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TIME OF TRAVEL STUDY ON THE RIVER  
WANDLE UNDER TWO DIFFERENT FLOW  
CONDITIONS

CO 3477

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COMMERCIAL IN CONFIDENCE

**TIME OF TRAVEL STUDY ON THE RIVER WANDLE UNDER TWO  
DIFFERENT FLOW CONDITIONS**

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ENVIRONMENT AGENCY



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## SUMMARY

The National Rivers Authority (Thames Region) has commissioned WRC to undertake two time of travel studies on a section of the river Wandle, one during high flow conditions and the other during medium flow conditions. The section of river investigated was from Beddington sewage treatment works to the confluence with the river Thames.

Having completed the medium flow study, it became apparent that there was a large daily variation of flow in the lower Wandle caused by the dominance of the Beddington discharge. Therefore, it was decided that the second tracer study should be undertaken when the flows in the upstream Wandle were similar to those found during the first study but with the flow from the Beddington works significantly higher. This would allow the effects of the Beddington discharge on the travel time in the Wandle to be studied. During each of the tracer studies the dye tracer, rhodamine\_wt, was added to the Beddington effluent channel and the resulting tracer cloud was monitored *in situ* as it passed through four preselected detection sites.

## 1. INTRODUCTION

The National Rivers Authority (Thames region) has commissioned WRC to undertake two time of travel studies on a section of the river Wandle, one during high flow conditions and the other during medium flow conditions. The section of river to be investigated was between Beddington sewage treatment works to a point just above its confluence with the Thames. The section river being investigated was split into four reaches. During each of the studies the dye tracer rhodamine\_wt (Rh-wt) was added to the effluent channel of Beddington Stw and the resulting tracer cloud was monitored as it passed through each of the four reaches.

## 2. METHODOLOGY

### 2.1 Choice of tracer

Rhodamine-wt (Rh-wt) was chosen as the tracer as it has been found to be cost-effective in previous studies and also allows in-situ detection methods to be used. A review of the literature concerning the toxicity of rhodamine-wt, undertaken by WRC's toxicologists, indicates that at low concentrations (less than  $1 \mu\text{g l}^{-1}$ ) the dye represents an insignificant hazard to consumers of water.

### 2.2 Detection site locations

The portion of the River Wandle being studied was from Beddington Stw to the confluence with the Thames. The choice of reaches was made by Thames NRA, the choice being dependent on the location of tributaries, effluent discharges, weirs and river sampling points. The section of the River Wandle being studied was divided into four reaches; these are detailed below:

Table 2.1 River Wandle time of travel study detection site locations

Reaches studied	Map ref	Dp km
Beddington STW	TQ2952 6631	
Effluent ditch u/s Wandle	TQ2790 6708	1.75
Watermeade Mitcham	TQ2752 6760	1.05
Plough Lane Wimbledon	TQ2609 7150	5.14
Armoury Way Wandsworth	TQ2560 7490	3.7

Notes: Dp - Distance from previous site

### 2.3 Tracer addition

The quantity of dye required for each tracer addition was calculated, using the flow at Connollys Mill gauging station (upstream of Beddington STW) on the day of each addition, such that the fully mixed concentration in the river Wandle downstream of the effluent channel would not exceed  $20 \mu\text{g l}^{-1}$ .

