OSCAR FABER

CLIENT: NATIONAL RIVERS AUTHORITY

SOUTH WESTERN REGION

PROJECT: TIME OF TRAVEL OF POLLUTANTS STUDY

RIVER TORRIDGE – Q28/Q32

DATE: 16 JANUARY 1995

OSCAR FABER WATER
NORTHERNHAY HOUSE
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EXETER
DEVON
EX4 3RY

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Revision	Purpose	Originated	Checked	Reviewed	Authorised	Date
Final	To Client for Approval	J Harris	M Spry	G Howells	J Harris	16 Jan 95

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1.0 SUMMARY

Oscar Faber Water was commissioned by the National Rivers Authority, South Western Region, to undertake a study of the time of travel of pollutants in the River Torridge between Black Torrington Bridge and Old Rothern Bridge, during high flow conditions. The study was carried out over the period 14th to the 15th December 1994.

The river was divided into six reaches and these were studied in succession in an upstream direction using Rhodamine–B as the tracer. Average daily flow reduced gradually during the study period from a Q28 percentile (Torrington gauge, 16.730 m^3/s) to a Q32 percentile (Torrington gauge, 14.324 m^3/s.)

The combined time of travel for the overall distance of 40.550 km for Black Torrington Bridge to Old Rothern Bridge, was 16 hours 35 minutes. The average velocity of travel was 0.68 m/s.

2.0 INTRODUCTION

Study of the time of travel of pollutants (TTP) in a river is an important aid to effective river management. If a pollution incident should occur, the results of such studies can provide accurate prediction of the arrival time of pollutants at any point downstream of the incident. This knowledge allows timely action to be taken to minimise the impact of polluting matter in the river upon legitimate uses such as abstraction for potable supply.

Oscar Faber Water was instructed to undertake time of travel of pollutants studies on the Rivers Axe, Taw and Torridge. This document details the results of the study carried out on the River Torridge over the period 14th to 15th December 1994. The objective of the study was to determine the time of travel of pollutants in the River Torridge from Black Torrington to Great Torrington at high flow, approximately Q20.

3.0 STUDY AREA

The length of river considered was that between Black Torrington Bridge, Black Torrington (NGR: SS 469 060) and Old Rothern Bridge, Great Torrington (NGR: SS 479 197). The Study Area is shown in Figure 1.

4.0 EQUIPMENT AND MATERIALS

The major items of equipment and materials used in undertaking the study were as follows:

- Chelsea Instruments Aquatracka III submersible fluorimeter
- *Data taker* digital logger
- Compaq 386 PC
- 12 v batteries and chargers
- Chart Recorder
- Rhodamine–B dye

5.0 METHODOLOGY

5.1 Reach Selection

The total length of river studied was approximately 40.550 km and this was divided into six reaches varying in length between 1.320 km and 14.730 km. The reaches were selected primarily for their ease of access and their proximity to major abstraction points and flow gauging stations. The length of each reach was measured from 1:50 000 scale Ordnance Survey sheets. The length of each reach is defined by dye input and monitoring points at their upstream and downstream ends. The locations of injection and monitoring points are shown on Figure 1 and National Grid References (NGR) are given in table 5.1 below.

SITE	NATIONAL GRID REFERENCE
Black Torrington Bridge	SS 469060
Hele Bridge	SS 540064
New Bridge	SS 548113
Beaford Bridge	SS 542142
New Bridge (Town Mills Torrington)	SS 499184
Taddiport Bridge	SS 488187
Old Rothern Bridge	SS 479197

Table 5.1 Dye Injection and Monitoring Points

5.2 Fieldwork

At each dye injection point, the appropriate weight of dye was mixed in a container with river water. The mixed solution was then injected into the main river flow and the time of injection recorded.

At the downstream end of each reach a fluorimeter was sited at an appropriate location in the main river flow to record the passing of the dye cloud. The fluorimeter signal was digitally logged at 15–second intervals and showed background level and levels as the dye cloud passed the submersed fluorimeter.

The signal was recorded by the datataker with real–time numerical and graphical display generated via an interface to a PC. As a backup, the signal was recorded manually with a continuous chart recorder.

6.0 RESULTS AND DISCUSSION

6.1 Flow

Flow in the River Torridge is monitored on a routine basis by the NRA, at Torrington gauging station. Figure 2 shows the flow record for the study period recorded at the gauging station. The study period ran between 13.15 hrs 14th December 1994 to approximately 20.00 hrs on 15th December 1994. In terms of percentile flow, an average of Q28 (Torrington gauge 16.730 m^3/s) was recorded on the 14th December and an average of Q32 (Torrington gauge, 14.324 m^3/s) was recorded on 15th December. These represent lower flows than those defined in the Brief, but were considered acceptable as presenting 'high' flow conditions.

6.2 Concentrations

Figures 3 to 8 show concentration of dye against time for each of the 6 monitoring sites. From each graph it is possible to determine, for each dye cloud, the time of first arrival of the dye at the fluorimeter, the time to reach peak concentration and the time for the peak to diminish by 50 percent. This information is summarised in Table 6.1 below.

Monitoring Point	Dye Injection Point	Reach Length (km)	Time of Travel		
			First Arrival	Peak	50% of Peak
Hele Bridge	Black Torrington Bridge	10.325	5hr 18m	6hr 19m	7hr 16m
New Bridge	Hele Bridge	6.795	3hr 06m	3hr 45m	4hr 25m
Beaford Bridge	New Bridge	5.770	2hr 03m	2hr 29m	3hr 10m
New Bridge (Town Mills Torrington)	Beaford Bridge	14.730	5hr 07m	5hr 56m	6hr 39m
Taddiport Bridge	New Bridge (Town Mills Torrington)	1.320	0hr 28m	0hr 33m	0hr 38m
Old Rothern Bridge	Taddiport Bridge	1.610	0hr 33m	0hr 39m	0hr 54m

Table 6.1 Summary of Time of Travel

Relatively little 'noise' is visible in the graphs. Where 'noise' does occur it may be as a result of vegetation or other matter interfering with the fluorimeter signal. The river was at 'high' flow for the duration of the study and significant quantities of suspended matter may have generated 'noise' by temporarily wrapping around the base of the fluorimeter.

It is believed that careful positioning of the fluorimeter throughout the study, in mid-stream locations, contributed to the overall low 'noise' levels observed. Positioning of the fluorimeter is important as locations near to the bank in weed, or adjacent to bridge piers were observed to generate the highest levels of background 'noise'.

