A Study into the Effect of Chertsey STW on the North Arm of the River Bourne

Paul Downing
Thames NRA
Ladymead
By-Pass Road
Guildford
Surrey

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A Study into the Effect of Chertsey STW on the North Arm of the River Bourne

1. Objectives of Study

The River Bourne downstream of Chertsey STW has been regularly failing its 1B RQO Classification at Bourne above Thames (TQ 0670 6570) on the ammoniacal nitrogen parameter, and also at Hamperstone Bridge (TQ 0350 6720) on the dissolved oxygen parameter (RQO 2A).

This study attempts to explain the reasons for these failures and to determine the best course of action to prevent further failures.

Data used in this study results from three, 24 hour surveys conducted over the dry 1991 summer and older archived material dating back several years.

2. Background

The north arm of the River Bourne flows south easterly from Egham through Chertsey to the confluence with the south arm of the River Bourne at Chertsey Meads. From here the Bourne flows into the River Thames at Weybridge.

The flow of the north arm consists of an input of treated sewage effluent from Chertsey STW (TQ 0160 6800) which may constitute as much as 50% of the total flow. There are no other major discharges into the North arm although the south arm does receive discharges from both Chobham (SU 9770 6110) and Lightwater (SU 9390 6220) STW's.

3. Chertsey STW

Chertsey STW has a consent to discharge up to 22,500 cubic metres of treated sewage effluent in any period of 24 hours under dry conditions.

The consented composition of the discharge is as follows.

a. 30 milligrams per litre of suspended solids (measured after drying at 105 degrees celsius)

b. 12 milligrams per litre of biological oxygen demand (determined in the presence of 0.5 milligrams per litre of allyl thiourea after five days at 20 degrees celsius).

c. 10 milligrams per litre of ammoniacal nitrogen expressed as nitrogen.

