GRAFHAM WATER

BIOLOGICAL MONITORING RE: $FeSO_4$ DOSING

SUPPLEMENTARY REPORT: NOV.1992-JAN.1993

BENTHIC INVERTEBRATES

1. Introduction

This report provides an update on benthic monitoring of Grafham Water and describes the results of surveys carried out November 1992 and January 1993.

2. Sampling Strategy

The reservoir was surveyed from August to December 1992, using an alternating grid and general survey approach. The grid system of sites was selected around the aeration (inlet) tower, to give a detailed assessment of the area of likeliest ferric contamination. Sites were also selected to give a general assessment across the whole reservoir. The grid and general sites were sampled on alternate months. The sites are shown in figure 1.
Since January 1993 the reservoir has been surveyed every other month using the grid system and one reference point away from the dosing point towards the dam and a second at the opposite end of the reservoir by Savages Creek.
Depth measurements have also been recorded using an echosounder and inferred depth contours are indicated in figure 2.

3. Sampling Methods

Benthic invertebrate samples are taken using an Ekman grab of 0.0225 m2 surface area. Duplicate samples are taken at each site and a small core is taken from the samples for iron analysis.
The samples are returned to the laboratory for live sorting, identification and counting. In cases where the number of individuals of a particular taxa are very high, the sorting method has been altered. The sample is thoroughly sieved as normal, it is divided evenly into as many petri-dishes as are required for easy sorting. All individuals of the abundant taxa are extracted and counted from a proportion of the total sample, yielding at least 500 individuals. An estimate of the total number of the taxa within the whole sample is calculated and recorded. The whole sample is sorted to ensure all other taxa are extracted and counted. In cases where there is an excessive amount of detrital matter the sample is sieved as normal, transfered and evenly distributed in a white tray with sub-divisions. A proportion of the sample is removed from the tray and divided into petri-dishes. All individuals are extracted and counted. An estimate of the total numbers of taxa are calculated and recorded.

4. Results

4.1 Sediments

Between August and October 1992, 56 samples were taken and analysed for total iron. The results are shown in Table 1 and represented diagramatically in figures 4-7.
During this time iron levels ranged from 27-396 mg/g dry weight.

There was discernible elevation of iron levels to the south east of the aeration (inlet) tower, covering approximately 8 % of the reservoir (Figure 10). In this area iron levels were generally in excess of 250 mg/g. Outside of this area, the results indicate the average level of iron in the sediments was between 50-60 mg/g, within a range of 26.6-86.6 mg/g.
A further 22 samples have been taken between October 1992 and January 1993 and analysed for total iron. The results are also shown in Table 1 and represented diagramatically in figures 8 and 9.
Since October the area of elevated iron levels has decreased to 1-2 % of the reservoir with the levels now being between 100-200 mg/g (Figure 11). In addition there is an intermediate area, also to the south east of the aeration tower, where the iron levels are 45-100 mg/g. This intermediate area represents approximately 14 % of the reservoir. Outside of these two areas the background level is around 45 mg/g.

4.2 Benthic Invertebrates

Direct comparison of iron levels with the invertebrate communities have been made (Figures 12-15). These show iron levels in sediment plotted against total number of individuals, numbers of chironomids and numbers of oligochaetes in the same sediments.The plots indicate that once iron levels in the sediments exceed 90 mg/g dry weight, the benthic communities show signs of damage.

5. Discussion

5.1 Sediments

Within the area of elevated iron levels results have been variable at some sites over the survey period. This may have been due to the behaviour of the ferric floc after dosing. It has been noticed that the iron does not all settle out immediately but forms a loose floc above the sediment. This floc is mobile and can therefore circulate with the water. If sampling occurs during such times the iron results are likely to be variable. Since dosing stopped in August the results have been more consistent, showing the iron finally settles into the sediment. The reduced levels also indicate that the iron is diluted by incoming matter and detritus and becomes incorporated in the sediment rather than just being a surface layer.

5.2 Benthic Invertebrates

Previous monitoring in 1990 and 1991 indicated significant reductions in invertebrate diversity and abundance, associated with areas of high ferric floc deposition (Grafham Water 1991, Biological Monitoring re:Ferric Dosing. Central Area Report, January 1992).

The direct comparison of iron levels with benthic communities have shown that there is a threshold of 90 mg/g, at levels higher than this the communities show signs of damage. The dominant taxa are oligochaetes and chironomids and the numbers of these are reduced quite dramatically in sediments where the iron levels are above 90 mg/g. Other taxa such as many molluscs, turbellarians and Emphemeroptera for example simply disappear from the affected area and do not return until the levels have dropped. This is demonstrated by the average number of taxa found over all the sites, in September it was 5.5 and in January it was 8.4.

6. Overall Assessment

Results from the survey work indicate that the area affected by elevated iron levels has been reduced from approximately 8% to between 1-2%. This has coincided with an increase in the number of taxa recorded at the sampling sites and an increase in the numbers of individuals recorded.

7. Recommendations

Further monitoring to assess recovery (and therefore the damage that was caused) and to mark the potential for other reservoirs is needed. It is important to continue monitoring through the summer and autumn to establish an annual pattern and to determine whether factors such as stratification or overturn will affect the iron levels in the sediments and the invertebrate communities.

References

Biology Central (1991) Grafham Water 1990, Biological Monitoring re: Ferric Sulphate Dosing.

Biology Central (1992) Grafham Water 1991, Biological Monitoring re: Ferric Sulphate Dosing.

Biology Central (1992) Grafham Water 1992, Biological Monitoring re: Ferric Sulphate Dosing.

Extence C. A., Brierley S. J. and Fenton D. M. (1992) Ferric Dosing of Reservoirs: A Review of Dosing and its Impact in the Northern Area.

Figures

figure	1	Sample sites
	2	depth contours
	3	Ferric Sulphate inputs 1990-1992
	4	Iron in sediment levels 9/9/92
	5	" " " " 16/9/92
	6	" " " " 29/9/92
	7	" " " " 28/10/92
	8	" " " " 24/11/92
	9	" " " " 5/1/93
	10	" " " general pattern-Oct
	11	" " " " " -Jan
	12	Iron level vs No. of individuals
	14	" " " No. of chironomids
	15	" " " No. of oligochaetes

Tables

Table	1	Iron levels (mg/g dry wt) results
	2	Invertebrate results

BENTHIC INVERTEBRATES

FIGURES AND TABLES

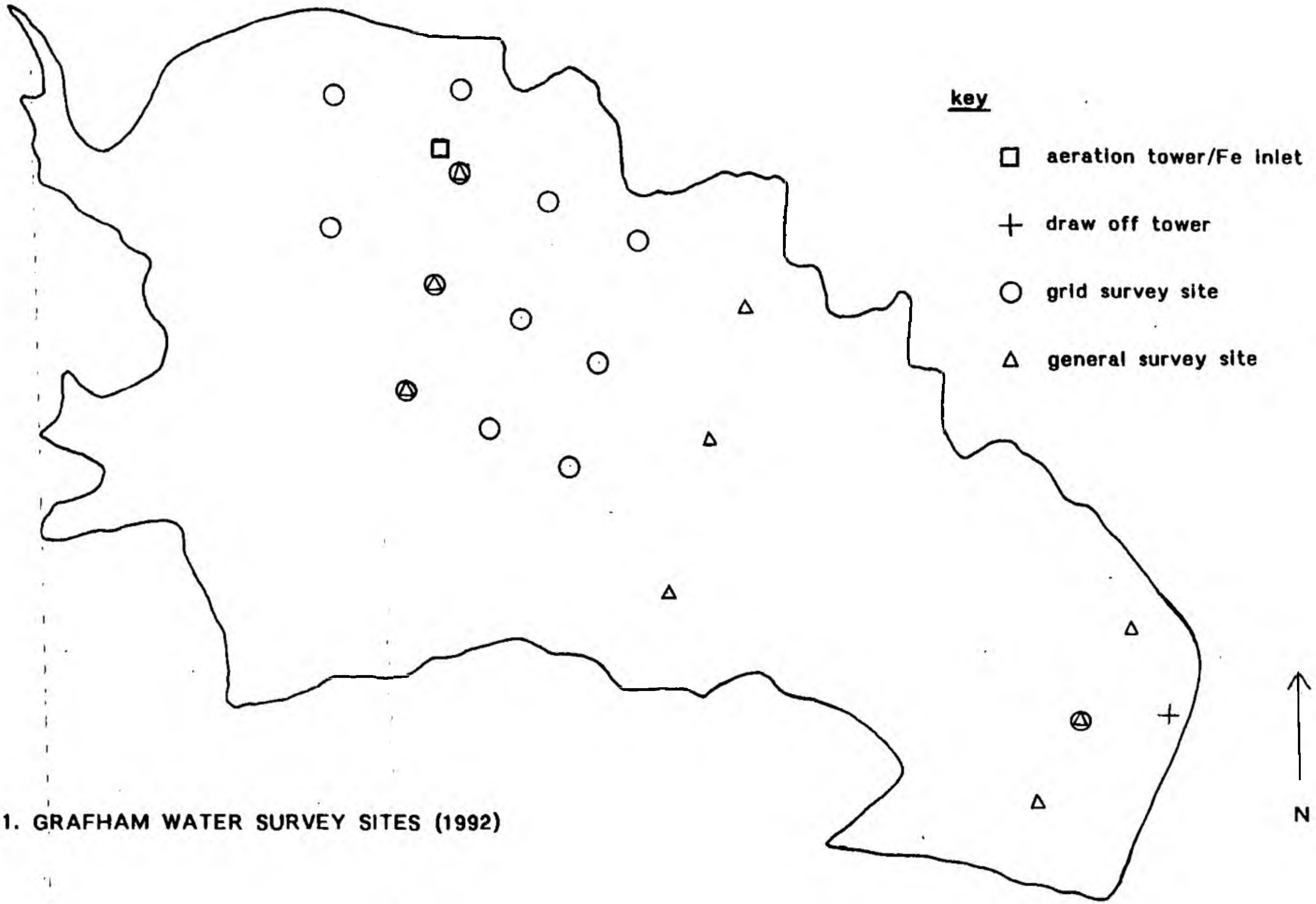


Figure 1. GRAFHAM WATER SURVEY SITES (1992)

