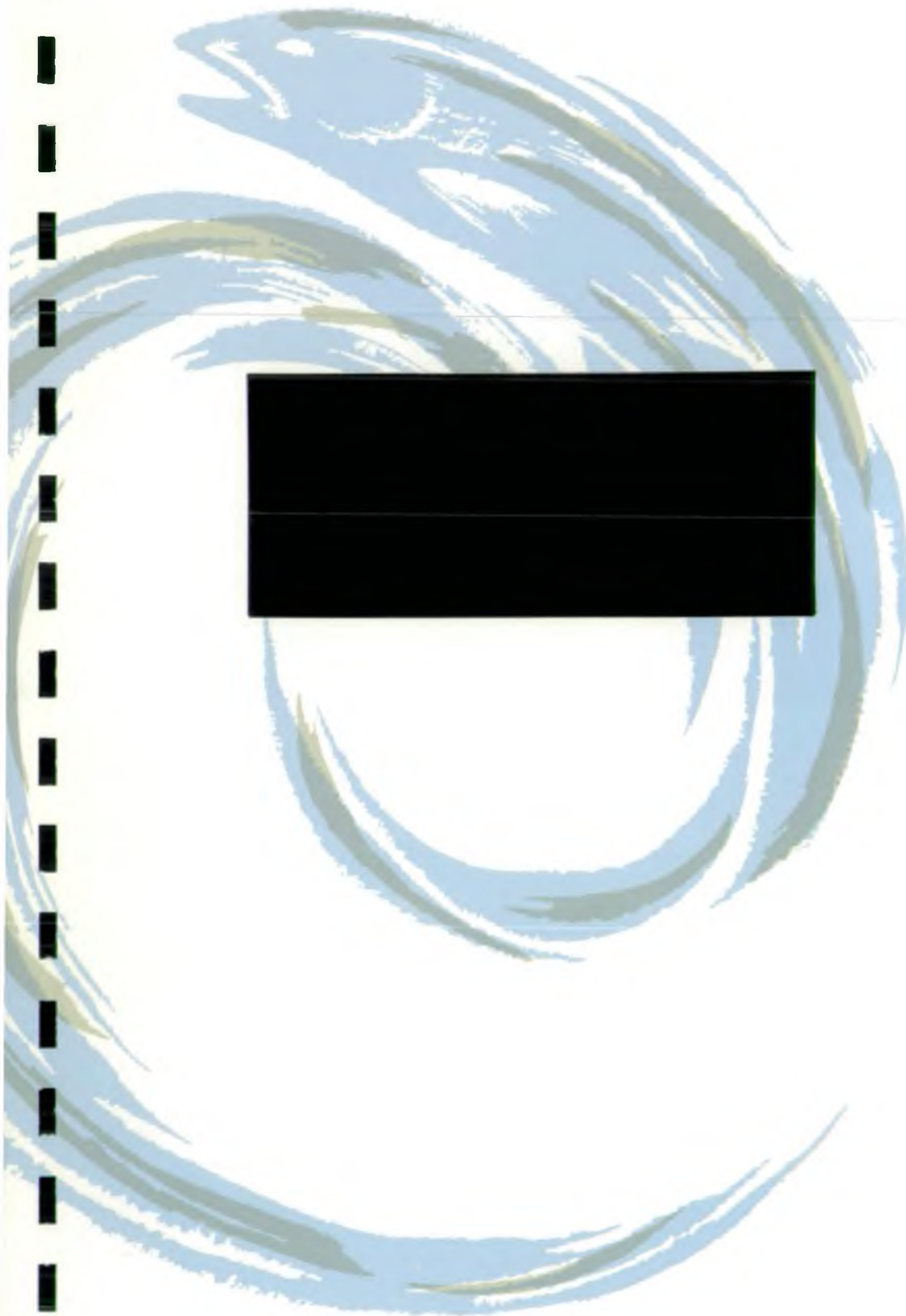
NRA Northumbria & Yorkshire 63

NRA

National Rivers Authority
Northumbria &
Yorkshire Region



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GUARDIANS OF THE WATER ENVIRONMENT

A Preliminary Investigative Study Into Tyne Estuary Water Quality Using Continuous Monitoring Techniques

January 1995

MC/95/01/D01

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EXECUTIVE SUMMARY

As a result of concerns over the value of spot sampling for water quality monitoring in dynamic estuarine environments a feasibility study was undertaken to assess the practicality of utilising the continuous monitoring facilities of the Coastal Survey Vessell "Water Guardian" as a more meaningful method of generating estuarine water quality data.

A survey was undertaken in November 1994 to assess the practical problems associated with deploying the equipment in shallow estuarine waters; using the auto-analyser to measure the highly variable nutrient levels along the length of the estuary, the ease and efficiency of data processing using available hardware and software on possible presentational layouts for this type of water quality data.

A secondary objective of the exercise was to generate data which would be of use for R & D work which is seeking to develop a General Quality Assessment (GQA) scheme for estuaries.

The survey was successfully completed, demonstrating the fundamental soundness of the approach and subsequent data processing and analysis provided examples of possible means of interpreting and presenting the data.

CONCLUSIONS

1. The continuous data collected during the survey provide a more complete picture of the estuary water quality than can be achieved via extrapolation of data between sample sites.

2. No insumountable promblems were encountered which would prevent the approach being adopted for routine WQ surveys. Similar surveys performed at appropriate tidal states, could be used to provide valuable information for GQA purposes for any of the navigable estuaries in the region.

3. All parameters are measured in real time in situ. Consequently quality data is provided without the worry of sample deterioration; caused by time elapsed between sample procurement and analysis.

4. Certain technical difficulties were encountered, all of which could be overcome by implementation of the following recommendations.

RECOMMENDATIONS

1. It can be seen from the results that there is such a profound effect on most determinands in the vicinity of Howdon that other lesser effects within the estuary seem insignificant by comparison. A consequence of setting the AutoAnalyser to record the high levels of nutrients in this area is that the scaling for the rest of the estuary was inappropriate. Thus a separate survey should be performed in this area of the estuary allowing the rest of the estuary to be surveyed using more appropriate scaling. The top standard for Ammonia should be reduced from 5000ppb to 500ppb. If high levels of ammonia are allowed to enter the system it can be detrimental to the subsequent data, in order to avoid this a dilution loop should be fitted to the ammonia channel, this would be used on the approach to areas with suspected high ammonia concentrations.

2. At high concentrations of T.O.N. and Ammonia the colour absorbency was found to be approaching 3 absorbency units (AU): at these levels the calibration curve is no longer valid (Beer Lambert Law). The current 40mm flowcells should therefore be replaced by 10mm flowcells, so reducing the absorbency and maintaining a valid calibration curve.

3. If chemical parameter sampling time were reduced from two minutes to one minute twice the volume of data could be collected and less would be lost due to time for AQC and drift sampling.

4. High and low level AQC should be sampled by the Auto analyser every 30 samples, and if inaccuracies are greater than 20% then the survey should be repeated. Calibration of probes for physical parameters should be performed before each survey and checked on completion of the survey.

5. More information could be obtained if the UOV were towed at a depth of say 3m and the flowcell left to sample surface water. This would be beneficial in allowing discrimination between phenomena which are restricted to the surface and those which penetrate further. This would also allow the interface between the salt and freshwater to be observed.

6. Following resolution of the technical problems identified from the pilot study, the survey should be repeated and extended to cover the Wear and Tees estuaries to provide a larger dataset for the evaluation of the approach as a replacement for spot sampling.

7. A business case should be prepared for the use of the CSV in estuarine waters before any decision is taken to change existing practices.

8. Existing data storage devices (floppy disc drives) on the vessel and shore-based computer systems should be replaced with equipment better suited to the high volume of data generated from such surveys (optical disc).

9. To aid the interpretation and presentation of data, a software package such as MAPINFO should be acquired.

1. INTRODUCTION

1.1 Background

Water quality monitoring and classification in estuarine waters of the Northumbria and Yorkshire Region has, to date, been undertaken using spot samples collected from vessels and analysed in a remote laboratory. This approach has several limitations:-

1. In a highly dynamic estuarine environment data from spot samples has limited value for the assessment of spatial and temporal trends in water quality, In an industrialised estuary this problem is compounded by the presence of numerous, sometimes overlapping, mixing zones from discrete discharges.

2. The process is time consuming and fairly expensive in terms of staff time to collect, analyse, report and interpret the data.

3. Some determinands eg ammonia are unstable and therefore reported laboratory results may be markedly different from real environmental values.

To overcome these difficulties and produce more meaningful estuarine water quality data there is considerable potential for the use of Coastal Survey Vessel (CSV) "Water Guardian" and its on-board continuous monitoring FCsystems to replace the traditional spot sampling approach.

1.2 Continuous monitoring and on board analysis of nutrients

The CSV is equipped with sensors to continuously monitor conductivity, temperature, dissolved oxygen, chlorophyll a, pH and transmission; and an autoanalyser to measure nutrient concentrations. All of these instruments are linked to an onboard navigation/data logging system to give continuous or semi-continuous water quality measurements linked to the vessels position. These systems have been extensively used and refined during the National Coastal Survey but have not, to date, been employed in estuaries.

1.3 Objectives

The purpose of this pilot study was to assess the practicality of continuous monitoring, on-board nutrient analysis and data processing using the CSV's computer systems as a cost effective and more meaningful means of monitoring water quality in estuaries. The investigation also provided a suitable vehicle to demonstrate the capabilities of the system and possible reporting formats to Water Quality staff within the region.

Attention focussed on the practical problems associated with deploying the equipment in shallow estuarine waters; using the auto-analyser to measure the highly variable nutrient levels along the length of the estuary; the ease and efficiency of data processing using available hardware and software and on possible presentational layouts for this type of water quality data.

A secondary objective of the exercise was to generate data which would be of use for R & D work which is seeking to develop a General Quality Assessment (GQA) scheme for estuaries.

Because of the current level of interest in the water quality of the Tyne estuary resulting from an ongoing investigation into the causes of seasonal salmon mortalities in the upper estuary, the Tyne was selected for the first field trials of the system and this report presents the preliminary findings and recommendations resulting from a survey carried out in November 1994.

2. METHOD

On 23rd November 1994 R.V. "Water Guardian" conducted a survey of the Tyne estuary; starting at Lloyd's Hailing station near the mouth of the estuary and terminating at Newburn Bridge approximately 25km upstream.

Tidal data for North Shields on 23/11/94; a spring tide, is shown below:-

Tide	Time	Height
HW	0605	4.6m
LW	1202	1.6m
HW	1813	4.7m

In order to complete the survey as near to low water as possible and also facilitate passage under Newcastle Bridge; the survey commenced at 1036 (approximately 1.5 hr before low water finishing at 1321 (approximately 1.5 hr after low water). The vessel track passed through the majority of existing water quality sampling sites as can been seen from figure 2.0.

Measurement of physical parameters was achieved using two ME ECO probes; one of which was mounted aboard the Undulating Oceanographic Vehicle (UOV) "Aquashuttle", the other in a flowcell with a pumped water supply from 1 metre below surface. Chemical parameters were measured using a "SKALAR" Auto Analyser with a sea water supply pumped via a Watson Marlow peristaltic pump from 1m below the surface. For schematic diagram of Autoanalyser channels see Appendix A.

The U.O.V. was towed approximately 30 metres behind the vessel, offset to the port side in an attempt to avoid the influence of the wake of the boat. A time delay was entered into the Qubit system to compensate for this and also the time taken to pump water to the flowcell.

Physical parameters were logged every ten seconds, chemical parameters every two minutes. For determinand information see tables 2.1 and 2.2.

The vessels position was fixed using a Racal-Decca 53G combined Global Positioning System (GPS) and Decca receiver, with differential capability for enhanced accuracy. The approximate accuracy of this instrument can be assumed to have been +/- 5 metres in the prevalent conditions.

All positional information, physical and chemical data was collated, time tagged and recorded via the QUBIT "Transportable Realtime Auto-navigation Computer" (TRAC V). Collected data was processed, edited and plotted using Skalar San Plus software, Qubit Chart V computer and Easycad.

See Appendix B for a description of the Qubit TRAC V system.

2.1 Quality Assurance

Calibration of the Physical sensors was performed before and after the survey, to allow for any instrument drift, using standard pH buffers of 4, 7 and 10 for the pH sensor.

