ASSESSMENT OF IVYBRIDGE MOBILE MONITORING STATION AND INVESTIGATION OF THE WATER QUALITY OF THE RIVER ERME AND THE EFFECT OF IVYBRIDGE SEWAGE TREATMENT WORKS FINAL EFFLUENT

JUNE 1990

JEAN BAPTISTE MARTIN
NRA SOUTH WEST
FRESHWATER INVESTIGATIONS
MANLEY HOUSE
KESTREL WAY
EXETER DEVON
ENGLAND

1.0 CONTENTS

2.0 ACKNOWLEDGEMENTS

I would like to thank Mr Barry Milford for the invitation to the National Rivers Authority at Exeter (South West Region). I would also like to thank my teachers Mr Le Roy and Mr Gentric who incited me to do my training at the NRA.

Thanks to the friendliness of all the staff, especially to Marie Carpenter and Roger Vernon, who were always ready to help me.

I would also like to thank the typist for preparing my report.

During my 2 months, I have gained a lot of working experience. I appreciated the fact that each time I have a problem in a subject of my work, there was always someone with whom I could discuss it with.

4.0 INTRODUCTION

4.1 Aims

The aims of my training were:

(i) first to assess the performance of a continuous water quality monitor analysing turbidity, conductivity, dissolved oxygen (D.O.), temperature, pH and ammonia concentration in a river. This was achieved by comparing the data of spot river samples with the data also recorded by the monitor.

(ii) To assess the performance of various methods of data transfer from the monitor to NRA Headquarters. This was carried out by comparing the data from the monitor with that produced by the meteor-burst communication system, and the Technolog data logging system.

(iii) Assess the changes in river quality recorded by the monitor over the period.

4.2 National Rivers Authority — Guardians of the Water Environment

The National Rivers Authority (NRA) took up its duties on September 1 1989. Overnight the NRA became the strongest environmental protection agency in Europe, invested with extensive powers and responsibilities by Parliament.

The responsibilities of the NRA are far-reaching. Foremost amongst them is to control pollution and improve the quality of the country's river systems and coastal waters.

The NRA do this by raising environmental awareness within industry, commerce, farming and among the public, and enforcing strict standards of environmental control.

The NRA Head Office is based in London and has a policy-making board consisting of 15 men and women appointed by the government. The Authority members are supported by a small control staff of around 60 headed by a chief executive. Although a national body the day to day operation of the NRA is handled by around 6,500 employees working in ten regions based on the geographical areas of the ten former water authorities.

The South West Region of the NRA is responsible for protecting the magnificent rivers, estuaries and coastal waters in an area covering 10,884 square kilometers including Devon, Cornwall, and small parts of Dorset and Somerset. The Headquarters is in Exeter and there is an office in Bodmin serving the western area. There are also several operational depots situated around the region.

The NRA's works is based on:

- Water Quality

  Discharges and abstraction require consent from the NRA.

  Environmental Quality Objectives are set for each section of water based on water use. Conditions are then applied to discharges and abstractions in order to maintain appropriate quality standards to ensure designated uses are protected.

- Water Resources

  Water abstractions takes place for many reasons but principally for water supply, industry and agriculture. Like discharging this is a carefully controlled activity and most abstractions need a licence.

- Pollution Control

  Pollution control staff spend a lot of effort on preventative measures by inspecting industrial, domestic and agricultural premises to ensure the safe use, storage and disposal of potentially polluting material and carrying out an enforcement policy on polluters.

- Monitoring and Analysis

  Routine monitoring and data gathering takes place all the year round. The analysis enables compliance with River Quality Objective to be assessed, and also can alert staff to a problem or confirm an improvement.

- Fisheries

  Fish stocks are conserved by a number of methods including the issue of rod and net licenses, net limitation orders and the control by byelaws of fishing methods and seasons.

- The Warden Service

  Multi-functional Wardens do routine patrolling of rivers and inspection to collect information on pollution, abstraction and fisheries.

- Conservation

  Watercourses are home to many varieties of flora and fauna and conservation of their sensitive fragile habitat is given great emphasis by the NRA.

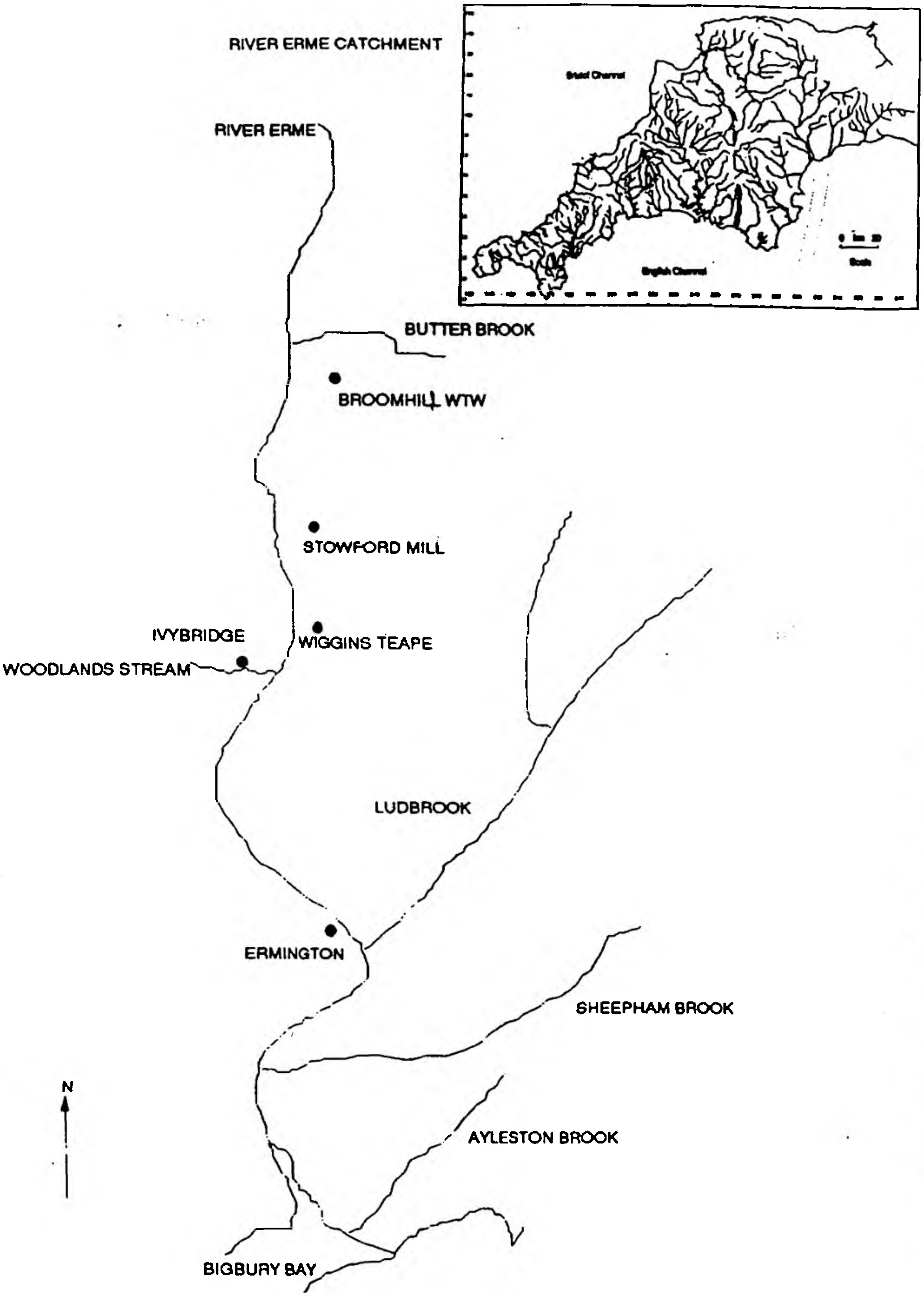
- Flood Defence

  Engineers are responsible for the design, construction and maintenance of schemes to alleviate flooding in susceptible towns and villages.

- Flood Warning

  A vital role is played by the Flood Warning Office which receives rainfall and rivers level information from over 100 sites around the region.

Figure 1


RIVER ERME CATCHMENT
RIVER ERME
BUTTER BROOK
BROOMHILL WTW
STOWFORD MILL
IVYBRIDGE
WIGGINS TEAPE
WOODLANDS STREAM
LUDBROOK
ERMINGTON
SHEEPHAM BROOK
N
AYLESTON BROOK
BIGBURY BAY

4.3 The River Erme

The River Erme Valley lies in West Devon between the catchment of the Rivers Avon and Yealm. It rises on South West Dartmoor and flow south to discharge to the sea at Bigbury Bay. The length of the catchment is 22km and the catchment area to the sea outfall is 105km² (Figure 1).

The only major tributary is Lud Brook which joins the River Erme just below Ermington (Figure 1). However, there are some smaller tributaries below this.

Ivybridge is the only major settlement. It is situated where the A38 crosses the River Erme. Apart from light industry in Ivybridge and the Wiggins Teape papermill the catchment has little industry.

Agriculture forms the major activity in the southern part of the catchment, whilst north of Ivybridge the land is suitable for rough grazing and walking based leisure activities.

Ivybridge Sewage Treatment Works is situated at Ivybridge on the River Erme (Figure 2).

All the rivers which are studied by the NRA have Environmental Quality Objectives which are determined by the uses of the river.

The Environmental Quality Objectives for the River Erme are:

- Aesthetic Quality
- Direct abstraction for potable supply
- Salmonid Fish
- Other aquatic life/dependant organisms
- Livestock Watering
- Irrigation of crops

The Environmental Quality Objectives (EQO) determine the River Quality Standards (RQS) ranging from a National Water Council Class (NWC) of 1A to 4 (see Appendix 1). The River Erme has a RQO of NWC 1A. The criteria for a NWC 1A is:

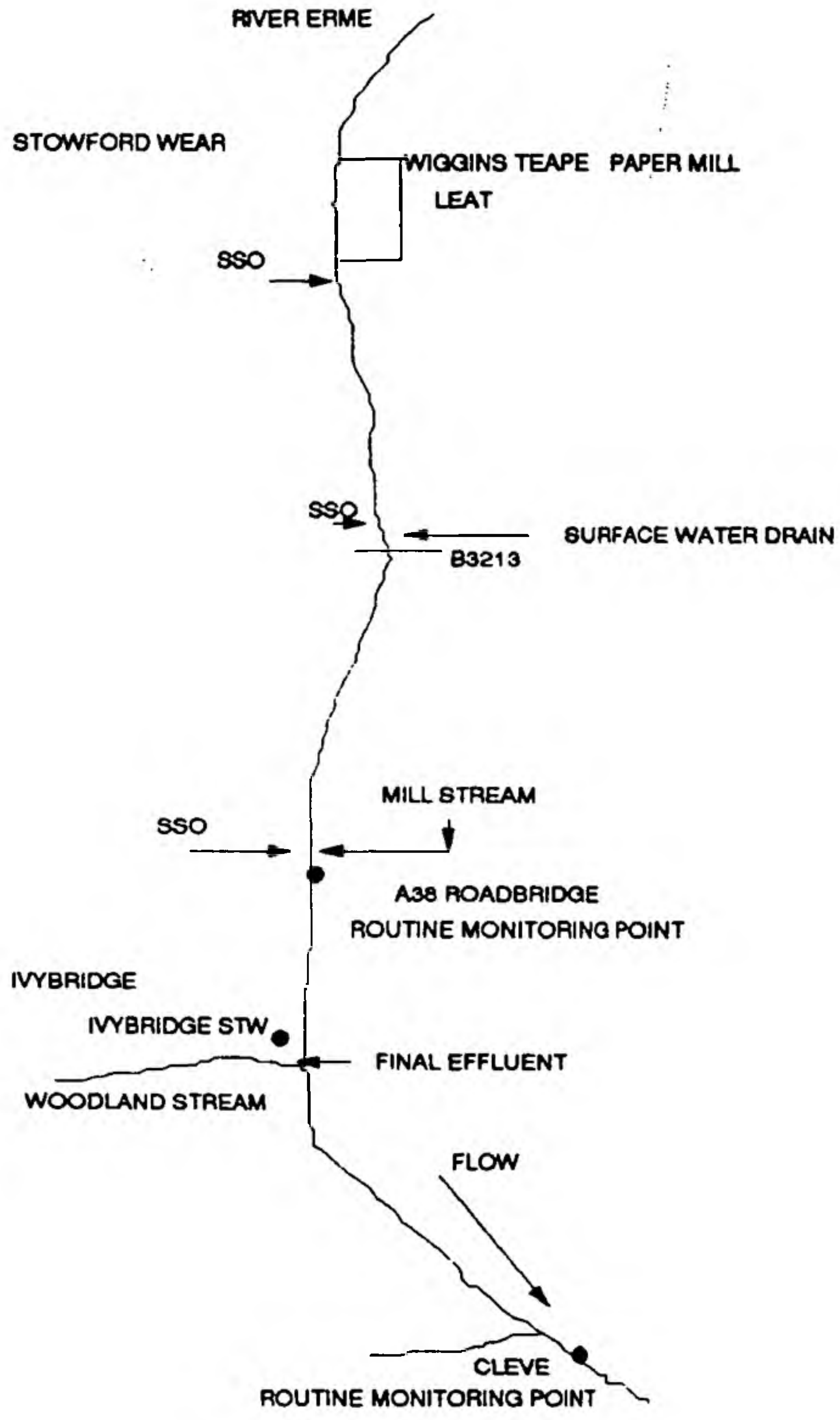
- Dissolved oxygen % saturation greater than 80%
- BOD (ATU) not greater than 3 mg/l 0
- Total ammonia not greater than 0.31 mg/l N
- Non ionised ammonia not greater than 0.021 mg/l N
- Temperature not greater than 21.5°C
- pH greater than 5.0 and less than 9.0
- Suspended solids not greater than 25 mg/l

Between 1985 and 1989 the River Erme at A38 road bridge (routine monitoring point) was classified as 1A. During this period the River Erme was classified as Class 2 at the Cleeve routine monitoring point.

Compliance with the assigned RQO was achieved at the routine monitoring point upstream of the STW at A38.

Figure 2

THE RIVER ERME - IVYBRIDGE



SSO - STORM SEWER OVERFLOW

But the routine monitoring point at Cleeve failed in:

1985

1 out of 8 samples on ammonia

1986

1 out of 11 samples on BOD
2 out of 11 samples on ammonia

1987

1	out	of	12	samples	on BOD
5	"	"	12	"	on ammonia
1	"	"	12	"	on suspended solids

1988

2	"	"	12	"	on ammonia

1989

3	"	"	14	"	on ammonia
1	"	"	14	"	on dissolved oxygen

The STW final effluent has a discharge consent of 20/30/10 (BOD; Suspended Solids; Ammonia) at a daily dry weather flow not exceeding 1900m³.

However the discharge has failed to comply with this consent:

1986

1	out	of	6	samples	on BOD
1	"	"	6	"	on suspended solids
1	"	"	6	"	on ammonia

1987

2	"	"	16	"	on BOD
1	"	"	16	"	on suspended solids
1	"	"	16	"	on ammonia

1988

3	"	"	4	"	on BOD
3	"	"	4	"	on suspended solids
1	"	"	4	"	on ammonia

1989

1	"	"	1	"	on ammonia

In order to determine the cause of non compliance at the Cleeve monitoring point, investigation of the discharges to the River Erme in the Ivybridge area was carried out in 1987 - 1988 (Ref 1).

This resulted in identification of the following inputs in the River Erme (Figure 2).

1 - The Sewage Treatment Works

Final effluent quality failed to comply with the consent during 1987, on two occasions were BOD, Suspended Solids and Ammonia levels exceeded.

From 1 January to 31 March 1988 the STW failed to achieve the final effluent consent standard. In the same period the river downstream complied with Class 1A standards.

2 - The Woodland Stream (adjacent to the works)

The Woodland Stream was suffering from intermittent discharges of suspended solids and minor organic contamination. The main source was identified as a major building development.

3 - The Sewer Storm Overflows (3 known)

There were no significant problems relating to the operation of storm sewer overflows, however, all such discharges should be screened to prevent discharge of objectionable material.

4 - The Trade Effluent Discharge from Wiggins Teape Limited.

In general discharges of trade effluent from the Paper Mill comply with the consented quality standards, although failures do occasionally occur.

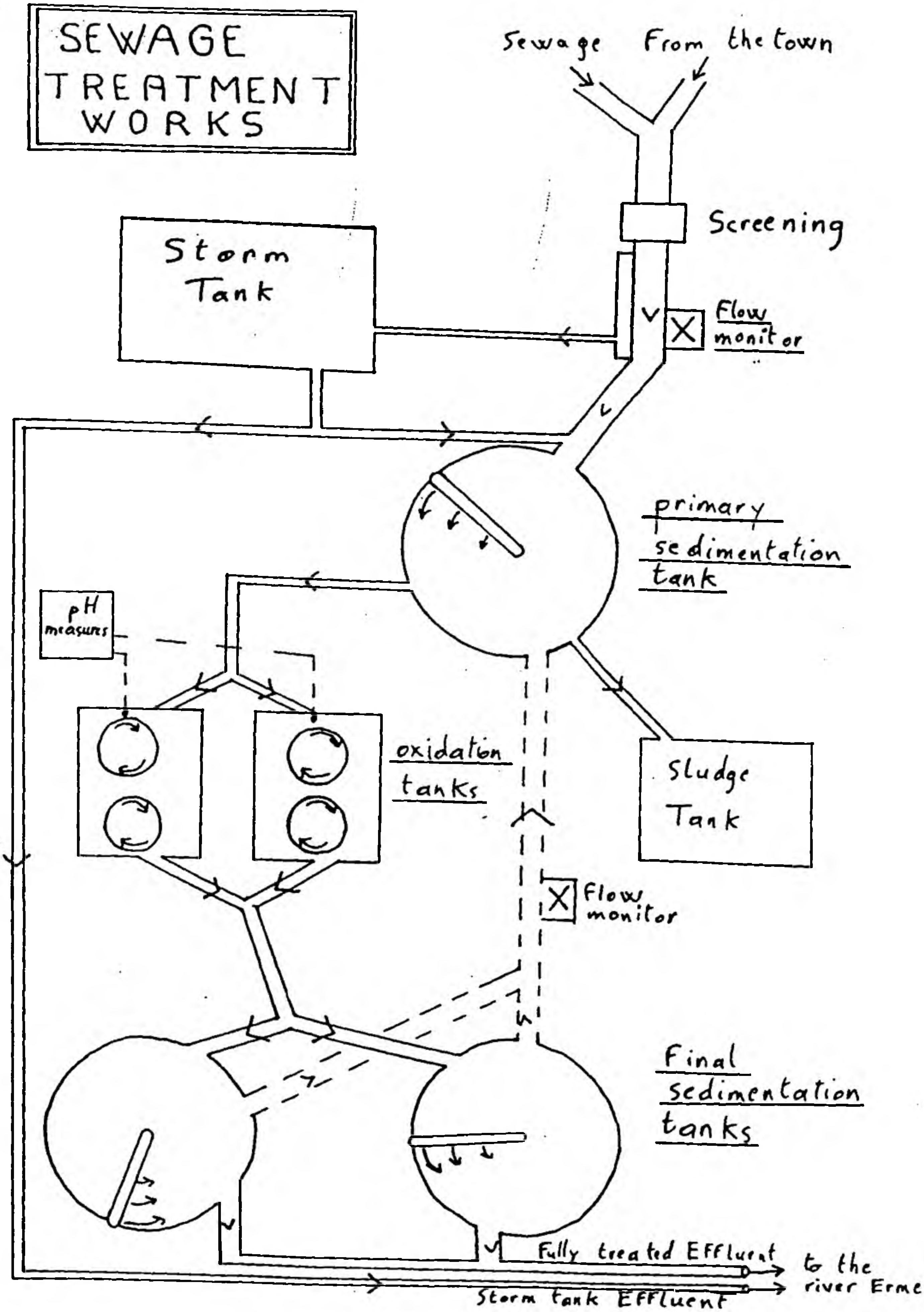
Upstream (Stowford Weir) and downstream (A38 Road Bridge) RQO of Class 1A is maintained.

