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ENVIRONMENT
AGENCY

[redacted]

STILLWATERS MONITORING PROGRAMME

Summary Results 2000

Hatch Mere, Marbury Big Mere, Comber Mere
Tabley Mere, Tatton Mere and Melchett Mere

Report: MSP-MER-01-01
Marine and Special Projects
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Distribution:

Main:

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Summary: (via E-mail)

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1. INTRODUCTION

During 2000, stillwaters monitored for the forth year of the Stillwaters Monitoring Programme were Hatch Mere, Marbury Big Mere, Comber Mere, Tabley Mere, Tatton Mere and Melchett Mere. Algal, zooplankton and water chemical samples were taken on all meres. Surveys of Tabley Mere and Comber Mere continued on from last year when water quality concerns were highlighted. Continuous monitoring in Oak Mere, including water level data continued in 2000. Fish surveys were carried out in Tatton Mere and Comber Mere. Tabley Mere survey was abandoned due to the awkward bathymetry of the mere. No invertebrate samples were taken in 2000 due to lack of resources.

Specific reasons highlighted by the Stillwaters Group for monitoring each stillwater were:

HATCH MERE:
- Unusual water chemistry
- Nitrogenous pollution suggested
- Wetland and bog communities
- Blue-greens

MARBURY BIG MERE:
- Whitchurch group of meres
- Monitoring recommended for nitrate directive
- Interesting phytoplankton communities

COMBER MERE:
- Largest mere in Environment Agency North West Region
- Artificially eutrophicated
- Records of native crayfish

TABLEY MERE:
- Knutsford Group of Meres
- Monitoring recommended for Nitrate Directive
- Assess status of mere following installment of M6 interceptor

TATTON MERE:
- Representative of Knutsford group of meres
- Monitoring recommended for nitrate directive

MELCHETT MERE:
- Adjacent to Tatton Mere
- Water chemistry largely unknown
- Result of sunken woodland

OAK MERE:
- Conservation Status
- Drought issue - water level falling
- Appearance of algal blooms in recent years
- Possible impact of mineral extraction
- An oligotrophic still water

Survey Dates

Algal and Water Quality	Hatch Mere	10/04/00	19/07/00	03/10/00
	Marbury Big Mere	10/04/00	17/07/00	02/10/00
	Comber Mere	07/04/99	16/07/99	04/10/99
	Tabley Mere	09/04/99	15/07/99	06/10/99
	Tatton Mere	11/04/00	18/07/00	04/10/00
	Melchett Mere	11/04/00	18/07/00	04/10/00
Fish Surveys	Tatton Mere	24/07/00		
	Comber Mere	08/08/00		

2. PHYSICO-CHEMICAL CHARACTERISTICS AND WATER CHEMISTRY

Introduction

This report documents the water chemical samples taken by Marine and Special Projects, on the dates shown above. Sample points were chosen to cover the deepest parts of the stillwater whilst at the same time giving good spatial coverage. At the sampling sites bottom and surface water samples were taken to determine nutrient concentrations. A multi-parameter probe measured temperature, pH, specific conductivity and dissolved oxygen (% saturation) through the water column at each site. The sampling methodology employed was largely identical to all previous stillwater surveys and is detailed in report MSP-CME-95-01.

As part of the overall growing interest in Oak Mere, a multi -parameter probe has been deployed since summer 1997. During visits to service the water quality instrument, nutrient and chlorophyll samples are taken. Water level measurements have continued since 1998.

Table 1 and 2 list the mean data for physico-chemical parameters and surface and bottom water nutrient concentrations for all stillwaters. The Appendix includes location maps; graphed physico-chemical profiles and nutrient levels; Oak Mere data (including continuous monitoring, nutrient and water level data) and finally the raw data.

The text description of each stillwater (section 2.1) is supported by the graphs and tables as detailed.

Instrumentation Problems and Nutrient Analysis

There were instrumentation problems in the April surveys when Hatch Mere, Marbury Big Mere and Comber Mere were not profiled. In October, the instrument failed during profiling of the first site in Marbury Big Mere.

Analytical problems at the EA's Nottingham Laboratory meant that Total Phosphorus was not consistently analysed for. Ortho-phosphate analysis was not affected. This is still an on-going problem, which will hopefully be resolved before next years sampling begins.

Table 1. Average profile readings in surface and bottom waters - April, July & October 2000

Hatchmere

Parameter	10-Apr-00 Surface	Bottom	19-Jul-00 Surface	Bottom	03-Oct-00 Surface	Bottom
Temperature °			19.1	15.9	13.7	13.6
pH units			8.4	7.5	7.6	7.7
Spec. Cond. µS/cm			407	411	386	387
DO % sat.			110.5	23	75.7	72.9

Tabley Mere

Parameter	11-Apr-00 Surface	Bottom	18-Jul-00 Surface	Bottom	04-Oct-00 Surface	Bottom
Temperature °	9.7	8.4	18.3	15.3	13.1	13
pH units	9.1	8.8	8.7	8	7.5	7.7
Spec. Cond. µS/cm	762	737	591	6.4	580	549
DO % sat.	158	103	112	5.4	65	62

Marbury Big Mere

Parameter	10-Apr-00 Surface	Bottom	17-Jul-00 Surface	Bottom	02-Oct-00 Surface	Bottom
Temperature °			18.6	12.1	14.5	
pH units			9.3	7.7	7.25	
Spec. Cond. µS/cm			447	597	489	
DO % sat.			165	5.8	50.5	

Tatton Mere

Parameter	11-Apr-00 Surface	Bottom	18-Jul-00 Surface	Bottom	04-Oct-00 Surface	Bottom
Temperature °	8.8	7.5	18.7	11.7	14.1	14
pH units	8.4	8.25	8.7	8	8	8
Spec. Cond. µS/cm	495	497	477	559	477	477
DO % sat.	98.1	77.9	124.7	5.4	73.7	68.4

Combermere

Parameter	10-Apr-00 Surface	Bottom	17-Jul-00 Surface	Bottom	02-Oct-00 Surface	Bottom
Temperature °			18	10.9	15	11.3
pH units			9.1	7.8	8.4	7.5
Spec. Cond. µS/cm			485	583	469	599
DO % sat.			123	5	83	4

Melchett Mere

Parameter	11-Apr-00 Surface	Bottom	18-Jul-00 Surface	Bottom	04-Oct-00 Surface	Bottom
Temperature °	9.1	7.1	17.8	11.9	13.9	9.9
pH units	7.9	7.8	8.2	7.3	7.8	7.5
Spec. Cond. µS/cm	435	439	431	513	436	582
DO % sat.	102.2	77.1	106.4	5.2	85.6	4.7

Table 2. Average readings in surface and bottom waters - April, July and October 2000

Stillwater	Date	Depth	Secchi m	Susp.Solids mg/l	Chlorophyll µg/l	Phaeophytin µg/l	Total P µg/l	ortho-P µg/l	Nitrite µg/l	Nitrate µg/l	Ammonia µg/l	Silicate µg/l
Hatchmere	10-Apr-00	surface	0.8	7.7	39.7	29.1		45	14.3	6087	51	3103
		bottom							13.9	6200	91	4463
	19-Jul-00	surface	1.1	12.7	47.5	33.3	54	1	27.4	2000	32	368
		bottom							29.4	2083	21	390
	03-Oct-00	surface	0.9	10.7	59.1		93	3	12.6	585	70	1117
		bottom						3	12.5	559	75	1133
Marbury Big Mere	10-Apr-00	surface	2.3					122	44.1	4773	46	323
		bottom						131	45.3	4743	96	390
	17-Jul-00	surface	0.4	46.7	112.8	84.7	206		1	3	7	1200
		bottom						424	17.4	314	1321	3663
	02-Oct-00	surface	1.2	8.7	35.8	25.8	359	322	42.7	520	713	3877
		bottom						393	44.2	474	1010	4127
Comber Mere	10-Apr-00	surface	1.8					74	10.3	1093	51	249
		bottom						81	1	1233	1010	955
	17-Jul-00	surface	1.3	13.3	35.5	26.6	84	9	1.6	3	6	416
		bottom						567	1.7	3	93	7730
	02-Oct-00	surface	1.5	12	52.5	32.8	190	152	9.9	131	119	2127
		bottom						853	5.8	59	1197	4823
Tabley Mere	11-Apr-00	surface	0.5	21	88			11	334	4247	39	300
		bottom						36	53	3480	646	307
	18-Jul-00	surface	1	13.3	110	14	291	102	226	1058	662	2227
		bottom						170	233	1018	596	3047
	04-Oct-00	surface	0.8	7.3	25	18	191	143	240	3927	302	6883
		bottom					189	142	149	4037	295	6720
Tatton Mere	11-Apr-00	surface	5.7	3	3.2	3.2		28	5	251	100	1073
		bottom						26	4.6	285	92	1163
	18-Jul-00	surface	1.6	5	18	3.3	68	68	3.3	3	237	4957
		bottom						85	2.4	3	371	6210
	04-Oct-00	surface	1.3	6	32.4	17.5	130	89	5.6	108	165	6347
		bottom						92	5.7	107	231	6547
Melchett Mere	11-Apr-00	surface	3.1	4	42	3.9		1	4.2	376	28	7120
		bottom						1	4.7	396	46	7587
	18-Jul-00	surface	2.6	4	7.9	1.7	16		1	3	5	3720
		bottom						1	2.2	6	234	7907
	04-Oct-00	surface	1.7	5	41	26.8	35	1	2.9	13	50	6743
		bottom						14	3.2	7	858	11667

Survey Conditions
The beginning of April was relatively warm. Melchett Mere, a relativly shallow mere, showed evidence that it was beginning to stratify but the deeper lakes, Tatton and Comber Mere, were still homogenuous. Mid July was hot and very sunny. Water temperatures increased to an average of 18 °C from April's average of 9°C. All meres showed some degree of stratification, during which bottom waters of the meres had low or no dissolved oxygen present. At the beginning of October ambient temperatures were beginning to cool and weather was very showery and windy (extreme heavy rain was to follow in November). Only Melchett and Comber Mere showed any evidence of stratification during October.

Seasonal Trends
In all the stillwaters, total phosphorus increased from July to October, although ortho-phosphate did not show a specific pattern. The expected seasonal trend would be for a decrease in phosphate concentration during summer months due to algal consumption. However, it must be noted that the meres surveyed in 1999 also showed an increase in phosphorus through the year, and it may come to be regarded as the 'norm'. Nitrate decreased over summer months due to algal consumption and increased (sometimes only slightly) again in October. This pattern was the expected seasonal trend.

Except for Hatch Mere and Melchett Mere, silicate increased throughout the year. Silicate follows a nearly one-way flow from rocks in the catchment to lake sediments, incorporating into diatom (algae) cell walls as an interim. The observed increase through the year indicated either more input from the catchment than sedimentation, and / or increased algal decay. Silica can be a limiting element for phytoplankton growth where diatoms are the predominant algae.

Site Details
HATCH MERE
- Stratification in July led to low oxygen conditions in the bottom waters (23 % sat.) and slight super-saturation in surface waters (110 % sat.). By October thermal stratification had broken down and dissolved oxygen levels were homogenous at 75% sat. through the water column.
- Chlorophyll a abundance was moderate all year, ranging from 40 to 60 µg/l. Correspondingly water clarity was low, with secchi disc readings only reaching to 1 m depth.
- Phosphorus levels were moderate. Nitrogen, present as nitrate, was high. Maximum levels of 6 000 µg/l NO^3 occurred in April, probably remnants of winter levels, and decreased through the rest of the year due to algal consumption. Although bottom water oxygen levels were low during stratification, ammonia levels remained moderate, indicating de-oxygenation had not occurred for long periods of time.
- Silicate levels were highest in April around 3 000 – 4 000 µg/l, indicating high run-off rates from the catchment.

MARBURY BIG MERE
- In July it appears that the thermocline layer was not sharply defined, lying from 1 m to 4 m depth. Above this, water temperature was 18 °C, dissolved oxygen was super-saturated to over 150 % sat and pH was high, averaging 9.3. Below the thermocline de-oxygenation occurred (6 % sat.).
- The high surface pH readings in July reflected the high productivity, with chlorophyll a

abundance recorded at a high of 112 µg/l.

- Unsurprisingly surface nitrogen levels were depleted in July due to algal consumption, and quite severely - to below the LoD. In October, once algal abundance had reduced due to nutrient exhaustion, nitrogen levels rose (500 µg/l No^3).
- Ammonia levels were very high in bottom waters during July and October, at 1 300 µg/l and 1 000 µg/l respectively. Due to low oxygen levels, formation of toxic ammonium hydroxide would directly cause stress to certain fish species.
- Silicate levels rose through the year from 300 to 3 000 µg/l.
- Water clarity was low during summer months and the water had a definite green hue to it. Not surprisingly, secchi disc readings were at a low of 0.4m depth in July since not only was chlorophyll abundance high, but also suspended solids were exceptionally high at 47 mg/l. However, water clarity was still low in October (1.3 m depth) when suspended solids and chlorophyll levels were much lower.

COMBER MERE

- During stratification (at 6 m depth) in July and October there were anoxic conditions in bottom waters (4 & 5 % sat.), high surface pH values (9.1 & 8.4) and super-saturation of surface waters (July only, 120 % sat.).
- Water clarity was low from spring to autumn, mean secchi disc transparency 1.5m. Suspended solids were not particularly high (13 mg/l).
- Chlorophyll a abundance increased between July and October from 35 to 50 µg/l, both high enough to cause poor water clarity.
- Levels of principle nutrients N and P decreased from April to July due to algal consumption, with nitrate levels near the LoD in both surface and bottom waters. Levels rose again in October, completing the expected seasonal pattern.
- It would appear that the thermocline was weaker in July than October. In July nitrate levels were similar in surface and bottom waters, suggesting mixing; and in July ammonia levels were lower (100 µg/l) than both April and October levels (1 000 µg/l), suggesting a shorter prevailing period of reducing conditions.

Comparison with 1999 data

In both years, during stratification there was severe oxygen depletion in the bottom waters. In 2000 surface ortho-phosphate values were much lower than 1999, yet bottom water values were much higher in 2000 than 1999. Nitrogen was higher in 1999 than 2000, except for ammonia when bottom values were higher during stratification in 2000. Silicate levels were much lower in 2000 than 1999 and secchi disc and chlorophyll a abundance were relatively similar in both years. From only 2 years' sampling it cannot be deduced if water quality has changed or not.

TABLEY MERE

- Tabley mere has a small, shallow bay into which the inlet feeds. In previous years this bay has had higher dissolved oxygen levels that the main body of the mere. Likewise, in April this year dissolved oxygen was super-saturated up to 200 % sat. (instrument limit), with the main body saturated to 100% sat. throughout the water column. In July there was a reversal with the bay recording 55 % sat. and the main body stratified to give readings of 150 % surface and 10 % sat. bottom waters. By October levels were more uniform, between 55 % and 65 % sat. throughout the mere.

- pH was very high in April and July in both surface and bottom waters, (between pH 8 and 9).
- This was reflected in the very high productivity, 90 µg/l and 110 µg/l chlorophyll a abundance. Such abundance would lead to a release of photo-synthetically produced oxygen, which would contribute to the excessive super-saturation of surface waters as seen in April and July.
- High chlorophyll a abundance and moderate suspended solids meant water clarity was low, secchi disc transparency between 0.5 and 1 m depth all year.
- Although the mere stratified in July, nutrient values in surface and bottom waters were very similar to the un-stratified values in April and October. This is not unusual as, at its deepest, the mere is only 4 m deep and wind-induced overturn would be common.
- Both N and P were present at high levels. Nitrogen, present primarily as nitrate, followed the expected seasonal pattern of decreasing during summer months: 4 000 µg/l (April) → 1 000 µg/l (July) → 4 000 µg/l (October). Ammonia was relatively high all year, between 300 µg/l and 600 µg/l.
- Silicate rose throughout the year, from 300 µg/l in April to a maximum of nearly 7 000 µg/l in October, indicating increasingly higher rates of input from the catchment through the year.

Comparison with 1999 data.

Both years saw excessive super-saturation of surface waters, coupled with high pH values. Overall, nutrient values were very similar in both years, with slightly higher readings in 1999. The only significant difference was the much higher chlorophyll a readings in April 1999 (200 µg/l) than 2000 (110 µg/l). Although it would appear there is no change in water quality, from only two years of data this is hard to deduce.

TATTON MERE

- Stratification was apparent in July, during which anoxic conditions prevailed in the bottom waters (5 % sat.) and super-saturation in the surface (125 % sat.).
- Chlorophyll a abundance was relatively low, increasing through-out the year from 3 µg/l to 32 µg/l. Secchi disc transparency corresponded well, decreasing in value from an average 5.7 m to 1.3 m depth.
- Principle nutrients were relatively low, total phosphorus ranged from about 30 µg/l to 130 µg/l and nitrate ranged from near the LoD during summer consumption to 285 µg/l. However, it must be noted that ammonia made a significant contribution to total N, ranging from 100 µg/l to nearly 400 µg/l through the year.
- Similar to other stillwaters, silcate increased through the year, from 1 000 to 6 000 µg/l.

MELCHETT MERE

- Melchett showed the first signs of stratification in April, with a strongly established thermocline in July, becoming weaker by October. During stratification bottom waters were anoxic (5 % sat.) although surface waters were not highly super-saturated (mean 104 % sat.)
- Between April and October, surface pH was significantly high, maximum 8.2 in July
- Chlorophyll a was lower in July (8 µg/l) than April and October (40 µg/l).
- This is reflected in the low nutrient abundance in surface waters in July (near / at the LoD), exhaustion of which led to algal die-off.
- As with Tatton Mere, principal nutrients were of relatively low concentration. Nitrate values

decreased from its post winter value of 400 µg/l (April) and had not recovered again by autumn. Again ammonia makes a significant contribution to total N, particularly in October (850 µg/l bottom waters).

- The very high silicate value of 11 700 µg/l in bottom waters in October would suggest a high rate of sedimentation.

OAK MERE

Continuous Monitoring

- Temperatures rose from a minimum of 3°C in January to a maximum of 22 °C at the end of July.
- Throughout the year dissolved oxygen in surface waters remained high. Super-saturation occurred intermittently from March to November, and reached over 110 % sat. on three occasions. This corresponded with chlorophyll abundance peaks, which would have provided photo-synthetically produced oxygen.
- pH in 2000 was extraordinary alkaline, with values ranging from 5.13. to 6.11, averaging 5.69.
- Nitrogen levels were particularly low between February and November, with many values at the LoD. The winter maximum reached 90 µg/l.
- Ortho-phosphorus levels remained low and stable all year, averaging 5 µg/l in surface waters and 17 µg/l in bottom waters. The two exceptions were the bottom waters in June and August when reducing conditions and stratification induced an increase in nutrient levels.
- Chlorophyll abundance showed the expected seasonal pattern in that there was a peak in April as the spring bloom occurred, a decline in summer from limited nutrient abundance, and then a second peak in October due to de-stratification releasing nutrients to the photic zone.
- Neither the suspended solids (maximum 8 mg/l) nor chlorophyll concentration can explain the low water clarity (1.8 m to 4 m depth).

Comparison with 1997, 1998 & 1999 data

The biggest change in 2000 compared with previous years is the increasing alkalinity in pH. pH averaged 5.69 compared to 4.6 from 1997, 1998 and 1999. Specific conductivity is also lower, averaging 78 µS/cm compared to 96 µS/cm in 1999. Such changes tie in with the rising water level, see below. This would give a *diluting* effect to the pH acidity and specific conductivity 'strength'.

Dissolved oxygen showed a similar pattern and value to previous years. Chlorophyll abundance did not reach the same maximums as in 1999, but yet again levels were atypically high in February (30 µg/l). In 2000 it appears the trend of decreasing levels of phosphorus continued, historical increasing silicate levels appear to have stabilised at 1999 levels, and nitrogen levels, including ammonia, continued the trend to decrease.

