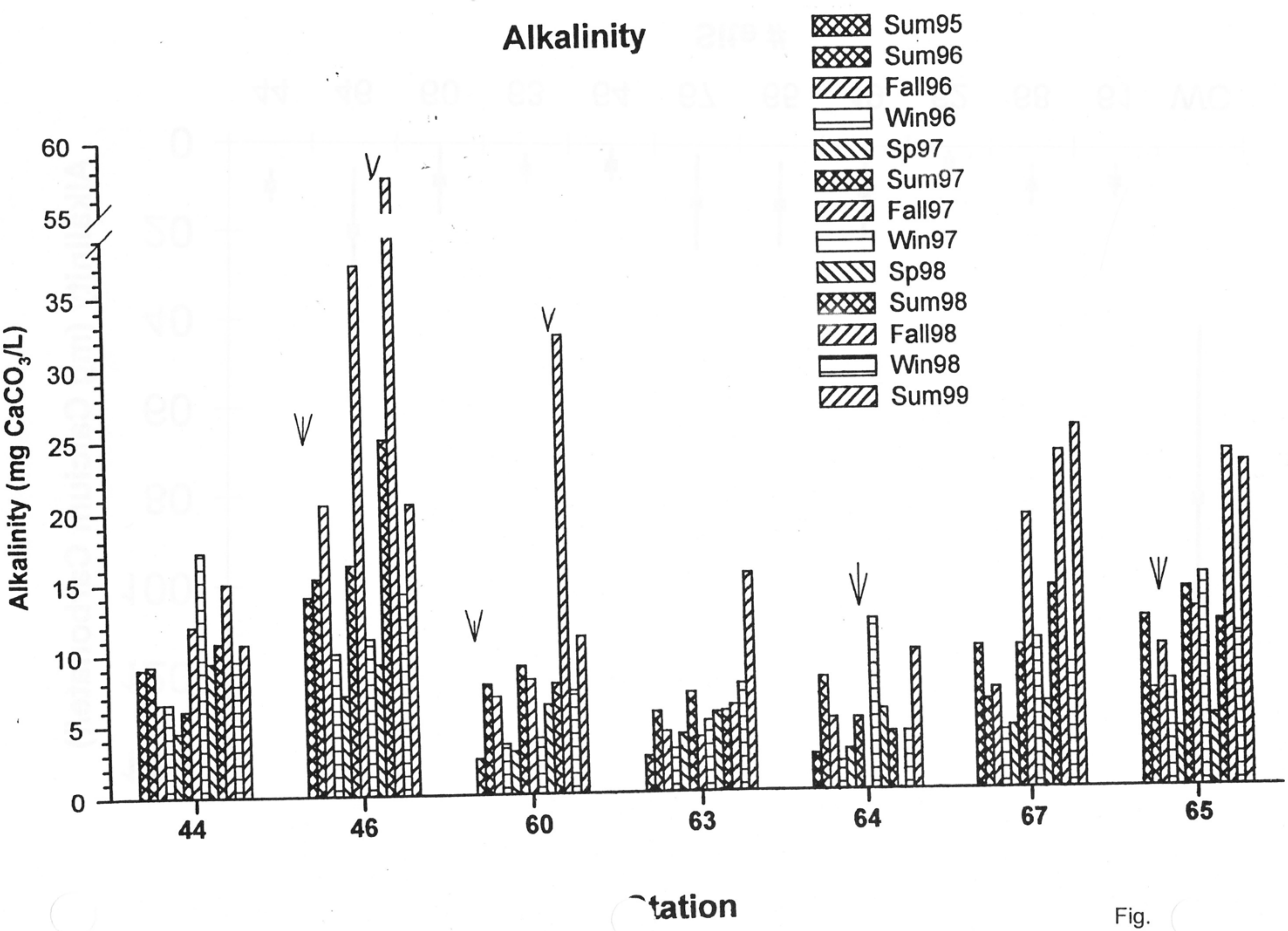

Alkalinity
Alkalinity (mg CaCO3/L)
60
55
35
30
25
20
15
10
5
0
44
46
60
63
64
67
65
Station
Sum95
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99

Fig.

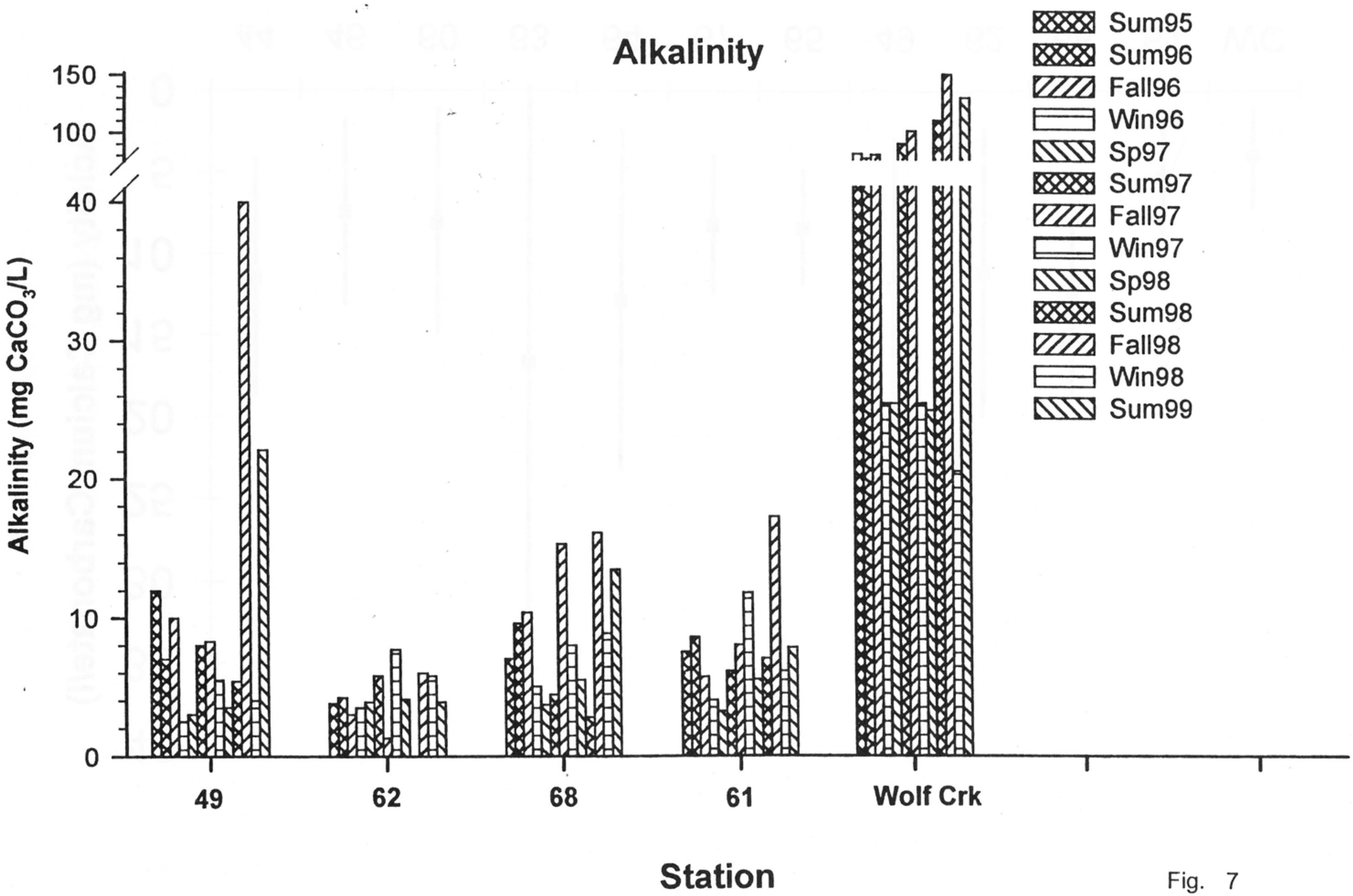
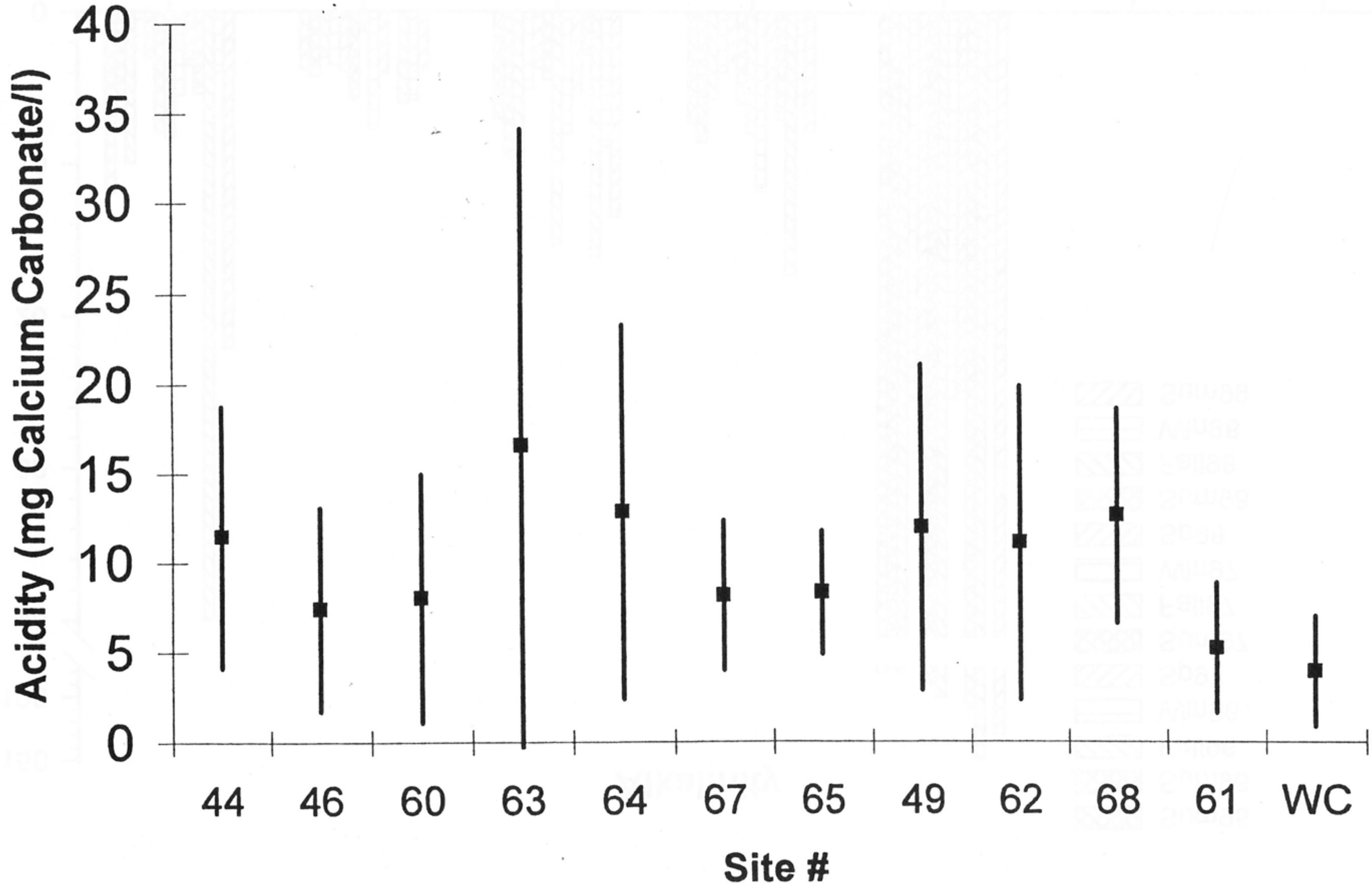
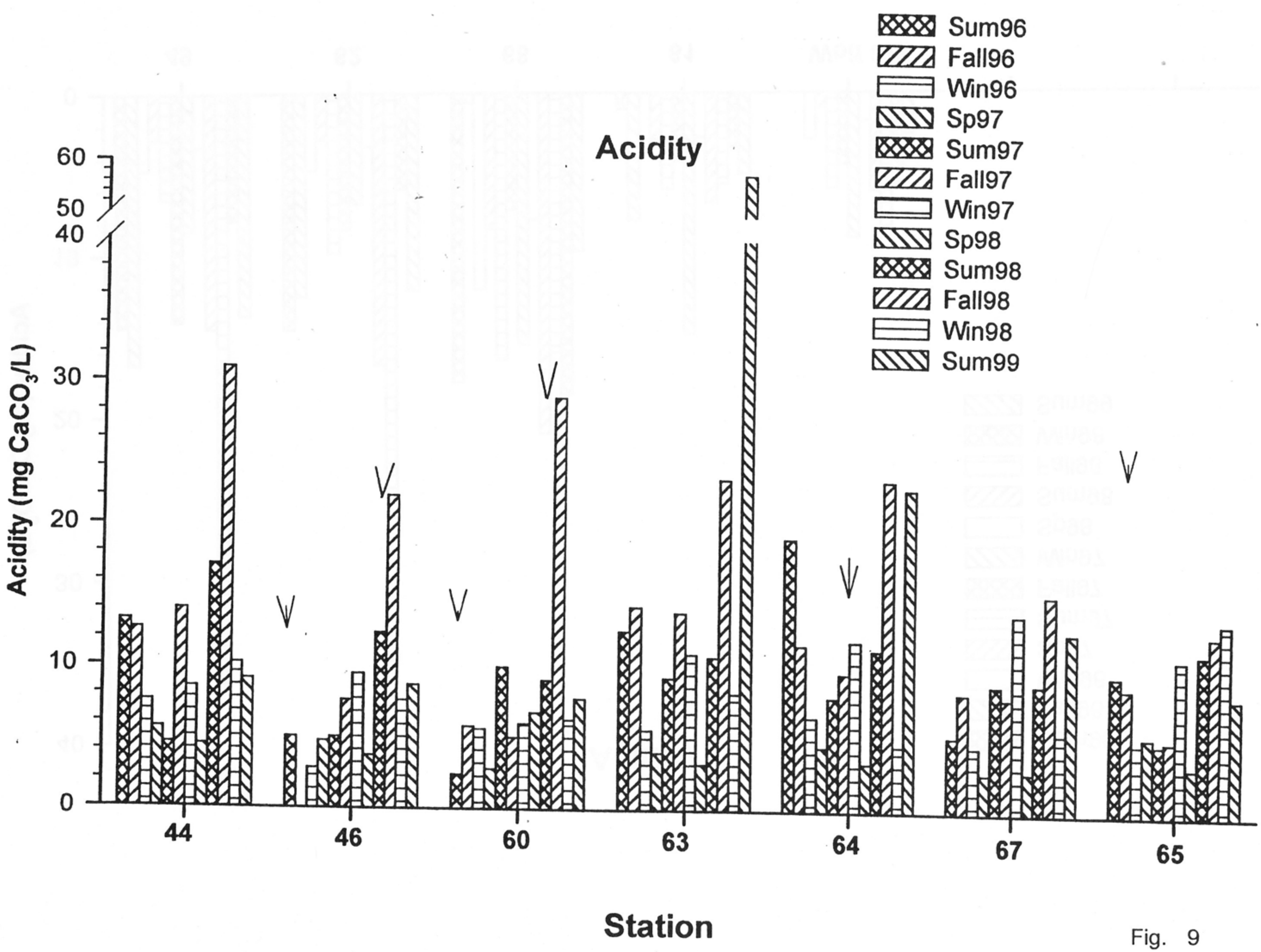

Alkalinity
Alkalinity (mg $CaCO_3$/L)
150
100
40
30
20
10
0
49
62
68
61
Wolf Crk
Station
Sum95
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99

Fig. 7

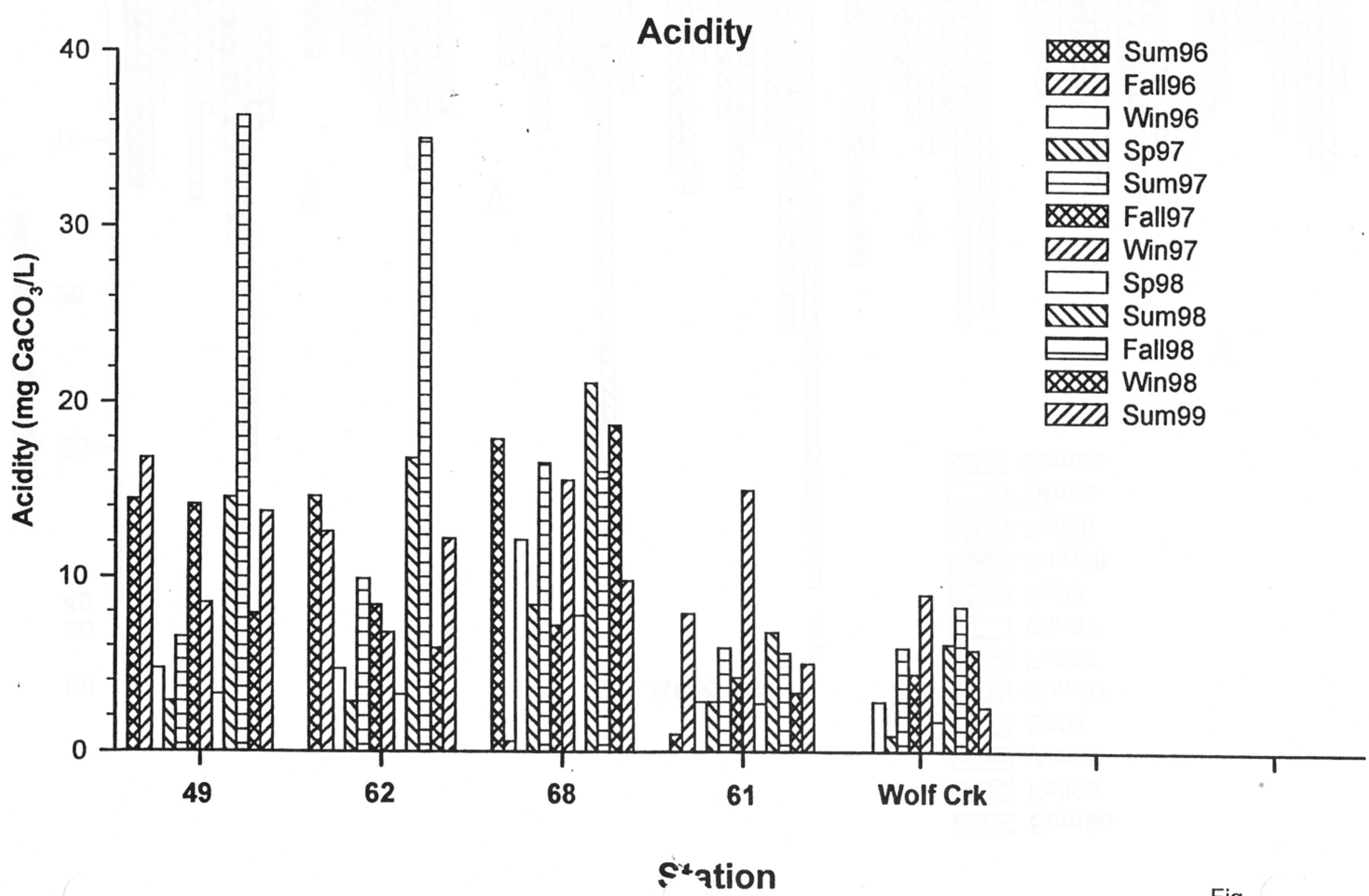

Acidity (mg Calcium Carbonate/l)
40
35
30
25
20
15
10
5
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fi‹ 8



Acidity
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99
Acidity (mg $CaCO_3$/L)
60
50
40
30
20
10
0
44
46
60
63
64
67
65
Station

Fig. 9



Acidity
Acidity (mg CaCO3/L)
40
30
20
10
0
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Win98
Sum99
49
62
68
61
Wolf Crk
Station

Fig.

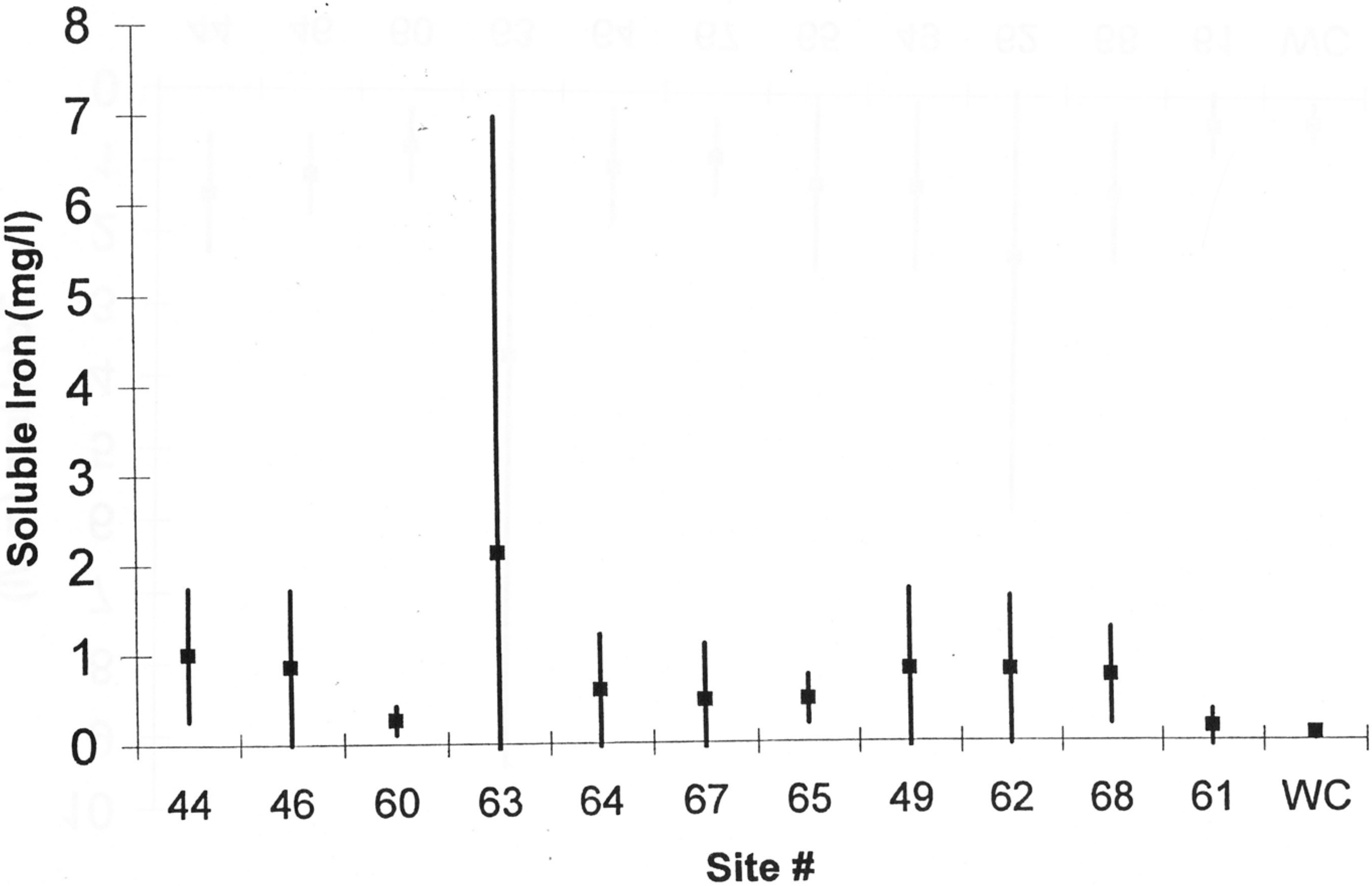
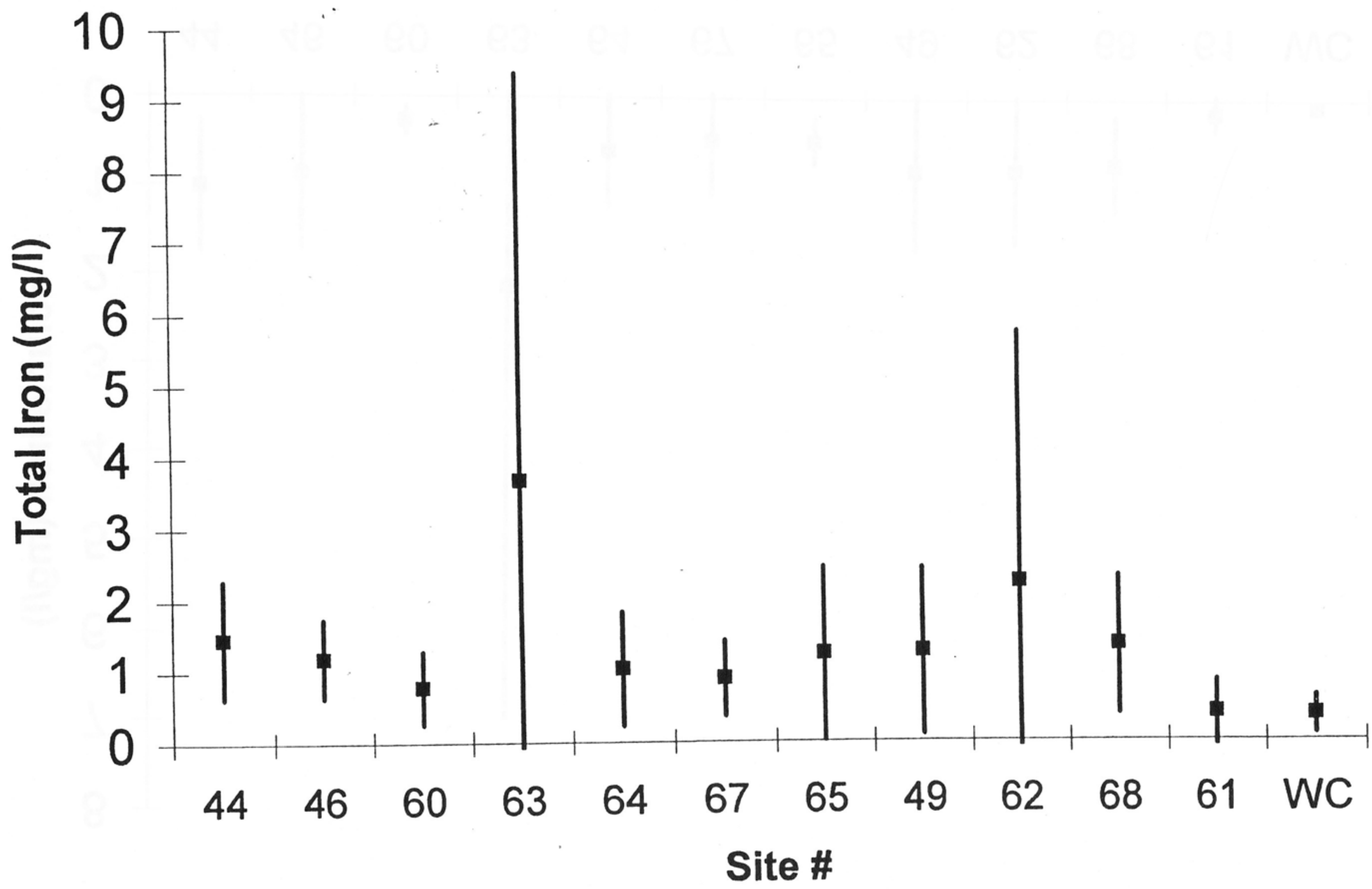

Soluble Iron (mg/l)
8
7
6
5
4
3
2
1
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 11



Total Iron (mg/l)
0
1
2
3
4
5
6
7
8
9
10
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 12

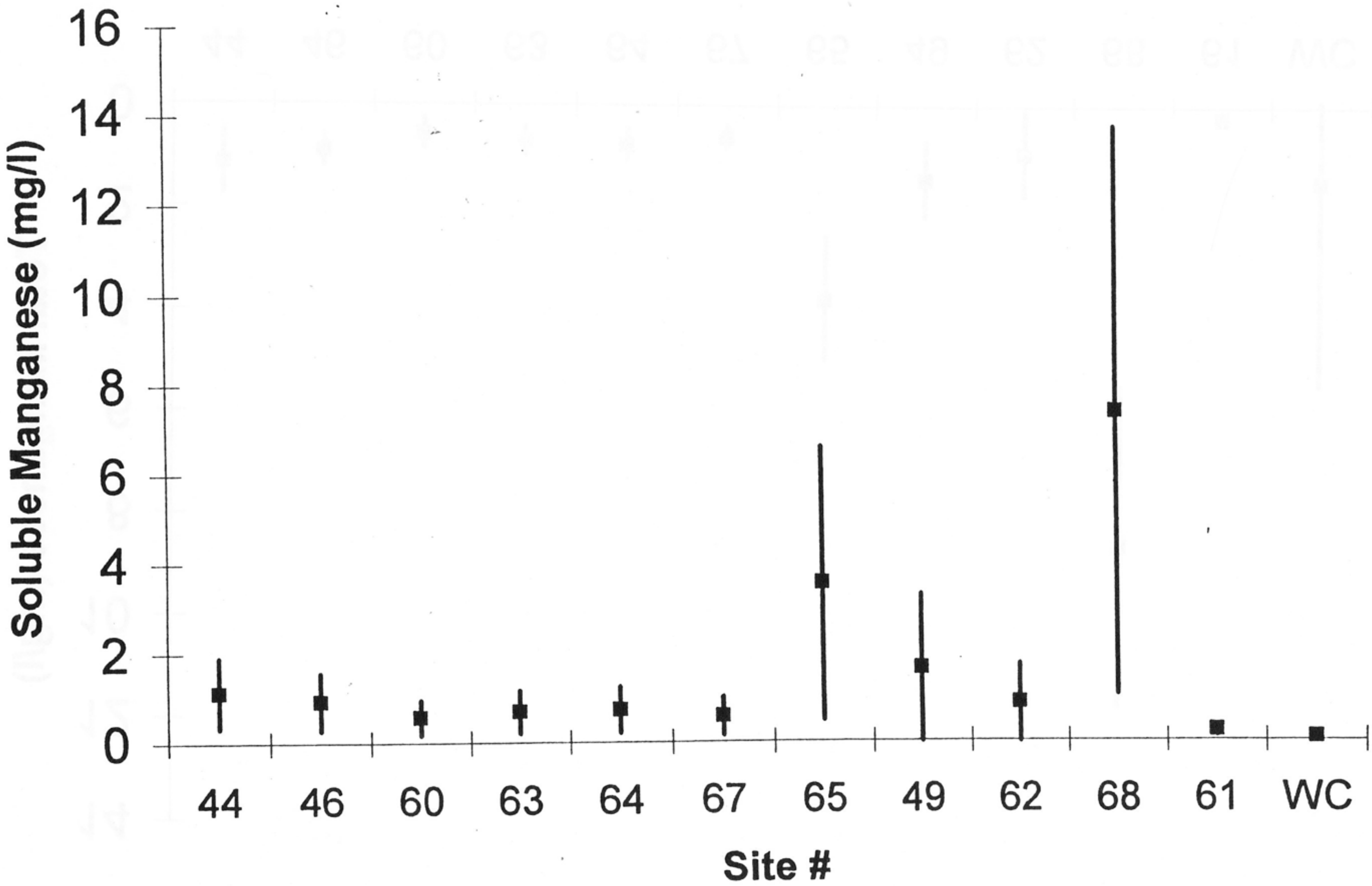

Soluble Manganese (mg/l)
16
14
12
10
8
6
4
2
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 13

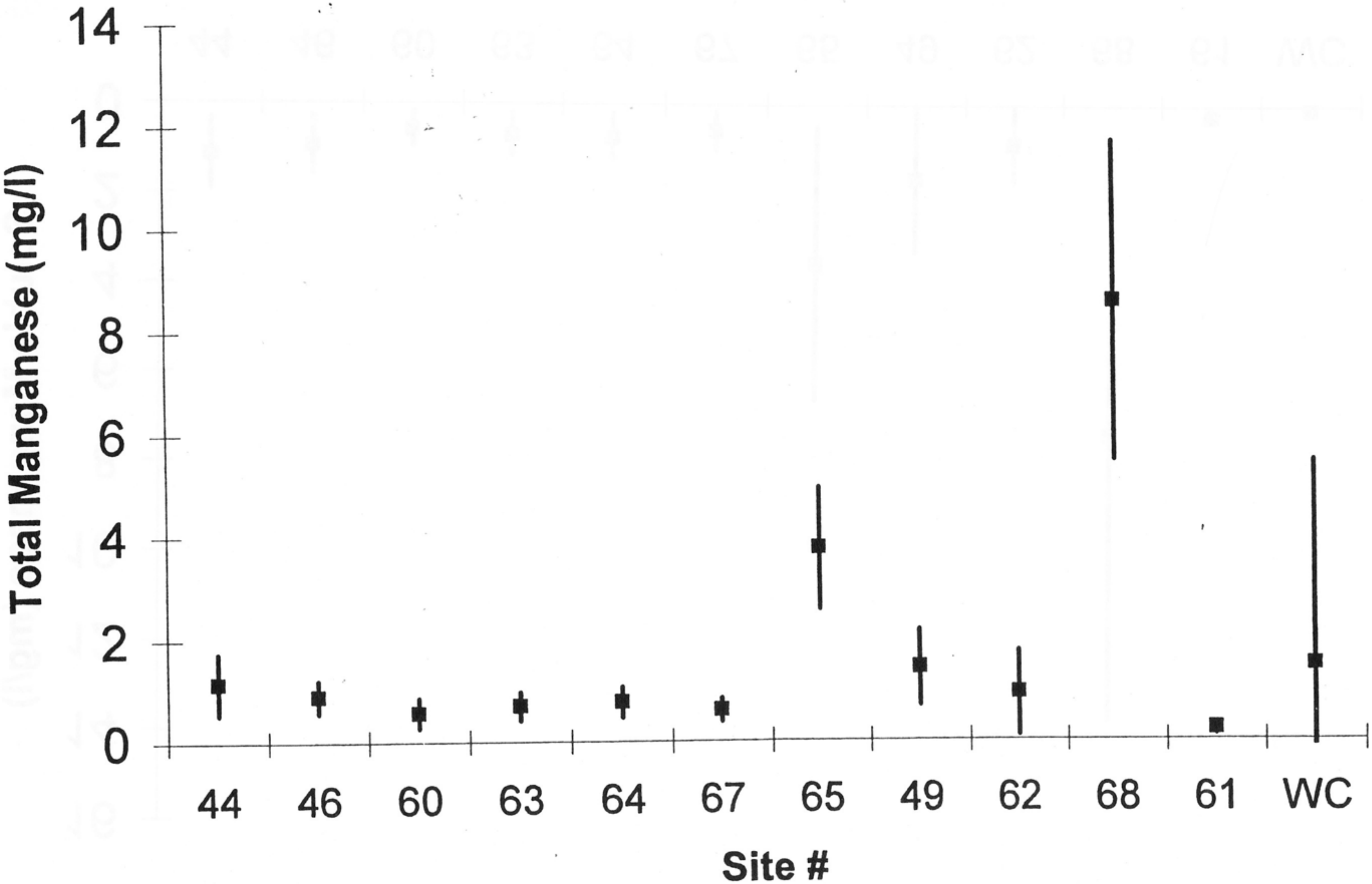

Total Manganese (mg/l)
14
12
10
8
6
4
2
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig.