CHERTSEY STW

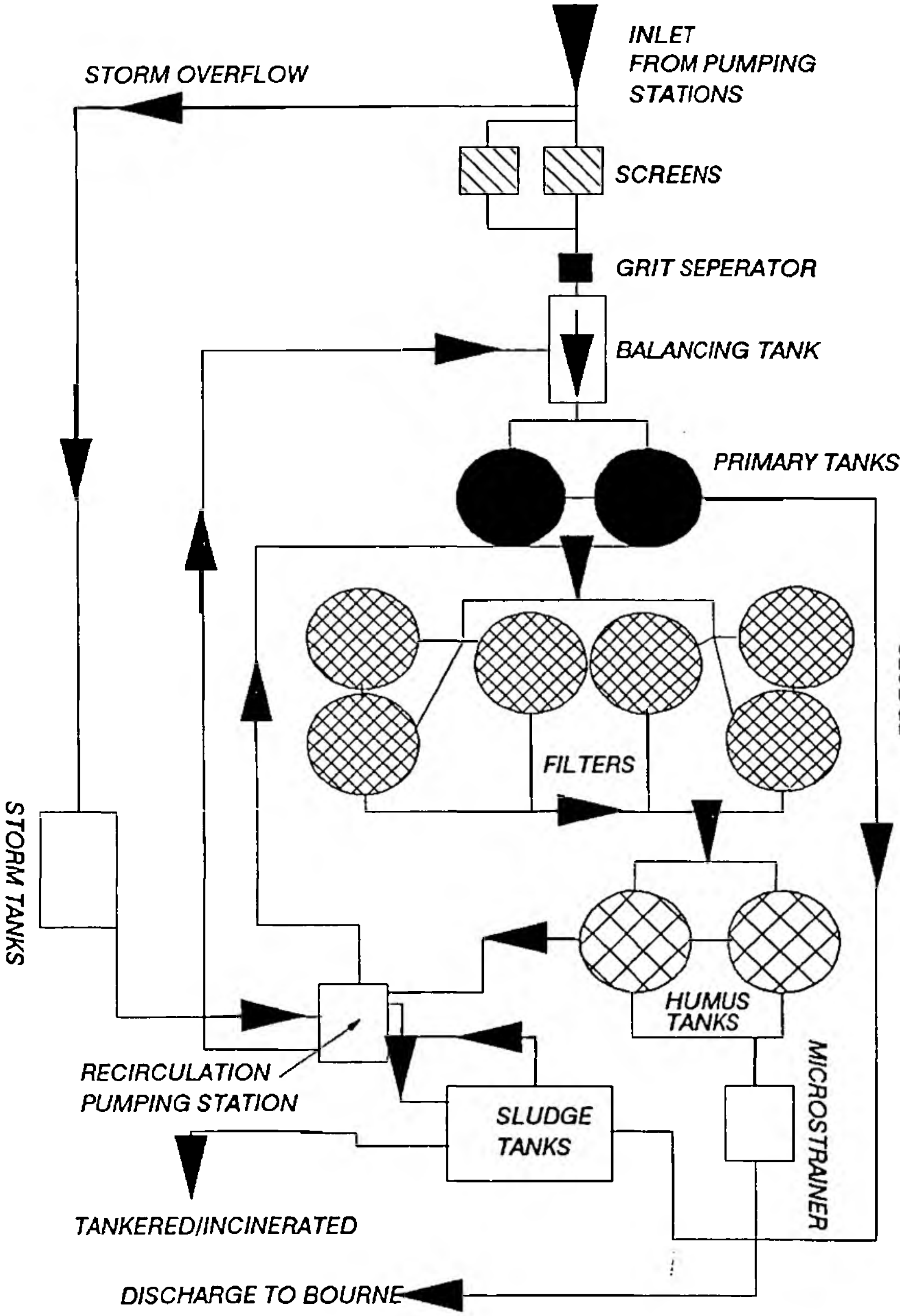


FIG 1

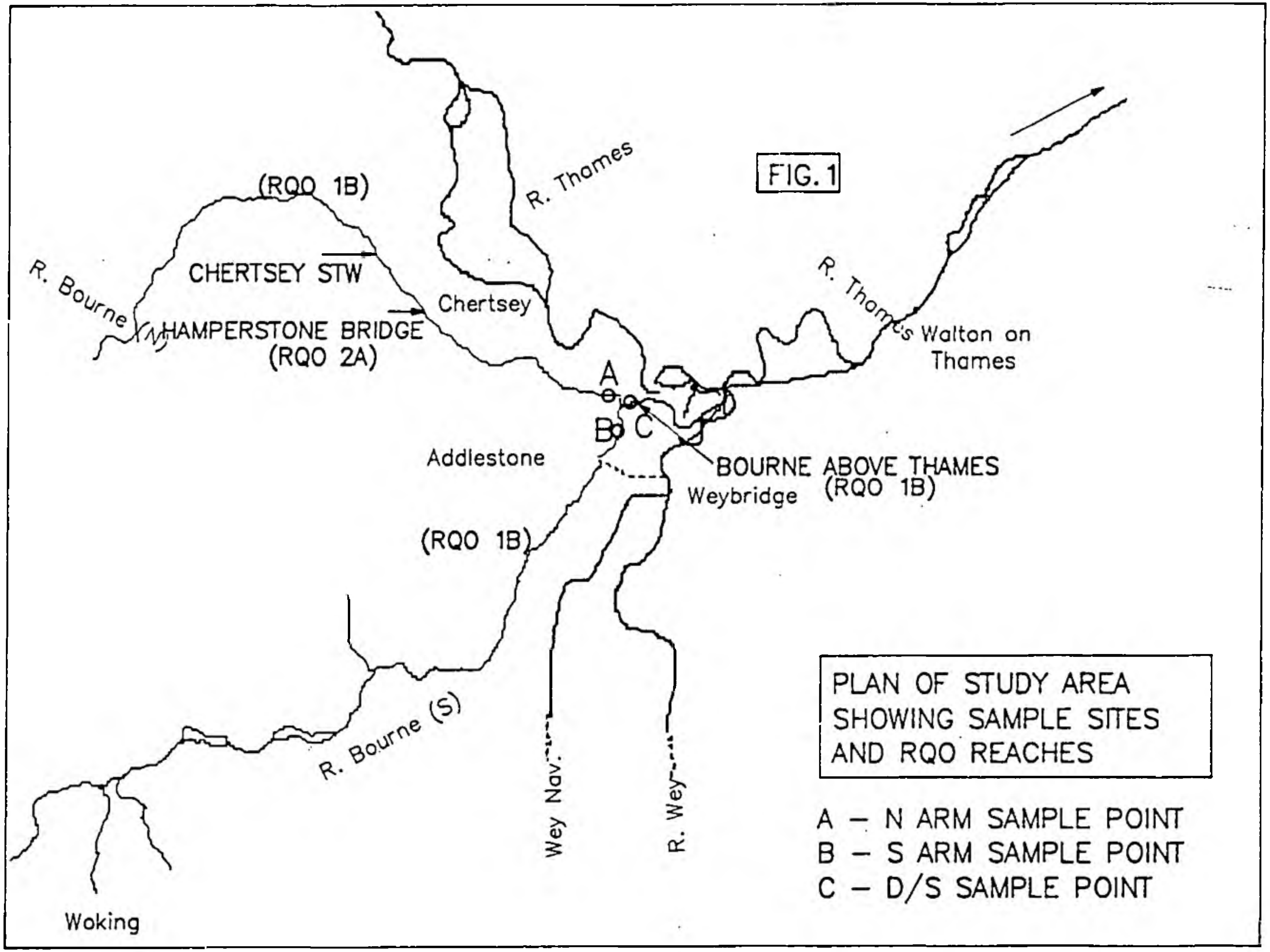


FIG. 1
R. Thames
(RQO 1B)
CHERTSEY STW
R. Bourne
Chertsey
HAMPERSTONE BRIDGE
(RQO 2A)
R. Thames
Walton on
Thames
A
B
C
Addlestone
BOURNE ABOVE THAMES
(RQO 1B)
Weybridge
(RQO 1B)
R. Bourne (S)
Wey Nav.
R. Wey
Woking
PLAN OF STUDY AREA
SHOWING SAMPLE SITES
AND RQO REACHES
A – N ARM SAMPLE POINT
B – S ARM SAMPLE POINT
C – D/S SAMPLE POINT

Fig. 2 Chertsey Outfall

4. Structure of Survey

To study the Bourne river system a 24 hour survey was carried out on the 20th, 25th and 26th June 1991 to determine the character of the effluent from Chertsey STW. This was carried out using autosamplers placed in the effluent channel. Subsequent samples were tested with a water dipper multimeter for percentage dissolved oxygen, temperature and ammoniacal nitrogen.

The second 24 hour survey was carried out on the 17th and 18th July at sites including upstream and downstream as well as the effluent channel itself. Once again the main parameter in question was ammoniacal nitrogen, but this time 2 hourly BOD's were also taken.

The third 24 hour survey conducted on 14th and 15th August compared the ammoniacal nitrogen, DO and BOD much further downstream at the confluence of the north and south arms. For this study flow measurements were also taken so that total loading of ammoniacal could be compared for the two arms plus the downstream section.

For all three of these 24 hour studies the flows were at a minimum due to the dry weather of the 1991 summer, although it must be remembered that the flows from the works were also at a minimum at this time.

5. Data from 24 hour Survey

Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7

6. Interpretation of 24 hour Data

Figs 2 (I) and (II) show that over the study period the ammoniacal nitrogen values emanating from Chertsey outfall did not exceed 4.5mg/l. This is also true of the outfall on 14th/15th August (Fig. 6(II) which shows the outfall reaching a maximum of 3.25mg/l ammoniacal nitrogen and the corresponding ammoniacal nitrogen values in the river at Bourne above Thames peaking at around 0.7mg.l at 0700 am on 15th August.

In order to superimpose the outfall values onto the Bourne above Thames values over this 24 period, the outfall and river sampling was staggered by approximately 10 hours which corresponds to the time of travel between these two sites (Fig. 6(II). The time of travel was determined by using Potassium Iodide as a tracer and an ion specific electrode to follow the tracer downstream. It must be noted however that on superimposing the outfall onto the river samples (Fig. 6(II) no account of flows from Chertsey or the river was considered.

(Figure 4(I) and (II)) show the dissolved oxygen and ammoniacal levels at sample points C and A in Fig. 1 respectively. As can be seen there is a diurnal pattern which seems to be mirrored in the north arm and below the confluence, this shows the DO levels at a maximum around sunset and at this time the ammoniacal nitrogen level is at a minimum. The DO peaks and troughs are a natural phenomena dependant upon the rate of photosynthesis etc, but the trough in ammoniacal nitrogen levels are dependent upon the discharges from the sewage works etc and the fact that these two appear to coincide must surely be coincidence unless there is some proven link between nitrification and DO levels.

Figs 5(II) and Fig 14 show the flow values taken over the 24 hour period of 14/15th August. Values for the north arm were obtained by subtracting the flow values of the north and south combined.

The flows in the downstream section are dominated by the flow from the North arm, the south arm not showing a very distinct flow pattern at all.

Fig 5(I) was obtained by multiplying the values in Fig. 5(II) by the ammoniacal nitrogen values found in Fig. 6(II) for the respective arm, once again it appears that the north arm tends to influence the load of the downstream section, the load of amoniacal nitrogen from the south arm being "relatively" consistant.

Fig. 7 shows the flows from Chertsey works over the period 14/15th August.

7. Interpretation of Archived Data

Fig. 7	Fig. 9	Fig. 11	Fig. 15
Fig. 8	Fig. 10	Fig. 12	Fig. 14

Figs 8(I) and 8(II) indicate the ammoniacal nitrogen levels and dissolved oxygen levels at both Hamperstone Bridge (RQO 2A) and Bourne above Thames (RQO 1B) since 1986.

Fig. 8(II) shows that of the 78 samples taken between 21/1/86 and 30/5/91 there were 8 failures of ammoniacal nitrogen (10.25%). If the 1B RQO criteria are taken then the failure rate rises to 67%.

Fig. 8 (I) shows the same time period as 8(II) but for the Bourne above Thames (1B) site. Here 17 out of the 60 samples 28% fail, but if we apply the 2A RQO value of 2.2 mg/l for ammoniacal nitrogen this failure rate drops to 1.6%, by only one sample in 60 failing.

Fig. 9 gives the ammoniacal nitrogen values for Chertsey outfall over the same time period as for 8(I) and 8(II) above, and shows a failure of 6% i.e. 12 out of 202 samples for ammoniacal nitrogen.

In order to compare ammoniacal values from Chertsey with those in the Bourne North at Hamperstone Bridge and Bourne above Thames the archive was searched for samples taken on or as close to, the same day as possible. In reality this involved samples which may have been taken up to 15 hours apart. These pairs of samples can be seen in Figs 10 and 11.

Fig. 12 shows these same samples plotted on the same graph, and as can be seen there is a very good correlation between outfall ammoniacal nitrogen values and ammoniacal nitrogen values in the river. These results are clearer when represented as a scatter plot as in Fig. 13.

As can be seen from 13(I) and (II), that when Chertsey is discharging say for example an effluent 9mg/l ammoniacal nitrogen (within consent limits) the predicted ammoniacal levels at Hamperstone and Bourne above Thames are 3.5 and 1.65 mg/l respectively, which both represent RQO failures. During this study Chertsey was discharging ammoniacal levels of no more than 4.4mg/l ammoniacal nitrogen, this would reflect in 1.5mg/l at Hamperstone (pass) and 0.8mg/l at Bourne above Thames (fail). It is not difficult therefore to envisage a situation where Chertsey's effluent is bordering on consent limits of 9 or 10mg/l ammoniacal nitrogen and the Bourne above Thames site is seeing its ammoniacal nitrogen values rise to the order of 1.75mg/l, hence giving rise to RQO failures. For the regressions on the two sets of data the Correlation Coefficients were 0.83 and 0.86 for 13(I) and (II) respectively. It must however be realised that these samples were "spot" samples not taken for this purpose of comparison. To achieve a better Correlation samples should be taken with approximately 8-10 hours time difference between outfall and Bourne above Thames sites on the same day. Although flows were not taken into account in this comparison it must be said that this correlation is quite striking when taking into consideration the time of year when samples were taken. This would possibly have taken into account summer and winter flows and further sampling would only serve to enhance this correlation.

Fig. 15 shows the calculated ammoniacal nitrogen values for the north arm based upon flows and concentrations from Chertsey's discharge over the 14/15th August. These have been superimposed over the actual ammoniacal nitrogen values for the north arm for the same time period. As can be seen the actual concentrations are much lower than calculated and this may be due to other external factors such as input to the Bourne system from balancing ponds, surface run-off etc, alternatively we may be seeing nitrification between these two points.

8. Summary of Interpretation

1. Chertsey outfall has failed 12 out of 202 samples taken since 1986 on the ammoniacal nitrogen value. It would appear that for this study ammoniacal nitrogen is usually of the order 1-6mg/l over any 24 hour period.

2. The north arm of the Bourne dominates the flows and ammoniacal nitrogen loadings at the Bourne above Thames site below the confluence.

3. Input of ammoniacal nitrogen loads and flows from the south arm seems to be of little importance in downstream sampling.