Figure 3 (Old Rothern Bridge) is an example of noise registered by a fluorimeter situated in turbulent conditions adjacent to bridge piers. Figure 5 (Torrington Town Mills) is an example of noise registered by a fluorimeter secured to one bank and floated out into mid-stream, under the bridge.

Other reaches were monitored in deep mid-stream with equipment secured from bridges.

The time of first arrival of the dye cloud at each site has been plotted against distance in Figure 9. This allows the time of travel of pollutants to be estimated between any two points within the area of study. From the graph an average velocity of 0.68 m/s can be inferred for the overall stretch of river between Black Torrington Bridge and Old Rothern Bridge.

7.0 CONCLUSIONS

The study of the River Torridge undertaken between 14th – 15th December 1994 successfully achieved the objective of determining the time of travel of pollutants in the specified reaches at high flow. The data collected accurately shows the passing of individual dye clouds in the river at each of the monitoring stations. The velocity of travel of the dye varied from approximately 0.81 m/s (observed in the lower reaches 14/12/94) to approximately 0.54 m/s (in the upper reaches 15/12/94). A mean velocity of approximately 0.68 m/s was recorded at an average flow rate of Q30.

APPENDIX A – FLOW DURATION ANALYSIS

SURFACE FLOW ANNUAL REPORT

STATION NO. SS51F004
STATION NAME TORRINGTON RIVER TORRIDGE
NGR SS 5000 1844
CATCHMENT AREA 663.0 SQ KM

MINIMUM DAILY MEAN FLOW 0.120 CUMECS
MAXIMUM DAILY MEAN FLOW 333.788 CUMECS
MEAN DAILY FLOW 15.295 CUMECS

FLOW DURATION ANALYSIS FOR 1963 TO 1992

FLOW IN CUMECS	% OF MEAN DAILY FLOW	% OF DAILY VALUES GREATER THAN FLOW
333.788	2182.371	0.000
256.267	1675.523	0.027
196.751	1286.395	0.055
151.056	987.636	0.256
115.974	758.263	0.721
89.040	582.160	1.716
68.361	446.957	3.450
52.484	343.154	5.777
40.295	263.458	9.418
30.937	202.271	13.926
23.752	155.295	19.383
18.236	119.228	25.406
14.001	91.538	32.187
10.749	70.279	40.053
8.253	53.957	47.737
6.336	41.426	54.545
4.864	31.805	60.832
3.735	24.418	67.093
2.867	18.747	73.134
2.201	14.393	78.728
1.690	11.051	84.459
1.298	8.484	89.624
0.996	6.514	93.749
0.765	5.001	96.998
0.587	3.840	98.339
0.451	2.948	99.051
0.346	2.263	99.589
0.266	1.738	99.763
0.204	1.334	99.845
0.157	1.024	99.909
0.120	0.786	99.991

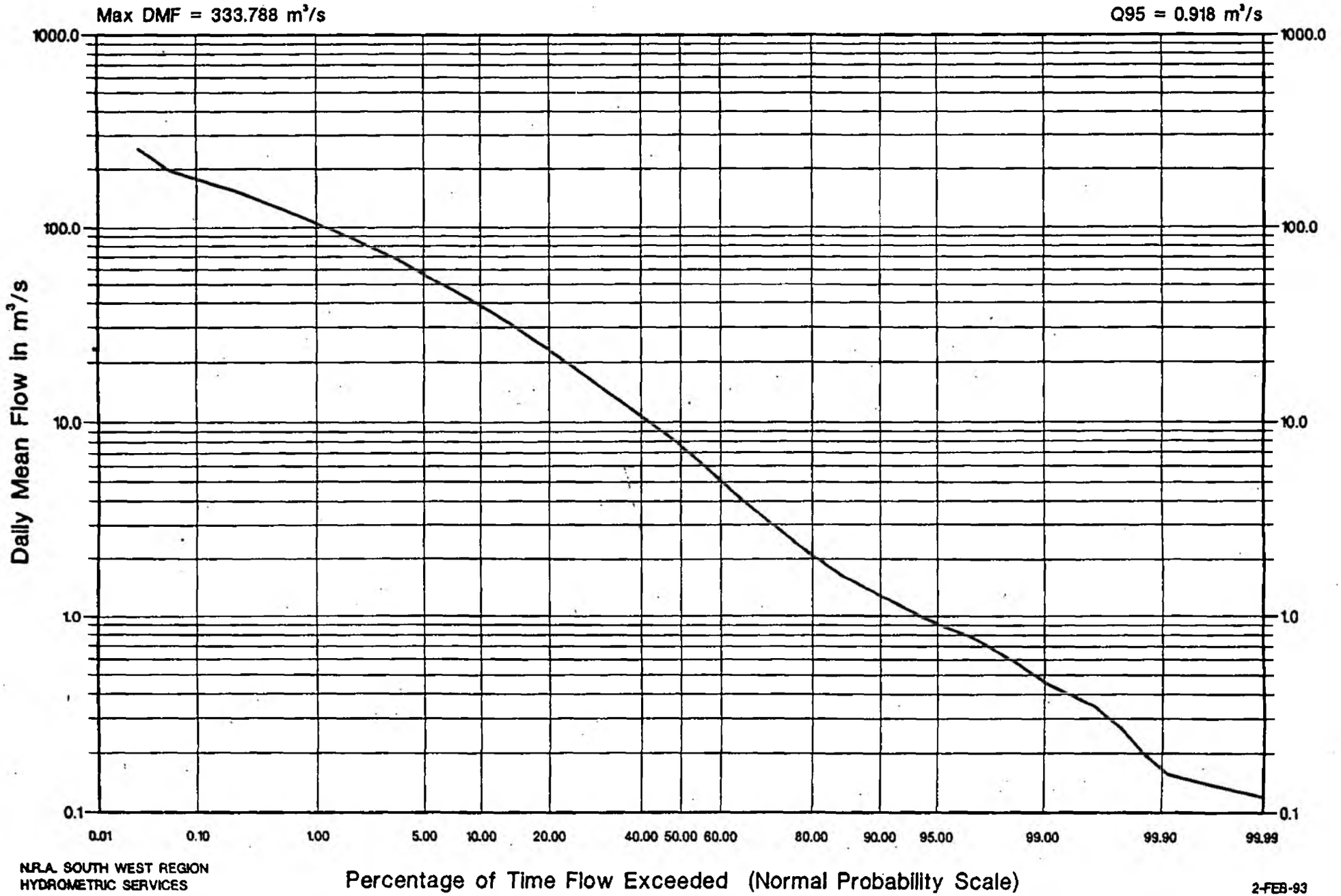
FLOW FREQUENCY ANALYSIS FOR 1963 TO 1992