5 - The Mill Stream

Although this stream receives intermittent discharges of crude sewage, the Mill Stream has no significant impact on the River Erme in respect of achieving the RQO of Class 1A downstream.

From this investigation a number of recommendations were made. These included that new consents for the sewage works discharge of final effluent and storm tank effluent must be obtained. A monitor should also be placed at the STW to assess the impact of the final effluent and storm tank overflow on the River Erme.

SUMMARY OF IVYBRIDGE SEWAGE TREATMENT



4.4 Ivybridge Sewage Treatment Works (Figure 3)

The sewage from Ivybridge town flows into the sewage treatment works from the main sewer to a single inlet channel. The sewage is then screened and passed to a primary sedimentation tank.

A flowmeter measures the flow of sewage into the works. If the flow exceeds 55 l/s the storm overflow procedure is operated.

The primary sedimentation tank allows the sewage to be filtered. It passes into the tank at the bottom and then flows upwards through a sludge blanket formed by suspended matter which acts as a filter media (photograph 1).

The sludge falls out of the bottom of the sludge blanket and is removed and taken to the sludge tanks.

The settled sewage then passes up to the surface of the primary sedimentation tank and over a weir into a collecting channel. The settled sewage from the collecting channel flows to two oxidation tanks.

The pH is adjusted to 7 by sodium carbonate prior to entering the oxidation tanks. In the oxidation tanks the organic matter in the sewage is broken down by aerobic bacteria which use the oxygen (photograph 2).

The settled sewage then flows to 2 final sedimentation tanks (photograph 3) and then finally to the River Erme (photograph 5).

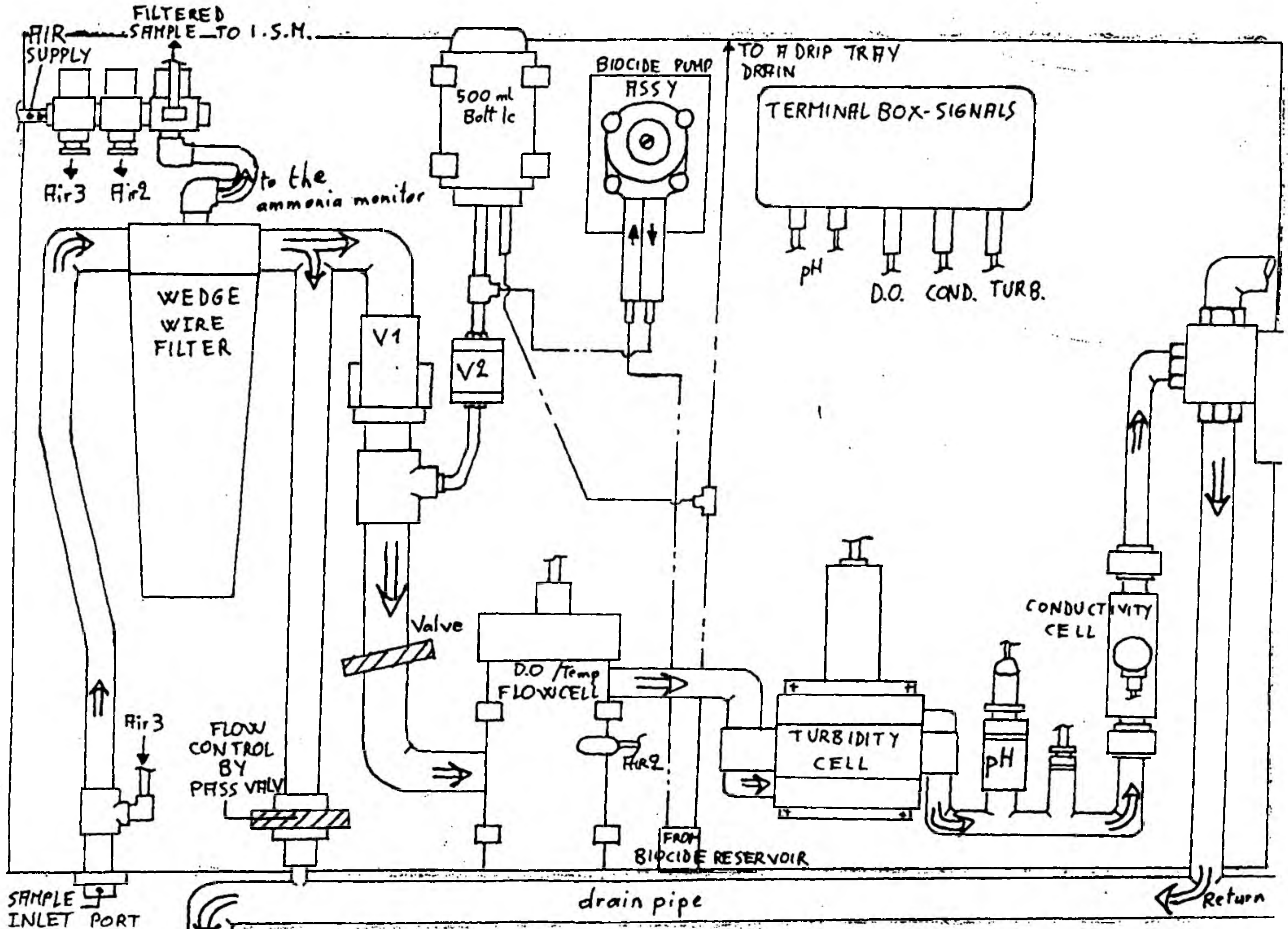
Sludge Tanks

The sludge from the sedimentation tanks is stored in the sludge tanks and then taken by lorry to be disposed of to land.

Storm Tanks

The storm tanks (photograph 4) start to fill when the flow to the works exceeds 55 l/s. The tanks allow the setting out of the crude solids. Storm sewage is then returned to the inlet for treatment. On occasions the storm tanks completely fill and storm sewage is discharged with the combined final effluent.

GENERAL FLOW DIAGRAM OF THE FLOW BOARD AND PROBES



5. THE IVYBRIDGE MOBILE MONITORING STATION

5.1 General Operation (Figure 4)

River water is pumped from 3 sources :

(a) 50m upstream of the STW final effluent (Pump 1).

(b) The Woodland Stream, 50m prior to the confluence with the River Erme (Pump 2).

(c) 200m downstream of STW final effluent - below the mixing zone (Pump 3) (photograph 7).

The pumps are submersible, each operating individually on an hourly time switch basis. The pumps are automatically backwashed prior to their operation (photograph 8).

Water is pumped to the mobile monitor (photograph 6) and enters two wedge filters. The first filter (not on the diagram) acts as a grit trap. The second filter is the main filter which acts as a fine sieve for removing damaging solids and silt. From here there is a separate flow to the ammonia monitor via three air valves which control the line pressure.

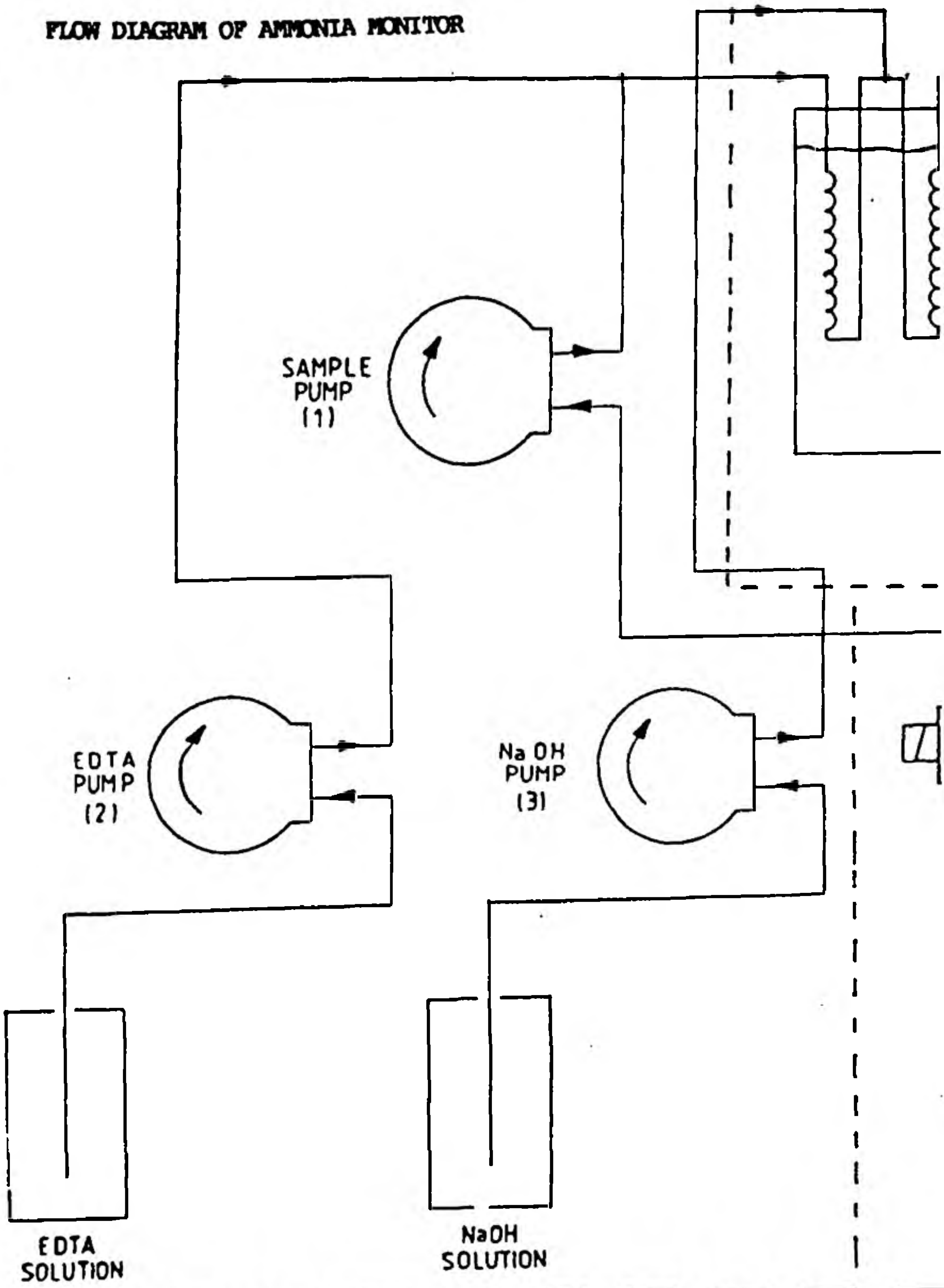
The main flow then passes to the dissolved oxygen (DO) probe. Prior to the DO probe biocide is pumped in every 6 hours from a small reservoir to the water system. This is to stop algae and fungi growing in the system during periods of warm weather.

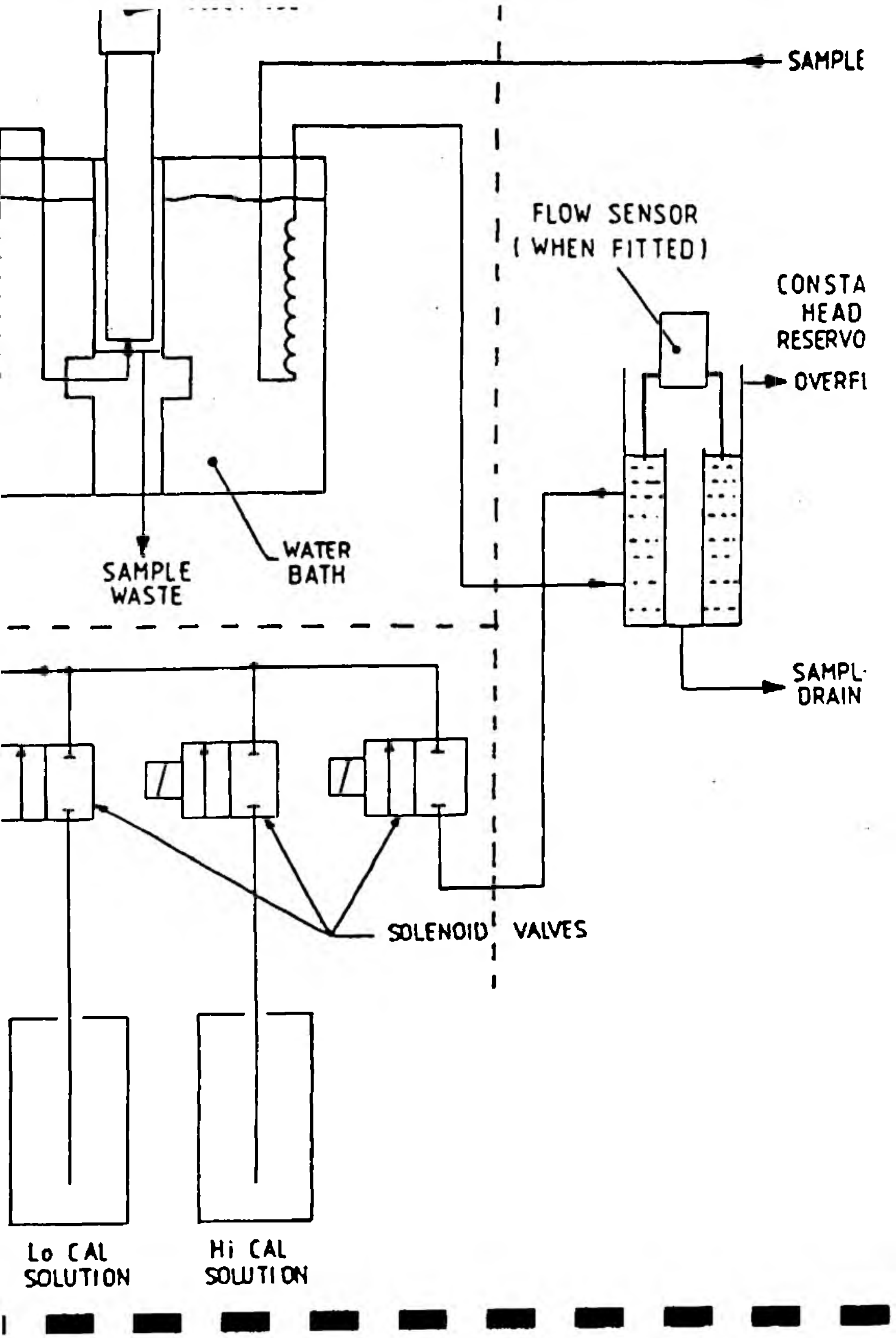
The water flow is then to the DO cell, then through a turbidity cell, a pH probe, a temperature probe, and finally a conductivity cell prior to returning to the River Erme (photograph 12).

The monitor has an automatic clearing cycle every 6 hours. This is performed by air and water purging of the line.

FIGURE 5

FLOW DIAGRAM OF AMMONIA MONITOR




SAMPLE
FLOW SENSOR
(WHEN FITTED)
CONSTA
HEAD
RESERVO
OVERFL
SAMPLE
WASTE
WATER
BATH
SAMPL
DRAIN
SOLENOID VALVES
Lo CAL
SOLUTION
Hi CAL
SOLUTION

5.2 **The Ammonia Monitor** (Figure 5)

(a) Ammonia

Ammonia is one of the forms of nitrogen found in water and is usually expressed in terms of mg/l N. Free ammonia, which is the same as free and saline ammonia or ammoniacal nitrogen, is the form most usually determined in rivers. It is so called because it exists either in the free state or as saline ammonium ion depending upon pH value. Deep well waters which are of good organic quality can contain high levels of free ammonia caused by the reduction of nitrates, either by bacteria or by the surrounding geological strata. However, ammonia can also indicate recent pollution of a waterbody, by either sewage or industrial effluent.

(b) The Monitor

The ammonia monitor (photograph 9) functions as a continuous on-line instrument. It is a potentiometric continuous analyser employing an ion selective probe to measure concentration of the ion in water. It performs automatic standardization and self adjustment against two known standard solutions (1pm and 4pm) to allow for drift in the probe sensitivity.

The gas-sensitive probe used in this monitor develops a potential proportional to the logointhem of the concentration of ions present in the sample.

Metal ions normally found in hard water areas, magnesium and calcium for example, may form insoluble hydroxides at high pH values, these ions are first complexed in the monitor with EDTA, to prevent precipitation at a later stage.

To ensure that all the ammonia present is converted to the non ionised form, the pH of the sample is then adjusted to a value greater than pH 12 by the addition of sodium hydroxide. The EDTA and sodium hydroxide also serve to maintain the total ionic strength in the treated sample approximately constant.

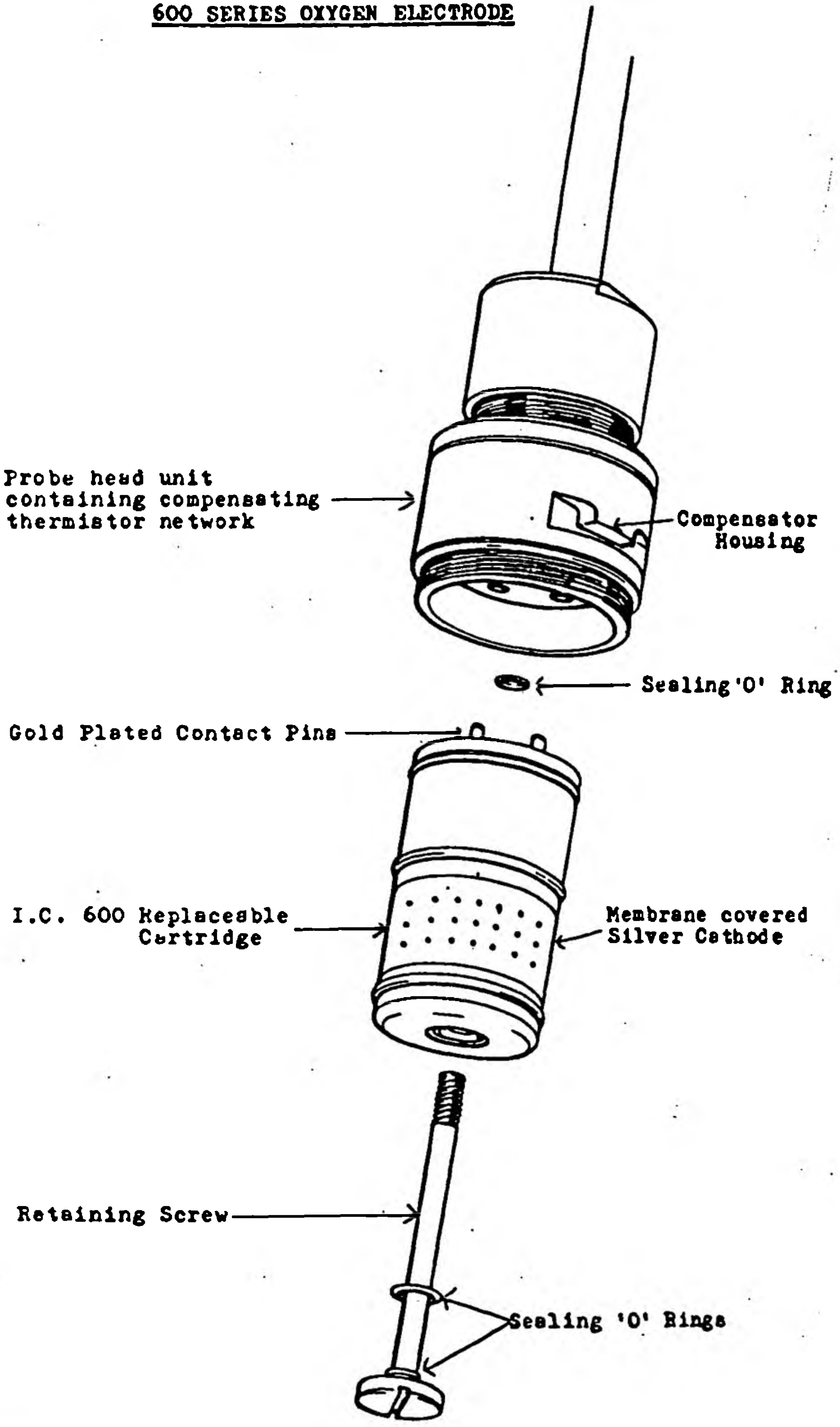
The monitor is normally automatically standardised at intervals of 6 or 12 hours by using first "low" and then "high" concentration standard solutions.