4. From flow data it would appear that Chertsey is not yet critically overloaded, and it would appear that its ammoniacal nitrogen consent value of 10mg/l is far too relaxed. A value of 5mg/l would still enable both downstream sites to achieve their RQO's. (See fig. 13 (I) and (II)).

5. It would appear that the 1B RQO at the Bourne above Thames site is inappropriate given the short length of river, its amenity value mainly as a cyprinid fishery and Chertsey's ammoniacal nitrogen consent.

   It would appear that the two factors i.e. Chertsey's consent and the RQO at Bourne above Thames were arrived at independently. It would be unwise to expect the RQO to meet 1B when Chertsey's ammoniacal nitrogen is 10mg/l, but this is the consented limit, and either a tightening of consents is required to meet the arbitrarily assigned RQO or a relaxation of the RQO to 2A to take into account the rivers amenity value.

9. Conclusions

Over the study periods Chertsey's effluent showed a peak in ammoniacal nitrogen at around 4 to 5 am each morning (Fig. 2 (I)). This would appear to be the time when the highest ammoniacal nitrogen values are recorded and hence spot samples taken between 9am and 5pm most days will have missed the worst scenario.

The ammoniacal peaks at Bourne above Thames seemed to be at a maximum at approximately 12 midnight (figs 4 and 5) which corresponds to an eight hour time of travel between the two points at this flow. Future sampling of Chertsey and Bourne above Thames should be taken on the same day with a time difference of eight hours if these two sites are to be comparable, at these flow conditions.

The relationship between outfall and Bourne above Thames site over 24 hours (Fig. 6 II) seems to be reinforced by the archived data over a number of years (Fig. 12). This shows (not surprisingly!) that the higher the concentration of ammoniacal nitrogen discharged by Chertsey, the higher the level of ammoniacal nitrogen found at the Bourne above Thames site.

The relationship seems to be adhered to regardless of time of year and presumably the flow conditions when samples were taken.

The amenity value of the Bourne above Thames site does not need to be In the 1B category, a 2A RQO would satisfy all of the requirements asked of this small stretch of river. It is mainly a river flowing through residential premises and is certainly not used as a potable water supply or game fishery. If the RQO at Bourne above Thames must for some political reasons stay as a 1B classification then Chertsey STW's consent must be tightened so as to be in line with the chemical analysis used for RQO compliance, and an ammoniacal nitrogen consent value of 4 or 5mg/l would not be beyond Chertsey's reach.

10. Future Monitoring

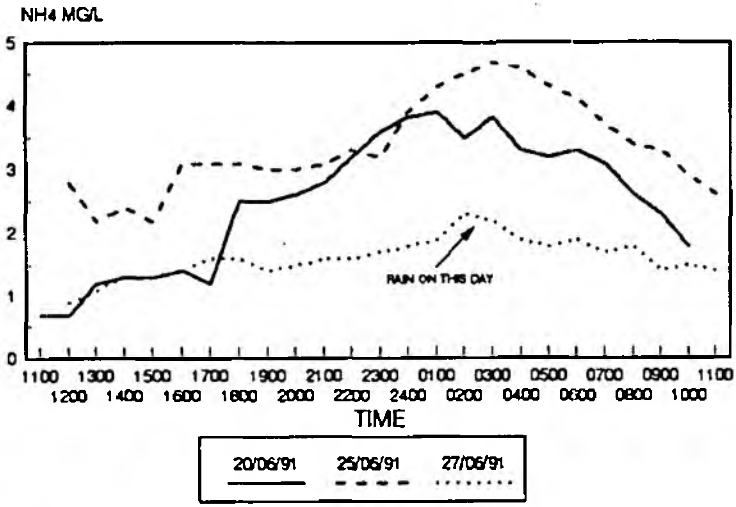
As mentioned in Section 9, to be able to compare samples at Chertsey and Bourne above Thames the sampling programme must take into account time of travel and flows between these two points, although this will give some comparison between the two it will not however always capture the "worst scenario" at Chertsey as this seems to happen in the early hours of the morning under these flows and conditions.

To take this into account I suggest that 24 hour surveys using either autosamplers or samples taken manually over 24 hours should be carried out at regular intervals to determine the ammoniacal nitrogen peak time, and level. If samples at Chertsey's outfall and samples in the river are to be compared, the samples must be taken on the same day preferably about eight hours apart to take into account the time of travel between the two points.

Of course to get the full picture a constant monitoring device such as an AQMS would be the most efficient at relaying constant river data.

FIG 2

1 CHERTSEY OUTFALL ON 20/25/27 JUNE



2 CHERTSEY OUTFALL 140891 AMMONIA

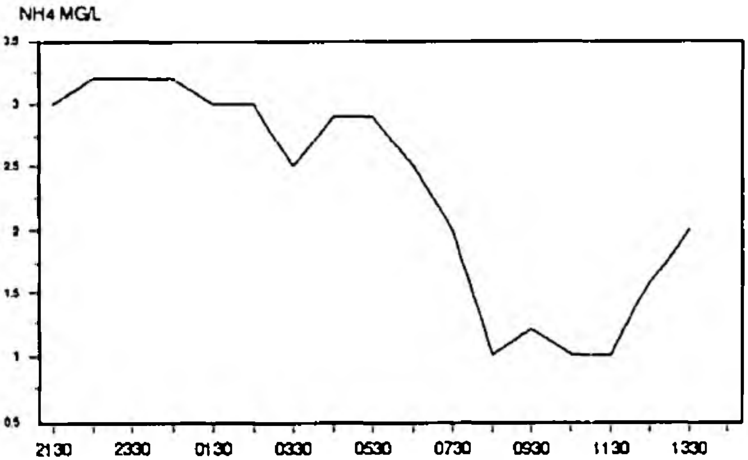
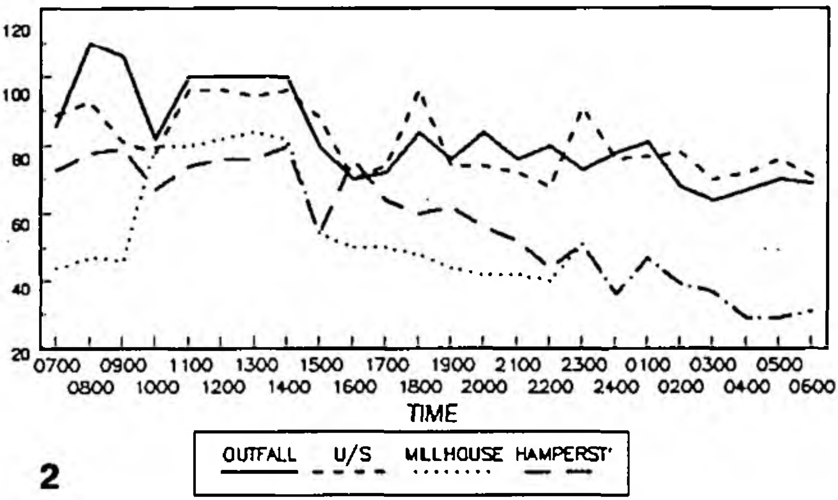