FLOW RANGE (CUMECS)	NUMBER OF DAILY VALUES IN FLOW RANGE
>333.788	0
256.268 - 333.788	3
196.752 - 256.267	3
151.057 - 196.751	22
115.975 - 151.056	51
89.041 - 115.974	109
68.362 - 89.040	190
52.485 - 68.361	255
40.296 - 52.484	399
30.938 - 40.295	494
23.753 - 30.937	598
18.237 - 23.752	660
14.002 - 18.236	743
10.750 - 14.001	862
8.254 - 10.749	842
6.337 - 8.253	746
4.865 - 6.336	689
3.736 - 4.864	686
2.868 - 3.735	662
2.202 - 2.867	613
1.691 - 2.201	628
1.299 - 1.690	566
0.997 - 1.298	452
0.766 - 0.996	356
0.588 - 0.765	147
0.452 - 0.587	78
0.347 - 0.451	59
0.267 - 0.346	19
0.205 - 0.266	9
0.158 - 0.204	7
0.121 - 0.157	9
<= 0.120	1

TOTAL NO. DAILY VALUES 10958

RIVER TORRIDGE AT TORRINGTON

FLOW DURATION CURVE 1963-1992



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HYDROMETRIC SERVICES

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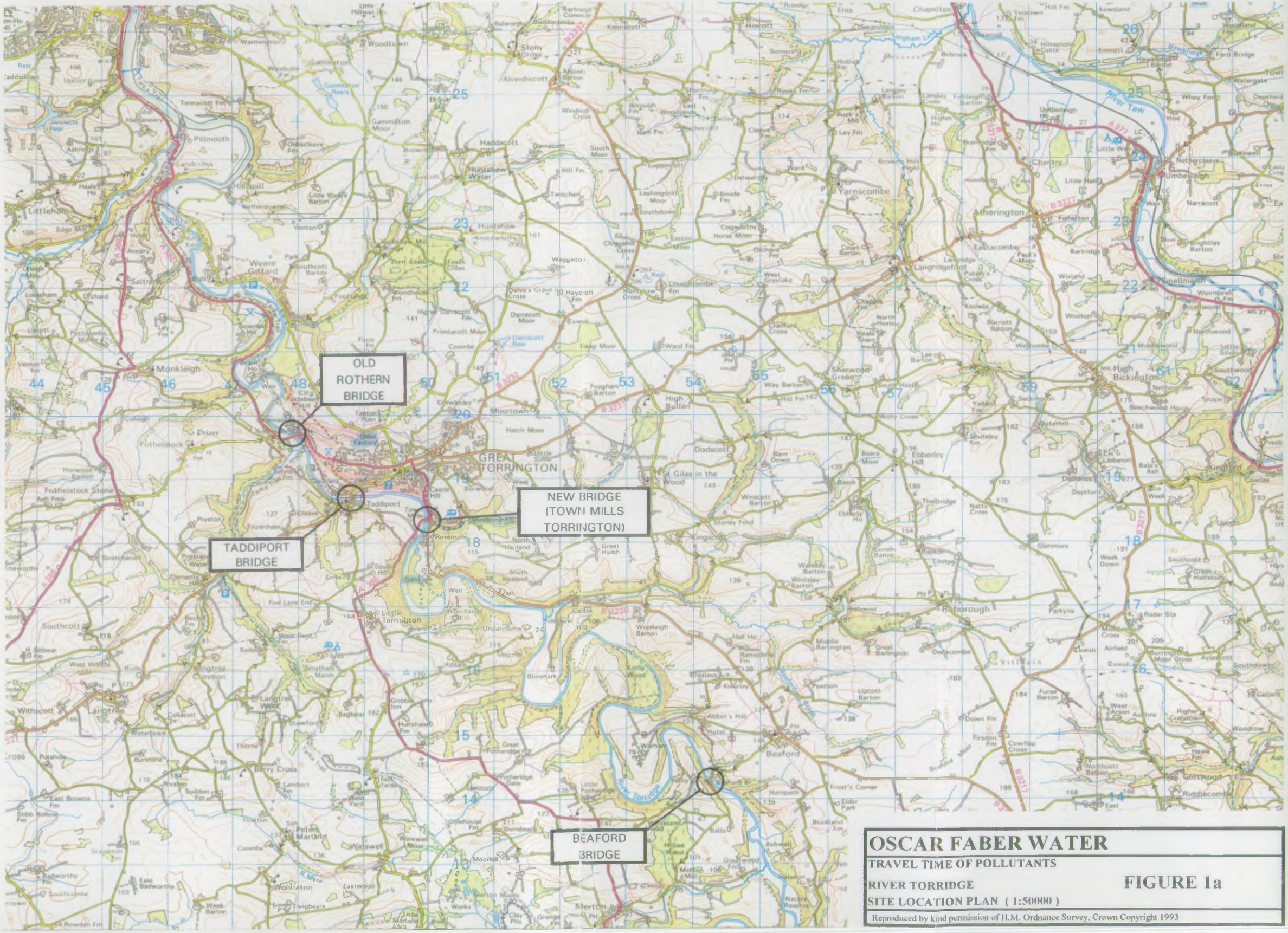
FIGURES



OSCAR FABER WATER

TRAVEL TIME OF POLLUTANTS

RIVER TORRIDGE

SITE LOCATION PLAN (1:50000)

FIGURE 1a

OSCAR FABER WATER

TRAVEL TIME OF POLLUTANTS

RIVER TORRIDGE **FIGURE 1b**

SITE LOCATION PLAN (1:50000)