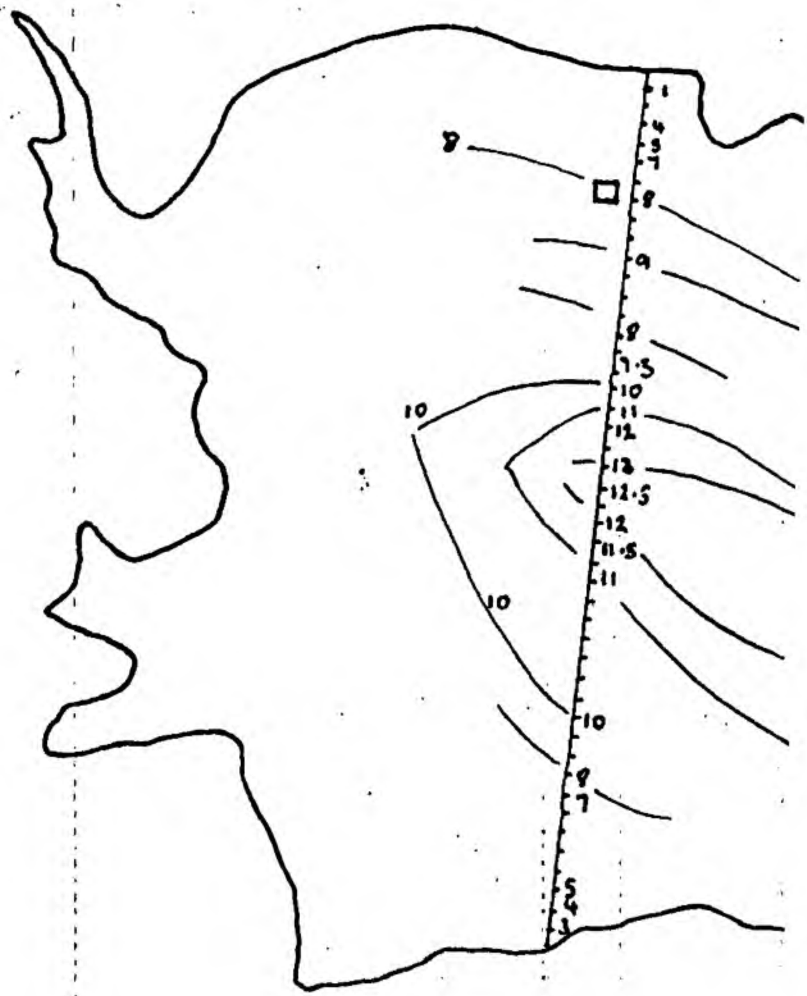
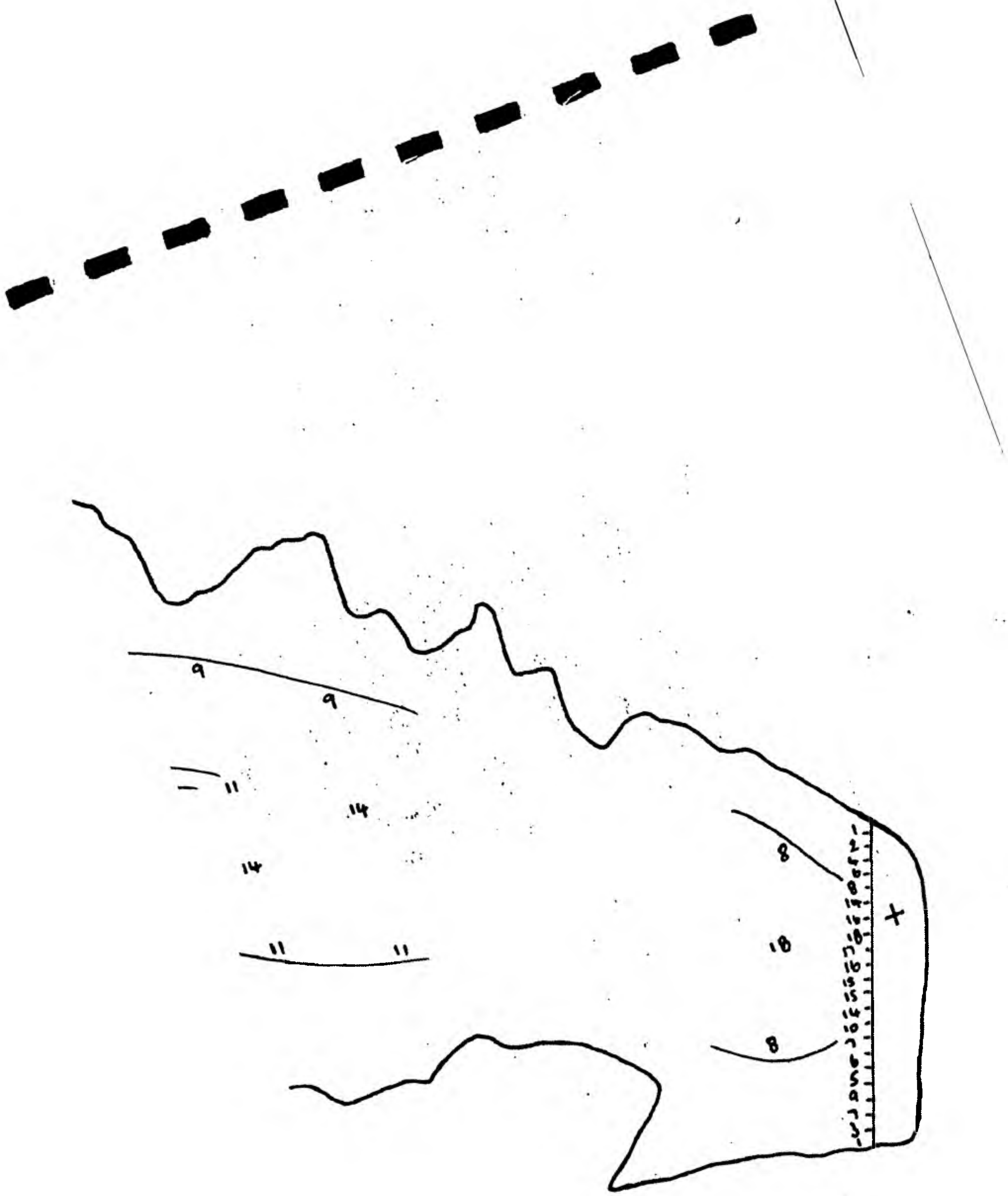


Figure 2. DEPTH: TRANSECTS AND CONTOURS


9
9
11
14
14
11
11
8
18
8

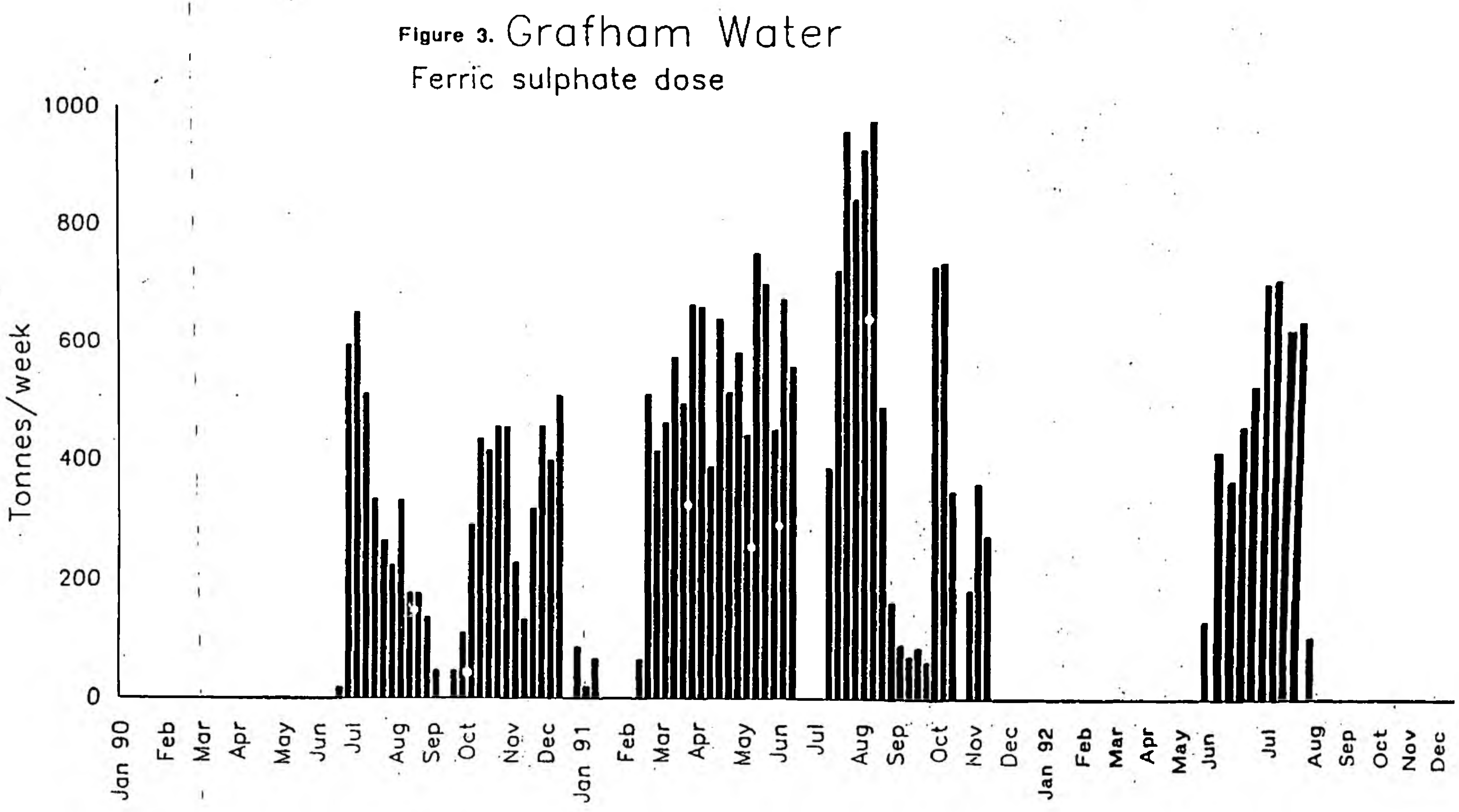


Figure 3. Grafham Water
Ferric sulphate dose
Tonnes/week
0
200
400
600
800
1000
Jan 90
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 91
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 92
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