The main sample flow is preheated by passing through a heat exchanger coil in the waterbath/flowcell go to the constant head reservoir. Then it goes away at a constant rate of approximately 0.5 litres per hour by the sample pump via the sample solenoid valve (figure 5).

EDTA solution from the EDTA pump is added to the sample just before the first mixing coil. Sodium hydroxide from the sodium hydroxide pump is added to the sample just before the second mixing coil.

The mixture flows onto the probe membrane in a continuous stream and falls into the waste channel (photograph 10).

600 SERIES OXYGEN ELECTRODE



5.3 The Mimmex Monitor

The Mimmex recorder (photograph 11) gives display readings of 5 different channels which are :

Channel 1 : D.O
Channel 2 : temperature
Channel 3 : pH
Channel 4 : conductivity
Channel 5 : turbidity

Dissolved Oxygen Probe

The D.O. is recorded by an electrode consisting of a lead anode and a perforated silver cylindrical cathode. The space between the silver and lead anode is factory filled with a gel bicarbonate electrolyte which is active throughout the electrode life (figure 6).

The reaction which occurs is as follows :

$$0_2 + 4e \quad — \quad 2\ 0^2$$

It can be seen that the amount of current is proportional to the amount of oxygen, and in this way the oxygen concentration can be measured. DO readings are temperature dependant, thus temperature probe containing a thermistor is located within the head of dissolved oxygen electrode.

Turbidity Cell

Turbidity is an indication of the clarity of a water and is defined as the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a sample of water. Although turbidity is caused by material in suspension, it is difficult to relate it to a quantitative measurement of suspended solids as the shape, size, and refractive indices of different particles in suspension all affect their light scattering properties in different ways.

The Ivybridge turbidity cell use nephelometry. Nephelometers measure the intensity of light scattered in one particular direction predominantly at right angles to the incident light. They are highly sensitive and are usually unaffected by dissolved colours.

pH Probe

The pH is measured with a Hydrogen ion sensitive electrode, which is of glass construction or with a reference electrode.

The pH value or hydrogen ion concentration is a measurement of the acidity or alkalinity (basicity) of a water. Pure water is very slightly ionised into positive hydrogen (H+) ions and negative hydroxyl (OH-) ions.

Conductivity

Conductivity is the measurement of the ability of a solution to carry electric current. As this ability is dependent upon the presence of ions in solution, a conductivity measurement is an excellent indicator of the total dissolved solids in a water.

In the conductivity cell a voltage (E) is applied which creates a current (i) in the water, so we have the relation :

$$E = R. i$$

with the resistance :

$$R = P. \frac{l}{s}$$

P : resistivity (NS^1/cm^1)
l : cell's length
s : cell's section

The conductivity (x) is :

$$x = \frac{1}{P}$$

The unit of conductivity is μ S/cm (microsiemen per cm).

5.4 Datalogging

The data logging system at Ivybridge consists of a data storing module called a Newlog. The Newlog stores data from the recorder Newlog is manufactured by a company called Technolog who supplied the equipment and software for the data handling system at Ivybridge. The data stored on the Newlog is transferred to a PSION pocket computer.

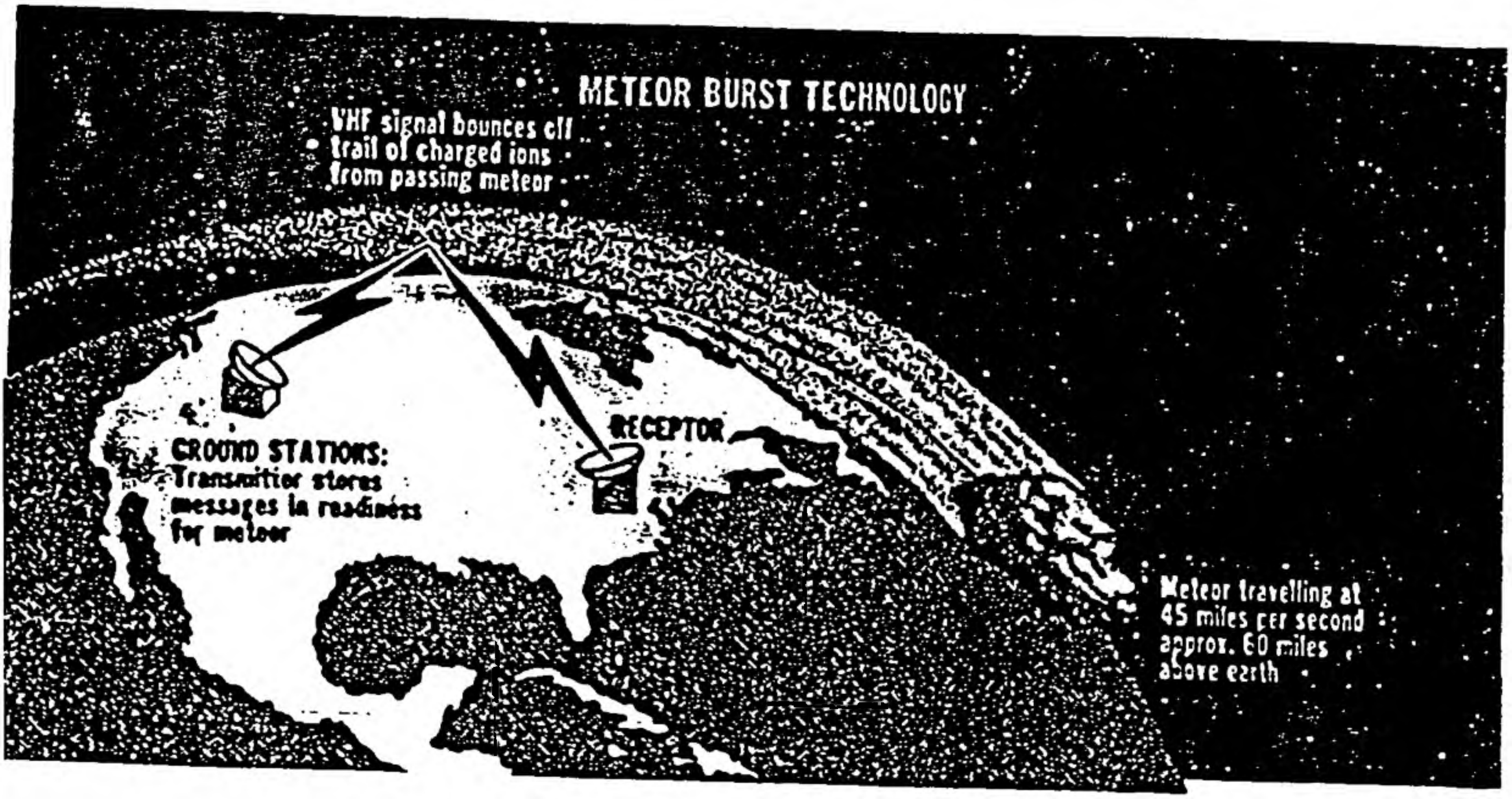
Data files collected on the PSION have to be transferred to a floppy disc with the help of a "Zenith" portable computer. In order to use the data easily (e.g. to print out graphs) the Newlog files on floppy disc are converted to report files. This allows the data to be formatted in a way that the computer system at the NRA can read.

Report files are then sent to "IBM" PC, and from the "IBM" PC sent to Vax user area. Vax is the "big computer", the network used in the South West NRA.

Once in the Vax user area, the data can be utilized and graphs drawn.

FIGURE 7

SUMMARY OF METEOR BURST TECHNOLOGY



5.5 Meteor Burst Communication

(a) Principle

Meteor-burst communication uses the fiery trails of meteors to reflect radio signals from one point on earth to another. High speed equipment controlled by computers can sense a meteor trail and broadcast information during the split second intervals so that it flashes through the sky.

When a meteor enters the earth's atmosphere, travelling at speeds of 70 to 75 km/sec, it possesses a large amount of kinetic energy. As it begins colliding with molecules of air, the meteor's kinetic energy is dissipated in the form of heat which serves to vaporise the surface atoms. These free atoms, travelling at the same speed as the meteor, also collide with the even denser molecules of air. These collisions result in the stripping of electrons from the atoms and air molecules leaving behind a trail of positively charged ions and free electrons. When a very high frequency radio beam strikes such a trail, the ions absorb the VHF radio energy and radiate it back toward the ground, acting as if they were tiny reflectors (figure 7).

(b) Practical aspect

The Ivybridge outstation (photograph 13 and 14) takes analogue data every 15 minutes. These data, produced by the monitor, are from 6 different sources: Dissolved Oxygen, temperature, pH, turbidity, ammonia, conductivity, and sample source (pump 1, 2 or 3). When the outstation detects a meteor in the atmosphere it send its information, which are reflected by the meteor trail. This information then comes back to earth at the master station at Newbury.

A code is sent at the end of each information package to say the whole data set has been sent. If this code is not received which can happen if a meteor burns out too quickly, the same information is sent out again until received correctly.

From the Newbury station information are sent by an identical meteor burst system to Exeter. At Exeter the data is stored on a computer where it can be used. Graphical displays are available to assist interpretation.

The data has to be sent to the Newbury station first because there are lots of meteor-burst communications occurring at the same time (in United Kingdom and in other countries). So as the frequencies used can sometimes be very similar a master station (Newbury) is necessary to control the communication protocol and the dissemination of the received information. However, the communication of data between Ivybridge and Newbury is usually carried out in a few minutes.

FIGURE 8

MONITOR LOG SHEET

SITE VISIT RECORD

DATE	TIME	NAME	READINGS						
4/5/90	11H05	J.B.M.	D.O.	TEMP	P.H		TURBIDITY		PUMP No	CON
INITIAL MONITOR READING			76%	15.9°C	7.28		-0.1		1	96
PRIOR TO CALIBRATION			110%	—	4.0: 4.39	9.2: 8.77	0: 0.45	40: 3.92	—	—
FOLLOWING CALIBRATION			100%	—	4.00	9.2	0.00	4.00	—	—
FINAL MONITOR READING			96.1%	15.4°C	7.91		5.5		2	399

OPERATION	LOW	HIGH
INITIAL MONITOR READING	0.18	
STANDARDS	1	4
% ERROR	+ 2%	-2%
STD PRIOR TO COMPENSATING	1.01	4.01
% ERROR AFTER COMPENSATING	00%	00%
FINAL MONITOR READING	0.09	

METER READING KWH	15296

NOTES

D.O.: electrode removed due to water in head

pump change from 1 to 2

SITE VISIT RECORD

DATE	TIME	NAME	READINGS						
			D.O.	TEMP	P.H		TURBIDITY		PUMP No
INITIAL MONITOR READING									
PRIOR TO CALIBRATION					4.0	9.2	0	40	
FOLLOWING CALIBRATION									
FINAL MONITOR READING									

OPERATION	LOW	HIGH
INITIAL MONITOR READING		
STANDARDS		
% ERROR		
STD PRIOR TO COMPENSATING		
% ERROR AFTER COMPENSATING		
FINAL MONITOR READING		

METER READING KWH	

NOTES

6.0 METHOD

6.1 The Maintenance of the Monitor

As part of my project I have had to maintain and service the monitor on a weekly basis.

The first action is to download the data from the Newlog with the PSION (pocket computer) by connecting it to the data logging of the Newlog.

Before any clearing or calibration is carried out, all the initial monitor readings are recorded on the weekly log sheet (Figure 8).

The next part of the maintenance programme is to clean and calibrate all the probes. The maintenance is done in the following order :

(a) Ammonia

i. The ion sensitive probe is taken out of the waterbath and topped up with a solution if required.

ii. The level of the waterbath is adjusted with distilled water until full.

iii. The flow tubes are cleared of suspended solids by pinching them with pliers to move any settled matter in the tubes.

iv. The four neagests are renowed in order that the monitor can have continuous operation. This must be done weekly to prevent the standards from drifting - EDTA and sodium hydroxide is stored at the monitor. The standards are made up weekly at a laboratory.

v. After the cleaning of the ammonia monitor calibration is carried out. This is done by a set programme built into the monitor. To start the programme, the "Initialise Calibration" button is pressed. The automatic calibration takes approximately 20 minutes. After the calibration the monitor will print out.

a. % error prior to calibration
b. % error after compensation

These are recorded on the site visit record.

vi. If necessary the chart recorder paper is changed.

(b) Mimmex Recorder and Flow Circuit

i. The chart recorder paper is changed. The new paper must be dated and started at the correct time on the paper.

ii. The pumps are switched off so there is not flow to the monitor.

iii. The DO probe is cleared to remove any dirt. Care must be taken not to damage the sensitive membrane.

iv. The DO/temp flowcell is air calibrated. The probe is unscrewed and allowed to sit in air for at least 5 minutes. The DO valve should be 100% in air. The actual reading prior to adjusting to 100% is recorded on the site visit sheet. The DO reading is adjusted to 100% by the span button on the mimmex recorder.

v. The turbidity cell is cleaned by removing the top and bottom of the cell. It is then cleaned with a brush inside to remove any dirt.

vi. Calibration of the turbidity cell is carried out using a 0 NTU standard (distilled water) and a 40 NTU standard starch solution.

The standard is poured into the turbidity cell. Rubber corks prevents the standard from leaving the cell. The cell is then re-assembled. After five minutes, the reading stabilises and noted the reading is adjusted to 0 NTU or 40 NTU accordingly by using the span knob.

vii. The pH probe is removed and cleaned.

viii. The pH probe is calibrated using 4.00 and 9.2 buffer reagents. Care must be taken to clean the probe between each calibration to prevent contamination. The readings are recorded before and after the calibration.

viii. After all these calibrations the two wedge filters from the water circuit must be cleaned. They are unscrewed and cleaned with a brush.

ix. The constant head reservoir on the ammonia monitor side must be cleared with a brush.

x. If necessary the biocide reservoir is refilled.

xi. After checking everything is replaced correctly the pumps are turned on.

xii. The monitor is allowed to settle. The final monitor readings are recorded.

(c) The Pumps

The last thing to do is to go in the river and shake each pump in order to remove anything that could obstruct it, providing it is safe to do so.

6.2 **Performance and Assessment Surveys**

(a) Comparison of the data recorded by the monitor with the actual water quality in the River Erme.

This was done by taking chemical samples from :

i. 50m upstream of STW final effluent (Pump 1)

ii. The Woodland Stream (Pump 2)

iii. 200m downstream of final effluent (Pump 3)

On 1 May 1990, 11 May 1990 and 18 May 1990 samples were taken from these sites for DO, ammonia, pH conductivity, temperature and suspended solids. DO was taken separately in a 125ml bottle taking care to remove any air in the bottle by filling up to the top. To this, 1.5ml manganese sulphate and 15ml Azide was added.

All the other parameters were taken in a single 1 litre bottle.

The readings were noted at the same time the samples were taken on the Mimmex recorder for DO, conductivity, pH temperature and turbidity. The reading of ammonia on the ammonia monitor was also recorded.

The last operation was to bring all the samples to Countess Wear laboratory for analysis.

(b) Comparison of the data recorded by the monitor with the data recorded on the Newlog Datalogger

On 18 May 1990 readings were taken from both sources at the same time and compared.

(c) Comparison of the data recorded by the monitor with the data transmitted by meteor-burst to NRA (South West)

On 18 May 1990 the monitor readings at specific times was recorded. At the same times the readings received at the NRA Headquarters from the meteor-burst system was recorded.

(d) Assessment of the water quality in the River Erme

In order to assess the water quality in the River Erme samples for DO, ammonia, temperature, pH, conductivity and suspended solids are taken at a river flow above the Q95 (the flow that should be exceeded for 95% of the year 0.212 cumecs) and a flow approximately at the Q95.

On 1 May 1990 the river flow was 0.420 cumecs. Samples were taken at :

i. the final effluent
ii. A38 roadbridge - River Erme
iii. River Erme at Cleeve routine monitoring point
iv. the Woodland Stream

On 29 May the river flow was near to the Q95 (0-212). The flow was 0.262 cummecs. The survey repeated.

The continuous recording of the parameter by the Ivybridge mobile monitor will also allow the water quality of the River Erme to be assessed upstream and downstream of the STW and the Woodland Stream.

6.3 Ivybridge Data Handling

To sort and use the Ivybrige data the following was carried out :-

Summary

1. Download Newlog with Psion
2. Files on Psion to floppy disc
3. Convert Newlog files on floppy to report files
4. Send report files to PC
5. Send report files from PC to Vax user area
6. Data handling in DEC 2020

Introduction

1. File Names

DATA0101 DATA 0102.
DATA0201 DATA 0202.

The DATA02 refers to a complete block of data transferred from the Newlog to the Psion on a particular occasion.

The DATA02 (01) - refers to the data file for a particular parameter.

eg DATA0201 refers to the second file transfer from Newlog to Psion, and the particular file refers to dissolved oxygen (01).

DATA0201)
DATA0202)
DATA0203)
DATA0204) will be downloaded in one session
DATA0205) of reading data from Newlog.
DATA0206)
DATA0207)

Downloading data from Newlog with Psion

1. Switch on Psion

2. Select status to check of Newlog logging

3. Select on/clear key to return to menu

4. Select Data

5. Select Read - will retrieve data from Newlog

6. To restart logging select start/stop

7. Press O to turn off Newlog

Note: Use arrow keys to move cursor to selected functions
Press Exe to select.

Download the Psion to a disc

Using laptop computer

1. Insert software disc in drive A and turn on computer

2. Insert Data disc in drive B

3. Select (1)

   demo/B
   data
   retrieve

4. Then on Psion press on
   data (Exe)
   send
   all files/one file (Exe)

5. Select enter on computer

6. Select exe on Psion

Convert Newlog files on disc to report files on disc

1. Insert software disc in drive A of laptop

2. Turn on and allow to boot up

3. Insert data disc in drive B

4. Select Data
   View
   Report

5. A list of files are displayed. Select a file to be formatted to report file by pressing + (return)

6. You will be asked if you want to send to printer. By pressing + you will then be asked if you want to send to a report file - Select by pressing return

7. The file will now be formed

<u>Report file on disc to PC to vax</u>

1. Insert software in drive A

2. Turn on PC

3. Select V

4. Type sd (.datalog) (return)
   Type r F7VMS (return)

5. Insert data disc in drive B

6. Select (1) PC to host

7. Name the file to host eg Data0101.Rep (return)

8. Name the file on PC eg a:Data0101.Rep (return)

This will send the file from the data disc to the Vax via the PC.

<u>Vax for handling data</u>

1. Go into Taw or Exe cluster

2. Select V

3. Type sd (.datalog)

4. Type S2020

5. Terminal type <VT340C>: return

6. Select / to retrieve menu

7. Select store
   import
   data
   delimited

8. Type in file to retrieve for display on spreadsheet

Note: filenames have changed
eg PH_35_2020Data0101.Rep Return.