Water Level Data

Oak Mere is a surface manifestation of groundwater and experiences considerable variation in water level. Lowering of water levels over recent times appears to have reversed in the last two years. The Appendixed Graph shows the increasing water depth recorded at the buoy since 1997. The installed Hydrometry water level logger has recorded water level since 1998. 1998/9 saw

Table 3. Physico-chemical paramters and Nutrient levels in Oakmere, 1997 to 2000

Surface water physico-chemical parameters

Year	1997			%	1998			%	1999			%	2000			%
Parameter	Min	Max	Average	Coverage	Min	Max	Average	Coverage	Min	Max	Average	Coverage	Min	Max	Average	Coverage
Temperature °C	2.8	25.3	13	44	2.8	23.2	15	59	1.9	24.1	12.4	66	3.4	22.7	11.9	75
Specific cond. µS/cm	103	122	114	33	79	122	99	59	78	118	96	61	64	98	78	70
Dissolved Oxygen %	43	115	78	21	72	113	91	59	58	116	93	55	74	115	94	75
pH	4.3	4.9	4.6	44	4.2	4.8	4.5	58	4.3	5.1	4.6	63	5.13	6.11	5.69	70
Depth metres	0.5	1.4	1.2	36	0.4	1.2	0.8	59	0.4	1.1	0.8	56	0.02	1.4	0.7	70

Surface water nutrient levels

	1997			1998			1999			2000		
Parameter	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Secchi m										1.8	4	2.4
Chlorophyll a µg/l	2.8	17.5	9.7	4.3	15.4	8.1	3.1	48.5	14.9	3.8	34.4	14.8
Total P µg/l	45	86	61	37	54	47	23	69	48			
Ortho - P µg/l	27.2	71.7	44.8	28.1	47.8	37.3	1	37.2	15.7	1.0	16.6	5.4
Nitrate µg/l	3	241.3	121.5	3.7	429	117.5	3	201	61.2	2.5	89.7	14.9
Ammonia µg/l	18.8	63.7	45.9	13.8	119.7	66.4	5.2	119	30.8	4	201	30
Silicate µg/l	72	376	178	71	558	287	42	730	393	17	773	300
No. of samples taken	4			7			11			13		

Bottom water Nutrient levels

	1997			1998			1999			2000		
Parameter	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Total P µg/l	57	82	72	30	48	39	35	127	66			
Ortho-P µg/l	36.8	65.7	54.3	31.4	49.7	39.1	1	82	26.6	1	96	17.4
Nitrate µg/l	3.8	136.3	87	10.7	411.3	205.5	3	157	39.4	2.5	89	19.2
Ammonia µg/l	30.7	112.4	62.9	17.8	135.7	68.3	12.8	167	51.1	5	193	62
Silcate µg/l	73	149	111	150	327	229	352	671	481	1	745	342
No. of samples taken	3			3			6			13		

an overall rise of 0.7 m from Ordnance Datum. In 2000 the graphed data shows that water levels kept rising through the year to reach a water level nearly 1.3 m from Ordnance Datum. Water levels were quite stable at 1 m for the first half of the year, dropped slightly in September / October and then rose sharply in November so readings at the end of the year were 1.3 m. The inset graph shows water level data for the three years. There is an obvious overall increase in water level.

3. ALGAL AND ZOOPLANKTON RESULTS

PHYTOPLANKTON RESULTS

TABLEY MERE

Species diversity was greatest in the July samples with mainly green alga, diatoms and flagellates present. Loss of the green algae species in October can be attributed to seasonal fluctuations within the algal community. Blue-green algae were present in small numbers in samples taken in April and July but did not reach warning levels

COMBER MERE

The April samples were dominated by green algae and diatoms. Low numbers of blue-green algal species were present in the July and October samples. The greatest species diversity was recorded in July with the presence of blue-greens, dinoflagellates, green algae, diatoms and cryptomonads. A shift in dominance from green algae to dinoflagellates occurred in October.

MARBURY BIG MERE

Greatest species abundance and diversity occurred in July with 5 species of green algae, 5 species of blue-green algae and 6 different diatom species. High numbers of various blue-green algae were present in July and were dominated by *Oscillatoria agardhii.* (It is not known whether they exceeded threshold warning levels due to the way in which they were measured ie mm/ml rather than ml/l or colonies) *Oscillatoria agardhii* was also the only species, which was recorded in the October samples.

HATCH MERE

On all occasions the algal community was composed of planktonic green algae (Chlorophyceae) mainly *Scenedesmus quadricula*, and Diatoms (Bacillariophyceae). Limited numbers of the blue-green alga, *Oscillatoria agardhii* were found at one site in the April sample. Increased species diversity was recorded in July with the additional presence of dinoflagellates and cryptomonads but no major numbers of blue-greens were recorded until October. Algal numbers appeared to have changed little between July and October.

MELCHETT MERE

Limited species diversity and abundance was recorded in April samples with only 6 species in total recorded. Algal numbers and diversity greatly increased in July and were dominated by the planktonic green alga, *Chlorella vulgaris*. Dominance shifted to the diatom *Aulacoseira granulata* in the October sample and increased blue-green species diversity and abundance was noted.

TATTON MERE
In April the flora was dominated by the green alga *Chlorella vulgaris* but limited diversity was generally noted at all three sites. As with the other Meres sampled, diversity significantly increased in July with the presence of diatoms, green and blue-green algae, bean shaped flagellates and dinoflagellates. In the October samples, the blue-green alga *Aphanizomenon flos-aquae* and the diatom, *Aulacoseira granulata* co-dominated.

ZOOPLANKTON RESULTS

TABLEY MERE
Low numbers of zooplankton species were recorded in the April samples with the exception of numbers of *Cyclops sp* at site 3. Numbers recorded in July 2000 were extremely low and did not increase much in October, apart from the numbers of *Bosmina sp*. Site 2 had significantly higher numbers of zooplankton than the other two sites. It is possible that insufficient habitats are available to provide refuge for the zooplankton, hence the limited abundance recorded.

COMBER MERE
Species diversity was fairly uniform throughout 2000 at all sites. High numbers of *Daphnia sp* dominated the samples in April and July but abundance dropped again in October. The October samples were dominated by the calanoid, *Diaptomus sp*.

MARBURY BIG MERE
Low species abundance was recorded in the April samples with *Daphnia sp* dominating. Abundances dropped slightly in the July samples but then significantly increased in October. *Diaptomus sp* dominated in October but was closely followed by a dominance of *Daphnia sp*. The increase in abundance can be directly linked to the increased phytoplankton numbers present in July.

HATCH MERE
Limited species diversity and abundance was recorded in the April samples taken. This gradually increased over the summer and peaked in the Autumn, with a change in dominance from *Daphnia sp* in July to the rotifer, *Asplanchna sp* in October. The peak was probably due to the high abundances of the alga, *Rhodomonas minuta*, which is a valuable food source in the zooplankton community.

MELCHETT MERE
The zooplankton community recorded is relatively limited at Melchett Mere. It is possible that there are insufficient habitats available for the zooplankton and that the water quality limits the phytoplankton community, hence effecting the diversity of zooplankton present.

TATTON MERE
The zooplankton community consists of cladocera, cyclopods, calanoids and rotifers. Abundance and diversity is significantly reduced during July but then peaks again in October. Lower abundances were possibly due to the production of toxins from the blue-green algal species

present. Dominance changes over the year from daphniidae in April, to calanoids in July and then gastropodidae in October.

4. FISHERIES HYDROACOUSTIC SURVEYS

Summary

Fisheries hydroacoustic surveys of Tatton Mere and Combermere were conducted in July and August as part of the Agency's routine monitoring of selected Cheshire stillwaters. Single target volume densities and size-class structures were estimated for three ranges from the transducer in horizontal orientation. Density estimates generally decreased with distance from the transducer and target strength frequency histograms also differed between the ranges, with a gradual loss of the smaller targets as the range increased. These differences were probably the result of noisy conditions (planktonic reverberation) which effectively drowned out echoes from distant targets near the TS detection threshold (-50dB). Mean densities for 4 – 20m, 20 – 35m and 35 – 50m 'depth' ranges were 78.2, 28.8 and 6.4 fish.1000m^{-3} at Tatton Mere and 56.8, 6.1 and 1.2 fish.1000m^{-3} at Combermere for fish above the minimum size detectable. Detailed examination of the Combermere data indicated the range closest to the transducer best represented the fish stock structure and densities present. Very high fish densities, wide ranges of fish sizes and good distributions of targets throughout the surveyed areas indicate the lakes should be excellent venues for both recreational and match angling. Vertical surveys were also conducted for basic bathymetric information.

Methods

A Simrad EY500 portable echosounder, using V5 software, controlled by a Toshiba 1950CT p.c. was employed using a 4x10^0 120KHz split beam transducer, with a pulse duration of 0.3ms, from a 4m punt. The transducer was mounted from an angle-adjustable frame on the starboard side of the boat. The survey was conducted at speeds between 2 and 3km.h^{-1}, the boat being powered by an electric outboard. Data were captured and stored at 1 Mb intervals. Post-processing of data was carried out using the Simrad EP500 V5.4 echo processing system and the results were described as volume densities for single targets for three ranges from the transducer face; 4 – 20m, 20 –35m and 35 – 50m.

The survey plan was to conduct 1 vertical survey and 2 horizontal surveys in opposite directions of the transects shown in Figures 1a and b. This satisfied a minimum length criterion for monitoring fish populations in still waters, where L(min)=3 x √Area (as described by Aglen,1989). At Tatton Mere, the 2 horizontal surveys were repeated for additional information on small-scale temporal variability.

Site dimensions

Area of Tatton Mere = 31.7 Ha, L(min)= 1689 m, Survey Length (one run) = 1450 m. Full survey coverage (4 runs) = 5800 m = 10.3 *√Area.

Area of Combermere = 51.5 Ha, L(min)= 2153 m, Survey Length (one run) = 2437 m. Full survey coverage (2 runs) = 4874 m = 6.79 *√Area.

Figure 1. Survey plans showing waypoints and transects.

a) Tatton Mere

b) Combermere

Table 1: Survey waypoints:

Way point No.	1	2	3	4	5	6	7	8	9	10
Tatton Mere NGR (SJ)	7548 8065	7559 8059	7544 8044	7562 8023	7544 7988	7565 7976	7558 7958			
Combermere NGR (SJ)	5833 4418	5865 4420	5848 4443	5882 4445	5888 4473	5912 4457	5917 4484	5929 4463	5947 4466	5952 4444

Survey conditions

24th July 2000: Tatton Mere was surveyed when the moon phase was at full-moon –7 with 8/8 cloud cover. At the start of the survey, air and water temperatures were respectively 16 °C and 18.5°C and wind was light / variable.

8th August 2000: Combermere was surveyed at new-moon –7 with 0/8 cloud cover. Air and water temperatures were 17.5 °C and 20 °C and wind was also light / variable.

For both surveys, conditions were generally considered very good for hydroacoustic surveying.

RESULTS

1) Density Estimates

The 1Mb files from the horizontal surveys were merged and analysed in subsets of 600 pings. This approach helps to standardise the sampling unit on which a mean estimate can be based. It also increases the number of sub-samples and thus the precision of the mean estimate, as opposed to using fewer 1Mb files.

a) Tatton Mere

In general the mere was clear of obstructions, although thick stands of submerged macrophytes limited boat movement at the margins and sailing buoys appeared as targets on the central transects. Some echograms exhibited a lot of noise, particularly the files collected from the deep water areas, suggesting interference from plankton. 20 files were collected from each of the paired horizontal surveys and a total of 23 and 26 subsets were analysed for three ranges from the transducer (results summarised in Appendix 1:Tables 2a and b). For the first pair of horizontal surveys, mean volume density for single targets above the minimum size detectable (TS detection threshold of -50db) computed to 78.23 +/- 18.38, 28.84 +/- 7.29 and 6.44 +/- 2.45 fish.1000 m^{-3} (+/-95% CI) for 4 – 20m, 20 –35m and 35 – 50m ranges respectively. The second pair of surveys generated similar density estimates from the shortest range analysed (77.63 +/- 15.79) but lower estimates from the more distant ranges (16.63 +/- 4.11 and 2.03 +/- 0.55).

b) Combermere

Combermere was clear of significant obstructions other than slalom buoys near transects 6-7, 7-8 and 8-9. However, echograms were very noisy as a result of reverberation from plankton. 35 files were collected from the horizontal survey resulting in 42 subsets analysed (Appendix 1:Table 3). Mean volume densities (fish.1000 m^{-3} +/-95% CI) were calculated to be 56.83 +/- 6.91, 6.12 +/- 0.7 and 1.22 +/- 0.19 for 4 – 20m, 20 –35m and 35 – 50m ranges respectively.

2) Size class distribution

Figure 3 presents target strength distributions of returning echoes obtained from horizontal surveys of the two lakes.

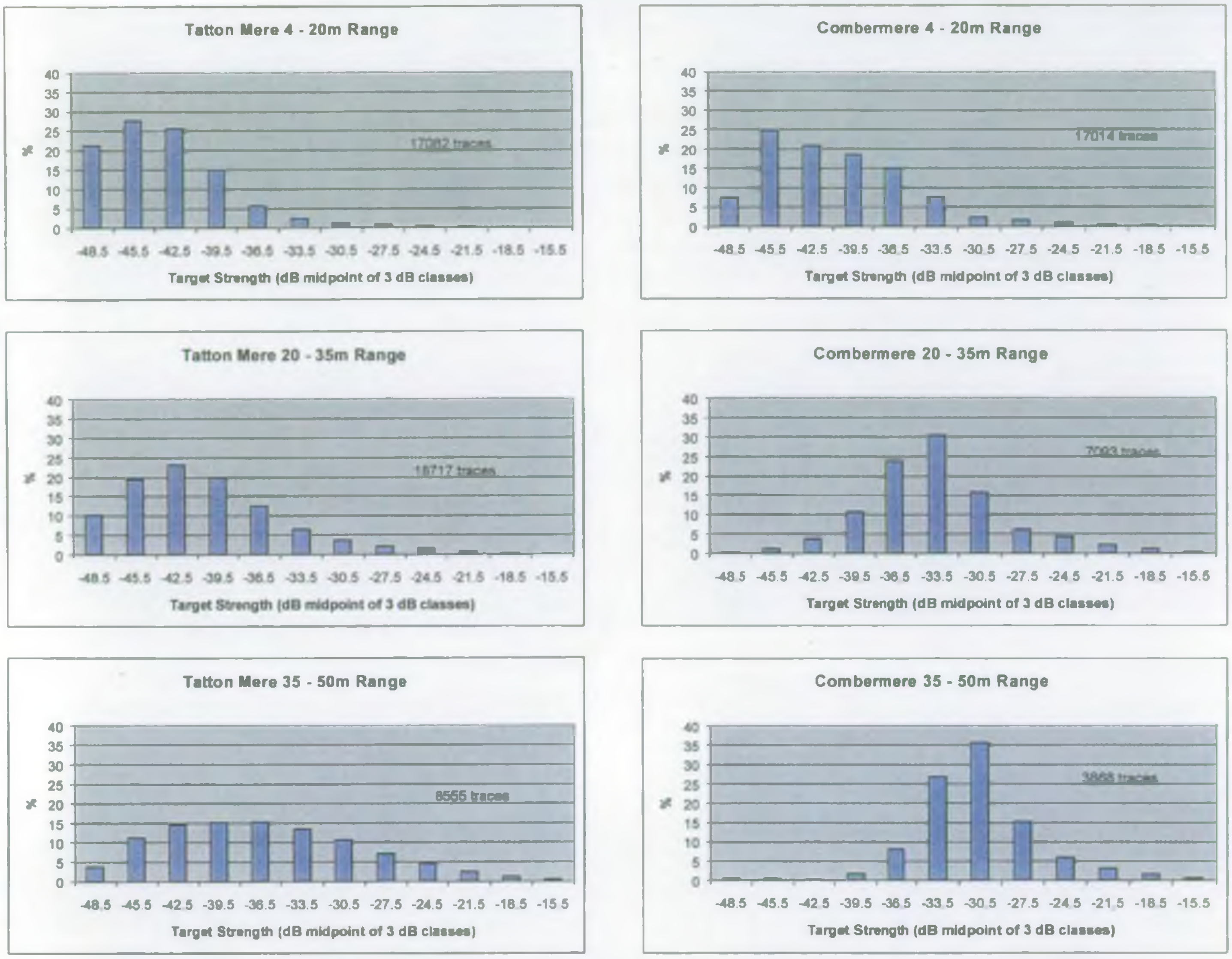


Figure 3(above): Percentage Distribution of Traces by Acoustic Size for 3 Ranges from the Transducer.

a) Tatton Mere (1st Horiz. Run) **b) Combermere**

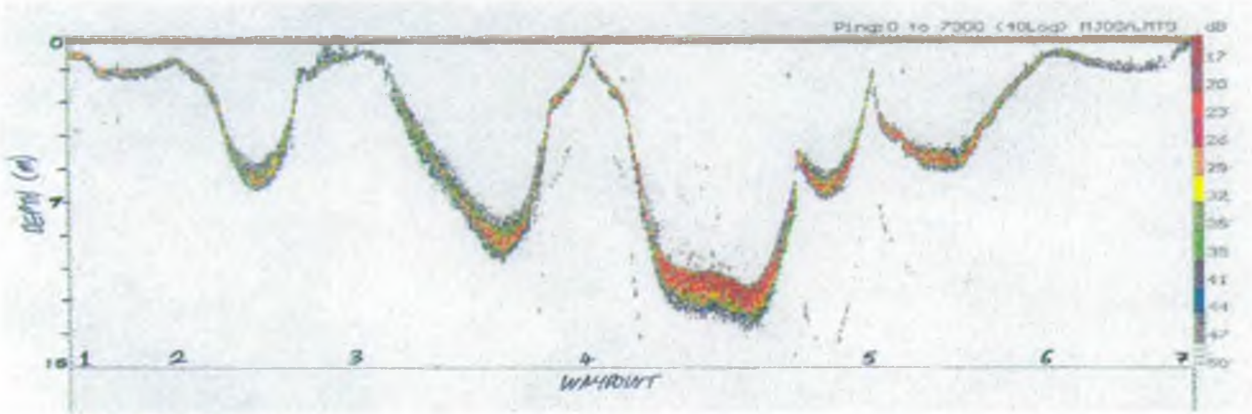
For both meres, there was a gradual loss of the smallest traces (-47 to –50 dB) and a corresponding increase in the relative frequency of larger traces (-33 to –44 dB) as distance from the transducer increased. Using the relationship between target strength (TS) and fish length-class in Appendix 2, 74.5% of all single traces in the 4 - 20m range at Tatton gave acoustic sizes of between –50 and –41dB, which approximate to fork lengths between 8.5 cm and 15.8 cm. The corresponding value at Combermere was 53%. The maximum acoustic size presented in the histogram (-14dB) is equivalent to a fork length in excess of 2m, however this may be attributed to two or more targets at exactly the same range or non-fish targets such as sunken branches or buoys.