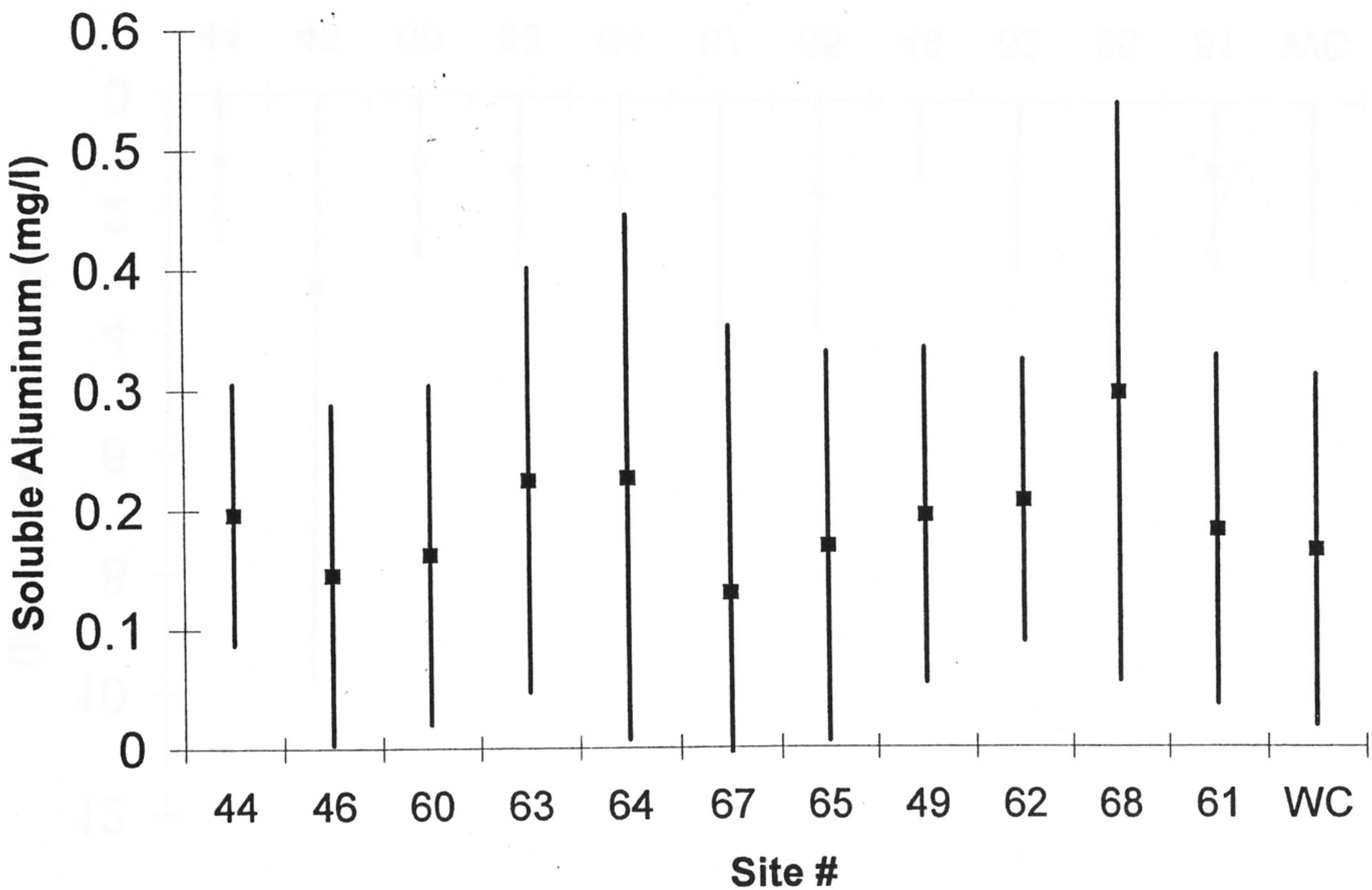
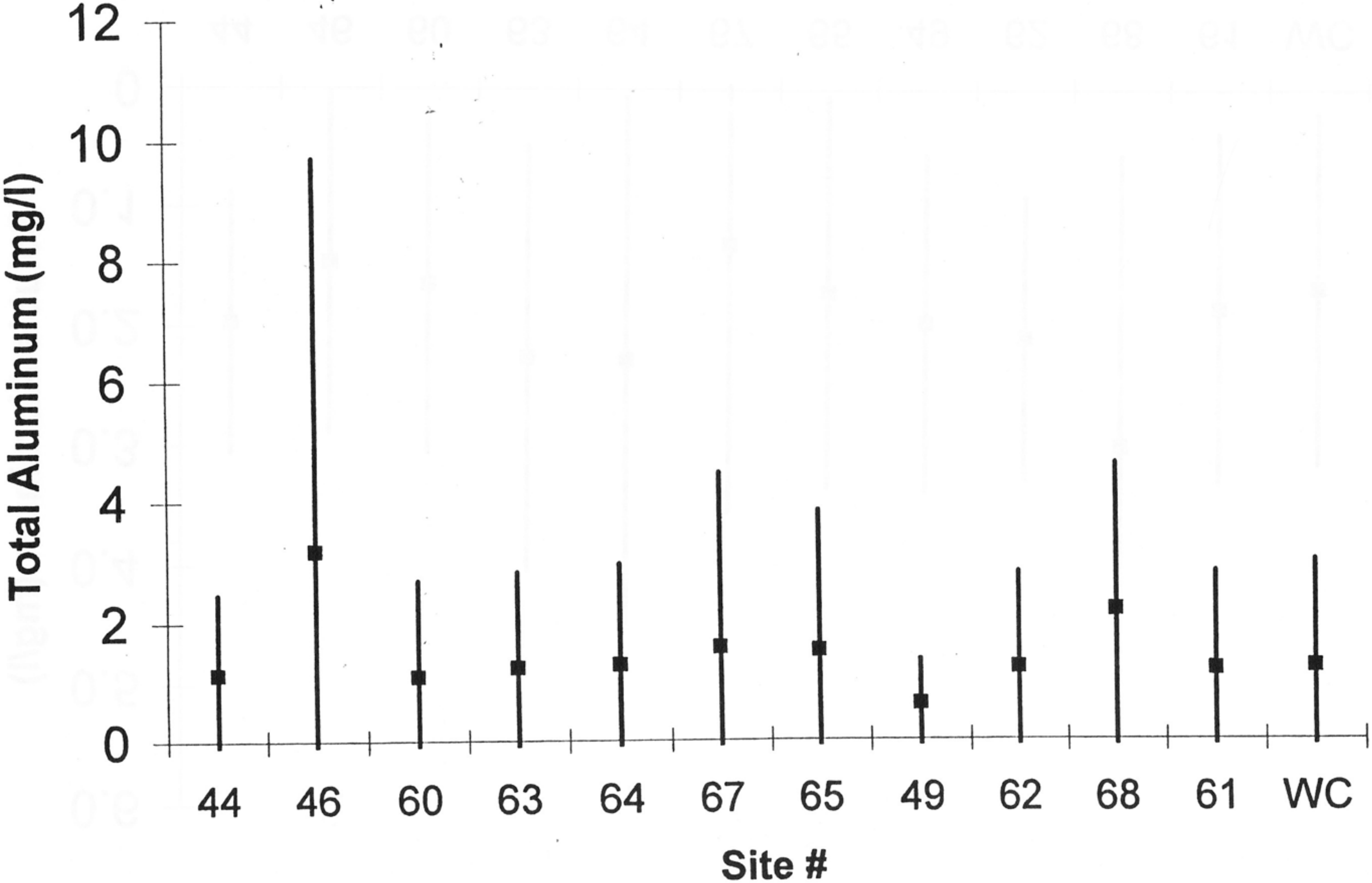
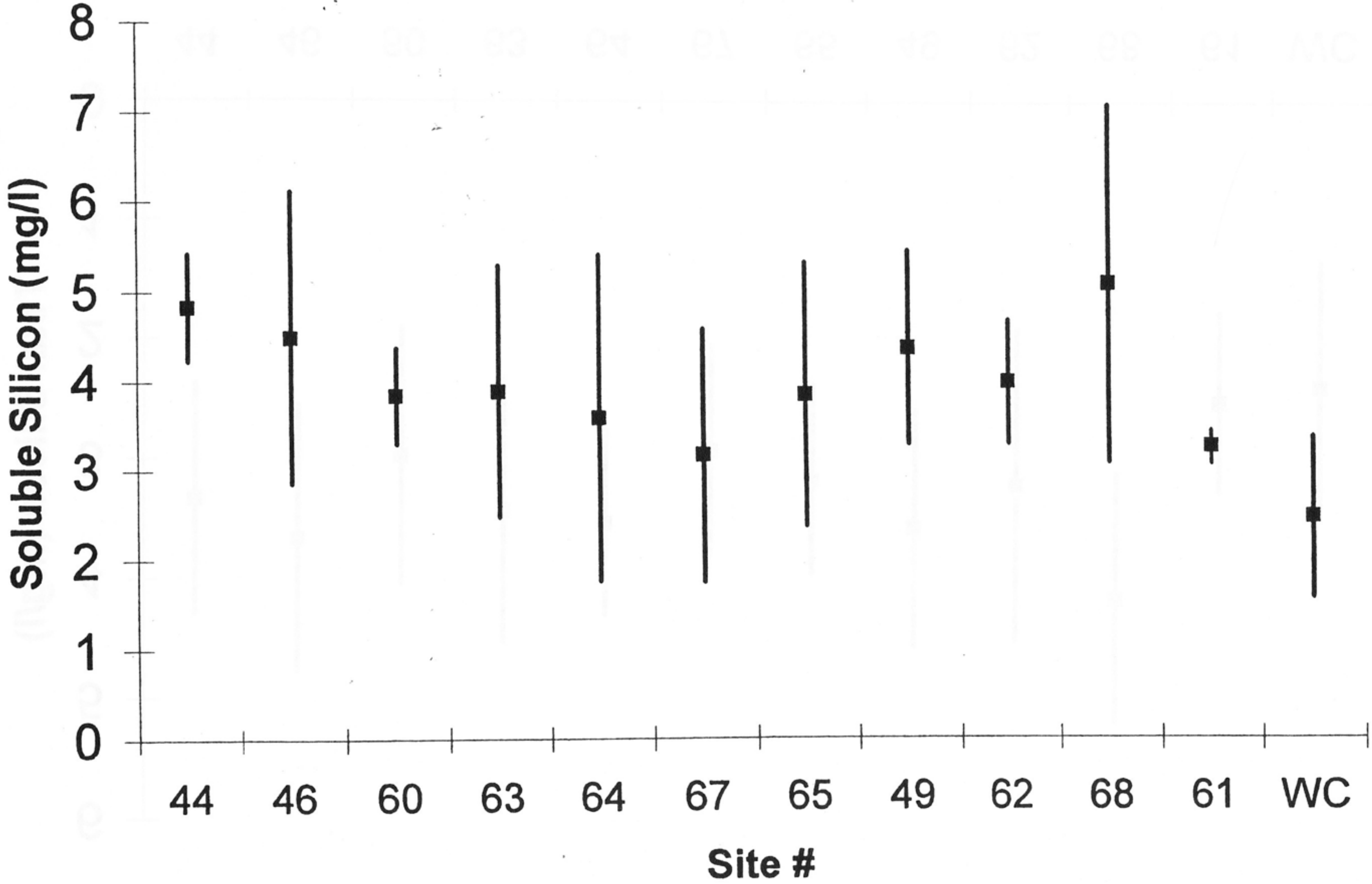

Soluble Aluminum (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 15


Total Aluminum (mg/l)
0
2
4
6
8
10
12
44
46
60
63
64
67
65
49
62
68
61
WC
Site #



Soluble Silicon (mg/l)
0
1
2
3
4
5
6
7
8
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 17

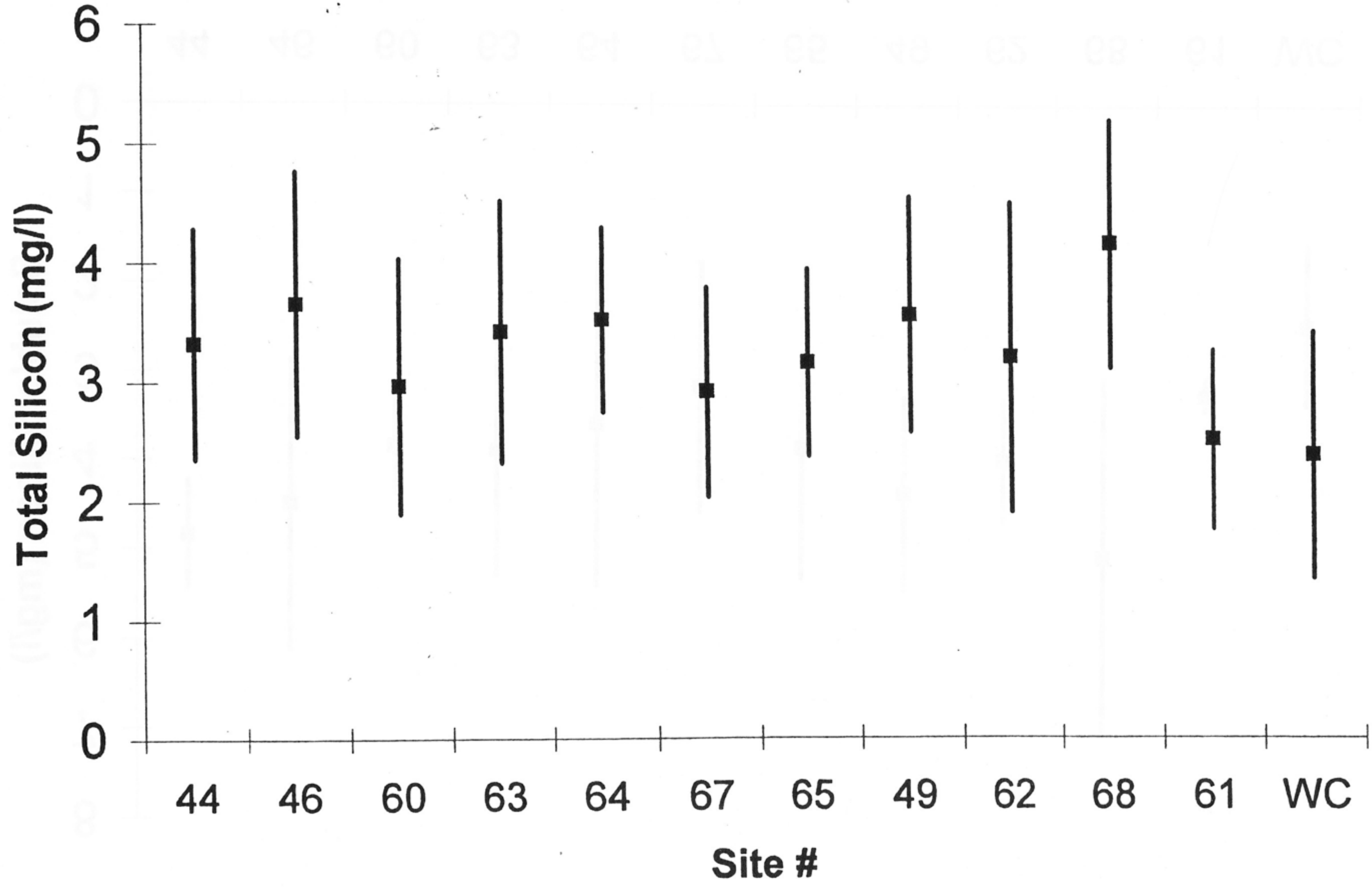

6
5
4
3
2
1
0
Total Silicon (mg/l)
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 18

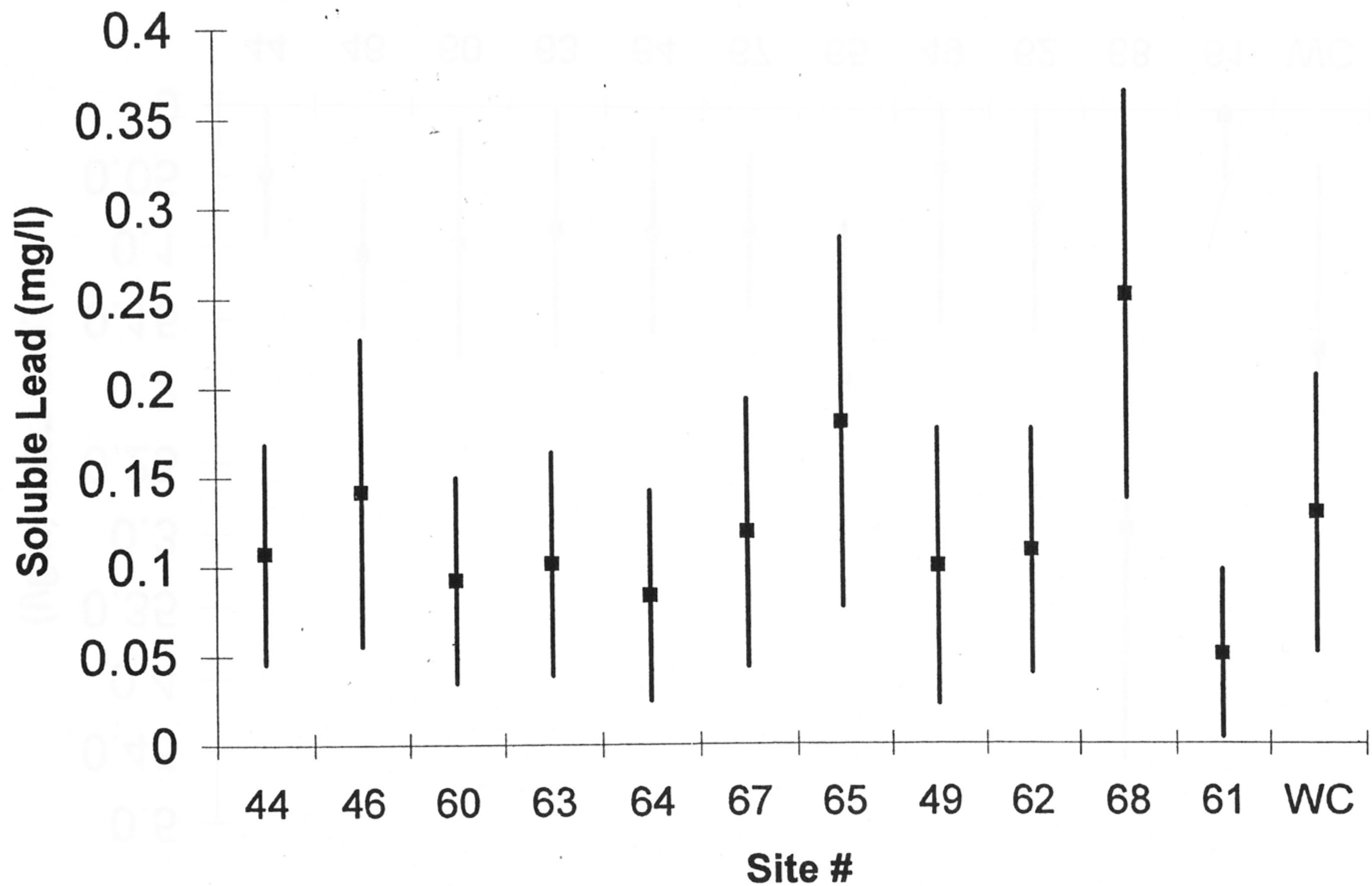

0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Soluble Lead (mg/l)
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 19

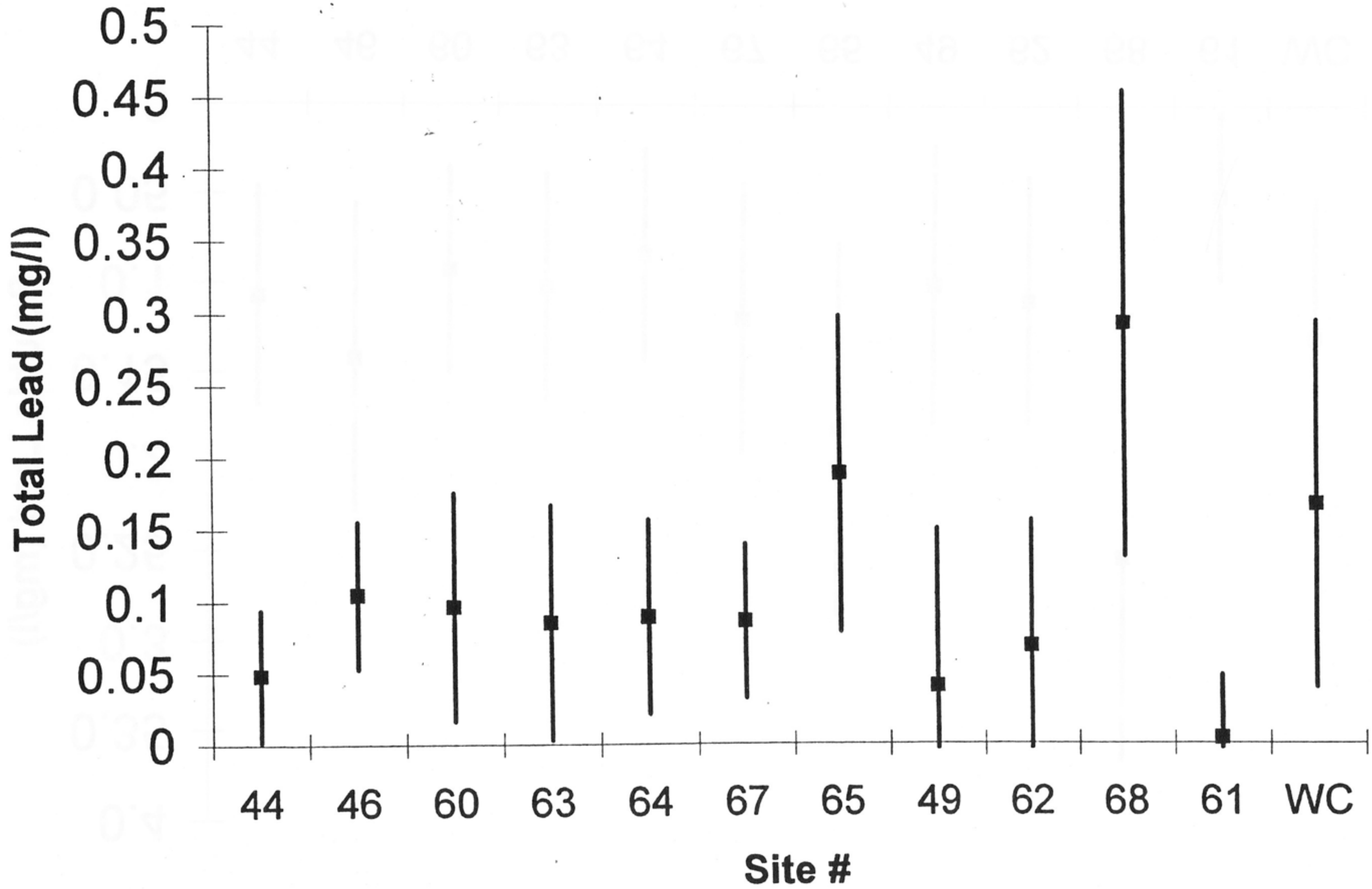

Total Lead (mg/l)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig.

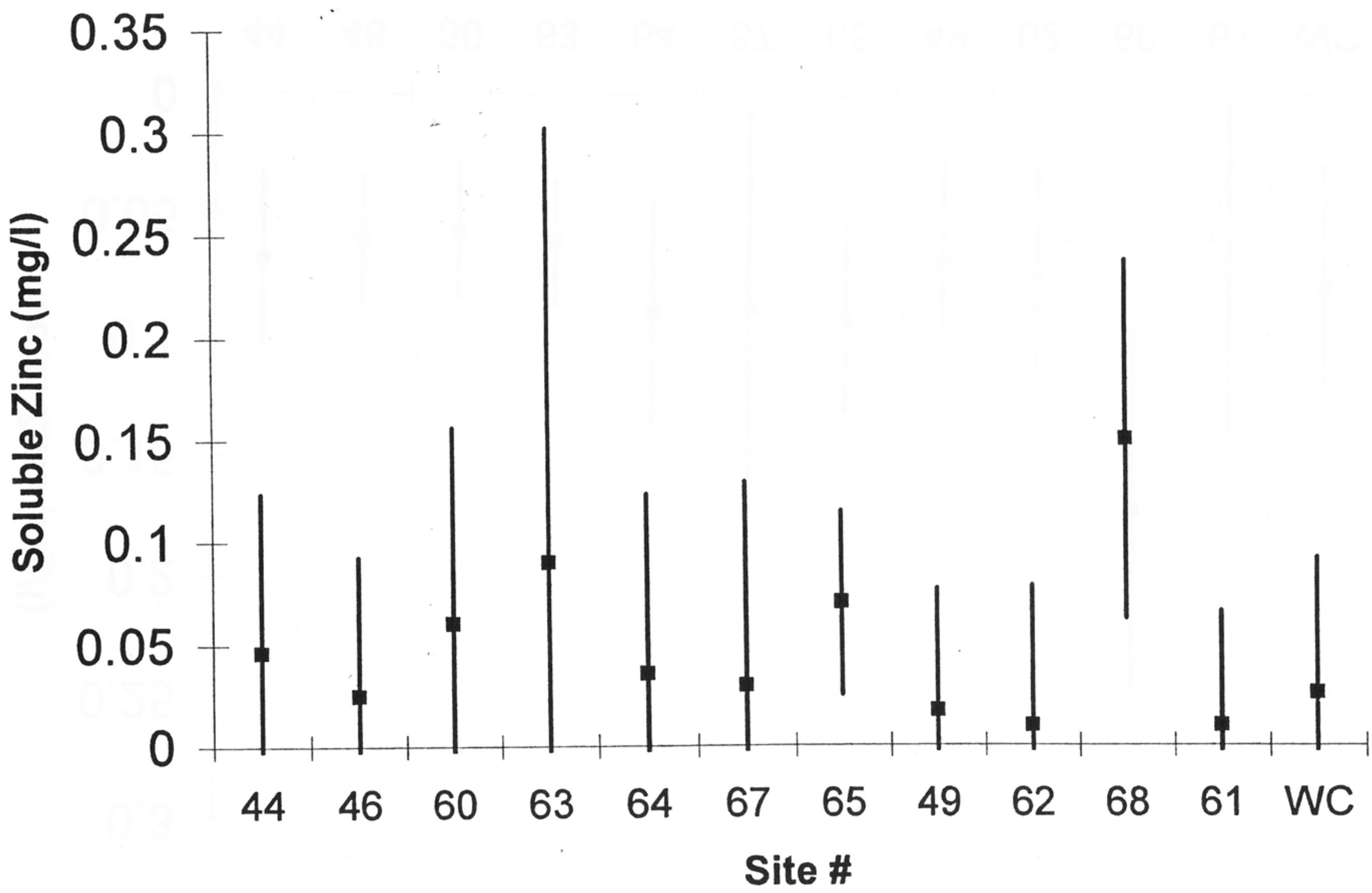

Soluble Zinc (mg/l)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 21

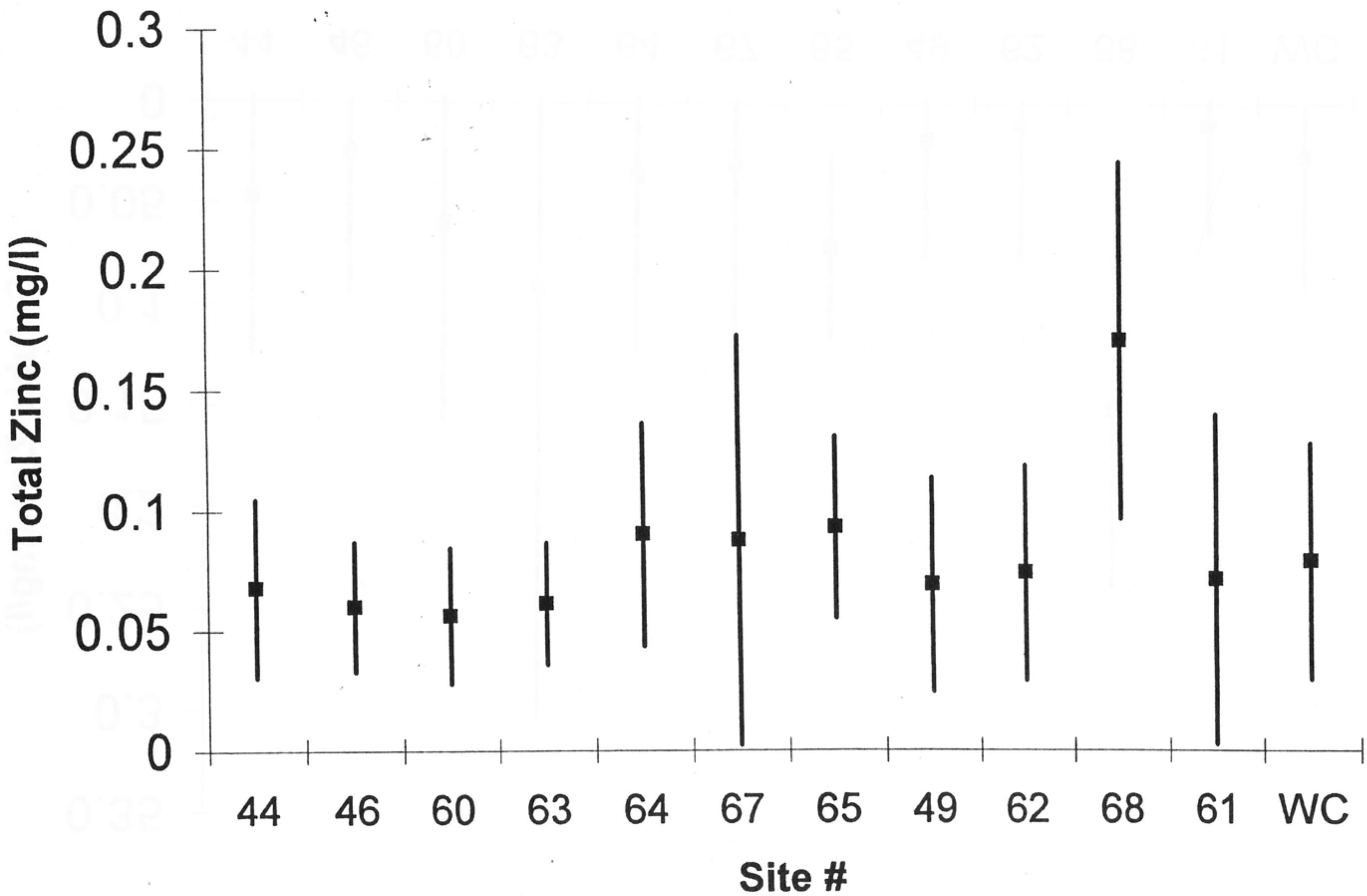

Total Zinc (mg/l)
0.3
0.25
0.2
0.15
0.1
0.05
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig.