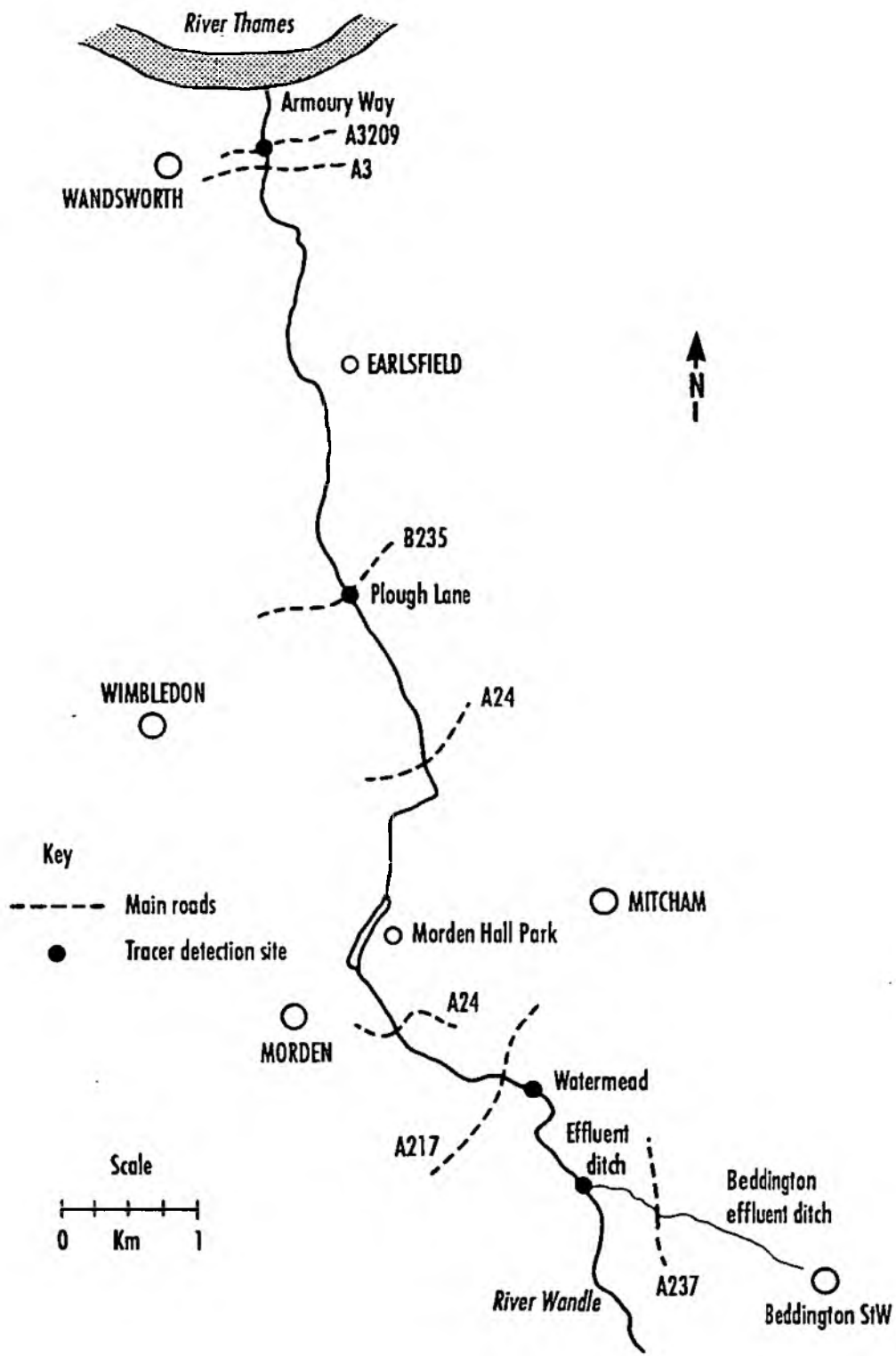


Figure 2.1 Sketch plan of the River Wandle showing the tracer detection sites



## 2.4 Tracer detection

The tracer was detected *in situ* at the downstream monitoring sites using portable fluorimeters. Detection was achieved by continually pumping water from the river through a flow cell in the fluorimeter. The data from the fluorimeter were logged digitally, at a constant time interval, as well as being recorded on a small chart recorder.

Calibration of the fluorimeters was carried out in the field using river water spiked with known quantities of Rh-wt which had been prepared in the laboratory.

### 3. RESULTS AND DISCUSSION

The data recorded by the logging equipment were first corrected for the background fluorescence of the river water and then converted to absolute dye concentrations using the on-site calibration data. Where nearly complete tracer curves were recorded, the data were extrapolated to the background reading enabling an estimate of the river flow at each of the detection points to be made by applying dilution gauging principles.

#### 3.1 First tracer study

The first tracer study was undertaken on the 24 March 1993 when the mean daily flow in the Wandle above the Beddington input was 0.33 cumecs and the flow in the effluent channel at the time of the tracer addition was 0.72 cumecs. Thirty six grams of Rh-wt were added to the head of the Beddington effluent channel at 0700 hours on the 24 March 1993

Table 3.1 sets out the travel times and the peak tracer concentration for each of the detection sites. The background corrected data have been plotted as dye concentration against time after tracer addition in Figures 3.1 to 3.4.

A noticeable skewing of the tracer curve after Watermead Mitcham can be seen in Figure 3.3. This was probably caused by the unusual configuration of the weir and sluice gate at Watermead.

**Table 3.1 River Wandle: First time of travel 24 March 1993**

Reach	Map ref	D km	WD m <sup>3</sup> s <sup>-1</sup>	Ta h	Tp h	Mt h	Tk h	Va km h <sup>-1</sup>	Vp km h <sup>-1</sup>	RD m <sup>3</sup> s <sup>-1</sup>	Cp µg l <sup>-1</sup>
Effluent Channel	TQ279 670	1.75	0.329	0.57	0.69	0.73	0.16	3.08	2.53	0.72	99.2
Watermeade	TQ275 676	1.05	0.329	1.48	1.74	1.77	0.45	0.71	0.60	1.96	12.3
Plough Lane	TQ261 715	5.14	0.329	4.57	5.24	6.23	2.12	1.13	0.98	2.23	2.2
Armoury Way	TQ256 749	3.7	0.329	3.05	3.77	3.69	2.76	1.22	0.98	2.05	1.8

Notes:

- WD - Mean daily discharge at Beddington gauging station
- D - Distance from previous site
- Ta - Time of arrival from previous site
- Tp - Time of travel of peak from previous site
- Tk - Mean time for tracer plume to pass site
- Va - Velocity of tracer arrival from previous site
- Vp - Velocity of tracer peak from previous site
- RD - River discharge calculated by dilution gauging
- Cp - Peak tracer concentration
- Mt - Mean travel time from the previous site