FIG 3

1

BOURNE 24 HOUR STUDY 17/18 JULY 1991



2

BOURNE U/S STW

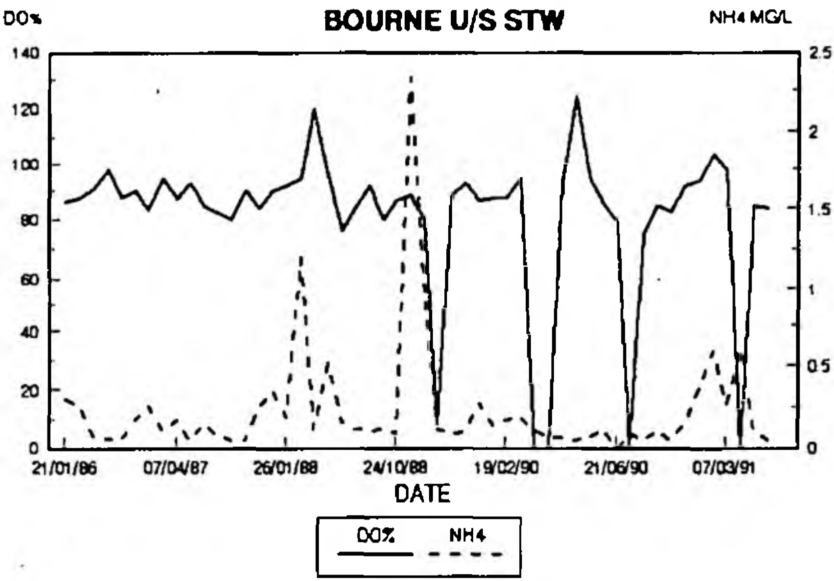
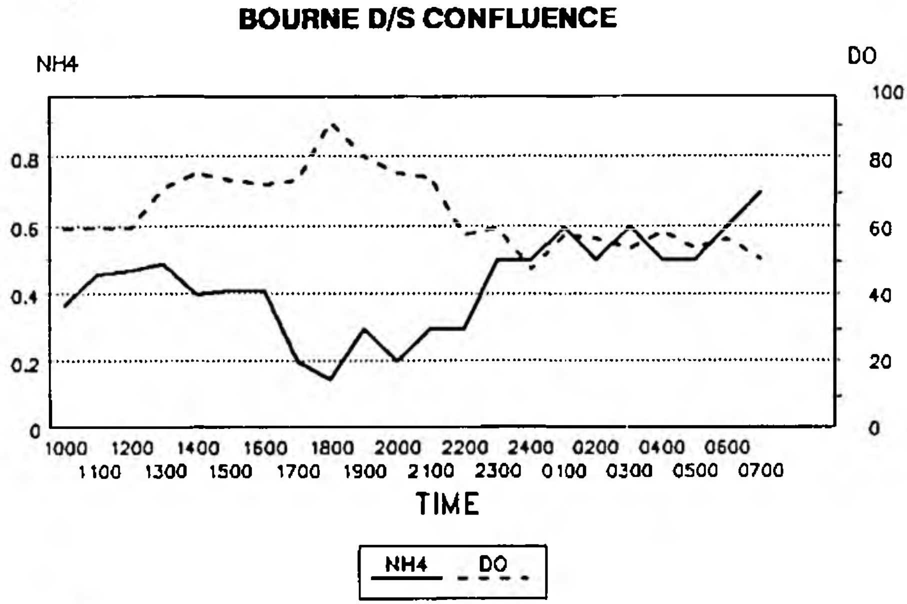


FIG 4

1


BOURNE D/S CONFLUENCE
NH4
DO
100
0.8
80
0.6
60
0.4
40
0.2
20
0
0
1000 1200 1400 1600 1800 2000 2200 2400 0200 0400 0600
1100 1300 1500 1700 1900 2100 2300 0100 0300 0500 0700
TIME
NH4
DO

2

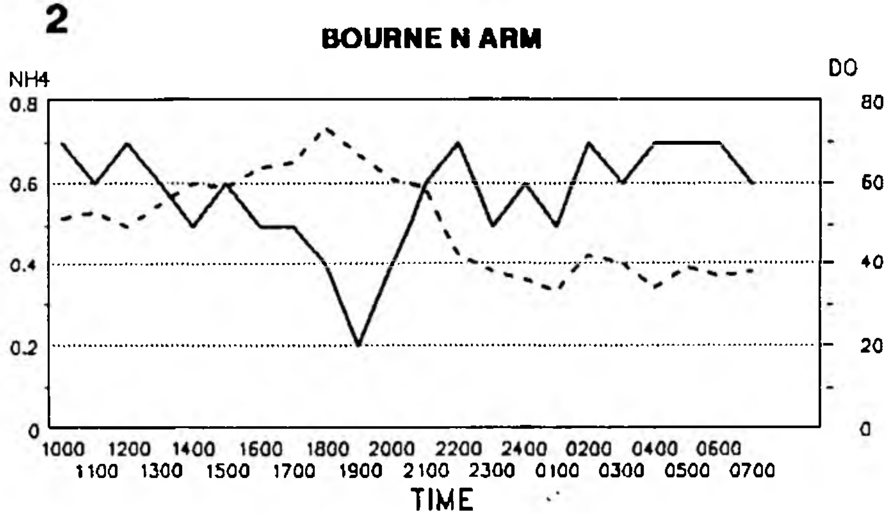
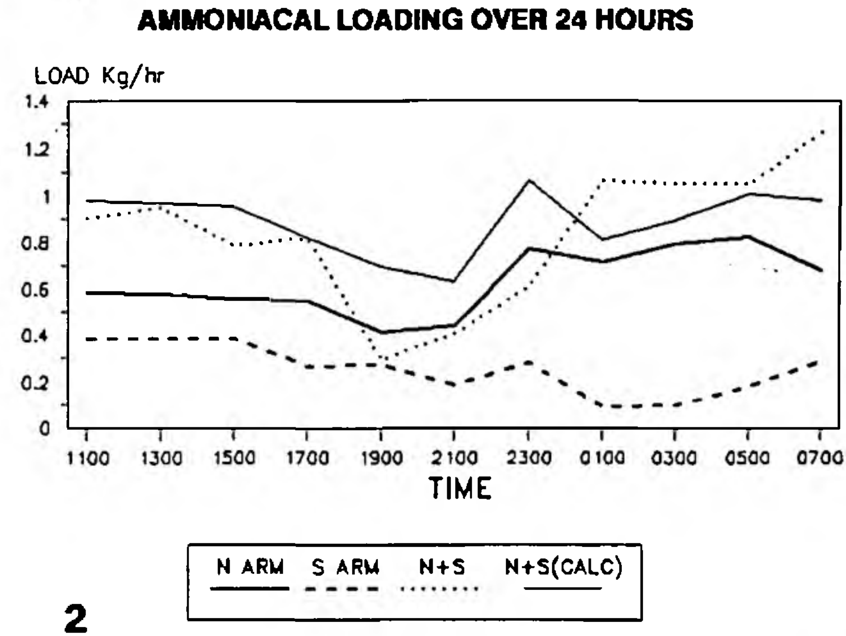
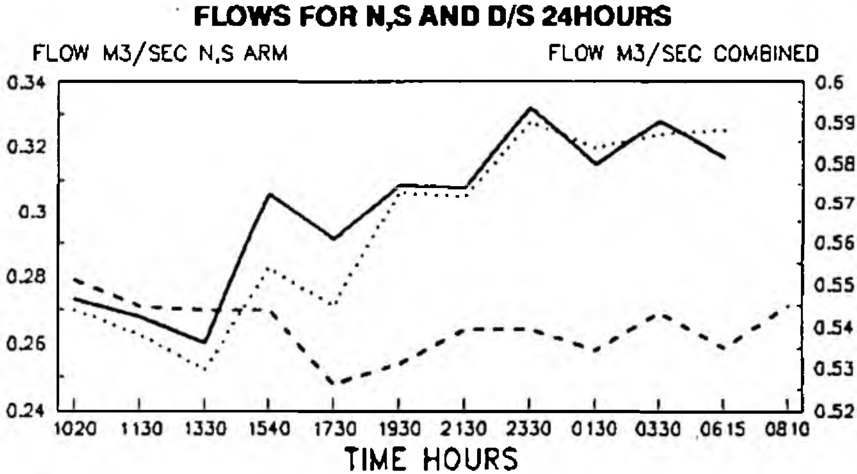

BOURNE N ARM
NH4
DO
0.8
80
0.6
60
0.4
40
0.2
20
0
0
1000 1200 1400 1600 1800 2000 2200 2400 0200 0400 0600
1100 1300 1500 1700 1900 2100 2300 0100 0300 0500 0700
TIME

FIG 5

1


AMMONIACAL LOADING OVER 24 HOURS
LOAD Kg/hr
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1100
1300
1500
1700
1900
2100
2300
0100
0300
0500
0700
TIME
N ARM
S ARM
N+S
N+S(CALC)

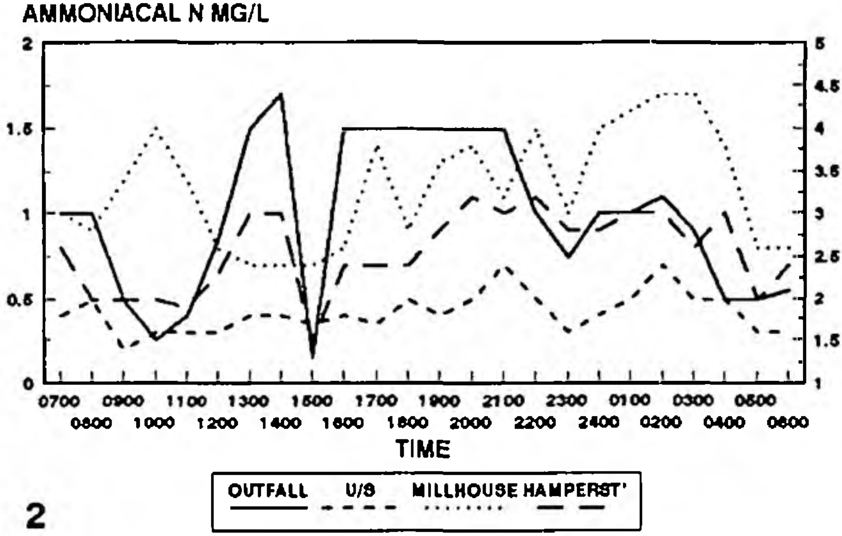
2


FLOWS FOR N,S AND D/S 24HOURS
FLOW M3/SEC N,S ARM
FLOW M3/SEC COMBINED
0.34
0.32
0.3
0.28
0.26
0.24
0.6
0.59
0.58
0.57
0.56
0.55
0.54
0.53
0.52
1020
1130
1330
1540
1730
1930
2130
2330
0130
0330
0615
0810
TIME HOURS