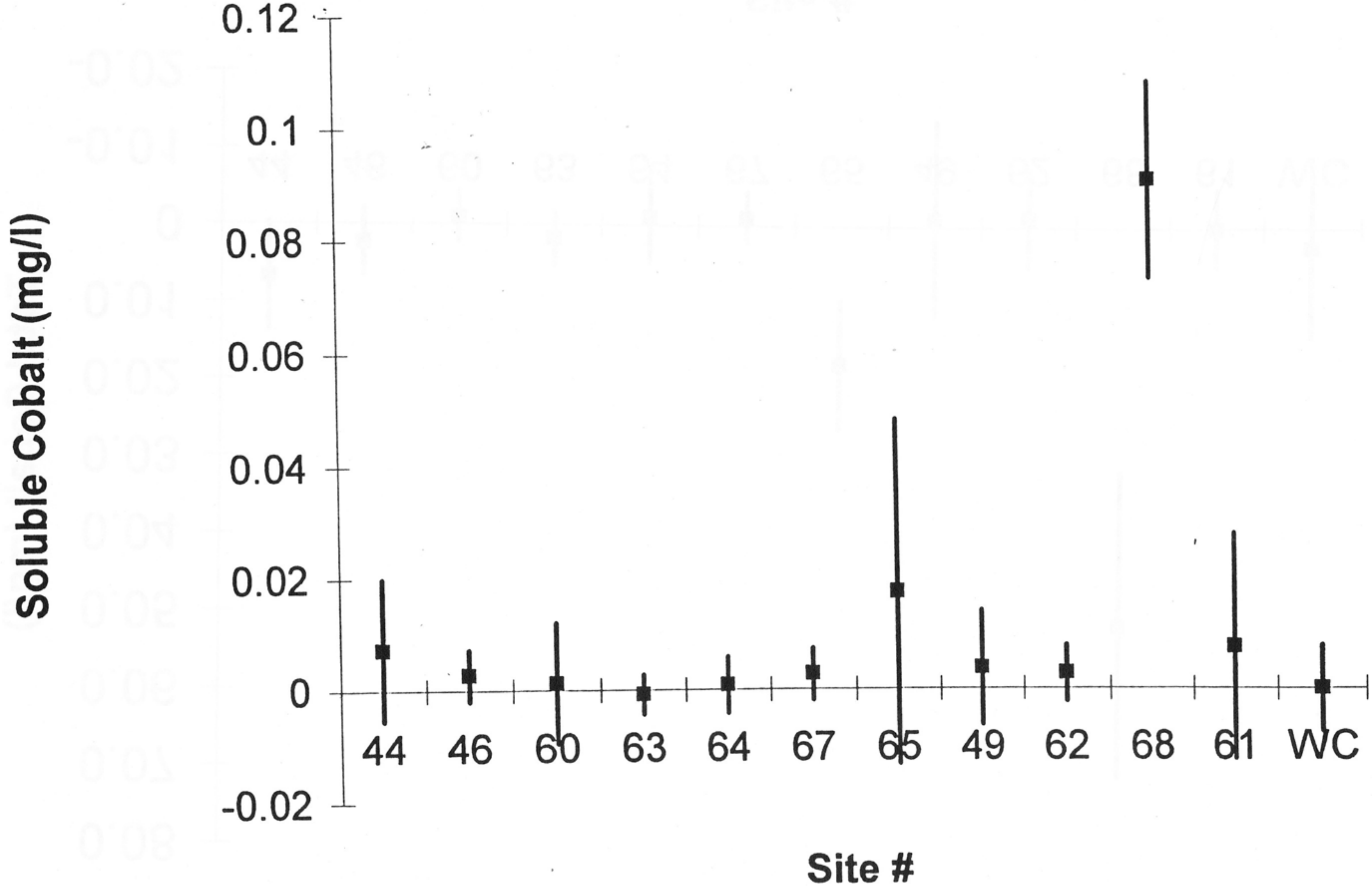
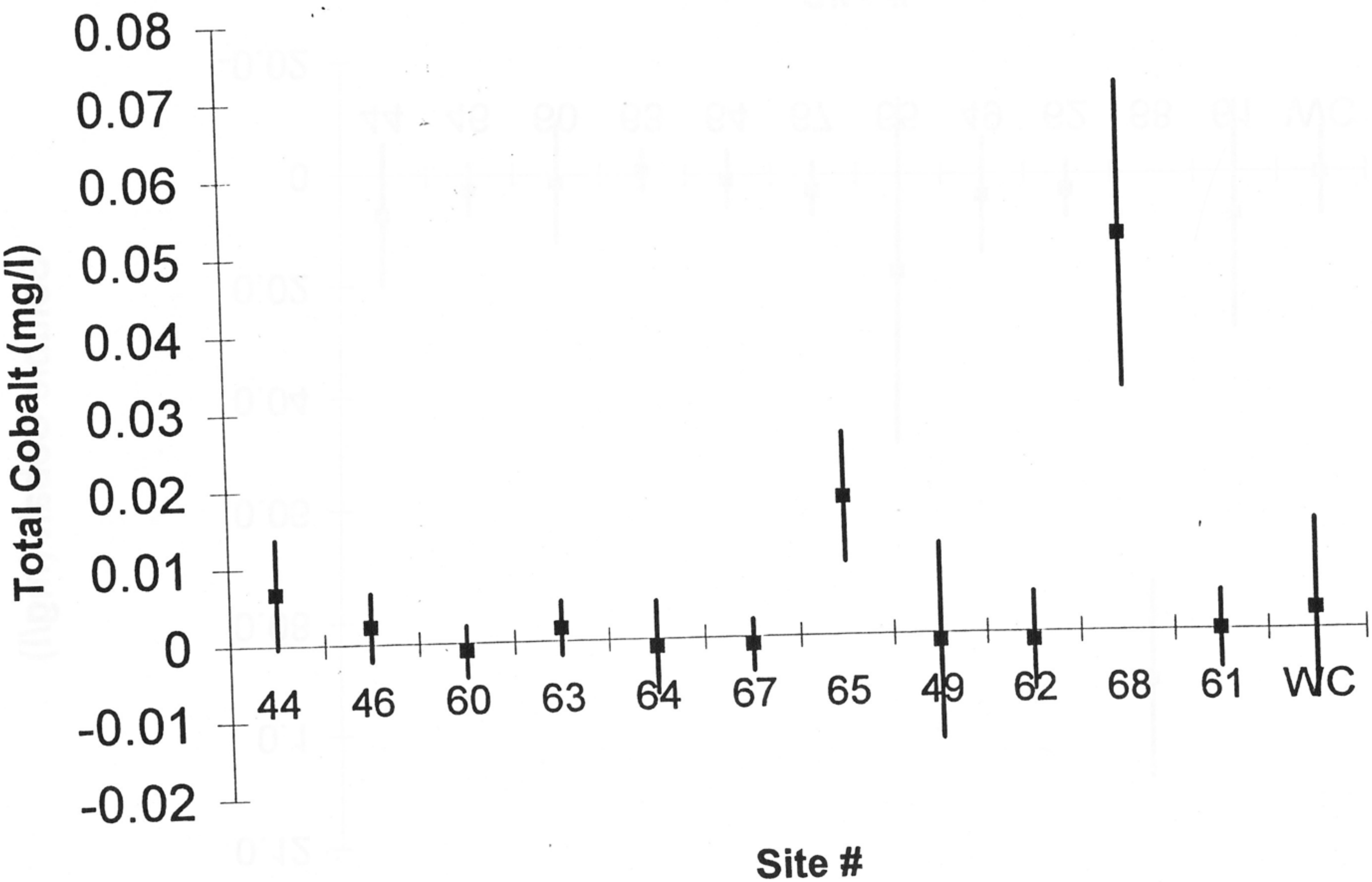
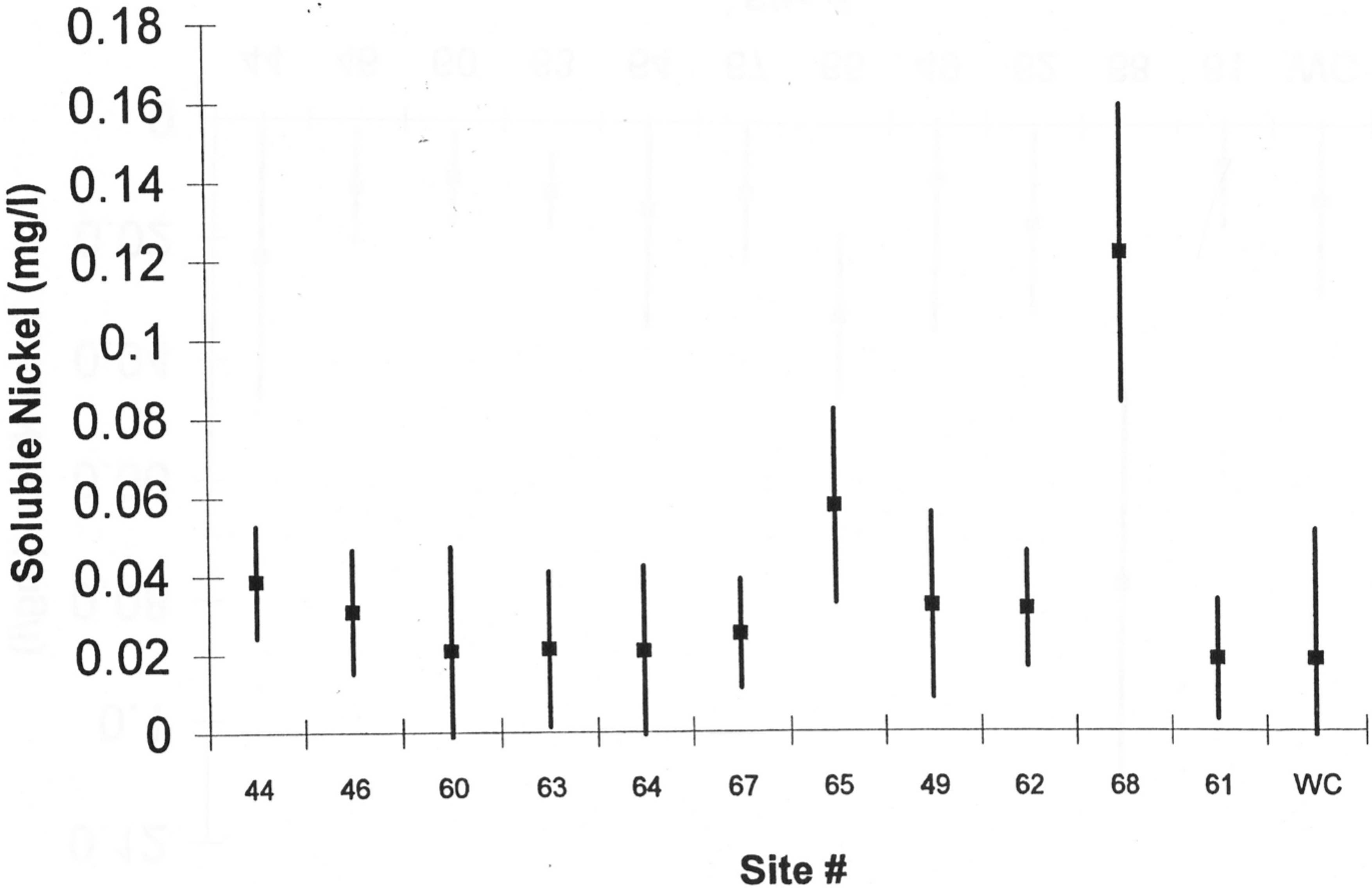

Soluble Cobalt (mg/l)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

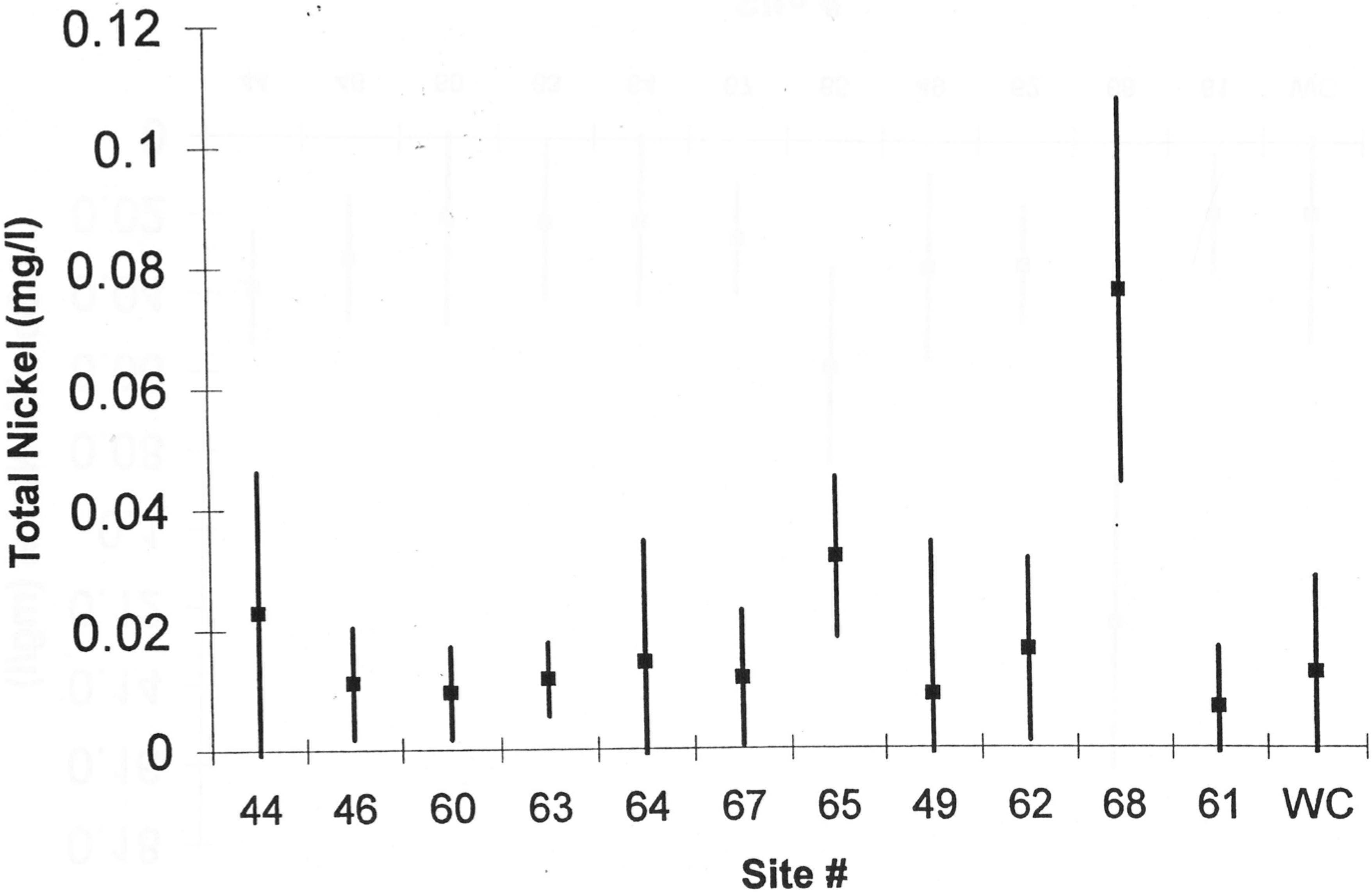
Fig. 23


Total Cobalt (mg/l)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
44
46
60
63
64
67
65
49
62
68
61
WC
Site #



Soluble Nickel (mg/l)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 25


Total Nickel (mg/l)
0.12
0.1
0.08
0.06
0.04
0.02
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fi ?6

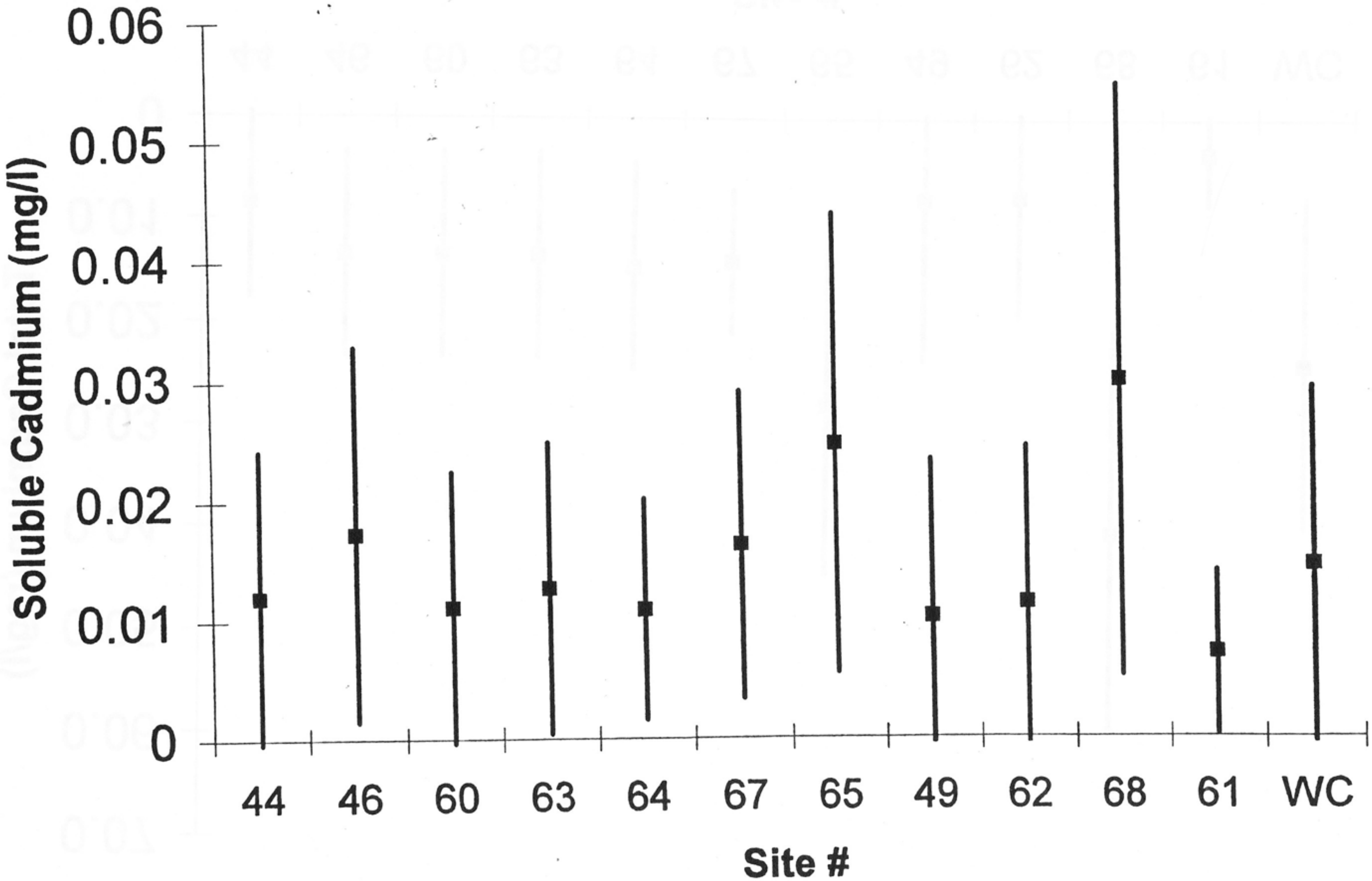

0.06
0.05
0.04
0.03
0.02
0.01
0
Soluble Cadmium (mg/l)
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 27