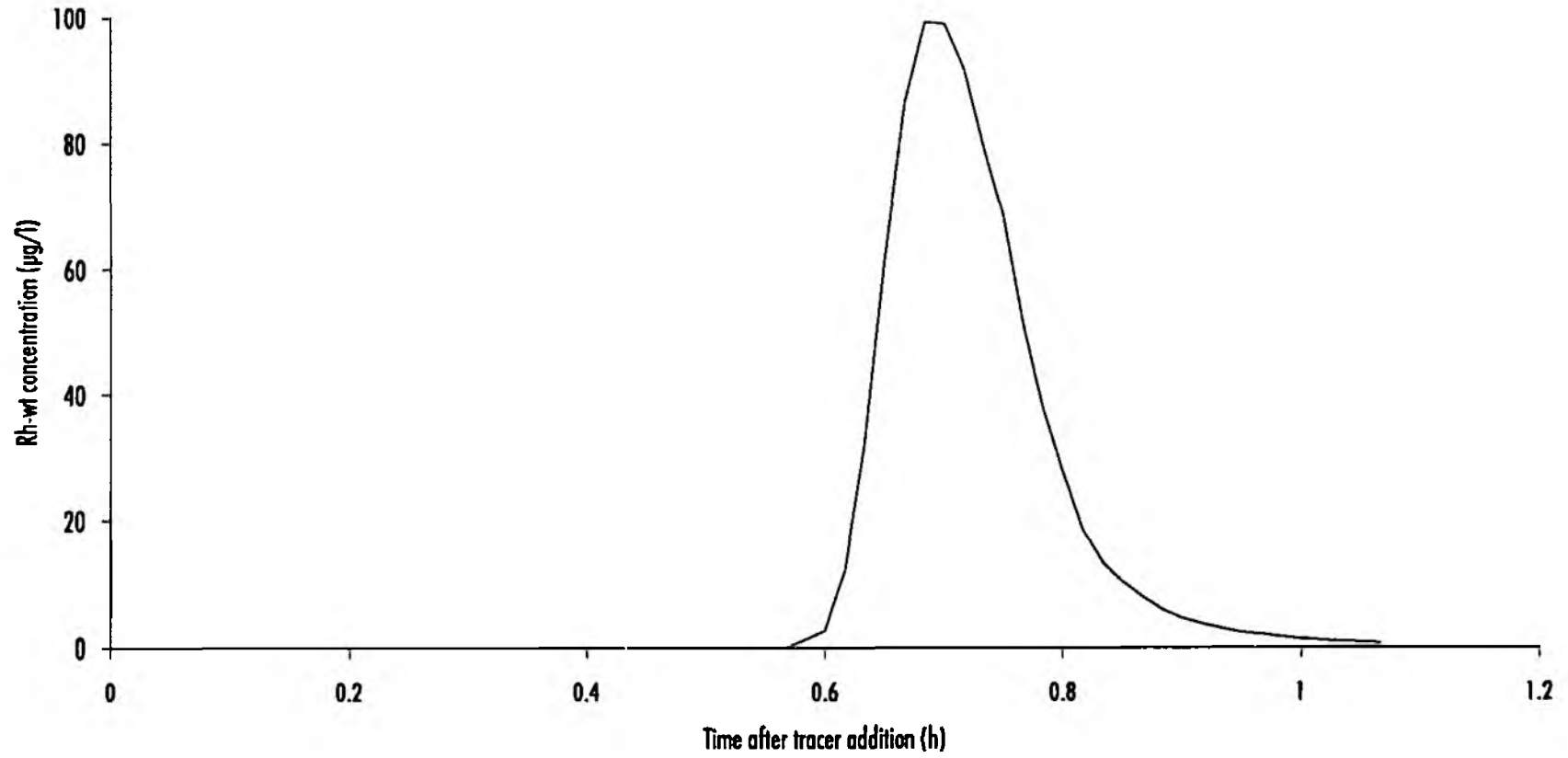
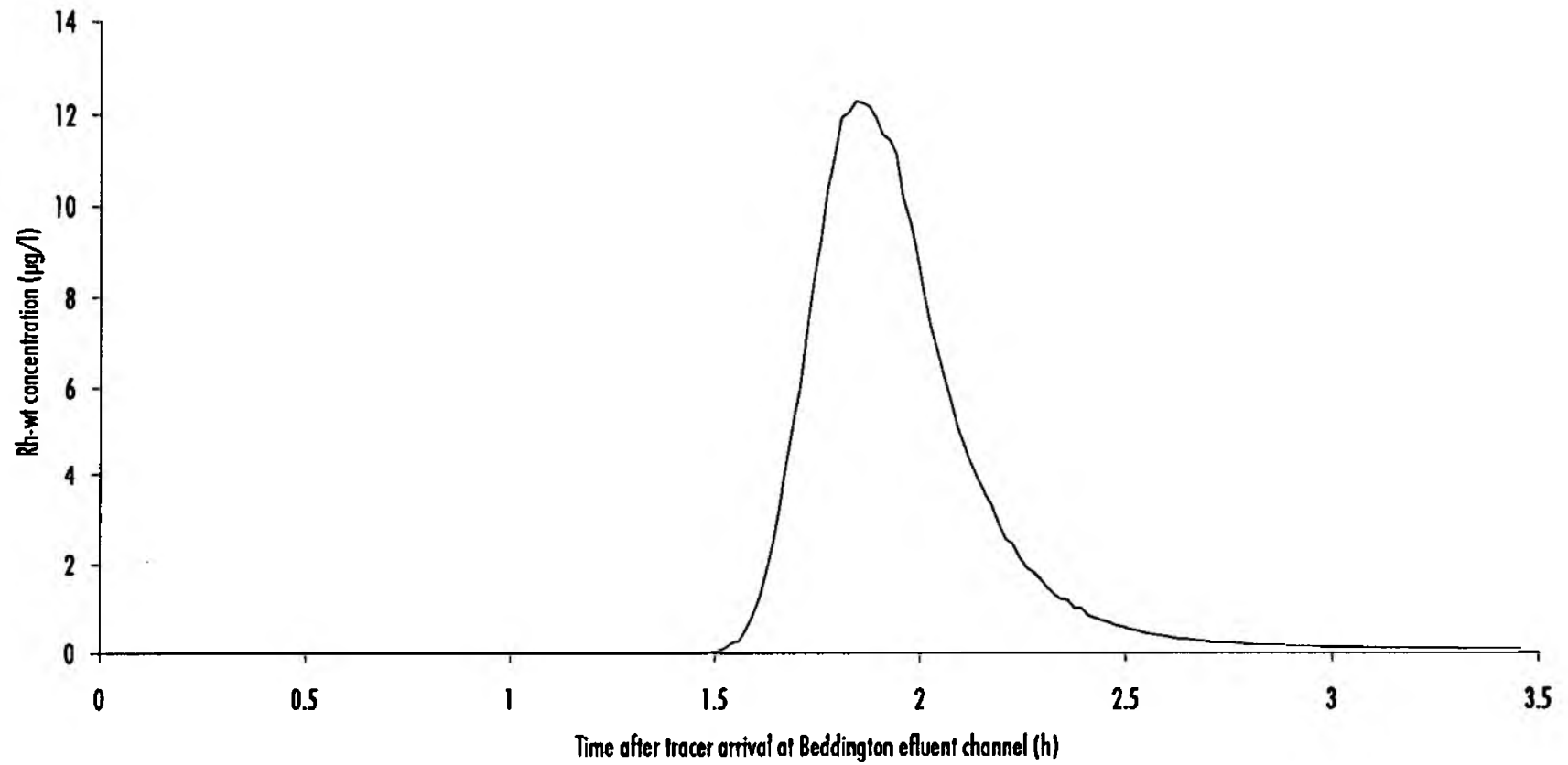


Figure 3.1 River Wandle time of travel: Beddington stw to Beddington effluent channel 24.03.93