3) Spatial distribution of targets

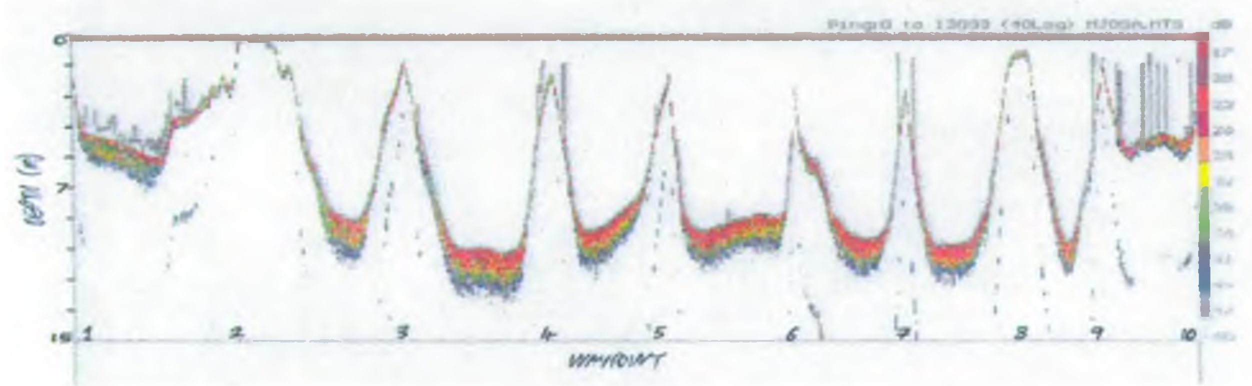
Although large differences in volume densities were identified between the 600 ping subsets, fish were distributed throughout the surveyed areas. The highest concentrations of targets were found on transect 3-4 at Combermere (> 100 fish.1000 m^{-3}) and transects 3-4 and 4-5 at Tatton (>130 fish.1000 m^{-3}).

4) Vertical surveys
The echograms created from the merged vertical survey files are presented in Figures 4a and b, giving basic bathymetric information on the survey areas. As the depths of both stillwaters were < 15m, fish density estimates were not calculated from the vertical survey data.

Figure 4: Vertical profile of survey area showing waypoints
a) Tatton Mere



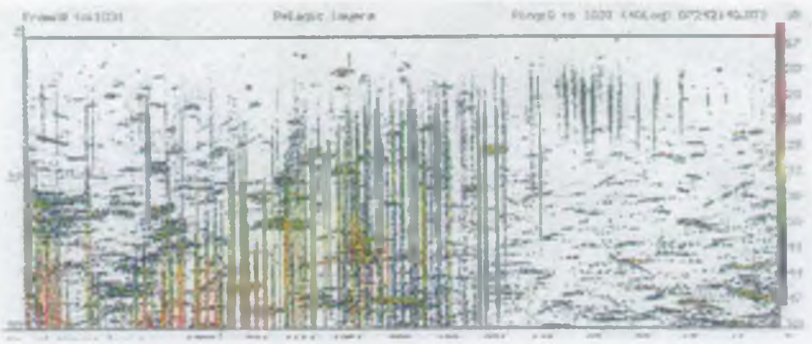
b) Combermere



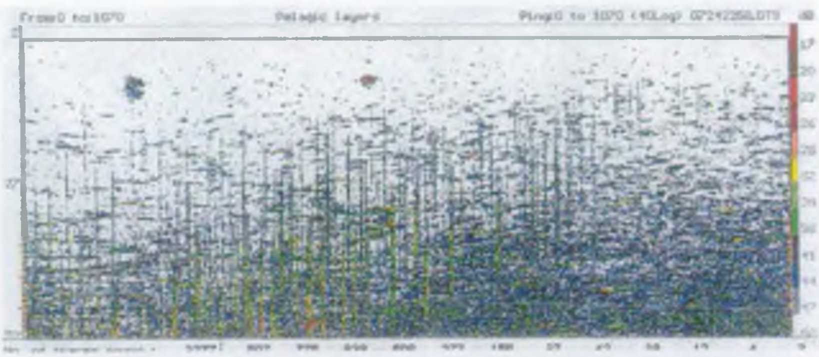
Discussion
When surveying in shallow waters, horizontal side scanning samples a larger volume of water than vertical sounding. Avoidance by fish is assumed less, given the greater ranges in sounding, and more fish targets are detected. In general, the most reliable estimates of fish abundance from hydroacoustic surveying are those made for single targets. Multiple fish targets occur when there are concentrations of fish that may be too close together to be resolved and counted as individuals. Outputs obtained from single targets will generally result in minimum estimates of fish density, whereas outputs from multiple (shoaling) targets may overestimate abundance.

Figure5: Partial echograms of transect 5-4 at Tatton.

a) 21:40



b) 22:58



The horizontal echograms from both lakes, but Combermere in particular, suffered from considerable noise interference. Two sample echograms in Figures 5a and b were recorded on different runs of the same transect and illustrate the increase in ambient noise (grey/blue shading) during the elapsed 80 minutes. These noise patterns were consistent with wind induced aeration of the water's surface or more probably, as conditions were still, reverberation from plankton migrating vertically. This noise can obscure the smaller echoes distant from the transducer, thereby reducing trace density estimates and biasing size structure estimates from the longer ranges.

The effect was clearly seen at Combermere, with single target density estimates (fish.1000m^{-3}) declining from 56.8 at 4 – 20m range to 6.1 at 20 – 35m and 1.2 at 35 – 50m. Similarly, acoustic size distributions varied by range, with higher observed mean target strengths recorded at ranges distant from the transducer (Figure 3). Although the 4 – 20m range gave higher density estimates, many of the larger targets may have been missed as a result of boat avoidance and the small volume sampled. Graphing the number of traces detected by acoustic size class for each range did result in more of the larger targets (e.g. > -30.5dB) being identified in the longer ranges (Figure 6). However, when the volume sampled was taken into consideration, the 4 – 20m range still produced higher volume densities for these large targets (Figure 7). It is therefore assumed that the range closest to the transducer best represented the fish community of Combermere in terms of densities and size-structure.

Figure 6: Number of single traces detected by acoustic size class for 3 ranges from the transducer – Combermere.

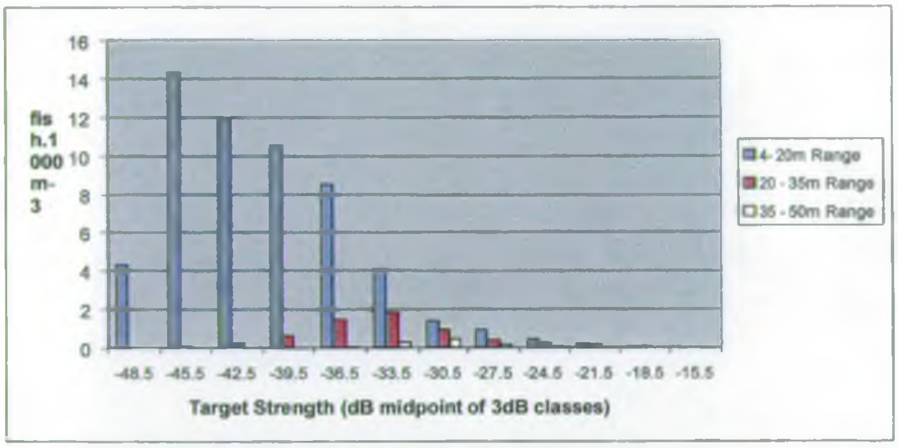
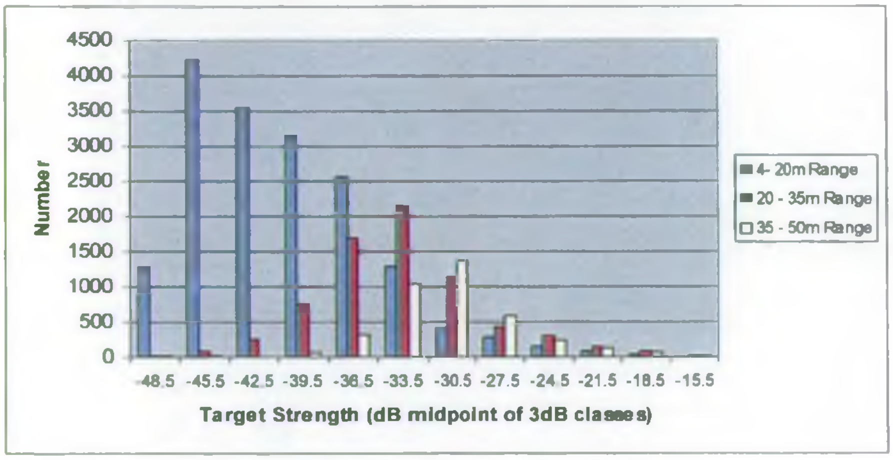


Figure 7: Mean volume density by acoustic size class for 3 ranges from the transducer – Combermere.



The densities of single targets in Tatton Mere and Combermere relative to comparable stillwater estimates are shown in Table 4.

Table 4: Fish density estimates from North West stillwaters.

Site	Time	Mean density of single targets (fish.1000m^{-3})
Tatton Mere	*Night*	*78.2, 28.8, 6.4*
Combermere	*Night*	*56.8, 6.1, 1.2*
Rivington Reservoir	Night	15.9
Horrock's Flash	Night	20.59
Rainford's Flash	Night	7.68
Turner's Flash	Night	14.36
Scotman's Flash	Night	8.67
Marley Tiles Lagoon	Night	6.23
Hurlestone Reservoir	Night	10.16
Pennington Flash	Night	12.74
Grimsargh	Night	7.89
Heesom's Pool	Night	8.05
Hatchmere	Night	1.58
Coniston	Night	5.30
Ennerdale	Night	3.70

Single target densities in Tatton Mere and Combermere were very high compared with other North West stillwaters. Actual densities were probably even higher as both lakes support significant populations of bottom-feeding fish (Tatton – carp, tench and bream. Combermere – bream) which inhabit the acoustic dead-zone of waters (Lyons, 1998). Recent angling matches support the acoustic results, with healthy winning weights in the region of 15 – 25 lbs. at Tatton (Simon Jones, Pers. Comm.) and up to 88 lbs. at Combermere (Wayne Moores, Pers. Comm.). Some 'clumping' of targets occurred as densities by transect varied by factors of approximately 3 at Combermere to 5 at Tatton. However even the lowest densities recorded would probably provide satisfactory recreational angling opportunities. The Combermere density estimates appear to contradict a presumptive assessment of the fishery conducted in 1994 which concluded the lake had a 'probable low fish stock' based on modest phytoplankton crops (English Nature, 1998).

The distribution of acoustic traces from the 4 – 20m range appear to indicate normal size-class structures, with a moderately high proportion (Tatton 75%, Combermere 53%) of small fish < 16.0 cm in length indicating successful recent spawning and recruitment. Neither water has been stocked in recent years and large numbers of juveniles and fry were seen during the course of the survey, particularly at Combermere. The largest targets on the echograms (> -17 dB) corresponded to fork lengths in excess of 200 cm. However, it should be noted that the size distribution information only provides a rough indication of fish sizes in stillwaters due to an absence of data on fish aspects (i.e. the angle at which the fish is presented to the acoustic beam). In addition, the software cannot discriminate between acoustic returns from fish and non-fish targets.

Conclusions

Both Tatton Mere and Combermere were well suited to hydroacoustic survey methods in terms of depth and access. However, high ambient noise levels, probably caused by dense plankton shoals affected density and size-structure estimates from horizontal surveys. The impact of this reverberation was therefore limited by restricting analyses to a small range near to the transducer. Very high fish densities, wide ranges of fish sizes and good distributions of targets throughout the surveyed areas indicate the lakes should be excellent venues for both recreational and match angling.

References

Aglen, A. 1989. Reliability of acoustic fish abundance estimates. *Dr. Scient. Thesis. Dept. of fisheries biology. University of Bergen, Norway*

Duncan, A. and J Kubecka, 1995. Acoustic size versus real size relationships for common species of fish. *National Rivers Authority R&D Note 374.* 17 pp.

English Nature, 1998. Lake SSSIs subject to eutrophication – an environmental audit.

Lyons, J. 1998. A hydroacoustic assessment of fish stocks in the River Trent, England. *Fisheries Research 35: 83 – 90.*

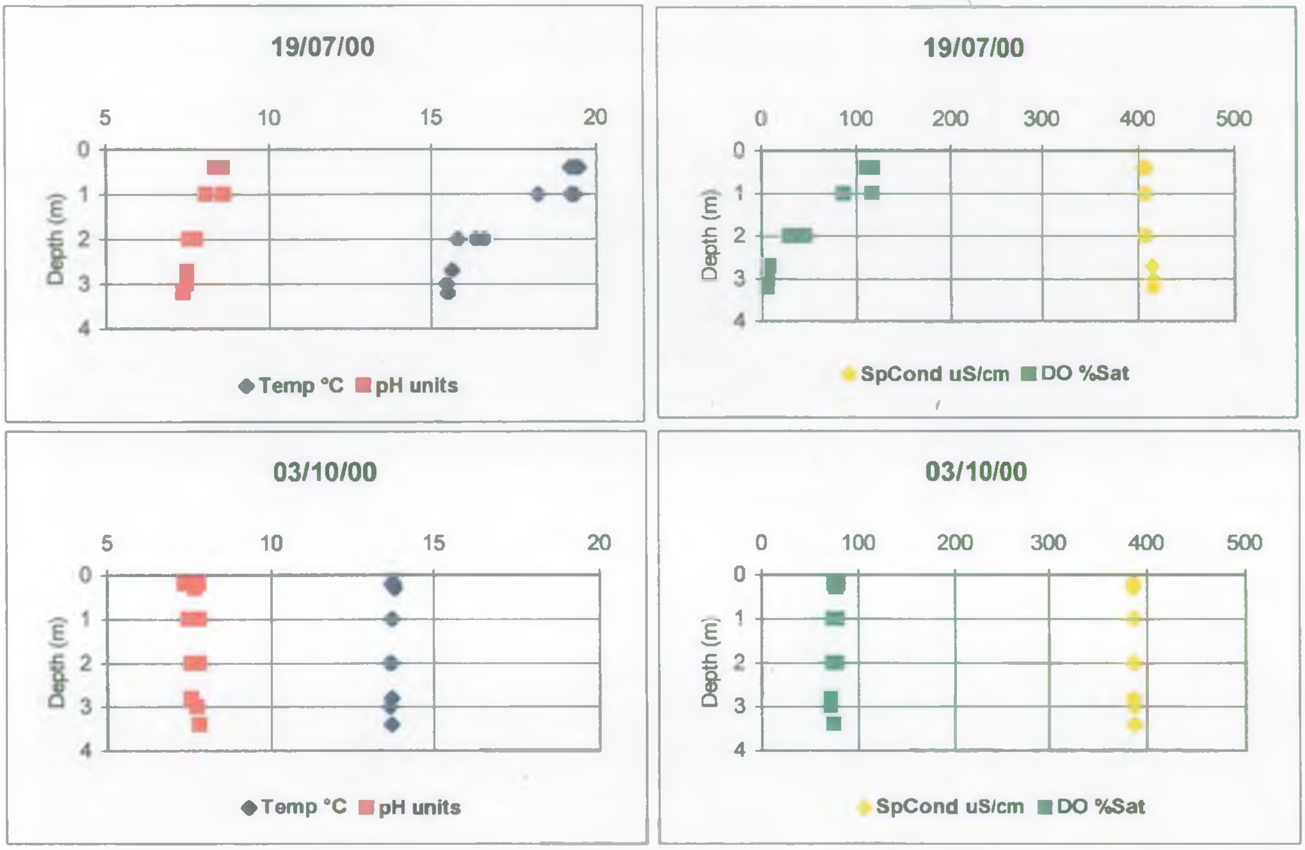
5. DISCUSSION

- 2000 water quality data classified the trophic status of Marbury Big Mere and Tabley Mere as hyper-eutrophic; Hatch Mere, Comber Mere and Tatton Mere as eutrophic and Melchett Mere as meso-eutrophic.
- The nutrient requirements of plankton are approximately in the ratio of 15:1 phosphorus to nitrogen (Redfield ratio). If the ratio is less than 15:1 there is more nitrogen present and phosphorus becomes the growth-limiting factor. Greater than 15:1 and nitrogen is deficient and becomes the growth-limiting factor. In freshwaters, phosphorus is the growth-limiting factor.
- Based on the Redfield ratio, and using an average from July and October data (there is no April Total P), all the stillwaters except Tabley Mere had ratios of less than 15:1.
- The decrease in levels of nitrogen below the summer phosphorus levels and only a nominal rise in autumn meant nitrogen became the growth - limiting factor for phytoplankton during summer and autumn.
- In 2000 Oak Mere was classified as eutrophic, an increase from the meso-eutrophic status of 1999. The N:P ratio was not calculated because Total Phosphorus was not recorded by the Laboratory.
- Blue green algae was present in all meres, with 5 species present in Marbury Big Mere.

- The design of the Stillwaters Sampling Programme will change in 2001. All meres (14 in total) will be sampled annually in February to record winter high nutrient levels. It is proposed that, along with Oak Mere, Bar Mere (SJ 53762 47959) will have a continuous monitoring programme. This is to coincide with FWAG / Ecology work in the catchment.