1

FIG 6

BOURNE 24 HOUR STUDY 17/18 JULY 1991



2

OUTFALL/BAT/N ARM IMPOSED

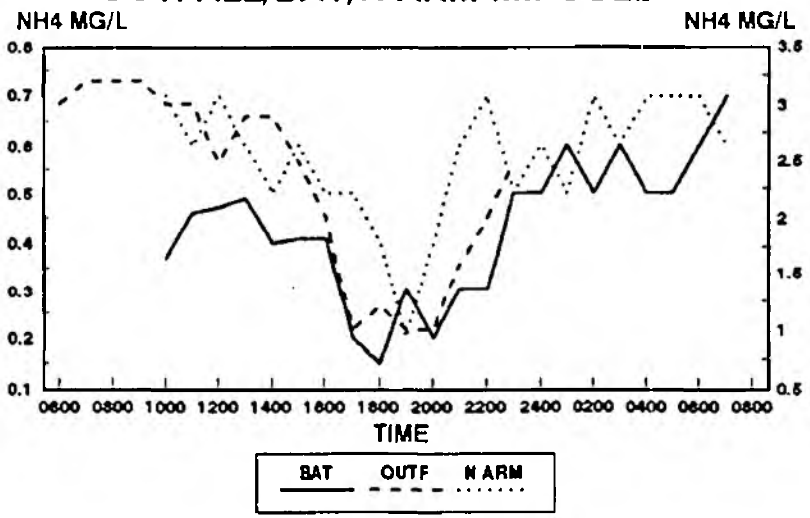


FIG 7

FLOWS FROM CHERTSEY STW 14/15 AUGUST

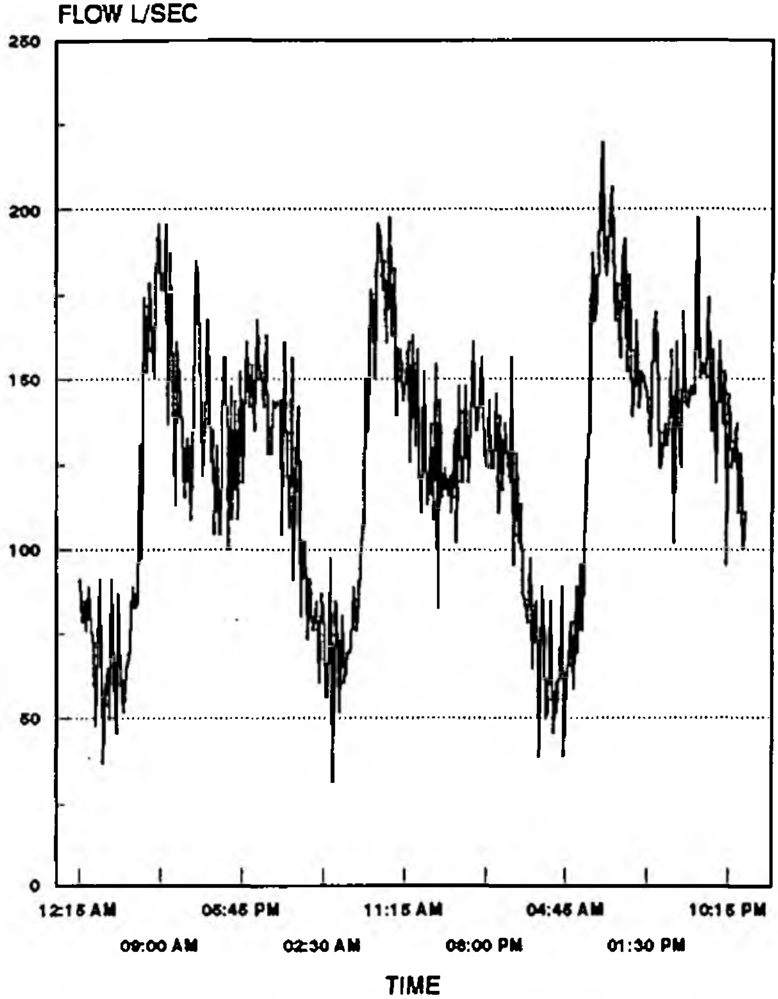
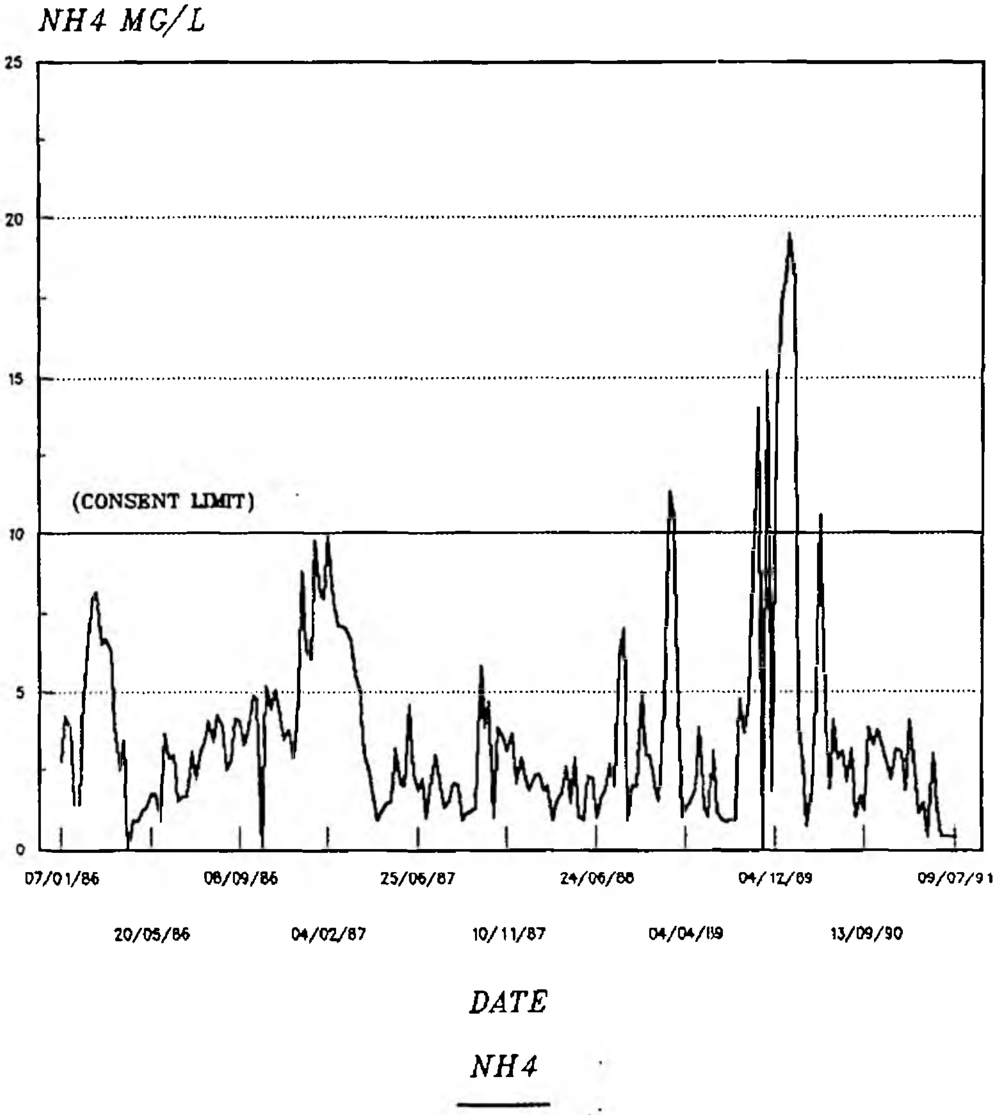