IAPSO standard sea-water of Salinity 35 ppt was used to check salinity and therefore conductivity and temperature.

Dissolved Oxygen was calibrated at 0 and 1000% at the start and end of the survey.

Transmission was calibrated at 0% (absolute darkness) and 100% de-ionised water).

The Auto Analyser was calibrated at the beginning of the survey using a mixed standard measured at four levels. Drifts and blanks were included throughout the survey to allow for any baseline drift. An AQC was included in the middle of the survey, equivalent to 80% of the top standard.

A drift and blank were analysed at the start of the survey, again at fixes 1140 and 1142, and also at the end of the survey. Using this method the software can compensate for any baseline drift which may have occurred.

3. RESULTS

The results of the survey are displayed in figures 3.1 to 3.12. Figures 3.1 to 3.4 show profiles of data with respect to the vessels track, this data has been extrapolated to prove the schematic plan views in figures 3.5 to 3.12.

Results can also be provided in numeric format; as hard copy or on floppy disc. This facilitates instant access to absolute values at any point along the vessel track.

Raw autoanalyser data can be found in Appendix C.

4. ANALYSIS AND DISCUSSION

From figures 3.1 to 3.4 it can be seen that the most salient feature occurs at around 1110: where nearly all determinands underwent a considerable fluctuation. This is in the vicinity of Howdon outfall, through the fact that there are other discharges to the river in this area should not be ignored. At this point (1110) the most substantial changes were in nutrient data where the following was observed.:-

T.O.N rose from: 561 ppb at 1100 to 887 ppb at 1110
Phosphate rose from: 129 ppb at 1100 to 946 ppb at 1110
Ammonia rose from: 356 ppb at 1100 to 6100 ppb at 1110

Corresponding changes were also observed in temperature, salinity, pH and transmission.

Another feature of note, which was largely overshadowed by events in the vicinity of Howdon, occurred around 1230; this is probably due to the influx of water from the River Team. This feature is particularly apparent when regarding figure 3.4 especially with respect to T.O.N. which reached its highest level of the whole survey. Corresponding increases were observed on ammonia and phosphate channels, (though these were of a lesser magnitude) while dissolved oxygen levels fell.

Table 2.1 **Physical Parameters**

Parameters	**Units**	**Accuracy**
Temperature	°C	±0.05
Conductivity	mS/cm	±0.1
Salinity	ppt	±0.1
Transmission	%	±2
pH	pH	±0.1
Dissolved Oxygen	%	±2
Pressure	dBar	±0.1

Table 2.2 **Chemical Parameters**

Parameters	**Units**	**L.O.D**
Ammonia	ppb N	300 ppb
T.O.N	ppb N	50 ppb
Phosphate	ppb P	20 ppb

The data from the towfish contains some spikes which are due to the fish undulating, cross referencing with fish depths helps distinguish these peaks. Peaks on the profiles from the ECO probe situated in the flowcell are not as well defined as those from the towfish, this is because it takes a certain amount of time for the flowcell to "flush".

Differences in physical data obtained from the towfish and that obtained from the flowcell are due to a combination of ample depth (c.F. fish undulation) flowcell flushing time and spatial offset; the towfish being towed from the port side and the flowcell intake being on the starboard side.

5. CONCLUSIONS

1. The continuous data collected during the survey provide a more complete picture of the estuary water quality than can be achieved via extrapolation of data between sample sites.

2. No insumountable promblems were encountered which would prevent the approach being adopted for routine WQ surveys. Similar surveys performed at appropriate tidal states, could be used to provide valuable information for GQA purposes for any of the navigable estuaries in the region.

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4. Certain technical difficulties were encountered, all of which could be overcome by implementation of the following recommendations.

6. RECOMMENDATIONS

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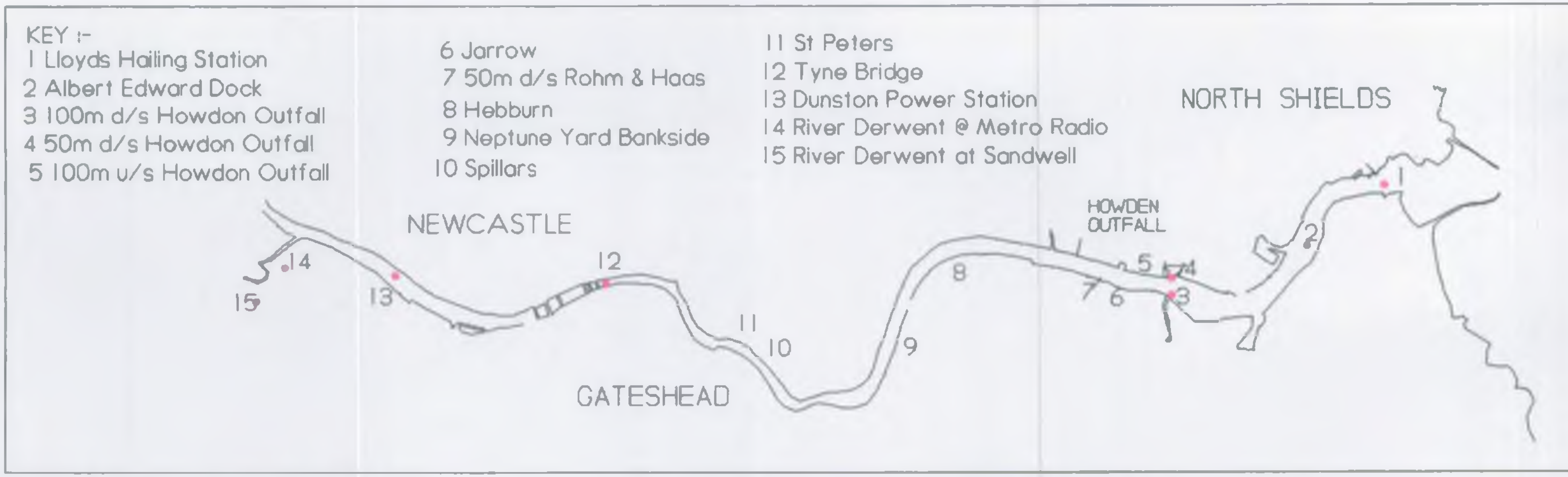
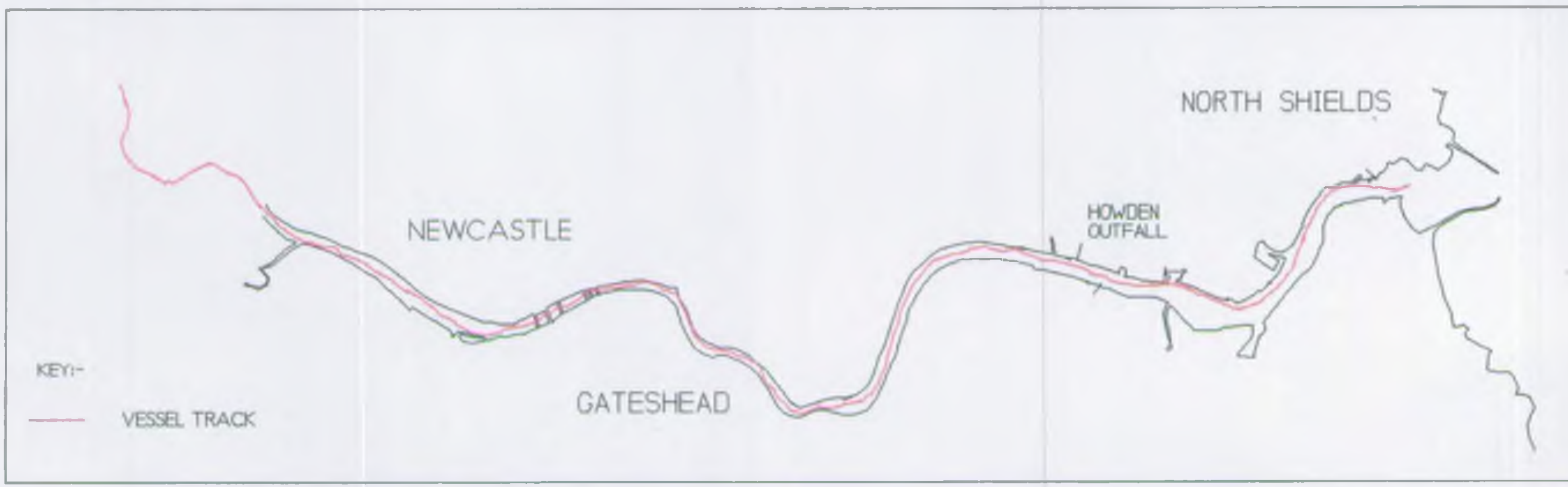


EXISTING TYNE WATER QUALITY SAMPLING SITES



VESSEL TRACK FOR CONTINUOUS MONITORING SURVEY 23\11\94

FIGURE 2.0

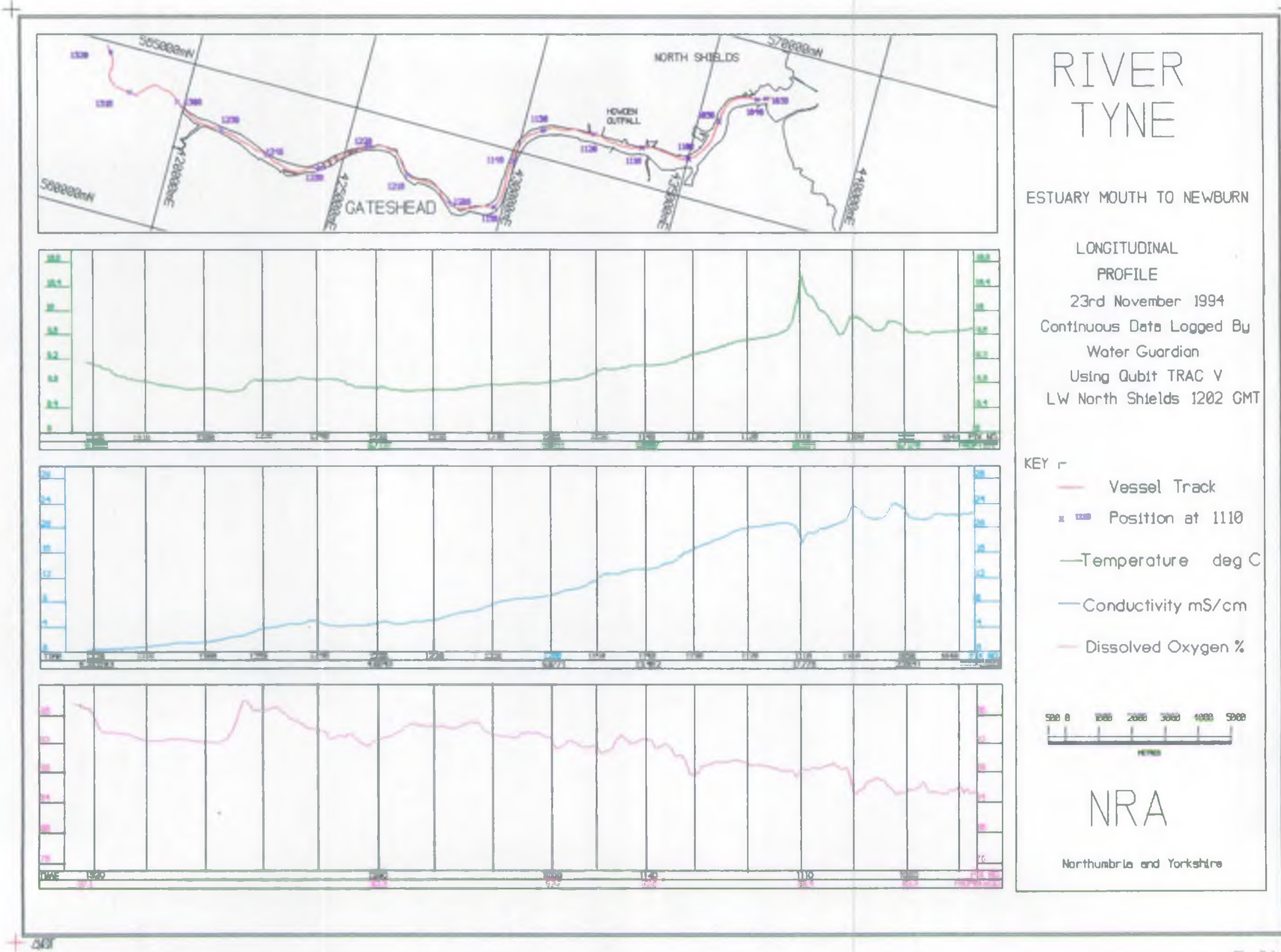

NORTH SHIELDS
HOWDEN OUTFALL
GATESHEAD
RIVER TYNE
ESTUARY MOUTH TO NEWBURN
LONGITUDINAL PROFILE
23rd November 1994
Continuous Data Logged By
Water Guardian
Using Qubit TRAC V
LW North Shields 1202 GMT
KEY
Vessel Track
Position at 1110
Temperature deg C
Conductivity mS/cm
Dissolved Oxygen %
NRA
Northumbria and Yorkshire