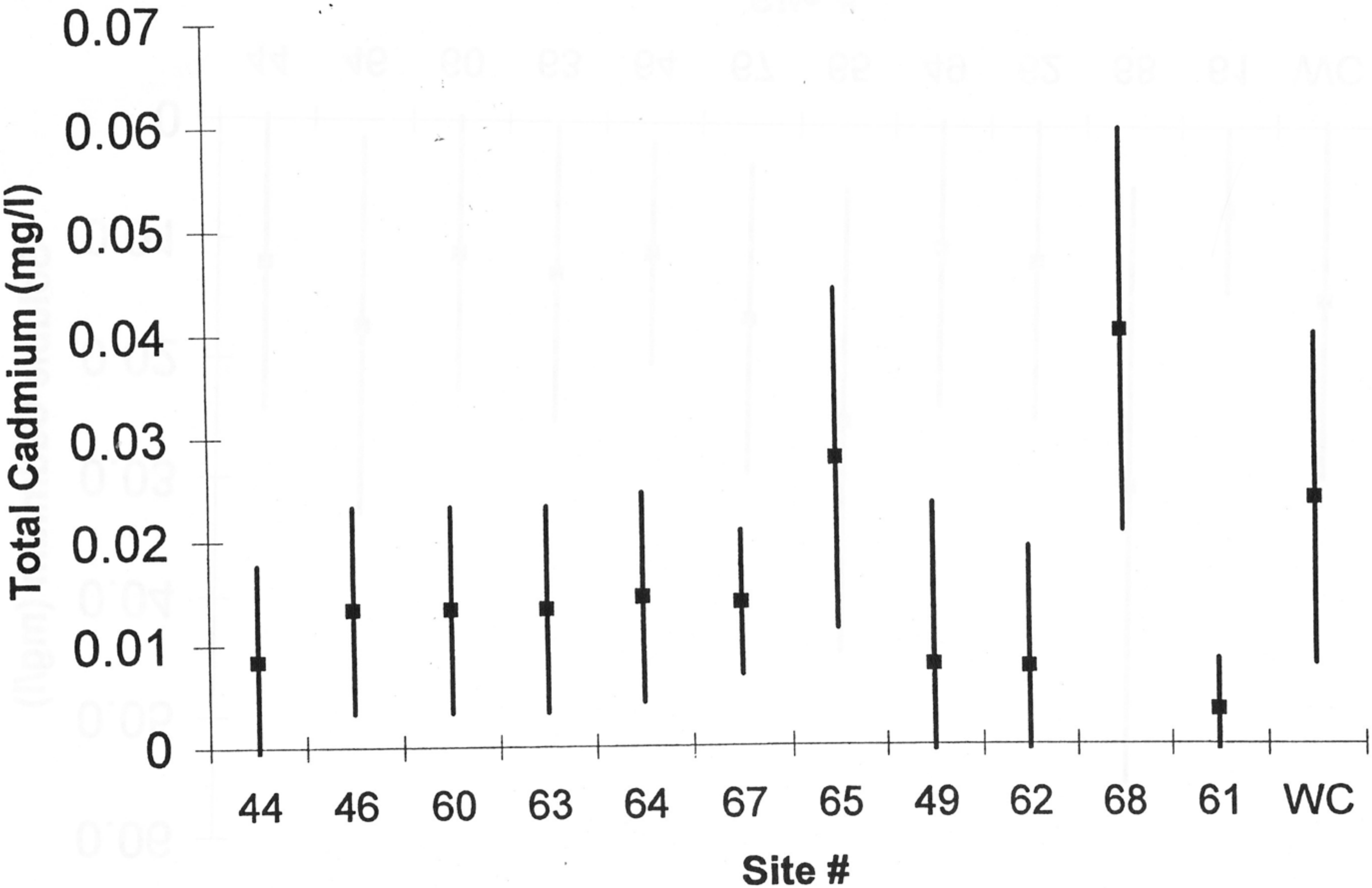

Total Cadmium (mg/l)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 28

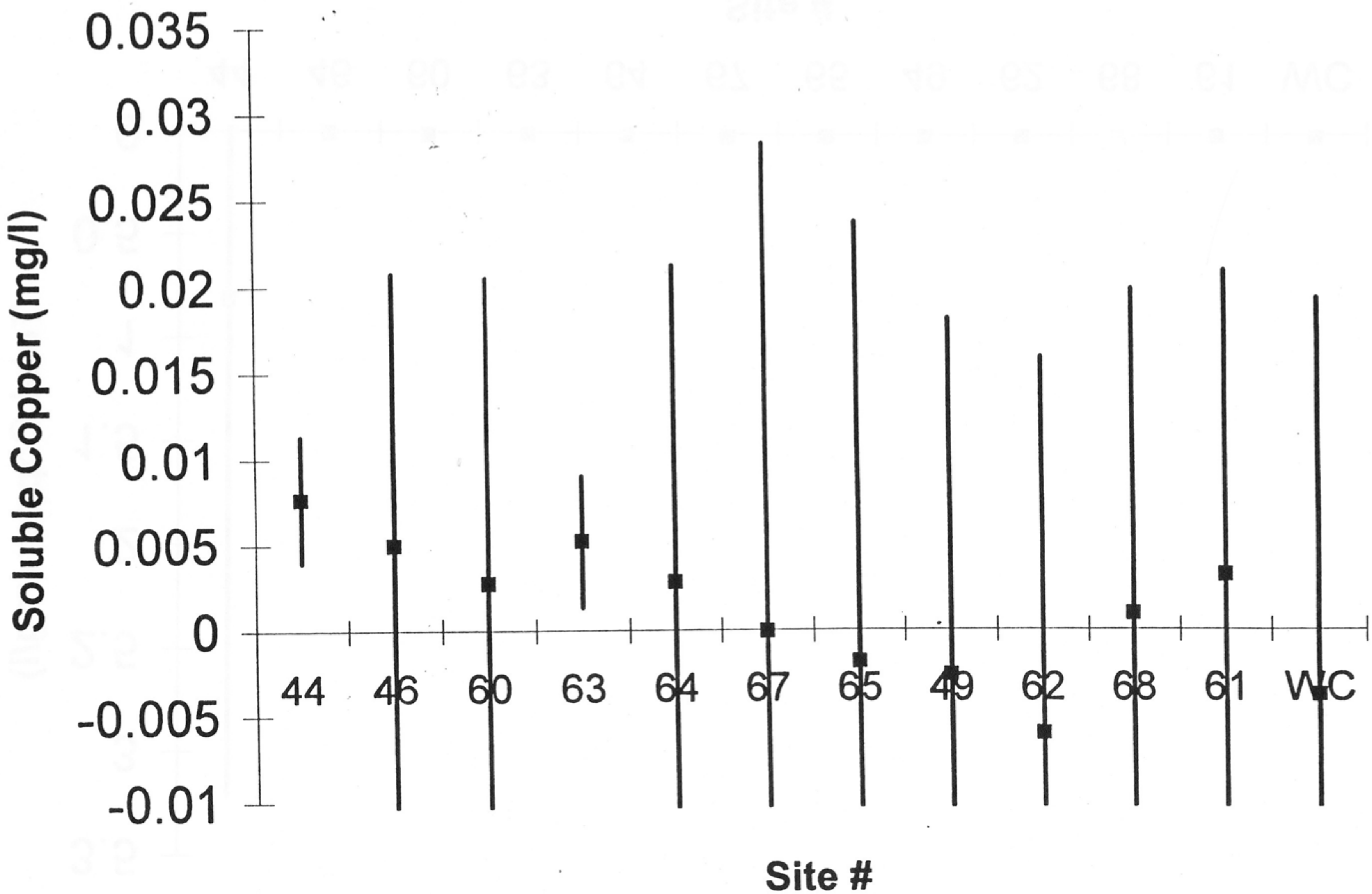

Soluble Copper (mg/l)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 29

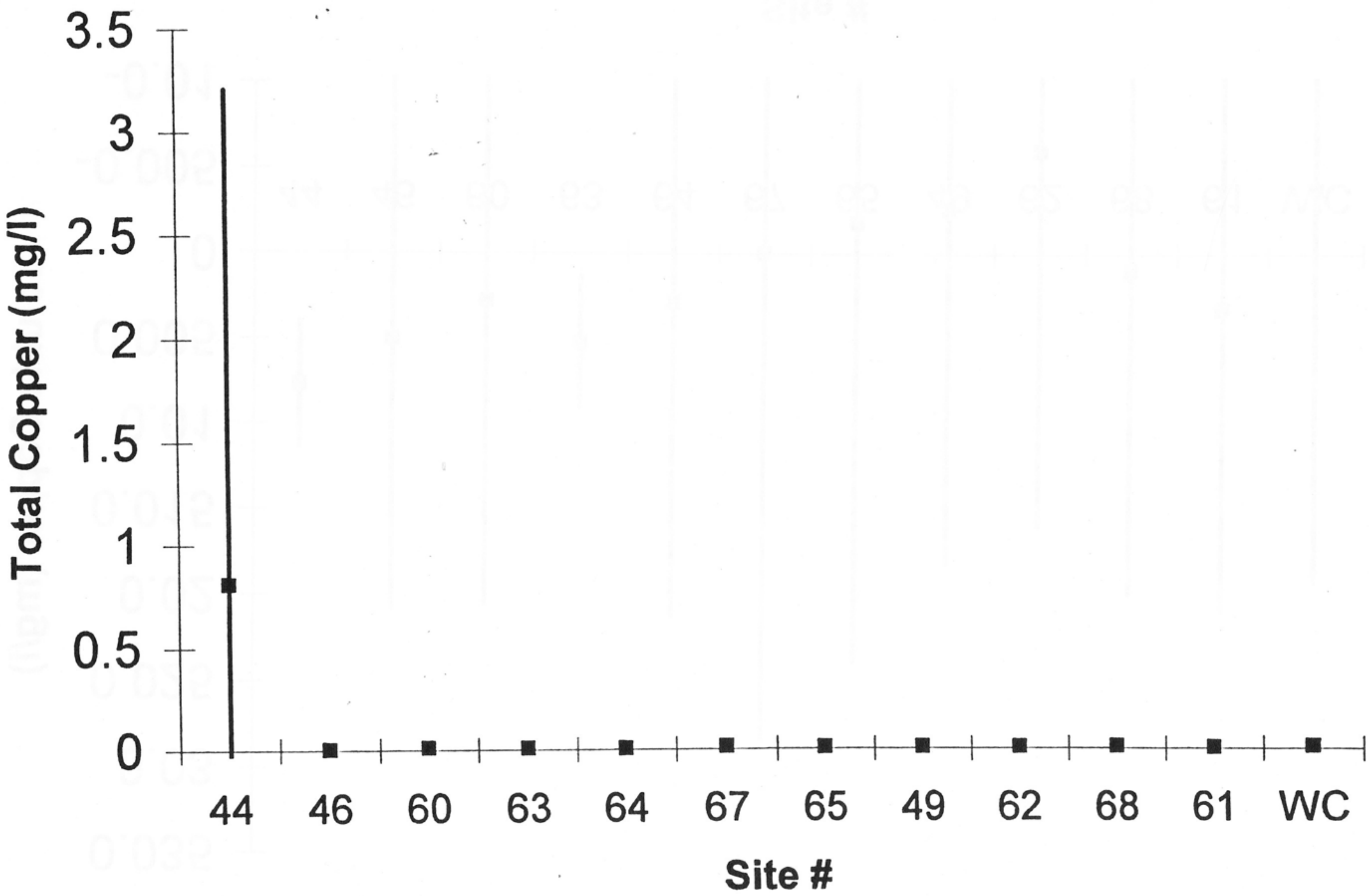
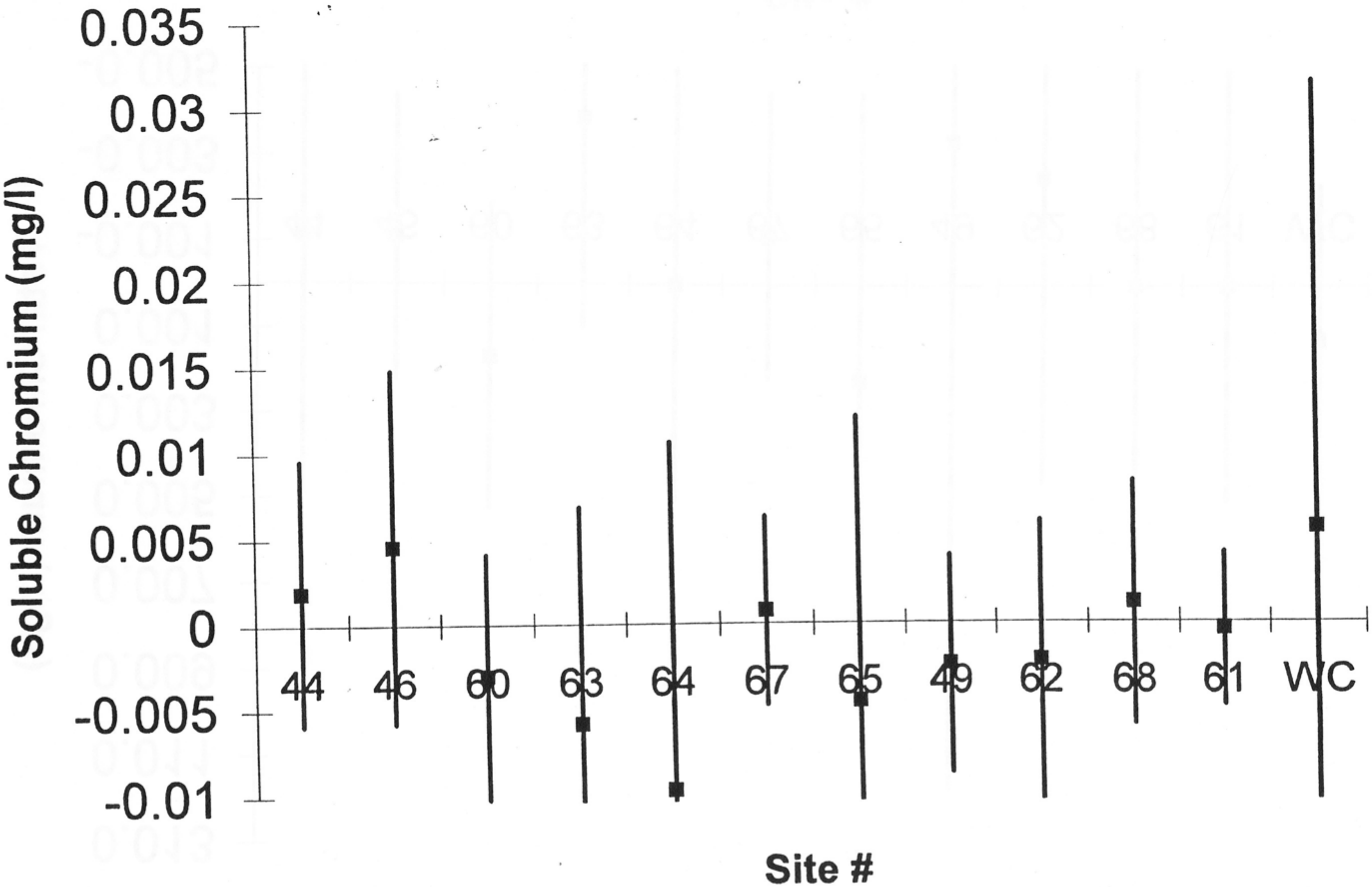
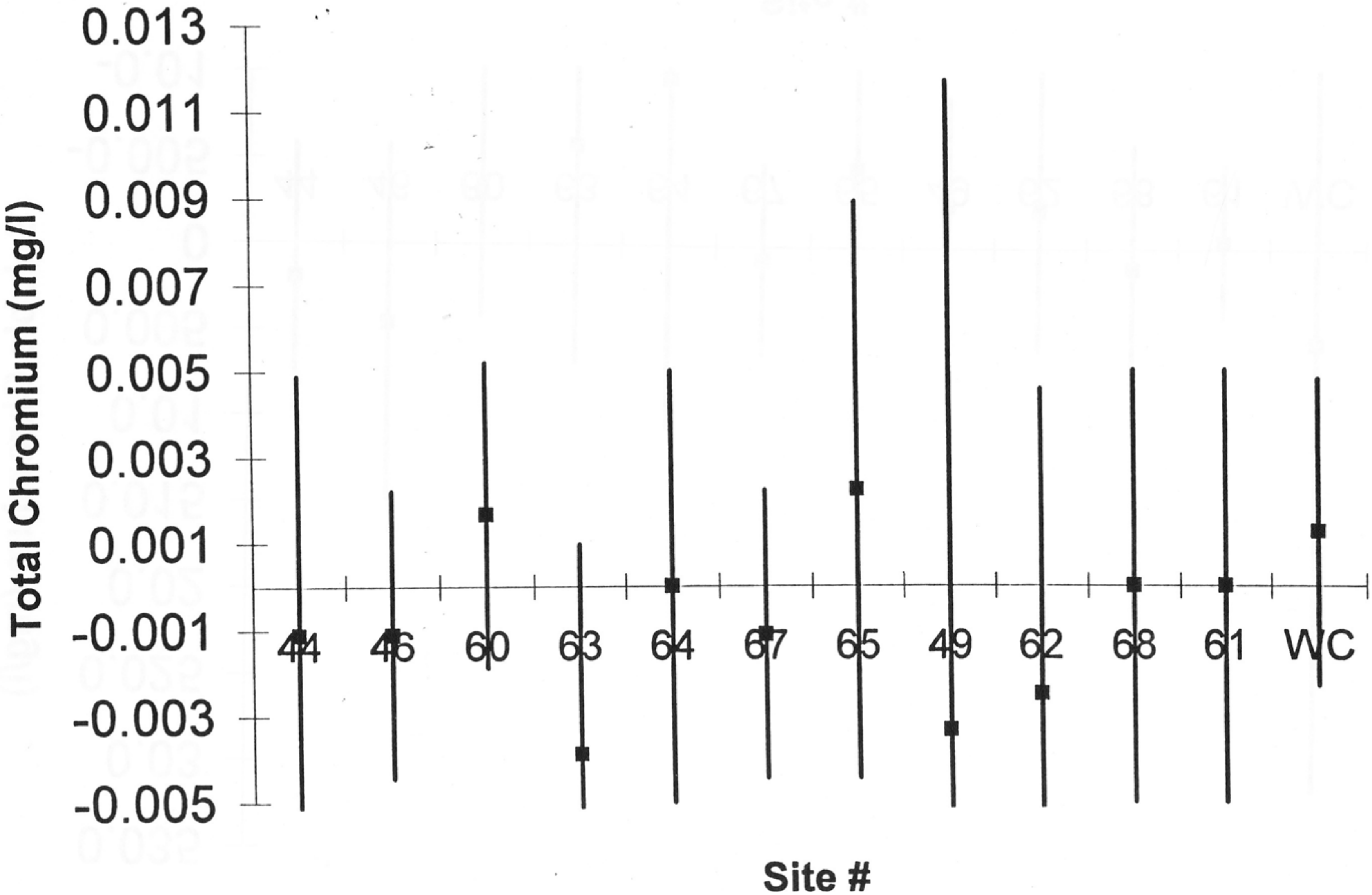

Total Copper (mg/l)
3.5
3
2.5
2
1.5
1
0.5
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 30



Soluble Chromium (mg/l)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 31



Total Chromium (mg/l)
0.013
0.011
0.009
0.007
0.005
0.003
0.001
-0.001
-0.003
-0.005
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 32

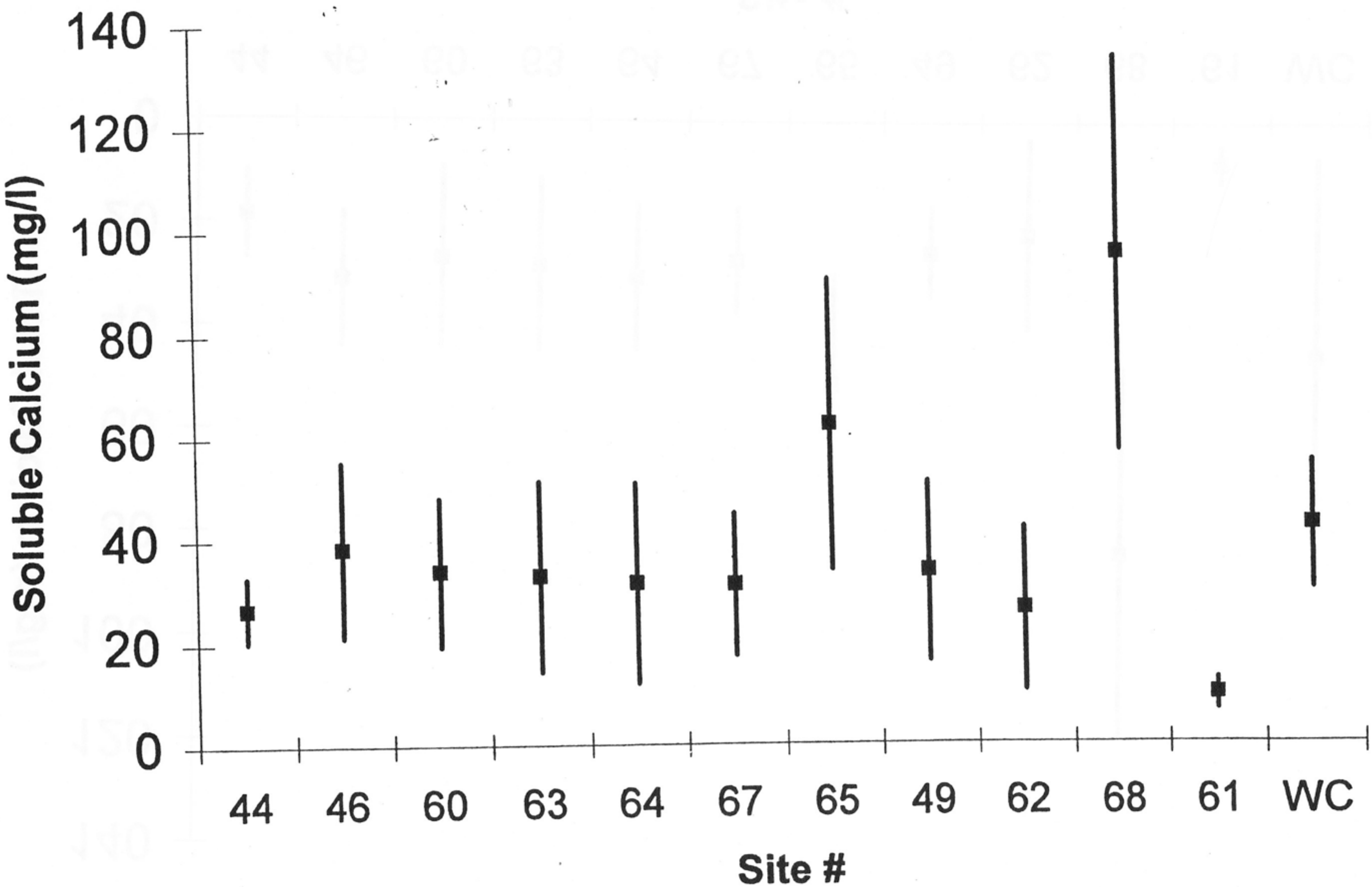

Soluble Calcium (mg/l)
140
120
100
80
60
40
20
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 33

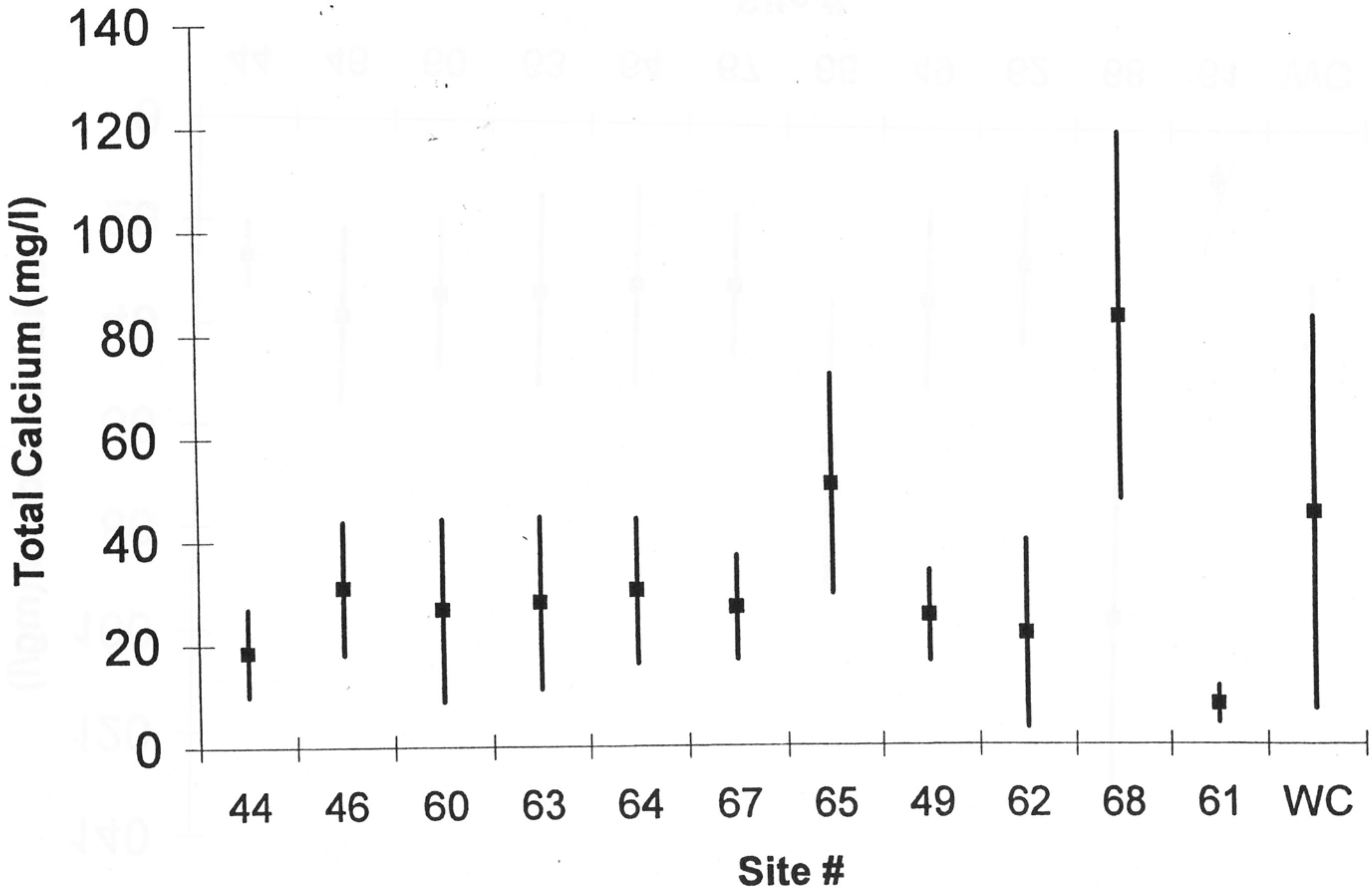

Total Calcium (mg/l)
140
120
100
80
60
40
20
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 34

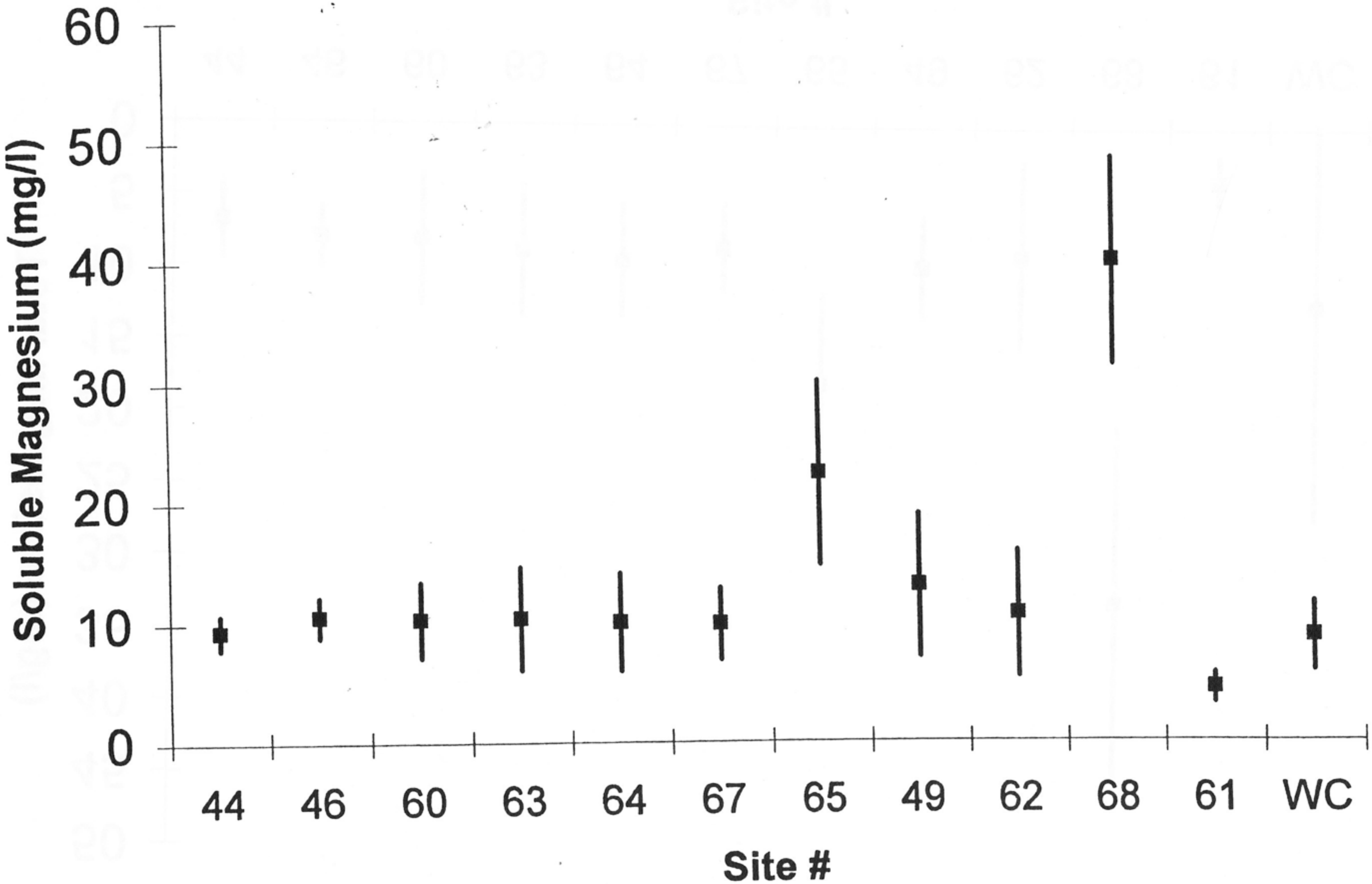

Soluble Magnesium (mg/l)
60
50
40
30
20
10
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 35

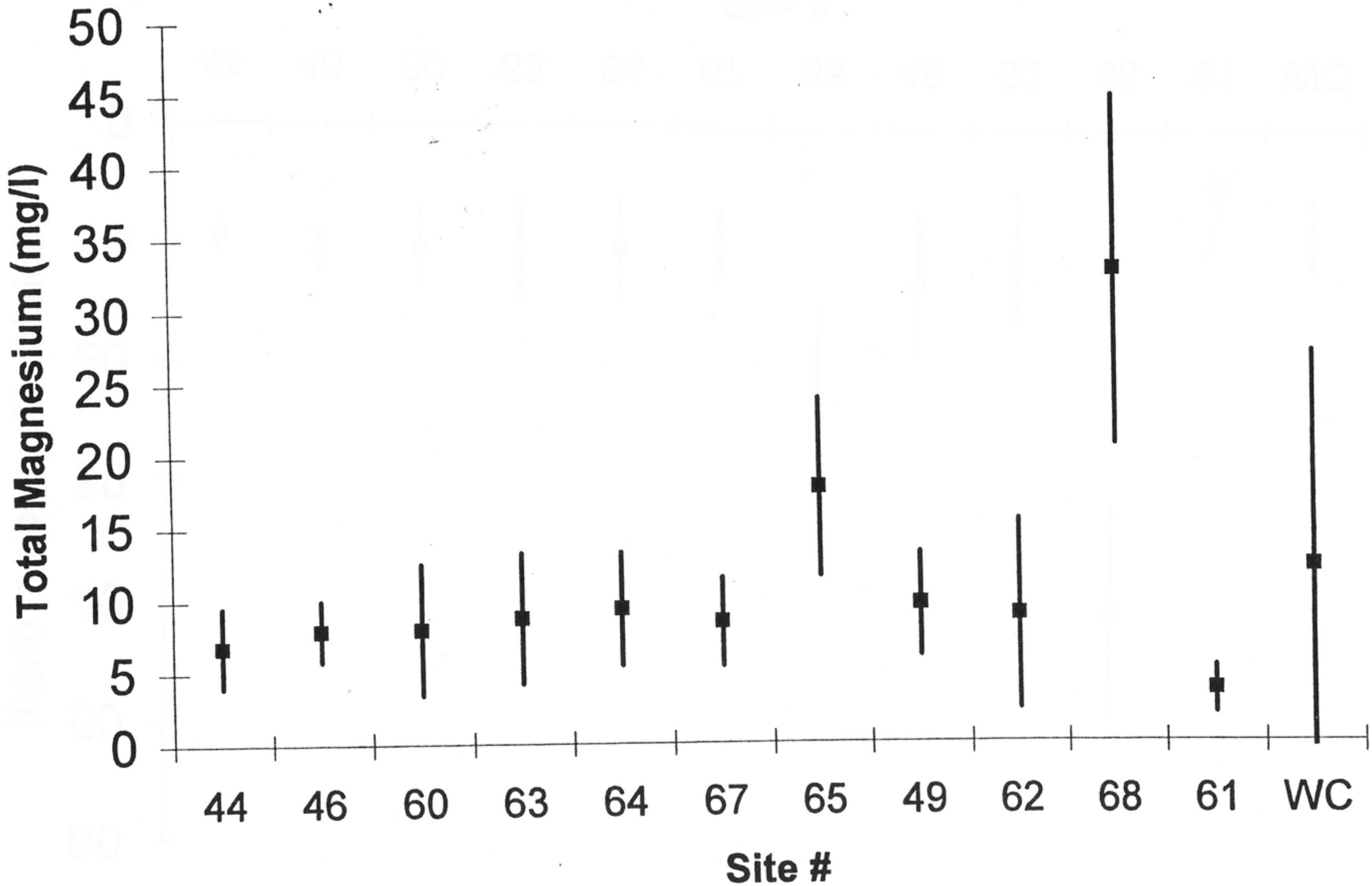

Total Magnesium (mg/l)
50
45
40
35
30
25
20
15
10
5
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 36

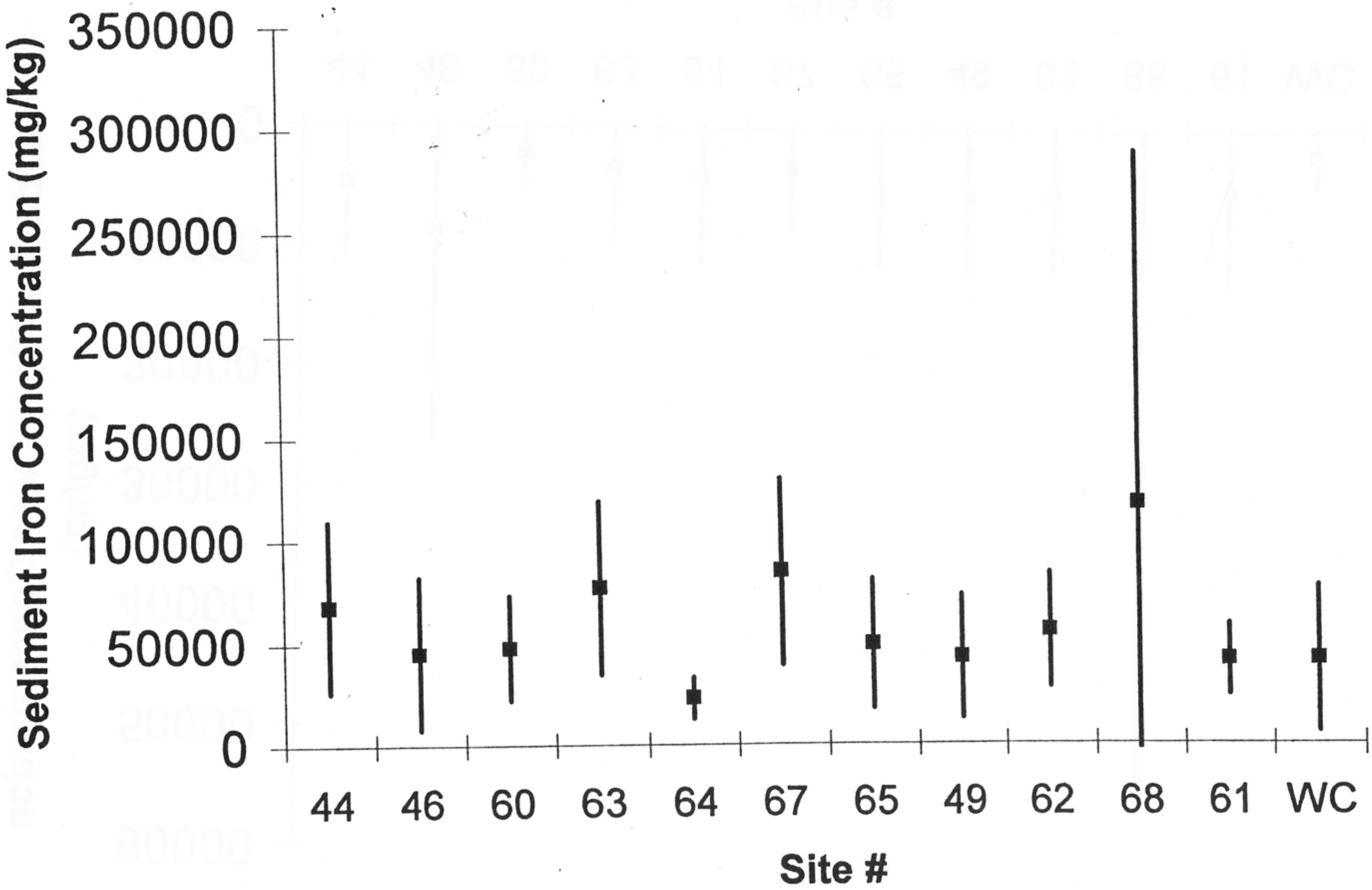

Sediment Iron Concentration (mg/kg)
350000
300000
250000
200000
150000
100000
50000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 38

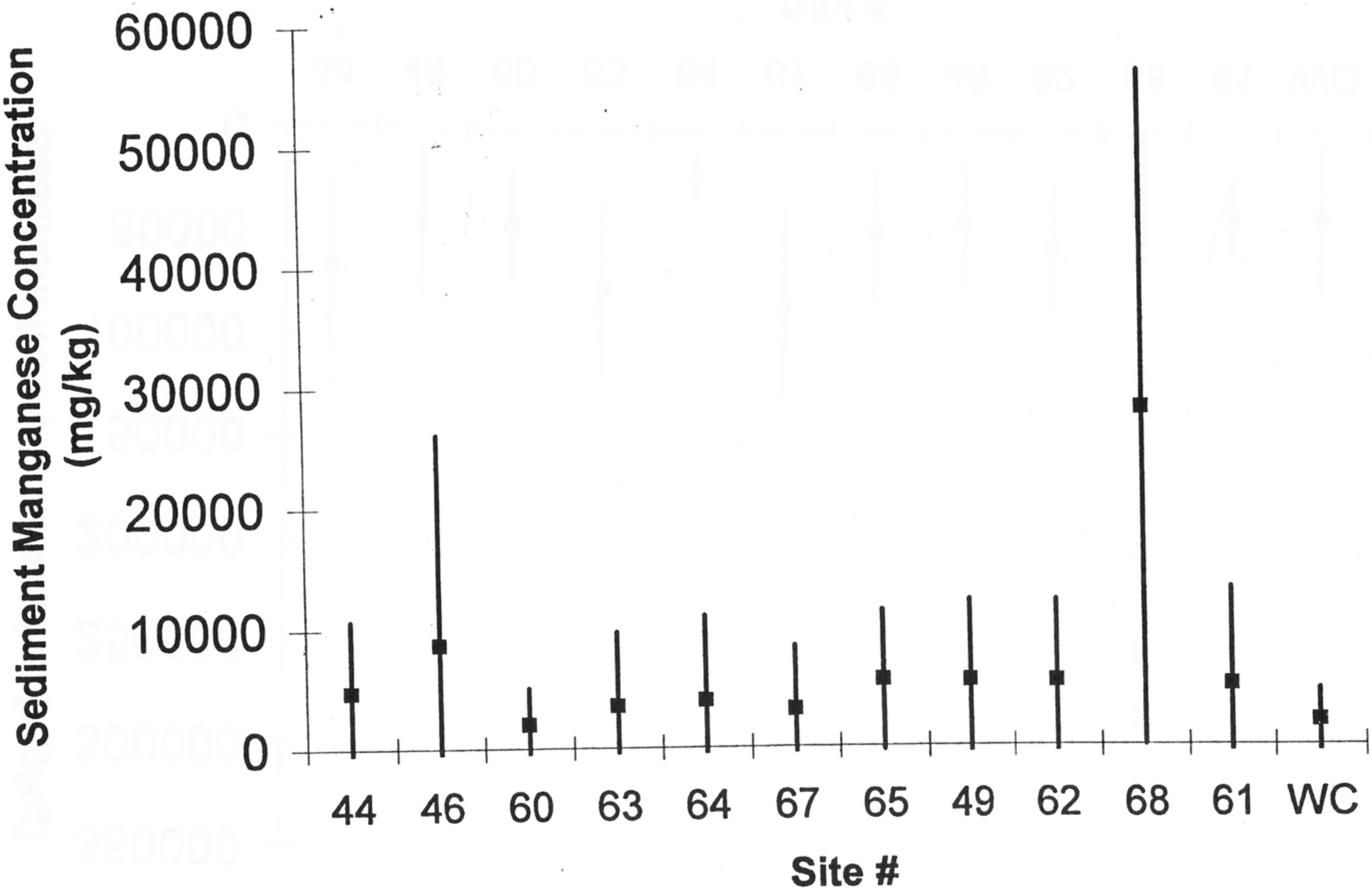

Sediment Manganese Concentration
(mg/kg)
60000
50000
40000
30000
20000
10000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 39

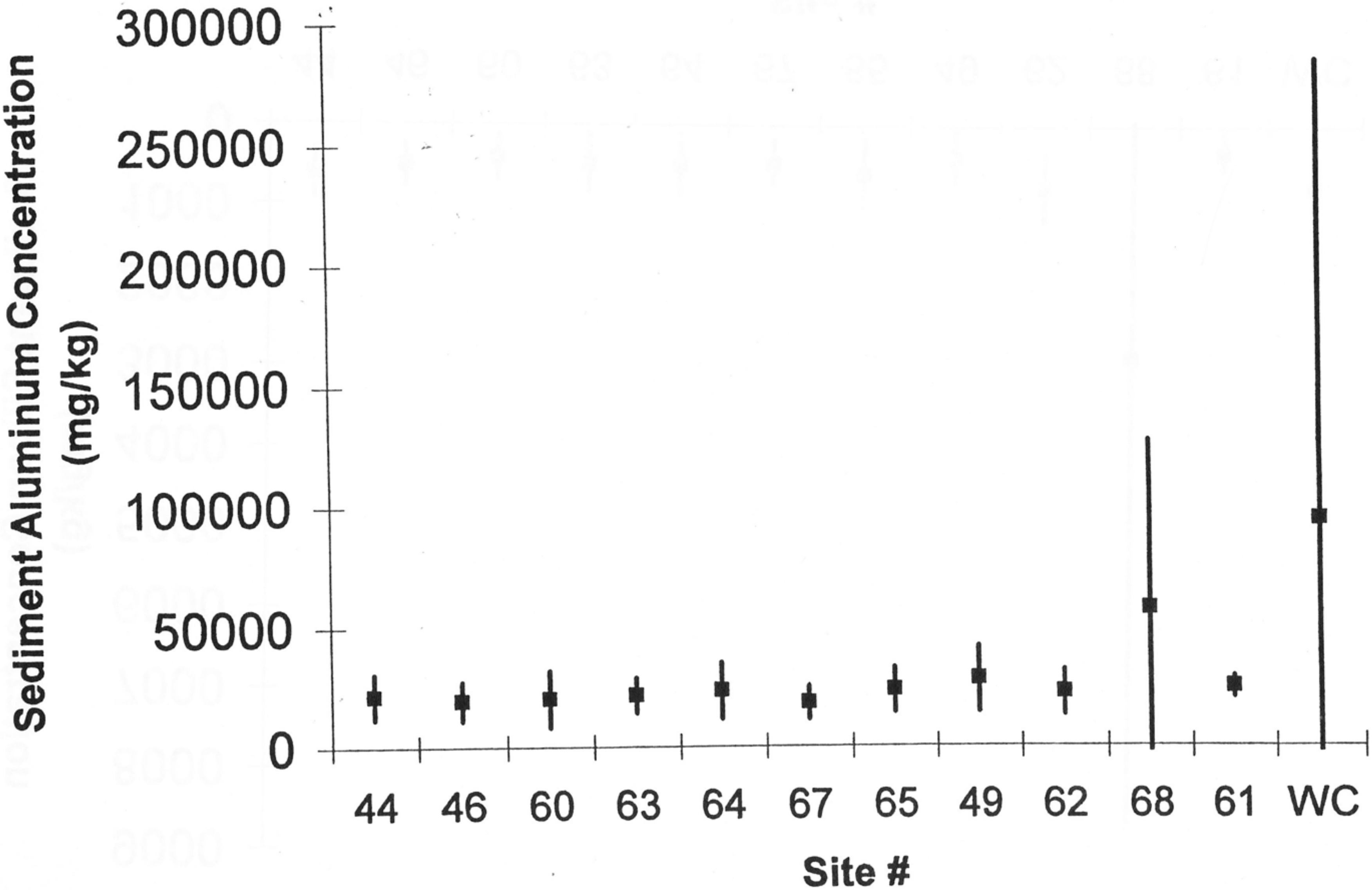

Sediment Aluminum Concentration (mg/kg)
300000
250000
200000
150000
100000
50000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 40