9. This will then display data on screen in 2020 format. The data can then be used and the spreadsheet adjusted with the 2020 commands

10. To convert dates and time to a digital reading required for the X Y graph

(a) Press (DO) key
(b) Type loggerin (return)
(c) Type file name (return)
(d) Press (DO) key
(e) Type loggertime (return)

The spreadsheet will display

A Day

B Month

C Year

D Hours

E Minutes

F Seconds

G Date

H Time

I Data

L Decimal date (number of days after start of 1st month)

M Decimal time

N Decimal date and time

The graphs can now be drawn and plotted using the DEC 2020 computer commands.

7.0 RESULTS AND DISCUSSION

7.1 The Performance of the Mobile Monitor

7.1.1 Comparison of the Monitor Readings with Spot River Samples

Results of the surveys carried out are shown in Table 1, 2 and 3.

Dissolved Oxygen

The average errors given by the surveys of May the 1st, 11th and 18th are the following :

13.44%, 14.10%, 3.58%

The smaller error is 4.34% (laboratory data : 98%)
(monitor data : 96%)

The largest error is 17.79% (laboratory data : 95%)
(monitor data : 78.1%)

The results show that the accuracy of the monitor is not very good. For example the percentage error of 10.31% is from a laboratory data of 98%, and a monitor data of 87.9%. The percentage error of 11.84% is from a laboratory data of 87% and a monitor data of 76.7%.

Temperature

The temperature accuracy was not assessed, but that the monitor never gave suprising temperature values (e.g. m-x 11.8°C, and 15°C were recorded).

pH

The average percentage errors recorded are :

1.77%, 3.47%, 4.47%

The percentage errors range from -10.9% (laboratory data : 7.2, monitor data : 6.41) to +4.38% (laboratory data : 7.3, monitor data : 6.98).

Examples of data shown for the percentage error of -7.74% are laboratory data of 7.1 and a monitor data of 7.65, or for the percentage error or 1.87% a laboratory data of 8 and a monitor data of 7.85.

The accuracy is sufficient in considering the range used for pH. Indeed for a River Class 1A we must have $5<pH<9$, and usually we have $6<pH<8$. If the pH was near to 5 or 9 the accuracy would be more critical.

Conductivity

The average % errors recorded are for the surveys are :
4.48%, 2.69%, 5.38%

The % error are between -10.4% (laboratory data : 134 μS/cm), and +6.66% (laboratory data : 105 μS/cm, monitor data : 98μS/cm).

The conductivity accuracy appear to be good, for example the percentage error of -5.75% with a laboratory data of 400μS/cm and a monitor data of 423 μS/cm.

Turbidity

The average % errors recorded are :

103.46% and 3564.8%

The % error range from -7580% (laboratory data : 1.0 mg/l, monitor data = 76.8 mg/l) to +160% (laboratory data : 0.5 mg/l, monitor data : -0.3 mg/l.

Turbidity is the main problem of the monitor, as the data that it gives does not represent the real values. For example when the laboratory data is 3.1 mg/l the monitor data is 0.4 mg/l (percentage error : 87.9%), or when the laboratory data is 0.6 mg/l the monitor data is 19 mg/l (percentage error : 87.9%), or when the laboratory data is 0.6 mg/l the monitor data is 19 mg/l (percentage error:-3066%).

Turbidity continually changes so if the two samples (for the laboratory and for the monitor) are not taken at the same time, a difference can appear between the results. However this cannot explain such a big percentage error. The problem must come from a malfunction of the monitor.

Ammonia

The average errors recorded are :

131.14% and 54.65%

The errors are from -350% (laboratory data : 0.04 mg/l, monitor data : 0.18 mg/l) to +98% (laboratory data : 2.0 mg/l, monitor data : 0.16 mg/l).

The accuracy is not very good for example laboratory data of 0.07 mg/l for a monitor data of 0.12 mg/l (error : -71.49%).

Each week the maintenance of the monitor is carried out, but only the accessible pipes are cleared. The other pipes must be very dirty as the accessible pipes always contain a lot of suspended solids from the water.

This may have an effect on the actual reading of the ammonia monitor.

7.1.2 Overall Assessment of the Monitor

Calibration

Results are shown in table 4.

DO

A drift is always recorded which vary from -20% to +7.8%.

This may influence the accuracy of the DO values. For example on May 11th the error between monitor and laboratory data is 14.10%, but the drift recorded after calibration is 8% (so the percentage error without drift would have been 6.1%).

pH

A drift is always recorded before each calibration: For example on 4.5 instead of 4, and nearly 8.7 instead of 9.2 is recorded.

Turbidity

On each calibration the average reading prior to correction is 0.4 instead of 0.0 (e.g. 0.70, 0.45, 0.53, ...) and instead of 40 nearly 39.4 (e.g. 37.6, 39.2, 40.4).

Ammonia

The drift recorded for the low standard is between 12% and 16%. The drift recorded for the high standard is between -87% and 0%.

Mimmex Recorder

On the Mimmex Recorder two pens do not operate on the chart paper (the turbidity and ammonia pens).

The calibration of the turbidity cell must be performed carefully to have good values as sometimes negative data were recorded. Careful cleaning and calibration should be performed.

Attention must be paid to the DO cell, on one occasion water appeared in the head of the probe and incorrect data was recorded.

However the Mimmex recorder is easy to use as everything is clearly disposed on the front side.

Ammonia Monitor

The Sodium Hydroxide pump may be developing a leak, this can be from a split in the pump tube.

All the pipes in the Ammonia Monitor need to be cleaned as there is a lot of suspended solids in the river water, which can remain in the pipes. The visible pipes are cleaned every week but the remaining pipes to be cleaned occasionally.

Pumps

A problem has developed over the final 3 weeks of the project (started 29 May 1990) with pump 3.

On visiting Ivybridge pump 3 has not been operating. However, after cleaning and re-setting, the pump is operating. The pump develops a fault later in the week and shuts down.

This needs to be investigated. There may be a fault with the actual pump or the pump line to the monitor.

7.2 Data Communications

7.2.1 Comparison of the Monitor Readings with the data recorded by the Newlog Datalogger

Results are shown in table 5.

DO

Average error : 2%

The error is between -2.25% (monitor : 89%, datalog : 91%) and 2.38% (monitor : 96.3%, datalog : 94%).

The accuracy is good, for example for a monitor data of 94.3%, the datalogger gives 93% (error : 1.37%).

Temperature

Average error : 2.79%

Error from 2.25% (monitor : 13.3°C, datalog : 13.0°C) to 3.15% (monitor : 18.7°C, datalog : 12.3°C).

The accuracy is good for example for a monitor data of 13.4 the datalogger gives 17.0 (error : 2.98%).

pH

Average error : 1.44%

The error ranges from -1.4% (monitor : 6.41, datalog : 6.50) to 2.06% (monitor : 7.76°C, datalog : 7.6°C).

The results show good accuracy, for example when the monitor data is 7.06 the datalog is 7.00 (% error of 0.85%).

Conductivity

The datalogger will not record the conductivity reading it records a constant value of zeros. The problem may come from the software.

Turbidity

The error recorded is :

-940% (monitor data : 20.0, datalogging : 208)

-577.08% (monitor data : 76.8, datalogging : 580)

There appears to be a problem which may be linked to the conductivity problem.

Ammonia

Average error : 28.25%

The percentage error ranges from 11.76% (monitor : 0.17 mg/l, datalog : 0.15 mg/l) to 44.44% (monitor : 0.09 mg/l, datalog : 0.05 mg/l).

The percentage error shows a poor accuracy. For example an error of 28.57% from the monitor data of 0.07 mg/l and a datalogging of 0.05 mg/l.

7.2.1 Overall assessment of the Newlog Datalogger

As the data from the monitor and those from the datalogger have not been taken at exactly the same time (4 minutes apart) the values may be expected to differ. The percentage error for the DO, temperature and pH data appear to show a good accuracy. However, there was a problem with the conductivity, turbidity and ammonia recording on the datalogger.

7.2.3 Comparison of the Monitor Readings with the Meteor-Burst Communications System

Results are shown in table 6.

DO

Average error : 1.26%

The error ranges from 0.53% (monitor : 96%, meteor-burst : 95.49%) to 2.61% (monitor : 89%, meteor-burst : 86.67%).

For example a percentage error of 0.66% have been calculated from the monitor data of 94.90% and a meteor-burst data of 94.27%. The accuracy is good.

Temperature

Average error : 1.38%

The error is between -1.66% (monitor : 13.8°C, meteor-burst : 13.48°C) to -0.97% (monitor : 13.4°C, meteor-burst : 13.53°C).

These values show good accuracy.

pH

Average error : 1.16%

The percentage error is from 0.45% (monitor : 7.68, meteor-burst : 7.64) to 2.34% (monitor : 6.41, meteor-burst : 6.86).

Here too the accuracy is good.

Conductivity

Average error : -91.25%

The percentage error is from -94.44% (monitor : 423 μS/cm, meteor-burst : 828.48 μS/cm) to -86.31% (monitor : 98 μS/cm, meteor-burst : 189.59 μS/cm).

There is a problem with the conductivity, again it may arise from the software the meteor-burst data it is always a slightly less than twice the real value.

Turbidity

Average error : 44.94%

The error ranges from 2.27% (monitor : 7.04 mg/l, meteor-burst : 6.88 mg/l) to 95.51% (monitor : 19 mg/l, meteor-burst : 0.852 mg/l).

The turbidity accuracy is poor and the percentage error is very unstable.

Ammonia

Average error : 17.49%

The error is from 9.64% (monitor : 9.28 mg/l, meteor-burst : 0.253 mg/l) to 37.85% (monitor : 0.070 mg/l, meteor-burst : 0.047 mg/l).

The accuracy for ammonia is poor and the percentage error is unstable.

7.3.1 Overall Assessment of Meteor-burst Data Communications System

The data received for DO, temperature and pH parameters are good but the accuracy for the conductivity, turbidity and ammonia data transfer needs to be improved.

The meteor-burst communication system has an effect on the chart paper of the Mimmex monitor. Since the start of the meteor-burst communication, spiking occurred on the DO and temperature chart recordings (Appendix 2).

7.3 Assessment of Water Quality in the River Erme and Woodland Stream

7.3.1 Spot Sampling Surveys

Spot river samples were taken on 1 May 1990 and 29 May 1990. Results are shown in tables 7 and 8.

From the results it can be seen that on 1 May 1990 the River Erme at A38 bridge (routine monitoring point) complied with the RQO of 1A, with

pH - 7-2
Temp - 14.2 °C
DO - 99%
Ammoniacal Nitrogen - < 1-0 mg/l

The routine monitoring point at Cleeve also complied with the RQO of 1A.

pH - 7-7
Temp - 14.3 °C
DO - 100%
Ammoniacal Nitrogen - < 1-0 mg/l

On 1 May 1990 the Woodland Stream was also classed as 14.

pH - 7-8
Temp - 14.1 °C
DO - 105%
Ammoniacal Nitrogen - < 1-0 mg/l

The final effluent met the consent of 30/20/10 (suspended solids/biochemical oxygen demand/ammoniacal nitrogen). However, suspended solids was not measured directly and turbidity was analysed. The turbidity of the final effluent is 4-7 NTU. This is a low value, thus it is assumed the sewage treatment works met the consent for suspended solids.

On 29 May 1990 the RQO of 1A was achieved for the River Erme at both routine monitoring points and one Woodland Stream (table 9).

Ivybridge STW final effluent complied with the ammoniacal nitrogen consent (<1-0 mg/l). However, the final effluent had a low DO of 40%. The DO upstream at A38 roadbridge was 94% downstream at Cleeve. The DO was 89%, and 85% in the Woodland Stream. The low DO in the final effluent does not appear to cause decreased DO readings downstream at the Cleeve routine monitoring point.

7.3.2 Assessment of Water Quality in the River Erme from the Ivybridge Monitor

Results are shown in the graphs and a summary of the data in Table 9, 10 and 11.

One of the aims of the project was to assess the water quality in the River Erme over the whole period of the project and to decide whether the sewage treatment works effluent is having an effect on the water quality in the River Erme.

The data was downloaded from the Newlog to the PSION weekly. However the system for getting the data from the PSION to a form that the data can be displayed and graphs drawn was still being developed whilst the project was being undertaken. During the final week of the project the data was still not in a form in which it could be handled completely. It was intended to assess and display the data recorded by the Ivybridge monitor during the complete period of the project. Due to the problem with the software, it was only possible to obtain and assess data for one week - 11 May 1990 to 19 May 1990. The data was recorded hourly from each pump source.

The River Erme has an RQO of NWC 14. The River Erme, 50m upstream of Ivybridge STW final effluent failed the DO criteria (80%) on 5 occasions. The weekly DO mean is 90%. The average ammonia concentration is 0.17 mg/l and only on four occasions did the ammonia concentration exceed the consent of (0.31 mg/l).

The average pH was 7-3. The pH range was between 7.7-9, thus it complied with the pH criteria in a class 1A river. The average temperature was 8.9°C and never greater than 12°C (class 1A - 21.5°C).

The average turbidity reading was 7 NTU. However, there was a wide range 0-355 NTU. On 14 May 1990 and 15 May 1990, turbidity values were the highest.

The River Erme upstream of Ivybridge STW final effluent complied with the RQO of 1A during the period 11 May 1990 to 19 May 1990 for pH and average. The dissolved oxygen readings average 90%. DO values of 10% and 55% were recorded on 2 occasions but the immediate readings taken after increased to 90-95%. The ammonia concentration exceeded the class 1A criteria of 4 occasions (0.31 mg/l) reaching a maximum of 3.5 mg/l.

The Woodland Stream had an average DO reading of 88%. It failed the 80% criteria on only 3 occasions on 17 and 18 May 1990. An average ammonia concentration of 0.11 mg/l was recorded with a maximum of 0.48 mg/l it failed to meet the Class 1A criteria (0.31 mg/l) only on 2 occasions. On 14 May 1990 the pH in the Woodland Stream complied as a Class 1A river with a pH range 6.5 - 7.5. The turbidity of the Woodland Stream reached comparatively higher values on 14 May 1990 and 15May 1990. This corresponds to the increased turbidity readings in the River Erme, 50m upstream of the final effluent. This suggests the possibility of some rain. The average temperature of the Woodland Stream was 8.7°C and in the range 7-12°C. The Woodland Stream on average met the Class 1A criteria. However, DO and ammonia failed on a few occasions.

The River Erme, downstream of Ivybridge STW final effluent failed the criteria for DO on 7 occasions. The average DO reading was 91%. The DO readings only fall below 78% on one occasion, when a reading of 67% was recorded. There is no corresponding increase in ammonia, pH or turbidity. The average ammonia concentration was 0.21 mg/l. However ammonia failed on 35 occasions. This may be attributed to the STW final effluent as the ammonia concentration upstream of the STW and the Woodland Stream complied with the Class 1A criteria on most of these occasions. The pH range was 7 - 7.8 and the temperature range 7.2 - 12°C. Again there was a marked increase in turbidity on 14 May 1990 indicating the possibility of rain.

The comparison of the values recorded show that there was a difference of ammonia concentration between the River Erme upstream and downstream of the final effluent 0.17 mg/l, 0.71 mg/l. However the ammonia concentration in Woodland Stream was lower than in River Erme (0.11 mg/l). The pH average value is lower in the River Erme upstream of the STW than River Erme downstream of the STW (7.2 and 7.3), but the pH average value for Woodland Stream was higher than River Erme.

This study shows that during the week from 11 May 1990 to 19 May 1990 the Woodland Stream did not have an effect on the River Erme. The difference that appears in the upstream and downstream points appears to come from the sewage treatment works final effluent.

8. CONCLUSIONS

8.1 The cleaning and calibration of the monitor and probe is a fairly simple operation. There are no real problems with the calibration procedure and the accuracy. However, the turbidity cell was constantly giving negative readings prior to the calibration adjustment.

8.2 The project shows that the accuracy of the monitor was reasonable for DO temperature and pH.

8.3 The pumps performed well. However when the river flow decreased the pumps occasionally failed due to them not being fully submersed.

8.4 The data logger is a successful way of communicating and using data with the aid of computers. However, problems arose from the conductivity channel as the data always read 0. The ammonia and the turbidity data stored by the Newlog also showed variation with the data recorded by the monitor.

8.5 Meteor burst is a surprising way of communication and a new rival to satellite technology. The results are consistent with the monitor readings. The only main problem was the spiking on the chart record readout associated with the meteor burst.

8.6 The spot river surveys show that on 1 May 1990 and 29 May 1990, compliance was achieved in the River Erme and the Woodland Stream.

8.7 It was intended to assess the water quality in the River Erme upstream and downstream of Ivybridge STW, Woodland Stream, and to decide whether the STW final effluent was causing a decrease in water quality in the Erme using the data from the monitor. However, as a result of problems in being able to access the data, the assessment was only possible for the week 11 May 1990 to 19 May 1990.

8.8 The River Erme, upstream of the final effluent, and the Woodland Stream, met the criteria for Class 1A on more than 95% of the time. The River Erme downstream of the final effluent failed to meet the ammonia criteria (0-31 mg/l) on at least 22% of the readings.

8.9 The source of the ammonia failure downstream of the sewage treatment works final effluent appears to be the Ivybridge final effluent.

8.10 I enjoyed my probationary period as I studied new ideas and in a different country and society. I have discovered a new aspect of scientific work and have contributed to the NRA.

The project has also enabled me to improve my English.

9. RECOMMENDATIONS

9.1 During spot samples surveys the suspended solids concentration was not assessed. This have to be done as it is a criteria for the river classification system.

9.2 The tubes of the ammonia monitor have to be cleaned, especially the tubes for which access is not easy.

9.3 If the meteor-burst communication system is to be used the problem of the spiking on the chart recorder paper has to be solved.

9.4 The conductivity given by the datalogging system is always 0, thus the problem with the software should be solved.

9.5 The accuracy of the turbidity and the ammonia concentration on the data logger has to be improved (the turbidity accuracy is extremely bad and ammonia is the main problem of the River Erme).

9.6 The conductivity accuracy from the meteor-burst system have to be improved as the data given is always nearly twice the real value.