FIG 9

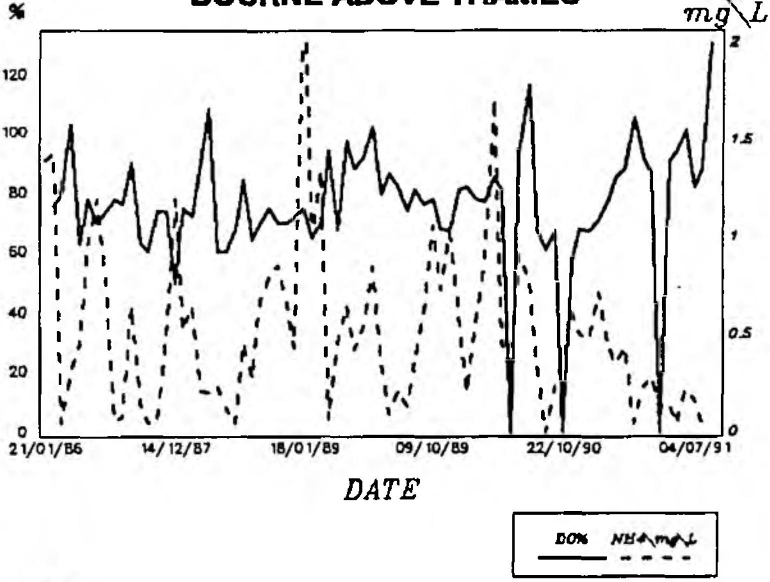
CHERTSEY STW



1

FIG 8

BOURNE ABOVE THAMES



2

HAMPERSTONE BRIDGE

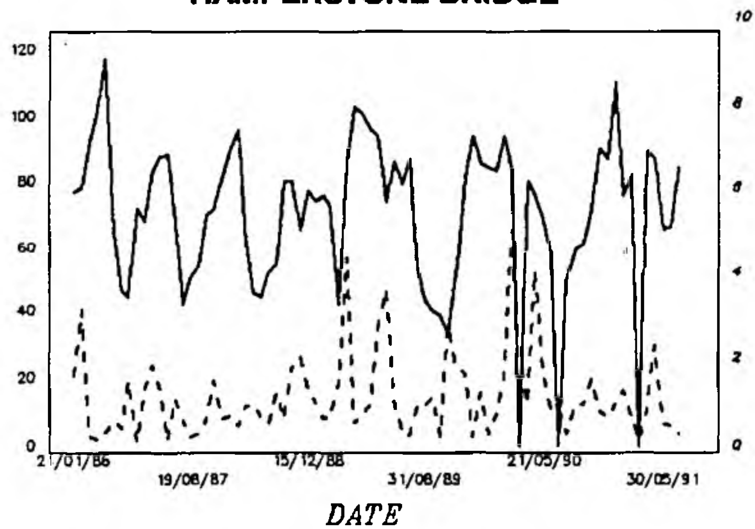


FIG 10

CHERTSEY AND HAMPERSTONE

SAME DAY NH4

	OUTFALL N mg/l	HAMPERSTONE N mg/l
20/08/86	4.00	0.56
08/01/87	6.00	1.30
03/03/87	7.00	1.80
09/06/87	4.60	1.07
18/08/87	2.10	0.20
26/04/88	1.10	0.46
15/02/89	10.60	4.36
27/07/89	0.95	0.24
06/11/89	3.74	1.81
09/01/90	4.42	1.63
24/01/90	2.70	0.22
05/02/90	0.83	0.27
19/02/90	1.86	0.73
05/03/90	4.83	1.57
20/03/90	10.65	5.04
18/04/90	1.92	0.94
21/05/90	2.84	1.68
13/06/90	3.11	0.84
26/06/90	3.20	0.85
18/03/91	1.23	0.68
30/05/91	1.39	0.48
26/06/91	0.50	0.45
04/07/91	0.50	0.28

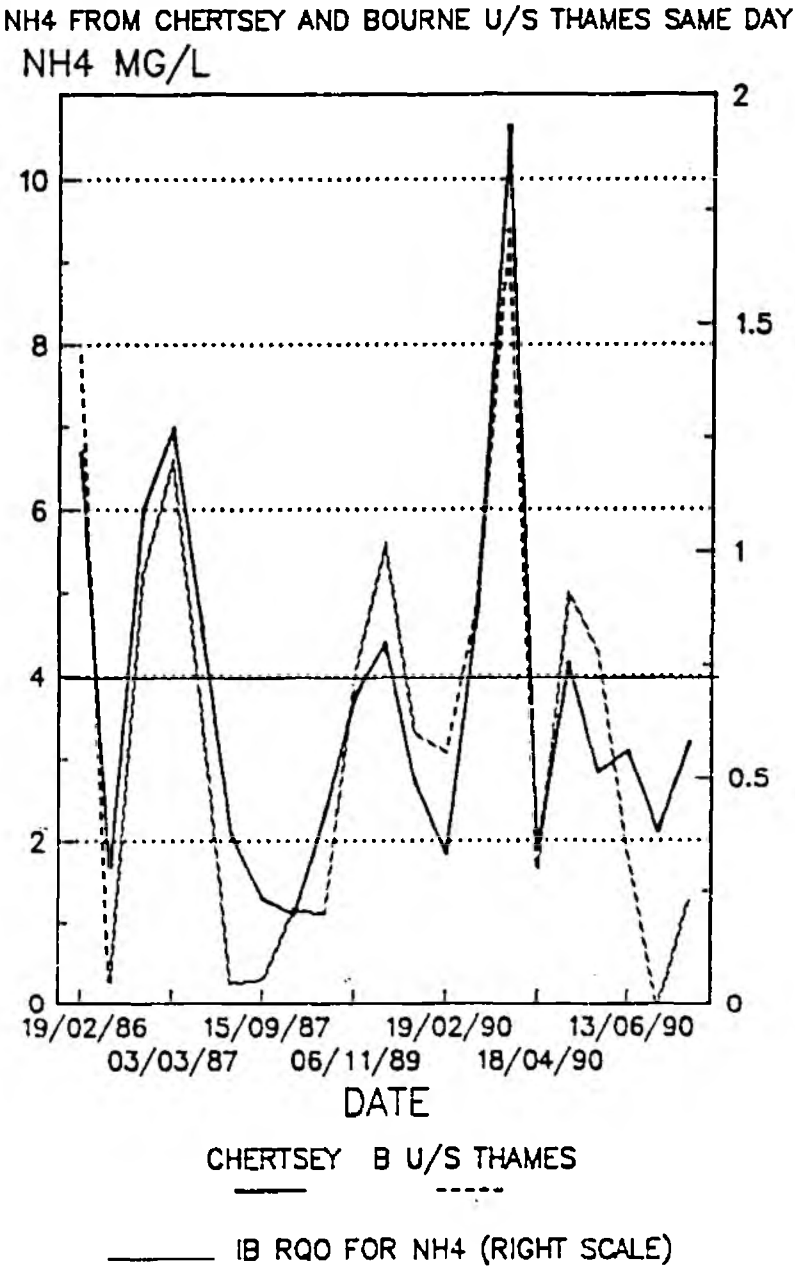
FIG 11

CHERTSEY AND BOURNE ABOVE THAMES

SAME DAY NH4

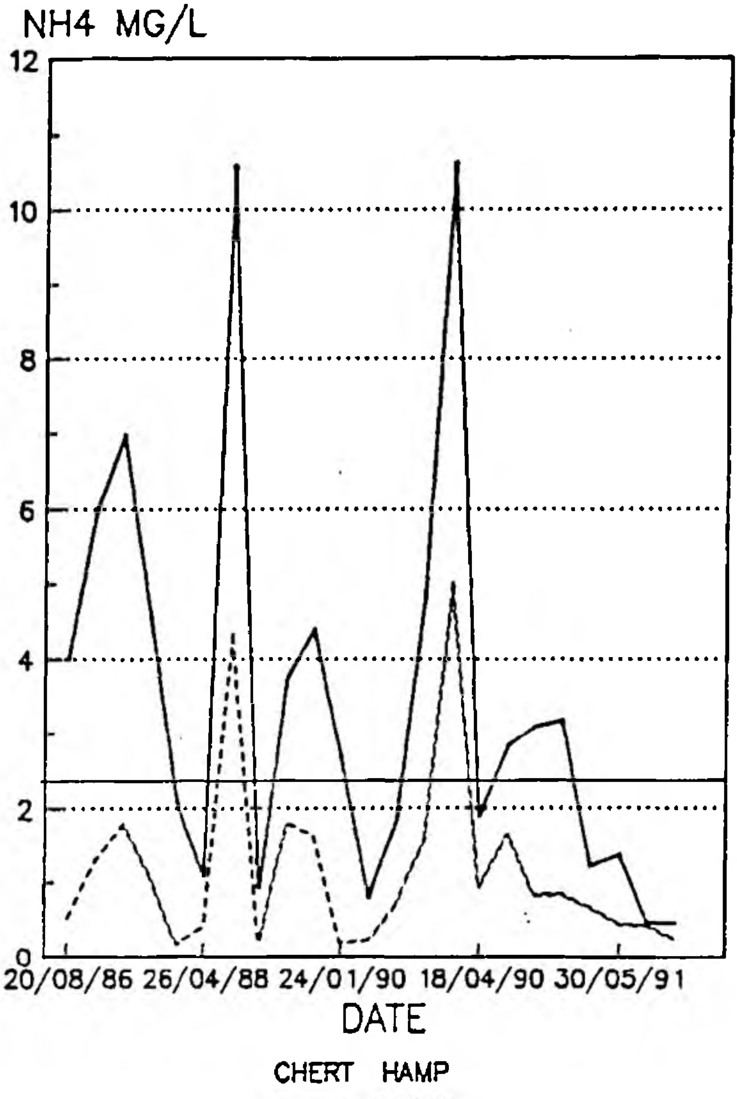
	CHERTSEY	B U/S THAMES
19/02/86	6.70	1.43
30/06/86	1.70	0.05
08/01/86	6.00	0.95
03/03/87	7.00	1.20
09/06/87	4.60	0.65
19/08/87	2.10	0.05
15/09/87	1.30	0.06
26/04/88	1.10	0.21
24/05/88	2.30	0.20
06/11/89	3.74	0.73
09/01/90	4.42	1.02
24/01/90	2.70	0.60
19/02/90	1.86	0.56
05/03/90	4.83	0.89
20/03/90	10.65	1.71
18/04/90	1.92	0.30
02/05/90	4.18	0.91
21/05/90	2.84	0.78
13/06/90	3.11	0.34
21/06/90	2.11	0.00
26/06/90	3.20	0.23