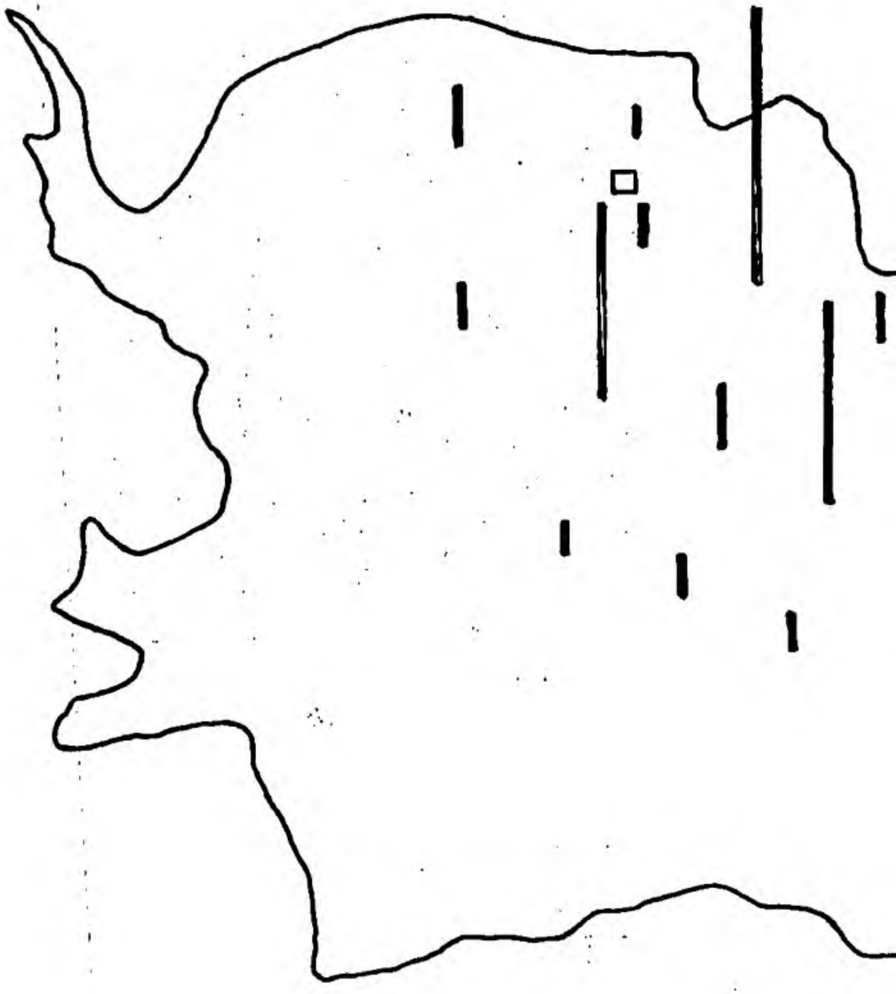


Figure 4. DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF

GRAFHAM WATER - 09/09/92

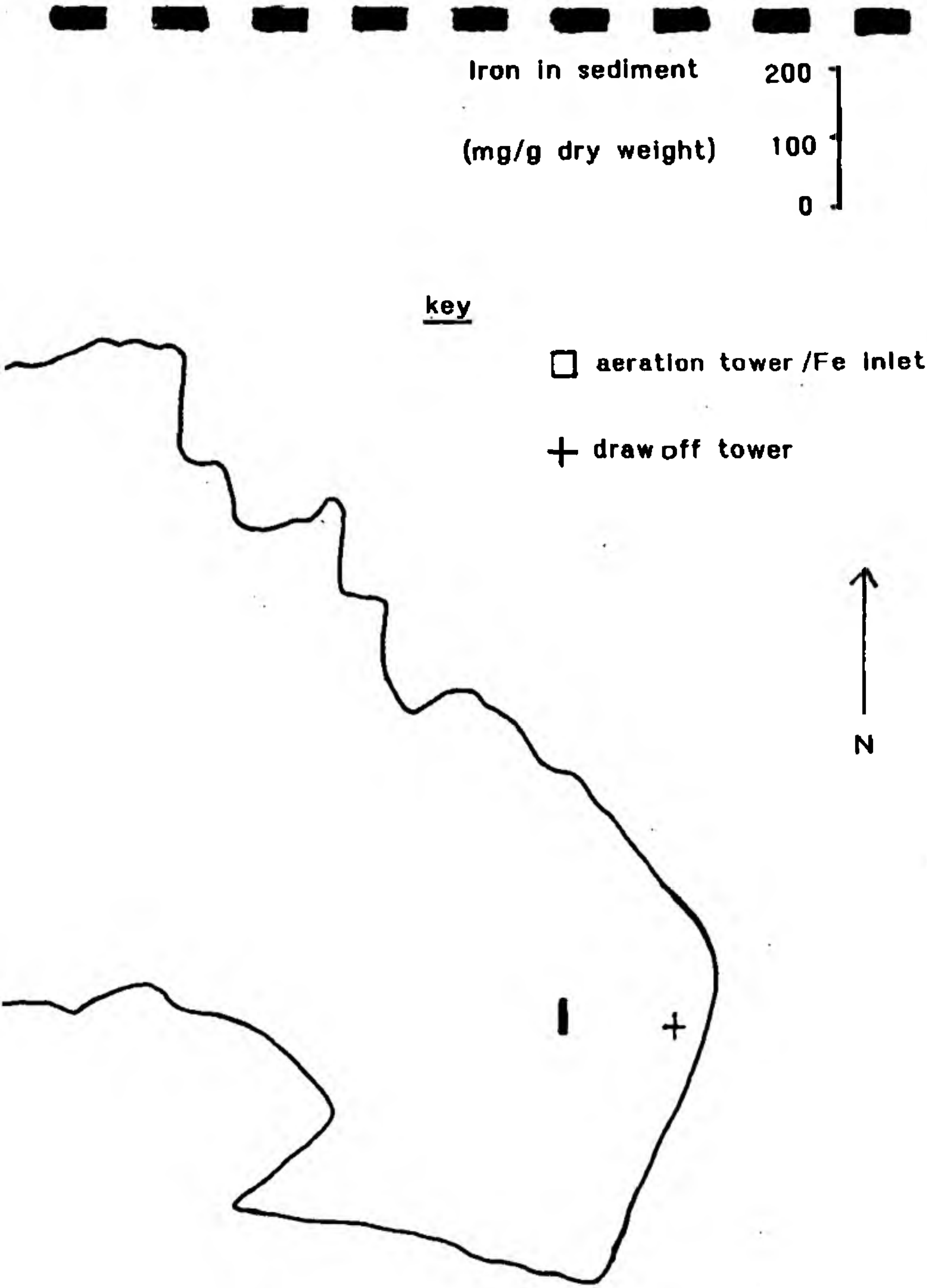
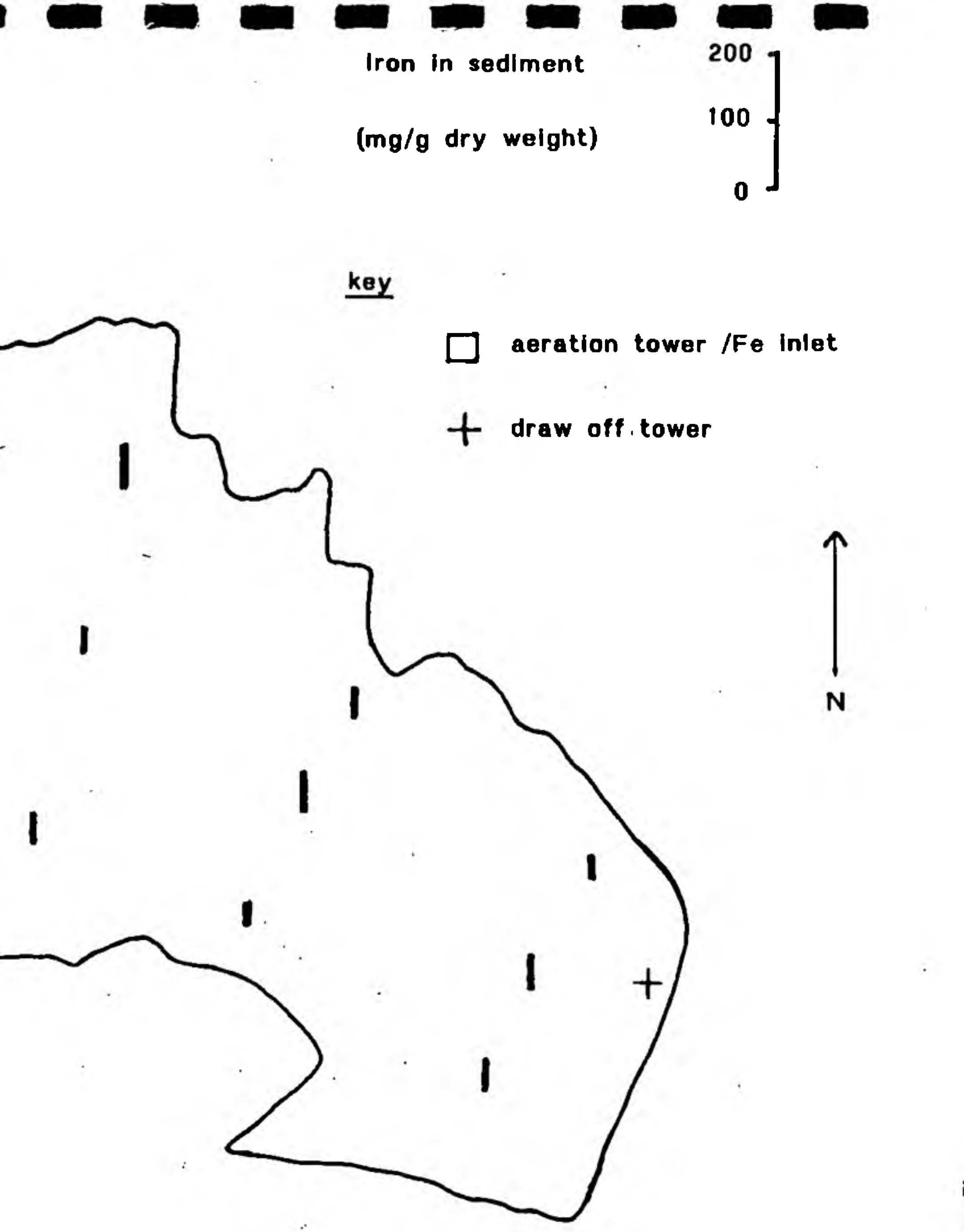

Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower /Fe inlet
draw off tower
N

Figure 5. DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF

GRAFHAM WATER - 16/09/92



Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower /Fe inlet
draw off tower
N

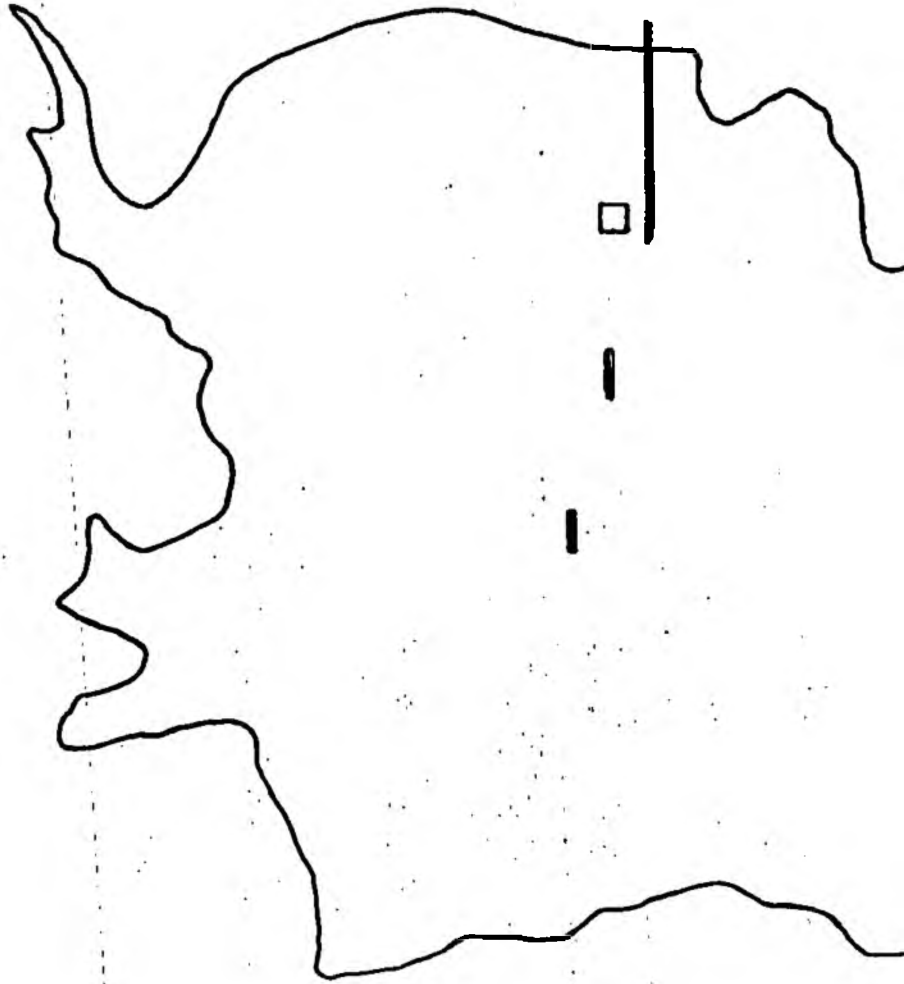
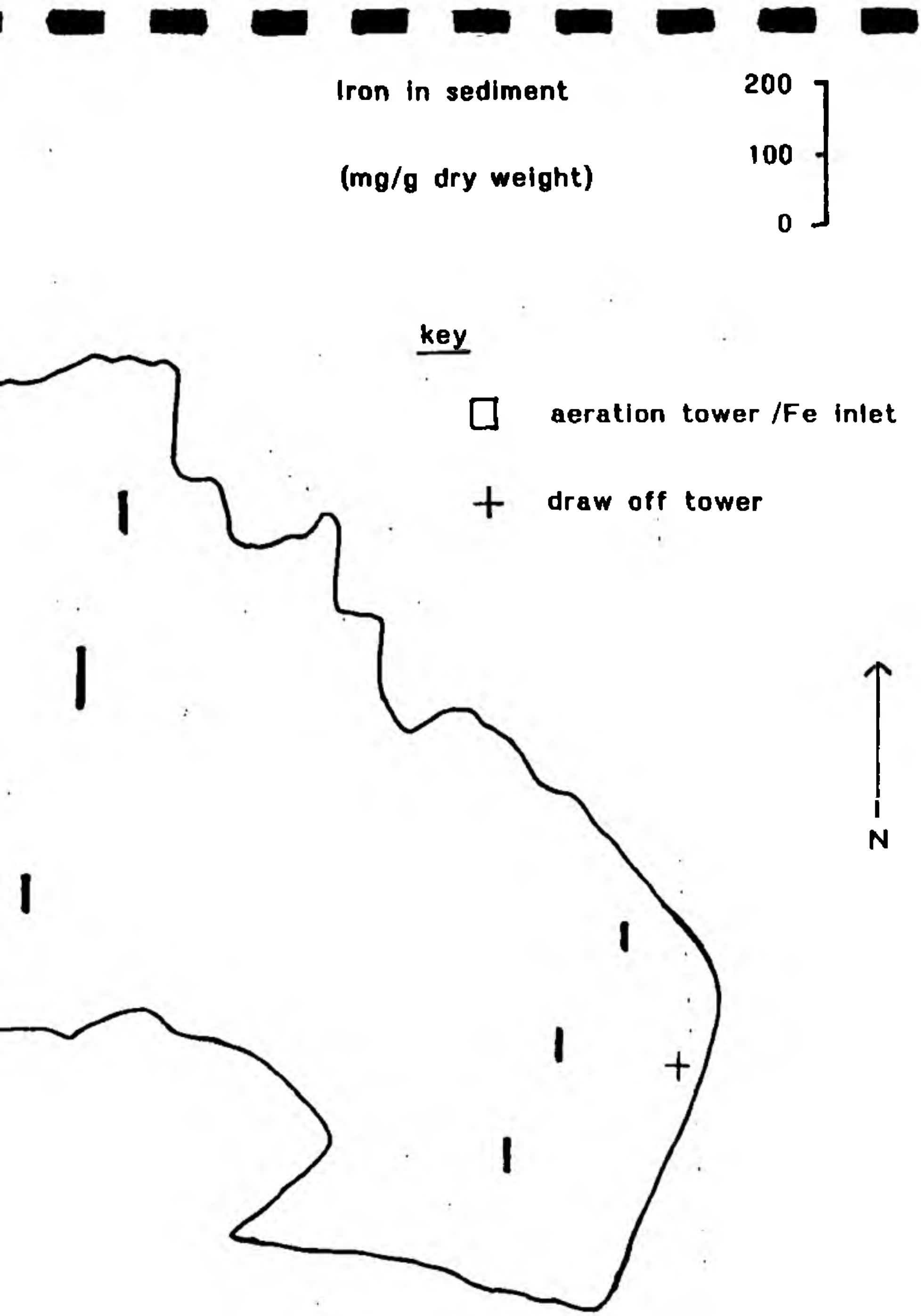


Figure 6. DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF

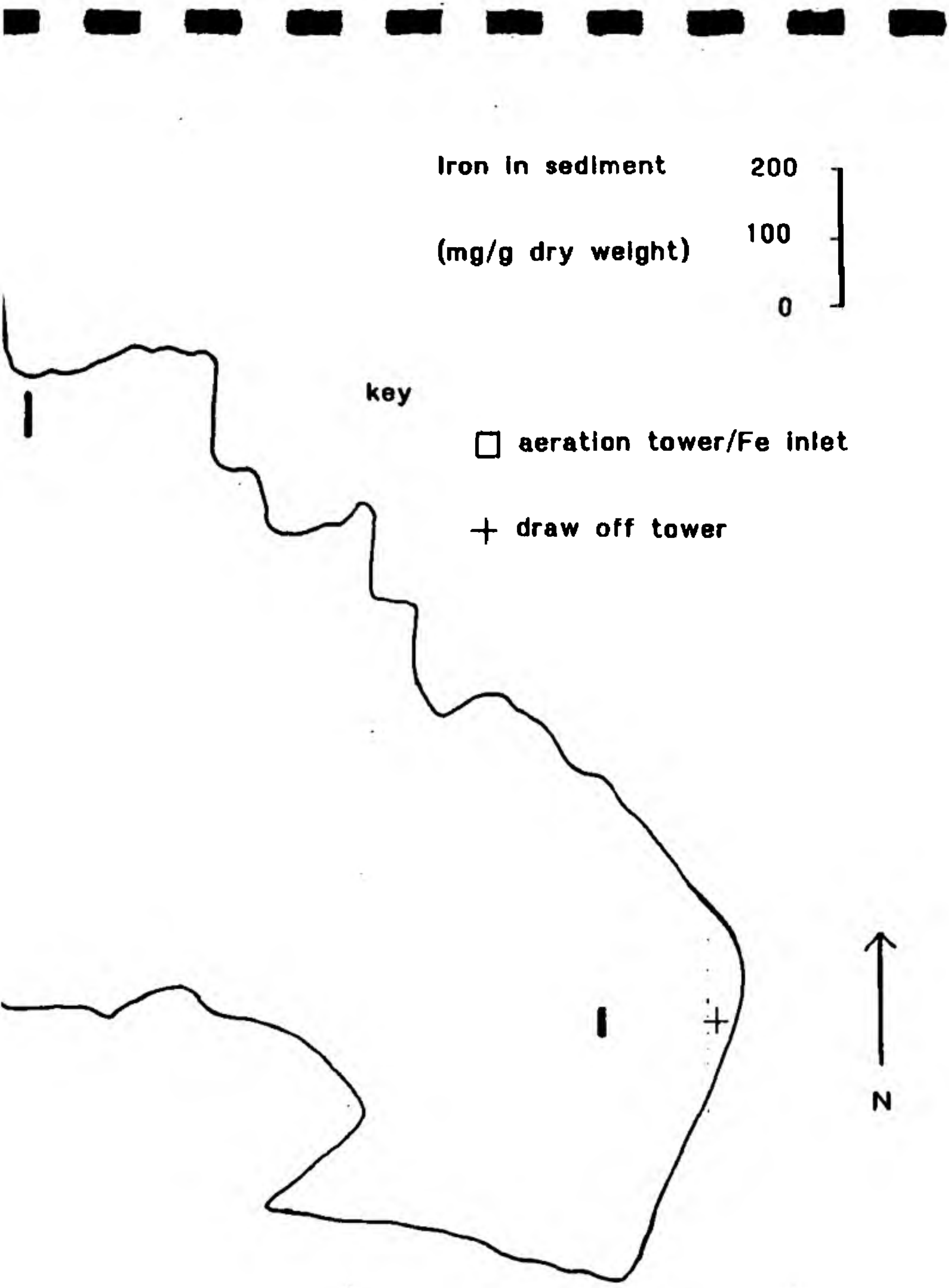
GRAFHAM WATER - 29/09/92



Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower /Fe inlet
draw off tower
N