9.7 Two pens for the Mimmex chart recorded paper do not work. They must be replaced.

10. REFERENCES

1. South West Water
   Ivybridge Sewage Treatment Works
   Environmental Impact Assessment
   Summary Report

TABLE 1

TABLE TO SHOW COMPARISON OF THE MONITOR
READINGS WITH SPOT RIVER SAMPLES ANALYSED BY A LABORATORY

Data from 1 May 1990	PUMP I (at 11.15)			PUMP II (at 12.00)			PUMP III (at 13.30)			Average Error (without taking the sign into account)
	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	
D.O. (%)	101.0	87.7	13.16%	105	87.3	16.86%	98	87.9	10.31%	13.44%
Temperature (°C)	-	14.2	-	-	14.1	-	-	15.0	-	-
p.H.	7.2	7.26	-0.83%	7.8	7.79	0.12%	7.3	0.98	4.38%	1.77%
Conductivity (μ5/cm)	105.0	98	6.66%	394.0	418	-6.09%	142.0	141	0.7%	4.48%
Turbidity (mg/l)	0.5	-0.3	160%	3.1	0.4	87.9%	0.8	1.3	-68.5%	103.46%
Ammonia (mg/l)	2.0	0.16	92%	<1.0	0.14	-	<1.0	0.14	-	-

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS WITH SPOT RIVER SAMPLES ANALYSED BY A LABORATORY

TABLE 2

Data from 11 May 1990	PUMP I (at 11.45)			PUMP II (at 11.35)			PUMP III (at 11.20)			Average Error (without taking the sign into account)
	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	
D.O. (%)	95	78.1	17.79%	87	76.7	11.84%	93	81.2	12.68%	14.10%
Temperature (°C)	-	11.8	-	-	12.4	-	-	12.1	-	-
p.H.	7.1	7.65	-7.74%	8	7.85	1.87%	7.4	7.34	0.81%	3.47%
Conductivity (μS/cm)	104	101	2.88%	407	417	-2.45%	157	153	2.54%	2.62%
Turbidity (mg/l)	-	0	-	-	0.07	-	-	7	-	-
Ammonia (mg/l)	0.31	0.24	22.58%	0.04	0.18	-350%	0.24	0.19	20.83%	131.14%

TABLE 3

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS
WITH SPOT RIVER SAMPLES ANALYSED BY A LABORATORY

Data from 18 May 1990	PUMP I (at 12.00)			PUMP II (at 13.00)			PUMP III (at 14.00)			Average Error (without taking the sign into account)
	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	Laboratory Data	Monitor Data	% Error Lab/ Monitor	
D.O. (%)	92	96	-4.34%	92	94.9	-3.15%	92	89	3.26%	3.58%
Temperature (°C)	-	13.2	-	-	12.4	-	-	13.4	-	-
p.H.	7	7.07	-1%	7.8	7.68	1.53%	7.2	6.41	-10.9%	4.47%
Conductivity (µ5/cm)	98	98	0%	400	423	-5.75%	134	148	-10.4%	5.38%
Turbidity (mg/1)	0.6	19	-3066%	4.8	7.04	-46.6%	1.0	76.8	-7580%	3564.2%
Ammonia (mg/1)	0.23	0.28	-21.73%	0.07	0.12	-71.42%	0.24	0.07	70.8%	54.65%

TABLE TO SHOW READINGS PRIOR TO CALIBRATION OF THE INSTRUMENT TABLE 4

	DISSOLVED OXYGEN	pH		TURBIDITY		AMMONIA			
	Error before Calibration	Buffer 4	Buffer 9.2	0 N.T.U.	40 N.T.U.	Low	High	Low Standard 1	Low Standard 4
		Prior to Calibration		Prior to Calibration		% Error		Prior to Calibration	
13 April 1990	-1.4%	4.57	8.64	0.24	39.6	6%	-10%	1.50	4.05
19 April 1990	+5.8%	4.52	-	2.54	39.7	16%	-11%	1.04	3.98
27 April 1990	+6%	4.5	8.8	0.21	39.8	16%	-27%	1.10	4.10
4 May 1990	-20%	4.32	8.77	0.45	39.2	2%	-2%	1.01	4.01
11 May 1990	+8%	4.46	8.69	0.44	37.6	-12%	0%	1.60	4.23
18 May 1990	+7.8%	4.54	8.7	0.3	40.4	6%	-11%	1.49	4.09
25 May 1990	+3.8%	4.42	8.83	0.53	39.6	16%	-9%	-	4.04

TABLE 5

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS WITH THE ACTUAL DATA STORED ON THE NEWLOG DATA LOGGER

Data from 18 May 1990	PUMP I			PUMP II			PUMP III			Average Error (without taking the sign into account)
	(at 12.15) Monitor Data	(at 12.11) Data Logging	% Error Monitor/ Data Logging	Monitor Data (at 13.15)	Data Logging (at 13.11)	% Error Monitor/ Data Logging	Monitor Data (at 14.00)	Data Logging (at 13.56)	% Error Monitor/ Data Logging	
D.O. (%)	96.3	94	2.38%	94.3	93	1.37%	89.0	91	-2.25%	2%
Temperature (°C)	13.3	13.0	2.25%	12.7	12.3	3.15%	13.4	13	2.98%	2.79%
p.H.	7.06	7	0.85%	7.76	7.6	2.06%	6.41	6.5	-1.4%	1.44%
Conductivity (µ5/cm)	97	0	100%	423	0	100%	148	0	100%	100%
Turbidity (mg/l)	0.00	3	-	20.0	208	-940%	76.8	52 520	~~-577.08%~~	-
Ammonia (mg/l)	0.17	0.15	11.76%	0.009	0.05	44.44%	0.07	0.05	28.57%	28.25%

Range on psion [illegible]

TABLE [illegible]

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS
WITH THE ACTUAL DATA STORED ON THE [illegible] DATA [illegible]

[illegible]

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS
WITH THE DATA TRANSMITTED AND RECEIVED FROM METEOR-BURST

TABLE 6

Data from 18 May 1990	PUMP I (at 12.00)			PUMP II (at 13.00)			PUMP III (at 14.00)			Average Error
	Monitor Data	Meteor-burst Data	% Error Monitor/Meteor	Monitor Data	Meteor-burst Data	% Error Monitor/Meteor	Monitor Data	Meteor-burst Data	% Error Monitor/Meteor	
D.O. (%)	96	95.49	0.53%	94.9	94.27	0.66%	89	86.67	2.61%	1.26%
Temperature (°C)	13.2	13.42	-1.66	12.4	12.58	-1.51%	13.4	13.53	-0.97%	-1.38%
p.H.	7.07	7.02	0.7%	7.68	7.64	0.45%	6.41	6.26	2.34%	1.16%
Conductivity (µ5/cm)	98	182.59	-86.31%	423	822.48	-94.44%	148	285.68	-93.02%	-91.25%
Turbidity (mg/l)	19	0.852	95.51%	7.04	6.88	2.27%	76.8	49.99	34.91%	44.23%
Ammonia (mg/l)	0.28	0.253	9.64%	0.12	0.108	10%	0.07	0.047	32.85%	17.49%

TABLE C

TABLE TO SHOW COMPARISON OF THE MONITOR READINGS
WITH THE DATA TRANSMITTED AND RECEIVED FROM METEOR-BURST

TABLE 7

TABLE TO SHOW RESULTS OF THE SURVEY
ON 1 MAY 1990 TO ASSESS WATER QUALITY IN THE RIVER ERME ABOVE Q95

1 May 1990	Final Effluent	Woodland Stream	River Erme at A38 Bridge	River Erme at Cleeve
pH	6.5	7.8	7.2	7.3
Water Temperature (°C)	-	14.1	14.2	14.3
Dissolved Oxygen (%)	-	105.0	99.0	100.0
Ammoniacal Nitrogen (mg/l)	<1.0	<1.0	<1.0	<1.0
Turbidity (NTU)	-	-	-	-

TABLE 7

TABLE TO SHOW RESULTS OF THE SURVEY
ON 1 MAY 1990 TO ASSESS WATER QUALITY IN THE RIVER ERME ABOVE C95

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 8

TABLE TO SHOW RESULTS OF THE SURVEY
ON 29 MAY 1990 TO ASSESS WATER QUALITY IN THE RIVER ERME AT Q95

29 May 1990	Final Effluent	Woodland Stream	River Erme at A38 Bridge	River Erme at Cleeve
pH	7.0	7.6	7.2	7.2
Water Temperature (°C)	18.0	14.0	13.5	14.0
Dissolved Oxygen (%)	40	85	94	89
Ammoniacal Nitrogen (mg/l)	<1.0	0.06	0.04	0.11

TABLE 8

TABLE TO SHOW RESULTS OF THE SURVEY
ON [illegible] MAY 1990 TO ASSESS WATER QUALITY IN THE RIVER ERME AT 095

TABLE 9

SUMMARY OF WATER QUALITY DATA IN THE RIVER ERME UPSTREAM
OF SEWAGE TREATMENT FINAL EFFLUENT FOR THE PERIOD 11 MAY 1990 TO 19 MAY 1990

Week from 11 May 199 to 19 May 1990	Dissolved Oxygen (%)	Ammonia (mg/l)	pH	Temperature (°C)	Turbidity (NTU)
Maximum	103%	0.35 mg/l	7.9	12°C	355
Minimum	11%	0.03 mg/l	7.0	7.2°C	0
Mean	90%	0.17 mg/l	7.3	8.9°C	7

TABLE 9 SUMMARY OF WATER QUALITY DATA IN THE RIVER ERME UPSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT FOR THE PERIOD 11 MAY 19[illegible] TO 1[illegible] MAY 1990

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SUMMARY OF WATER QUALITY IN THE WOODLAND STREAM FOR THE PERIOD 11 MAY 1990 TO 19 MAY 1990

TABLE 10

Week from 11 May 199 to 19 May 1990	Dissolved Oxygen (%)	Ammonia (mg/l)	pH	Temperature (°C)	Turbidity (NTU)
Maximum	101%	0.48 mg/l	7.9	12°C	530
Minimum	78%	0.00 mg/l	6.5	7°C	0
Mean	88%	0.11 mg/l	7.5	8.7°C	70

TABLE 10

SUMMARY OF WATER QUALITY IN THE WOODLAND STREAM
FOR THE PERIOD 1 MAY 1990 TO 15 MAY 1990

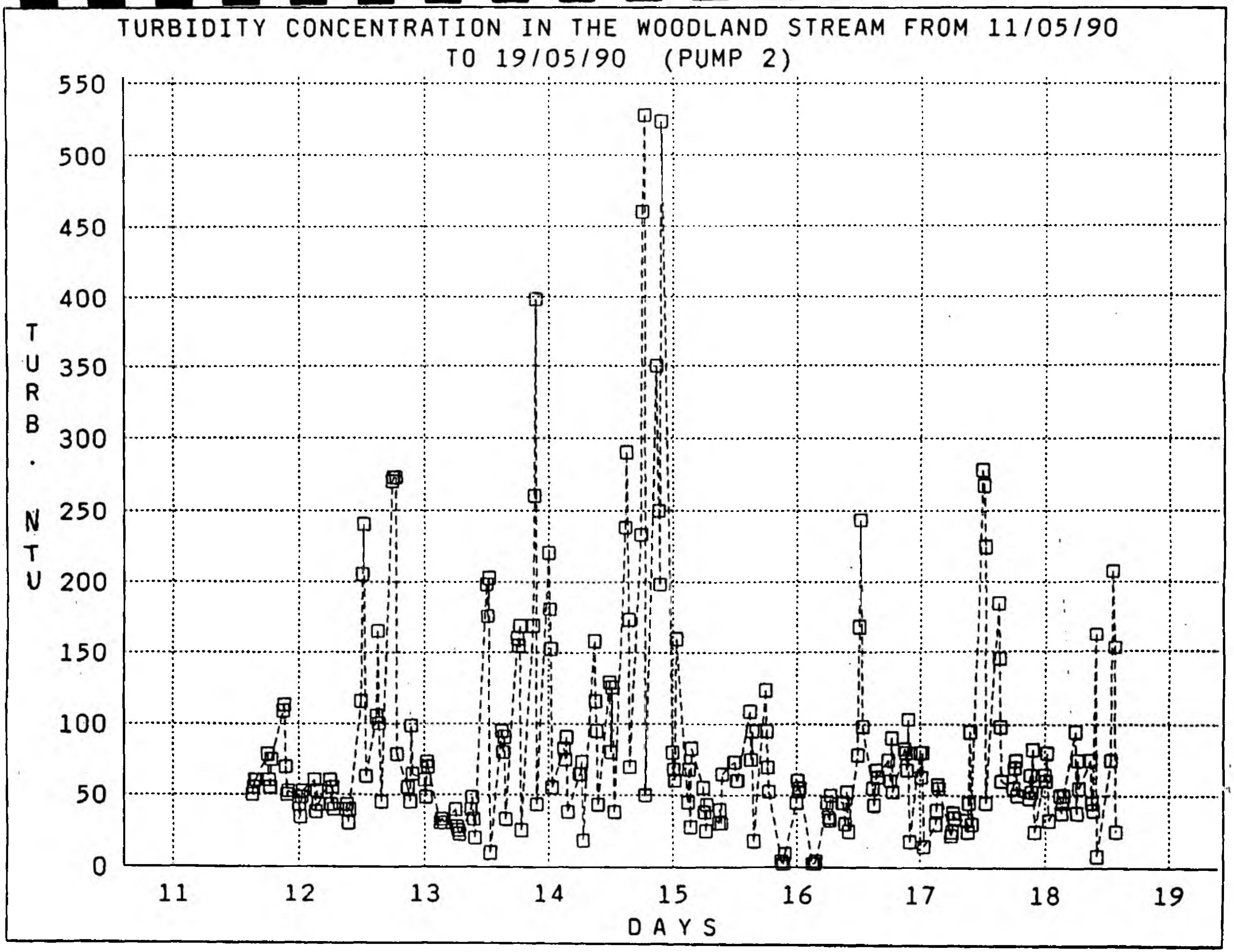
SUMMARY OF WATER QUALITY DATA IN THE RIVER ERME DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT TABLE 11
FOR THE PERIOD 11 MAY 1990 TO 19 MAY 1990

Week from 11 May 199 to 19 May 1990	Dissolved Oxygen (%)	Ammonia (mg/l)	pH	Temperature (°C)	Turbidity (NTU)
Maximum	103%	0.55 mg/l	7.8	12°C	585
Minimum	67%	0.00 mg/l	7.0	7.2°C	0
Mean	91%	0.21 mg/l	7.2	8.9°C	10

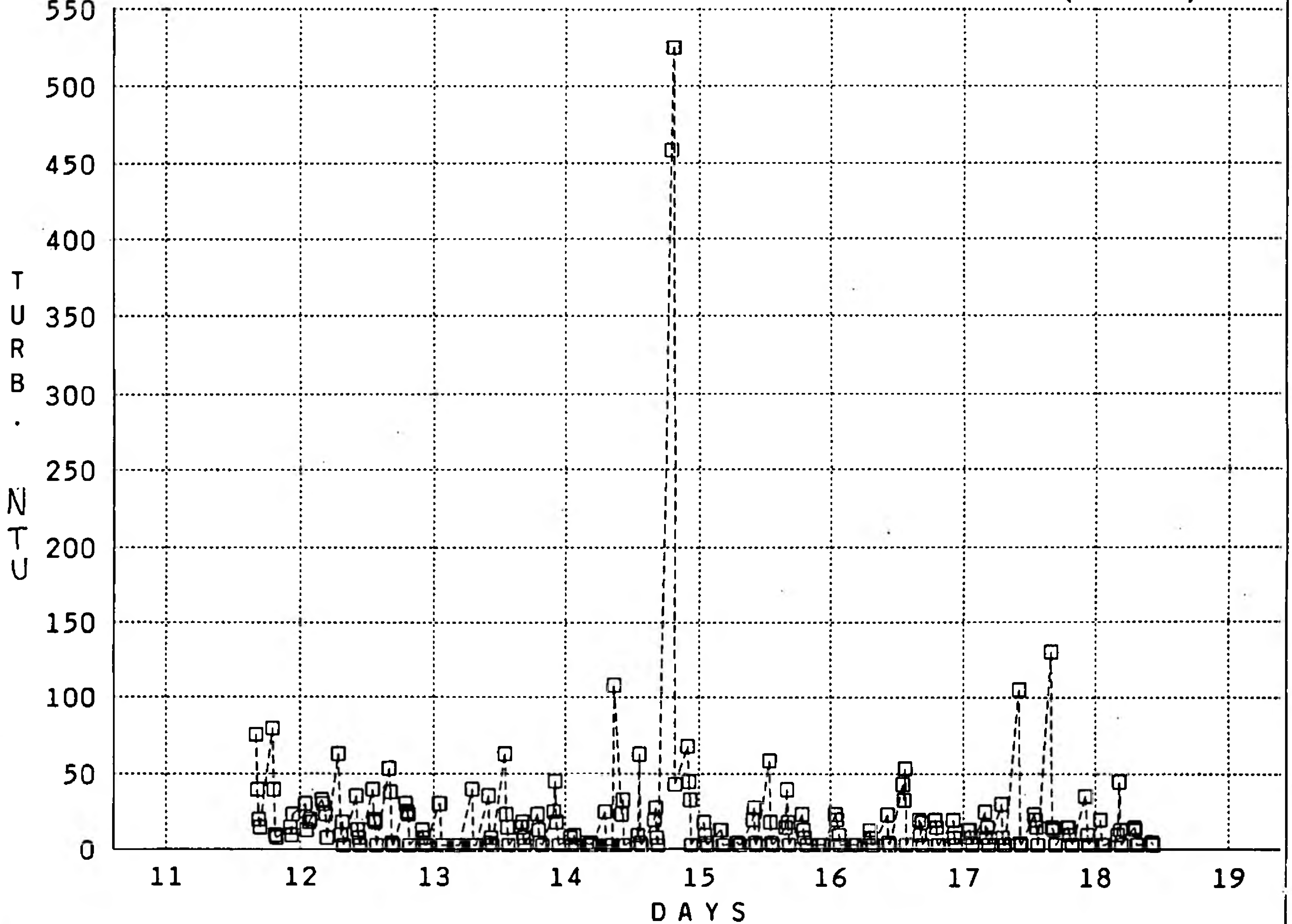
SUMMARY OF WATER QUALITY DATA IN THE RIVER ERNE DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT   TABLE 11

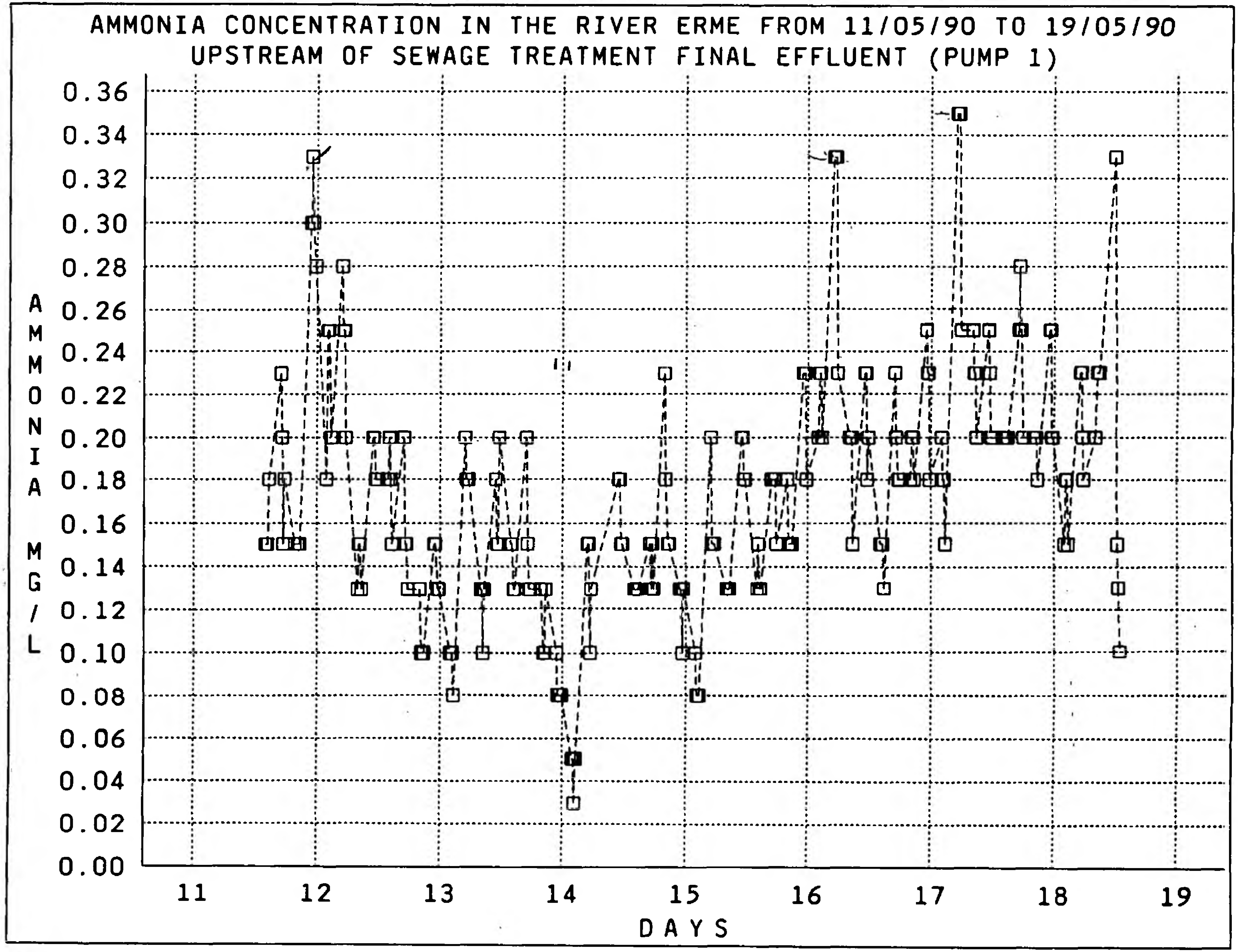
FOR THE PERIOD 1 MAY 1990 TO 19 MAY 1990