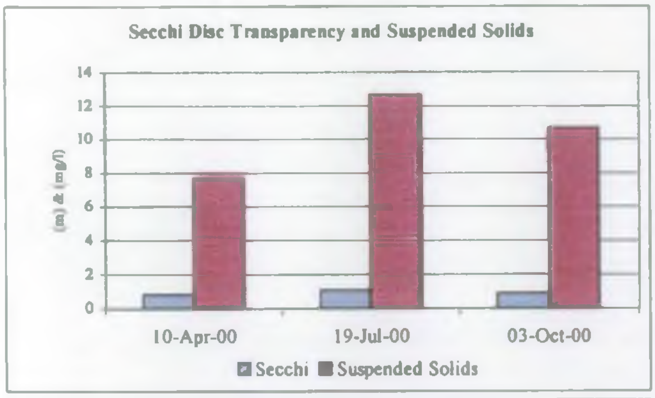
PHYSICO-CHEMICAL PROFILE READINGS, 2000

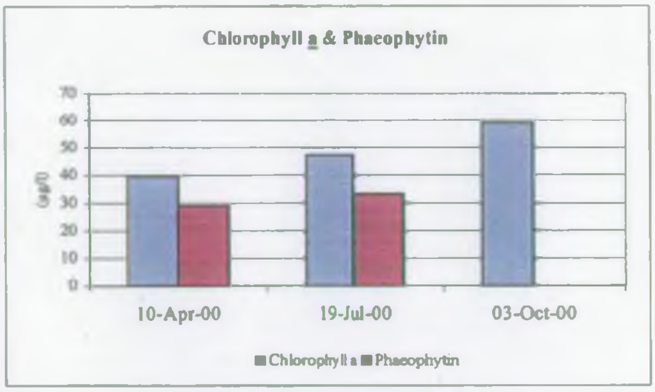
HATCHMERE

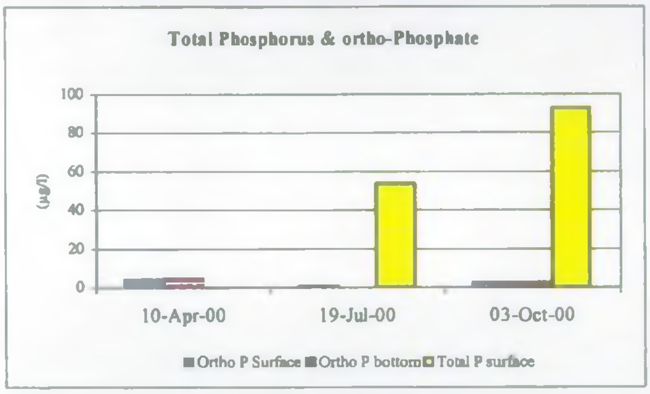


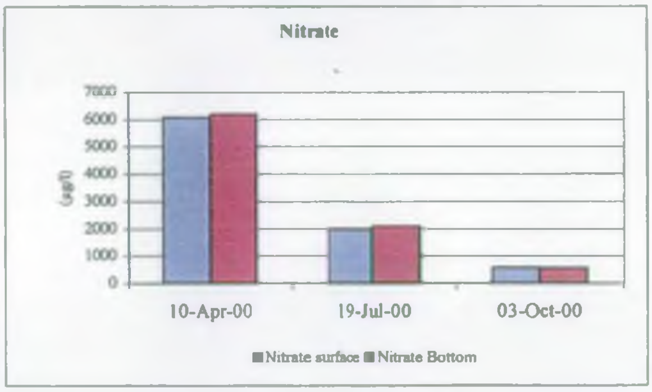
Nutrient Readings, 2000

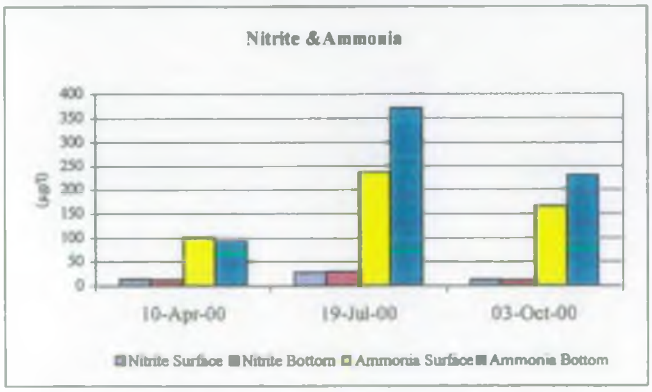
HATCHMERE

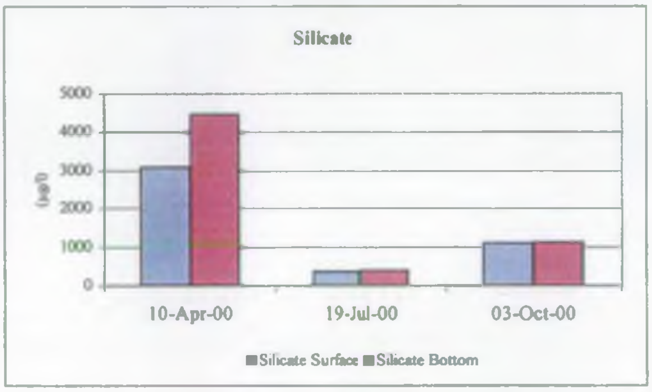






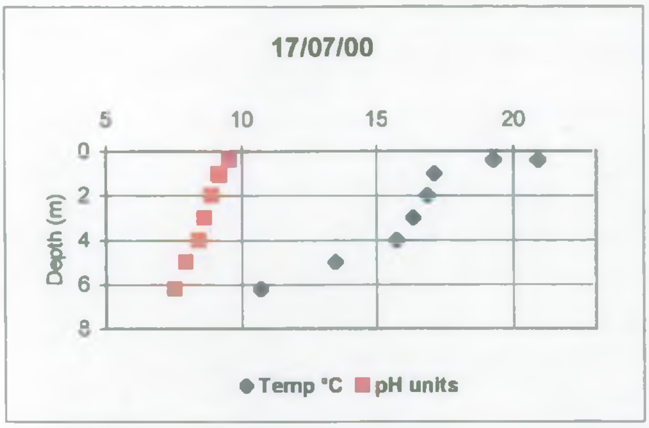


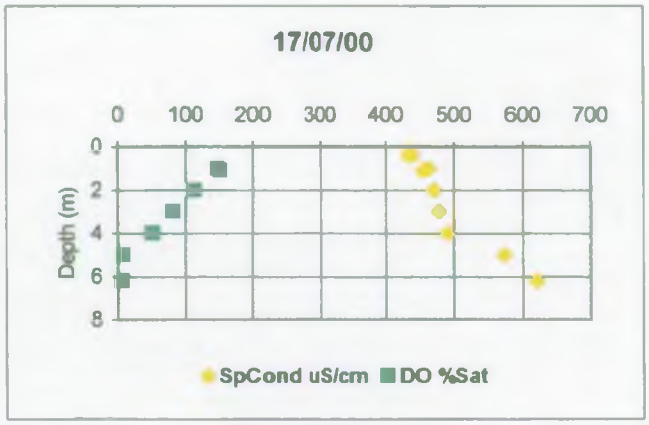


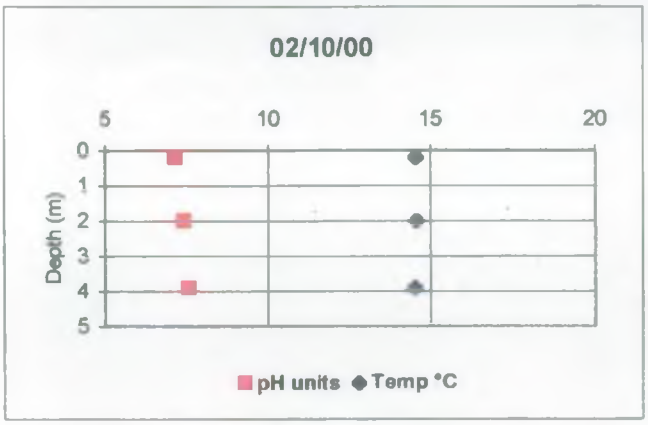


PHYSICO-CHEMICAL PROFILE READINGS, 2000

MARBURY BIG MERE

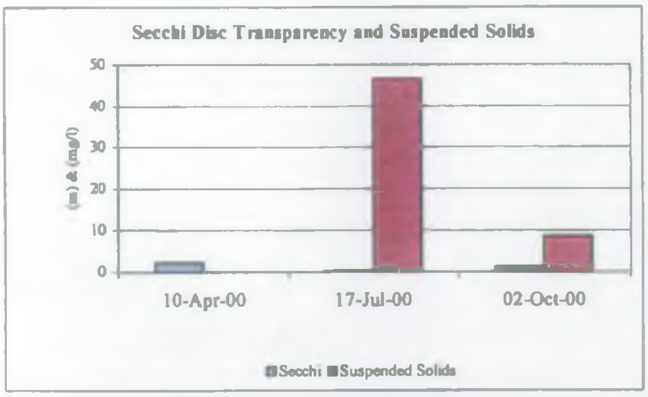


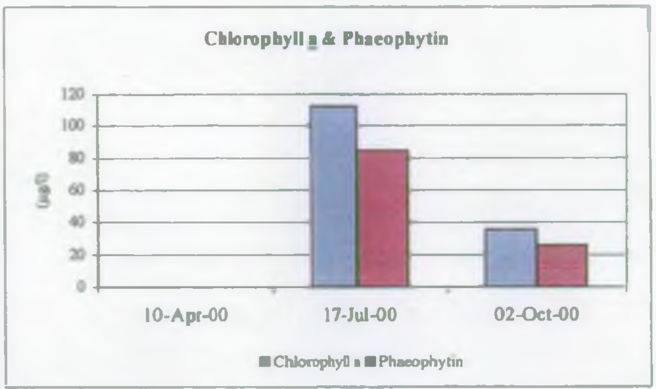


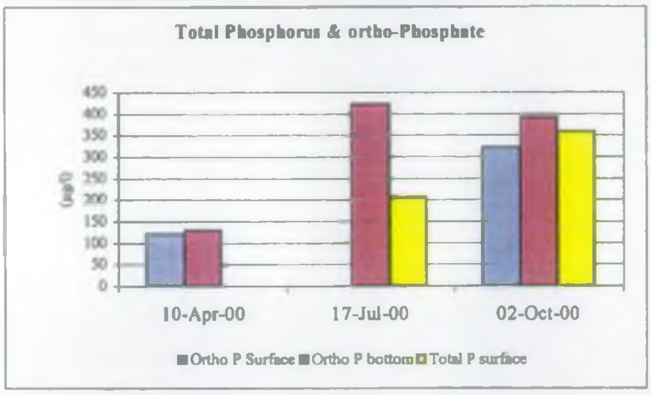


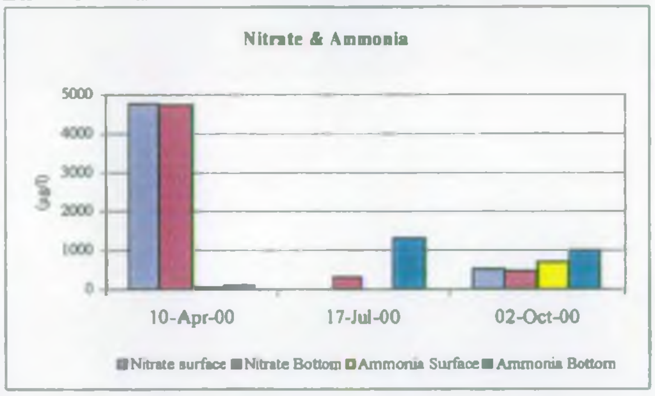
Nutrient Readings, 2000

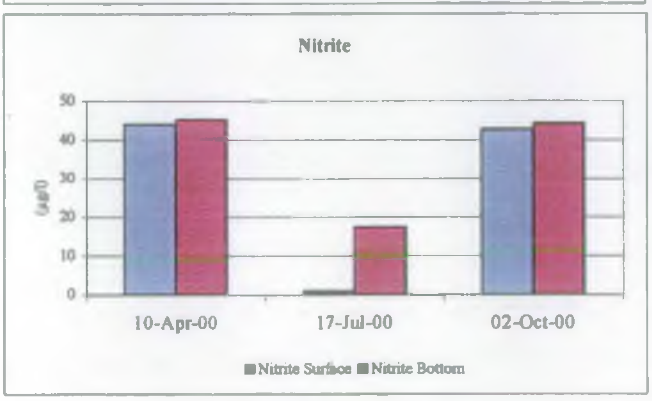
MARBURY BIG MERE

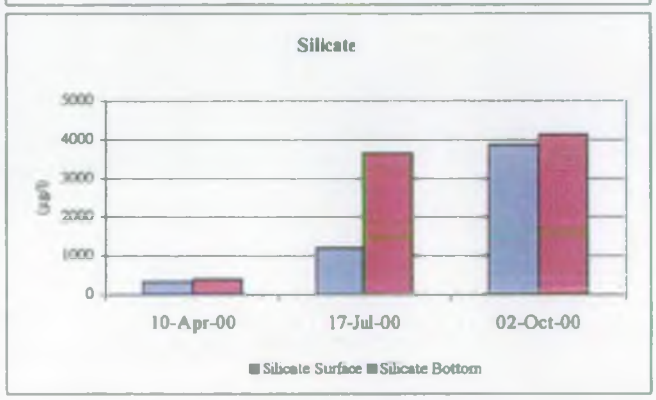






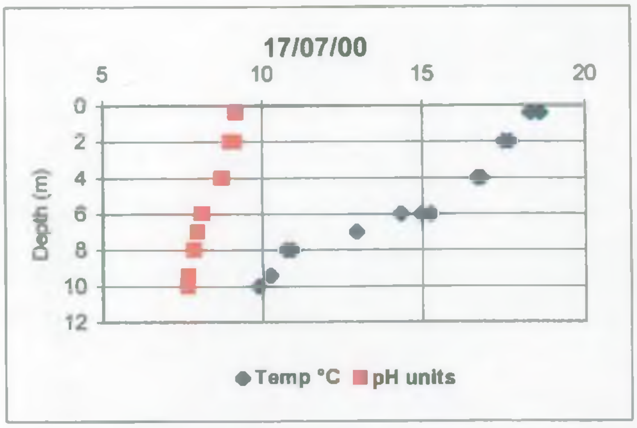


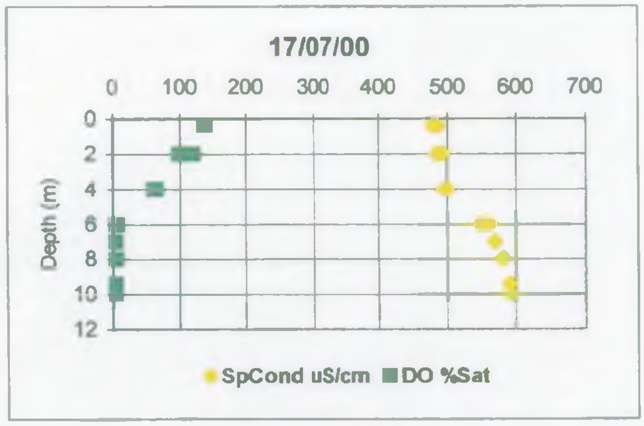


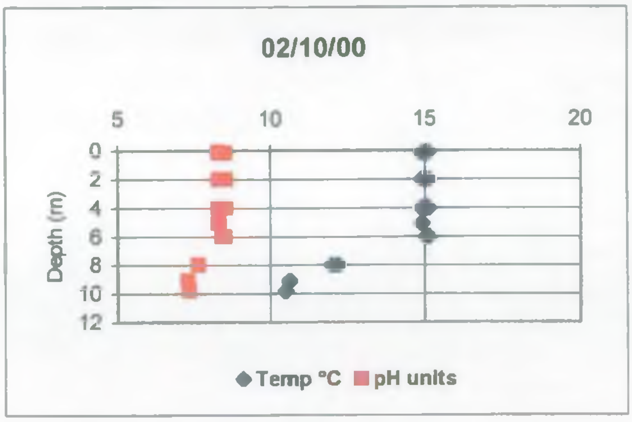


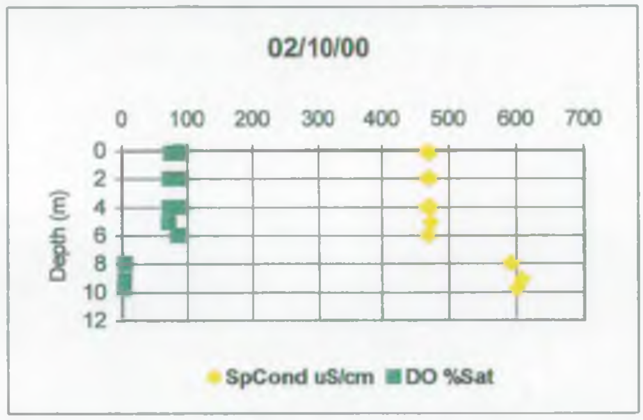