OSCAR FABER WATER

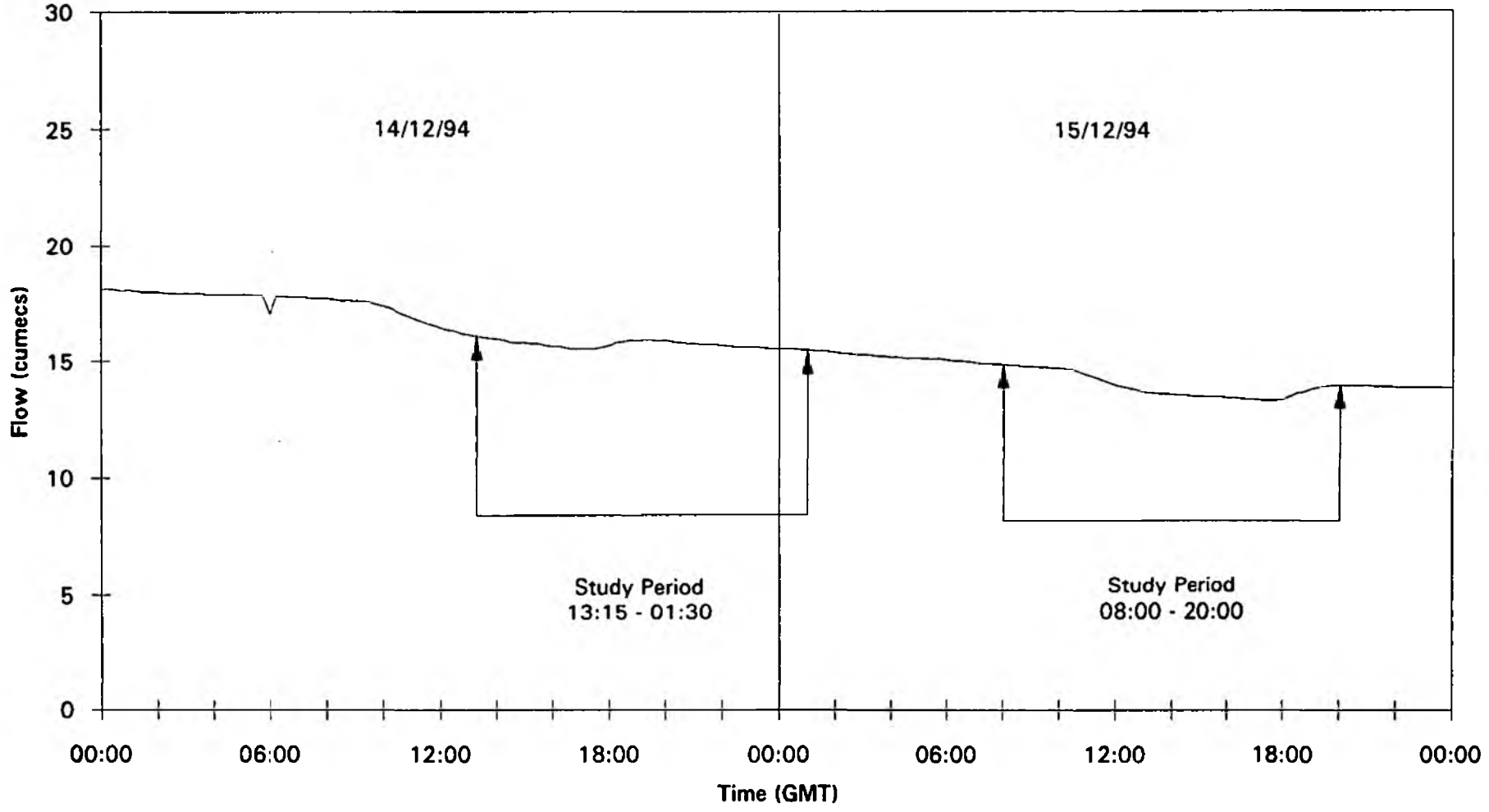
TRAVEL TIME OF POLLUTANTS

RIVER TORRIDGE

FIGURE 1c

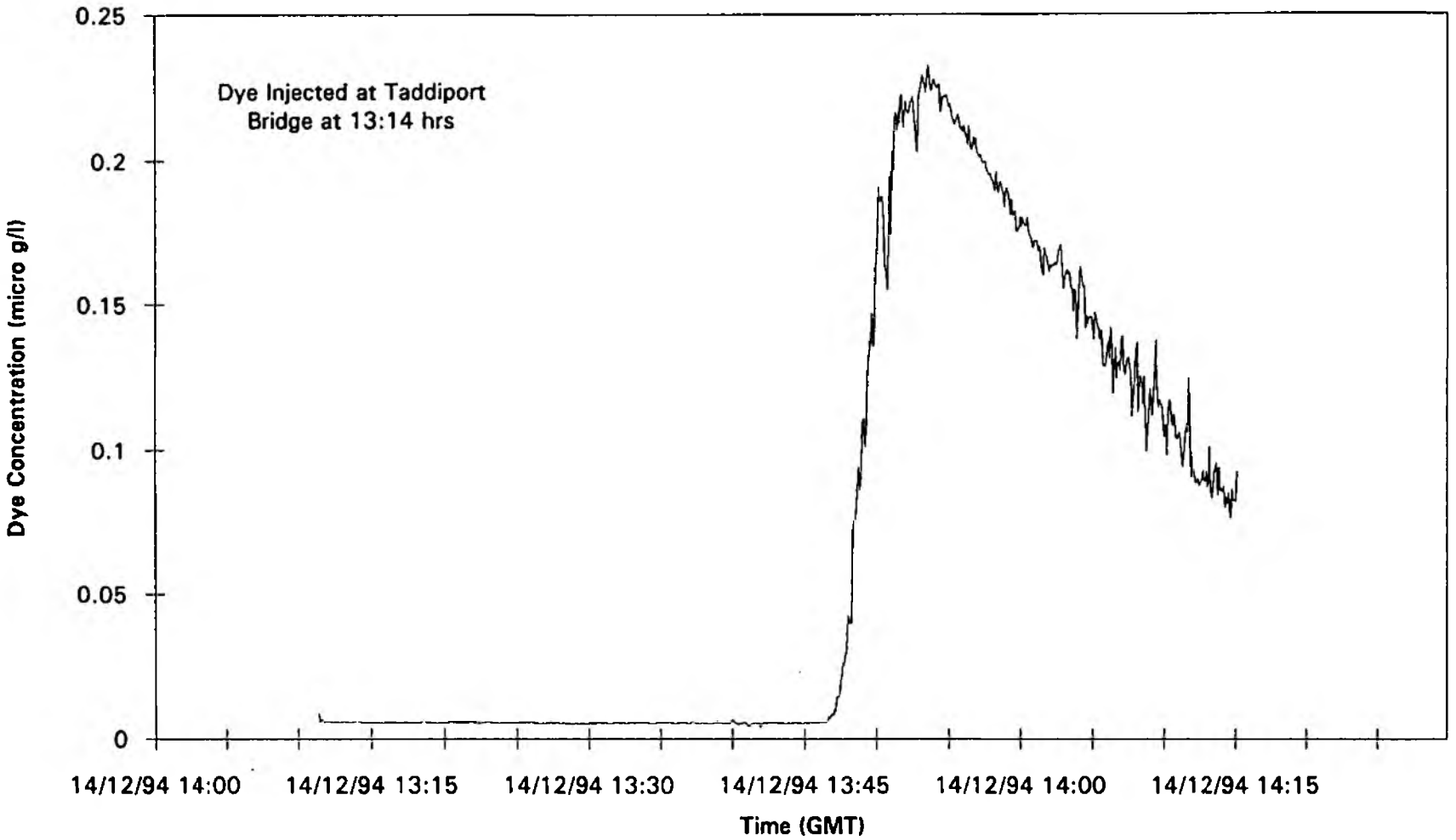
SITE LOCATION PLAN (1:50000)