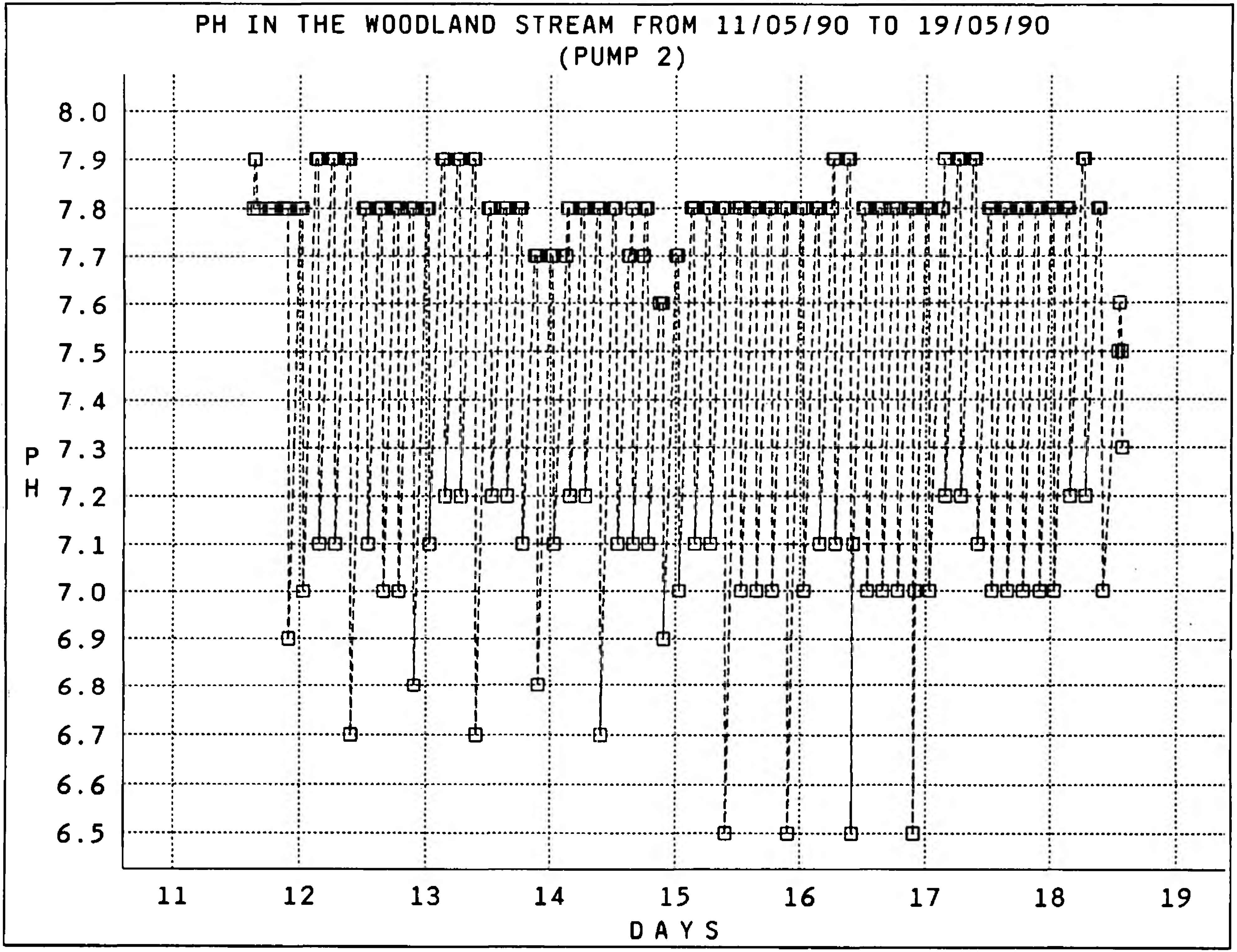
[illegible]	[illegible]	[illegible]	pH	[illegible]Temperature	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

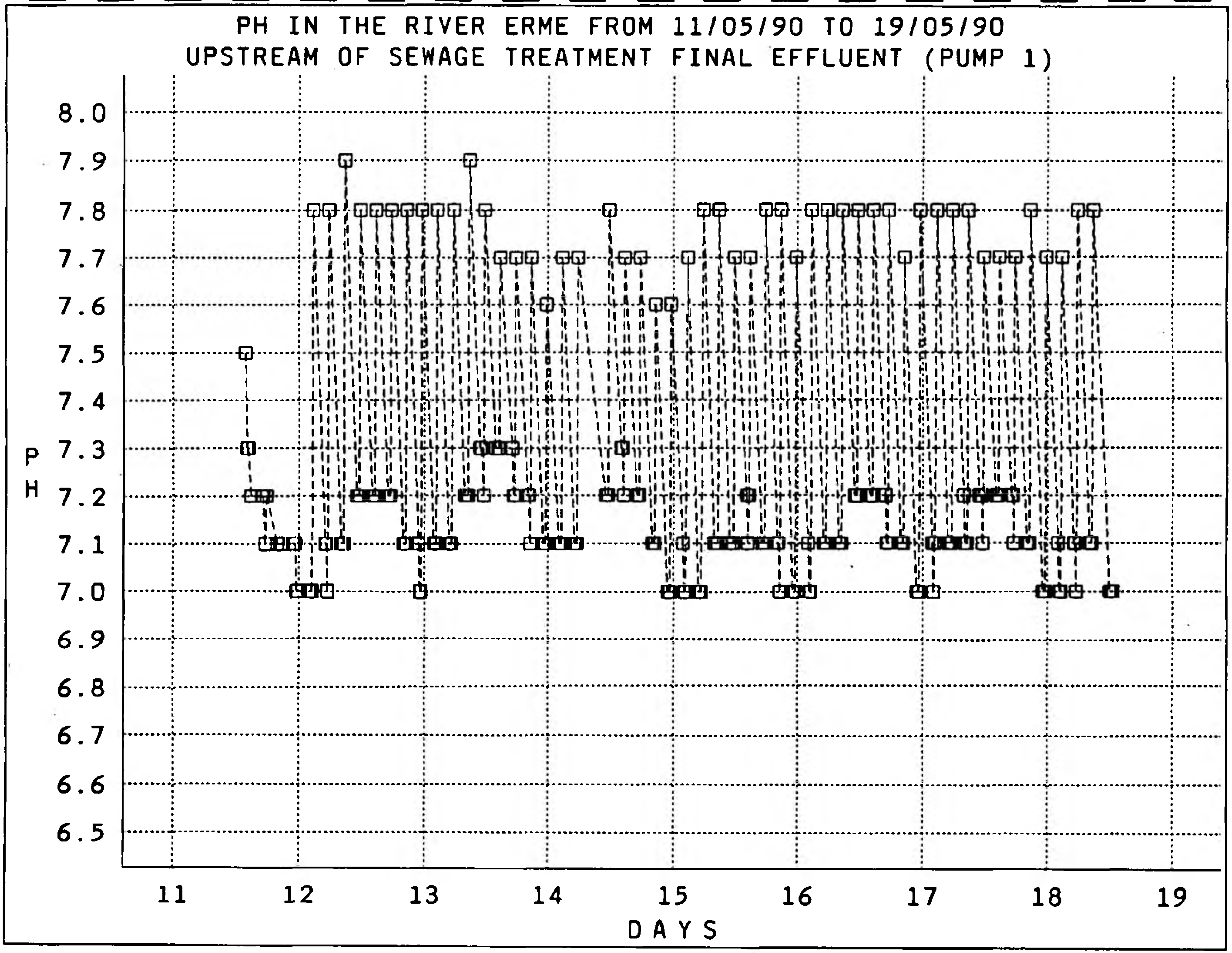

TURBIDITY CONCENTRATION IN THE WOODLAND STREAM FROM 11/05/90
TO 19/05/90 (PUMP 2)
TURB. NTU
550
500
450
400
350
300
250
200
150
100
50
0
11
12
13
14
15
16
17
18
19
DAYS

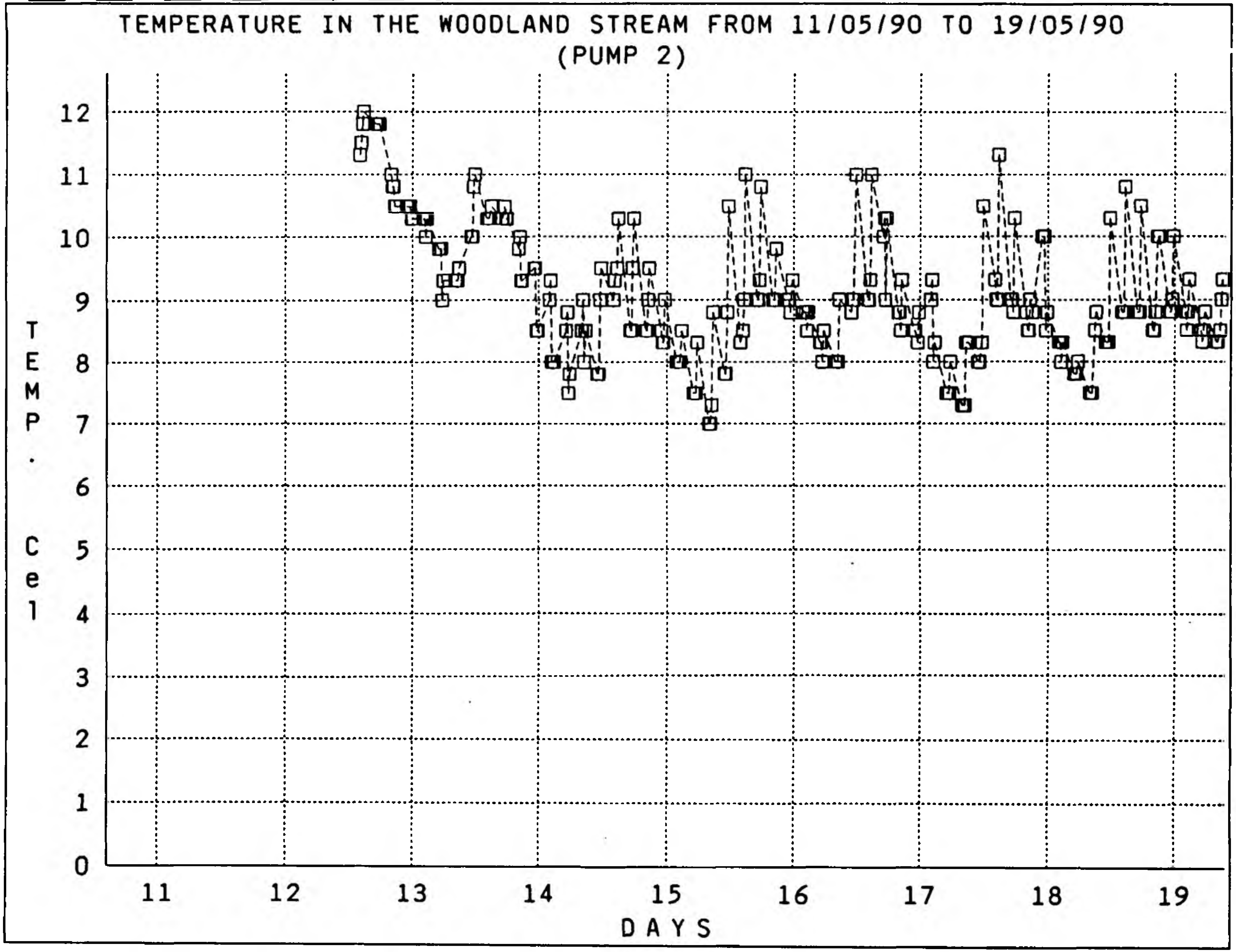
TURBIDITY CONCENTRATION IN THE RIVER ERME FROM 11/05/90 TO 19/05/90 DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 3)

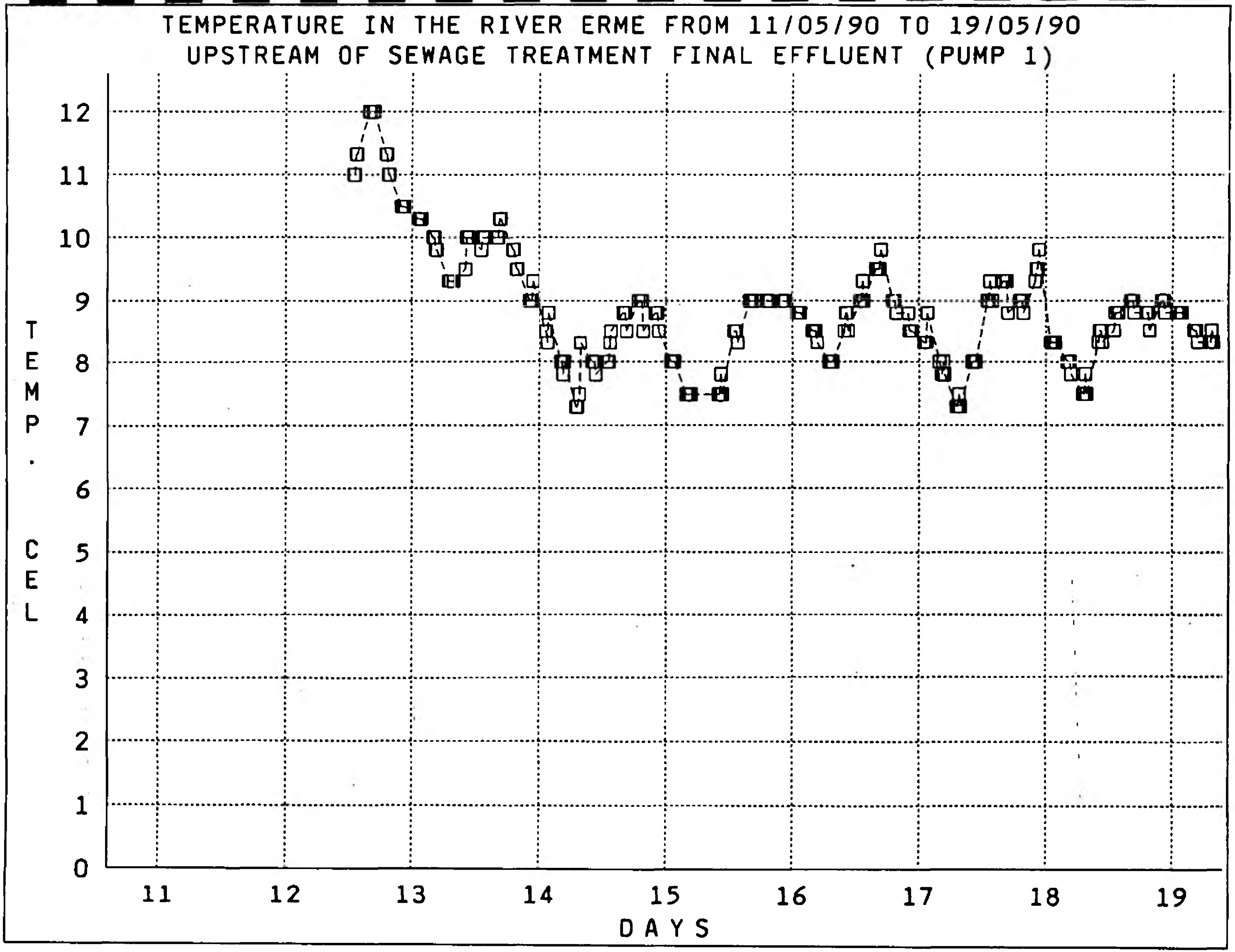


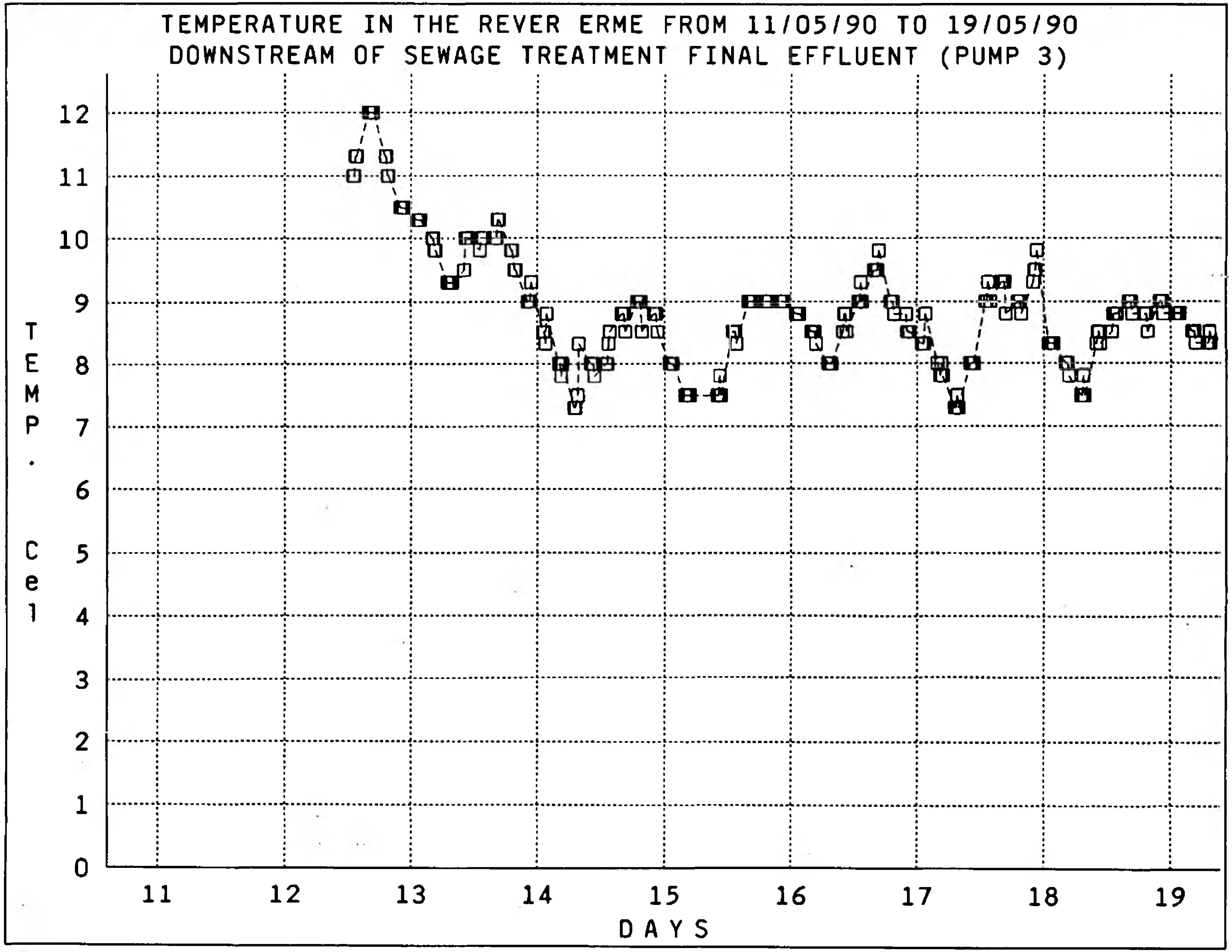

AMMONIA CONCENTRATION IN THE RIVER ERME FROM 11/05/90 TO 19/05/90
UPSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 1)
AMMONIA MG/L
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
11
12
13
14
15
16
17
18
19
DAYS