Fig 3.1

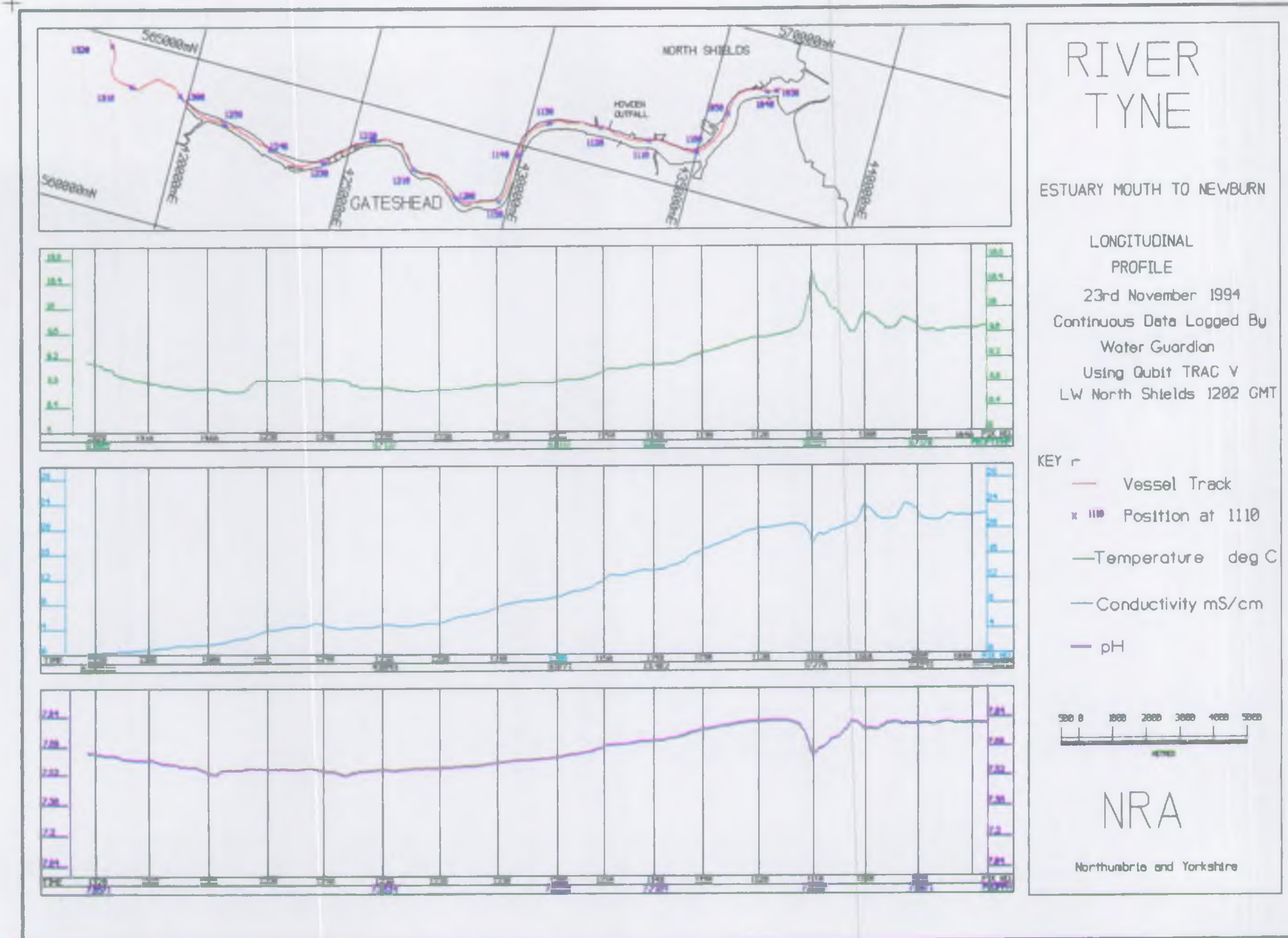
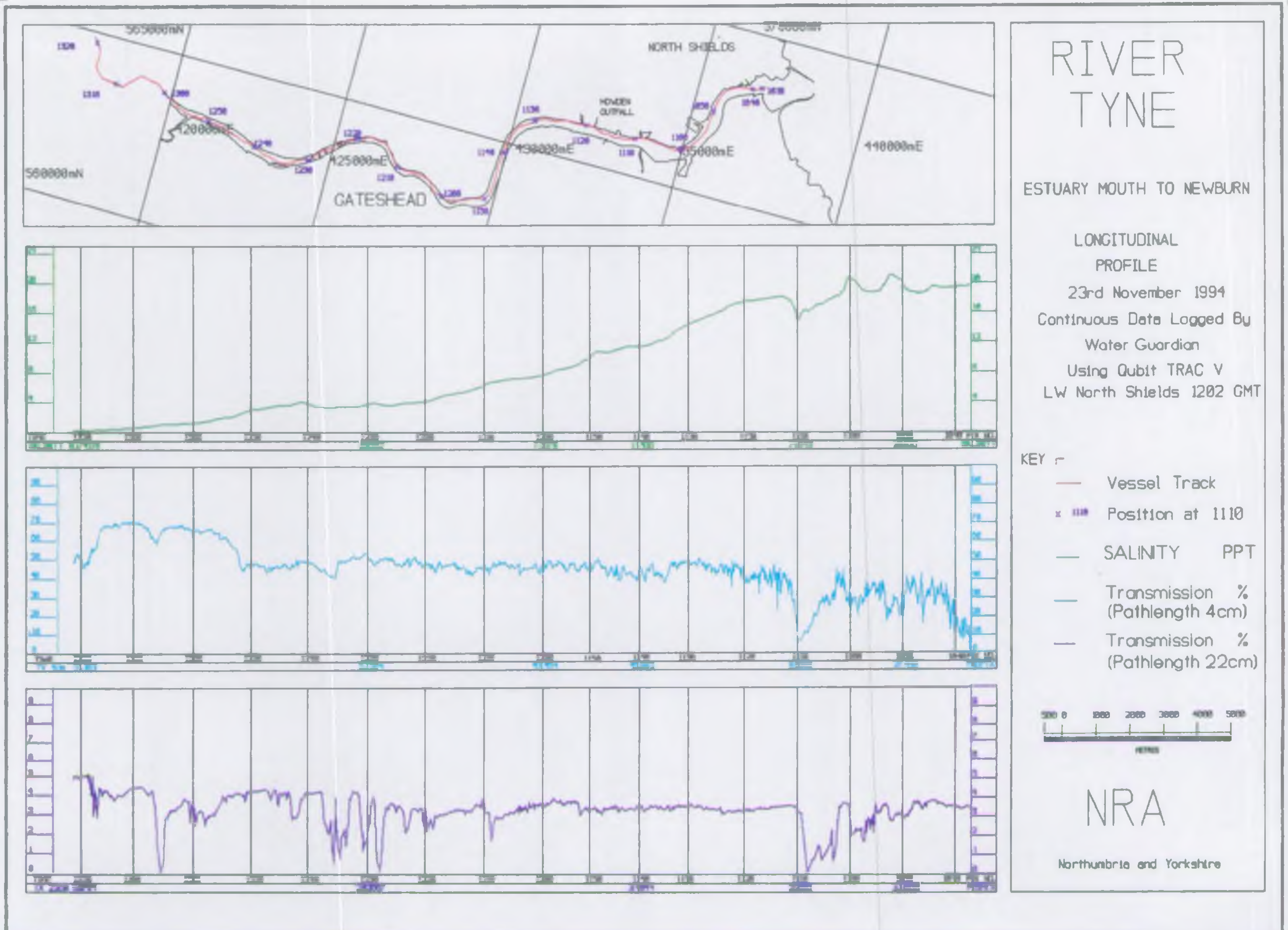

RIVER TYNE
ESTUARY MOUTH TO NEWBURN
LONGITUDINAL PROFILE
23rd November 1994
Continuous Data Logged By Water Guardian
Using Qubit TRAC V
LW North Shields 1202 GMT
KEY
Vessel Track
Position at 1110
Temperature deg C
Conductivity mS/cm
pH
NRA
Northumbria and Yorkshire
NORTH SHIELDS
HOWDEN OUTFALL
GATESHEAD
565000mN
570000mN
560000mN

Figure 3.2



NORTH SHIELDS
HOWDEN OUTFALL
GATESHEAD
560000mN
420000mE
425000mE
430000mE
435000mE
440000mE
RIVER TYNE
ESTUARY MOUTH TO NEWBURN
LONGITUDINAL PROFILE
23rd November 1994
Continuous Data Logged By
Water Guardian
Using Qubit TRAC V
LW North Shields 1202 GMT
KEY
Vessel Track
Position at 1110
SALINITY PPT
Transmission % (Pathlength 4cm)
Transmission % (Pathlength 22cm)
NRA
Northumbria and Yorkshire