Figure 2 - River Torridge 15 Minute Flows 14-15/12/94



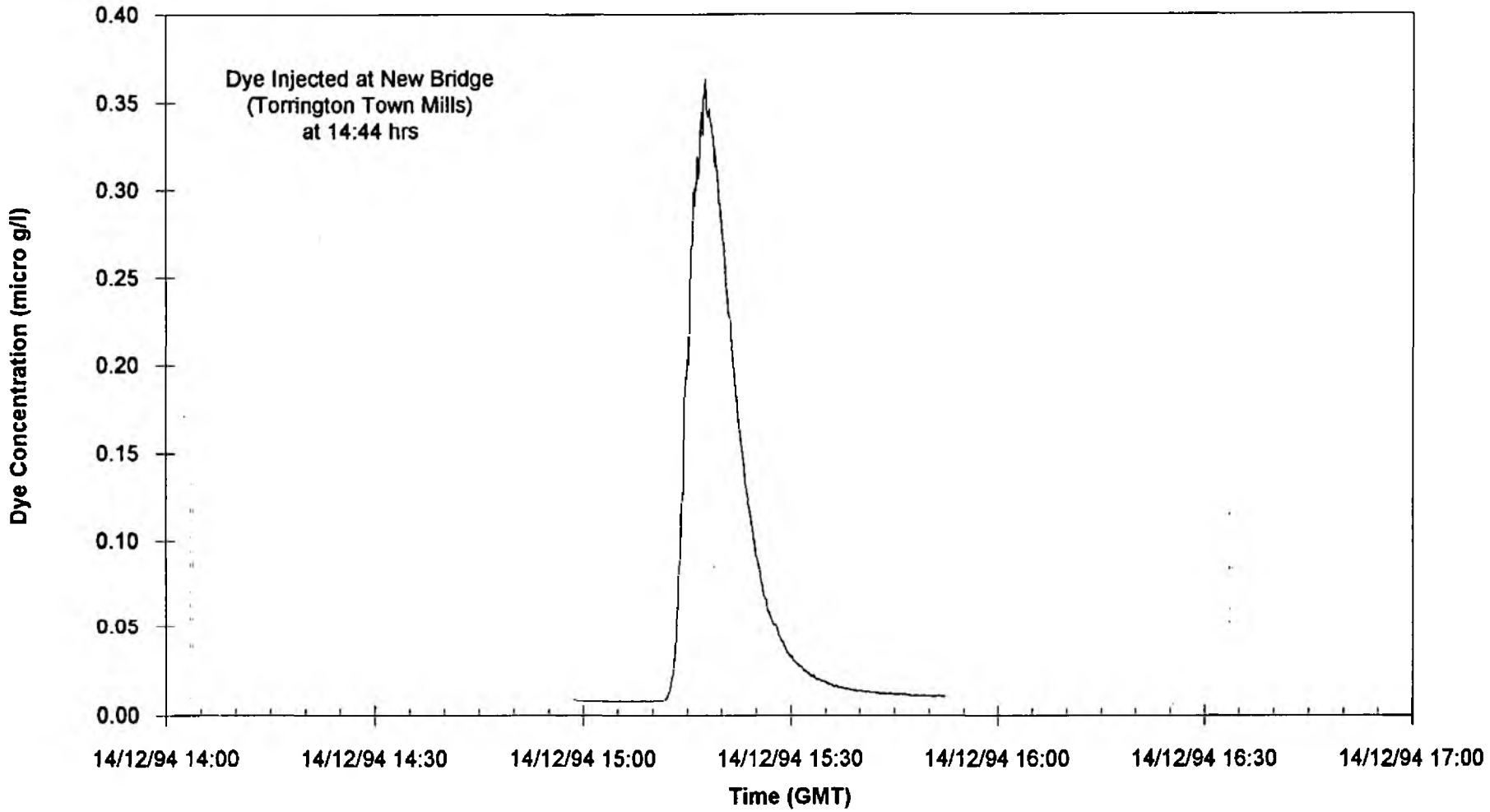
NGR Monitoring Point
SS 479197
NGR Injection Point
SS 488187