**Figure 3. 2 River Wandle time of travel: Beddington effluent channel to Watermead Mitcham 24.03.93**

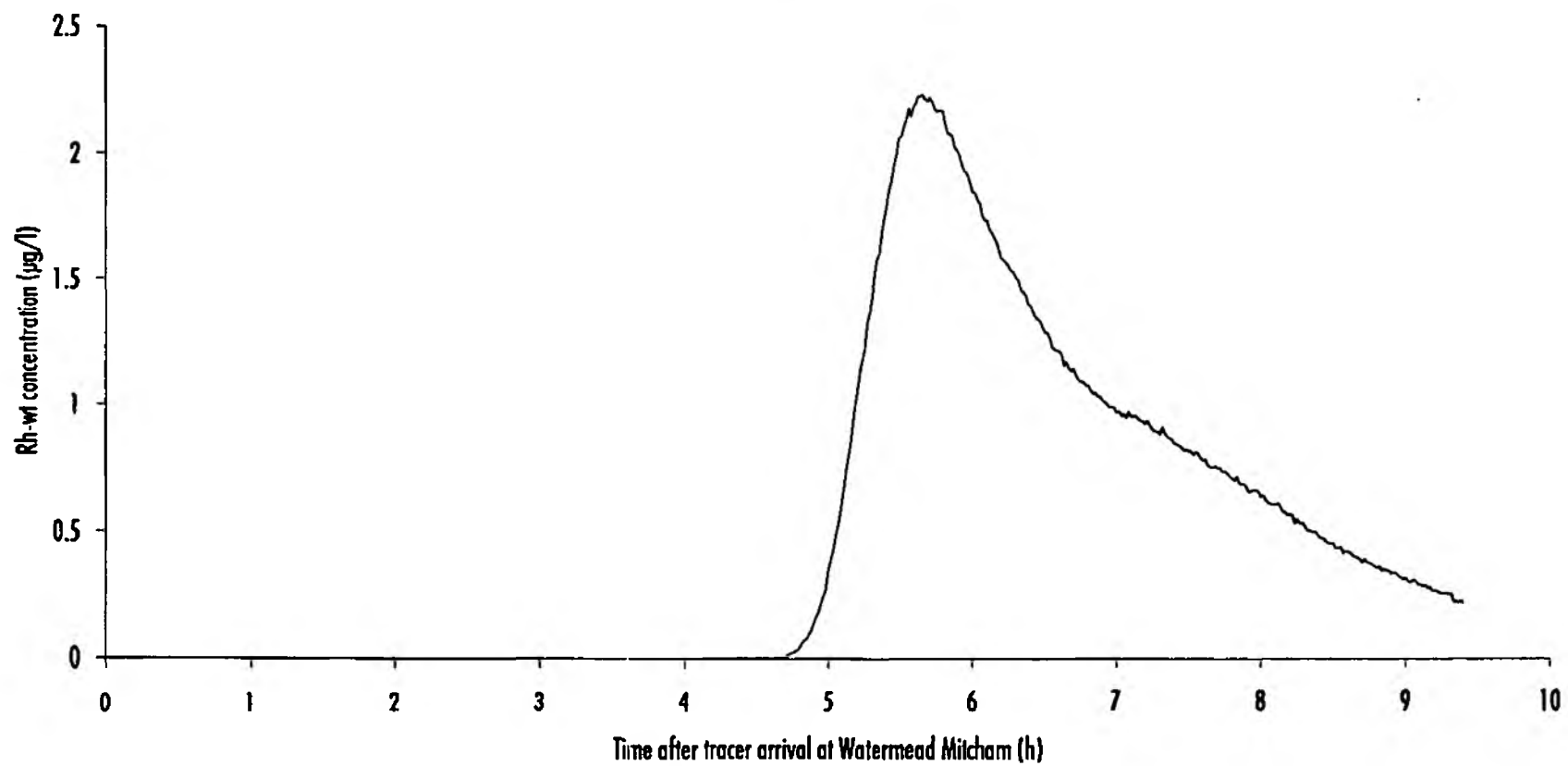


Figure 3.3 River Wandle time of travel: Watermeade Mitcham to Plough Lane 24.03.93