PHYSICO-CHEMICAL PROFILE READINGS, 2000

COMBERMERE



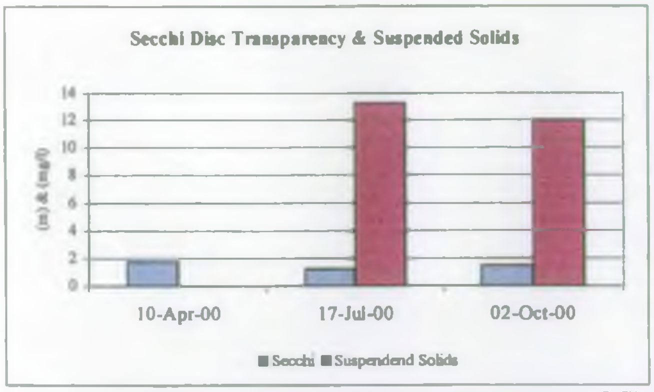


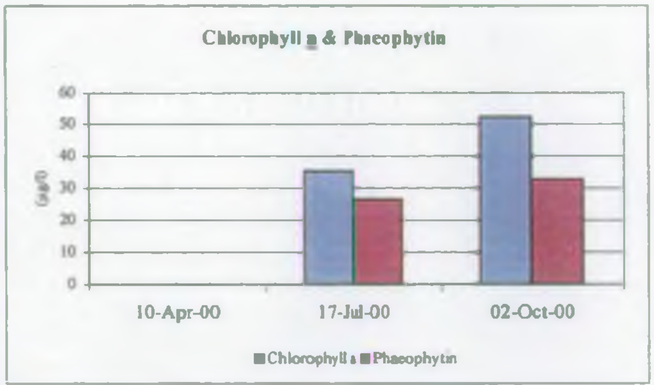


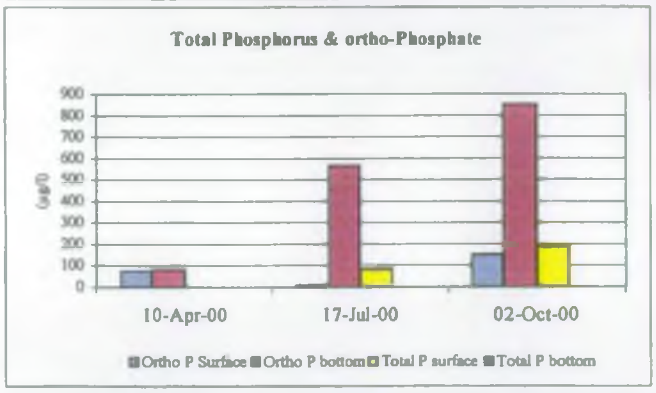


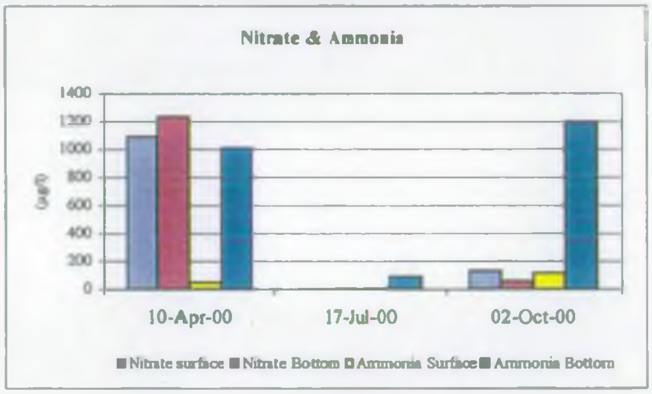
Nutrient Readings, 2000

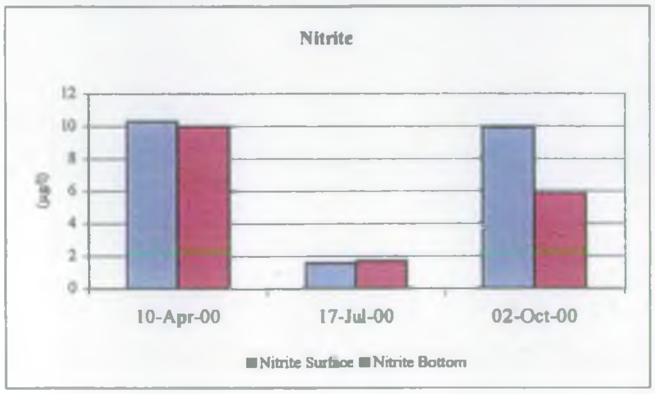
COMBERMERE

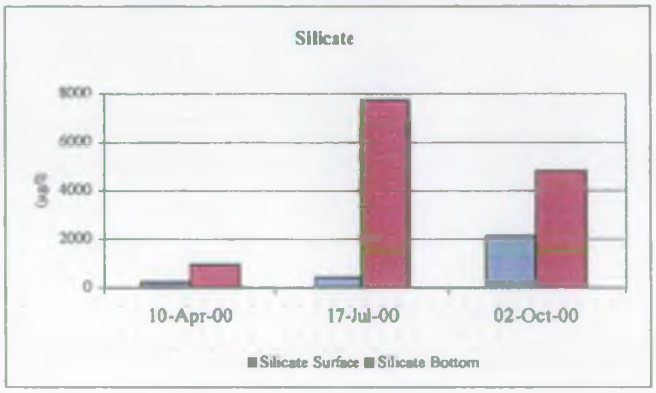






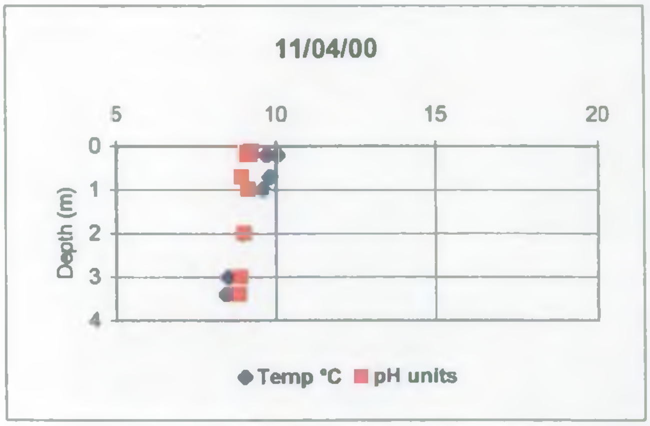


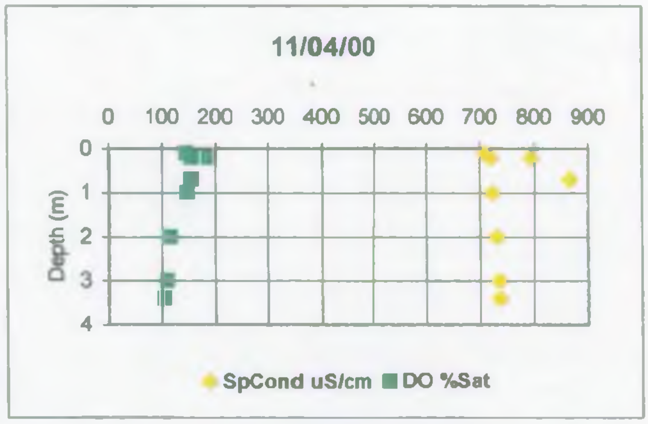


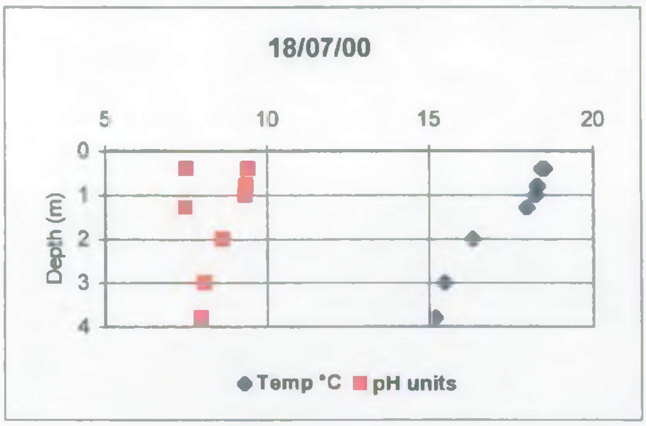


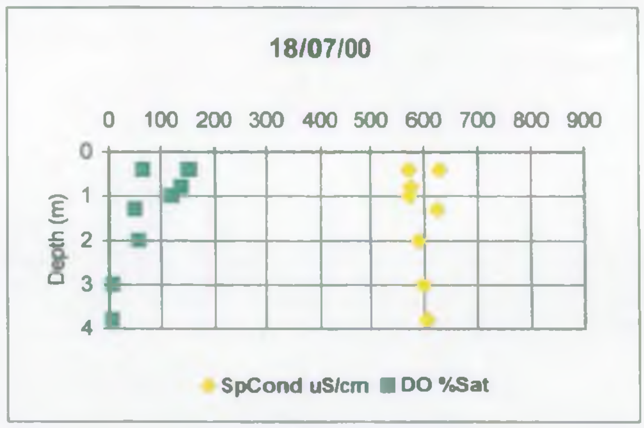
PHYSICO-CHEMICAL PROFILE READINGS, 2000

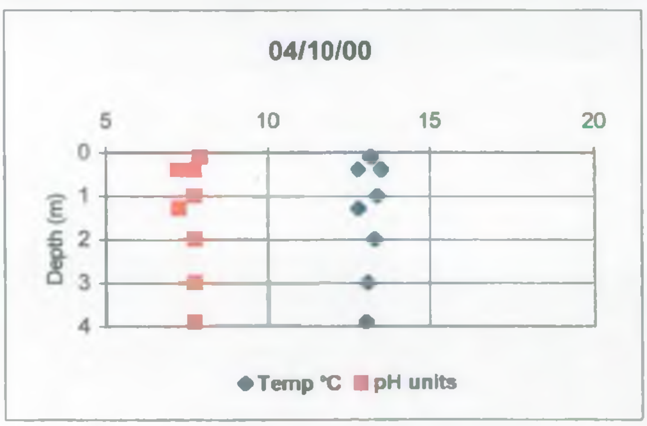
TABLEY MERE

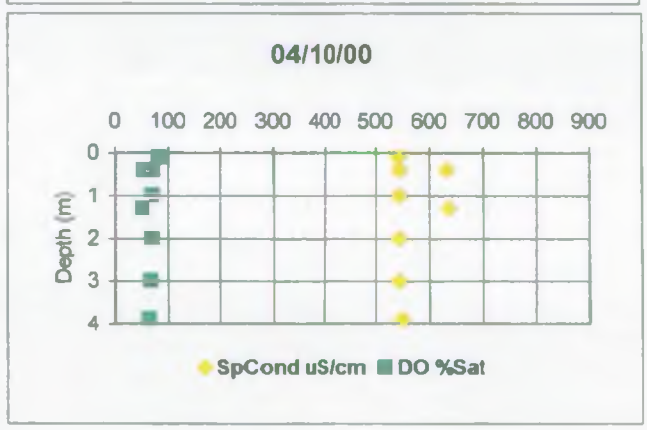






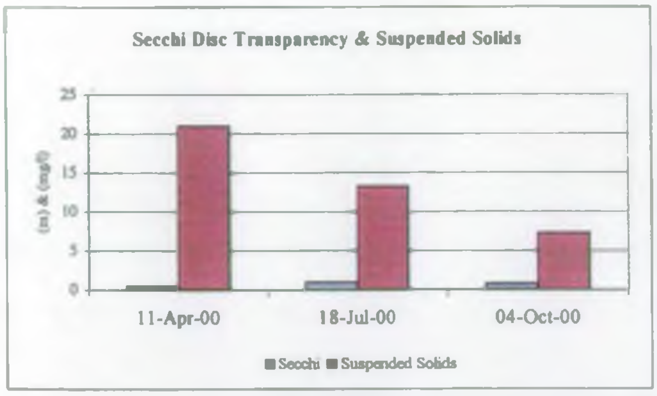


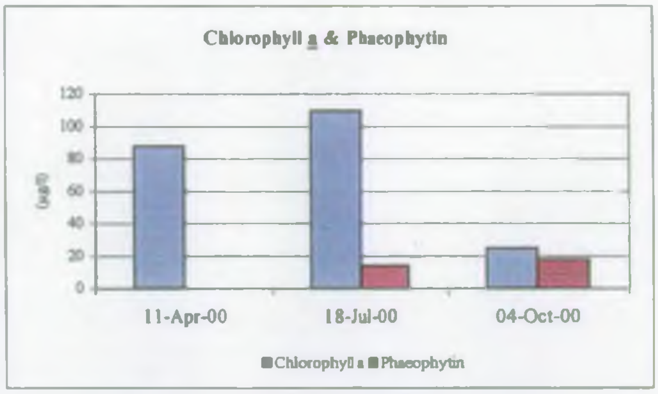


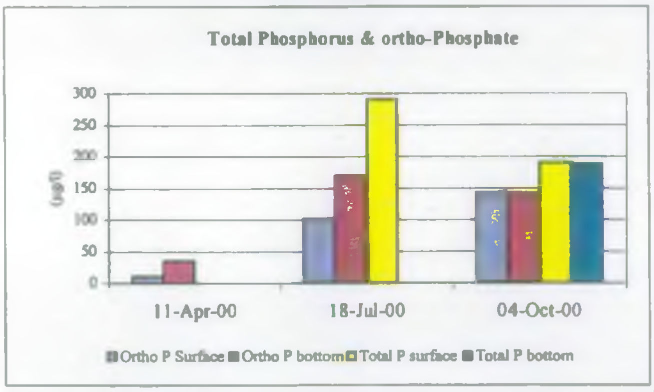


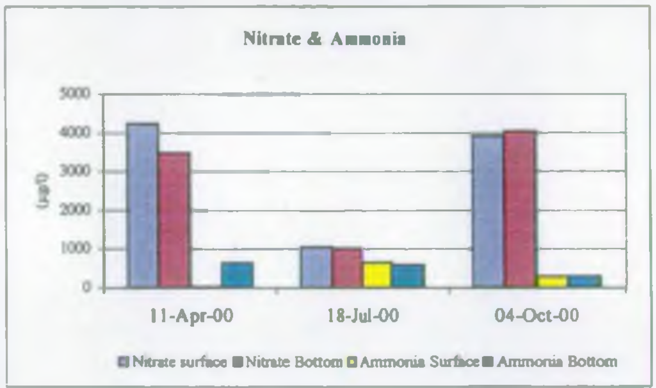
Nutrient Readings, 2000

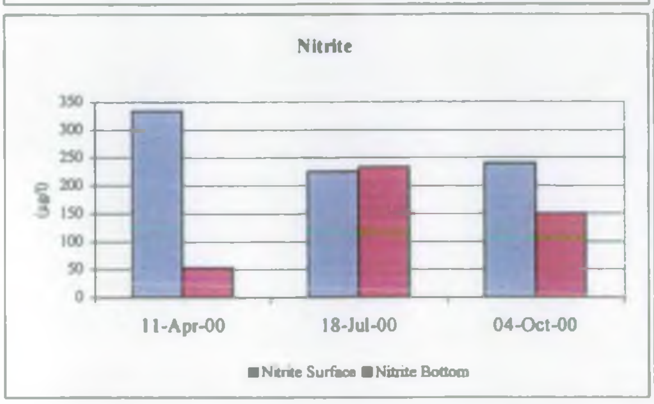
TABLEY MERE

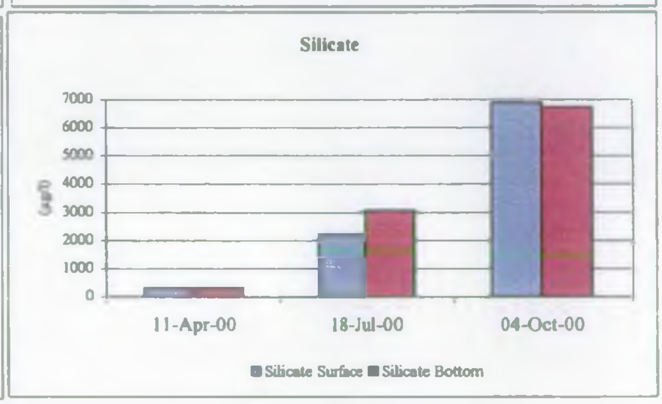