FIG 12



NH4 FROM CHERTSEY AND BOURNE U/S THAMES SAME DAY
NH4 MG/L
10
8
6
4
2
0
2
1.5
1
0.5
0
19/02/86
03/03/87
15/09/87
06/11/89
19/02/90
18/04/90
13/06/90
DATE
CHERTSEY
B U/S THAMES
IB RQO FOR NH4 (RIGHT SCALE)

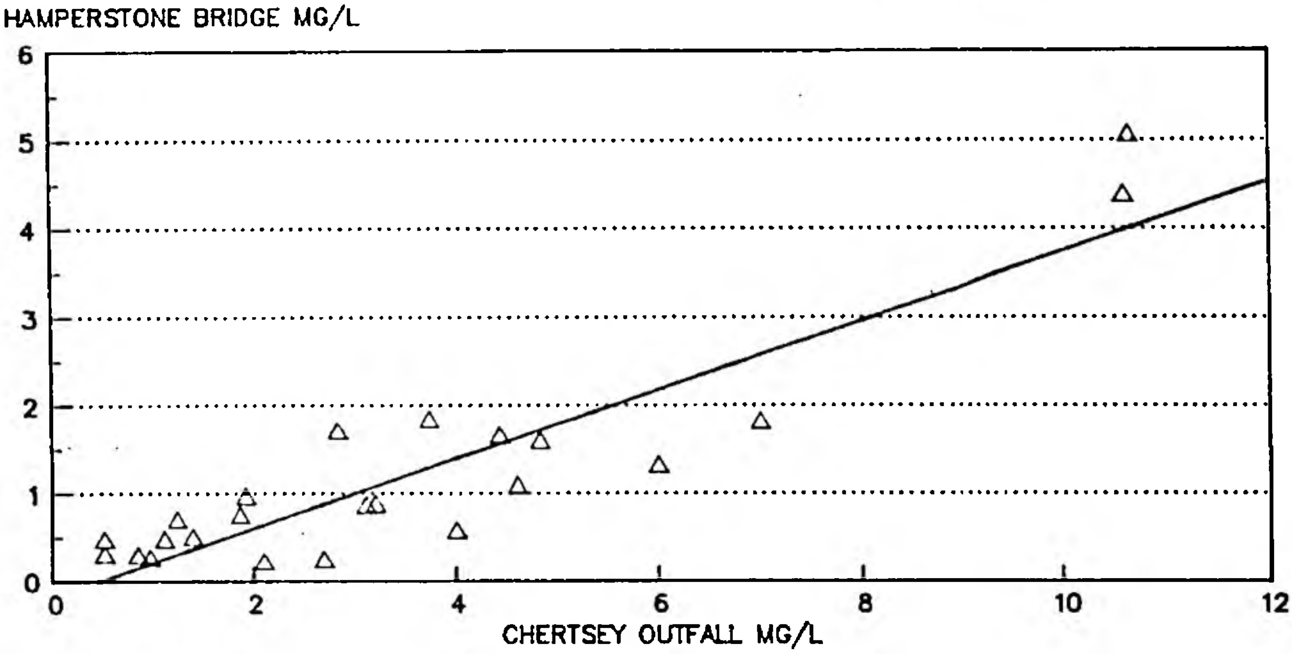
CHERTSEY AND HAMPERSTONE SAME DAY NH4



2A RQO FOR NH4

FIG 13

CHERTSEY AND HAMPERSTONE SAME DAY NH4



CHERTSEY AND BOURNE U/S THAMES SAME DAY NH4

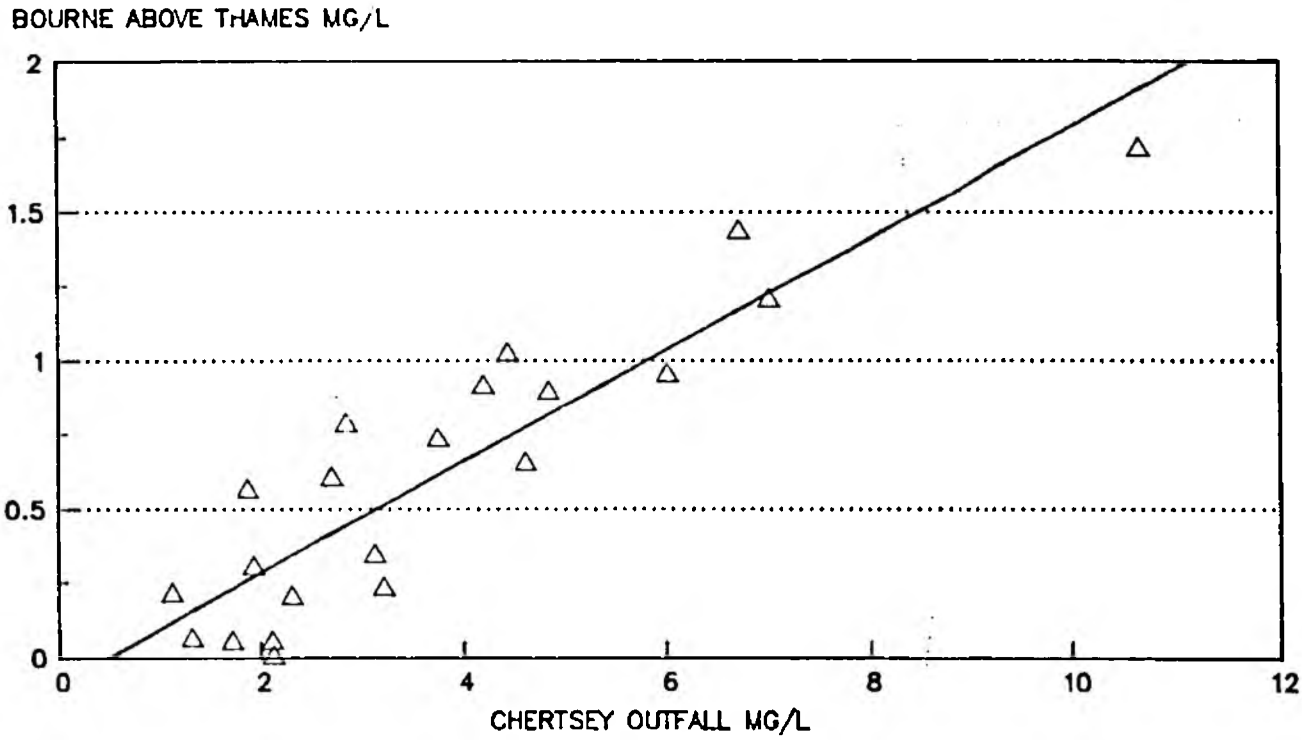


FIG 14

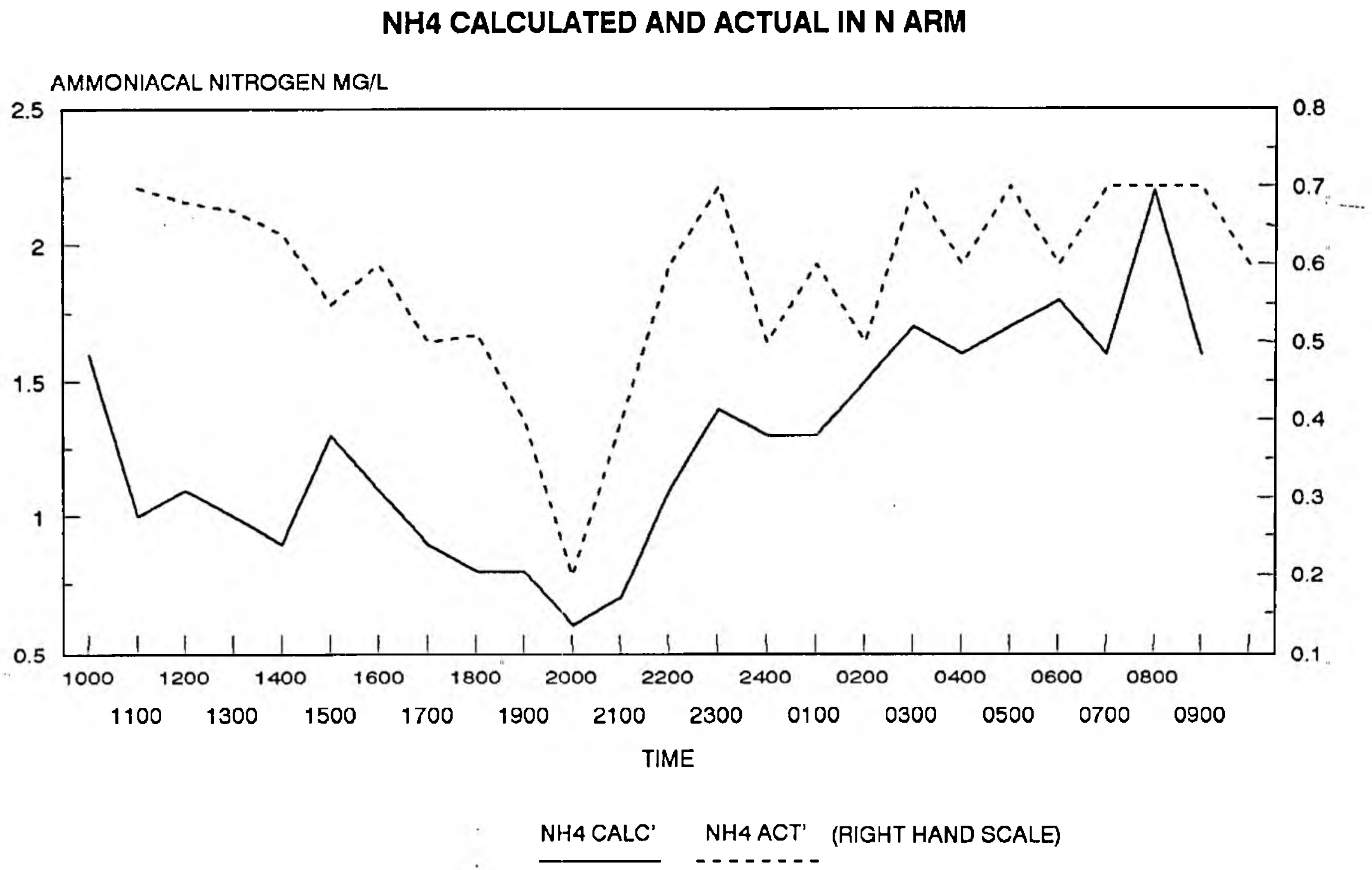
FLOW GAUGING 14th and 15th August 1991

RIVER BOURNE (SOUTH) — **RIVER BOURNE (TOTAL)**

TIME	FLOW	TIME	FLOW
10.20 - 10.40	0.279		
11.30 - 11.45	0.271	11.25 - 11.55	0.544
13.30 - 13.50	0.270	14.00 - 14.25	0.538
15.40 - 16.00	0.270	16.05 - 16.30	0.530
17.30 - 18.10	0.248	18.15 - 18.45	0.554
19.30 - 19.55	0.254	20.00 - 20.25	0.545
21.30 - 21.50	0.264	22.00 - 22.30	0.573
23.30 - 23.45	0.264	00.15 - 00.45	0.572
01.30 - 01.45	0.258	02.00 - 02.30	0.590
03.30 - 03.50	0.269	04.00 - 04.25	0.584
06.15 - 06.30	0.259	05.30 - 06.10	0.587
08.10 - 08.25	0.271	07.30 - 08.05	0.588

CHERTSEY U/S STW TQ 015 680
15/8/91 09.40 FLOW= 0.035

FIG 15


NH4 CALCULATED AND ACTUAL IN N ARM
AMMONIACAL NITROGEN MG/L
2.5
2
1.5
1
0.5
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
0100
0200
0300
0400
0500
0600
0700
0800
0900
TIME
NH4 CALC'
NH4 ACT'
(RIGHT HAND SCALE)

SURVEY DATA

CHERTSEY OUTFALL 27/06/1991

TIME	pH	AMMONIACAL N mg/l
1200	8.2	0.9
1300	8.2	1.1
1400	8.18	1.3
1500	8.17	1.3
1600	8.17	1.4
1700	8.01	1.6
1800	8.2	1.6
1900	8.13	1.4
2000	8.14	1.5
2100	8.08	1.6
2200	8	1.6
2300	8	1.7
2400	7.95	1.8
0100	8.04	1.9
0200	7.86	2.3
0300	8.14	2.2