Figure 3.3

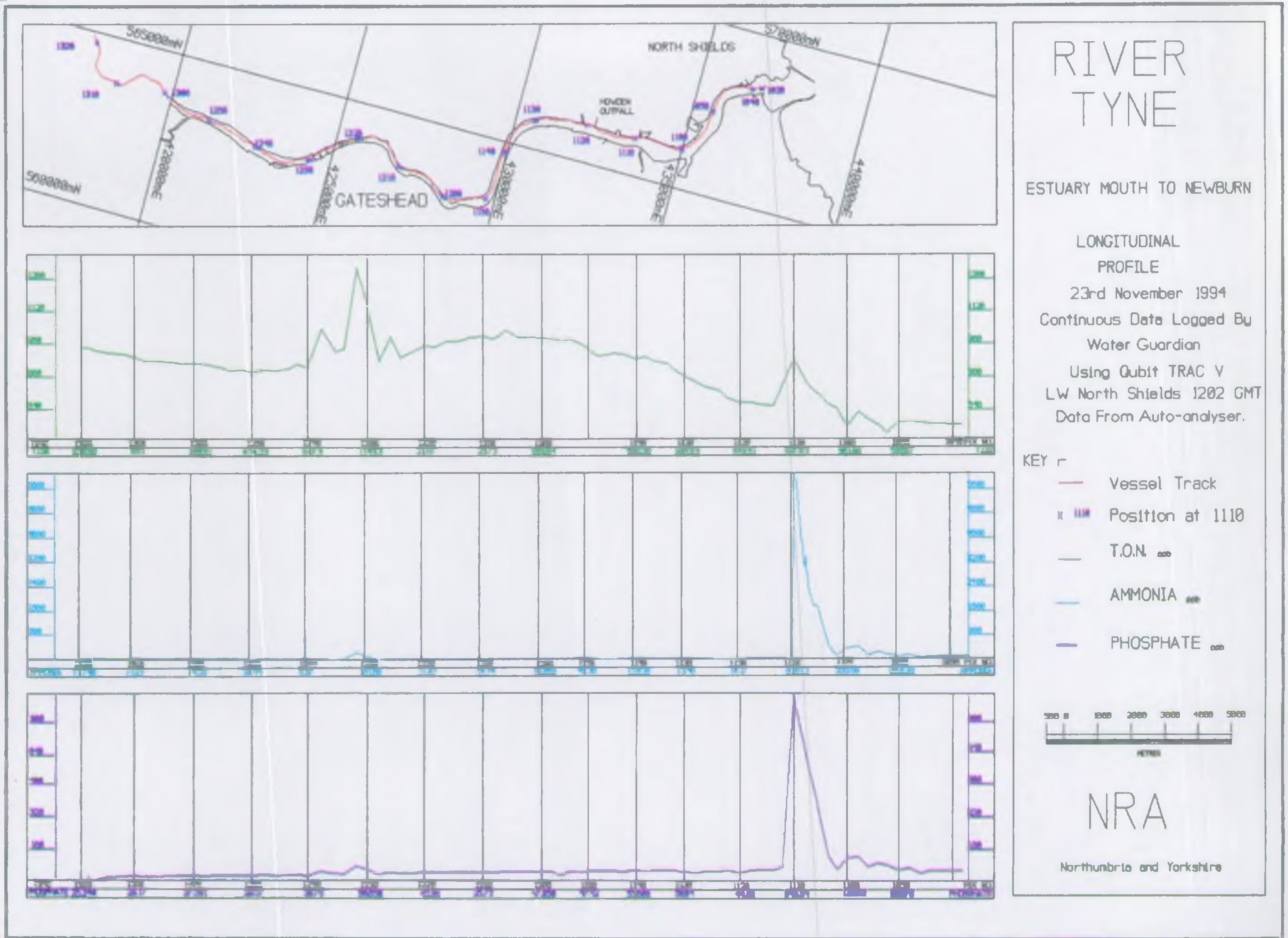
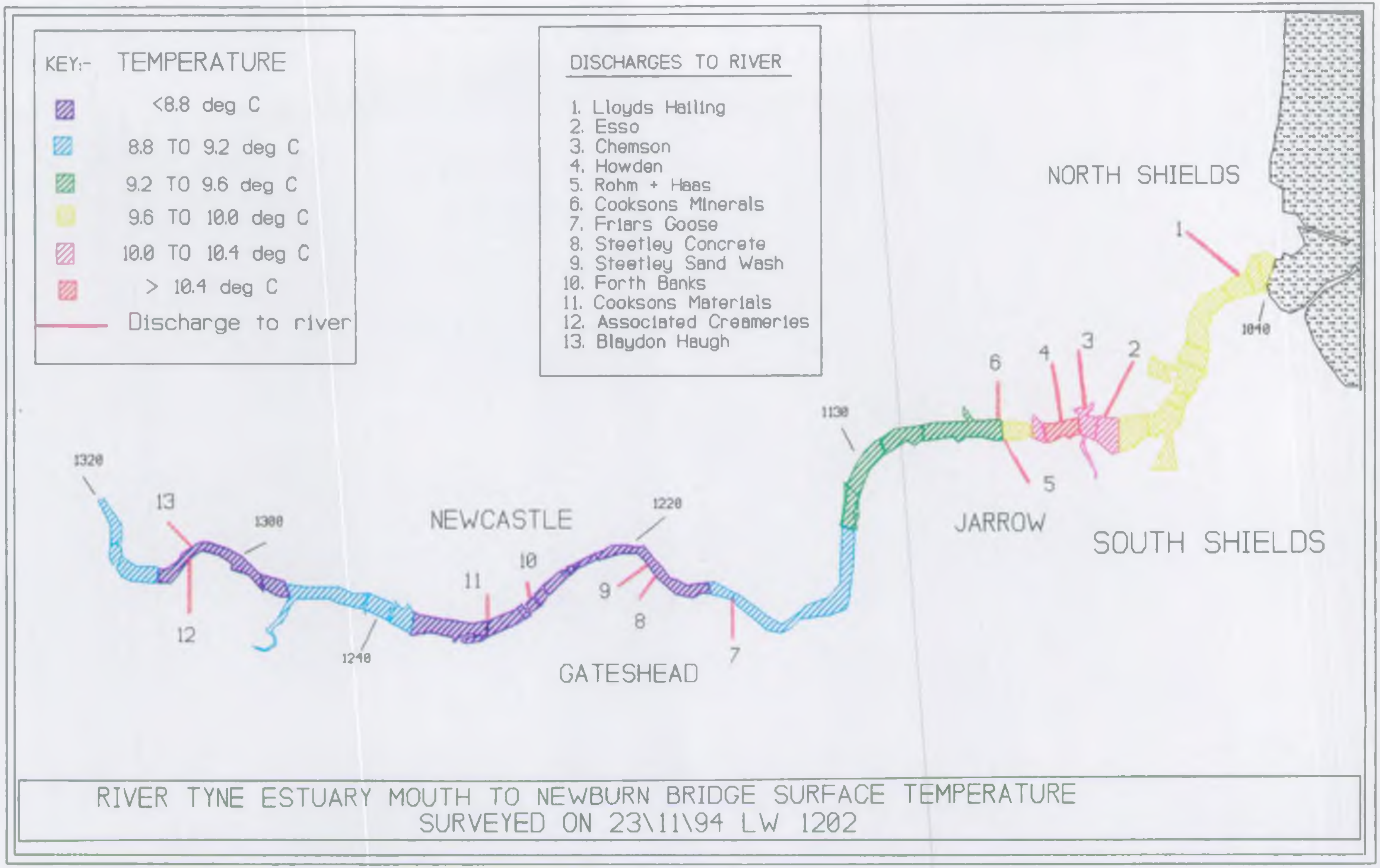

NORTH SHIELDS
HOWDEN OUTFALL
GATESHEAD
RIVER TYNE
ESTUARY MOUTH TO NEWBURN
LONGITUDINAL PROFILE
23rd November 1994
Continuous Data Logged By
Water Guardian
Using Qubit TRAC V
LW North Shields 1202 GMT
Data From Auto-analyser.
KEY
Vessel Track
Position at 1110
T.O.N.
AMMONIA
PHOSPHATE
NRA
Northumbria and Yorkshire

Figure 3.4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<8.8 deg C
8.8 TO 9.2 deg C
9.2 TO 9.6 deg C
9.6 TO 10.0 deg C
10.0 TO 10.4 deg C
> 10.4 deg C
Discharge to river
DISCHARGES TO RIVER
1. Lloyds Hailing
2. Esso
3. Chemson
4. Howden
5. Rohm + Haas
6. Cooksons Minerals
7. Friars Goose
8. Steetley Concrete
9. Steetley Sand Wash
10. Forth Banks
11. Cooksons Materials
12. Associated Creameries
13. Blaydon Haugh
NORTH SHIELDS
SOUTH SHIELDS
JARROW
NEWCASTLE
GATESHEAD
1040
1130
1220
1240
1300
1320
1
2
3
4
5
6
7
8
9
10
11
12
13
RIVER TYNE ESTUARY MOUTH TO NEWBURN BRIDGE SURFACE TEMPERATURE
SURVEYED ON 23\11\94 LW 1202

Figure 3.5

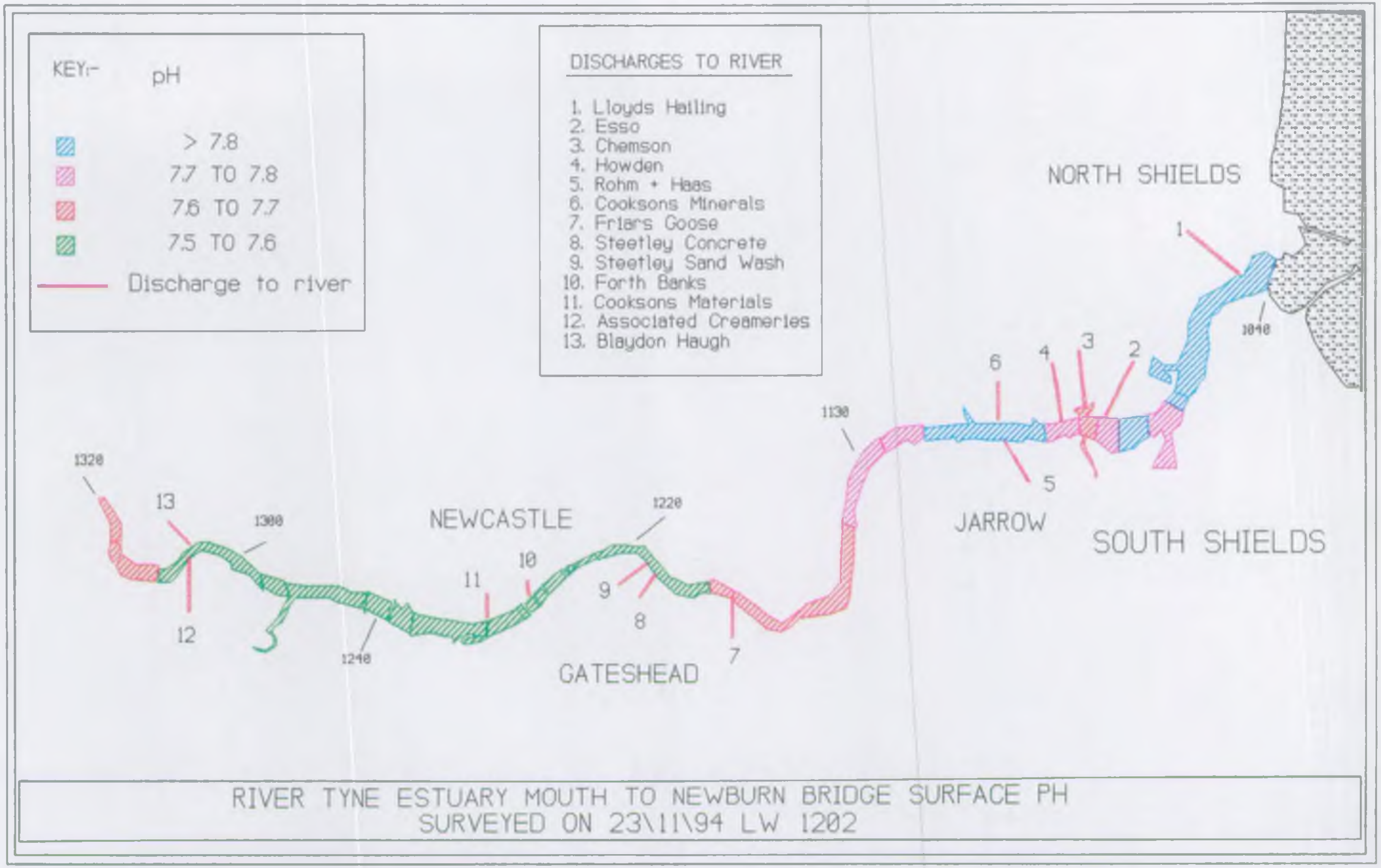
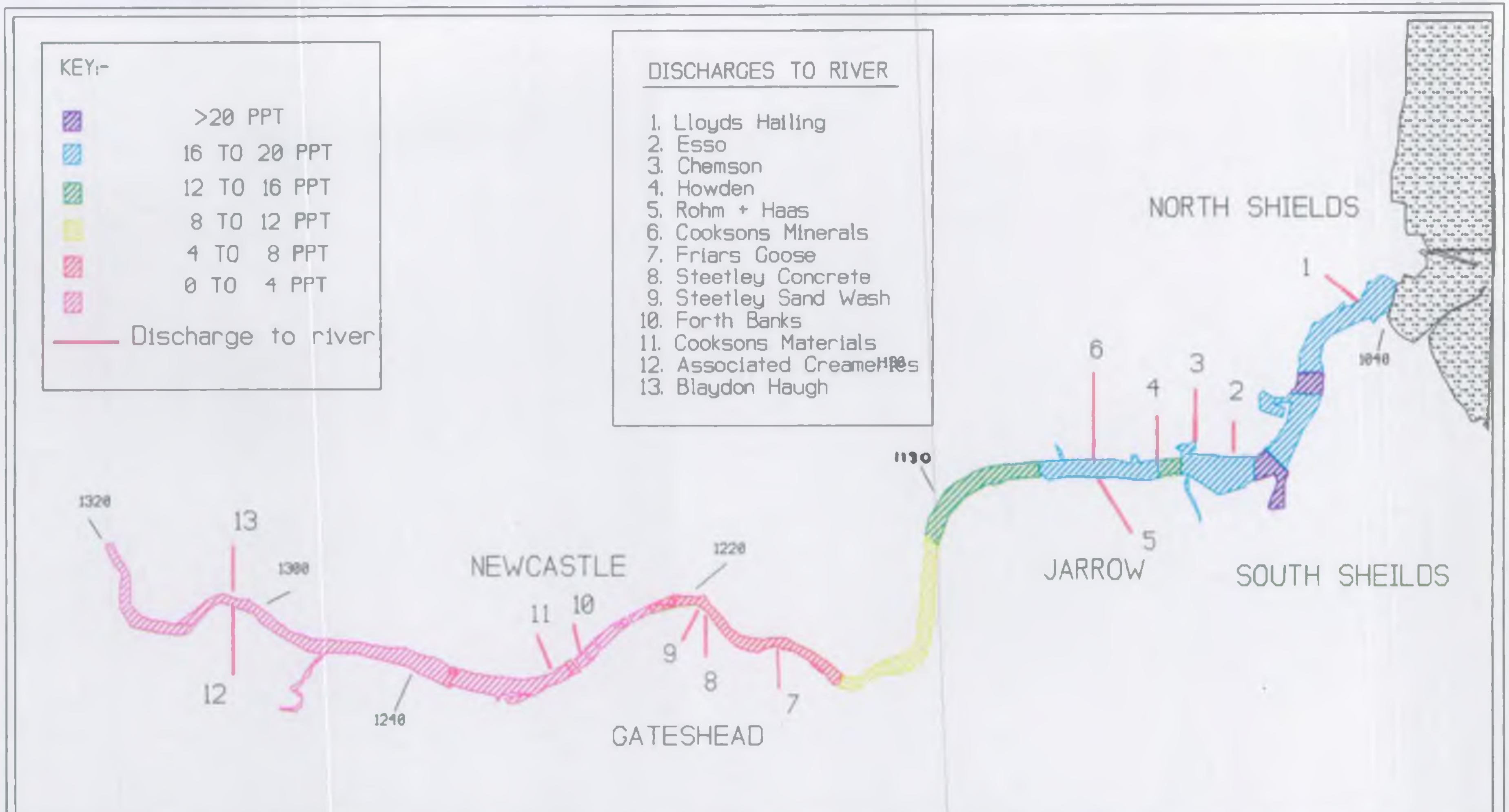