Figure 7. DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF

GRAFHAM WATER - 28/10/92


Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower/Fe inlet
draw off tower
N

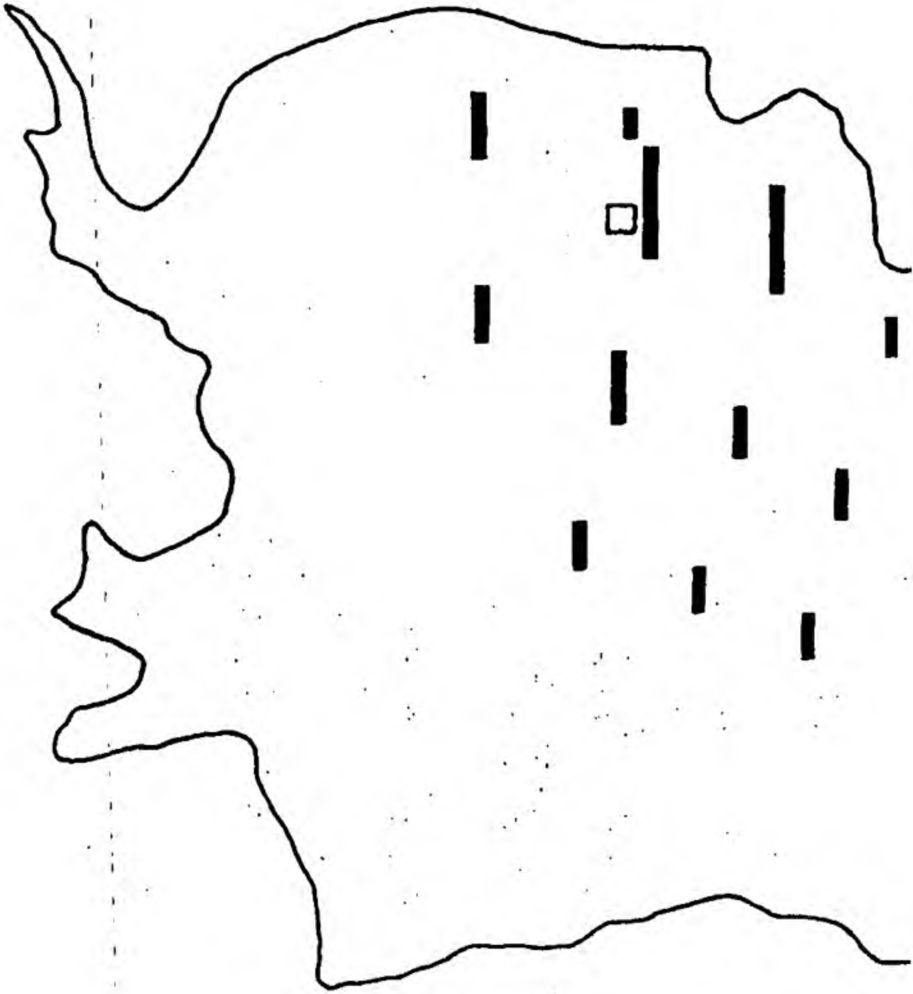
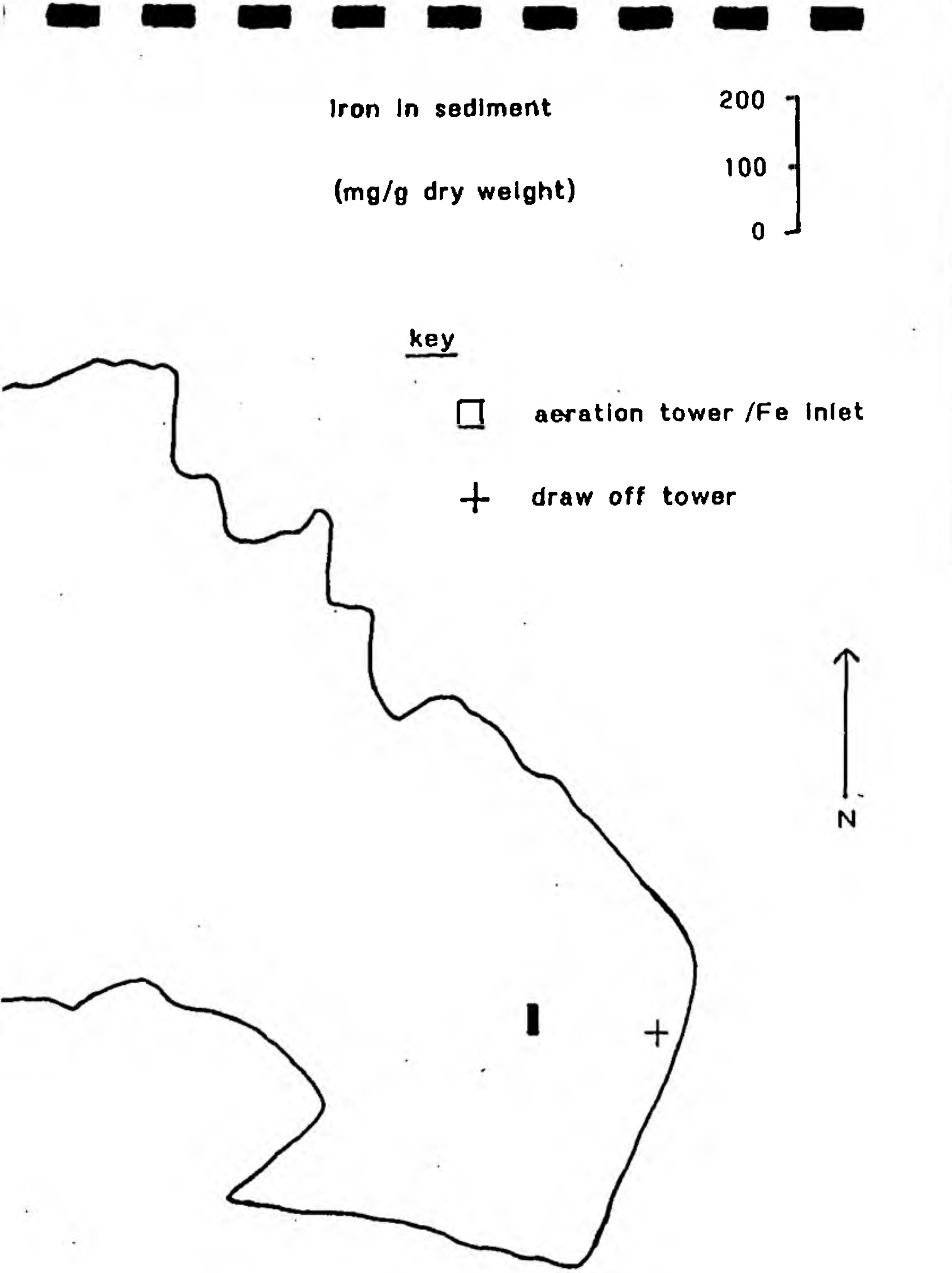


Figure 8 DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF GRAFHAM WATER - 24.11.92.


Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower /Fe inlet
draw off tower
N