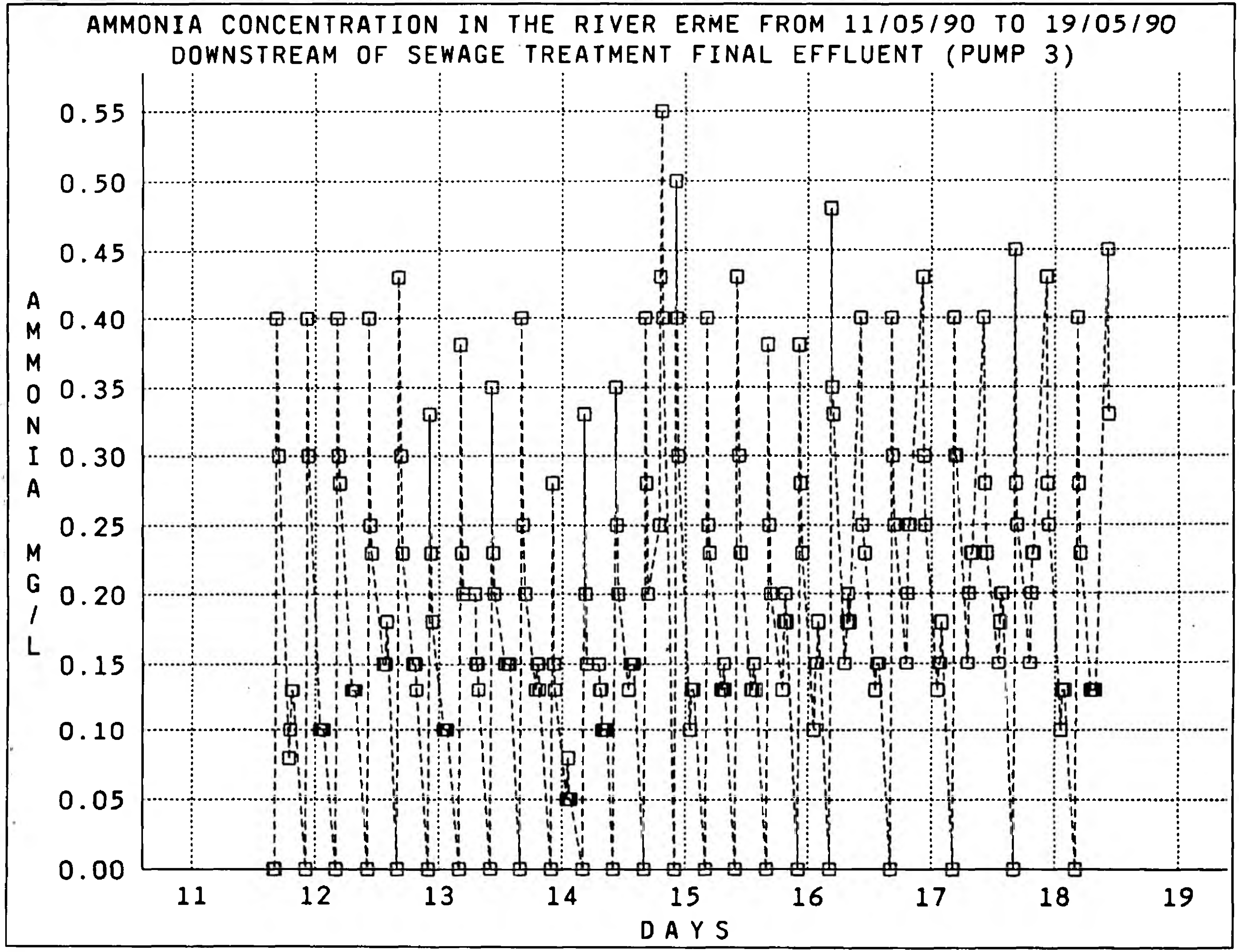

PH IN THE WOODLAND STREAM FROM 11/05/90 TO 19/05/90
(PUMP 2)
PH
8.0
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
6.5
11
12
13
14
15
16
17
18
19
DAYS

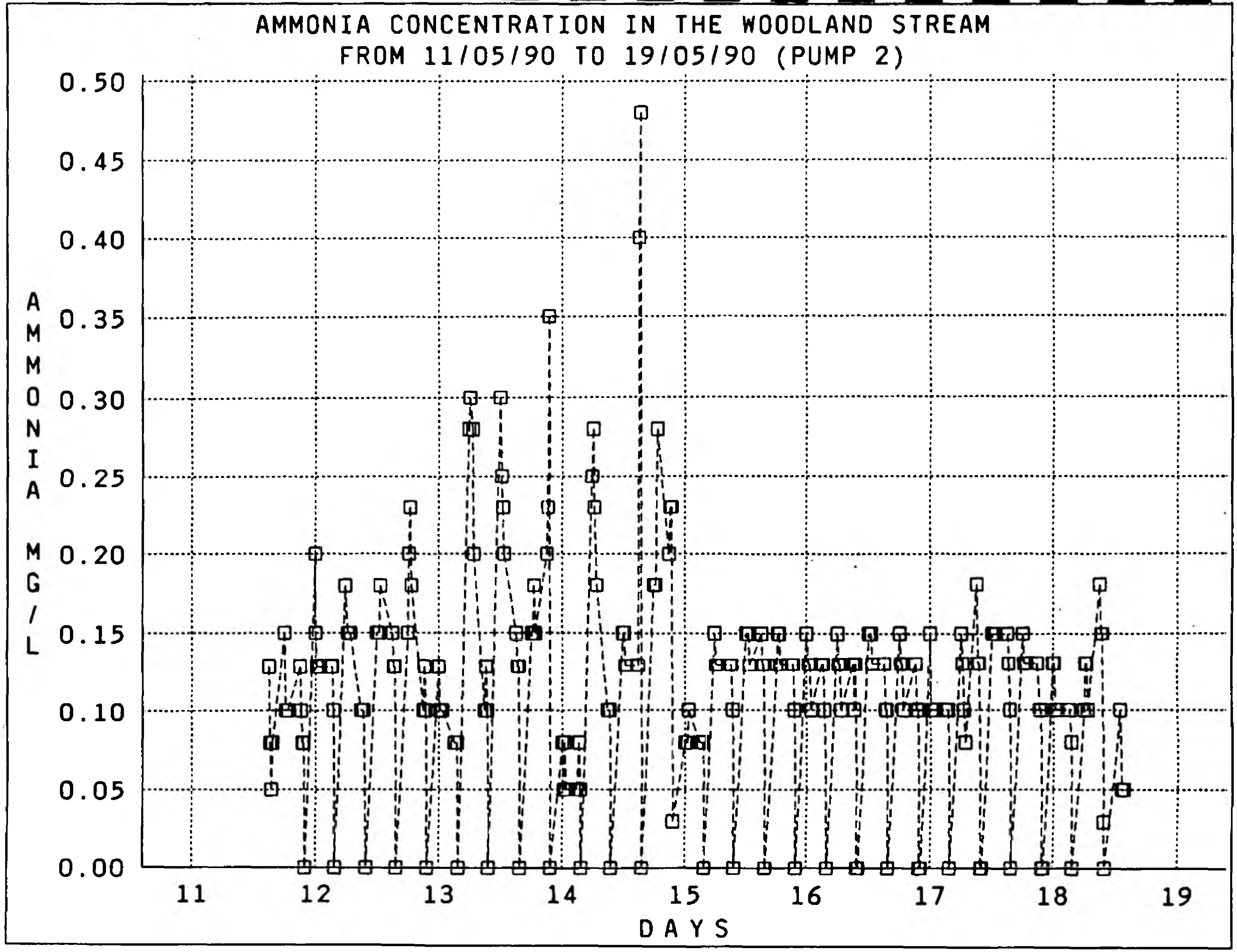

PH IN THE RIVER ERME FROM 11/05/90 TO 19/05/90
UPSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 1)
P H
8.0
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
6.5
11
12
13
14
15
16
17
18
19
DAYS


TEMPERATURE IN THE WOODLAND STREAM FROM 11/05/90 TO 19/05/90
(PUMP 2)
TEMP. Cel
0
1
2
3
4
5
6
7
8
9
10
11
12
11
12
13
14
15
16
17
18
19
DAYS

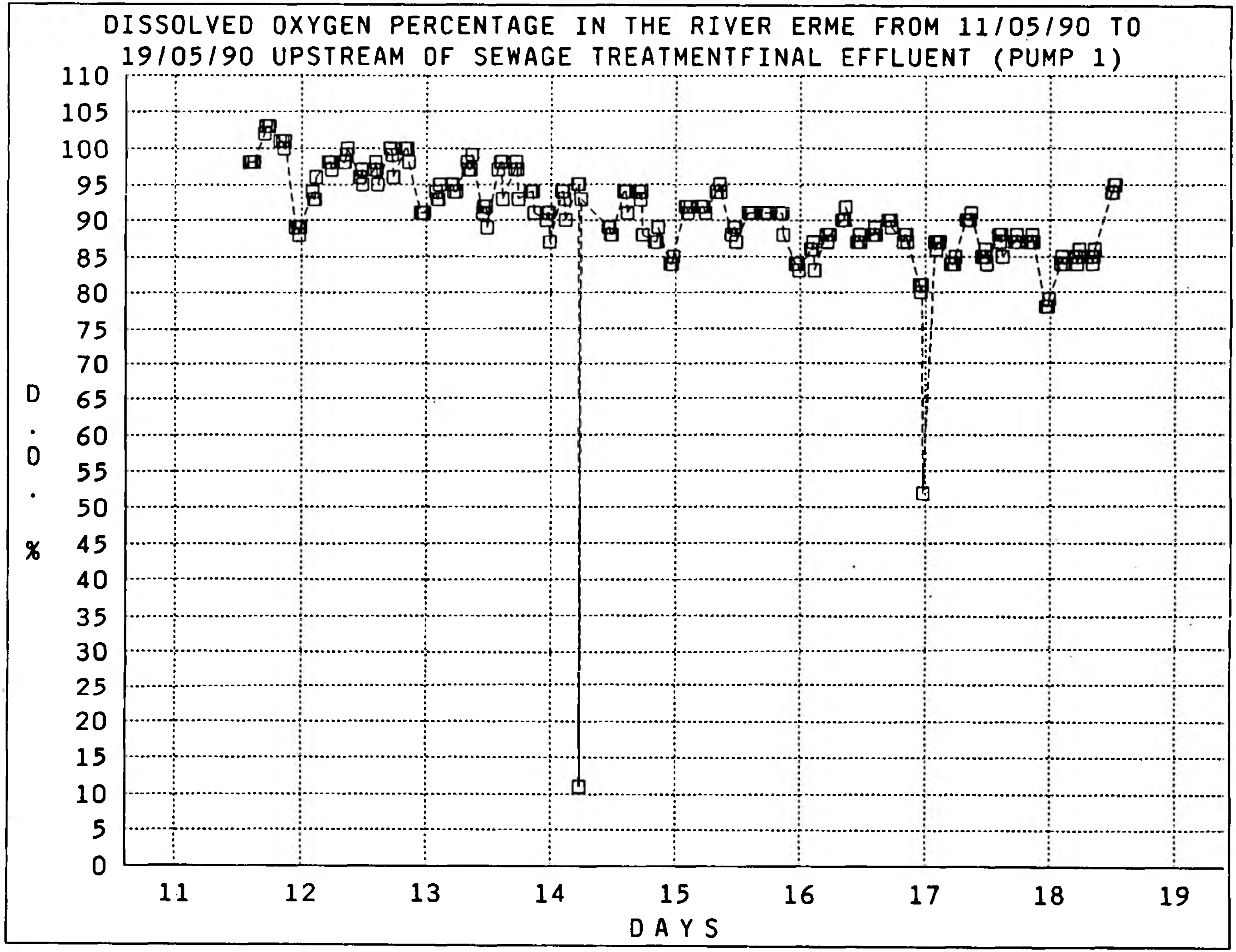

TEMPERATURE IN THE RIVER ERME FROM 11/05/90 TO 19/05/90
UPSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 1)
TEMP. CEL
12
11
10
9
8
7
6
5
4
3
2
1
0
11
12
13
14
15
16
17
18
19
DAYS

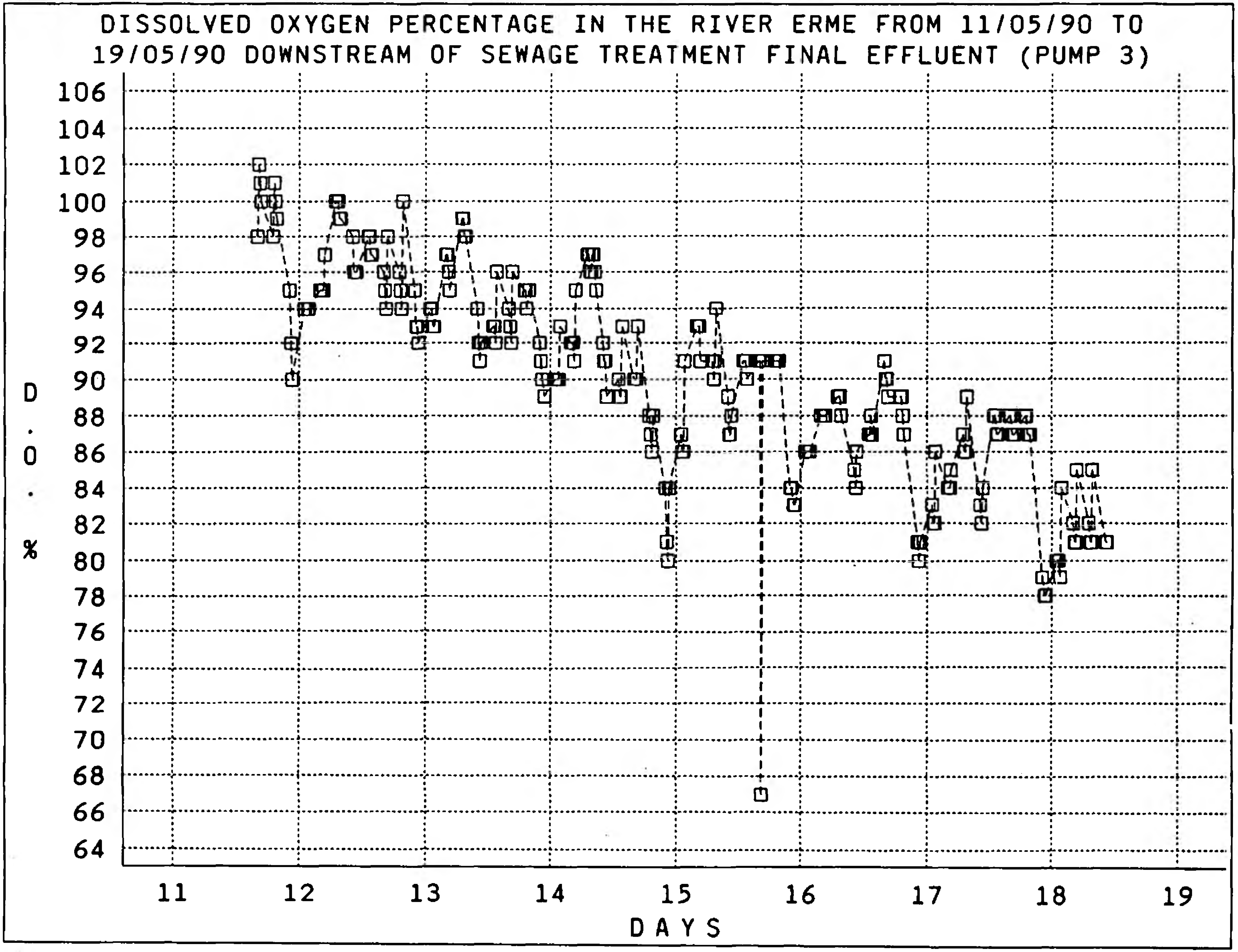

TEMPERATURE IN THE REVER ERME FROM 11/05/90 TO 19/05/90
DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 3)
TEMP. Cel
0
1
2
3
4
5
6
7
8
9
10
11
12
11
12
13
14
15
16
17
18
19
DAYS

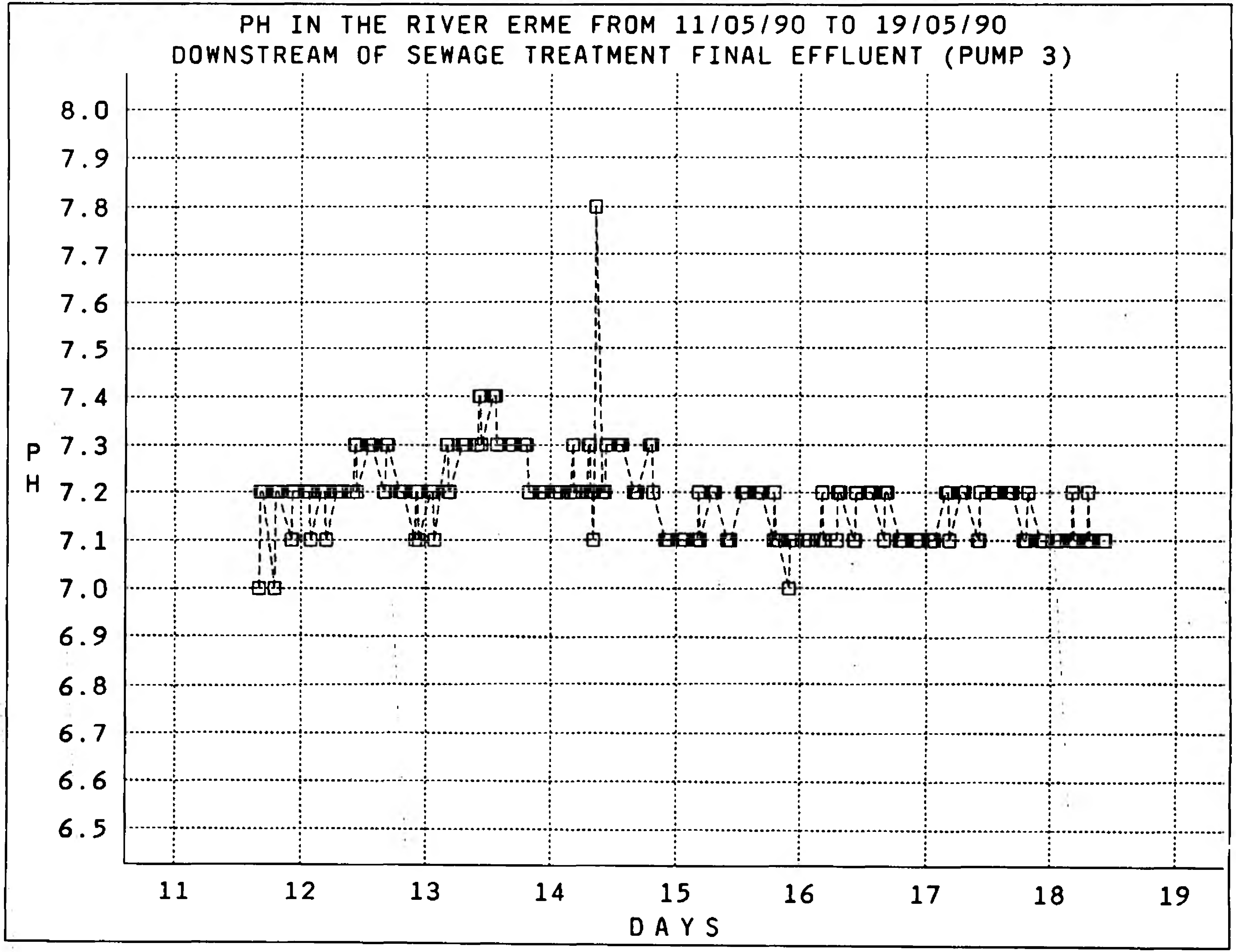

AMMONIA CONCENTRATION IN THE RIVER ERME FROM 11/05/90 TO 19/05/90
DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 3)
AMMONIA MG/L
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11
12
13
14
15
16
17
18
19
DAYS