KEY:- pH
> 7.8
7.7 TO 7.8
7.6 TO 7.7
7.5 TO 7.6
Discharge to river
DISCHARGES TO RIVER
1. Lloyds Hailing
2. Esso
3. Chemson
4. Howden
5. Rohm + Haas
6. Cooksons Minerals
7. Friars Goose
8. Steetley Concrete
9. Steetley Sand Wash
10. Forth Banks
11. Cooksons Materials
12. Associated Creameries
13. Blaydon Haugh
NORTH SHIELDS
SOUTH SHIELDS
JARROW
NEWCASTLE
GATESHEAD
1040
1130
1220
1240
1300
1320
RIVER TYNE ESTUARY MOUTH TO NEWBURN BRIDGE SURFACE PH
SURVEYED ON 23\11\94 LW 1202

Figure 3.6



RIVER TYNE ESTUARY MOUTH TO NEWBURN BRIDGE SURFACE SALINITY
SURVEYED ON 23/11/94. LW 1202

Figure 3.7

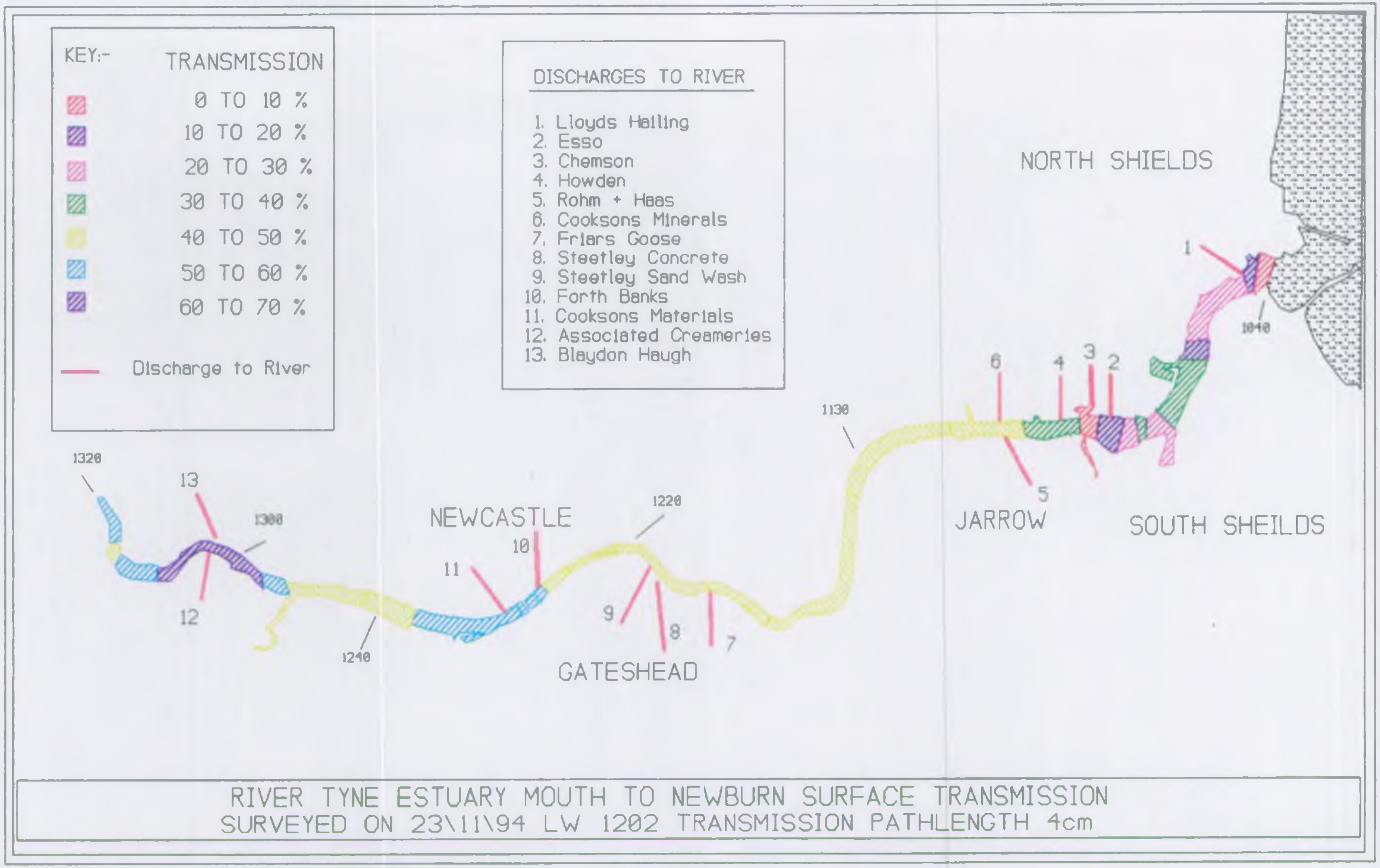
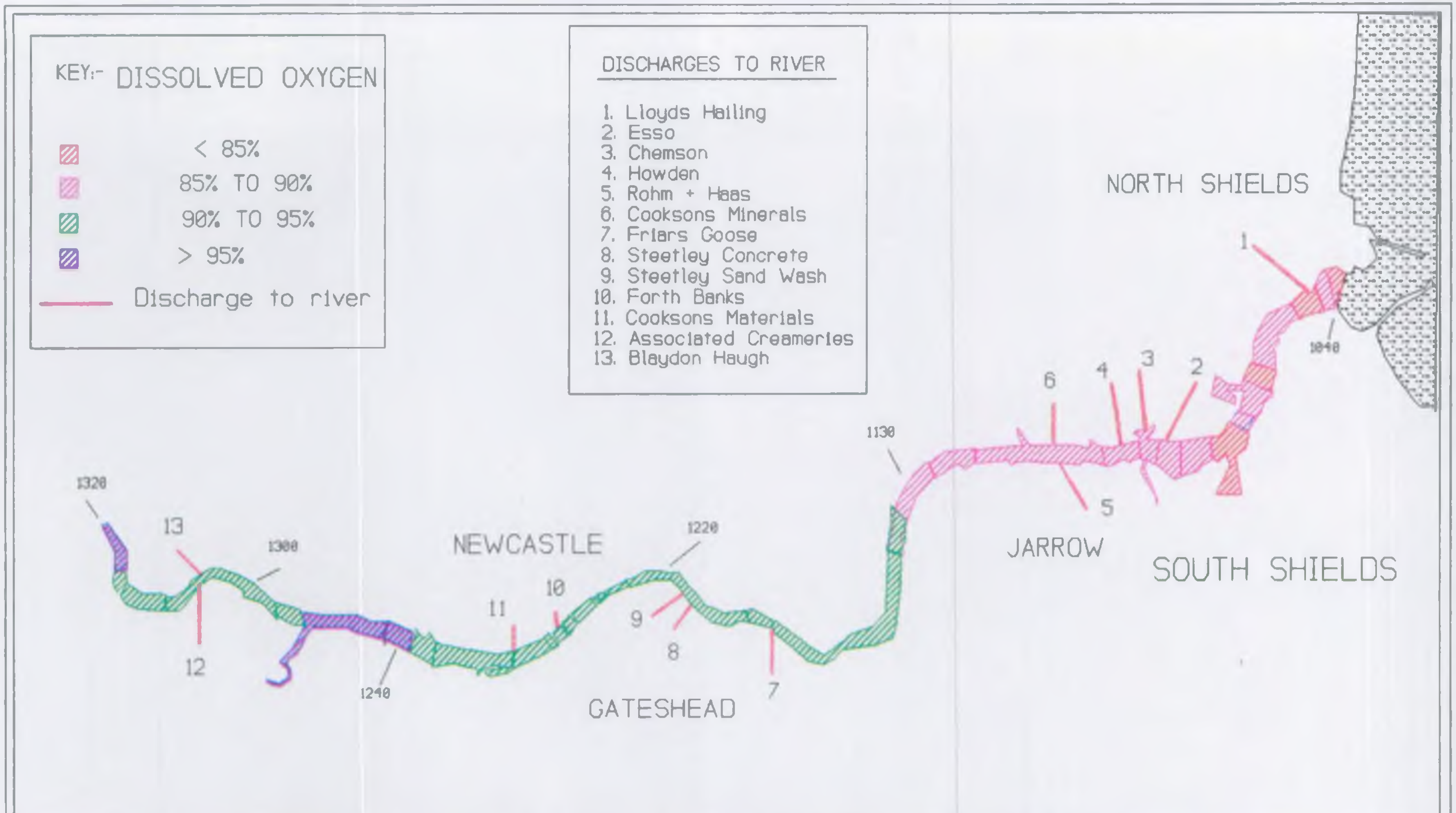

KEY:- TRANSMISSION
0 TO 10 %
10 TO 20 %
20 TO 30 %
30 TO 40 %
40 TO 50 %
50 TO 60 %
60 TO 70 %
Discharge to River
DISCHARGES TO RIVER
1. Lloyds Hailing
2. Esso
3. Chemson
4. Howden
5. Rohm + Haas
6. Cooksons Minerals
7. Friars Goose
8. Steetley Concrete
9. Steetley Sand Wash
10. Forth Banks
11. Cooksons Materials
12. Associated Creameries
13. Blaydon Haugh
NORTH SHIELDS
SOUTH SHEILDS
JARROW
NEWCASTLE
GATESHEAD
1320
1300
1240
1220
1130
1040
RIVER TYNE ESTUARY MOUTH TO NEWBURN SURFACE TRANSMISSION
SURVEYED ON 23\11\94 LW 1202 TRANSMISSION PATHLENGTH 4cm