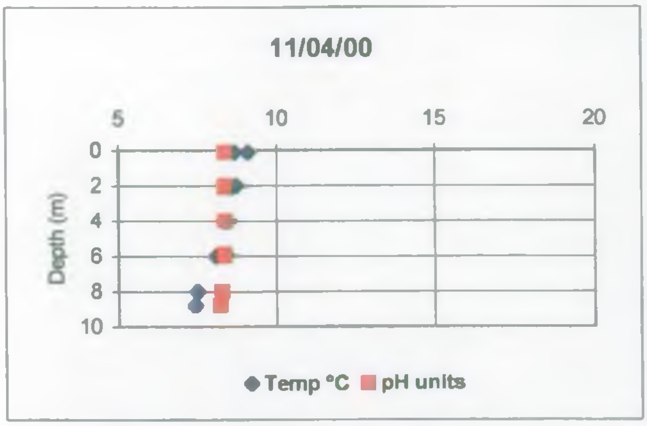


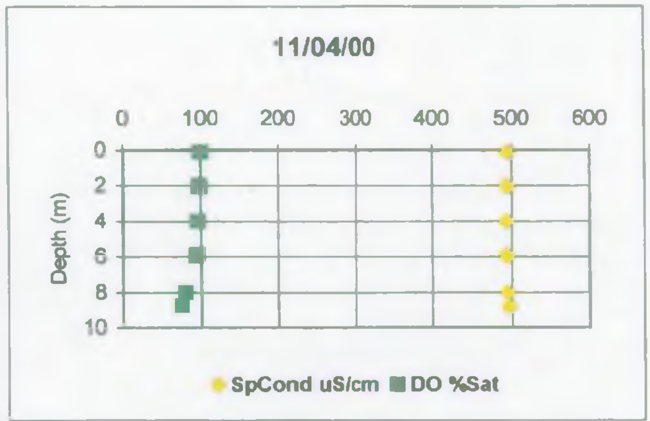


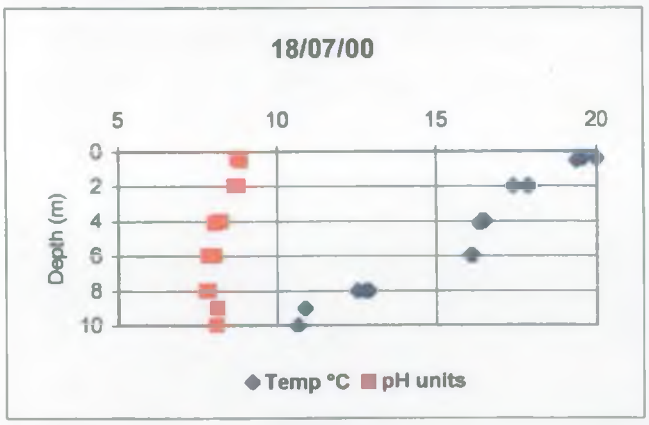


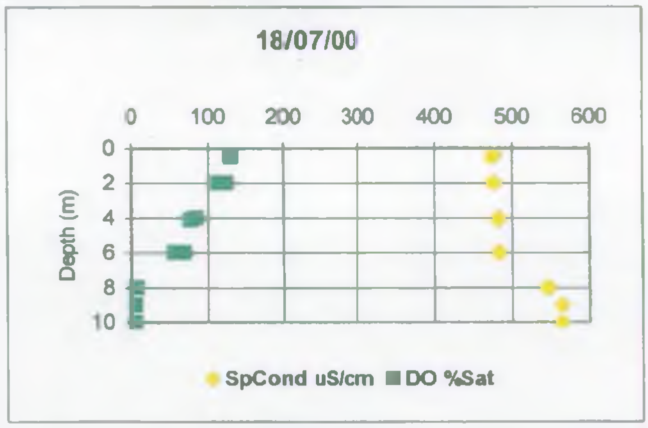
PHYSICO-CHEMICAL PROFILE READINGS, 2000

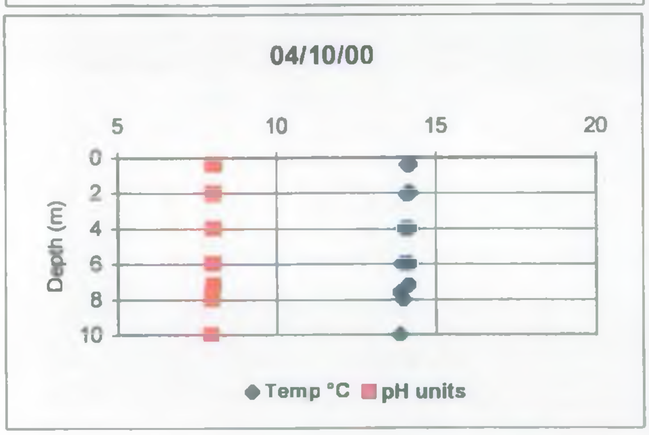
TATTON MERE

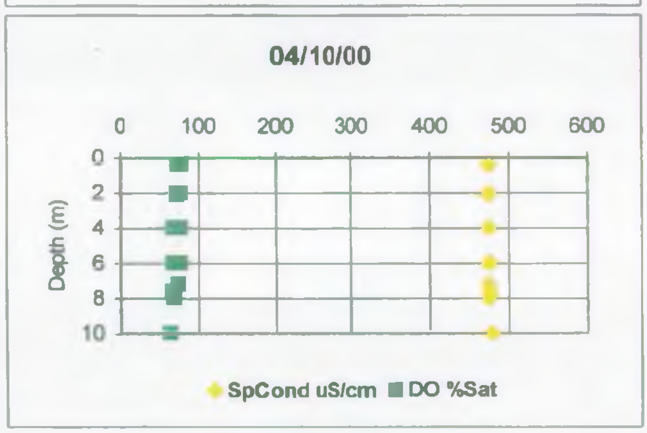






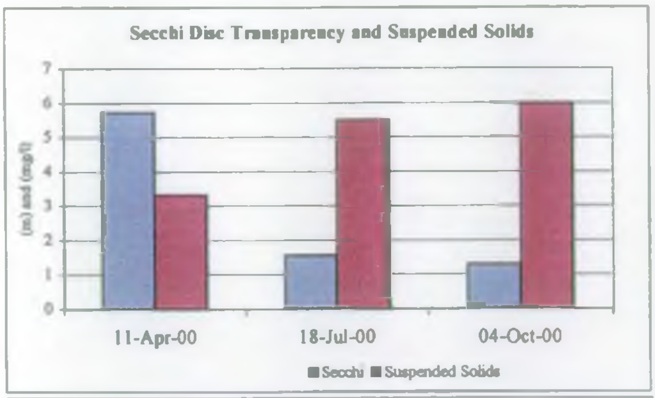


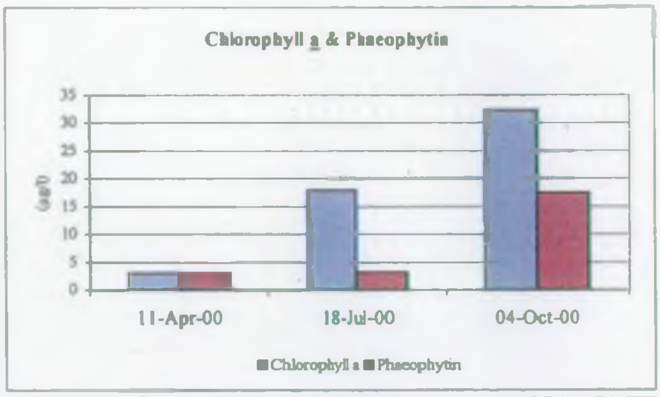


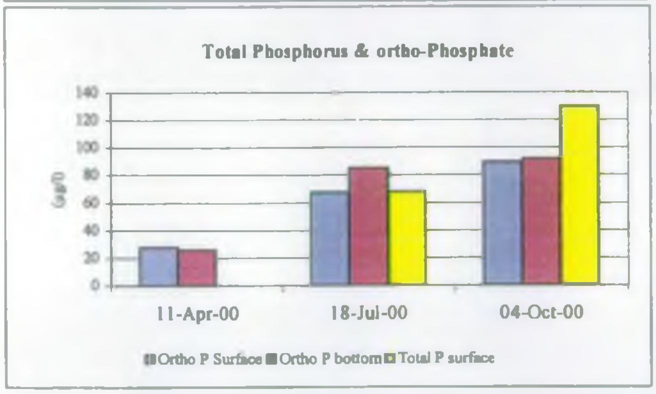


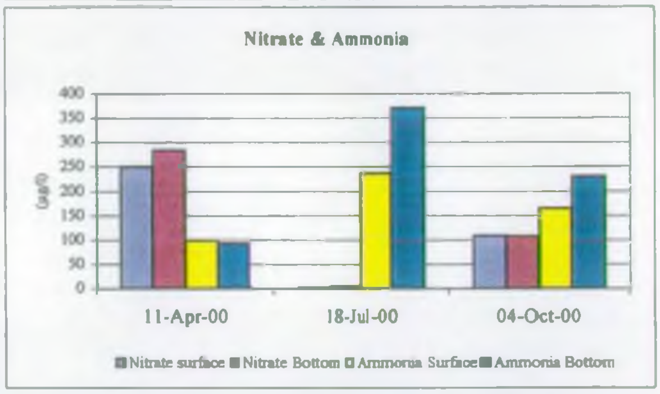
Nutrient Readings, 2000

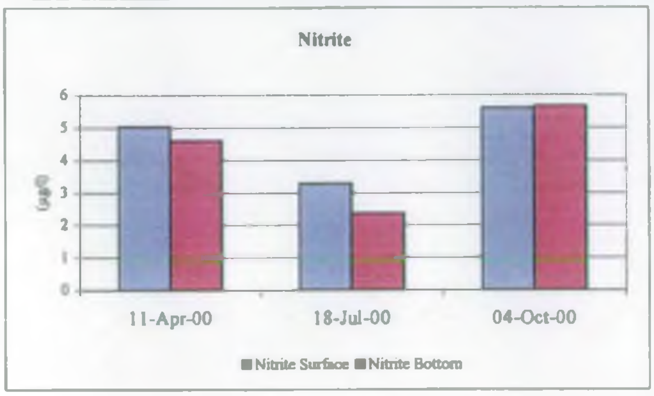
TATTON MERE

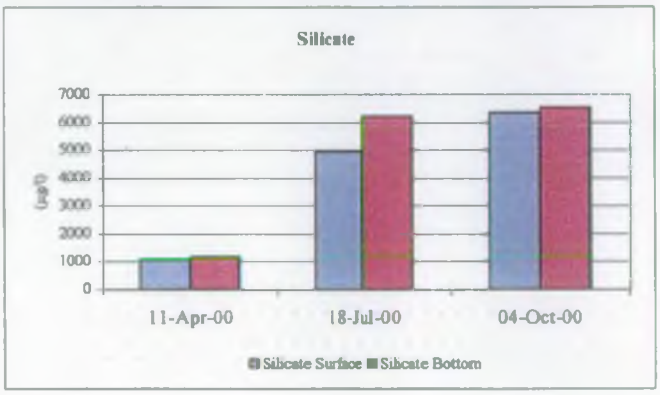






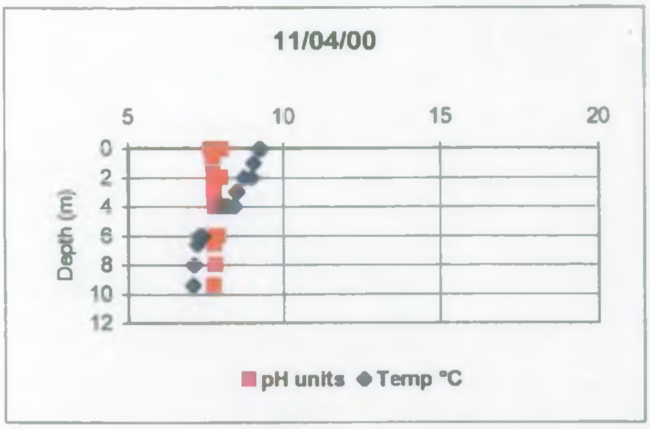


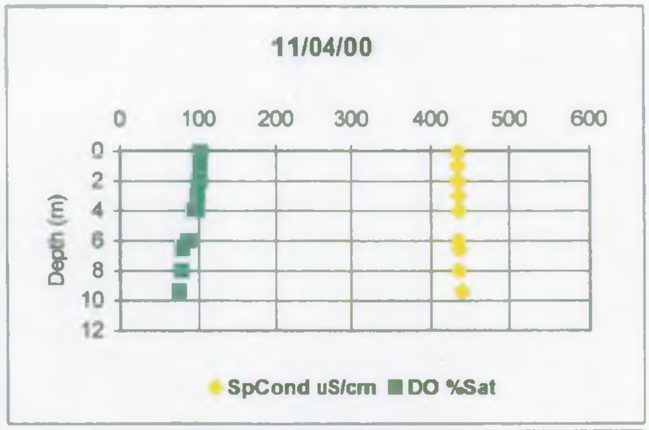


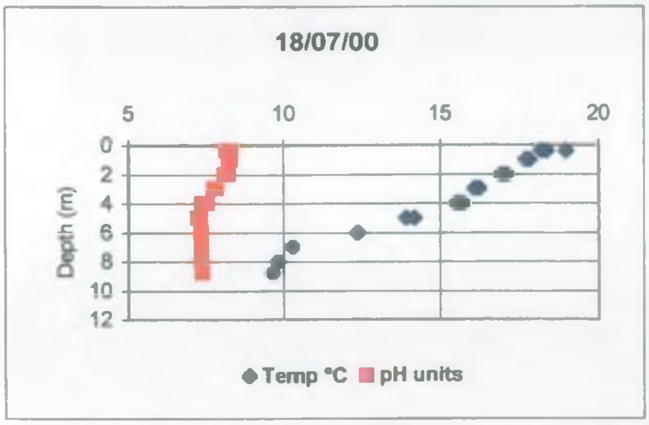


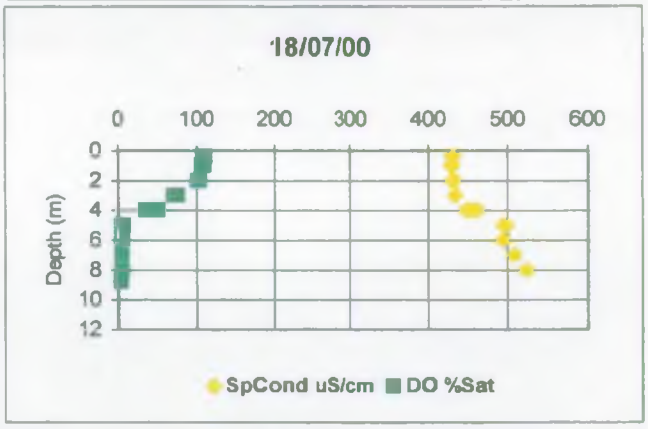
PHYSICO-CHEMICAL PROFILE READINGS, 2000

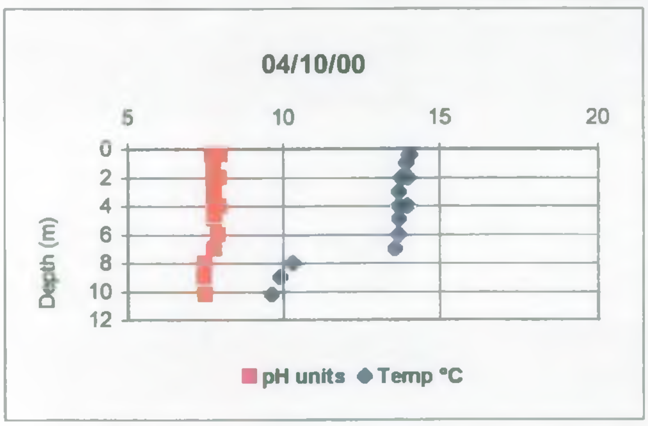
MELCHETT MERE

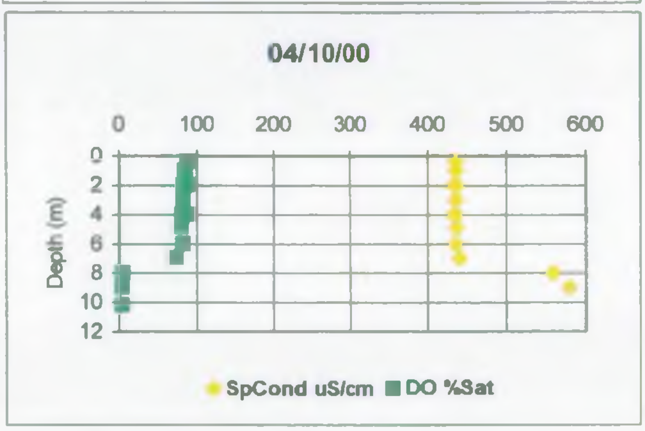






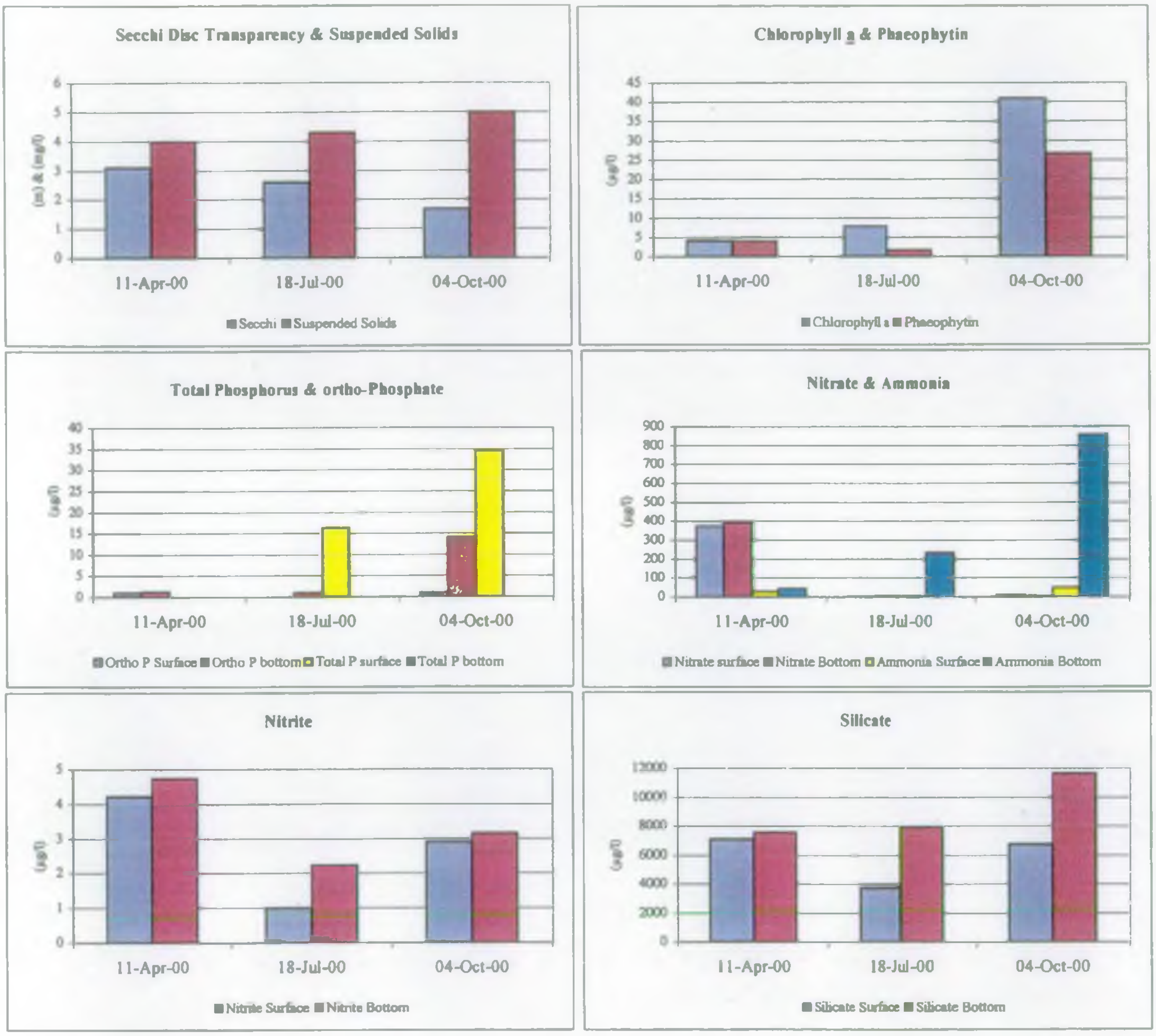






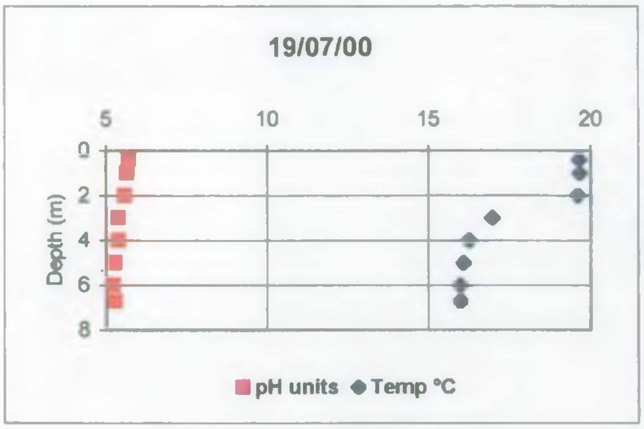