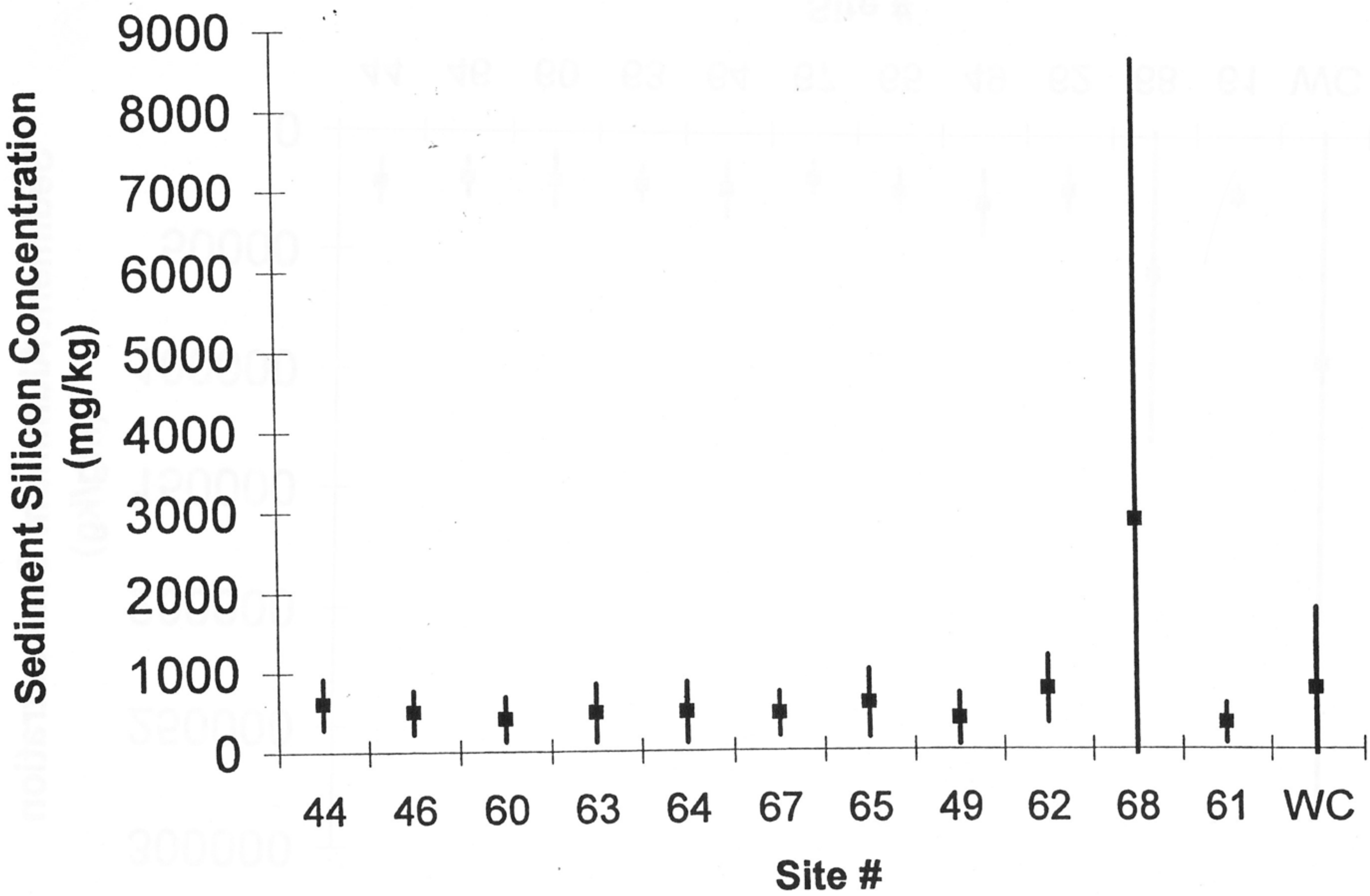

Sediment Silicon Concentration (mg/kg)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig.

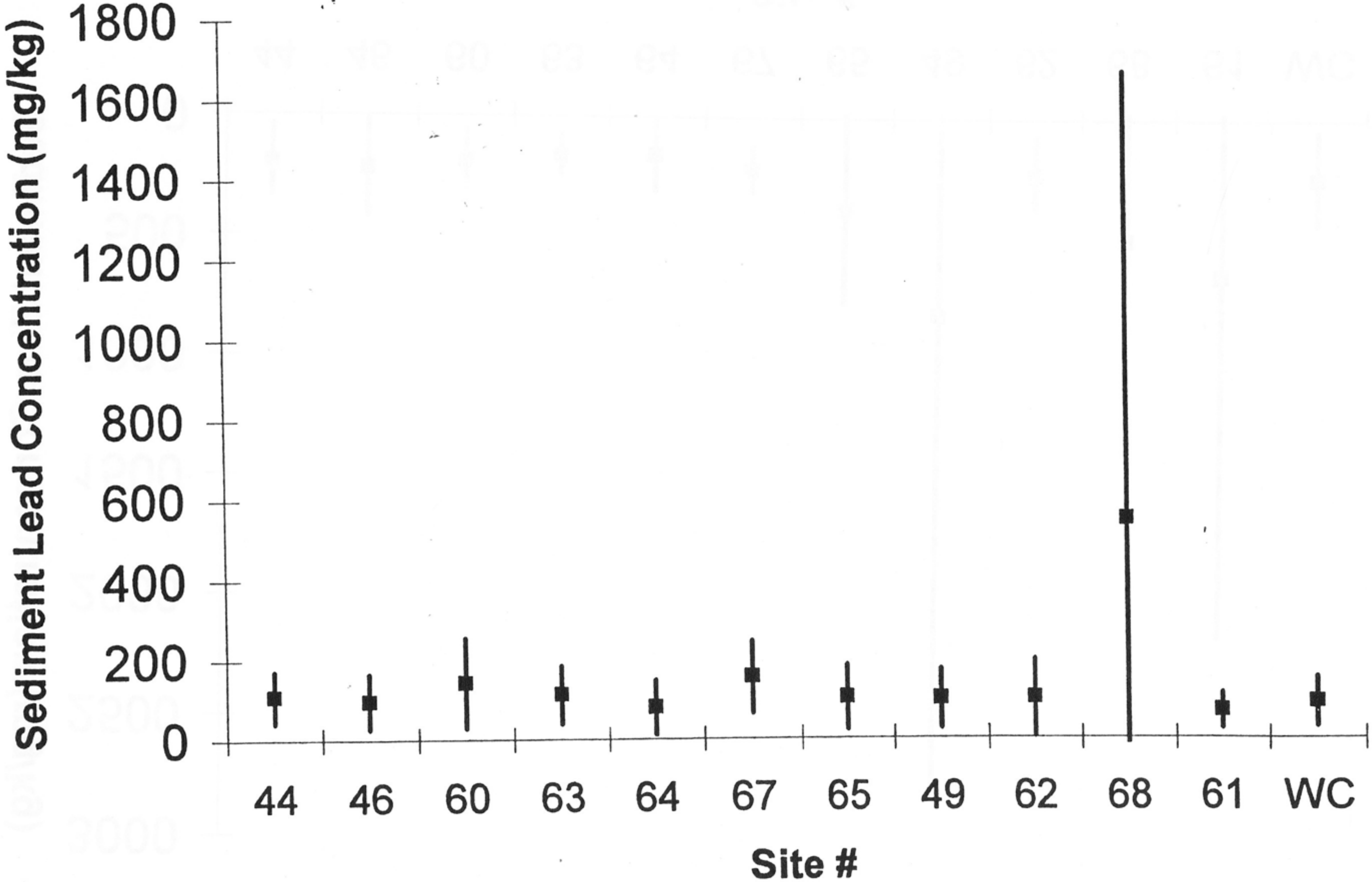

Sediment Lead Concentration (mg/kg)
1800
1600
1400
1200
1000
800
600
400
200
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 42

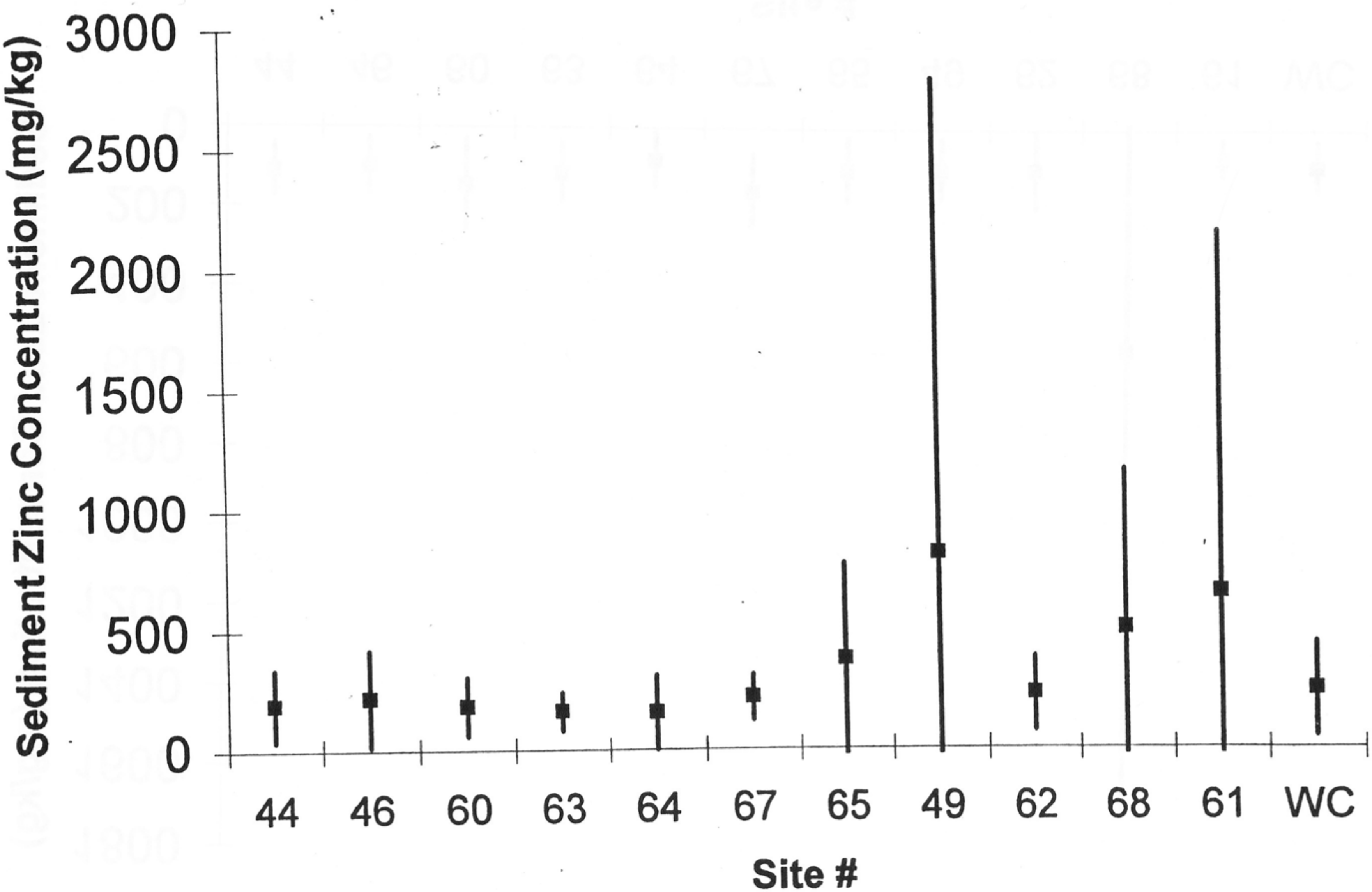

Sediment Zinc Concentration (mg/kg)
3000
2500
2000
1500
1000
500
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 43

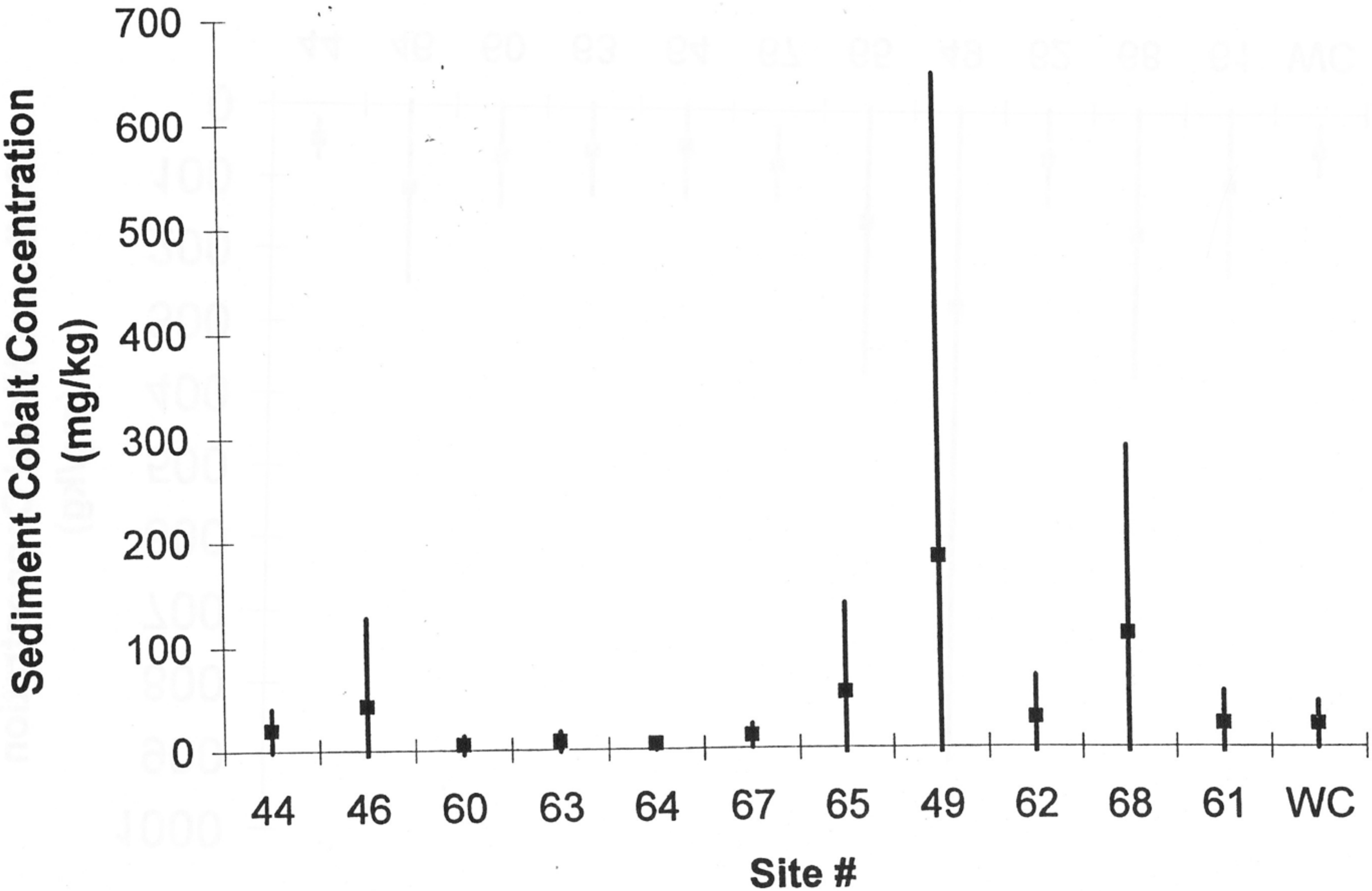

Sediment Cobalt Concentration (mg/kg)
700
600
500
400
300
200
100
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 44

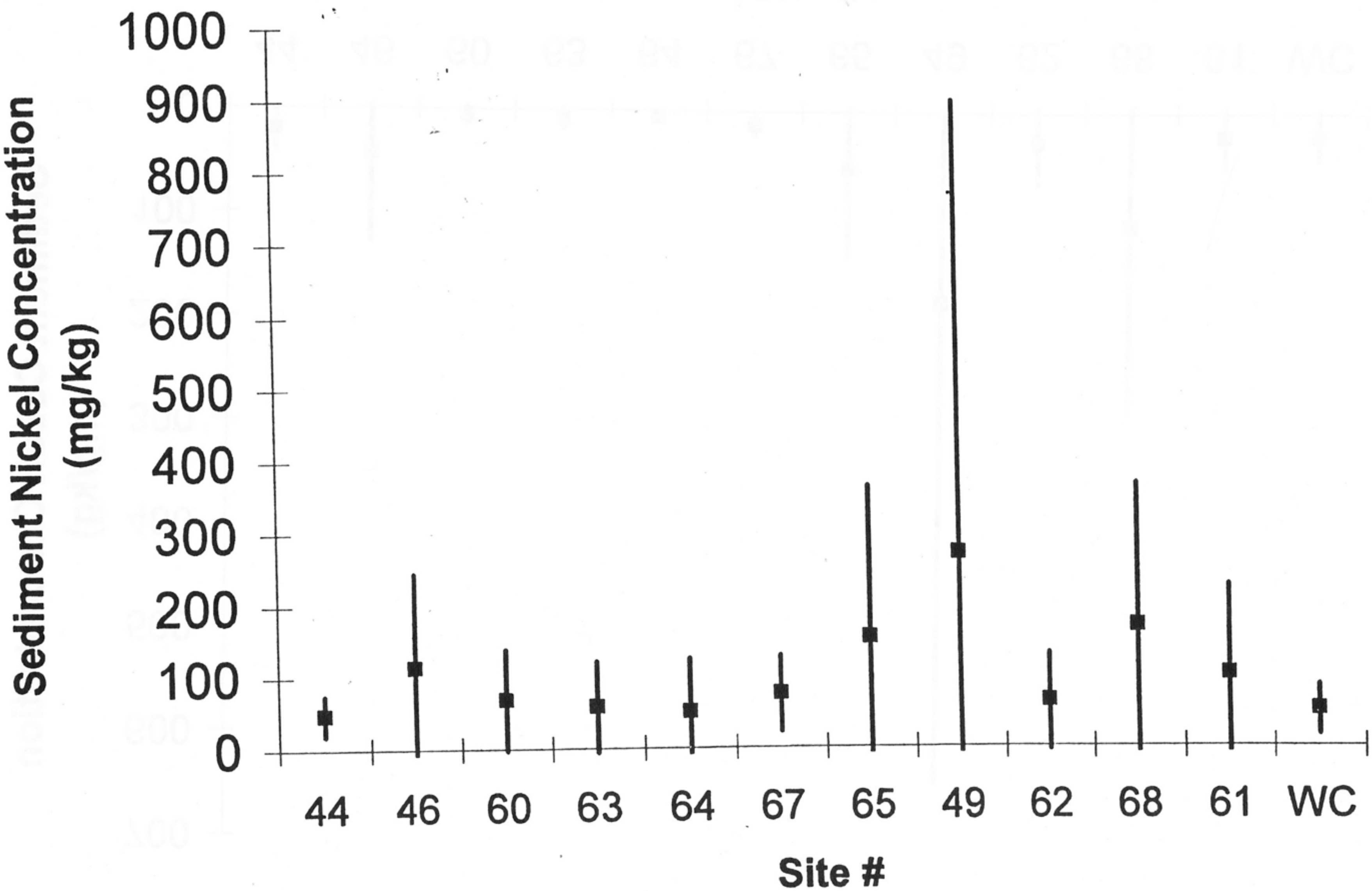

Sediment Nickel Concentration (mg/kg)
1000
900
800
700
600
500
400
300
200
100
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 45

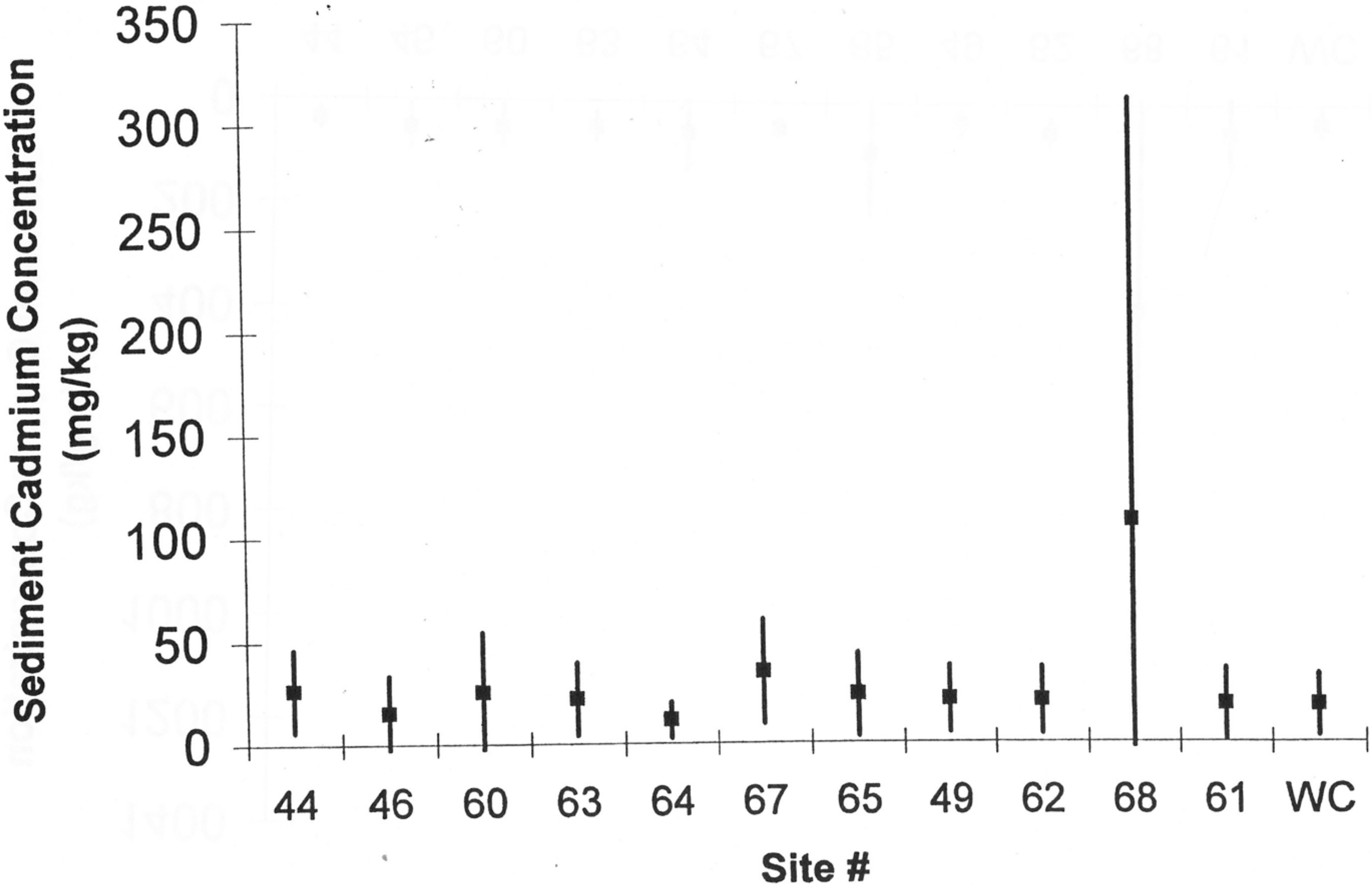

Sediment Cadmium Concentration
(mg/kg)
350
300
250
200
150
100
50
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 46

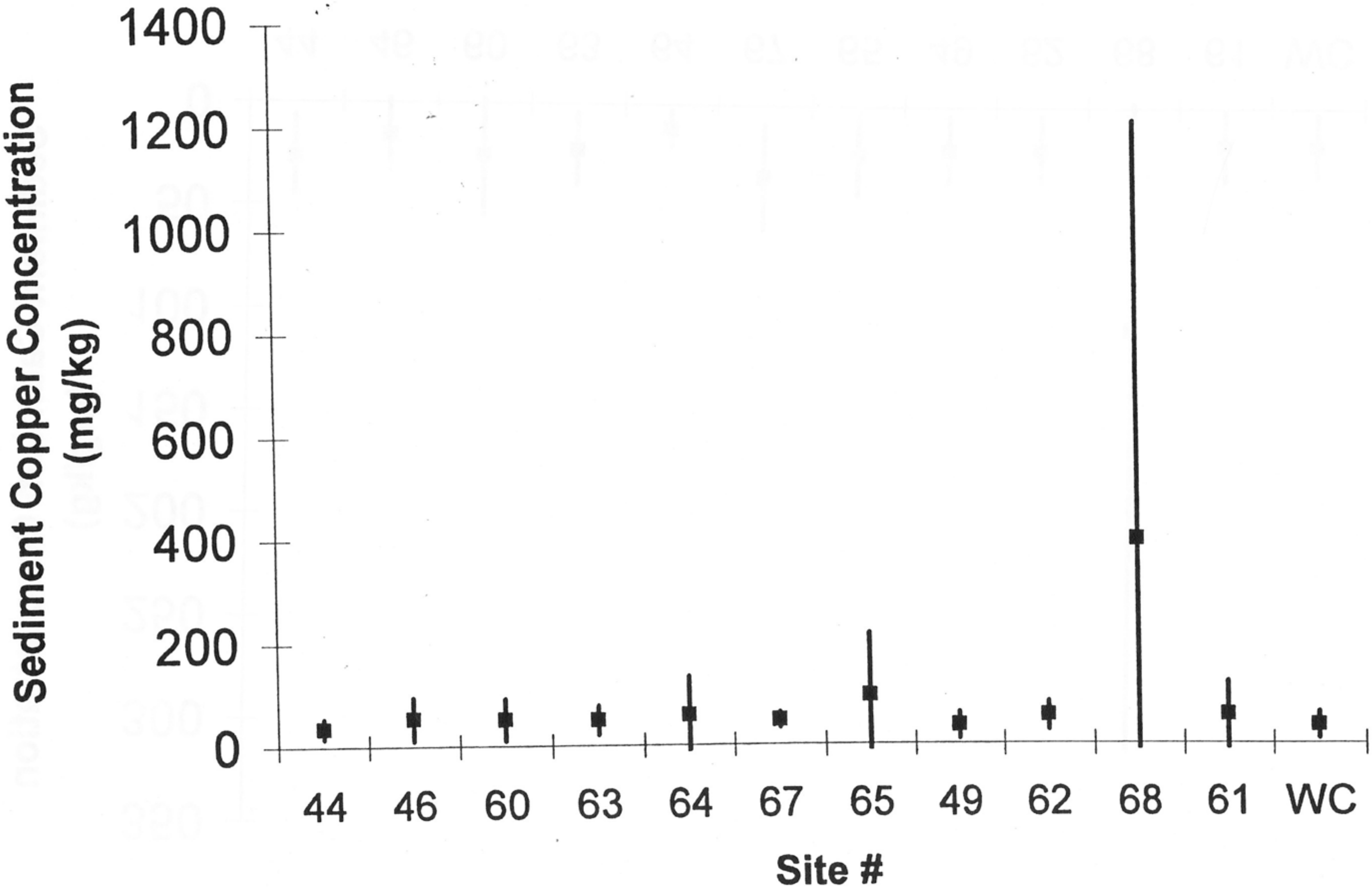

1400
1200
1000
800
600
400
200
0
Sediment Copper Concentration (mg/kg)
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 47

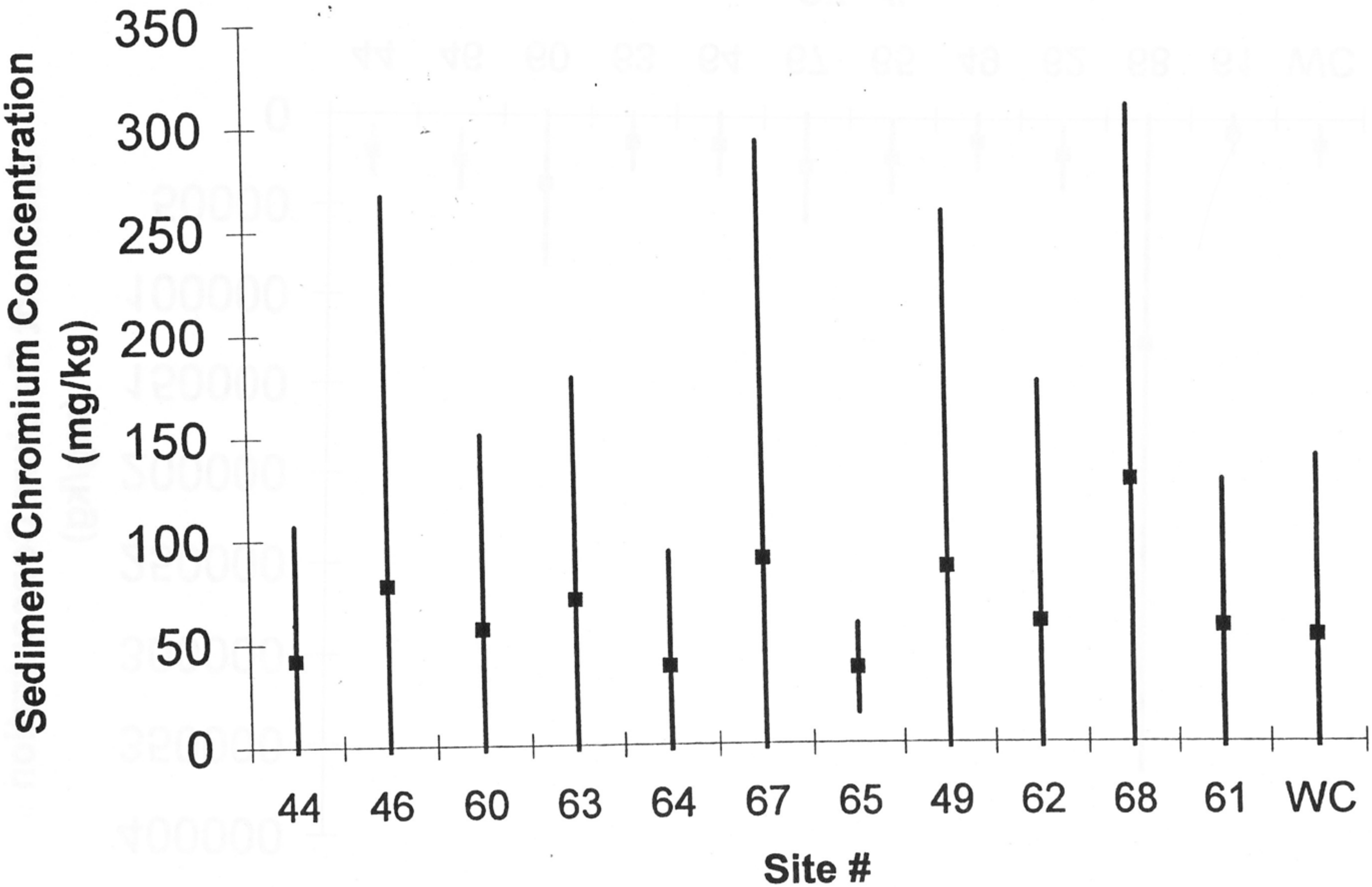

Sediment Chromium Concentration (mg/kg)
350
300
250
200
150
100
50
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 48