0400	7.9	1.9
0500	7.8	1.8
0600	8	1.9
0700	7.9	1.7
0800	7.87	1.8
0900	7.8	1.4
1000	7.86	1.5
1100	8	1.4

CHERTSEY OUTFALL 20/06/1991

TIME	AMMONIACAL N mg/l	DO %
1100	0.7	76.6
1200	0.7	62
1300	1.2	74.1
1400	1.3	77
1500	1.3	73.8
1600	1.4	76.2
1700	1.7	73.2
1800	2.5	74
1900	2.5	60
2000	2.6	55.5
2100	2.8	53
2200	3.2	71
2300	3.6	82
2400	3.8	86
0100	3.9	84
0200	3.5	83
0300	3.8	86
0400	3.3	83
0500	3.2	86
0600	3.3	85
0700	3.1	88
0800	2.6	87
0900	2.3	85
1000	1.8	86

CHERTSEY OUTFALL 25/06/1991

TIME	AMMONIACAL N mg/l
1220	2.8
1320	2.2
1420	2.5
1520	2.2
1620	3.1
1620	3.1
1720	3.1
1820	3.0
1920	3.0
2020	3.1
2120	3.3
2220	3.2
2320	3.9
0120	4.3
0220	4.5
0320	4.7
0420	4.6
0520	4.3
0620	4.1
0720	3.7
0820	3.4
0920	3.3
1020	2.9
1120	2.6

24 HOUR RUN 14/15 AUGUST 1991

	N ARM	N ARM	S ARM	S ARM	DOWNSTREAM	DOWNSTREAM
	AMMONIACAL N/mg/l	DO %	AMMONIACAL N/mg/l	DO %	AMMONIACAL N/mg/l	DO%
1000	0.7	52	0.3		0.37	
1100	0.6	63	0.4	80	0.45	60
1200	0.7	60	0.4	80	0.47	60
1300	0.6	55	0.4	78	0.49	72
1400	0.5	60	0.4	87	0.4	76
1500	0.6	69	0.4	85	0.41	74
1600	0.5	64	0.4	83	0.41	73
1700	0.6	66	0.3	82	0.2	74
1800	0.4	74	0.3	96	0.15	91
1900	0.2	67	0.3	94	0.3	81
2000	0.4	61	0.2	96	0.2	76
2100	0.6	69	0.3	85	0.3	75
2200	0.7	42	0.3	62	0.3	58
2300	0.6	38	0.6	74	0.6	60
2400	0.6	36	0.0	72	0.6	48
0100	0.5	33	0.2	76	0.6	58
0200	0.7	42	0.1	79	0.6	67
0300	0.6	40	0.2	74	0.6	54
0400	0.7	34	0.2	72	0.6	59
0500	0.7	39	0.4	77	0.5	64
0600	0.7	37	0.3	76	0.6	67
0700	0.6	38	0.45	75	0.7	51

CHERTSEY OUTFALL 14/08/1991

TIME	AMMONIACAL N mg/l
2130	3
2230	3.2
2330	3.2
0030	3.2
0130	3
0230	3
0330	2.6
0430	2.9
0530	2.9
0630	2.6
0730	2
0830	1
0930	1.2
1030	1
1130	1
1230	1.6
1330	2