Nutrient Readings, 2000

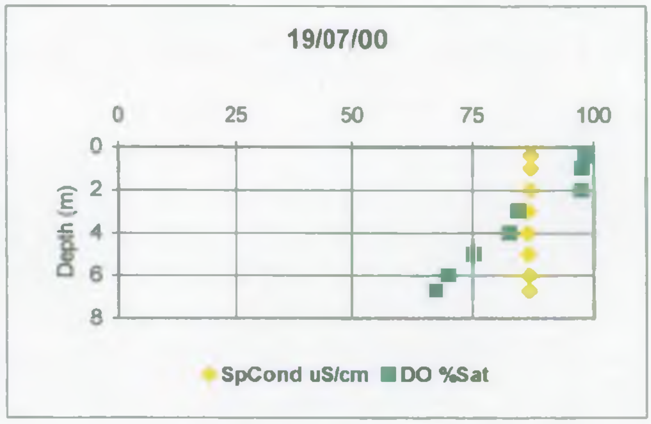
MELCHETT MERE



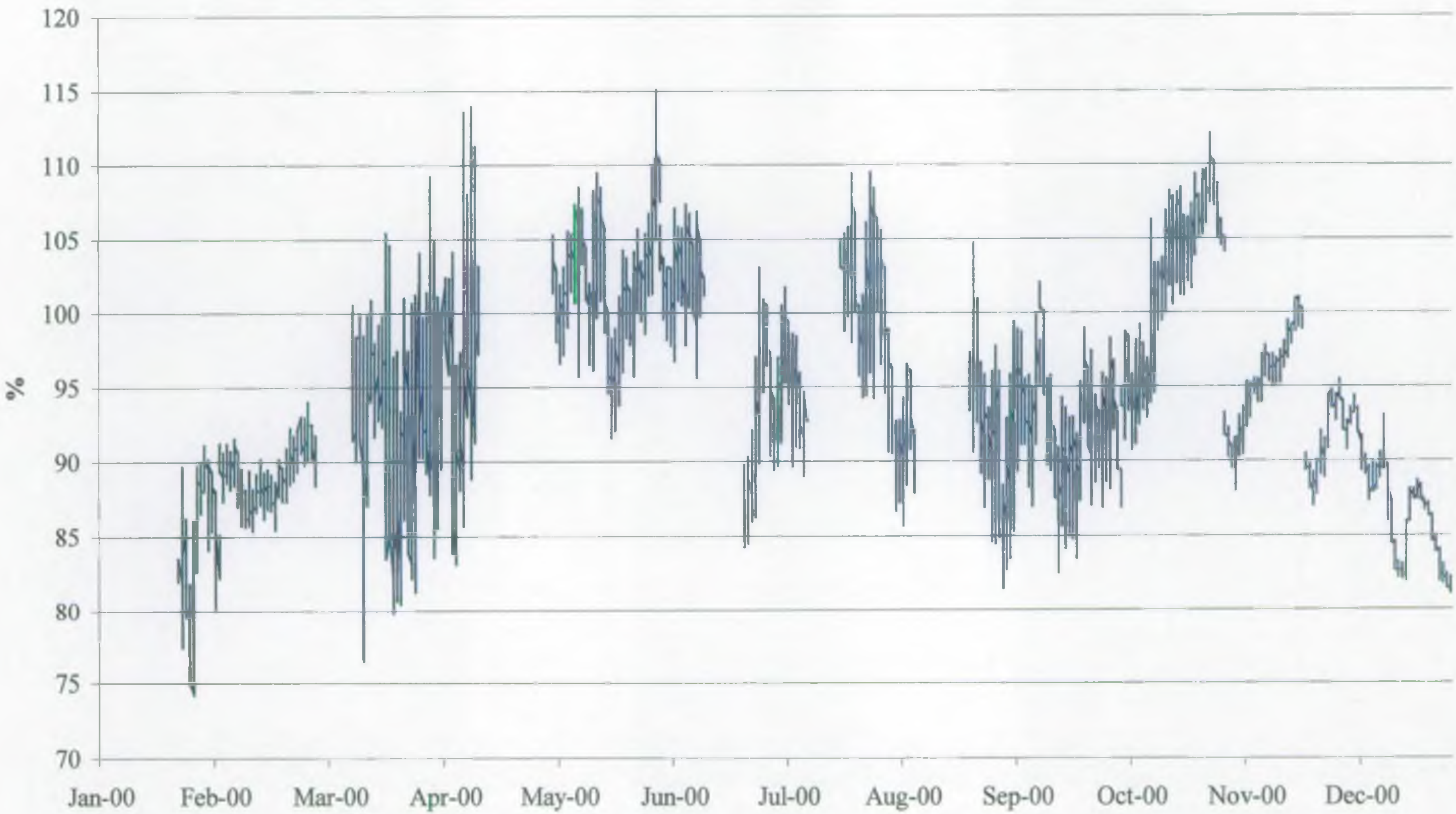
PHYSICO-CHEMICAL PROFILE READINGS, 2000

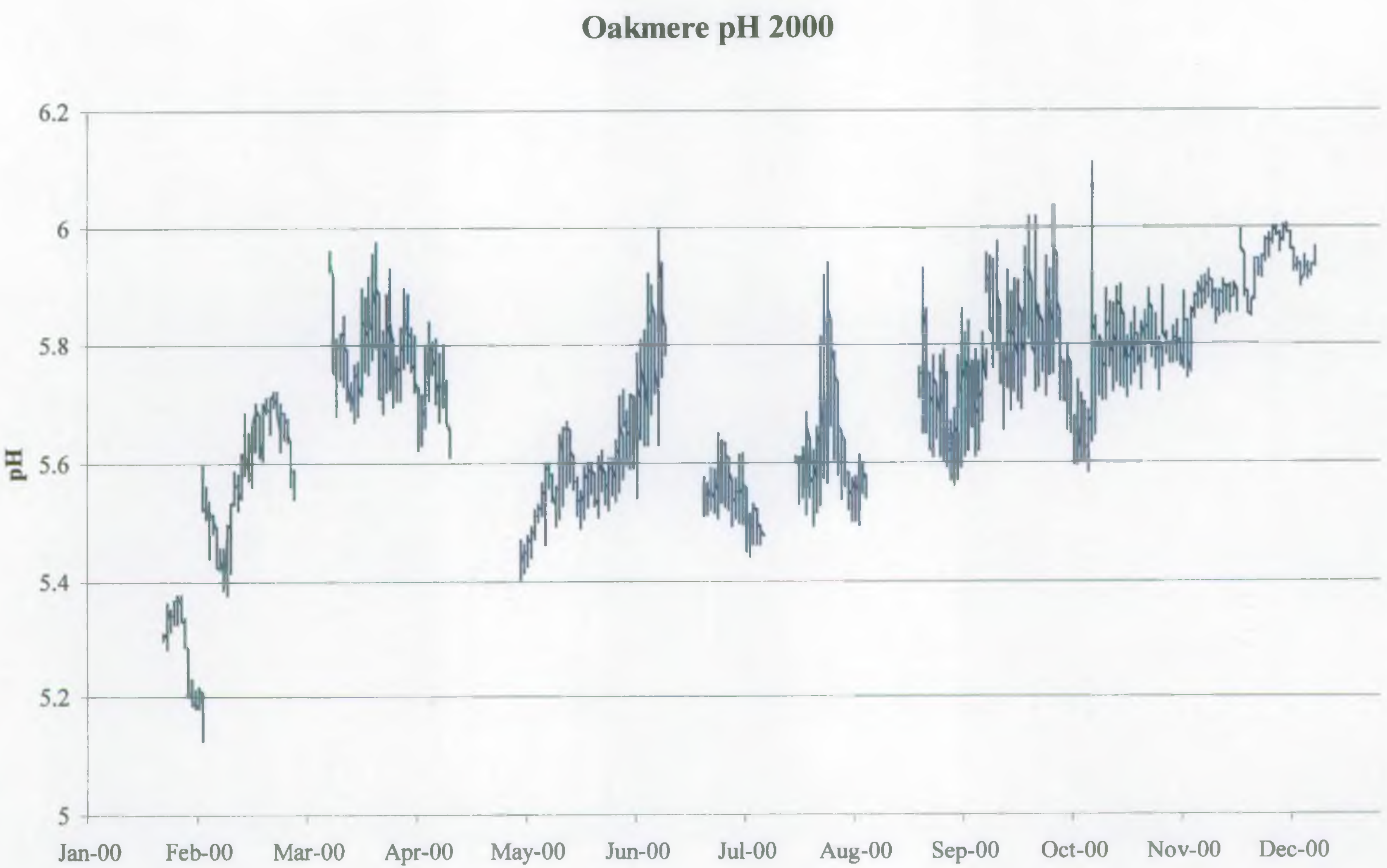
OAKMERE





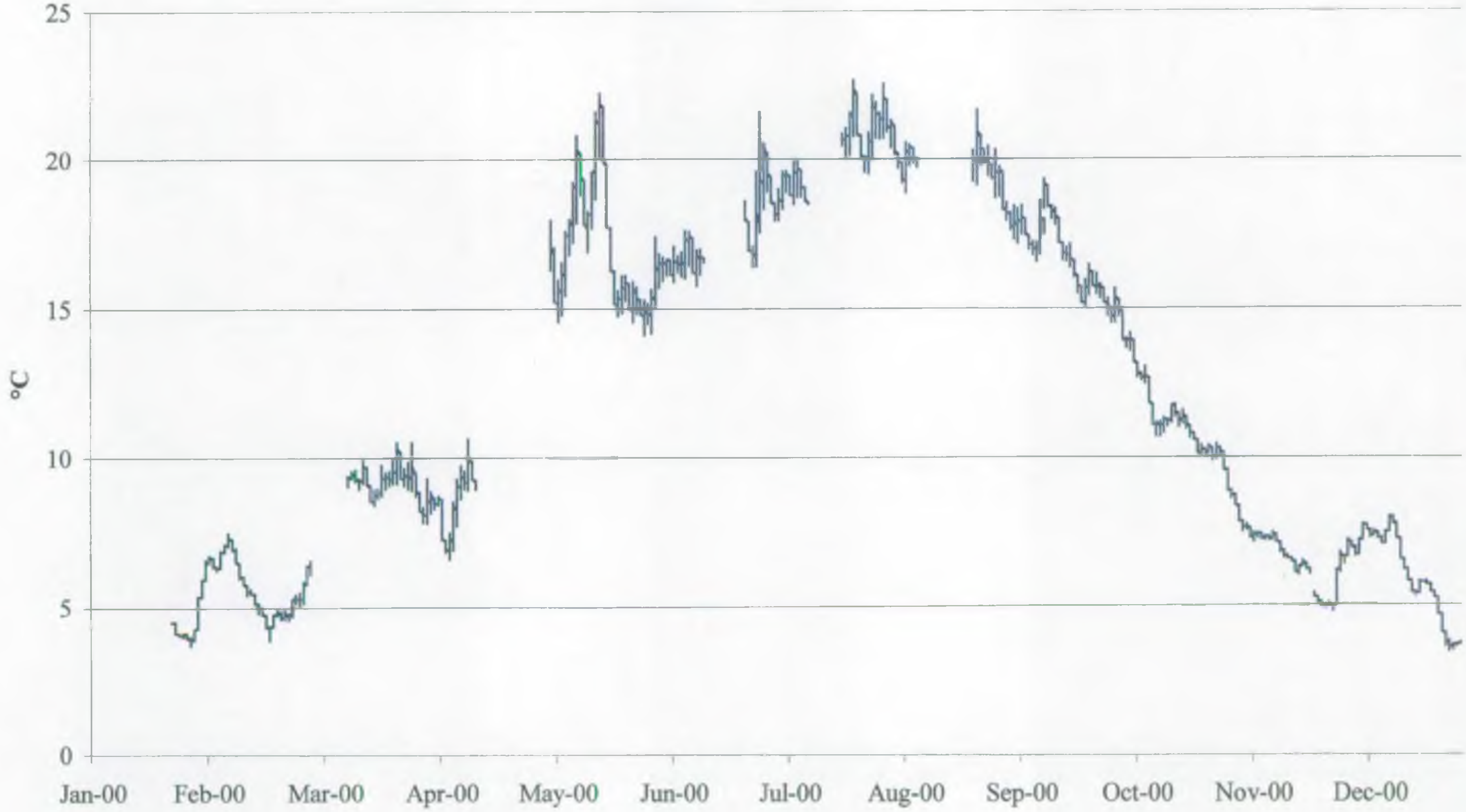
Oakmere Dissolved Oxygen 2000

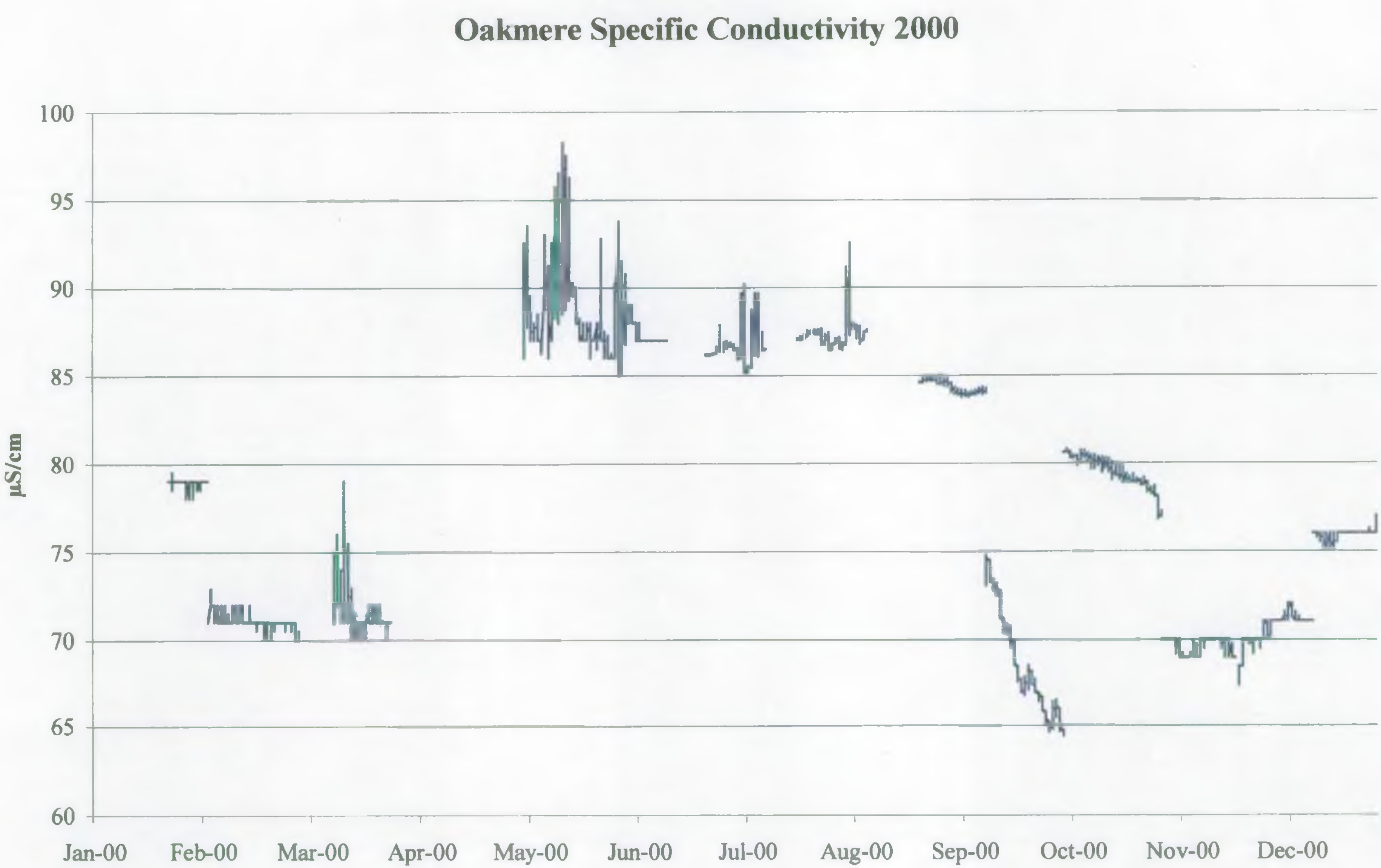




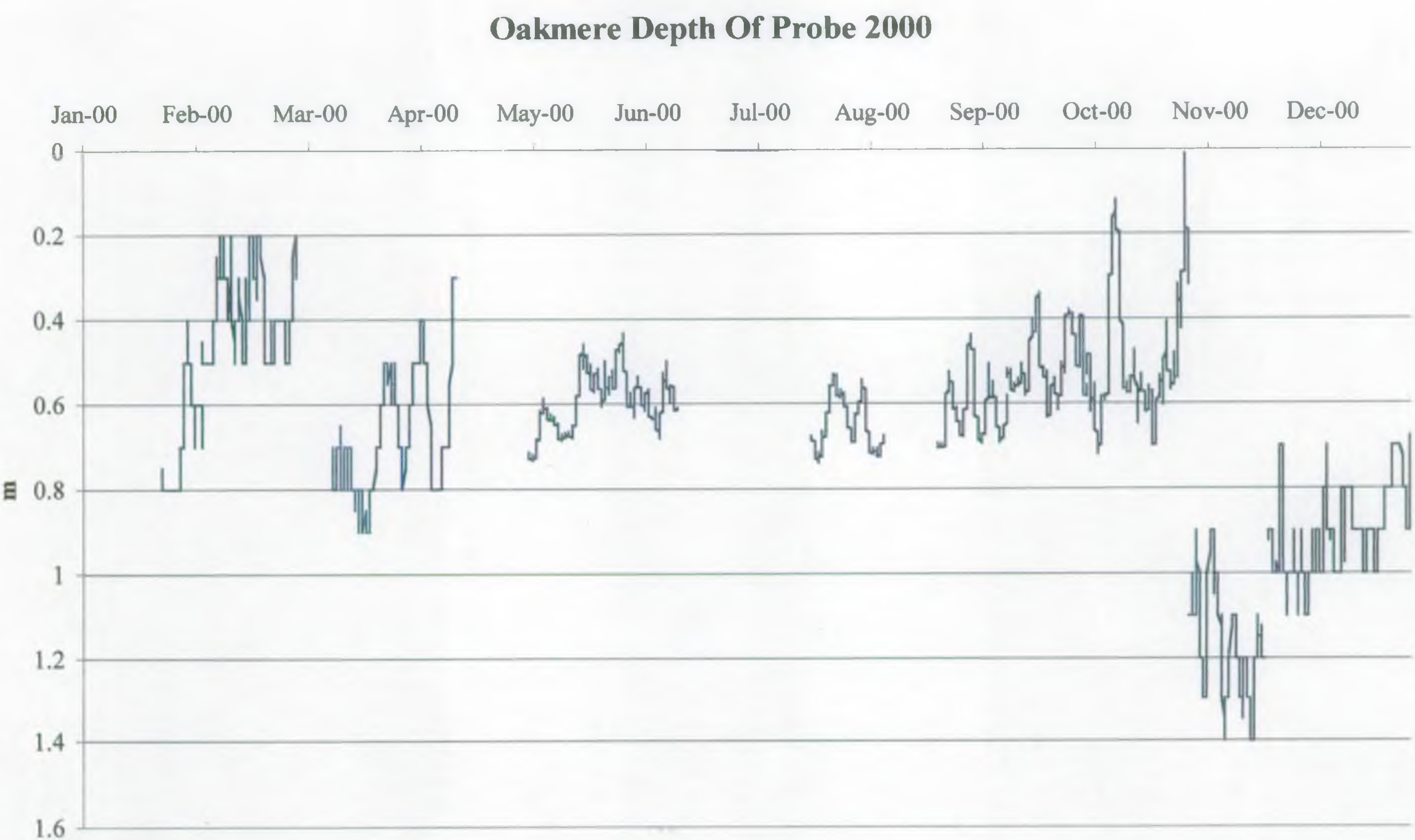
Oakmere pH 2000
pH
6.2
6
5.8
5.6
5.4
5.2
5
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00
Nov-00
Dec-00

Oakmere Temperature 2000

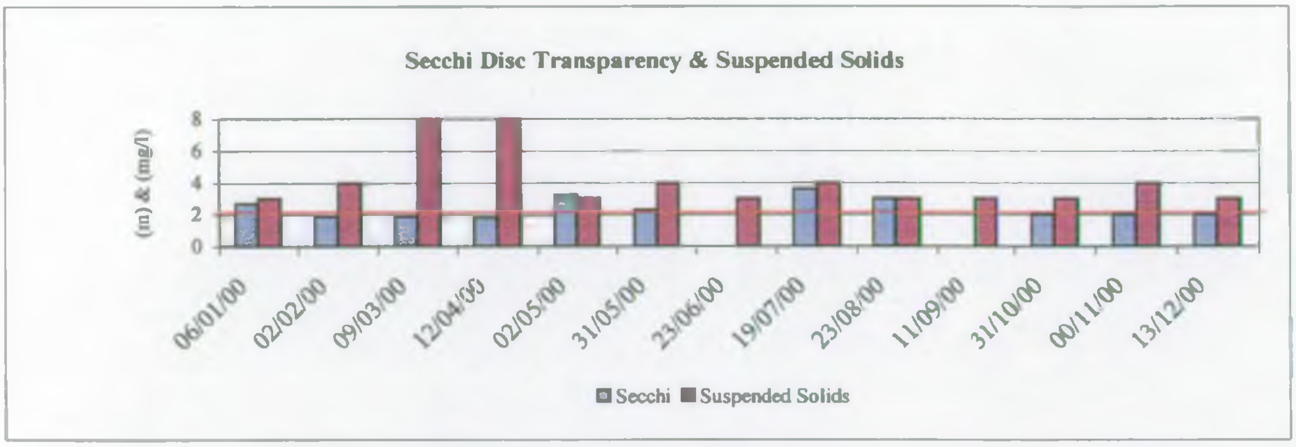


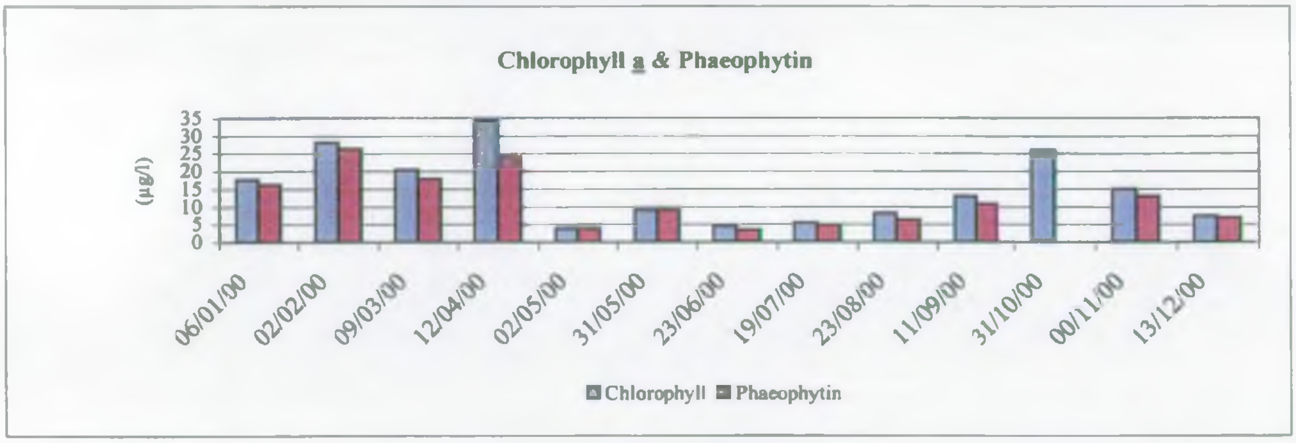


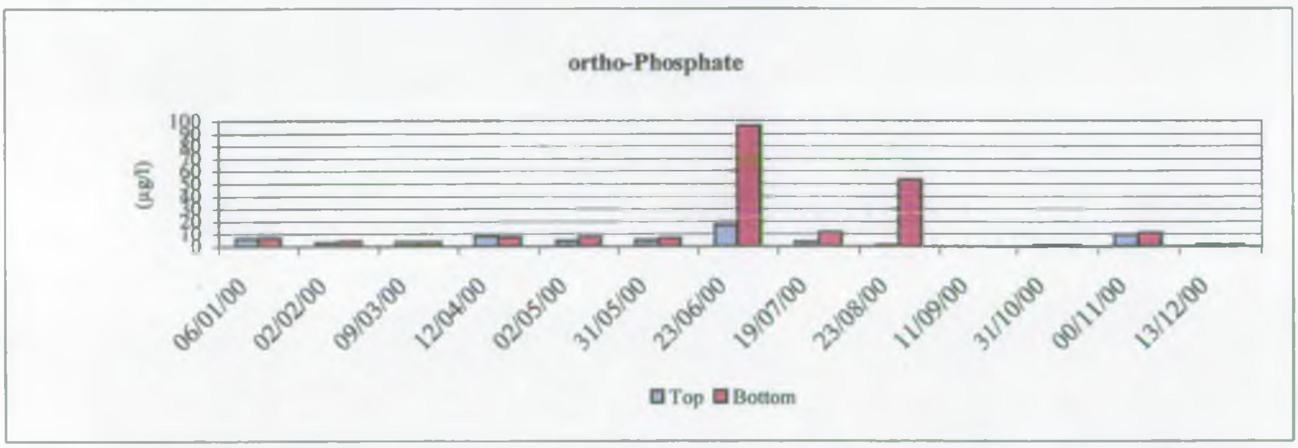
Oakmere Specific Conductivity 2000
100
95
90
85
80
75
70
65
60
µS/cm
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00
Nov-00
Dec-00

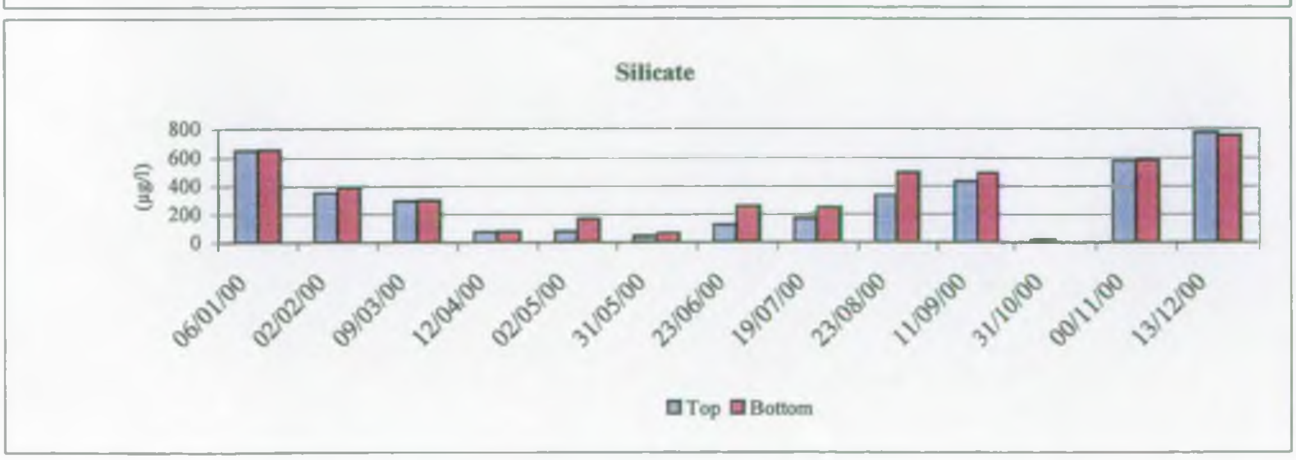

Oakmere Depth Of Probe 2000
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00
Nov-00
Dec-00
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
m