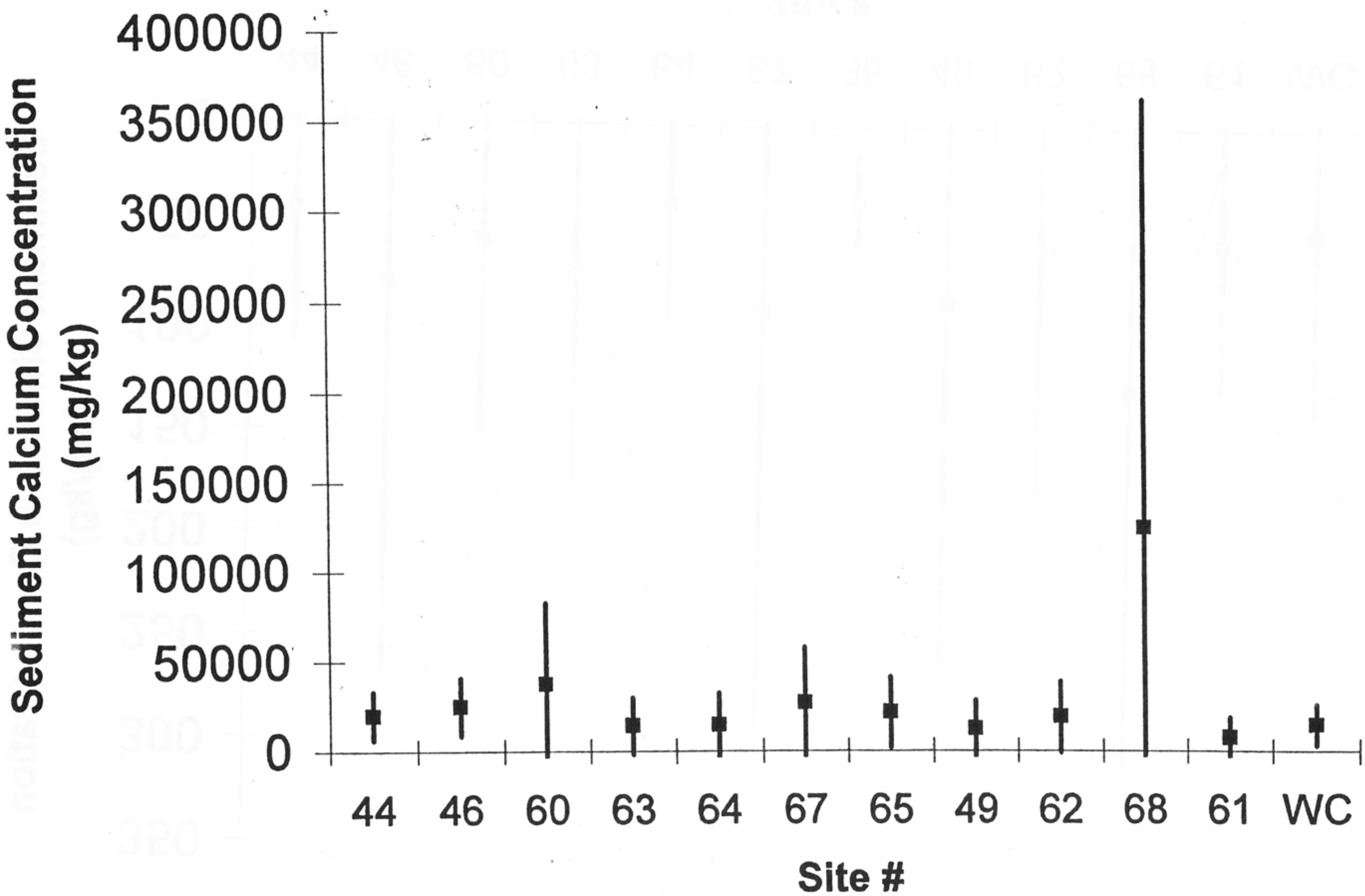

Sediment Calcium Concentration (mg/kg)
400000
350000
300000
250000
200000
150000
100000
50000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 49

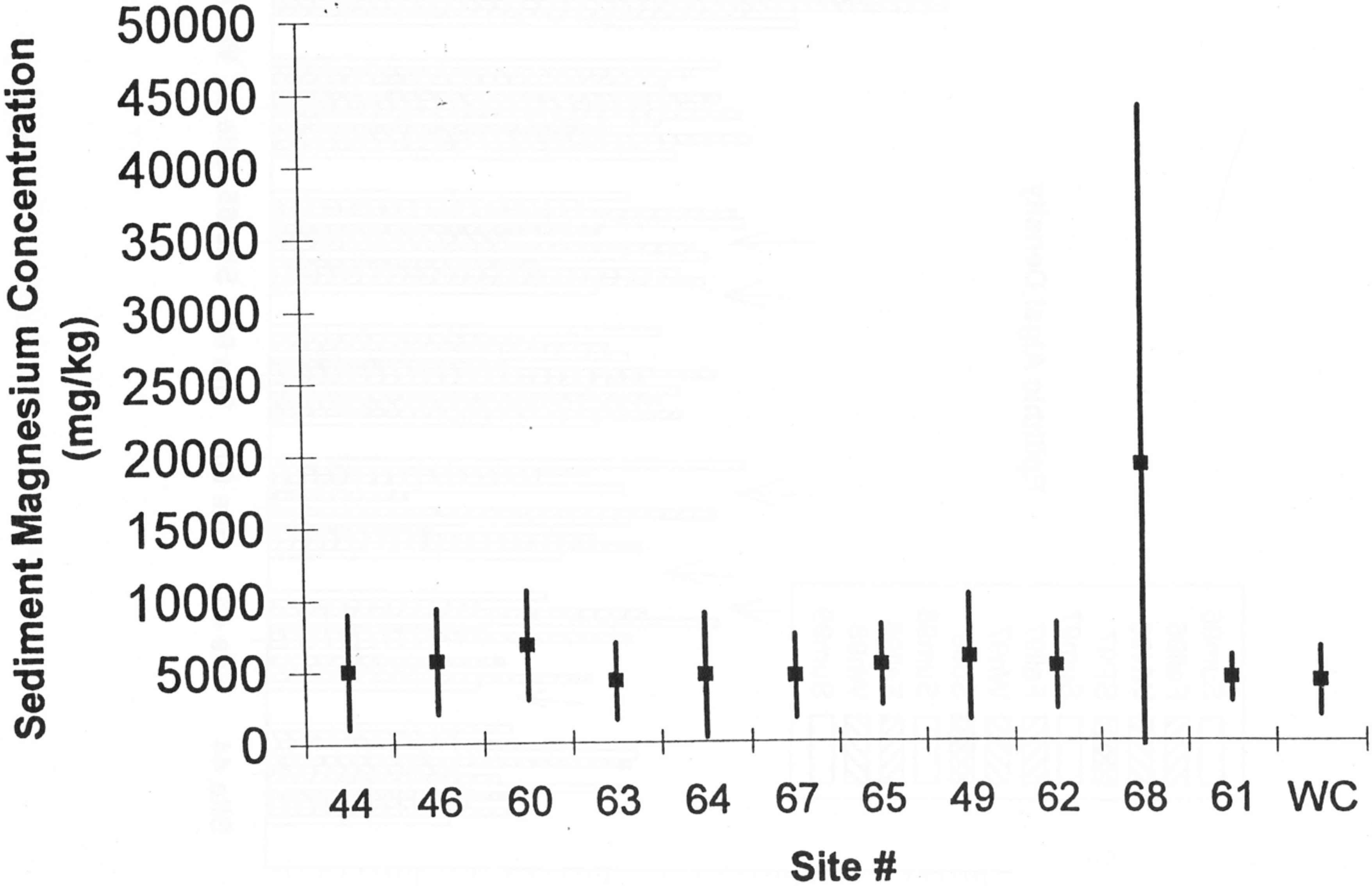

Sediment Magnesium Concentration (mg/kg)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
44
46
60
63
64
67
65
49
62
68
61
WC
Site #

Fig. 50

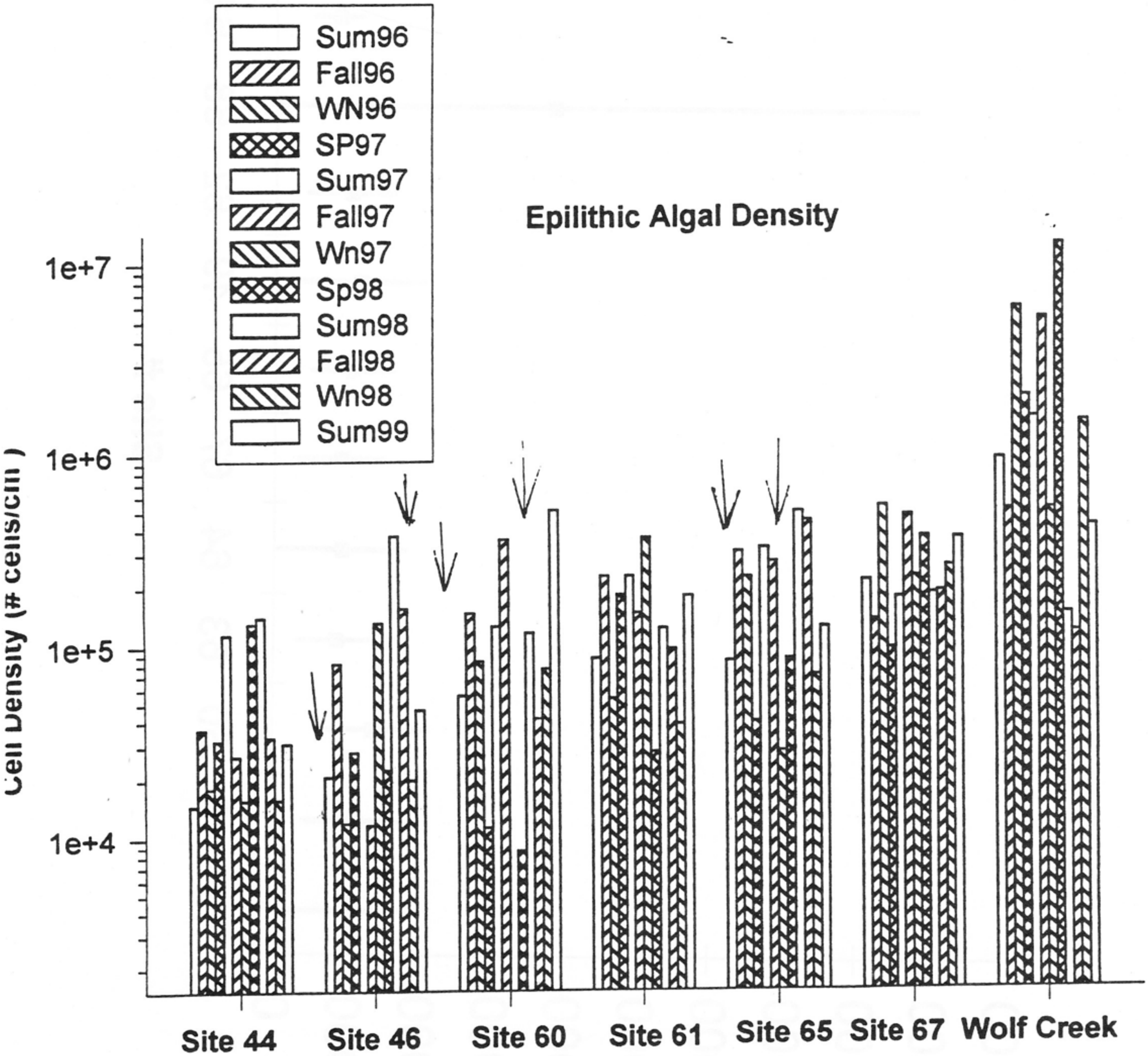

Epilithic Algal Density
Sum96
Fall96
WN96
SP97
Sum97
Fall97
Wn97
Sp98
Sum98
Fall98
Wn98
Sum99
Cell Density (# cells/cm²)
1e+7
1e+6
1e+5
1e+4
Site 44
Site 46
Site 60
Site 61
Site 65
Site 67
Wolf Creek

Fig. 51

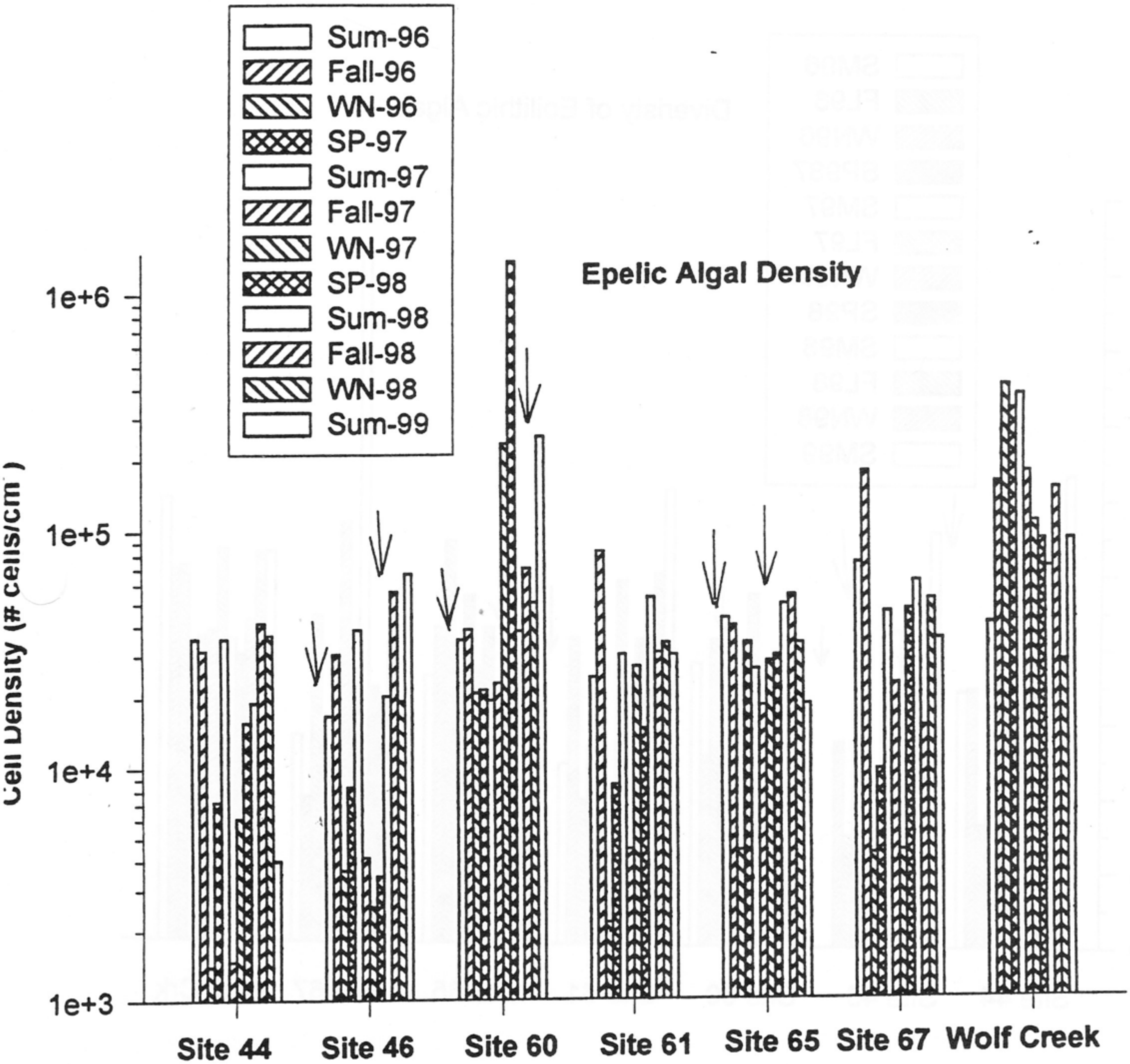
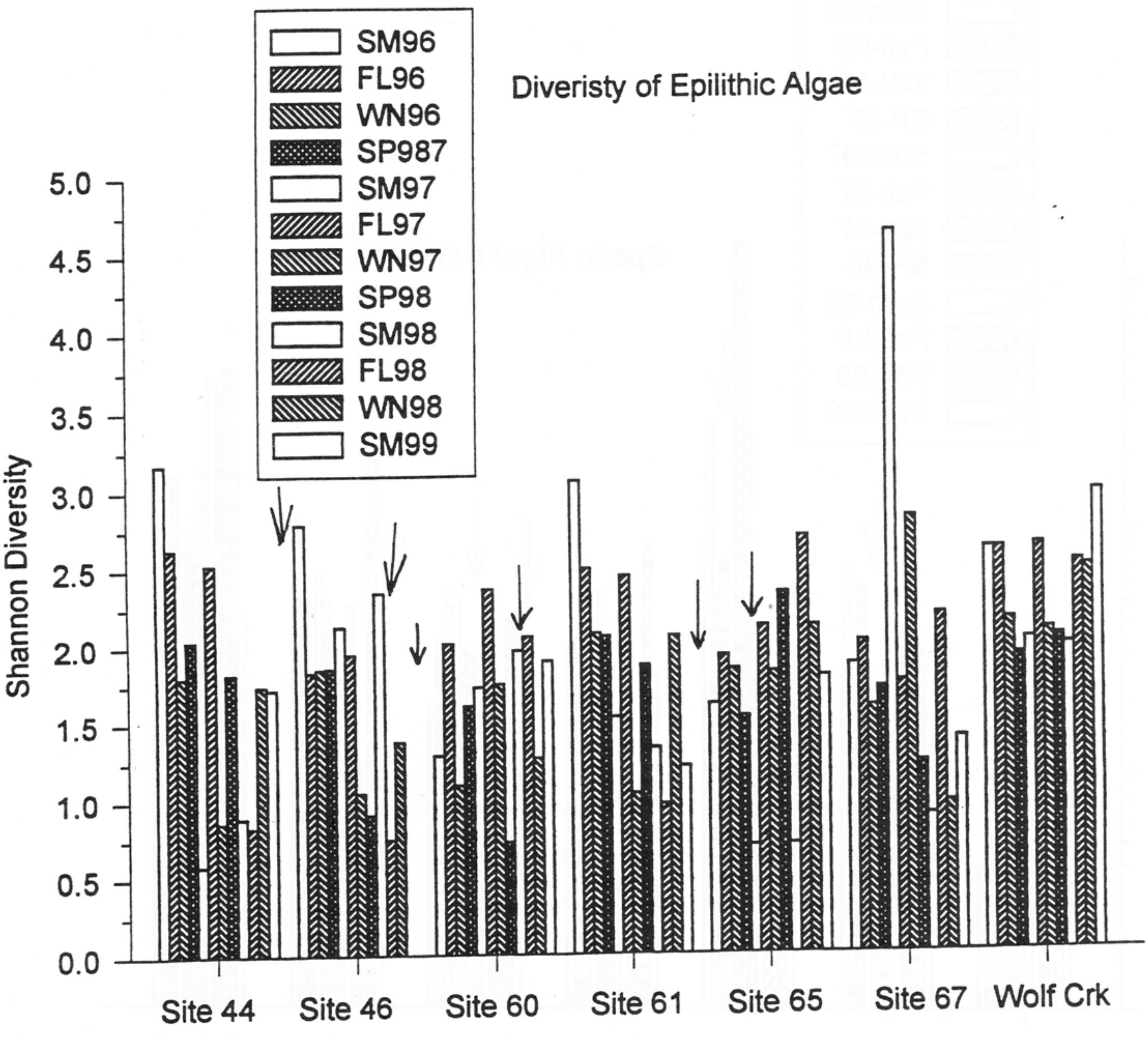

Epelic Algal Density
Sum-96
Fall-96
WN-96
SP-97
Sum-97
Fall-97
WN-97
SP-98
Sum-98
Fall-98
WN-98
Sum-99
Cell Density (# cells/cm²)
1e+6
1e+5
1e+4
1e+3
Site 44
Site 46
Site 60
Site 61
Site 65
Site 67
Wolf Creek

Fig. 52



Diveristy of Epilithic Algae
SM96
FL96
WN96
SP987
SM97
FL97
WN97
SP98
SM98
FL98
WN98
SM99
Shannon Diversity
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Site 44
Site 46
Site 60
Site 61
Site 65
Site 67
Wolf Crk

Fig. 53

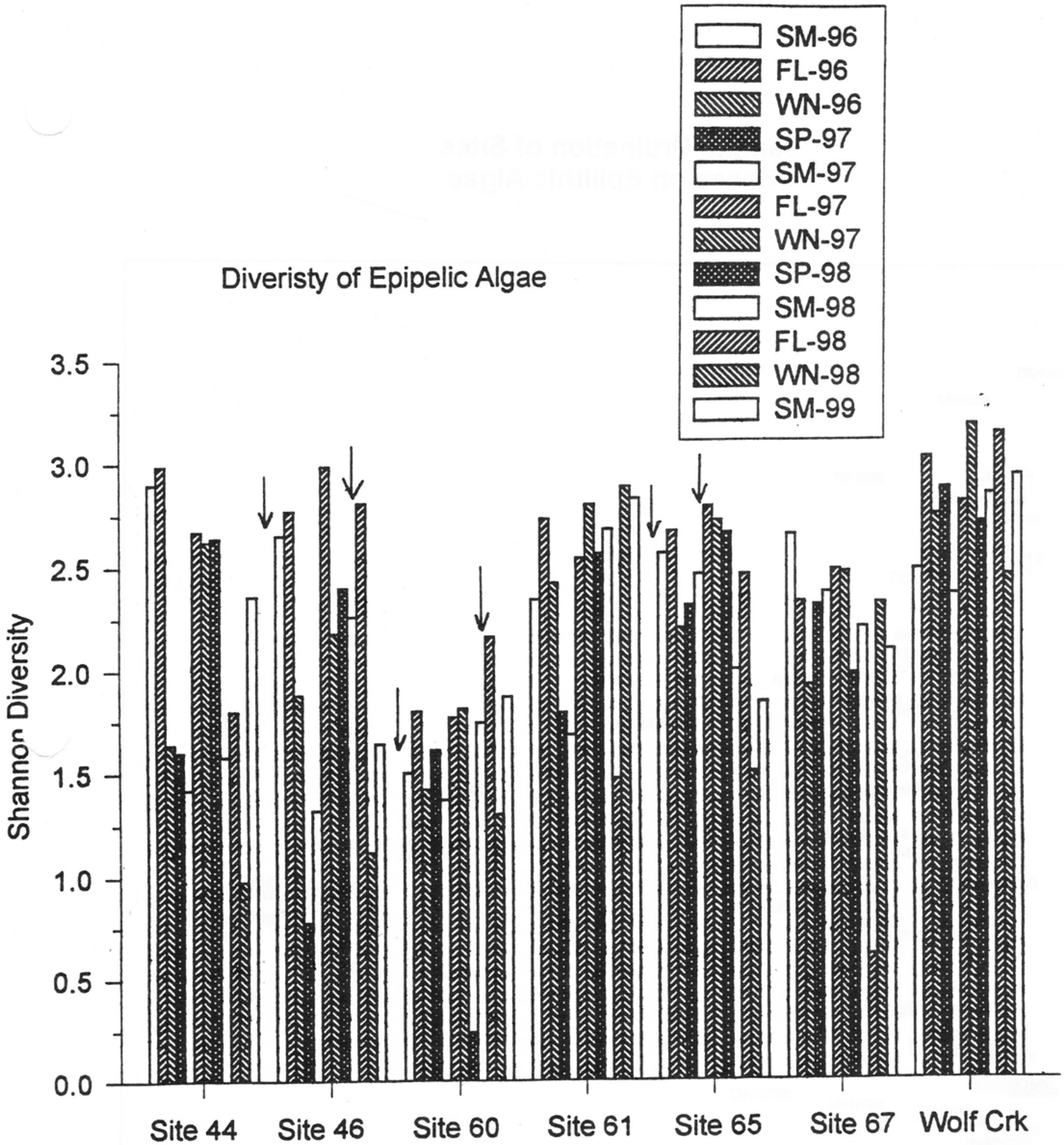

Diveristy of Epipelic Algae
SM-96
FL-96
WN-96
SP-97
SM-97
FL-97
WN-97
SP-98
SM-98
FL-98
WN-98
SM-99
Shannon Diversity
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Site 44
Site 46
Site 60
Site 61
Site 65
Site 67
Wolf Crk