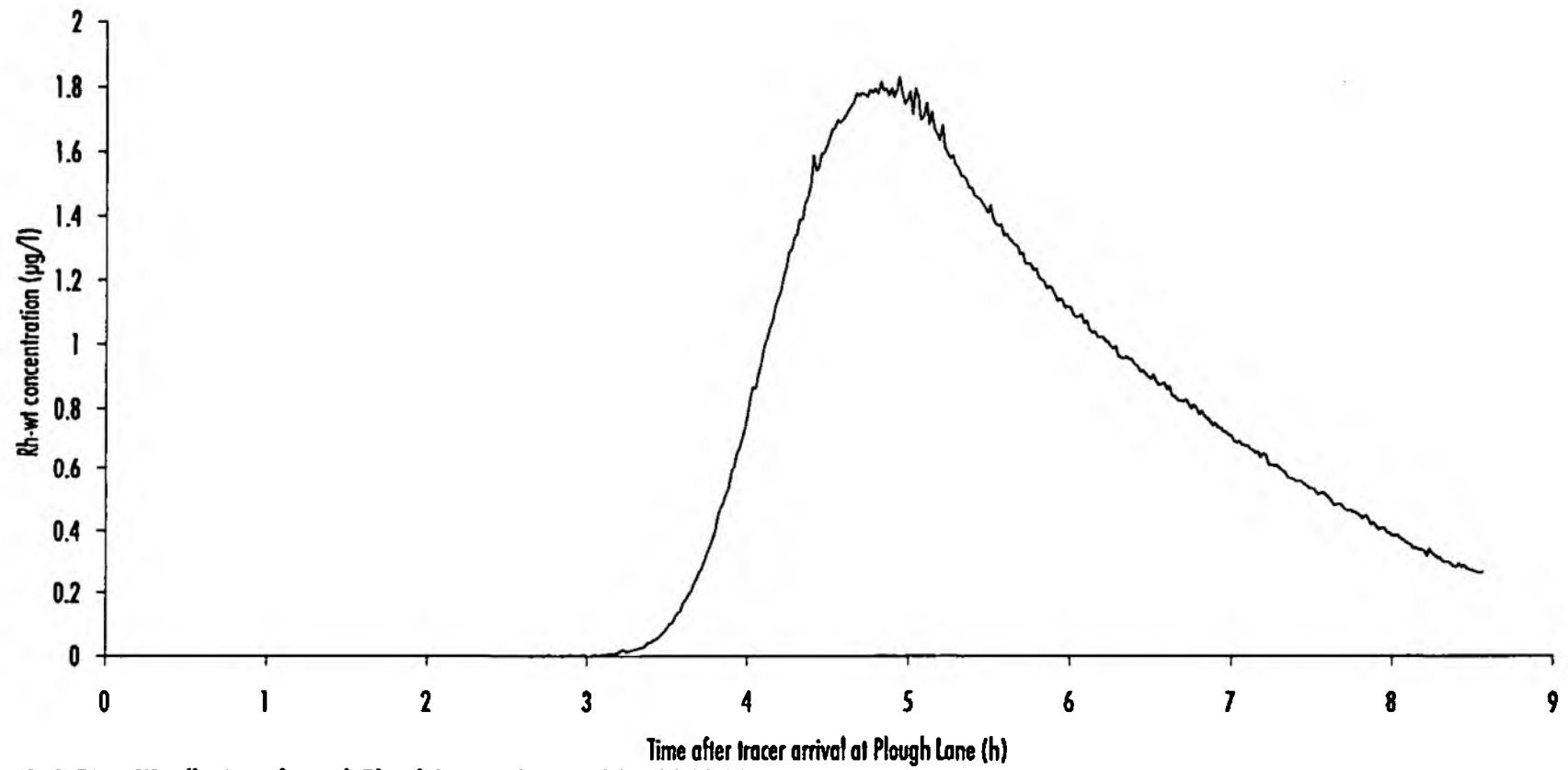


Figure 3.4 River Wandle time of travel: Plough Lane to Armoury Way 24.03.93

### 3.2 Second tracer study

After completing the medium flow study, it became apparent that there was a large daily variation of flow in the lower Wandle caused by the dominance of the Beddington discharge. Therefore, it was decided that the second tracer study should be undertaken when the flows in the Wandle were similar to those found during the first study but with the flow from the Beddington Stw significantly higher. This would allow the effects of the Beddington discharge on the travel time in the Wandle to be assessed.

The second tracer study took place on the 5 May 1993 when the mean daily flow above the Beddington effluent channel was 0.305 cumecs (cf. 0.33 cumecs during first study) and the flow in the effluent channel during the tracer addition was 1.72 cumecs (cf. 0.72 cumecs during first study).

Thirty four grams of Rh-wt were added to the head of the Beddington effluent channel at 1030 hours on the 5 May 1993.

Table 3.2 sets out the travel times and the peak tracer concentration for each of the detection sites. The background corrected data have been plotted as dye concentration against time after tracer addition in Figures 3.5 to 3.8.

The skewing of the tracer curve after Watermead Mitcham seen during the first study also took place during this study, although the skewness was less pronounced (Figure 3.7).



**Table 3.2 River Wandle: Second Time of travel Study 5 May 1993**

Reach	Map ref	D km	WD m <sup>3</sup> s <sup>-1</sup>	Ta h	Tp h	Mt h	Tk h	Va km h <sup>-1</sup>	Vp km h <sup>-1</sup>	RD m <sup>3</sup> s <sup>-1</sup>	Cp µg l <sup>-1</sup>
Effluent Channel	TQ279 670	1.75	0.305	0.42	0.49	0.50	0.09	4.12	3.54	1.64	66.0
Watermeade	TQ275 676	1.05	0.305	1.15	1.51	1.57	0.51	0.91	0.70	1.97	10.2
Plough Lane	TQ261 715	5.14	0.305	4.99	6.10	6.62	2.14	1.03	0.84	2.14	2.2
Armoury Way	TQ256 749	3.7	0.305	3.61	4.06	4.02	2.55	1.02	0.91	2.04	2.0

Notes:

- WD - Mean daily discharge at Beddington gauging station
- D - Distance from previous site
- Ta - Time of arrival from previous site
- Tp - Time of travel of peak from previous site
- Tk - Mean time for tracer plume to pass site
- Va - Velocity of tracer arrival from previous site
- Vp - Velocity of tracer peak from previous site
- RD - River discharge calculated by dilution gauging
- Cp - Peak tracer concentration
- Mt - Mean travel time from the previous site