Figure 3.8



RIVER TYNE ESTUARY MOUTH TO NEWBURN BRIDGE SURFACE DISSOLVED OXYGEN
SURVEYED ON 23\11\94 LW 1202

Figure 3.9

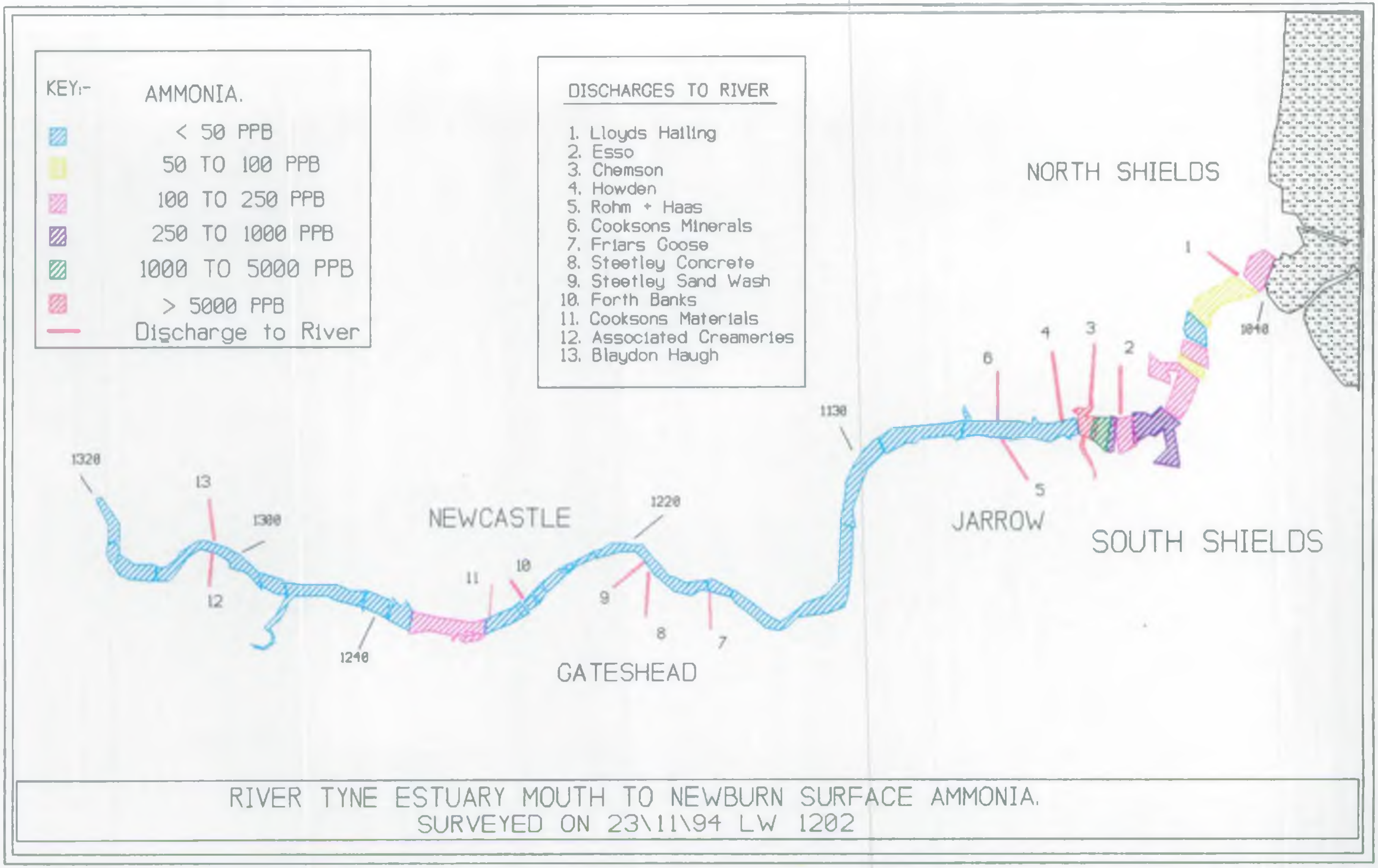
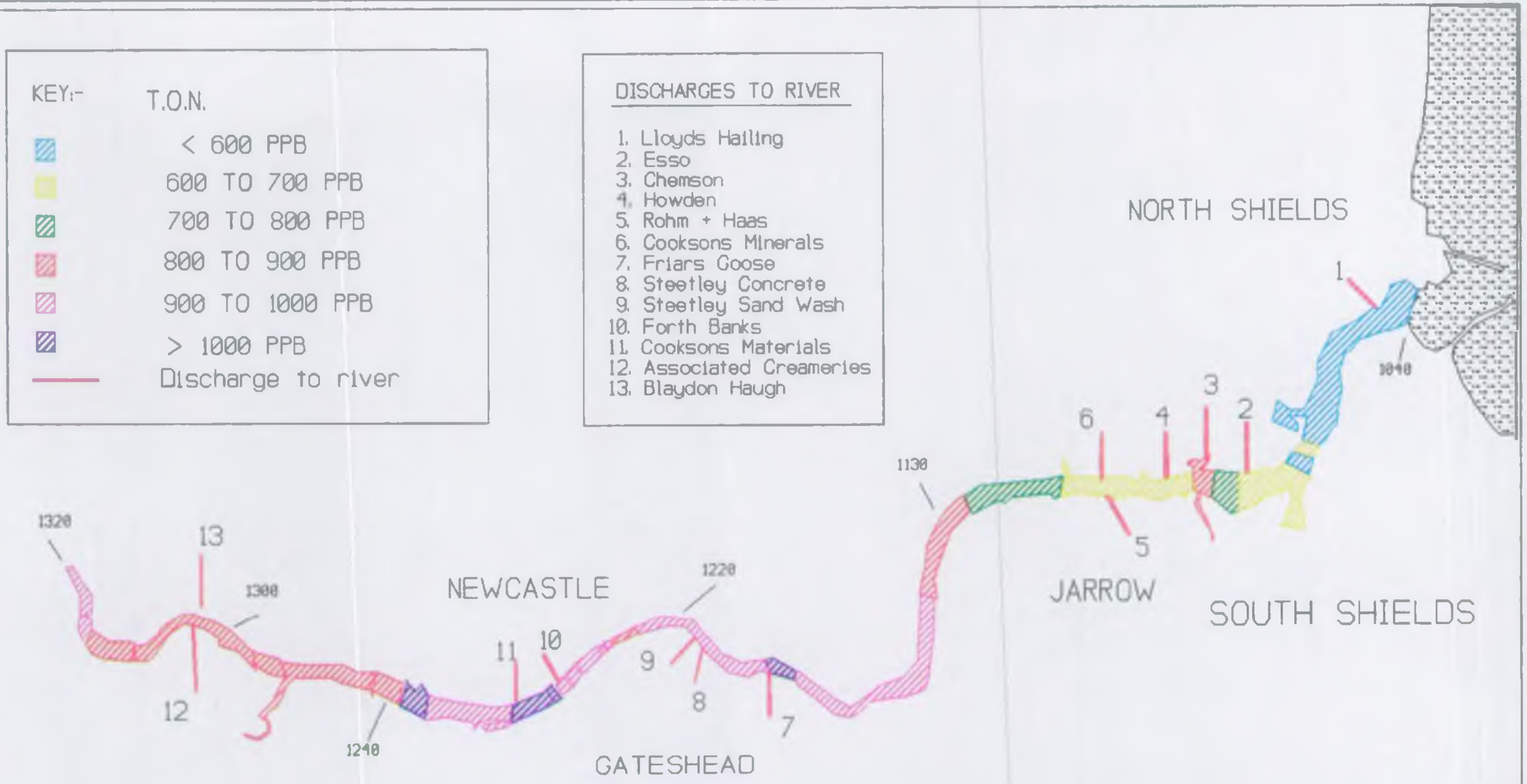
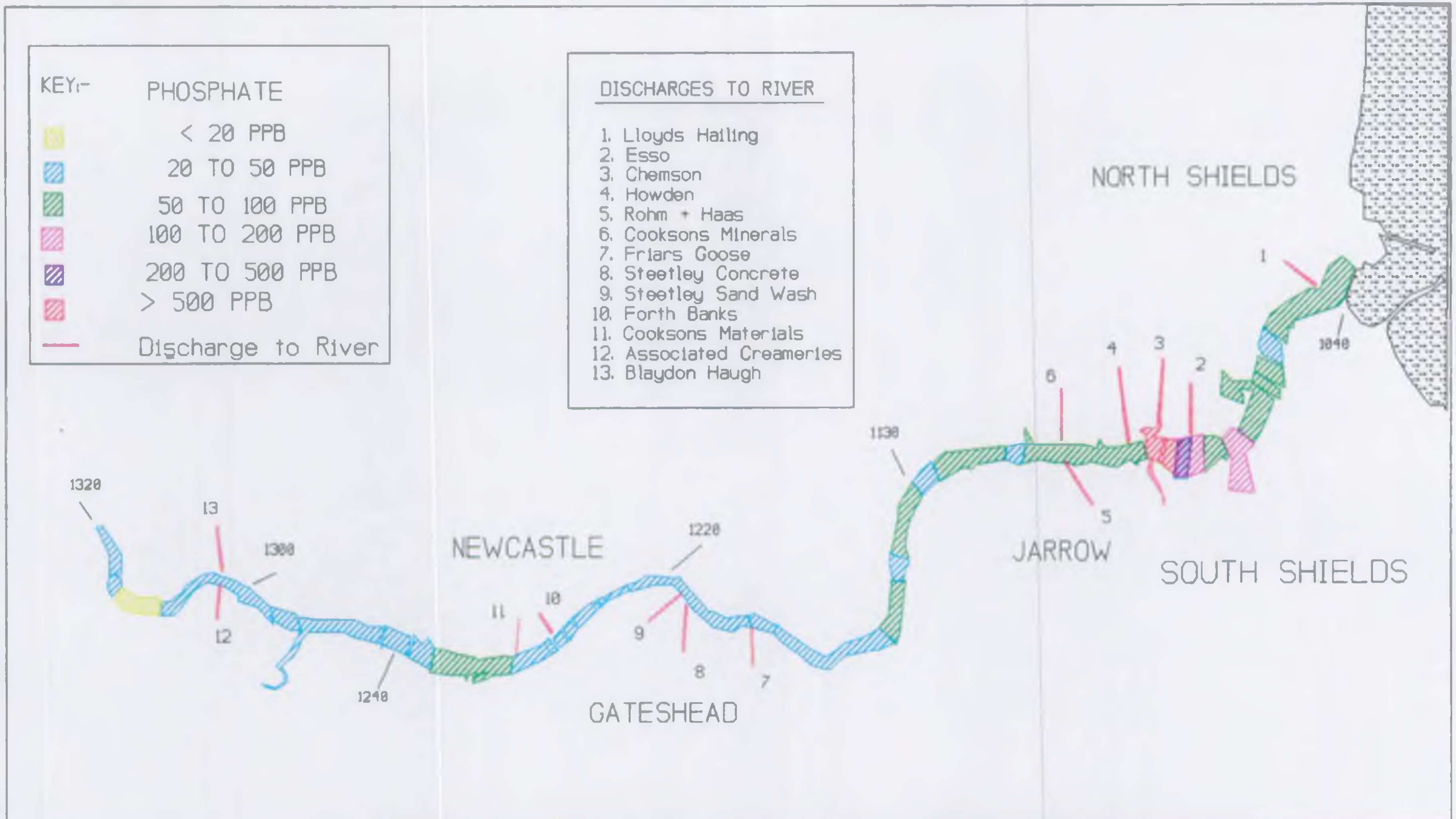

KEY:-
AMMONIA.
< 50 PPB
50 TO 100 PPB
100 TO 250 PPB
250 TO 1000 PPB
1000 TO 5000 PPB
> 5000 PPB
Discharge to River
DISCHARGES TO RIVER
1. Lloyds Hailing
2. Esso
3. Chemson
4. Howden
5. Rohm + Haas
6. Cooksons Minerals
7. Friars Goose
8. Steetley Concrete
9. Steetley Sand Wash
10. Forth Banks
11. Cooksons Materials
12. Associated Creameries
13. Blaydon Haugh
NORTH SHIELDS
SOUTH SHIELDS
JARROW
NEWCASTLE
GATESHEAD
1040
1130
1220
1240
1300
1320
RIVER TYNE ESTUARY MOUTH TO NEWBURN SURFACE AMMONIA.
SURVEYED ON 23\11\94 LW 1202