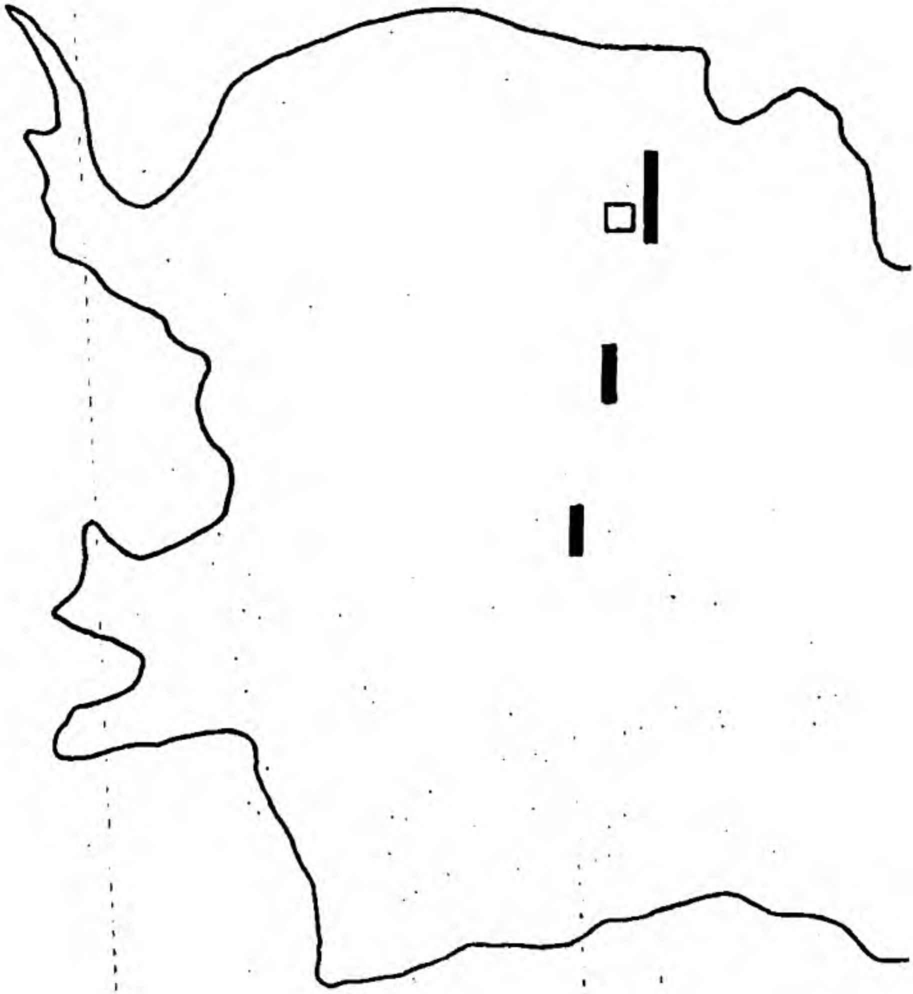
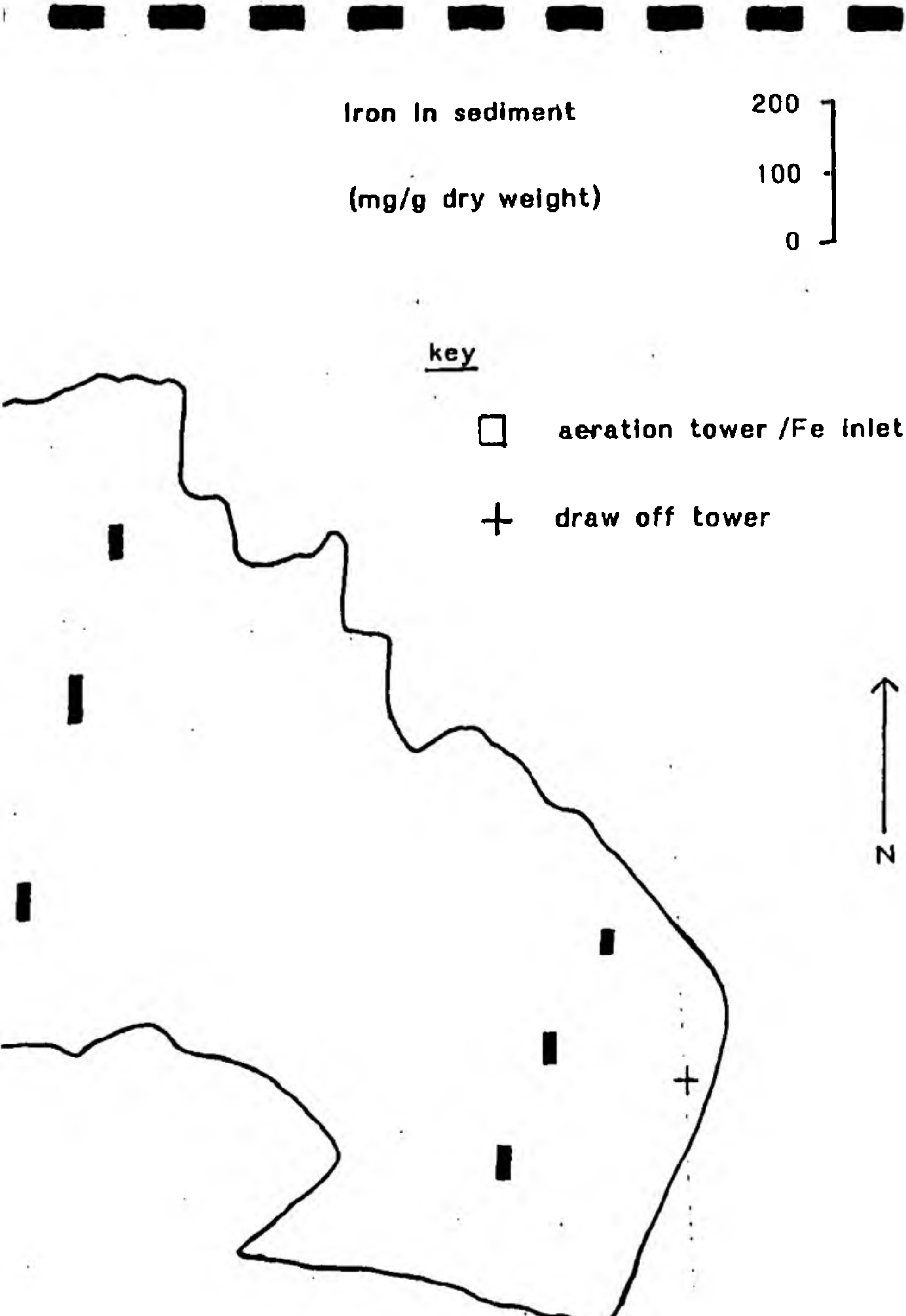


Figure 9 DISTRIBUTION OF TOTAL IRON IN THE SEDIMENTS OF GRAFHAM WATER - 05.01.93.



Iron in sediment
(mg/g dry weight)
200
100
0
key
aeration tower /Fe inlet
draw off tower
N