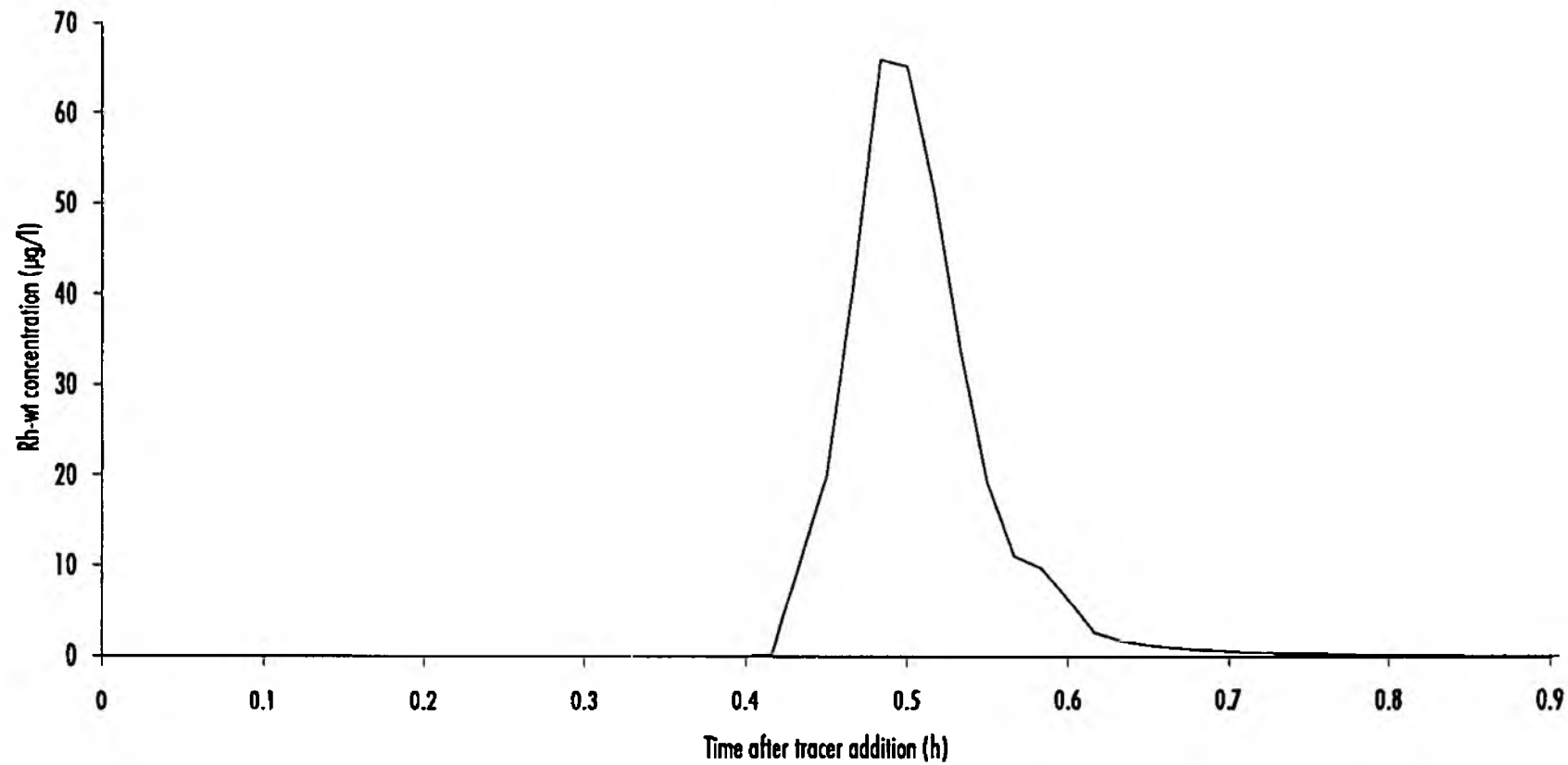


Figure 3.5 River Wandle time of travel: Beddington stw to Beddington effluent channel 05.05.93

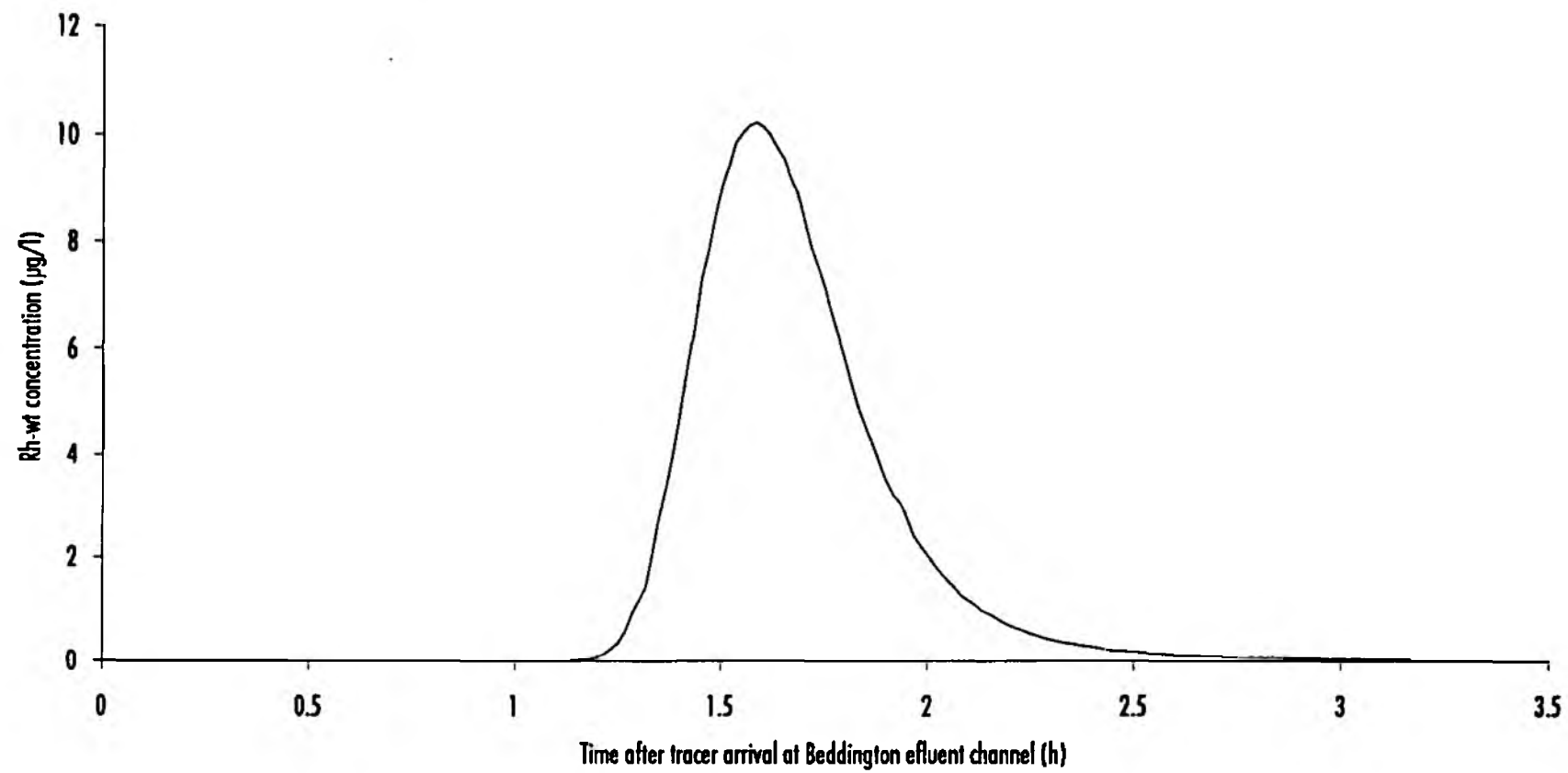


Figure 3.6 River Wandle time of travel: Beddington effluent channel to Watermead Mitcham 05.05.93