Fig. 54

Sample Ordination of Sites Based on Epilithic Algae

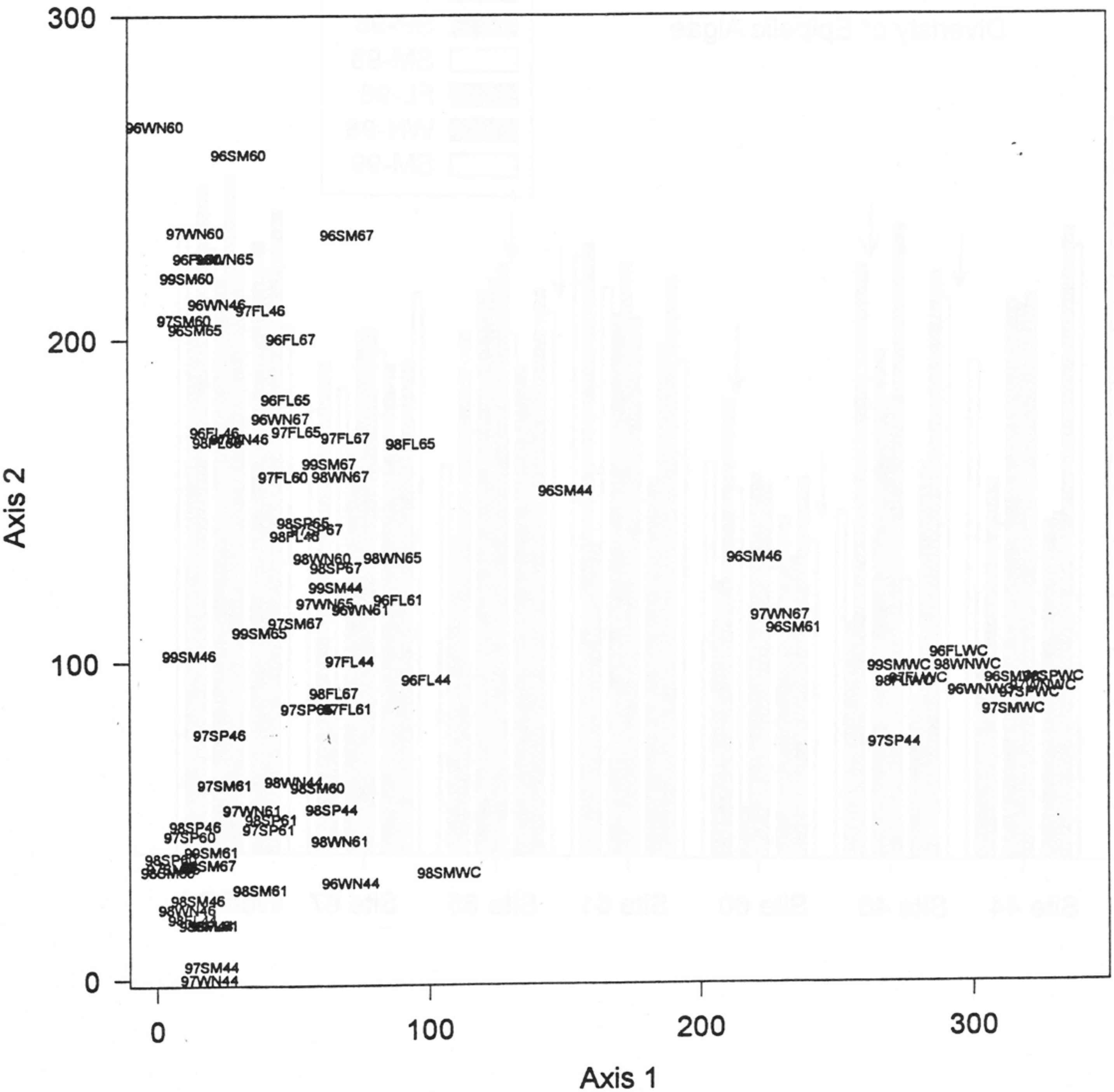


Fig. 55

Eplithic Algae Species Ordination

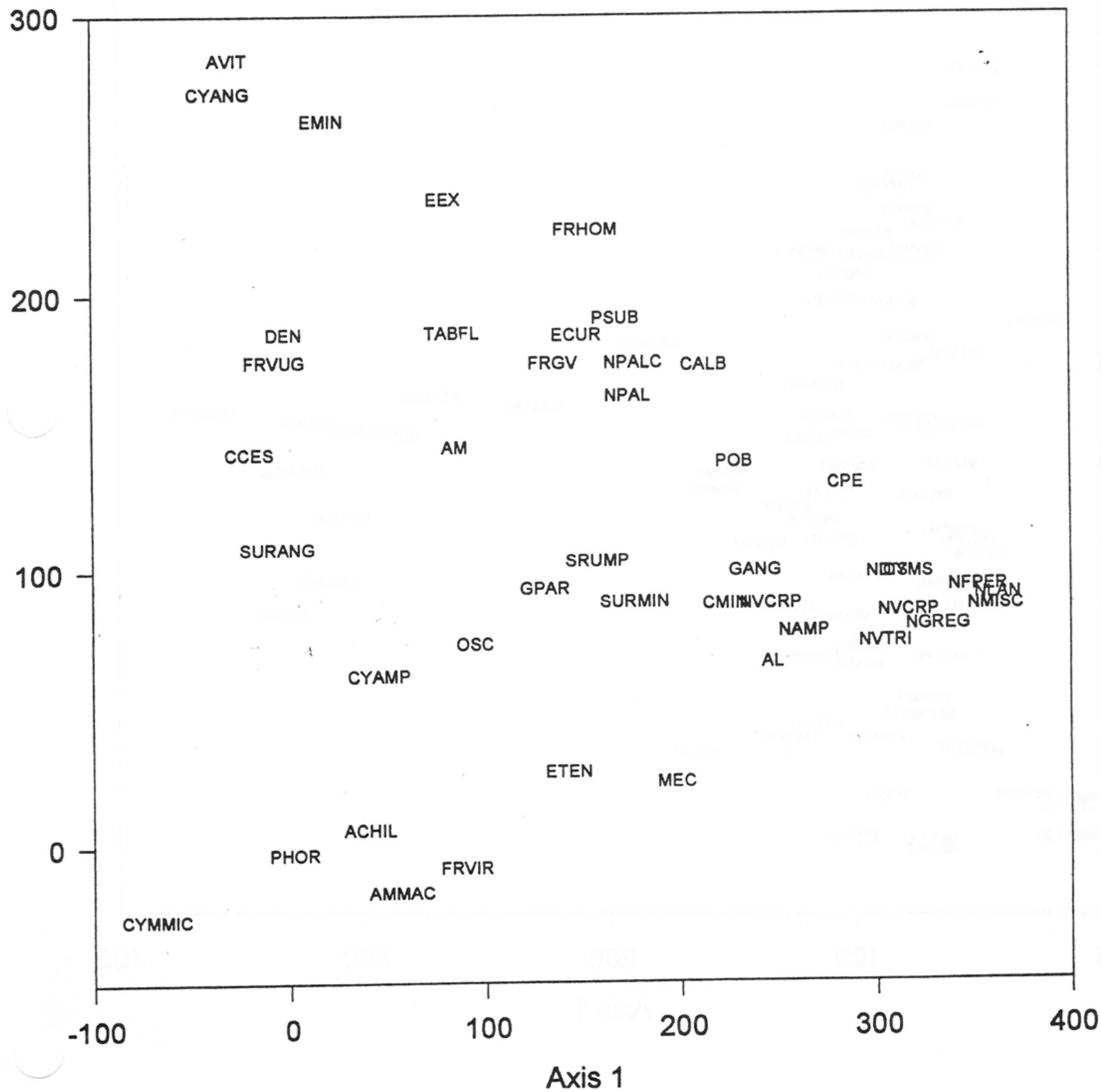


Fig. 56

Sample Ordination of Sites Based on Epipelic Algae

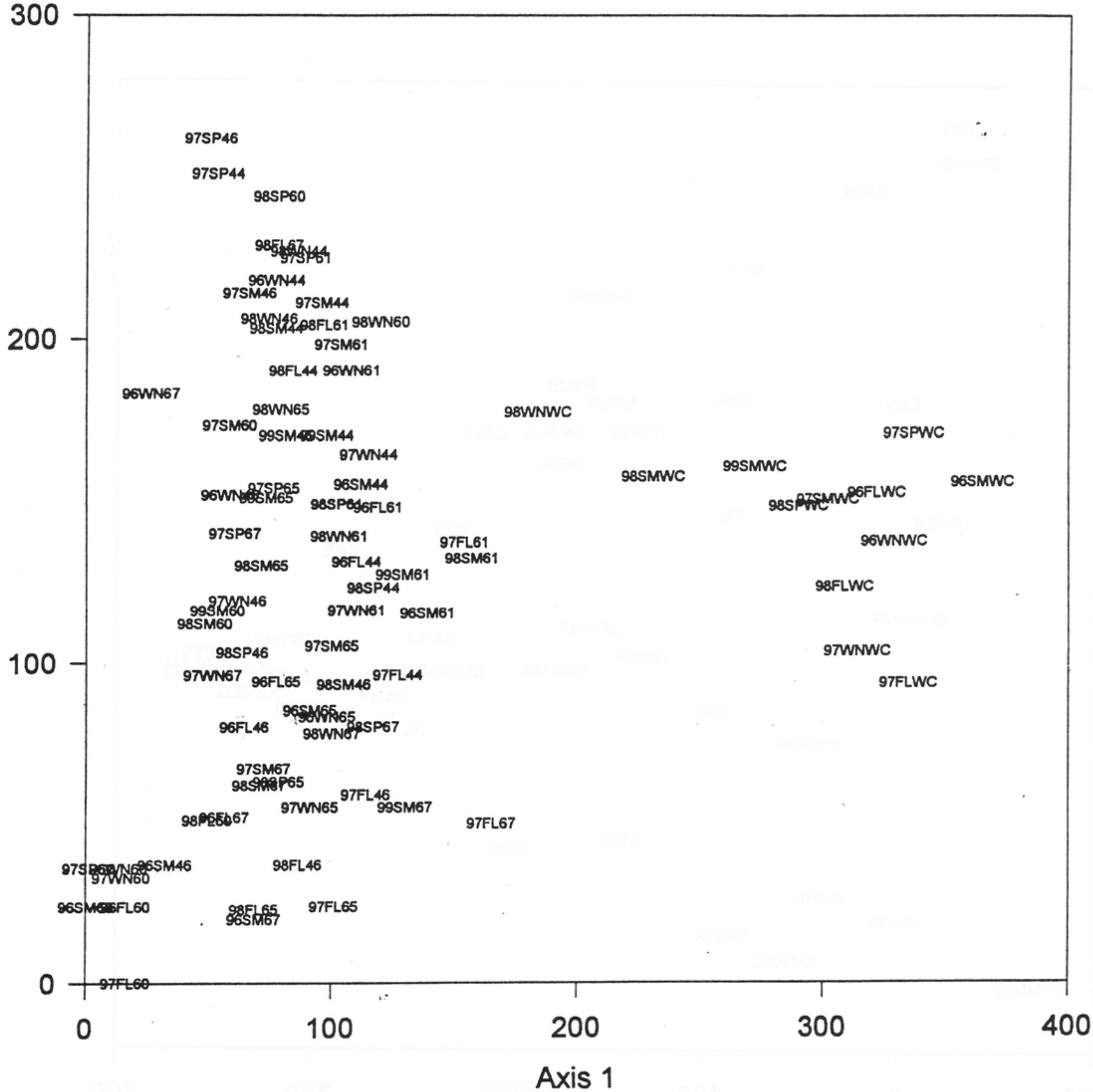


Fig. 57

Epipelic Algae Species Ordination

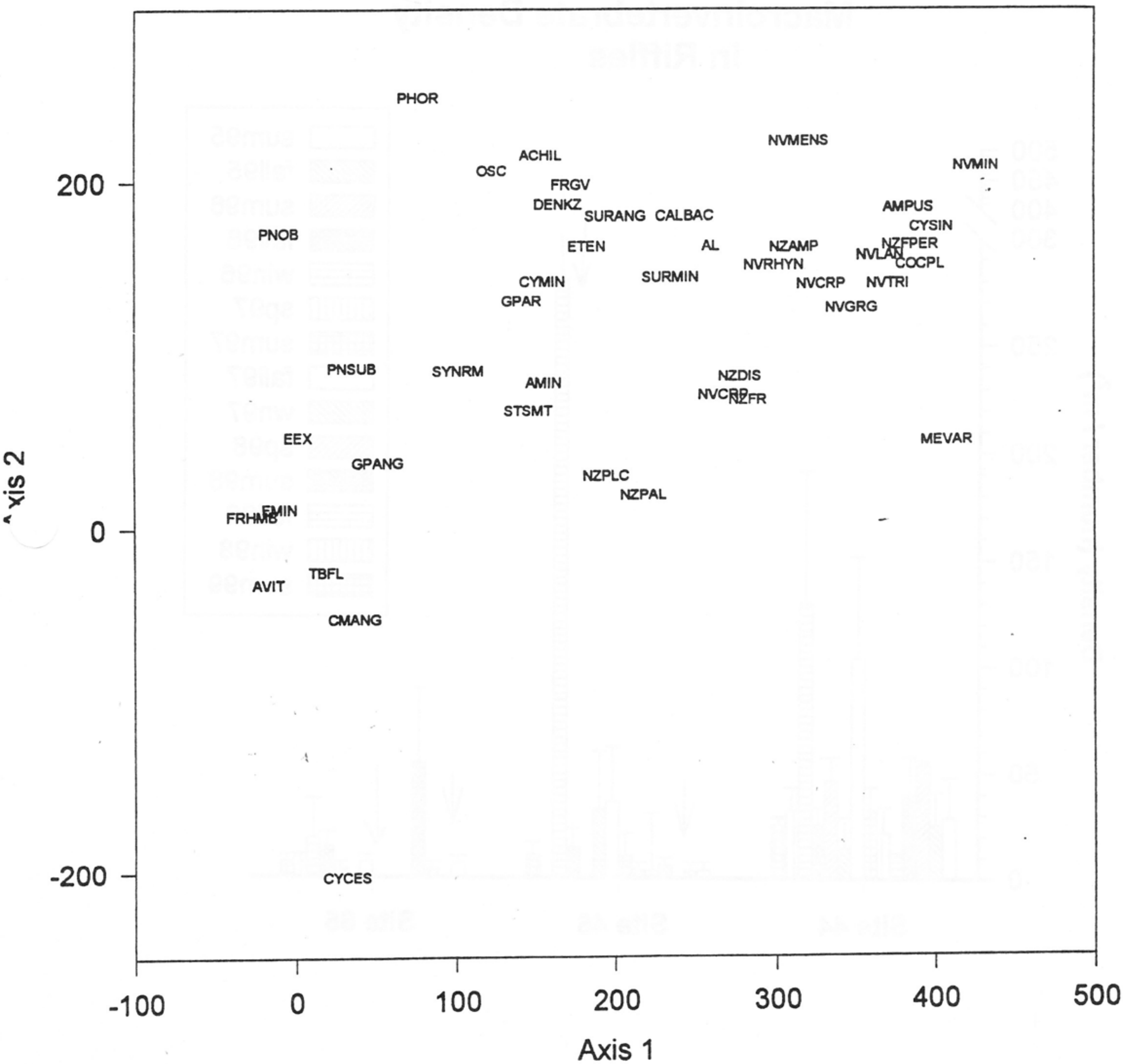
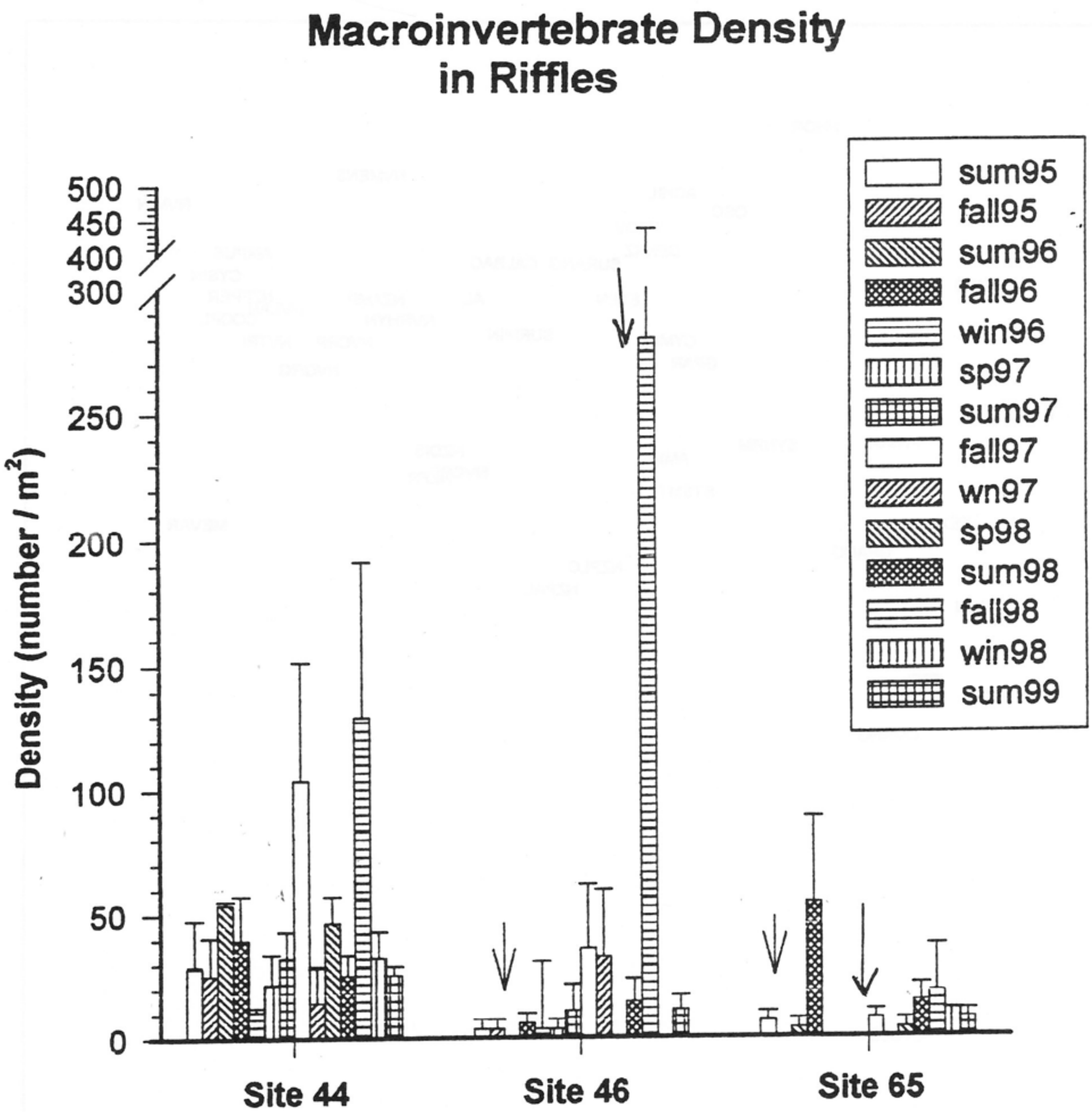


Fig. 58



Macroinvertebrate Density
in Riffles
Density (number / m²)
500
450
400
300
250
200
150
100
50
0
sum95
fall95
sum96
fall96
win96
sp97
sum97
fall97
wn97
sp98
sum98
fall98
win98
sum99
Site 44
Site 46
Site 65

Fig. 59

Macroinvertebrate Density in Riffles

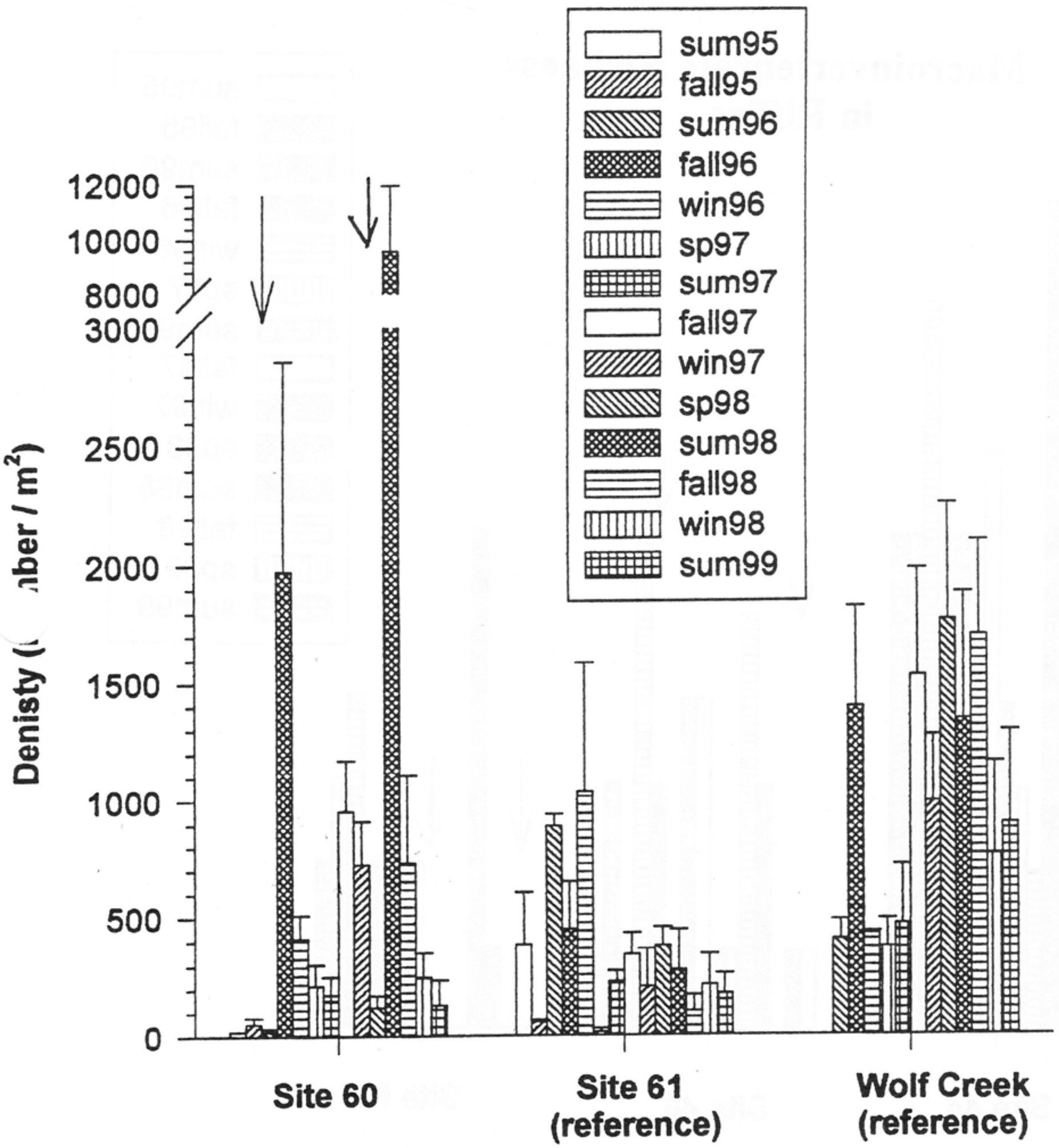


Fig. 60

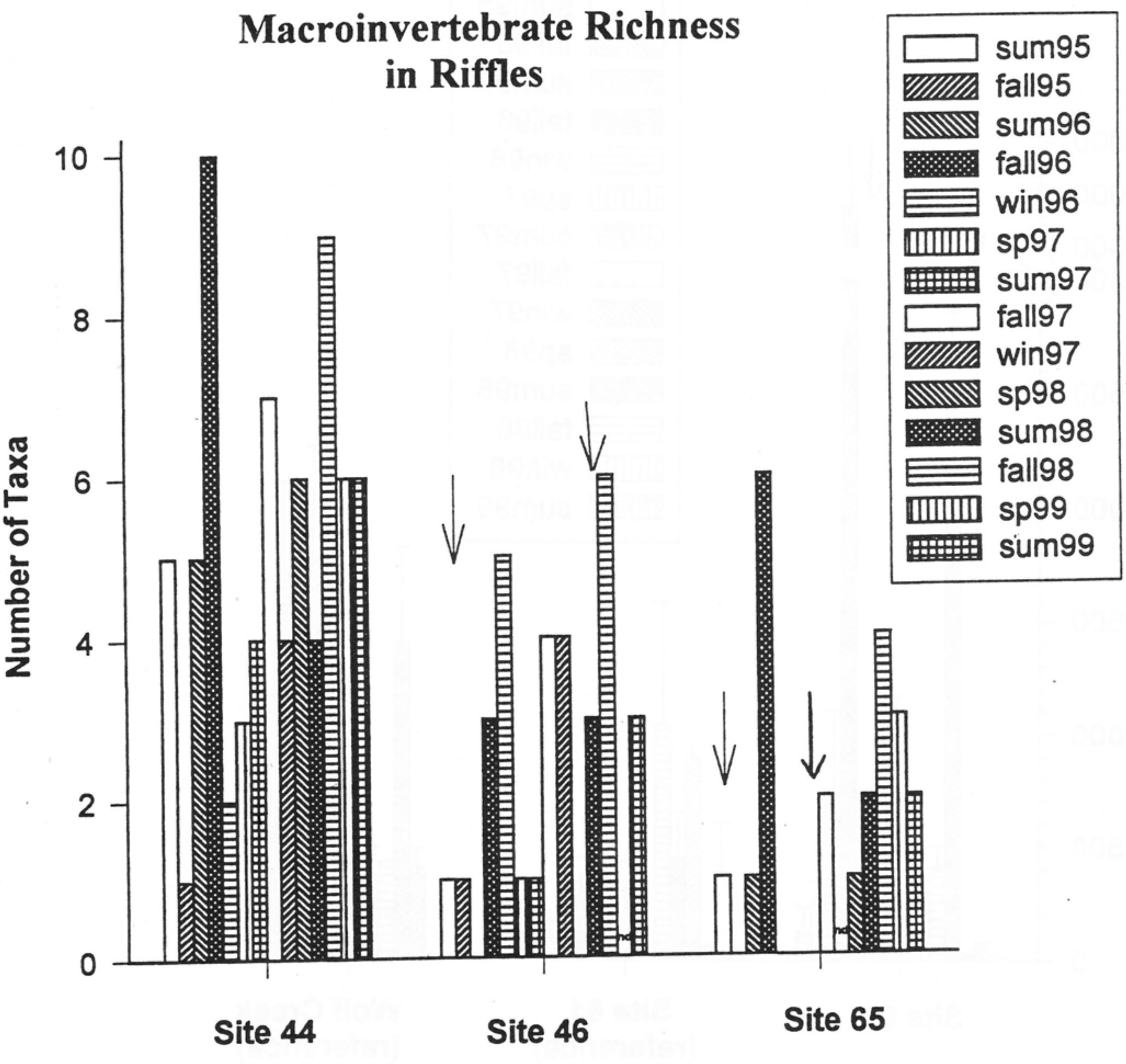

Macroinvertebrate Richness
in Riffles
sum95
fall95
sum96
fall96
win96
sp97
sum97
fall97
win97
sp98
sum98
fall98
sp99
sum99
Number of Taxa
0
2
4
6
8
10
nd
nd
Site 44
Site 46
Site 65

Fig. 61

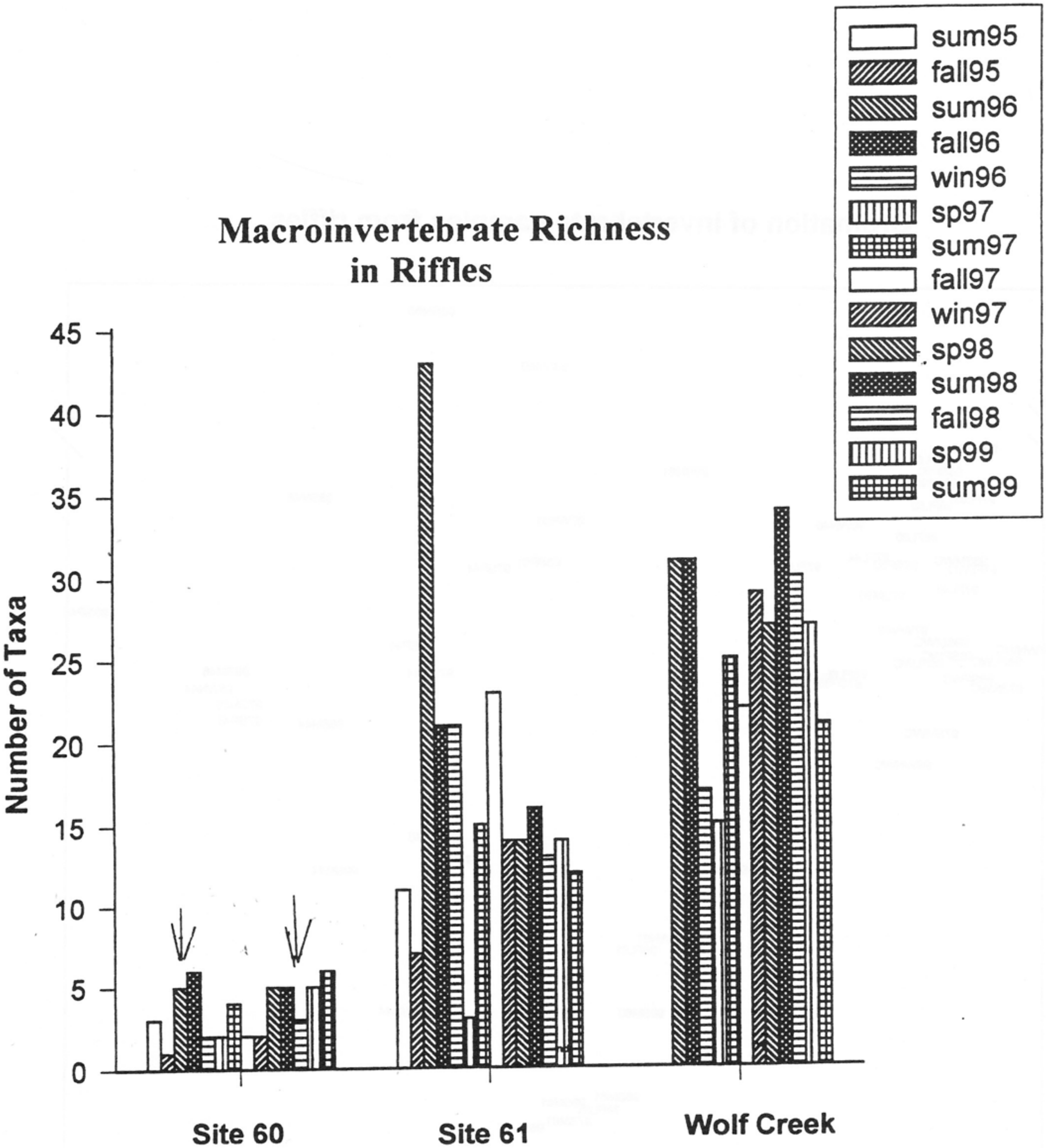

Macroinvertebrate Richness
in Riffles
Number of Taxa
45
40
35
30
25
20
15
10
5
0
Site 60
Site 61
Wolf Creek
sum95
fall95
sum96
fall96
win96
sp97
sum97
fall97
win97
sp98
sum98
fall98
sp99
sum99