Figure 3.10



RIVER TYNE ESTUARY MOUTH TO NEWBURN SURFACE T.O.N.
SURVEYED ON 23\11\94 LW 1202

Figure 3.11



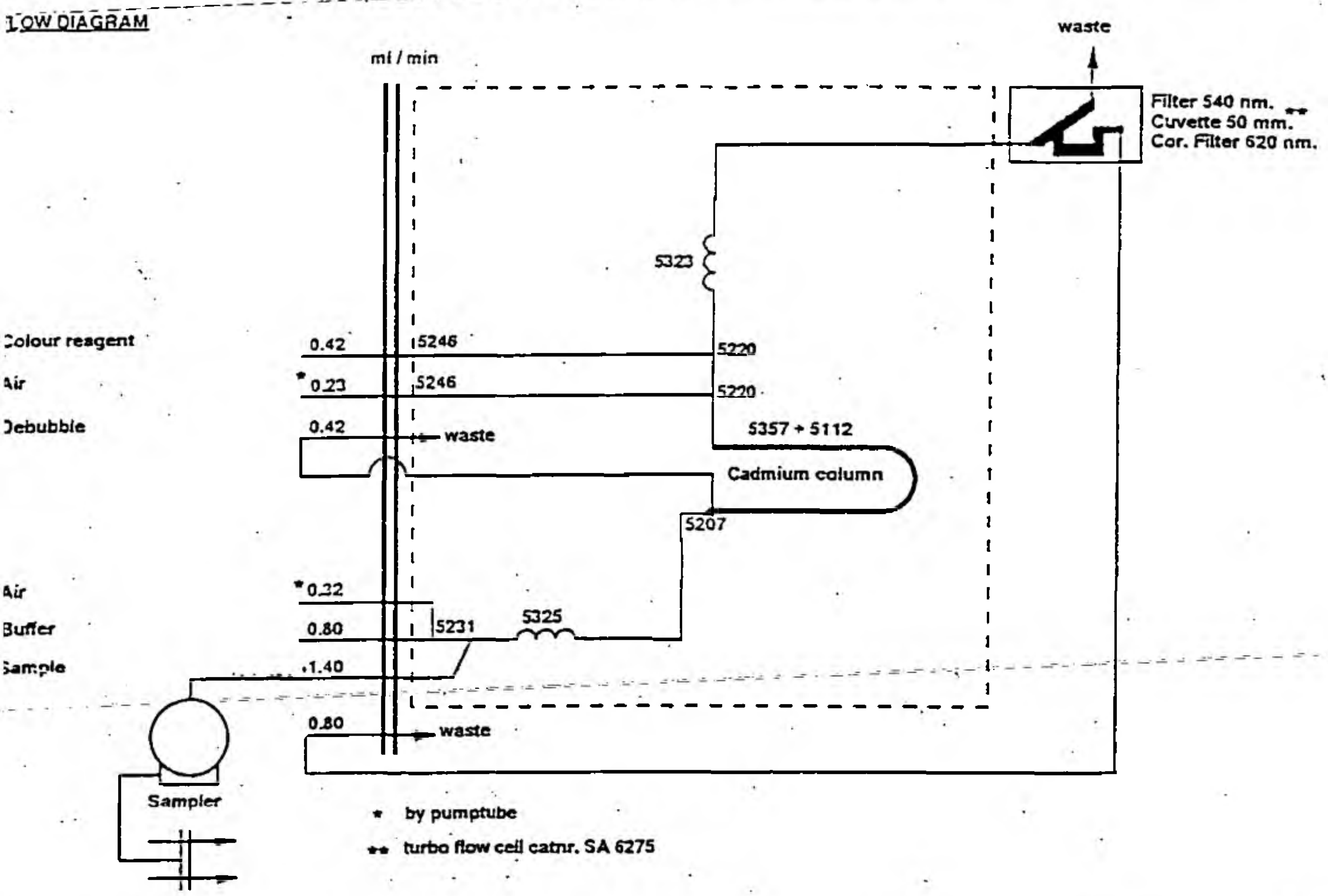
RIVER TYNE ESTUARY MOUTH TO NEWBURN BRIDGE SURFACE PHOSPHATE
SURVEYED ON 23\11\94 LW 1202

Figure 3.12

APPENDIX A

Schematic Diagram Of T.O.N Channel

NITRATE + NITRITE 4 - 100 ppb N WATER
Catnr. 1100402 issue 110790/90048300

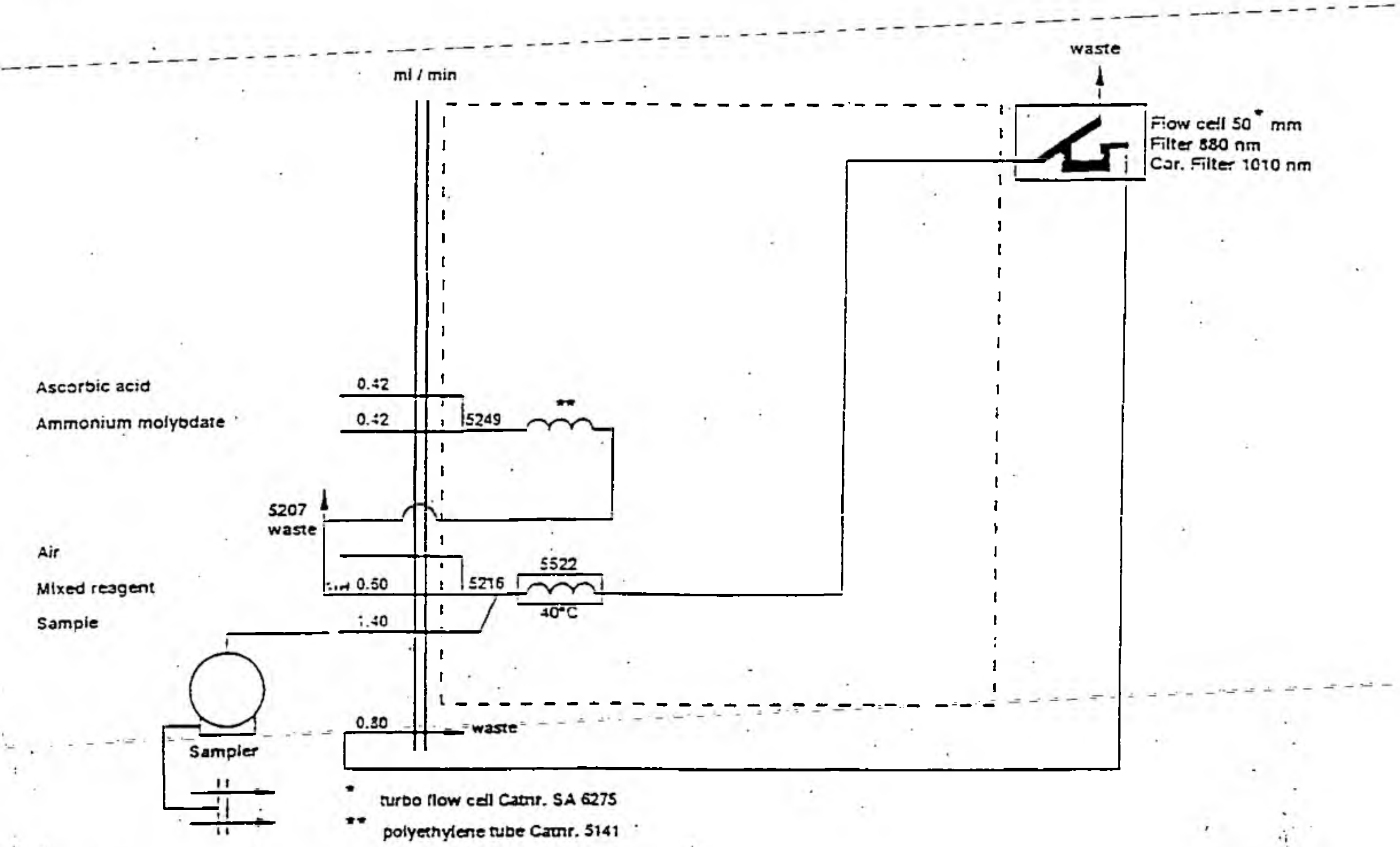


* by pumptube

** turbo flow cell catnr. SA 6275

Schematic Diagram Of Phosphate Channel

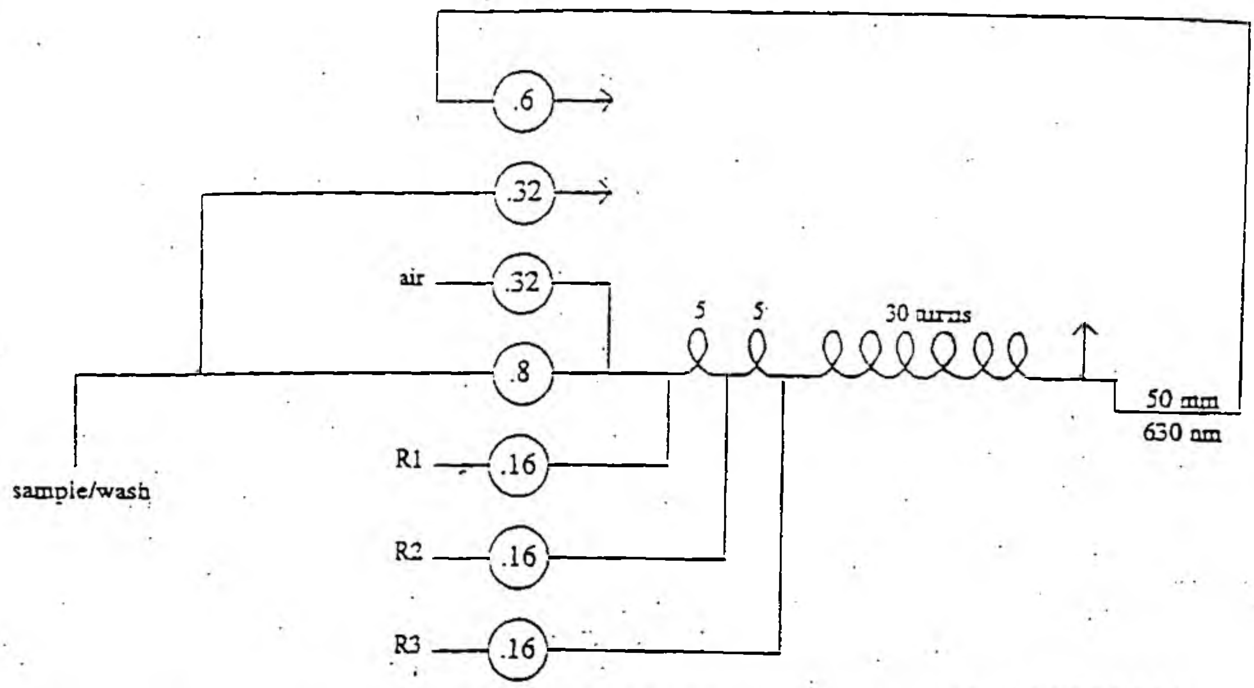
FLOW DIAGRAM



* turbo flow cell Catnr. SA 6275

** polyethylene tube Catnr. 5141

Schematic Diagram Of Ammonia Channel



Reagent 1	Trisodium citrate	62.5 g]	
	Sodium nitroprusside	0.5 g]	→ 500 ml
	10 % BRIJ-35 (wetting agent)	0.5 ml]	
Reagent 2	Phenol	5.0 g	→ 500 ml
Reagent 3	Sodium hydroxide	3.4 g]	
	Chlorine donor*	1.0 g]	→ 500 ml

*Solutions of hypochlorite have lost favour due to their instability and have generally been replaced by salts (Na or K) of dichloroisocyanuric acid, for example $C_3C_2N_3O_3Na$ (mol. wt. 219.9) Eastman product no. 10511.