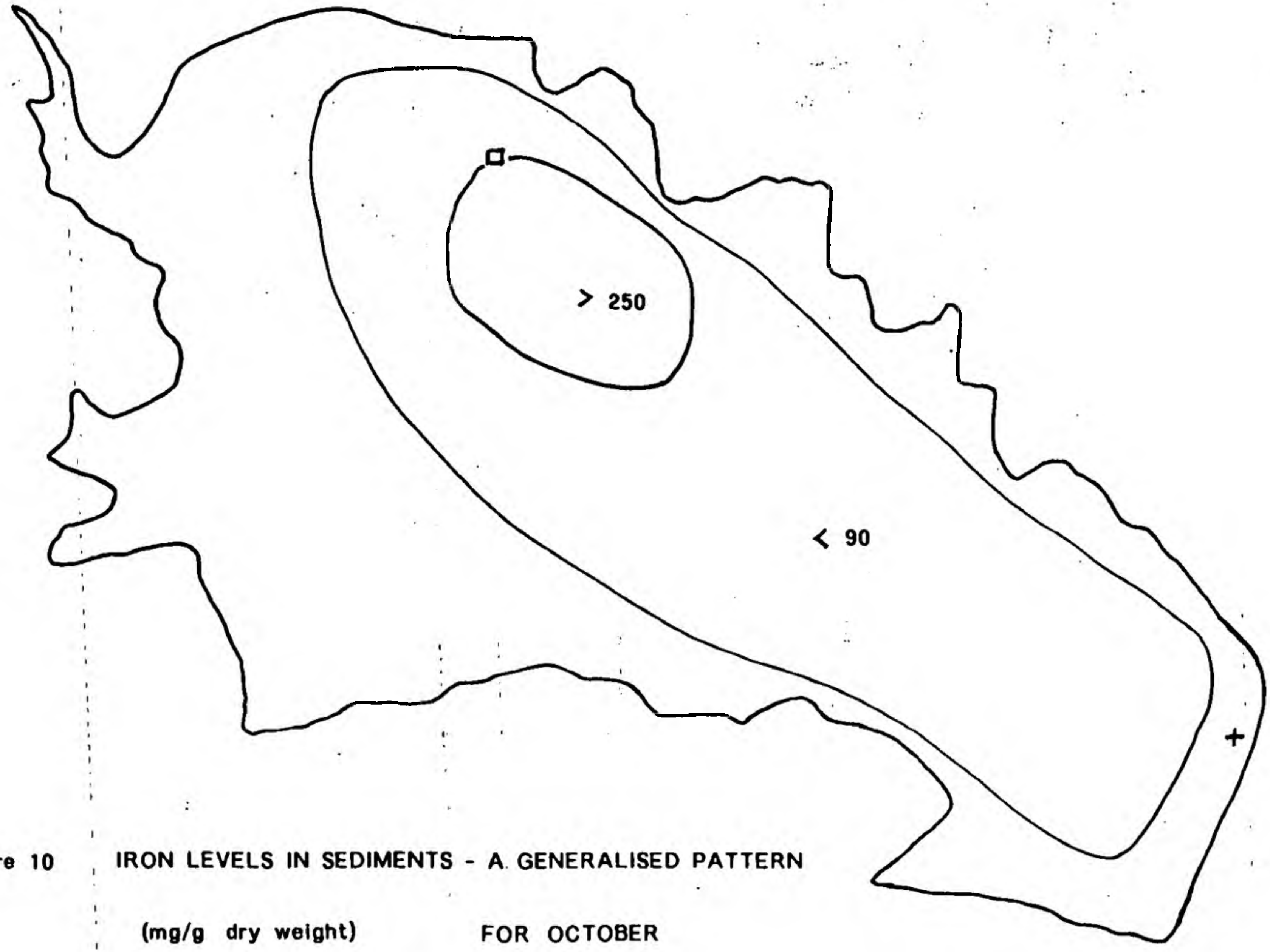


Figure 10 IRON LEVELS IN SEDIMENTS - A GENERALISED PATTERN

(mg/g dry weight) FOR OCTOBER

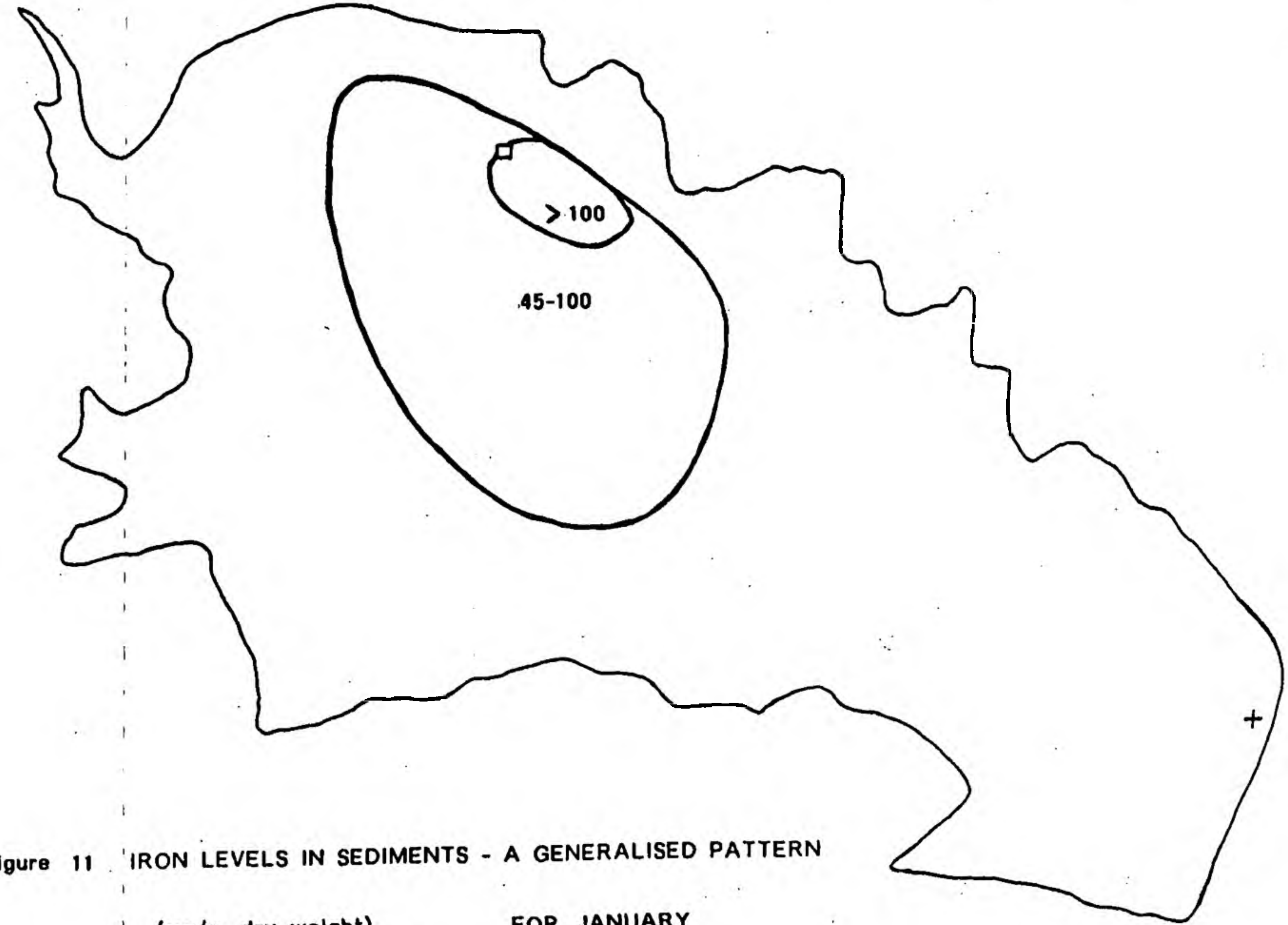


Figure 11 IRON LEVELS IN SEDIMENTS - A GENERALISED PATTERN

(mg/g dry weight) FOR JANUARY

Figure 12

GRAFHAM WATER

TOTAL NUMBER OF INDIVIDUALS IN SEDIMENT / M Sq.

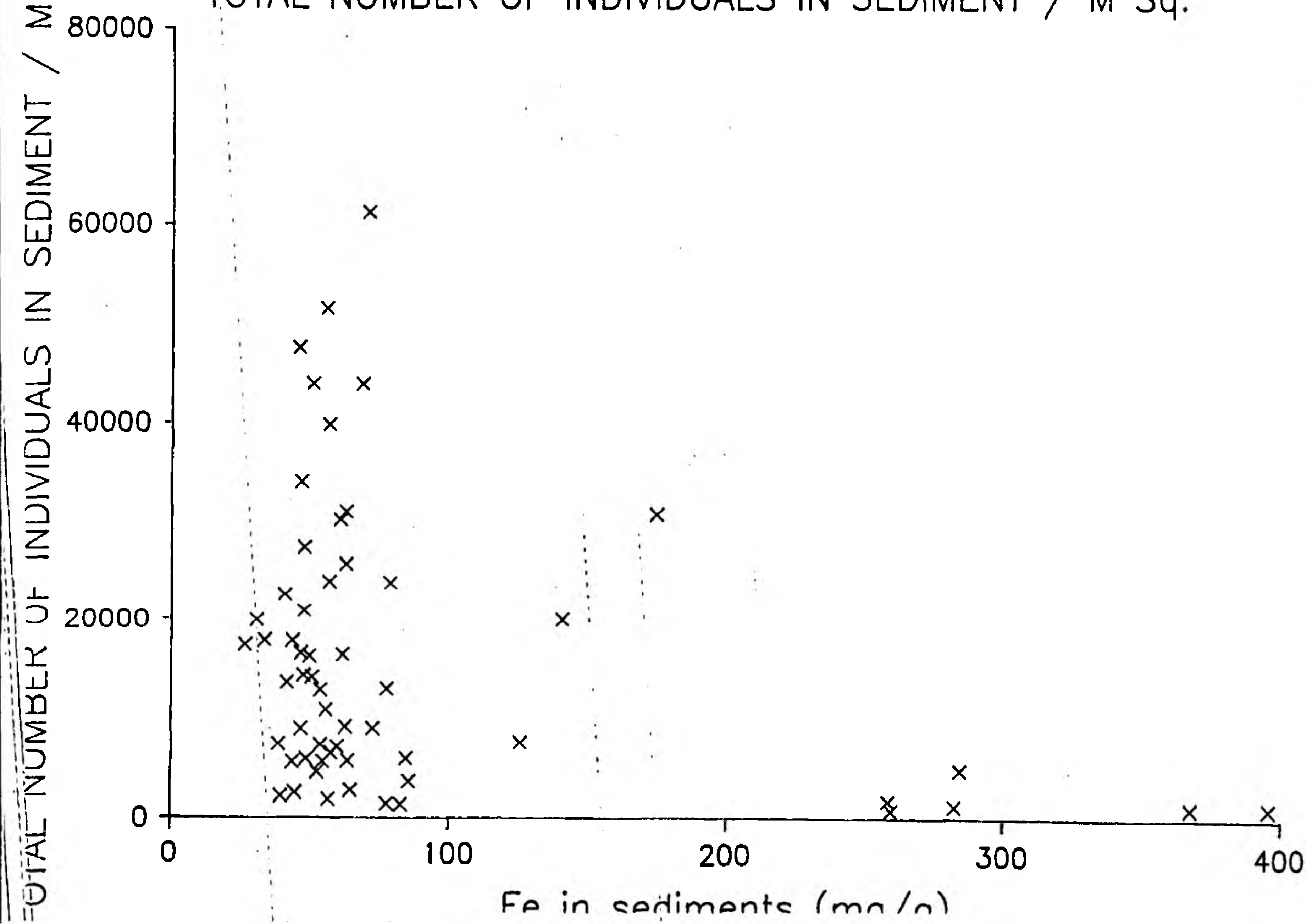


Figure 14

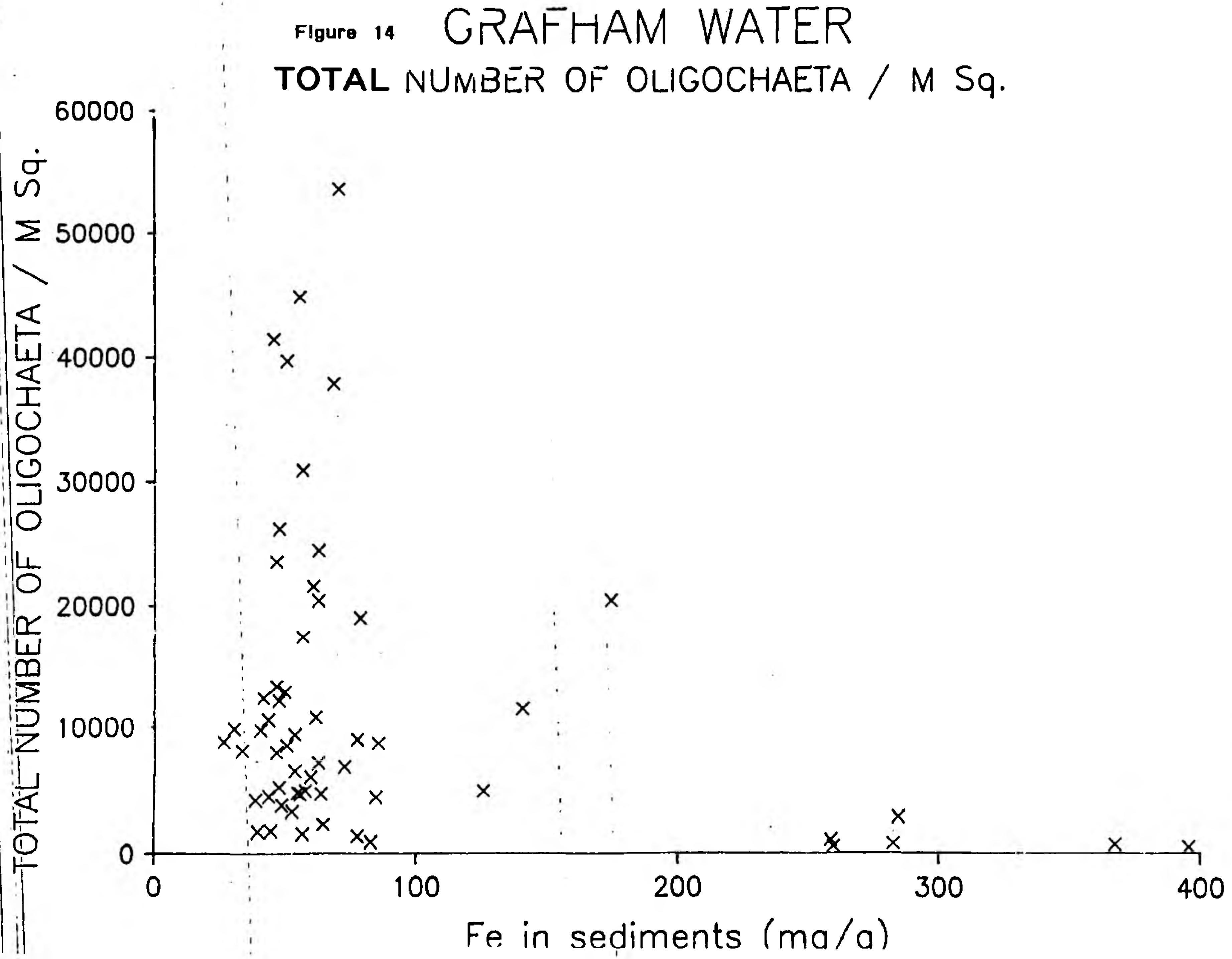

GRAFHAM WATER
TOTAL NUMBER OF OLIGOCHAETA / M Sq.
TOTAL NUMBER OF OLIGOCHAETA / M Sq.
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
Fe in sediments (mg/g)