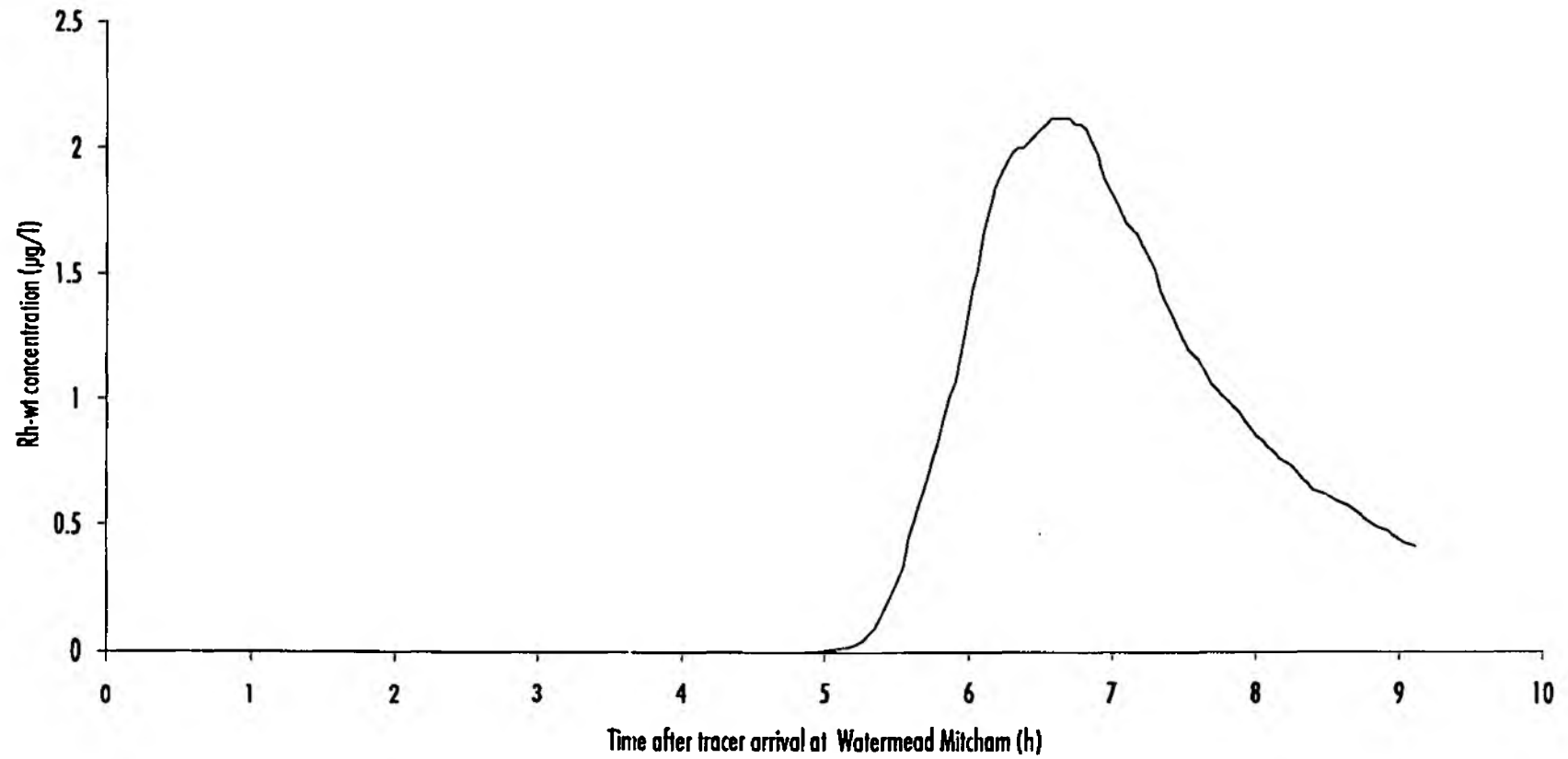


Figure 3. 7 River Wandle time of travel: Watermead Mitcham to Plough lane 05.05.93