Figure 3 : Old Rothern Bridge 14/12/94



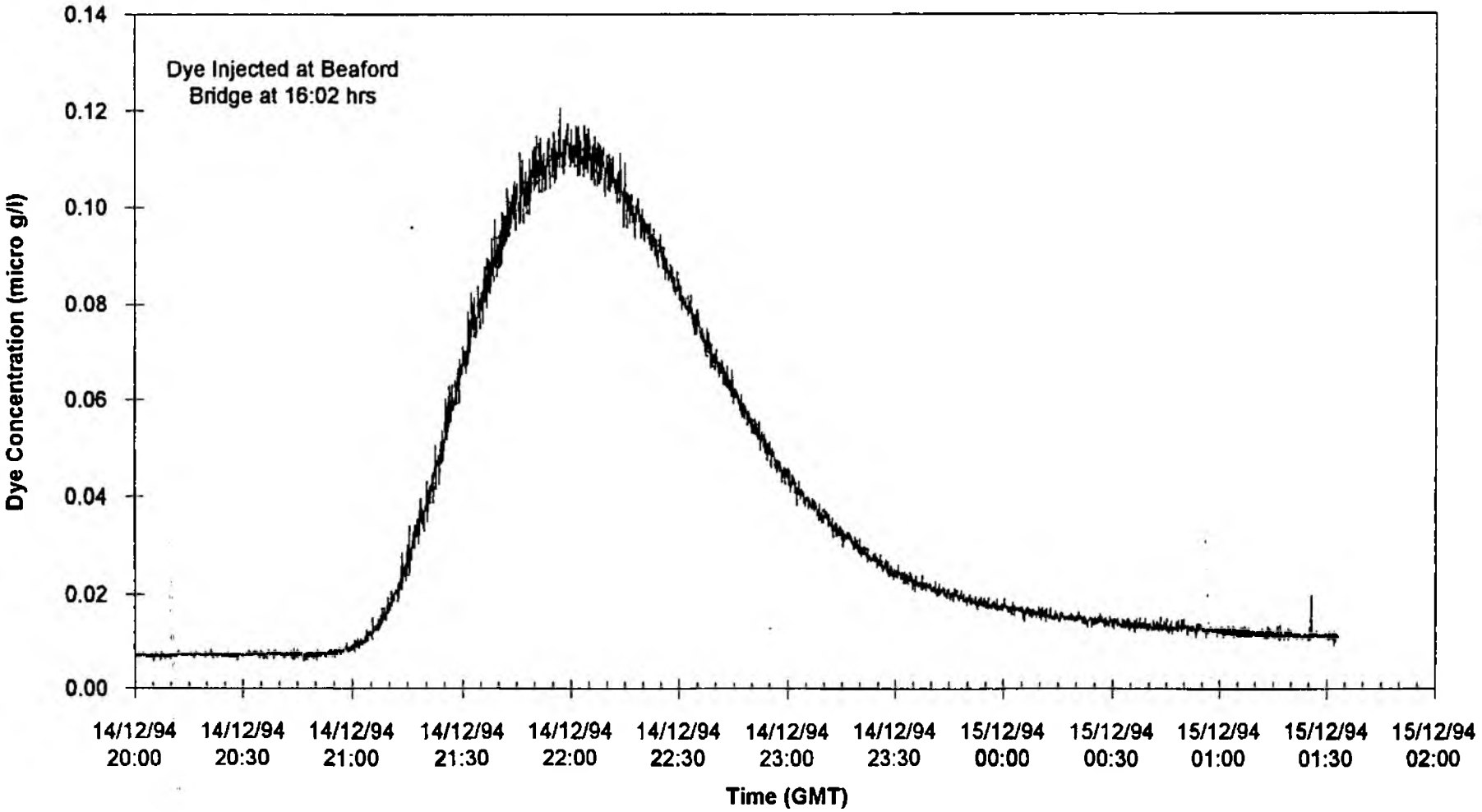
NGR Monitoring Point
SS 488187
NGR Injection Point
SS 499184

Figure 4 : Taddiport Bridge 14/12/94



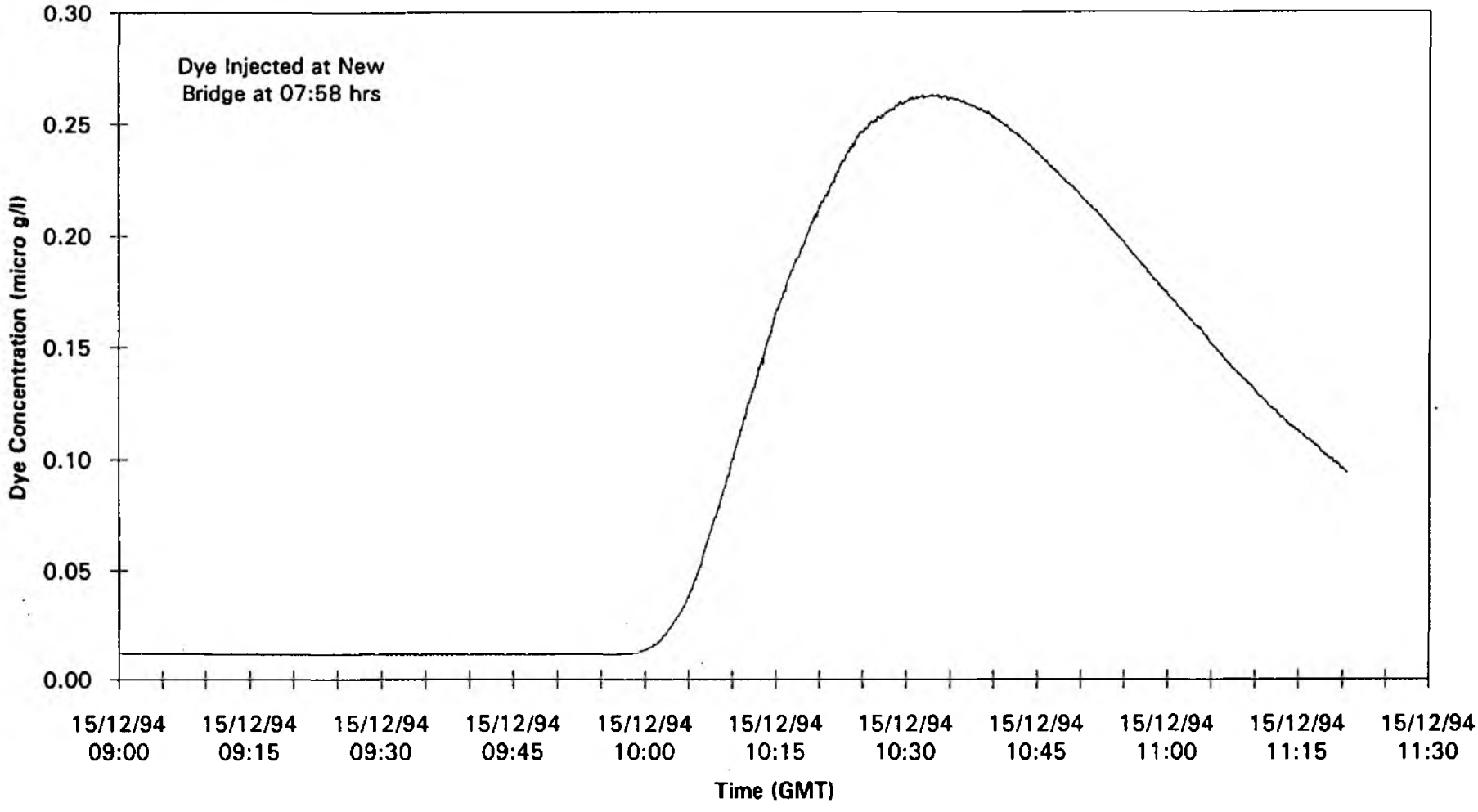
NGR Monitoring Point
SS 499184
NGR Injection Point
SS 542142