Figure 13

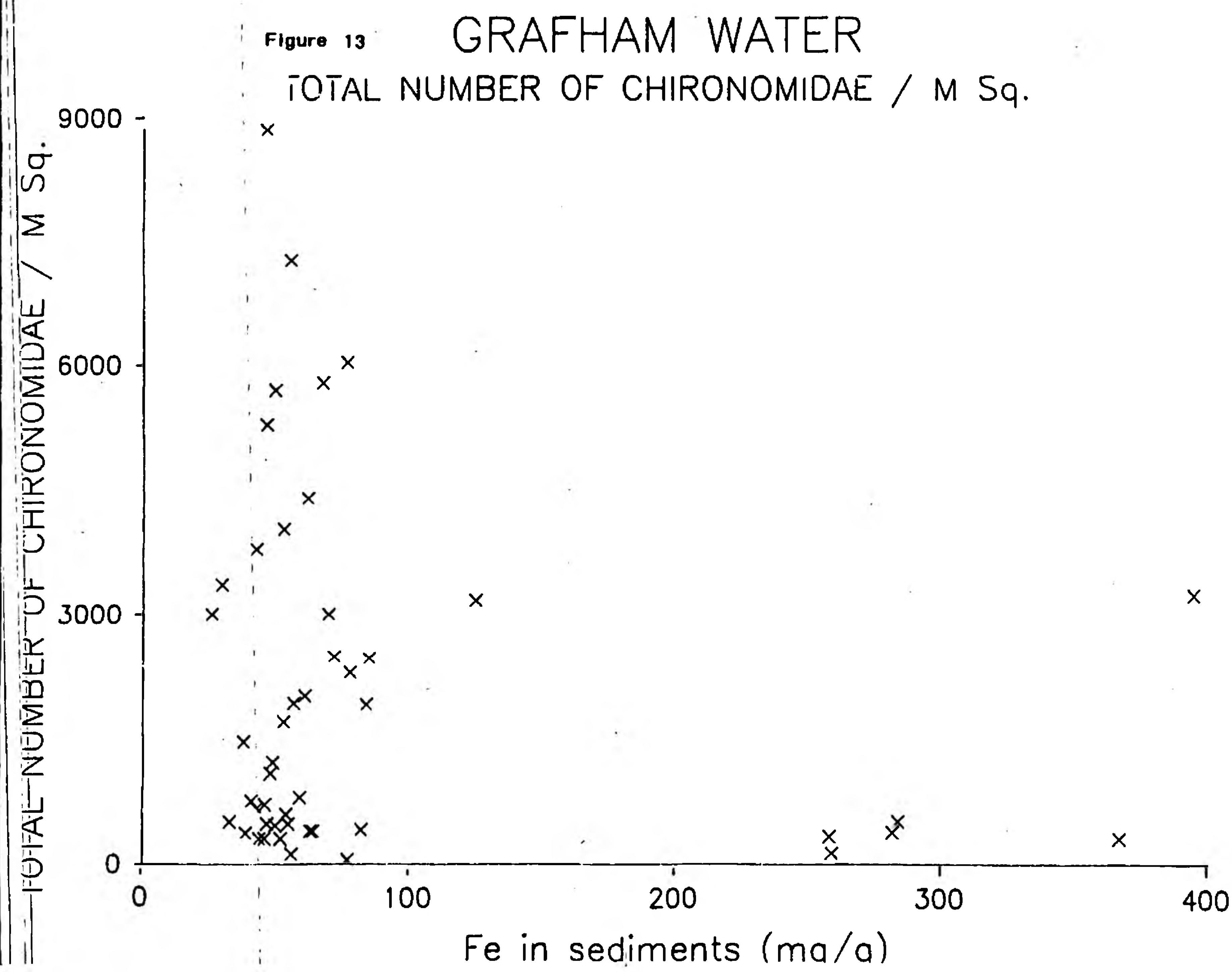

GRAFHAM WATER
TOTAL NUMBER OF CHIRONOMIDAE / M Sq.
TOTAL NUMBER OF CHIRONOMIDAE / M Sq.
9000
6000
3000
0
0
100
200
300
400
Fe in sediments (mg/g)

Table 1 GRAFHAM WATER

Fe in sediments (mg/g)

DATE/SITE	1	2	3	4	5	6	7	8	A	B	C	D	E
09.09.92	44	57	259	65	366	46	76	42	39	55	65	260	45
23.09.92	54		64			285		47					
26.10.92	53	50	60	63	253	396	59	46	27	56	56	73	54
24.11.92	62		79			128		51					
05.01.93	57	62	71	63	141	175	63	46	41	57	47	61	58

Table 2. GRAFHAM WATER 1992 SURVEY (Numbers/msq.)

09.09.92 — No. INDIVIDUALS / Msq.

TAXA / SITE	1	2	3	4	5	6	7	8	A	B	C	D	E
CHIRONOMIDAE	638	110	330	396	308	352	44	726	1,430	572	374	132	286
OLIGOCHAETA	4,400	1,474	1,122	902	682	1,672	1,320	12,320	4,114	4,664	2,244	594	1,716
NEMATODA	220	22	44	22				264		88	66	44	176
HYDRACARINA	176	66	110			44	22	88	44	66			154
SPHAERIIDAE	22	22						66	660				88
OSTRACODA			44					44	418	66			22
CERATOPOGONIDAE	22		66		44	88				44			
GLOSSIPHONIDAE	22	88								22			
ERPOBDELLIDAE		22			22				22				
ASELLUS													
COROPHIIDAE													
HYDRA									594				
CULICIDAE	22									22			22
SIALIDAE													22
LEPTOCERIDAE									22				
VALVATIDAE													
HYDROBIIDAE													

29.09.92 — No. INDIVIDUALS / Msq.

TAXA / SITE	1	3	6	8	10	11	13	14	16
CHIRONOMIDAE	1,628	352	499	682	814	7,458	3,762	1,122	1,606
OLIGOCHAETA	12,012	4,840	2,850	7,920	4,356	8,074	8,470	3,718	13,266
NEMATODA	396	264	15	132	286	286	836	704	242
HYDRACARINA	660	176	176	110	132	1,232	264	66	506
SPHAERIIDAE	44		15			22	44	66	
OSTRACODA			15						
CERATOPOGONIDAE									
GLOSSIPHONIDAE									
ERPOBDELLIDAE									
ASELLUS			73						
COROPHIIDAE			88						
HYDRA			328				22		
CULICIDAE			29			22			
SIALIDAE									
LEPTOCERIDAE									
VALVATIDAE			15						
HYDROBIIDAE					22				

28.10.92 — No. INDIVIDUALS / Msq.

TAXA / SITE	1	2	3	4	5	6	7	8	A	B	C	D	E
CHIRONOMIDAE	1,880	484	440	1,056	286	286	2,442	770	4,400	374	3,234	1,188	462
OLIGOCHAETA	3,234	2,662	5,962	7,062	792	484	12,804	26,136	3,778	4,840	4,576	5,778	6,424
NEMATODA	220	616	770	484	44		308	156	1,012	902	1,496	374	264
HYDRACARINA	44	66	66	44		88	154	110	330	44	396	44	22
SPHAERIIDAE	44	132		286			132	132	1,166	88	638	462	22
OSTRACODA	66	176	44	286	58	22	286		352	110	330	22	
CERATOPOGONIDAE	22	22			22	44	22		22		44		
GLOSSIPHONIDAE													
ERPOBDELLIDAE													
PLANORBIS													
PISCICOLA													
ELMIS													
ASELLUS													
COROPHIIDAE													
HYDRA						66			22				
CULICIDAE													
SIALIDAE													
LEPTOCERIDAE									154				
VALVATIDAE						44			44				
HYDROBIIDAE									44	22	66		
CAENIDAE									22				
DUGESIA						22							

Table 2 (cont.)

24.11.92 — No. INDIVIDUALS / Msq.

TAXA / SITE	1	3	8	9	10	11	13	14	16
CHIRONOMIDAE	2,992	1,892	462	2,464	2,068	6,578	2,992	6,424	1,760
OLIGOCHAETA	10,736	19,008	4,840	39,644	6,976	9,834	10,538	5,104	12,100
NEMATODA	748	418	110	484	572	792	660	946	440
HYDRACARINA	330	572	198	308	176	660	308	176	462
SPHAERIIDAE	528	308	704	858	286	1,100	968	748	440
OSTRACODA	924	1,474	704	66	748	638	990	660	1,320
CERATOPOGONIDAE			110			22	110	88	
GLOSSIPHONIDAE			22						
ERPOBDELLIDAE									
PLANORBIS									
PISCICOLA									
ELMIS									
ASELLUS									
COROPHIIDAE			44			44			
HYDRA			66					22	
CULICIDAE									
LEPTOCERIDAE							22		
VALVATIDAE			154		22		22		
HYDROBIIDAE		88	66	22		154	22	22	220
CAENIDAE							22		
DUGESIA									
LYMNAEA	22								
MICROTURBELLARIA			22	44					
UNIONIDAE							22		
TOTAL	16,280	23,760	7,524	43,912	12,645	19,822	17,666	14,190	20,765

05.01.93 — No. INDIVIDUALS / Msq.

TAXA / SITE	1	2	3	4	5	6	7	8	A	B	C	D	E
CHIRONOMIDAE	4,026	1,980	2,266	3,168	5,698	6,028	2,344	3,784	5,844	5,280	7,260	5,768	2,992
OLIGOCHAETA	17,468	37,840	53,460	24,442	11,440	20,416	20,372	41,360	9,724	30,844	23,518	21,318	44,770
NEMATODA	484	880	462	594	264	286	484	682	506	550	484	462	660
HYDRACARINA	418	418	792	484	550	836	330	242	990	748	440	264	946
SPHAERIIDAE	396	660	1,760	990	550	220	550	858	924	814	990	748	704
OSTRACODA	1,056	1,760	2,266	1,254	1,034	2,618	462	176	770	1,210	1,210	1,342	1,320
CERATOPOGONIDAE					154	242	22	22	154		44		
GLOSSIPHONIDAE													
ERPOBDELLIDAE													
PLANORBIS													
PISCICOLA													
ELMIS													
ASELLUS													
COROPHIIDAE													
HYDRA								330	22	330			
CULICIDAE													
LEPTOCERIDAE	22										22		
VALVATIDAE									220			22	
HYDROBIIDAE		66	110	44		22	44	44	286	22		22	
CAENIDAE													
DUGESIA													
LYMNAEA													
MICROTURBELLARIA	22				154	110		22	132	22	44		22
UNIONIDAE			22										
TOTAL	23,892	43,824	61,138	30,976	19,844	30,778	25,606	47,520	22,572	39,820	34,012	30,162	51,414