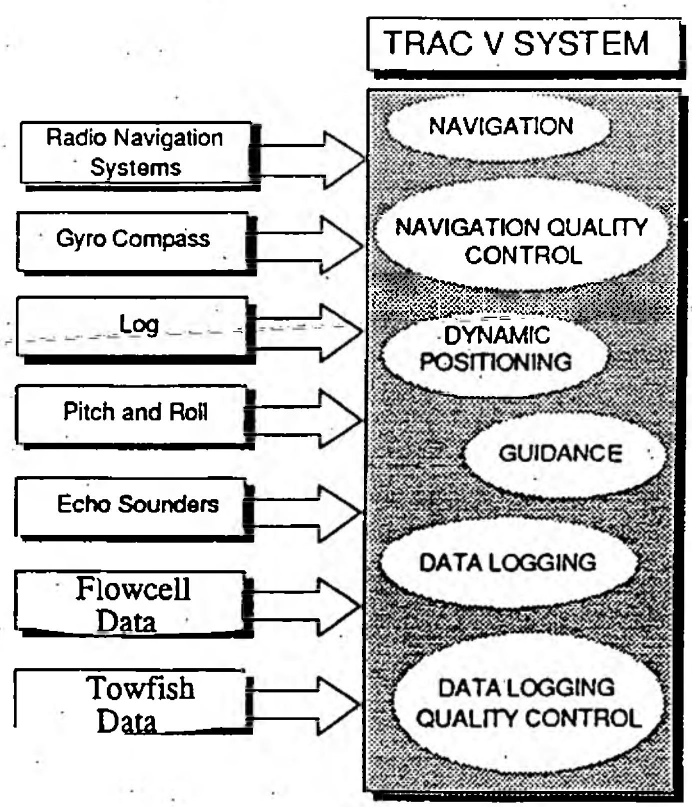
APPENDIX B

Introduction

TRAC V is Qubit's Transportable Realtime Autonavigation Computer Series V. The system is fully integrated and is used to provide some or all of the following:

- Realtime data acquisition from a variety of oceonagraphic sensors including echo sounders, heave compensators and sonars.
- Navigation processing and computation from a variety of navigational inputs including radio navigation systems, log and gyro.
- Guidance facilities enabling the vessel to be guided along a series of pre-set lines. Guidance data can either be displayed to the helmsman or input directly to the ship's autopilot for fully automated track keeping.
- Dynamic positioning from Acoustic Navigation inputs and ROV tracking.
- Logging of all data to hard or floppy disc as required.
- Online quality control of the navigation systems in use.

A functional schematic of the system is shown below



TRAC V Functional Schematic

APPENDIX C

TRAC V System Equipment

The TRAC V system comprises the following major items of equipment:

- HP9000/300 Series computer.
- Disc drive unit (comprising hard and floppy disc drives).
- A Q278 intelligent interface unit.

These three items are fitted into a shock mounted frame assembly. This frame can be fitted in either a rugged transit case as a portable system or in a standard 19" rack as a permanent installation.

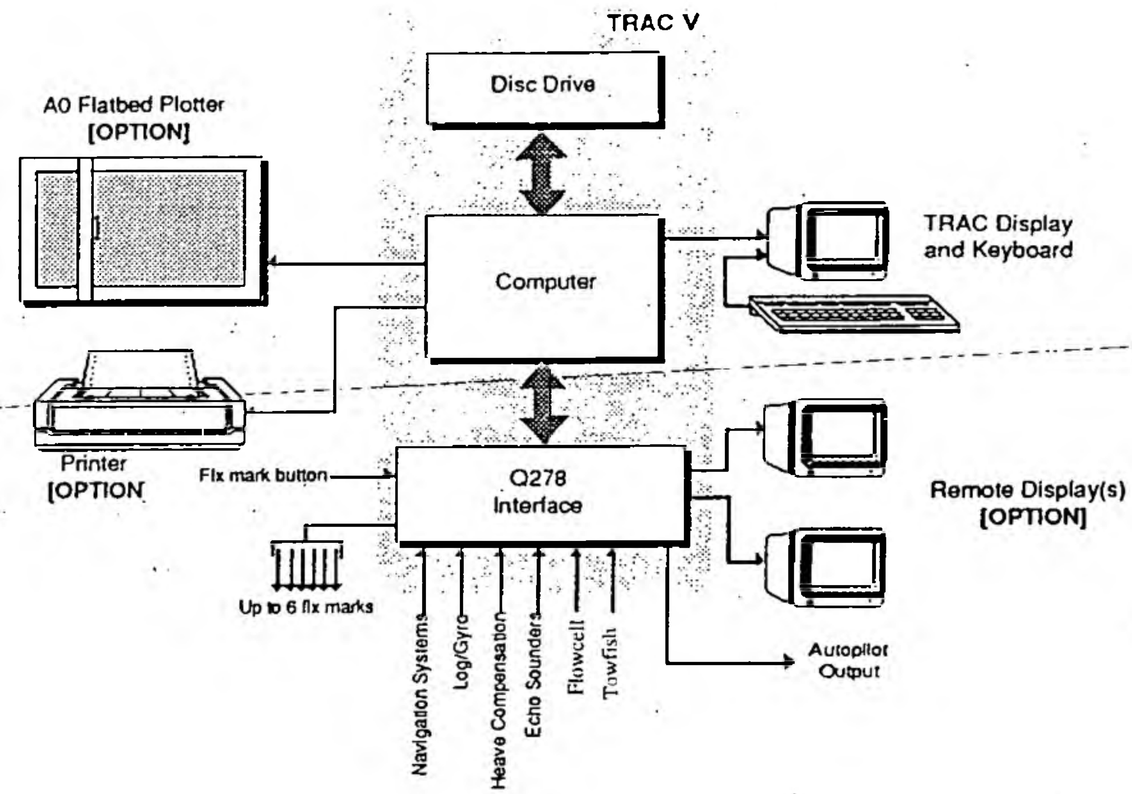
The TRAC V overall dimensions, including the transit case, are as follows:

Height:	543 mm
Width:	511 mm
Depth (Lid On):	673 mm
Depth (Lid Off):	527 mm
Weight:	55 kg

The system also requires a main display and associated keyboard. A variety of end user specified monochrome and colour displays are available for use with the system. The type required is dependant upon the client requirement.

The system also supports plotters, printers and remote displays. These are all options to the user. In most cases, Qubit are capable of interfacing TRAC V to any plotter or printer specified by the user.

A functional layout of the TRAC V system showing some of the options is shown on the following page



- TRAC V Functional Layout

Computer

At the heart of the TRAC system is a HP9000/300 Series microcomputer with a random access memory (RAM) of 4 Mbytes. This carries out all the processing and control tasks defined by the TRAC system software, though there is a limited degree of pre-processing of data carried out by the intelligent interface units.

Disc Drive

Data storage is provided by a combined hard and floppy disc drive unit with storage capabilities of 20/40 Mbytes and 1.2 Mbytes respectively.

All of the system software is supplied on the hard disc and is write protected to prevent accidental erasure. Back-up copies of the software are supplied on floppy disc. The hard disc is also used for logging survey data online. In normal circumstances up to 36 hours of data can be logged before the hard disc capacity is reached. In practice data would be transferred to floppy disc or tape streamer at more frequent intervals than this.

All system operating parameters and basic data is also stored on the hard disc. This however can be altered by the user and is not write protected.

Interface Unit

The Q278 intelligent interface unit provide the interface between the system and its input sensors and output devices. The interface supports all standard Qubit interface modules and cables, as well as the Qubit Rainbow 8 colour graphic generator module. The interface is an integral part of the 19" rack mountable frame complete with microprocessor controller. The microprocessor controller incorporates an HPIB (IEEE-488) interface and trigger in/out facilities.

Many of the interface modules are multipurpose. The changing of a sensor will only involve exchanging a cable and internal links/switches in most cases. This technique reduces the spares holding requirement and gives great flexibility to the end user.

The computer is linked to the interface modules via the HPIB bus and communicates directly with the interface controller. The interface controller continually monitors the navigation and other sensors interfaced to the system. On power up of the system, the interface controller establishes which modules and devices are present and signals this information to the host computer via the HPIB link.

The interface will sample up to 10 echo sounder readings per second and pass this data to the computer every second. All other available data is also passed to the computer together with the time. Each of the 10 soundings is taken in a 100 ms time cell to permit an accurate position to be extrapolated for each sounding.

Devices are sensed at the device output rate and the data handed to the computer is the latest available for each second. Precisely correlated navaid and echo sounder data is therefore available to the computer every second.

Apart from an ON/OFF switch the interface units have no external controls, and they do not need setting up by the user.

A fix button is provided on the exterior of the TRAC V which provides a closing contact to enable the operator to make an 'external event'. A fix button on a lead is also available as an option.

Display and Keyboard

The normal user interface for the TRAC V is a keyboard and either a monochrome or colour display which are mounted away from the main TRAC V unit. Operation is relatively straightforward with most of the system facilities accessed using specific keyboard keys the functions of which are designated on the display, and which change depending upon the operation currently in progress. These functions keys are arranged in a logical menu structure which directly reflects the layout of the system facilities.

For applications in harsh environment a remote touch display in a sealed unit can be supplied to provide protection against dust and water from all directions, making it particularly suitable for use in small boats.

1994-11-28 16:26 OutPut of : 941123A1
Software : version 6.1 c1990,93
Operator : Alan Shepherd
Date of the Analysis : 1994-11-23 07:49
Analysis File Name : A:\941123A1

T.O.N
Calibration order = 2 + BaseLine
Result = a2 * x» + a1 * x + a0
a2 = 0.00003
a1 = 0.57218
a0 = 0.00000

AMMONIA
Calibration order = 2 + BaseLine
Result = a2 * x» + a1 * x + a0
a2 = 0.00049
a1 = 0.22802
a0 = 0.00000

PHOSPHATE
Calibration order = 2 + BaseLine
Result = a2 * x» + a1 * x + a0
a2 = 0.00008
a1 = 0.17346
a0 = 0.00000

Pos	Result TON	Result NH3	Result PO4
3	576.27	105.13	61.10
4	567.41	83.76	58.66
5	566.78	76.46	58.00
6	573.11	78.26	57.35
7	571.21	65.55	55.60
8	580.07	44.44	44.05
9	585.15	133.38	67.83
10	580.07	85.62	60.87
11	529.58	157.11	84.56
12	569.31	241.04	93.47
13	594.67	135.06	76.79
14	631.62	406.05	122.81
15	561.09	356.98	122.02
16	648.90	103.11	60.87
17	668.79	436.91	129.94
18	720.41	1760.38	378.80
19	775.06	3401.91	625.80
20	887.03	6101.21	946.54
21	648.26	47.45	71.47
22	659.80	23.22	62.43
23	664.94	16.88	61.10
24	673.94	12.90	57.78
25	676.51	10.17	44.68
26	693.26	10.17	57.13
27	735.98	10.98	56.69
28	746.38	12.07	53.64
29	769.83	12.90	45.73
0	805.83	13.46	50.84
1	833.45	14.30	56.47
2	865.15	14.02	55.81
3	872.43	13.18	55.16
4	895.00	13.46	54.51
5	886.36	12.62	55.60

36	912.31	11.79	47.42	
37	913.64	10.98	52.99	
38	905.65	10.71	53.86	
39	903.65	9.10	54.72	
42	1777.62	4076.32	889.19	(A.Q.C)
43	962.48	49.36	47.42	
44	979.96	32.00	47.64	
45	975.25	22.29	34.98	
46	981.30	20.45	49.34	
47	988.04	19.85	47.85	
48	989.38	21.06	47.64	
49	991.41	22.60	49.12	
50	1024.51	26.39	46.15	
51	983.32	26.07	46.79	
52	995.45	25.75	46.36	
53	992.08	27.68	45.31	
54	971.88	26.07	45.73	
55	970.54	26.07	43.42	
56	943.71	19.55	43.21	
57	947.73	21.67	42.80	
58	917.64	14.87	39.48	
59	890.35	12.34	40.51	
60	992.08	24.79	45.52	
61	875.08	10.17	35.39	
62	1143.32	101.60	60.65	
63	1335.75	238.88	75.86	
64	933.67	14.30	37.63	
65	922.31	10.71	39.68	
66	1031.29	11.79	47.42	
67	847.30	9.37	30.76	
68	859.85	9.90	34.78	
69	836.74	7.80	31.36	
70	830.81	9.10	30.56	
71	835.42	12.07	32.96	
72	824.23	10.44	29.57	
73	834.10	12.07	28.38	
74	832.13	13.46	28.97	
75	847.96	14.87	28.77	
76	859.85	12.90	26.80	
77	865.81	14.58	27.59	
78	865.81	19.85	30.16	
79	871.11	14.58	29.76	
80	874.42	9.90	26.41	
81	875.08	10.44	24.85	
82	895.00	12.07	29.17	
83	909.64	12.62	24.65	
84	914.98	14.58	19.84	
85	924.98	14.58	10.14	
86	939.69	13.74	25.24	
87	940.36	14.58	24.85	

NRA

National Rivers Authority
Northumbria &
Yorkshire Region