Figure 5 : New Bridge (Torrington Town Mills) 14/12/94



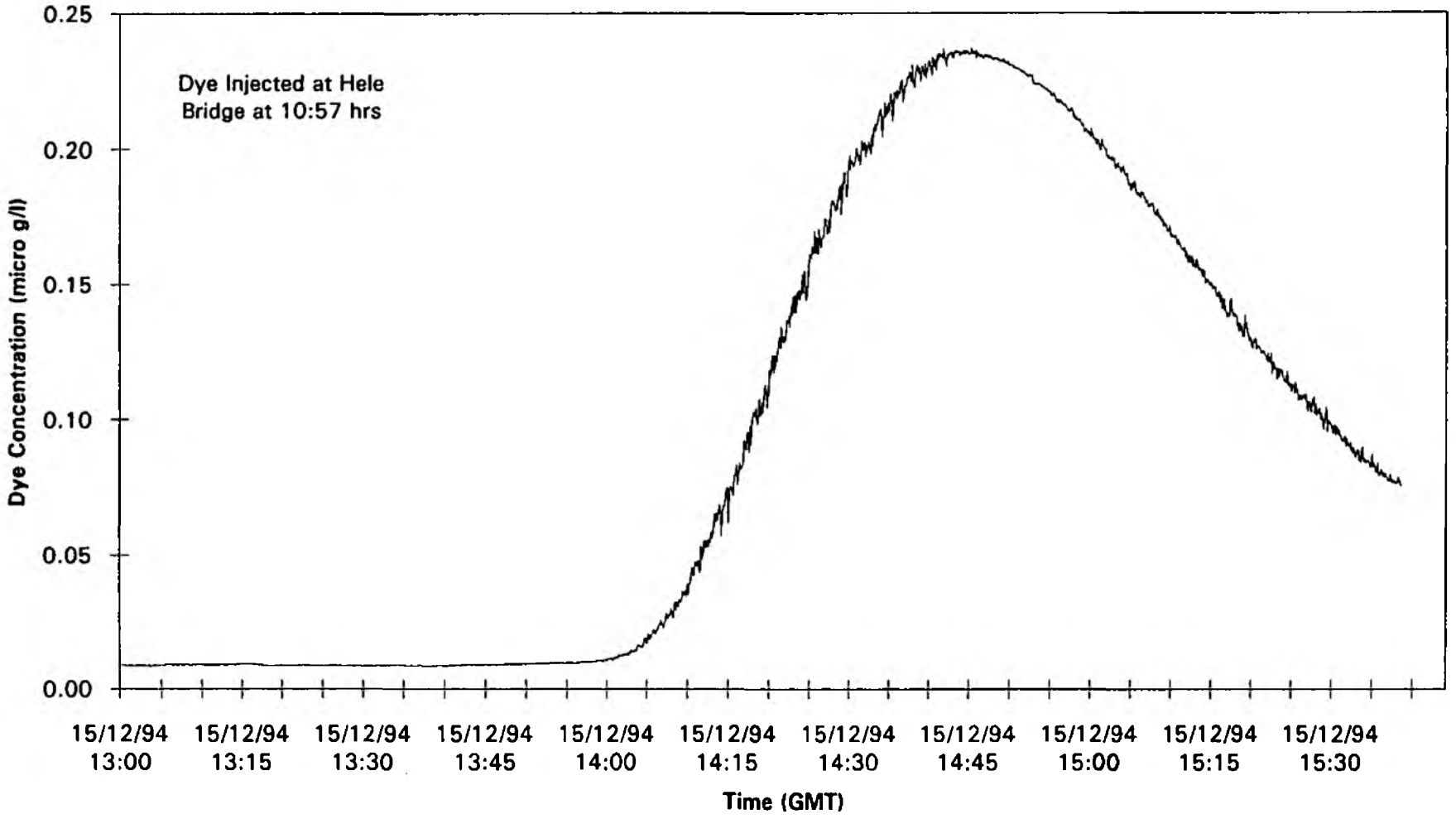
NGR Monitoring Point
SS 542142
NGR Injection Point
SS 548113