Fig. 62

Ordination of invertebrate samples from riffles

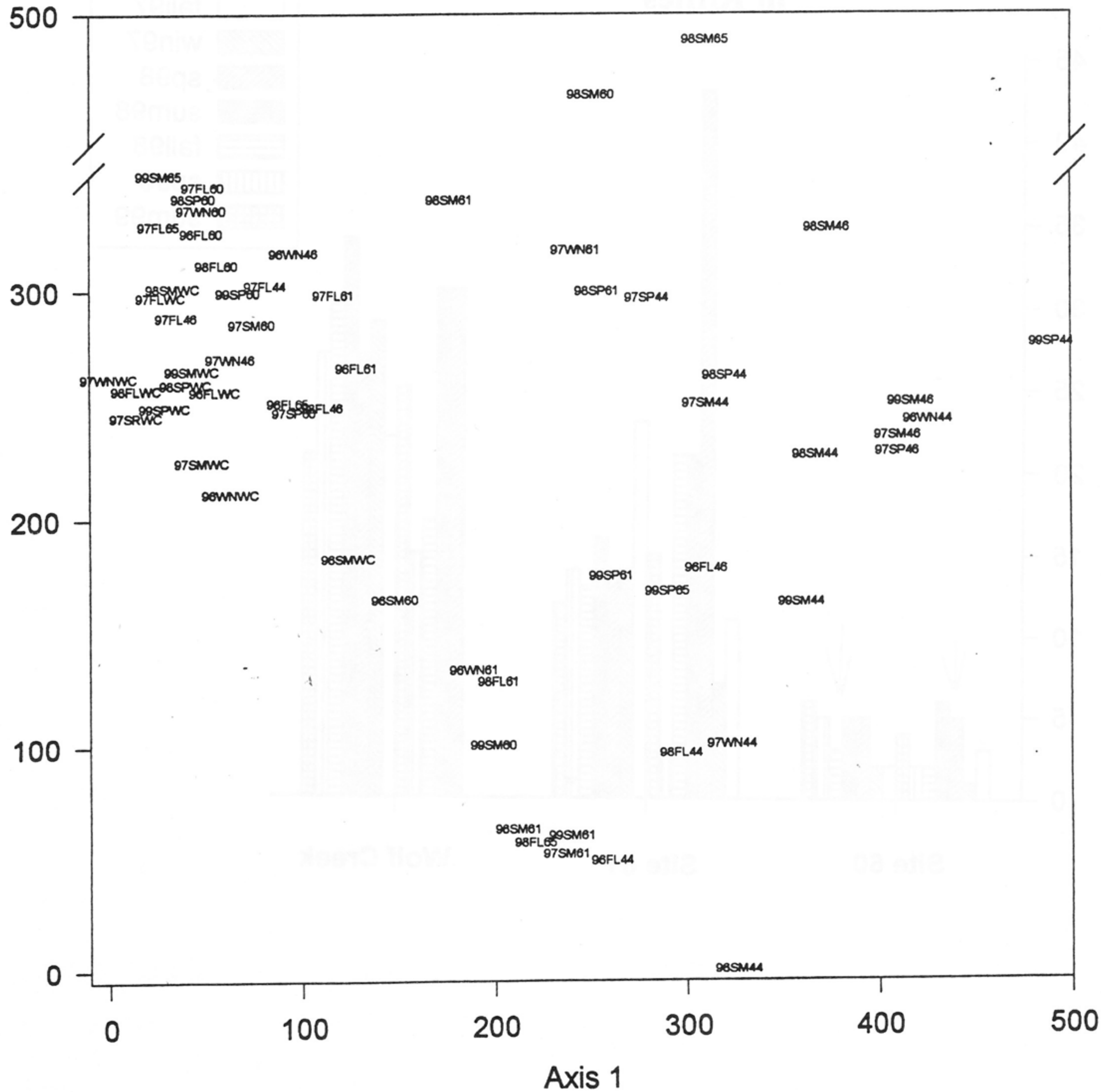


Fig. 63

Invertebrate species ordination

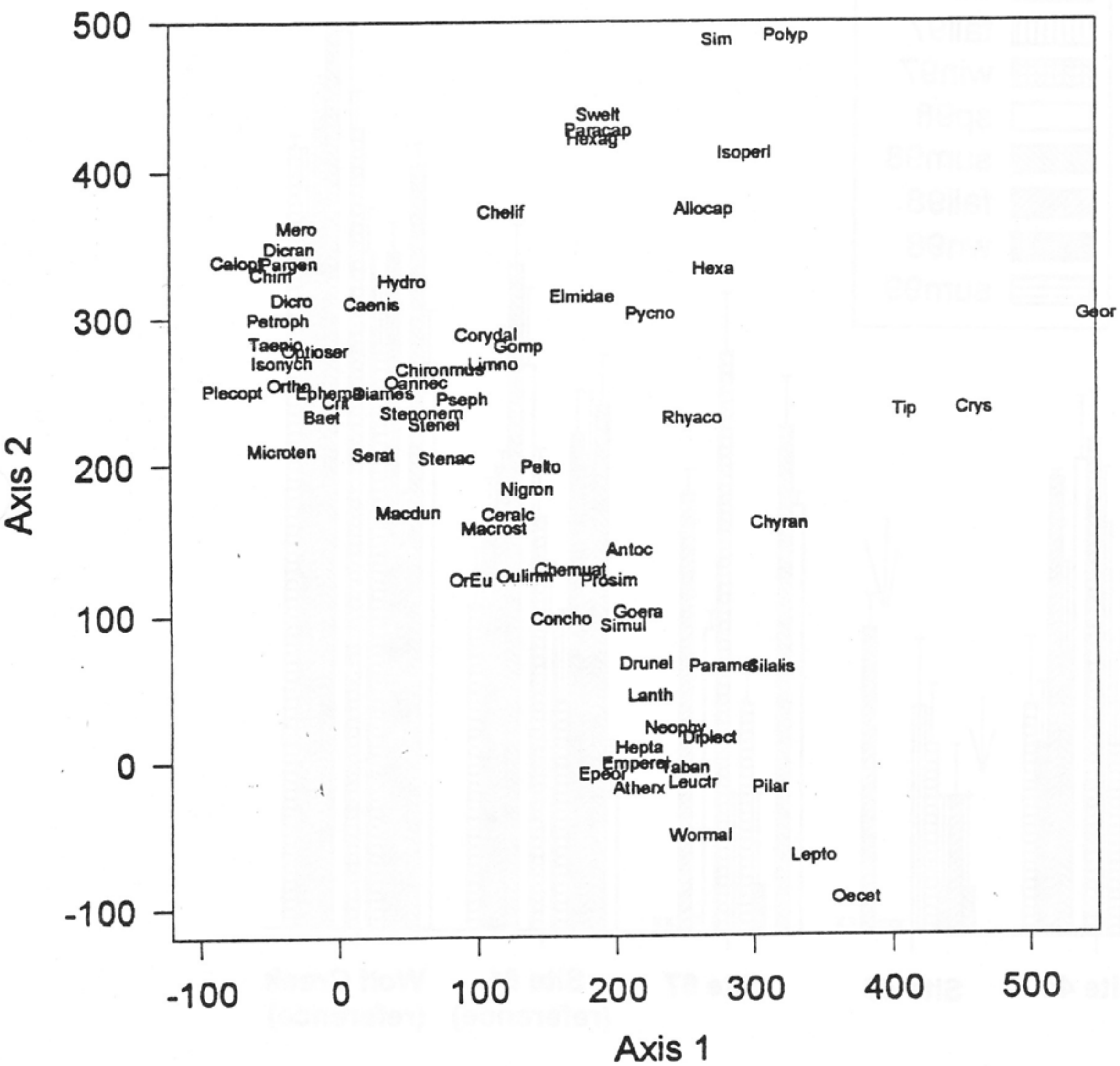


Fig. 64

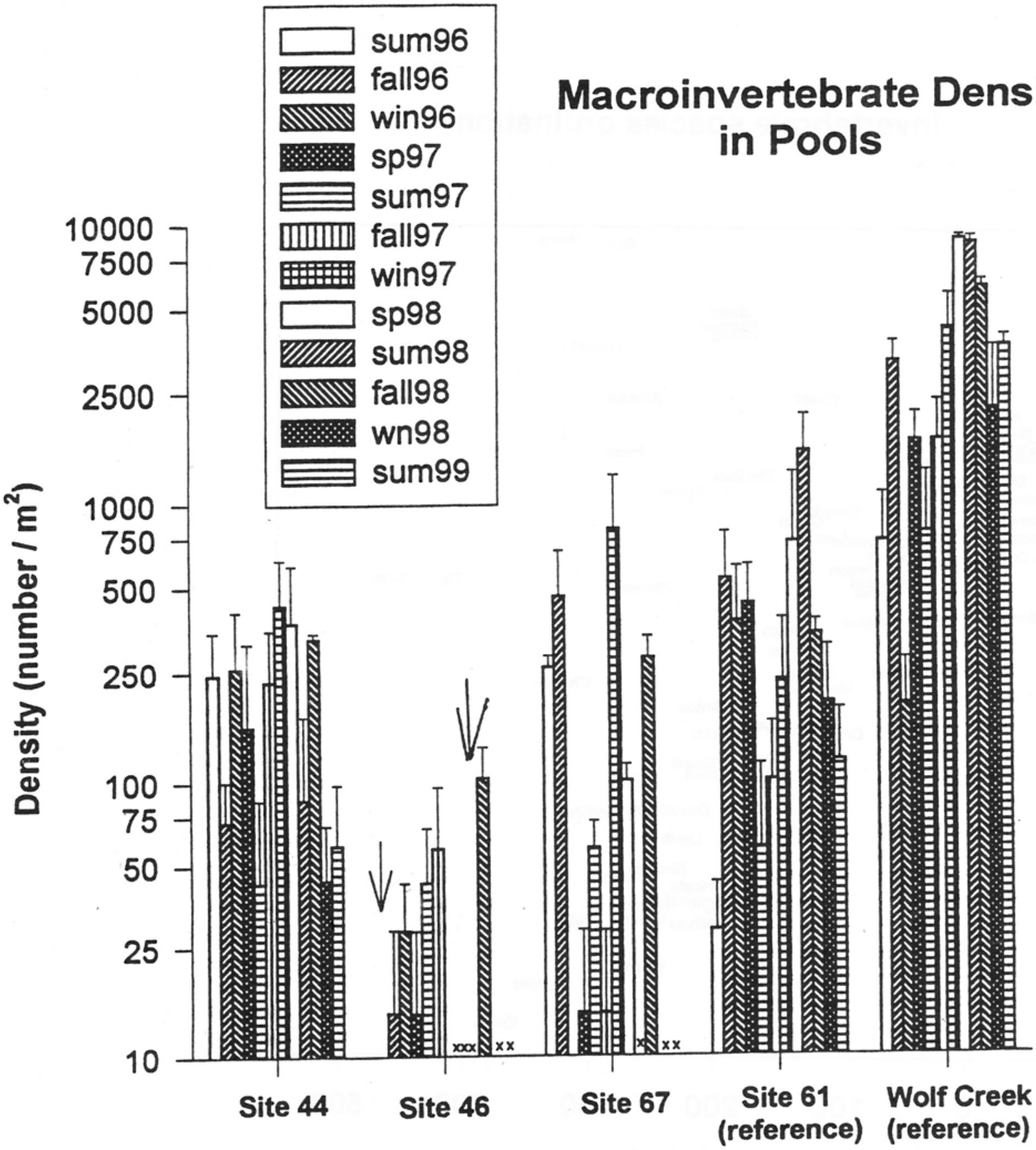
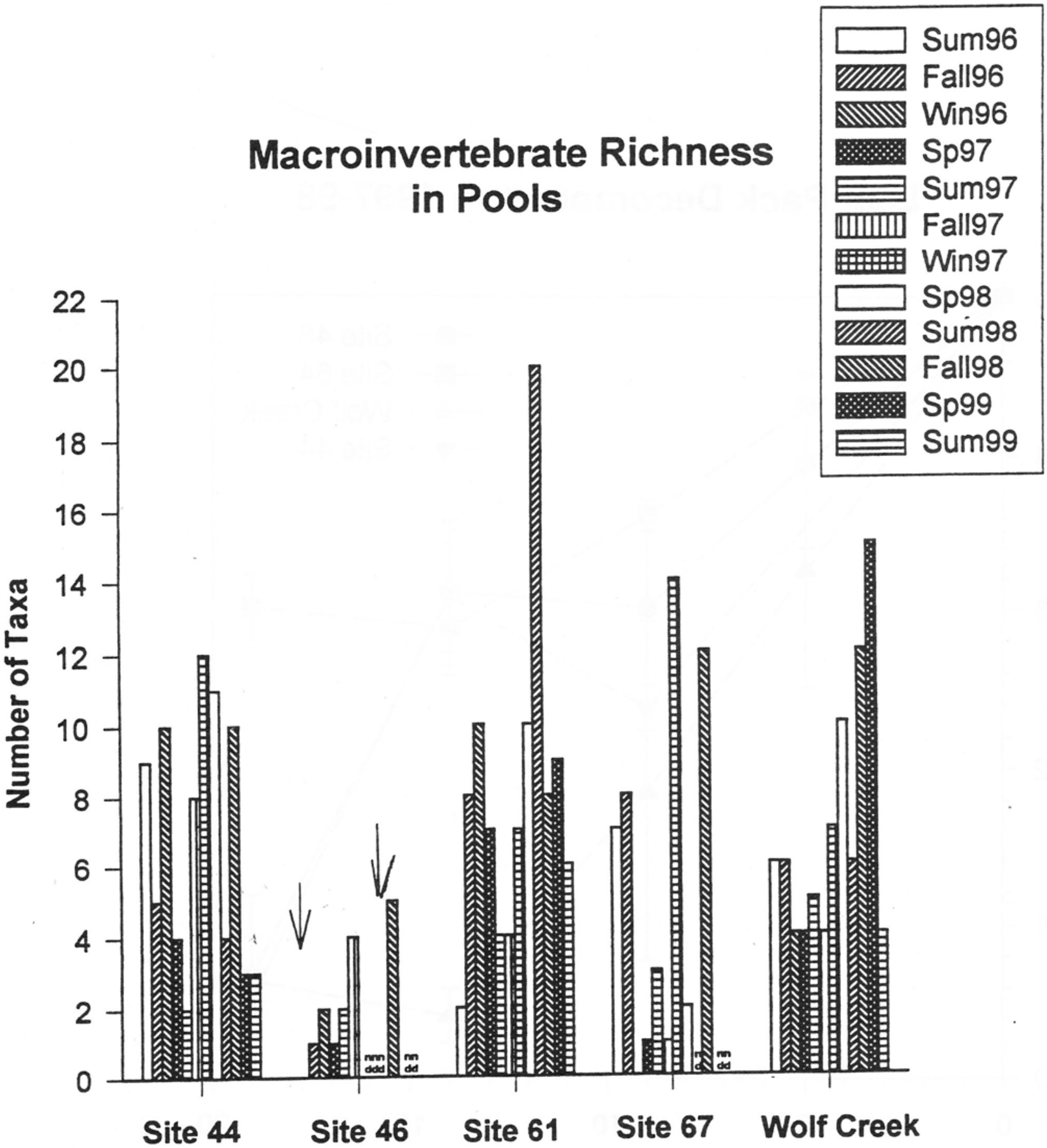

Macroinvertebrate Density
in Pools
sum96
fall96
win96
sp97
sum97
fall97
win97
sp98
sum98
fall98
wn98
sum99
Density (number / m²)
10000
7500
5000
2500
1000
750
500
250
100
75
50
25
10
Site 44
Site 46
Site 67
Site 61
(reference)
Wolf Creek
(reference)

Fig. 65



Macroinvertebrate Richness
in Pools
Number of Taxa
22
20
18
16
14
12
10
8
6
4
2
0
Site 44
Site 46
Site 61
Site 67
Wolf Creek
Sum96
Fall96
Win96
Sp97
Sum97
Fall97
Win97
Sp98
Sum98
Fall98
Sp99
Sum99

Fig. 66

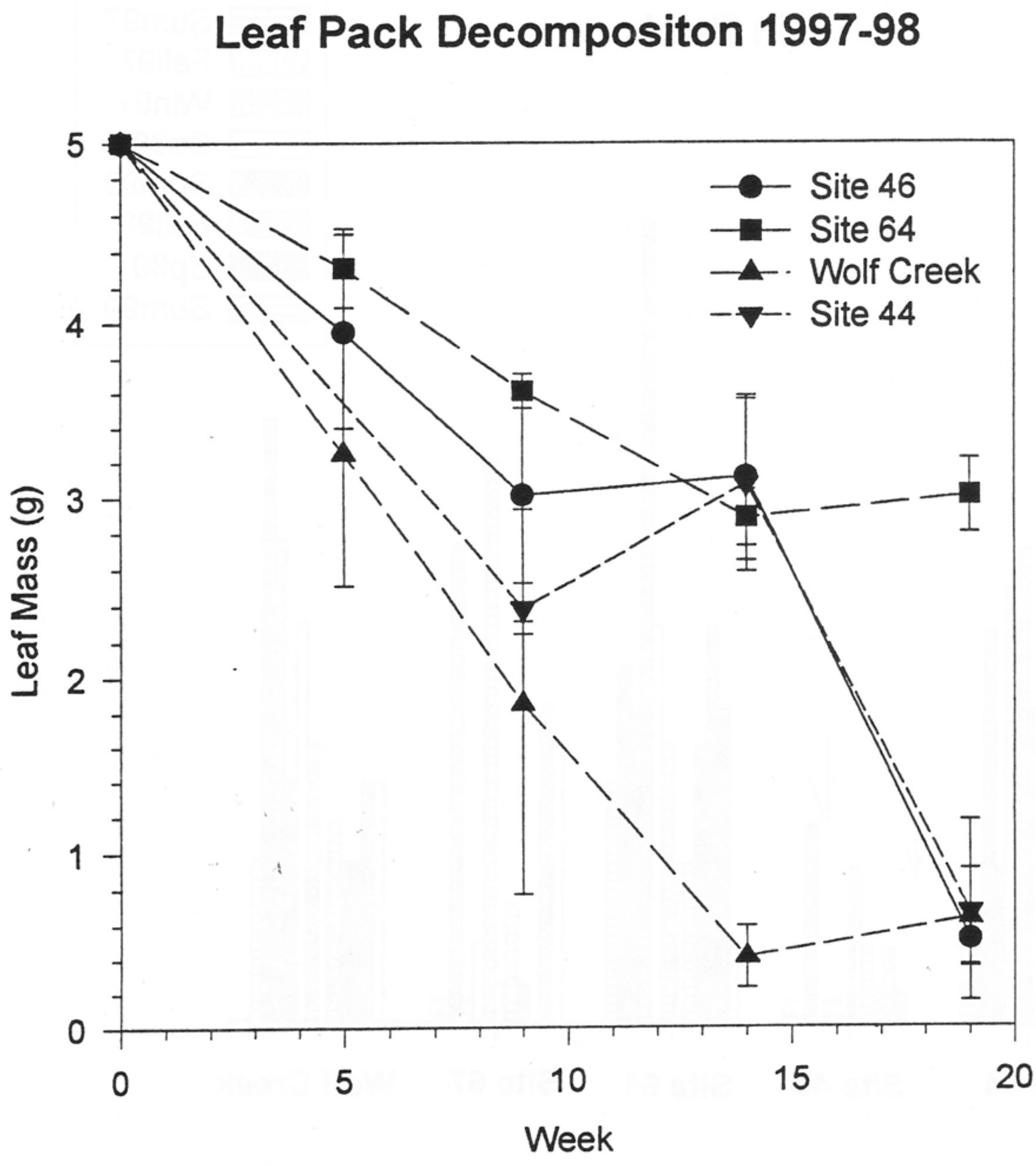

Leaf Pack Decompositon 1997-98
Leaf Mass (g)
Week
Site 46
Site 64
Wolf Creek
Site 44
0
1
2
3
4
5
0
5
10
15
20

Fig. 67

TREATMENT COMBATS MINE DRAINAGE IN SLIPPERY ROCK CREEK

Two passive treatment systems in the Slippery Rock Creek watershed are currently under construction on state game lands in Venango, Washington, Marion and Cherry townships, Butler County.

A 900-ton anoxic limestone drain with a retention pond and wetland system is being constructed by Dr. Robert Hedin and Margaret Dunn for a particular acid mine discharge. Jesteadt Excavation is providing the earthwork for the system, funded through an EPA Section 319 grant awarded by DEP.

Puryear Excavating is constructing a 450-ton vertical flow wetland followed by a combination retention pond/wetland for another mine discharge, funded through an EPA 104(b)(3) grant. Accounting services for the project are being handled by the Penn's Corner Conservancy Charitable Trust. Project design, construction contract and site layout is being provided by the DEP's Knox District Mining Office. Both projects should be completed by the end of August.

These two projects join five other passive treatment systems constructed since 1995 to remediate acid mine drainage that pollutes the main branch of Slippery Rock Creek.

<> For more information, contact Roger Bowman at 814 797-1191 or e-mail bowman.roger@dep.state.pa.us .

A

WEEK OF AUGUST 24 – AUGUST 28, 1998

GOOD NEWS/MAJOR ACCOMPLISHMENTS:

Slippery Rock Creek Watershed Project, Venango Township, Butler County: On August 21, 32 volunteers gathered on State Game Lands No. 95 to plant two wetland areas. The wetlands were designed to treat discharges SR109 and SR101. SR101 consists of an anoxic limestone drain with a holding pond and two wetland areas. SR 109 is a vertical flow system with a wetland that was designed by Roger Bowman. Cattails were planted at the SR101 wetland and Tim Van Dyke chose burr reed, spaderdock, pondweeds, and moss to be planted at the SR109 wetland.

Volunteers from the Knox DMO Office included Bill Foringer, Bill Allen, Terry Elicker, Steve Amsler, Bill Edmiston, Roger Bowman and Tim Van Dyke. Students from Butler County Community College and the University of Pittsburgh also helped. There were a few families from the Pittsburgh area and several local families who helped in the effort as well as representatives from Puryear Excavating, Jesteadt Excavating, and Quality Aggregates. Bob Hedin, Margaret Dunn, Tim Danehy, and Charlie Cooper also participated.

A reporter from the Pittsburgh Tribune Review attended the event. The Pa. Game Commission provided materials for planting. Quality Aggregates provided food for the workers while Bill Foringer provided pop for everyone to drink.

After the areas were planted, a shore bird flew in to check out the work. (Contact: Roger Bowman, 814-797-1191, Knox DMO)

August 1998

THE CATALYST

Slippery Rock Watershed Coalition Monthly Activities Update

Next meeting: **There will be no meeting in August**. Prior meeting: 7/9/98, 1st floor Vincent Science Hall, SRU. Attendees: F. Brenner, T. Danehy, M. Dunn, C. Cooper, J. Clark, D. DeNicola, M. Stapleton, L. Hunter

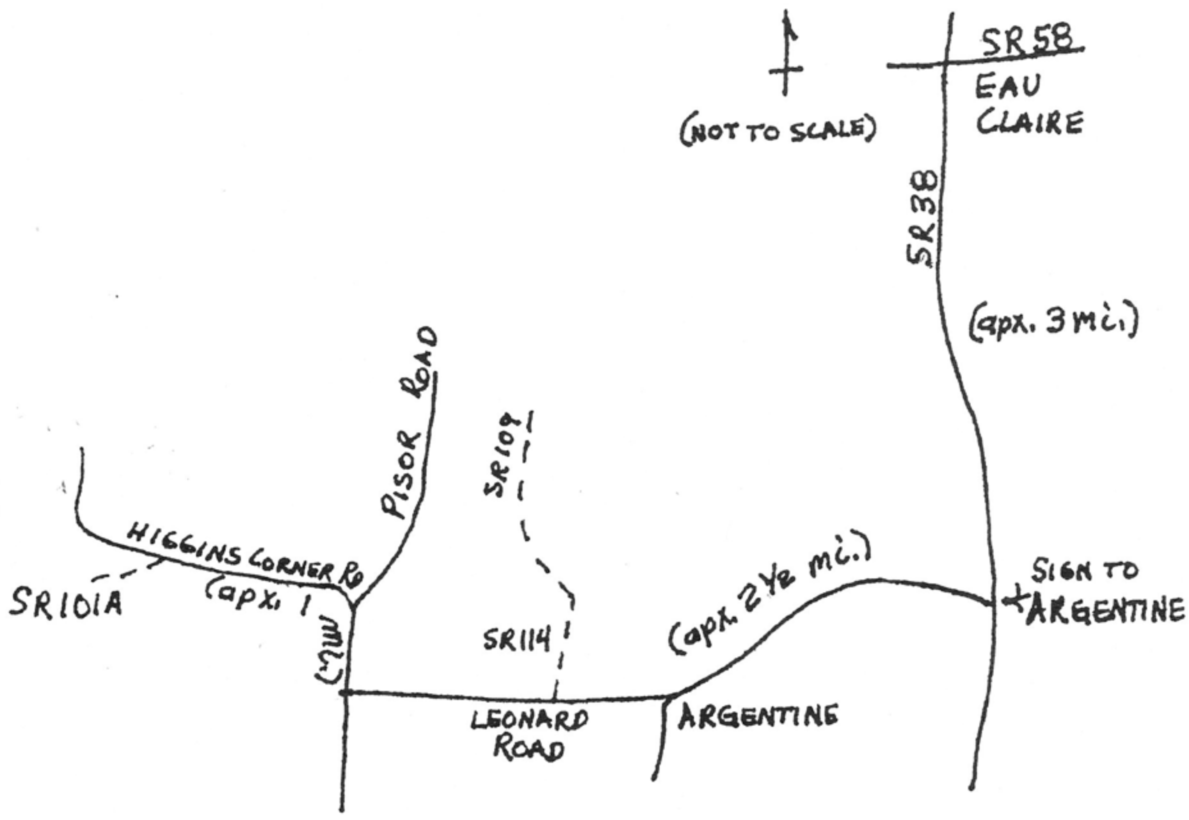
WE NEED HELP ON FRIDAY, AUGUST 21, 1998

The SR 101A anoxic limestone drain and the SR 109 vertical-flow system are nearing completion. Aerobic wetlands remain to be constructed at both systems. Planting these wetlands requires a team effort. Please help!!! Bob Hedin, Hedin Environmental, and Roger Bowman, Knox District Mining Office, will be available to answer questions about the function and design of the systems and Jerry Jesteadt, Dave Macurak, and Joe Puryear are planning to be available to address questions about construction. About 2500 cattails and other wetland species are to be planted. Wear boots (rubber is best) and field clothes. Come join us!!! Bring your appetite!!! Food and beverages will be provided.

The "early birds" can meet at the gamelands access road at the SR 114 site in Argentine at 8:00 a.m. to start work on the SR 109 site. Come any time!! Lunch will be at the SR 101A site.

Thanks to Dale Hockenberry, PA Game Commission, for approving our picnic!!! A special thanks to Quality Aggregates, Inc. for their support!!!

In order to make sure that we have "food a-plenty", please contact us at the number below.



For more informantion:
Slippery Rock Watershed Coalition, c/o Stream Restoration Inc. (PA Non-Profit), 338 Glen Eden Rd., Rochester, PA 15074
(724) 774-2813; fax (724) 774-1219

C

THE CATALYST

Slippery Rock Watershed Coalition Monthly Activities Update

Next meeting: **Thursday, 9/10/98, 7:00 PM**, SRU Vincent Science Hall (Rm. 105 or other room on first floor). Topics: 10/14/98 watershed & Jennings tour; Three Rivers Sportmen's Club proj.

8/21/98 WETLANDS PLANTINGS

"A picture is worth a thousand words." The above photo taken at the completion of the wetland cell at the SR 101A site illustrates part of the team effort. **Thirty-six volunteers worked diligently to make this a successful event!!!** Everyone was muddy and tired but this was a great opportunity to "catch-up" on the many activities of the Coalition and to make new friends. These sites will be a focal point of the 10/14/98 tour and of the 1999 Symposium. "Hats off" to the following people who contributed to the effort:

Tony Lowminski; Gerald Jesteadt; Dave Macurak; Tim & Josh VanDyke; Regan Cupps; Bob Beran; Ned Weston; Nate, Ben, Sam, Beth, and Bob Hedin; Shawn Mayle; Steve Amsler; Bill Edmiston; Bob Stalker; Bill Allen; Roger Bowman; Bill Foringer; Terry Rush; Tom, Paul, and Mike McMullen; Chuck Stewart; Mary Lynn Yurko; Sherry Stafford; Terry Elicker; Ray O'Toole; Joe & Jill Puryear; Charles Cooper; Dan Cinowalt; Joe Appel; Tim Danehy; Margaret Dunn

Of special note is the effort of the youngsters, Tom and Paul McMullen, Chuck Stewart, and Ben Hedin, who worked alongside the men the entire day!!!

Thanks to Bill Forringer, who voluntarily provided cold drinks to the work crew at the SR 109 site.

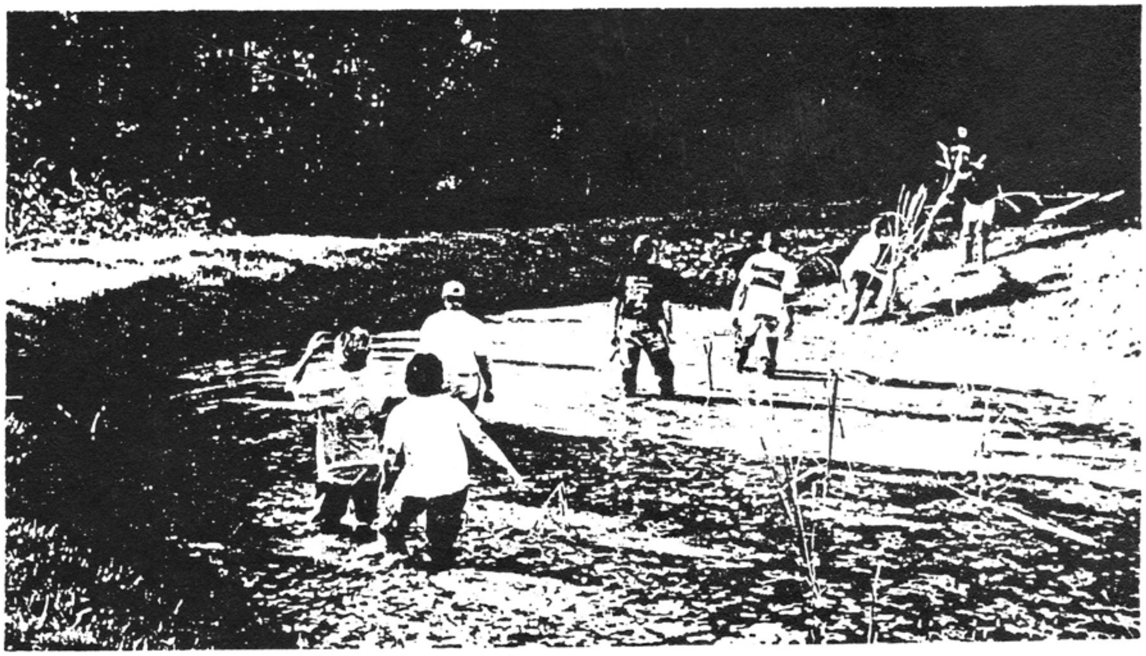
Thanks to Quality Aggregates, Inc. for the food from Thompson's Market, Eau Claire, PA which was as good and as popular as always!

D

THE CATALYST

SLIPPERY ROCK WATERSHED COALITION MONTHLY ACTIVITIES UPDATE

Next meeting: Thursday 12/10/98 SRU Vincent Science Hall (Rm. 105 or other room on first floor). Topics: 1999 Annual Symposium and related events. Prior meeting (11/12/98) attendees: T. Danehy, D. DeNicola, M. Riddell, M. Dunn, D. Lamperski, F. Brenner, J. Ankrom, R. Beran, T. Gillen, K. Duncan, M. Clark, K. Peart, C. Cooper, J. Belgredan, J. Clark, R. Fodor.



10/12/98 WETLANDS PLANTING BY SLIPPERY ROCK UNIVERSITY STUDENTS

The above photo shows wetland cell # 1 at the recently completed SR101A passive treatment system being planted by Dr. Jerry Chmielewski's, SRU Dept. of Biology, Aquatic Plants class. This opportunity provided the students with an "up close and hands-on" look at several technologies being applied to treat acid mine drainage. A brief explanation of the how the system works and why it was installed was provided by Margaret Dunn, Stream Restoration Inc. and Tim Danehy, BioMost, Inc. These interested and excited students "dug in to help out":

B. Phillippi, A. Cantanese, H. Kempki, M. Klink, S. Stefko, R. Carroll, S. Kzeminski, A. Ciliberto, L. Ferguson, H. Kaminsky, R. Kohnke, H. Doyle, S. Santiapillai, R. Cline, A. Kinney, D. Young, T. Nolan.

Also, this same class has completed a study (10/26/98)on the demonstration wetland at the Jennings Env. Education Center which will help to determine the effectiveness of using biosolids in the construction of treatment wetlands. Thank you Dr. Chmielewski and Class!!

DR. FRED BRENNER ELECTED AS A FELLOW OF OHIO ACADEMY OF SCIENCE

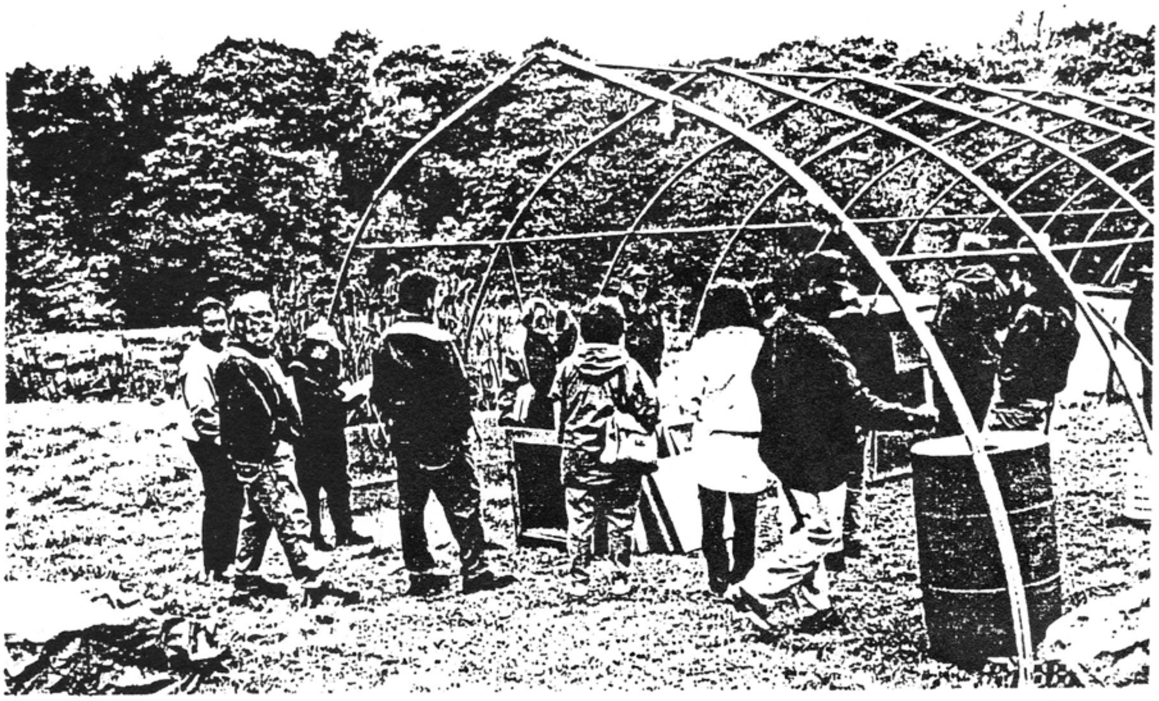
CONGRATULATIONS to Dr. Brenner for his recent election as a Fellow of Ohio Academy of Science. Dr. Brenner is an extremely active participant in the Coalition and has an extensive list of honors and achievements which include (but certainly not limited to) the following: PA Acad. of Science Lifetime Achievement Award, President-Elect of the National Assoc. of Academies of Science, VP of the Beta Beta Beta Biological Honorary, and an editor for the American Society for Surface Mining and Reclamation. He has authored over 200 scientific papers and edited 8 books. Congrats Dr. Brenner

SCRUBGRASS GENERATING RECEIVES GOVERNOR'S AWARD FOR ENV. EXCELLENCE

Scrubgrass Generating Co., L.P., is a winner of the 1998 Governor's Award for Environmental Excellence for Pollution Prevention. Scrubgrass uses the most advanced technology for burning waste coal and generates alkaline ash which is used to reclaim abandoned mines and prevent acid mine drainage. Through the efforts of Scrubgrass over 509 acres of abandoned mine lands have been reclaimed in Allegheny, Armstrong, Butler, and Clearfield Counties. About 70 of these acres are in the Slippery Rock Creek Headwaters area. Congratulations and THANKS to Scrubgrass for their efforts.

SRU's DR. DEAN DeNICOLA PRESENTS PAPERS IN IRELAND AND UNITED KINGDOM

This past August Dr. Dean DeNicola, Slippery Rock University, Dept. of Biology, presented two papers which document the changes in the ecosystem of the Slippery Rock Creek headwaters due to the restoration efforts. The first paper was presented at The International Limnological Congress in Dublin, Ireland. The second at a conference on Highly Acidic Environments in Durham, UK. Thanks to Dr. Dean for spreading the word about our efforts!!



10/14/98 Tour of Section 319 Projects at the Jennings Pilot Scale Systems

US EPA & PA DEP TOUR RECENTLY COMPLETED SECTION 319 PROJECTS

On 10/14/98, members of the US EPA and PA DEP joined Coalition participants on a tour of two passive treatment systems recently completed under the EPA Section 319 Funding Program. The tour was lead by Robert Hedin, Hedin Environmental and Margaret Dunn and Tim Danehy, Stream Restoration Inc.

The tour started at the Jennings Environmental Education Center which features a full-scale demonstration vertical flow system followed by wetlands and a settling pond. The Jennings facility also provides the opportunity for on-going development of passive treatment technology. The pilot-scale systems and student participation was explained by Dr. Fred Brenner from Grove City College. The design engineer Charles Cooper, PE, C D S Assoc., Inc., described the construction of the full-scale system.

The next stop on the tour was the SR101A site. This system uses a 900-ton Anoxic Limestone Drain to treat a 30 gallon per minute acid discharge containing approx. 70 ppm of iron. The ALD is followed by a settling pond and two constructed wetland cells which collect the iron prior to discharging into the headwaters of Slippery Rock Creek. A big **THANKS** is extended to all who were involved:

R. Wagener, J. Holden, R. Coleman, E. Ammentorp, J. Earle, G. Price, M. Sherman, S Blackman, J. Mirza, L. Odenthal, F. Brenner, T. Jageman, F. Koch, M. Dunn, T. Danehy, R. Hedin.

Thanks also to Jerry Jesteadt and Dave Macurak, Jesteadt Excavating, for providing the excavation services for both systems.

FEATURE ARTICLE
"JENNINGS: LEADING THE WAY WITH CUTTING-EDGE TECNOLOGY"

An article published in the Nov. 1998 edition of the DCNR's publication RESOURCE is attached. Special thanks goes out to Josh First for his contribution of this excellent and exciting article.

Extra-special thanks is extended to the Jennings Staff and particularly Cindy Shirley, Gary Jenkins and Ray Markle whose help at the Celebration made everything run smoothly. We could not have done it with out you. **THANKS!!!!**

Thanks to the Slippery Rock Watershed Association for their support.

For more information contact:
Slippery Rock Watershed Coalition, c/o Stream Restoration Incorporated (PA non-profit), 338 Glen Eden Road, Rochester PA 15074, (724)774-2813, fax (724)774-1219

December Distribution: approx. 300 copies

Coalition reviews SR creek efforts

By SUZAN SZAKELYHIDI
Eagle Staff Writer

BOYERS — If you live near Slippery Rock Creek, you may be familiar with its less glamorous nickname, "Sulfur Creek."

The nickname refers to the red coloring of areas of the creek caused by acid mine drainage.

Thanks to the Slippery Rock Watershed Coalition, that nickname may become a thing of the past.

The coalition held a public meeting Wednesday at Epiphany Catholic Church in Boyers to update the public on its progress.

Founded in 1994, the coalition draws on the resources of volunteers from residents, state agencies and academic institutes, donations and some government funding to help clean up the watershed.

"The coalition has several missions," said Margaret Dunn, one its founders. "We're trying to restore the abandoned mines in the headwater area, restore the streams to viable fisheries, and provide an educational opportunity for anybody."

The coalition is focused on restoring the creek's headwaters, a 27-mile span from Boyers to Eau Clair.

Coal has been mined in this area for more than 100 years, leaving 12,000 of the watershed's 16,000 acres sitting on or above old mining sites.

"Acid mine drainage is the number one water pollutant," said coalition member Tim Danehy.

This pollution occurs when pyrite, a mineral in coal containing sulfur and iron, is oxidized by exposure to air, Danehy said. When water washes over the oxidized pyrite, sulfuric acid is produced.

Sulfuric acid lowers the water's pH, a measure of the acidity or alkalinity of a solution. Once the pH goes below five, the result is a damaged insect and fish population.

In 1977, a Surface Mine Conservation and Reclamation Act was passed, demanding that unused coal be kept where it can not oxidize. But pollution remains a problem.

The coalition has used two natural systems to neutralize the water, Danehy said.

One uses limestone to neutralize sulfuric acid and iron, while organic compounds like mushroom compost, removes aluminum.

A wetland area is built downstream of both systems, which helps to further neutralize the acid.

The coalition began installing the systems in 1995. Currently, there are seven systems in Argentine, Higgins Corner and Ferris. Since 1996, there have been dramatic improvements in selected areas of the watershed, but not everywhere.

"The coalition is only treating about 20 percent of the acid drainage coming into the watershed," said Dean DeNicola, a Slippery Rock University biology professor. "Locally, there is some improvement but there is still a long way to go."

F