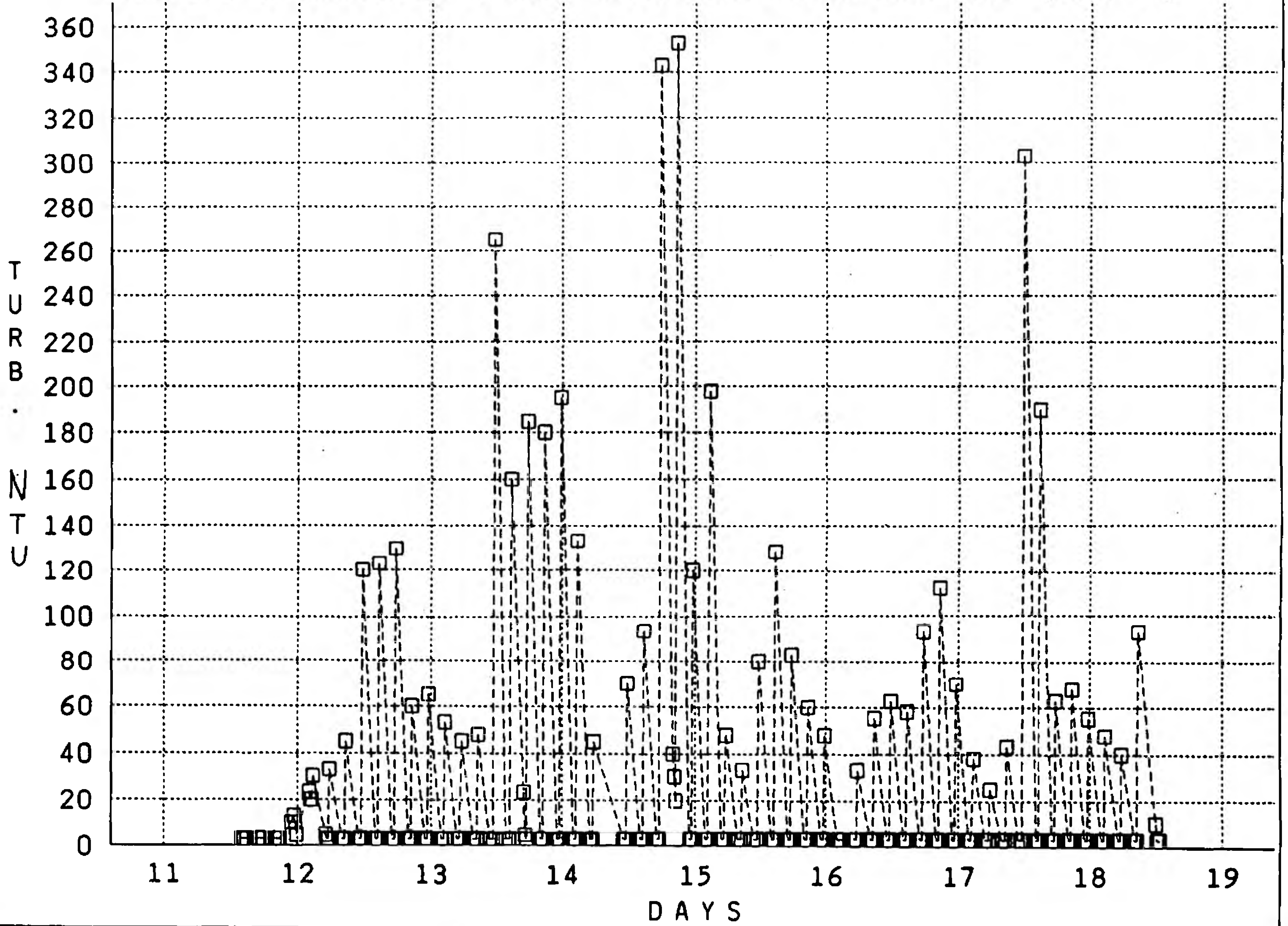
AMMONIA CONCENTRATION IN THE WOODLAND STREAM
FROM 11/05/90 TO 19/05/90 (PUMP 2)
AMMONIA MG/L
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11
12
13
14
15
16
17
18
19
DAYS

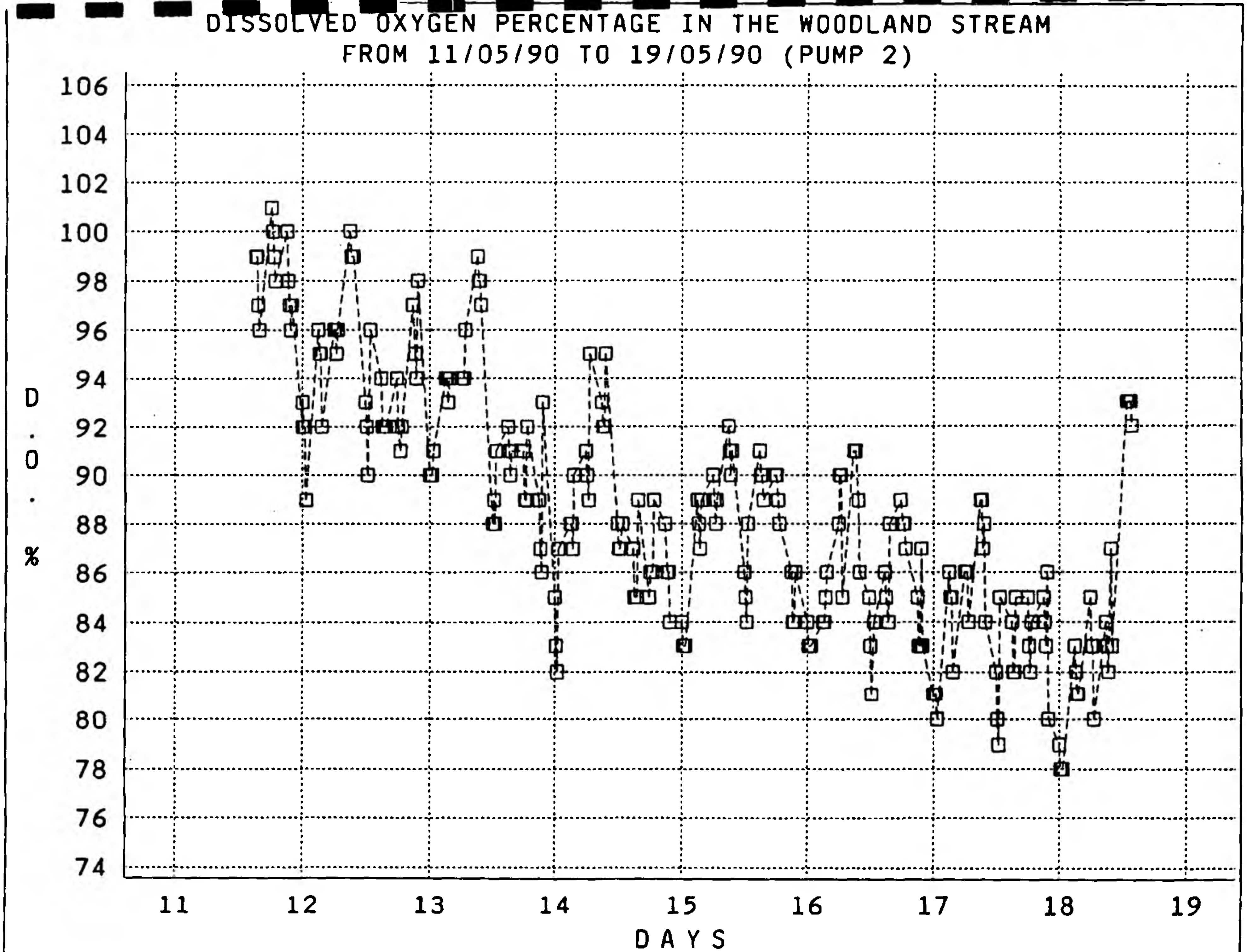

DISSOLVED OXYGEN PERCENTAGE IN THE RIVER ERME FROM 11/05/90 TO 19/05/90 UPSTREAM OF SEWAGE TREATMENTFINAL EFFLUENT (PUMP 1)
D.O. %
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
11
12
13
14
15
16
17
18
19
DAYS


DISSOLVED OXYGEN PERCENTAGE IN THE RIVER ERME FROM 11/05/90 TO 19/05/90 DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 3)
D.O. %
106
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
64
11
12
13
14
15
16
17
18
19
DAYS


PH IN THE RIVER ERME FROM 11/05/90 TO 19/05/90
DOWNSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 3)
PH
8.0
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
6.5
11
12
13
14
15
16
17
18
19
DAYS

TURBIDITY CONCENTRATION OF THE RIVER ERME FROM 11/05/90 TO 19/05/90 UPSTREAM OF SEWAGE TREATMENT FINAL EFFLUENT (PUMP 1)




DISSOLVED OXYGEN PERCENTAGE IN THE WOODLAND STREAM
FROM 11/05/90 TO 19/05/90 (PUMP 2)
D.O.%
106
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
11
12
13
14
15
16
17
18
19
DAYS

PHOTOGRAPH 1

IVYBRIDGE SEWAGE TREATMENT WORKS
PRIMARY SEDIMENTATION TANK

PHOTOGRAPH 2

IVYBRIDGE SEWAGE TREATMENT WORKS
OXIDATION DITCH

PHOTOGRAPH 3

IVYBRIDGE SEWAGE TREATMENT WORKS
FINAL SEDIMENTATION TANK

PHOTOGRAPH 4

IVYBRIDGE SEWAGE TREATMENT WORKS
STORM TANK

PHOTOGRAPH 5

IVYBRIDGE SEWAGE TREATMENT WORKS
FINAL EFFLUENT

PHOTOGRAPH 6

IVYBRIDGE MOBILE MONITORING STATION

PHOTOGRAPH 7

MAINTENANCE OF PUMP 3

PHOTOGRAPH 8

PUMP CONTROL SYSTEM

PHOTOGRAPH 9

AMMONIA MONITOR

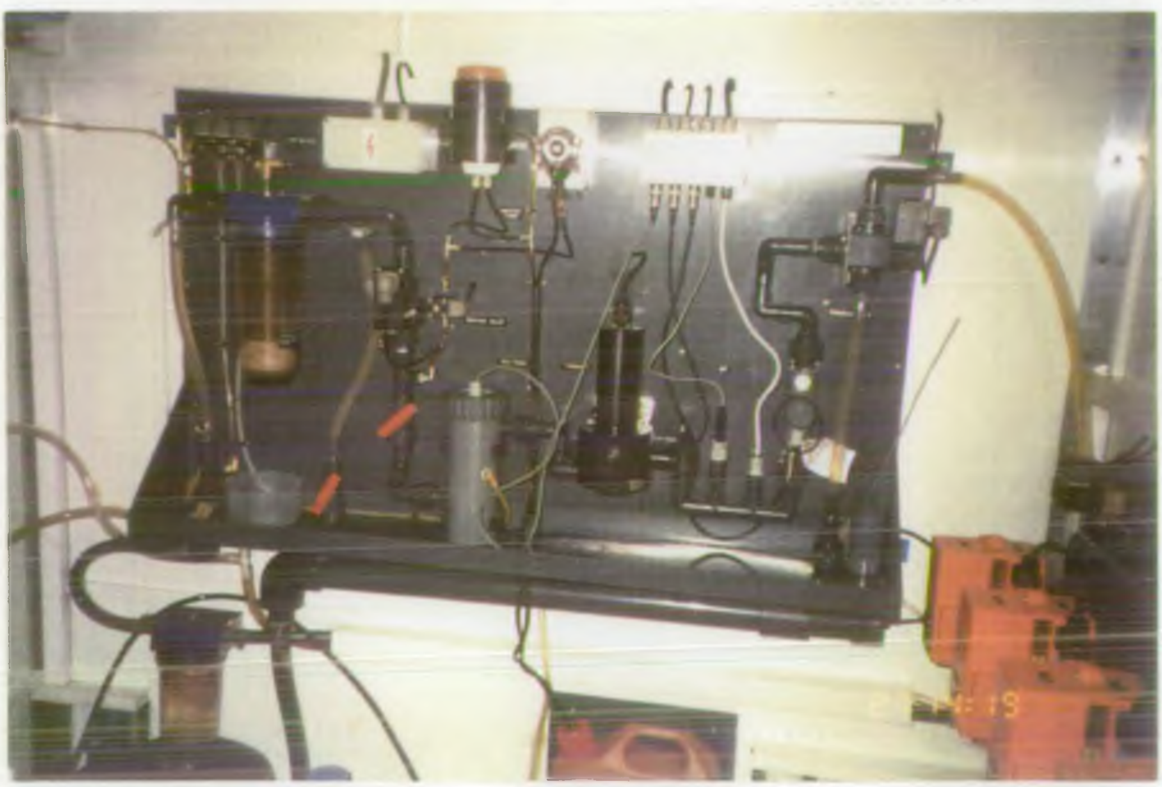
PHOTOGRAPH 10

PHOTOGRAPH 11

MIMMEX RECORDER

PHOTOGRAPH 12

FLOW CIRCUIT AND PROBES



PHOTOGRAPH 13

METEOR-BURST TRANSMITTER

PHOTOGRAPH 14

METEOR-BURST CONTROL BOX

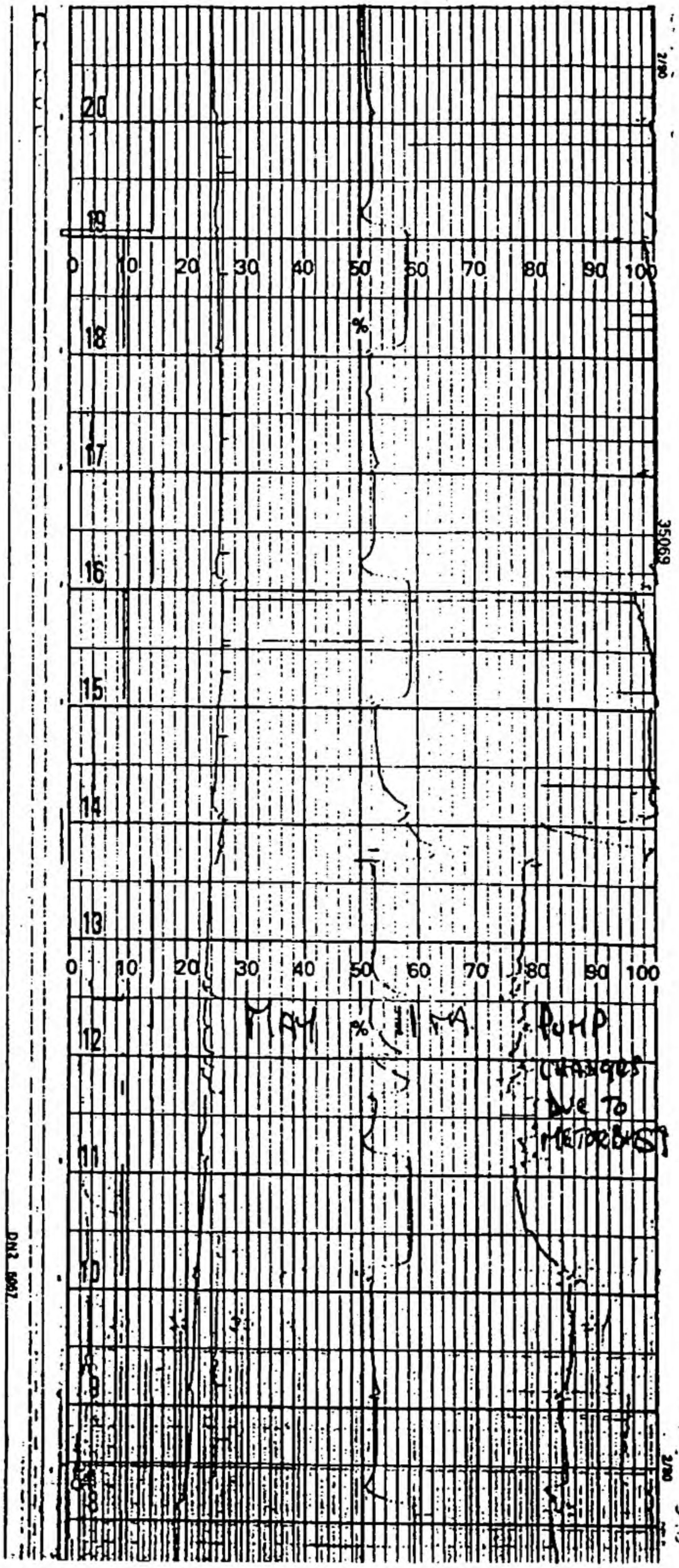
APPENDIX

APPENDIX 1

RIVER CLASSIFICATION SYSTEM
CRITERIA USED BY SWW FOR NON-METALLIC DETERMINANDS

River Class	Quality Criteria
1 A	Dissolved oxygen % saturation greater than 80% BOD [ATU] not greater than 3 mg/l O. Total ammonia not greater than 0.31 mg/l N. Non-ionised ammonia not greater than 0.021 mg/l N. Temperature not greater than 21.5°C pH greater than 5.0 and less than 9.0 Suspended solids not greater than 25mg/l.
1 B	Dissolved oxygen % saturation greater than 60%. BOD [ATU] not greater than 5 mg/l O. Total ammonia not greater than 0.70 mg/l N. Non-ionised ammonia not greater than 0.021 mg/l N. Temperature not greater than 21.5 C. pH greater than 5.0 and less than 9.0. Suspended solids not greater than 25 mg/l.
2 A	Dissolved oxygen % saturation greater than 50%. BOD [ATU] not greater than 7 mg/l O. Total ammonia not greater than 1.0 mg/l N. Non-ionised ammonia not greater than 0.021 mg/l N. Temperature not greater than 21.5°C. pH greater than 5.0 and less than 9.0. Suspended solids not greater than 25 mg/l.
2 B	Dissolved oxygen % saturation greater than 40%. BOD [ATU] not greater than 9 mg/l O. Total ammonia not greater than 1.56 mg/l N. Non-ionised ammonia not greater than 0.021 mg/l N. Temperature not greater than 21.5°C. pH greater than 5.0 and less than 9.0. Suspended solids not greater than 25 mg/l.
3 A	Dissolved oxygen % saturation greater than 25%. BOD [ATU] not greater than 13 mg/l O. Total ammonia not greater than 2.0 mg/l N. Non-ionised ammonia not greater than 0.021 mg/l N. Temperature not greater than 21.5°C. pH greater than 5.0 and less than 9.0. Suspended solids not greater than 25 mg/l.
3 B	Dissolved oxygen % saturation greater than 10%. BOD [ATU] greater than 17 mg/l O.
4	Dissolved oxygen % saturation not greater than 10%. BOD [ATU] greater than 17 mg/l O.

APPENDIX 2



After the start of meteor-burst communication (appearance of peaks)

Before the start of Meteor-burst communication