Figure 6 : Beaford Bridge 15/12/94



NGR Monitoring Point
SS 548113
NGR Injection Point
SS 540064

Figure 7 : New Bridge 15/12/94



NGR Monitoring Point
SS 540064
NGR Injection Point
SS 469060

Figure 8 : Hele Bridge 15/12/94

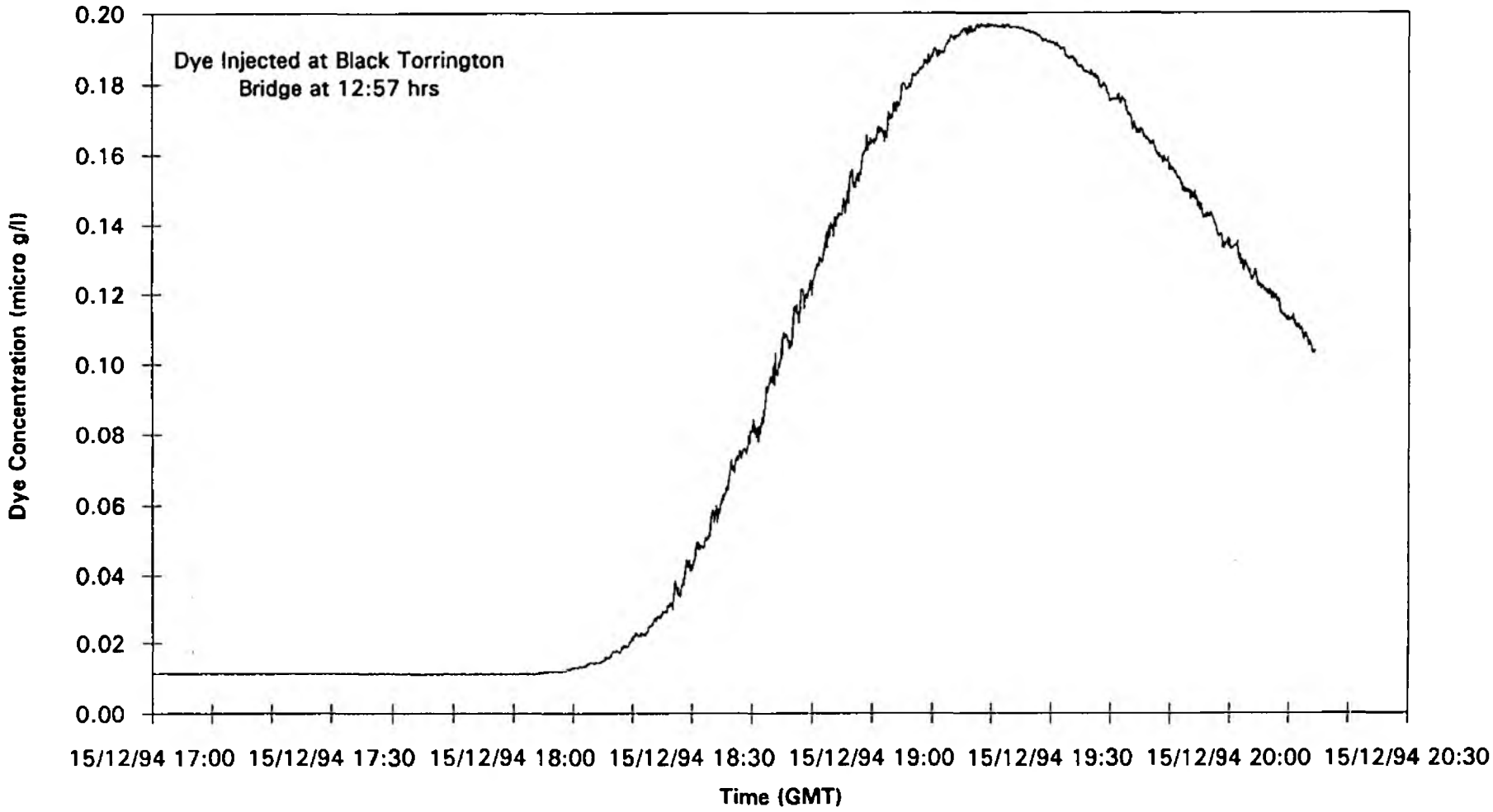
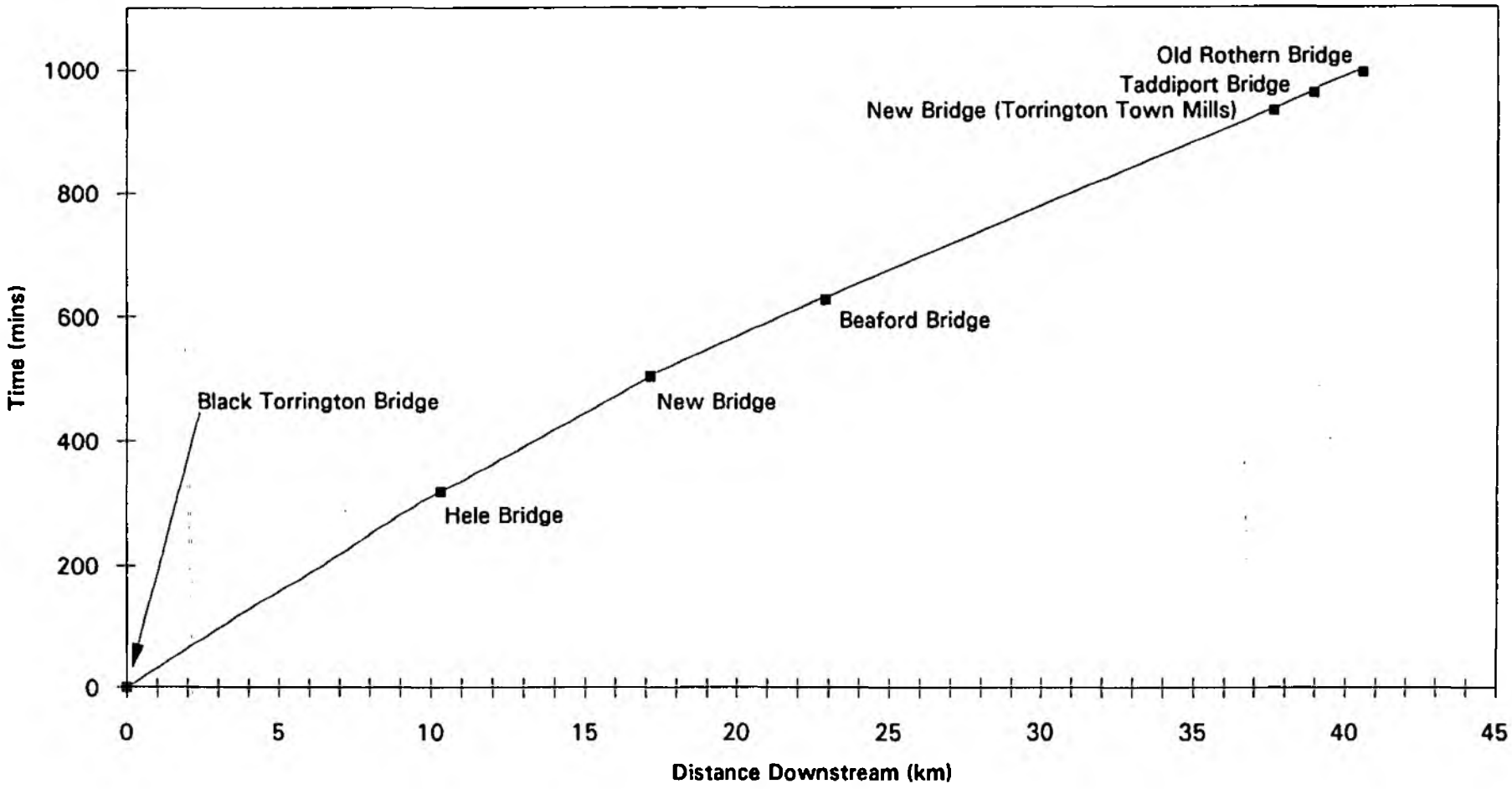


Figure 9 - Time of Travel of Tracer Dye along River Torridge
Black Torrington Bridge to Old Rothern Bridge



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