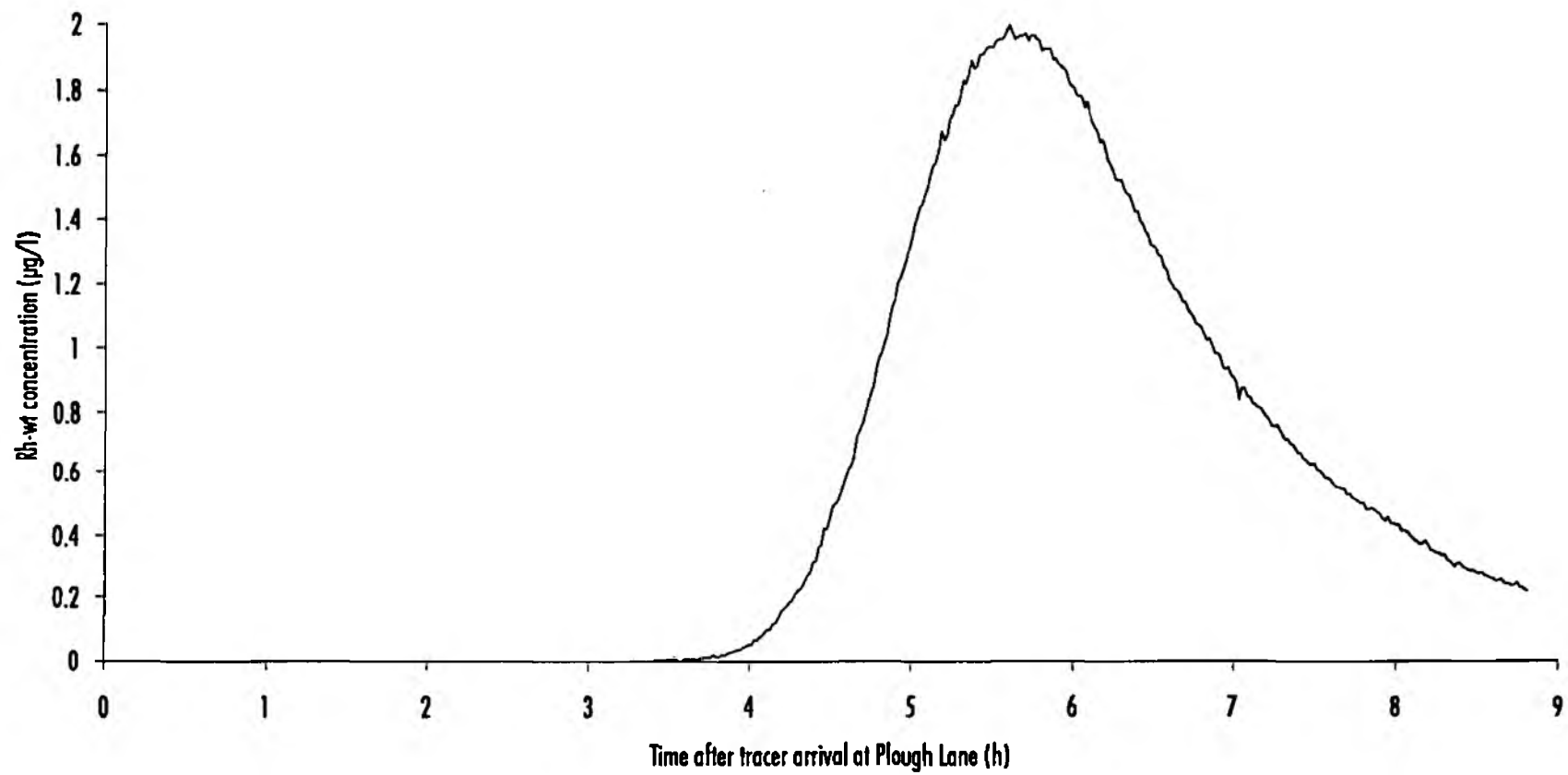


Figure 3. 8 River Wandle time of travel: Plough Lane to Armoury Way 05.05.93

### 3.3 Summary of results

The following tables give details of the peak and mean travel times, and velocities obtained during the two trial studies.

Table 3.3 River Wandle time of travel: Summary of the travel time and velocity between sites

Reach	First Study			Second Study	
	D km	Pt h	Vp km h <sup>-1</sup>	Pt h	Vp km h <sup>-1</sup>
Beddington	0	0	0	0	0
Effluent ditch	1.75	0.69	2.53	0.49	3.54
Watermeade Mitcham	1.05	1.74	0.60	1.51	0.70
Plough Lane Wimbledon	5.14	5.24	0.98	6.10	0.84
Armoury Way Wandsworth	3.7	3.77	0.98	4.06	0.91
Total	11.64	11.44	-	12.16	-

Pt - Peak travel time from previous site  
 Vp - Velocity of tracer peak from previous site  
 D - Distance from previous site

Table 3.4 River Wandle time of travel: Summary of the mean travel time and mean velocity between sites

Reach	First Study			Second Study	
	D km	Mt h	Mv km h <sup>-1</sup>	Mt h	Mv km h <sup>-1</sup>
Beddington STW	0	0	0	0	0
Effluent ditch	1.75	0.73	2.40	0.50	3.50
Watermeade Mitcham	1.05	1.77	0.60	1.57	0.67
Plough Lane Wimbledon	5.14	6.23	0.83	6.62	0.78
Armoury Way Wandsworth	3.70	3.69	1.00	4.02	0.92
Total	11.64	12.42	-	12.71	-

Mt - Mean travel time from previous site  
 Mv - Mean velocity of tracer from previous site  
 D - Distance from previous site

#### 4. CONCLUSIONS

Times of travel were obtained along four reaches of the river Wandle between Beddington Stw and the confluence with the Thames on two different occasions.

The first tracer study was undertaken on the 24 March 1993 when the mean daily flow in the Wandle above the Beddington input was 0.329 cumecs and the flow in the effluent channel at the time of the tracer addition was 0.72 cumecs. The tracer cloud took 9.67 hours to reach Armoury Way and around 1.78 hours to peak.

The second tracer study took place on the 5 May 1993 when the mean daily flow above the Beddington effluent channel was 0.305 cumecs and the flow in the effluent channel during the tracer addition was 1.72 cumecs. The tracer cloud took 10.17 hours to reach Armoury Way and around 1.99 hrs to peak.

The maximum concentration of Rh-wt entering the river Thames during the two study's was  $2 \mu\text{g l}^{-1}$ .

## APPENDIX A - NRA SPECIFICATION FOR THE WANDLE TIME OF TRAVEL STUDIES

### A1. INTRODUCTION

The National Rivers Authority, Thames Region require information on 'time of travel' for certain reaches of the Rivers Wandle, Lee, Chertsey Bourne, and the Ock. This information will be derived using suitable tracer experiments. In the long term this should cover a range of flow conditions, from low to bankfill discharge so that a relationship between discharge and travel times can be derived. Due to current medium and high flows, we require studies of only these conditions to be done in the next few months and it is for this work that we require a quotation. This document sets out the requirements of the investigation and provides information which may be of use to tenderers.

### A2. LOCATION OF RIVERS

The rivers have been split into various reaches; these are detailed in Table A1. The choice of reach has been dictated by the location of tributaries, effluent discharges, weirs and river sampling points. Other features, such as lakes, have also been considered in case these have an impact on the travel time. Comments are welcome on the choice of reach points, in terms of reach length or whether the number of reaches should be increased or decreased. Costs for alternative layouts should be given, and costs given for each of the areas covered in Table A1.

### A3. DATA REQUIREMENTS

The travel times along each reach are required for medium and high flow conditions. The tracer pulse at the downstream end of reach reach should be defined in sufficient detail to provide an accurate calculation of the travel time in terms of first arrival, peak travel time and average travel time for the plume to pass. In order to use the currently medium to high flow period, the studies should be done from January to June 1993. The NRA will require the tracer information for modelling work, so that data should be available in tabular form on floppy disk. Graphical plots should also be provided.

### A4. TRACER MATERIAL

The following tracers have been approved by the NRA in previous studies:

*Serratia macescens* bacteriophage  
Rhodamine WT  
Sodium iodide

Specific approval will be required by the NRA for whatever tracer is used. Tenderers should state which of these or alternative tracers they would like to use and in what concentrations. It will be necessary to inform local NRA pollution officers prior to the



undertaking of each tracer experiments. The arrangements for this will be agreed with the successful consultant. The submission should include full details of the methods to be used in carrying out the tracer experiments, such as proposed equipment and manpower and length of river to be monitored for each experiment.

## A5. STUDY DURATION AND REPORTING

Although it is appreciated that hydrological conditions may dictate when the tracer experiments can be undertaken, the tender submissions should provide an overall schedule for undertaking the tracer experiments. An interim report (three copies) must be produced for each river and at completion of the studies, a final report. Ten copies of the final report will be required.

Principal Planner  
Water Quality

Table A1 River Wandle: Reaches to be studied

Site description	NGR	Approx. distance
Beddington STW to	TQ2952 6631	
Beddington Effluent Ditch u/s Wandle	TQ2793 6704	1.96
Wandle at Watermeade, Mitcham	TQ2752 6760	0.95
Wandle at Plough Lane, Wimbledon	TQ2609 7150	5.14
Wandle at the Causeway, Wandsworth	TQ2558 7484	3.53