Nutrient and Algal Concentrations for Oakmere 2000

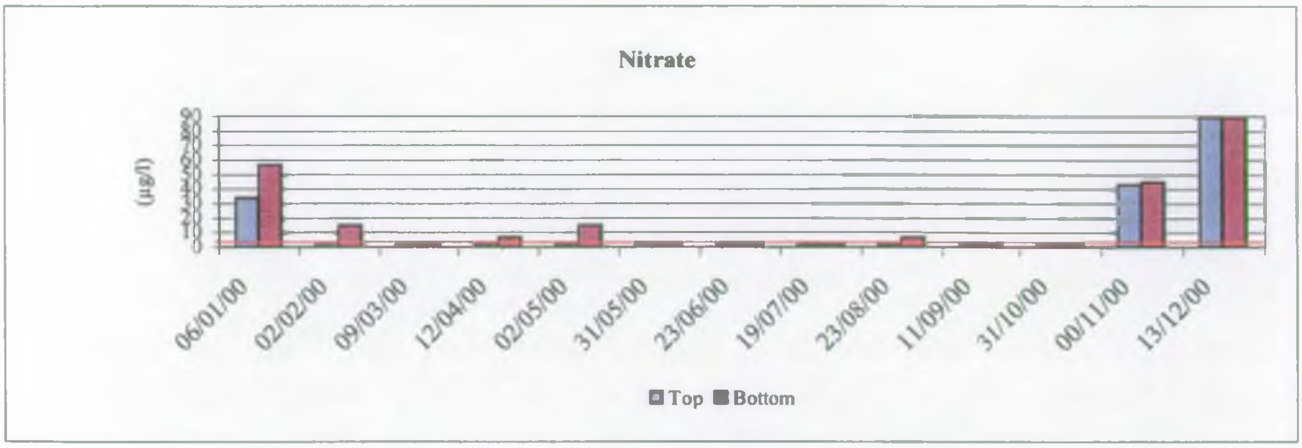


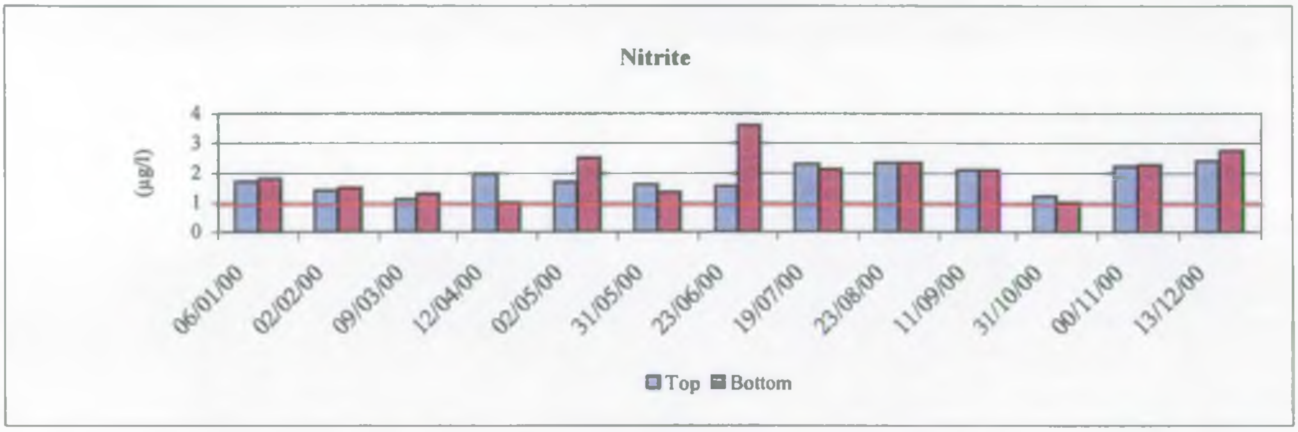


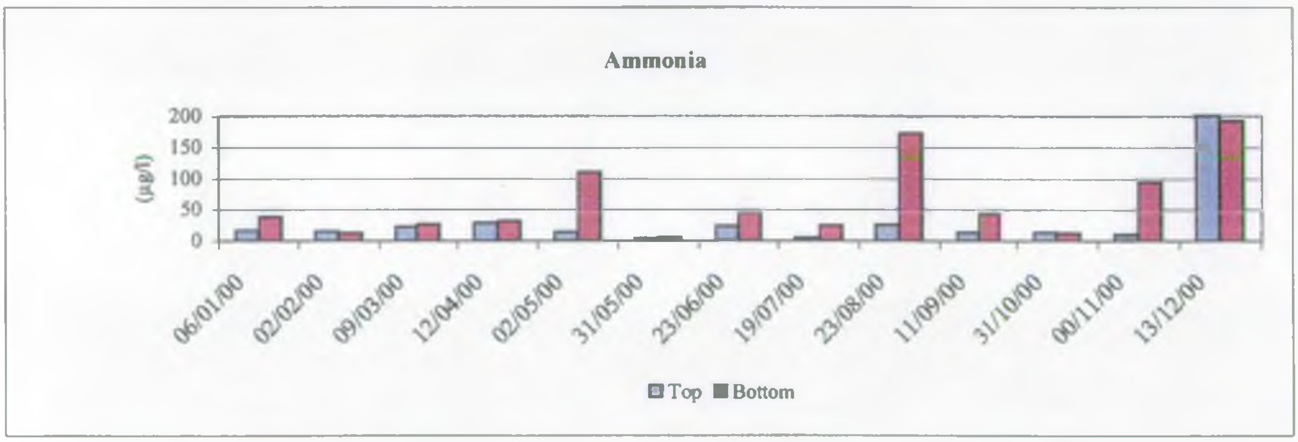




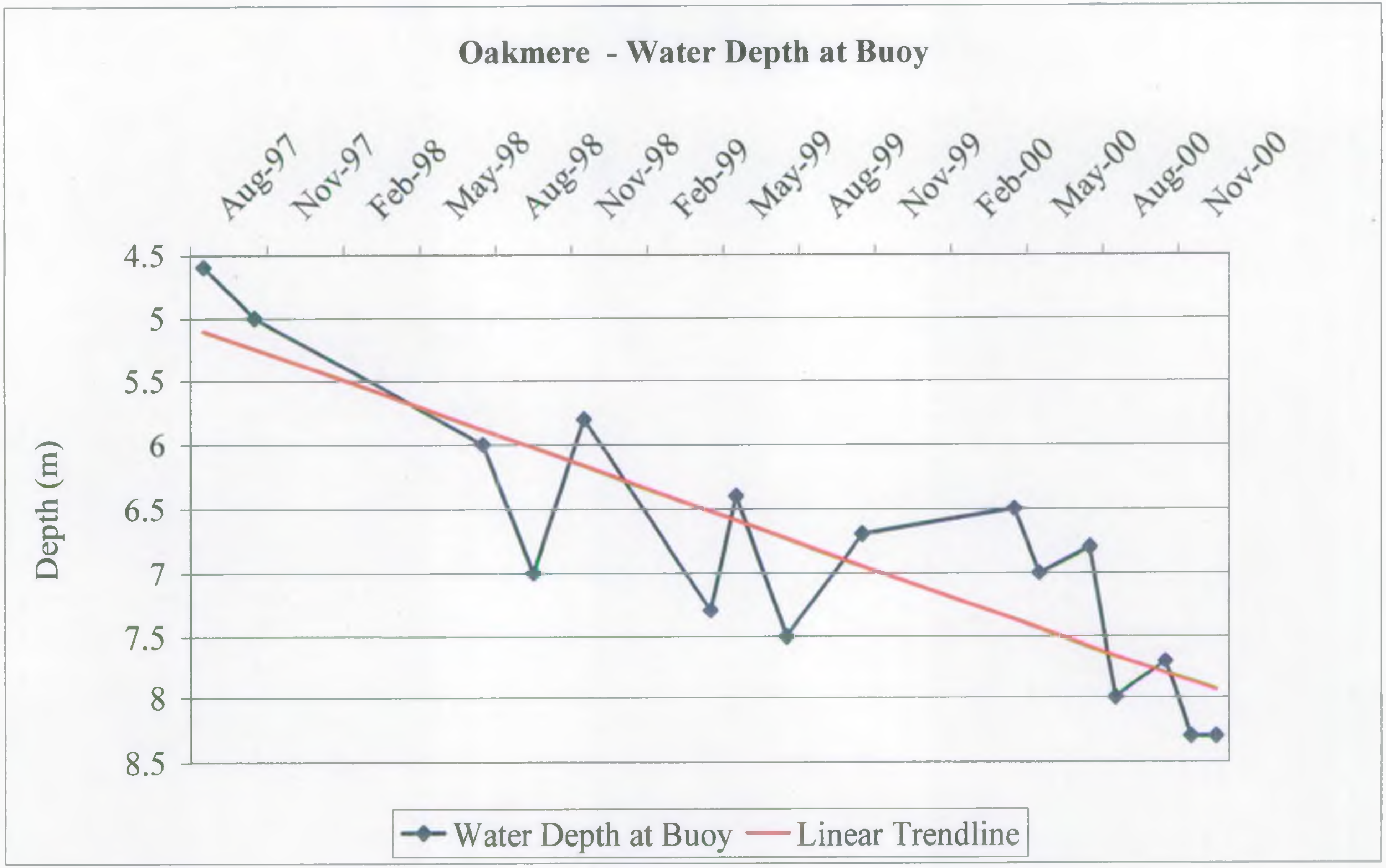
Nutrient and Algal Concentrations for Oakmere 2000, continued



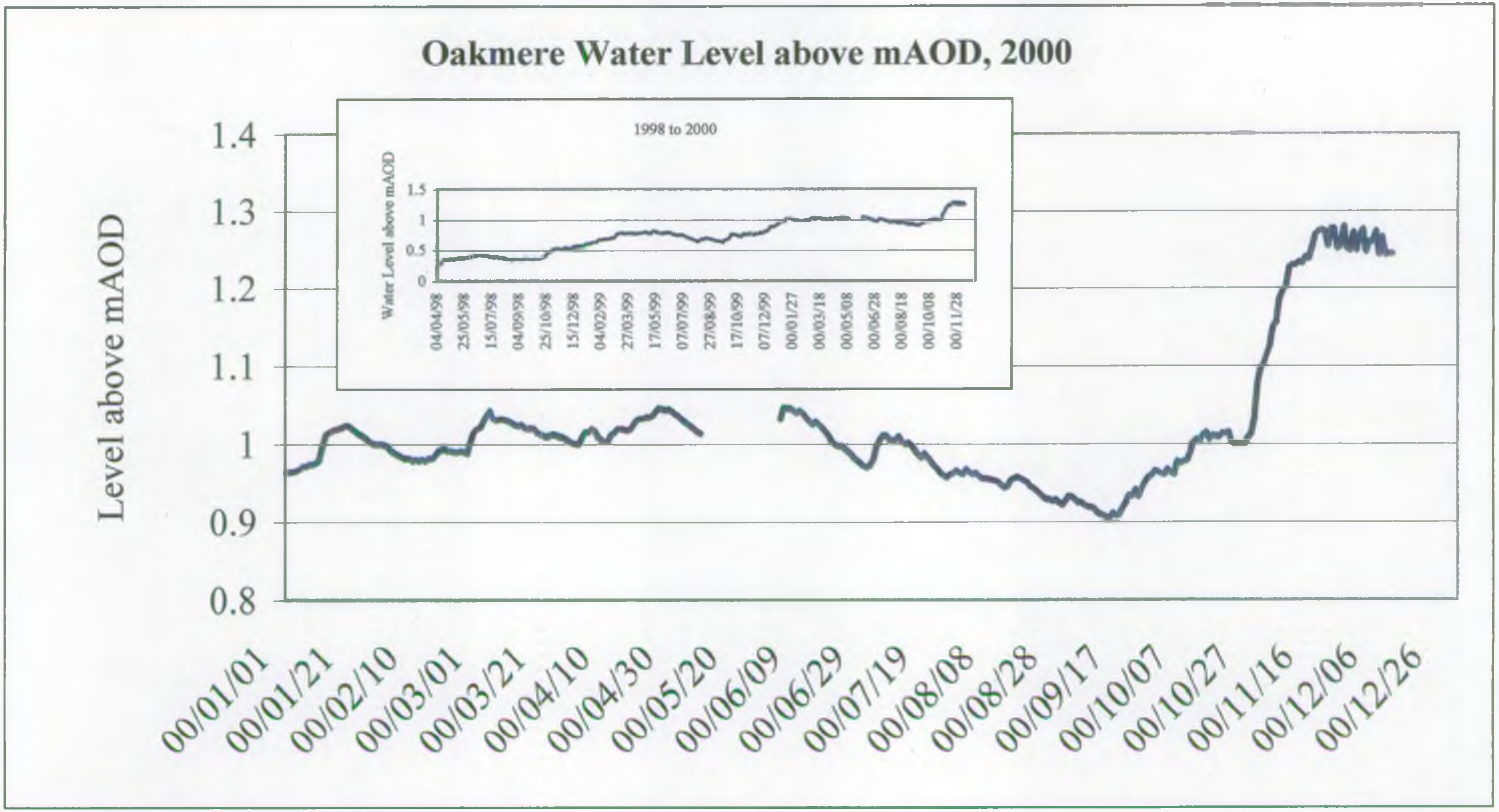




LoD



Oakmere - Water Depth at Buoy
Aug-97
Nov-97
Feb-98
May-98
Aug-98
Nov-98
Feb-99
May-99
Aug-99
Nov-99
Feb-00
May-00
Aug-00
Nov-00
Depth (m)
4.5
5
5.5
6
6.5
7
7.5
8
8.5
Water Depth at Buoy
Linear Trendline


Oakmere Water Level above mAOD, 2000
1998 to 2000
Water Level above mAOD
0
0.5
1
1.5
04/04/98
25/05/98
15/07/98
04/09/98
25/10/98
15/12/98
04/02/99
27/03/99
17/05/99
07/07/99
27/08/99
17/10/99
07/12/99
00/01/27
00/03/18
00/05/08
00/06/28
00/08/18
00/10/08
00/11/28
Level above mAOD
1.4
1.3
1.2
1.1
1
0.9
0.8
00/01/01
00/01/21
00/02/10
00/03/01
00/03/21
00/04/10
00/04/30
00/05/20
00/06/09
00/06/29
00/07/19
00/08/08
00/08/28
00/09/17
00/10/07
00/10/27
00/11/16
00/12/06
00/12/26

APPENDIX 1

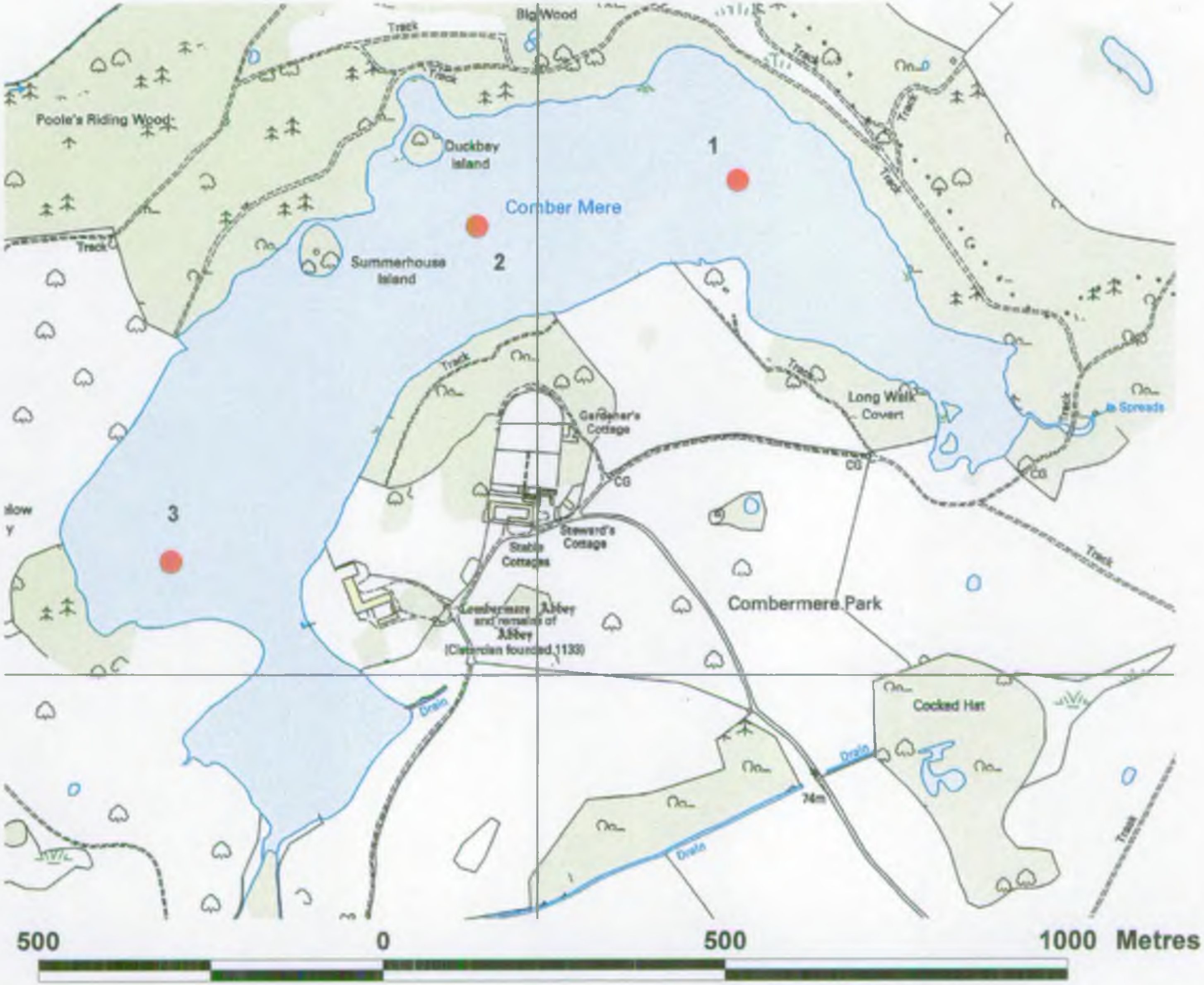
Cheshire Stillwaters – 2000 surveys

Stillwater	Date	Site	NGR	Time	Secchi (m)
Combermere	10/04/00	1	SJ 59357 44640	11:15	1.8
		2	SJ 58843 44580	11:40	1.8
		3	SJ 58577 44160	12:00	1.7
	17/07/00	1	SJ 59289 44696	10:00	1.2
		2	SJ 58873 44589	10:50	1.2
		3	SJ 58542 44292	11:20	1.4
	02/10/00	1	SJ 59280 44697	10:25	1.4
		2	SJ 58899 44631	10:55	1.5
		3	SJ 58455 44154	11:20	1.6
Marbury Big Mere	10/04/00	1	SJ 55849 45606	09:10	2.4
		2	SJ 55926 45476	09:55	2.4
		3	SJ 55925 45338	09:55	2.4
	17/07/00	1	SJ 55944 45565	13:30	0.4
		2	SJ 55979 45398	14:15	0.35
		3	SJ 56027 45512	14:45	0.4
	02/10/00	1	SJ 55903 45607	13:30	1.2
		2	SJ 55987 45320	14:05	1.2
		3	SJ 56029 45486	14:20	1.1
Hatchmere	10/04/00	1	SJ 55262 72240	14:00	0.8
		2	SJ 55301 72156	14:15	0.9
		3	SJ 55367 72074	14:30	0.9
	19/07/00	1	SJ 55288 72204	09:35	1.1
		2	SJ 55329 72100	10:05	1.1
		3	SJ 55350 72144	10:30	1.1
	03/10/00	1	SJ 55283 72204	14:20	0.9
		2	SJ 55299 72131	14:45	0.95
		3	SJ 55362 72168	15:10	0.9

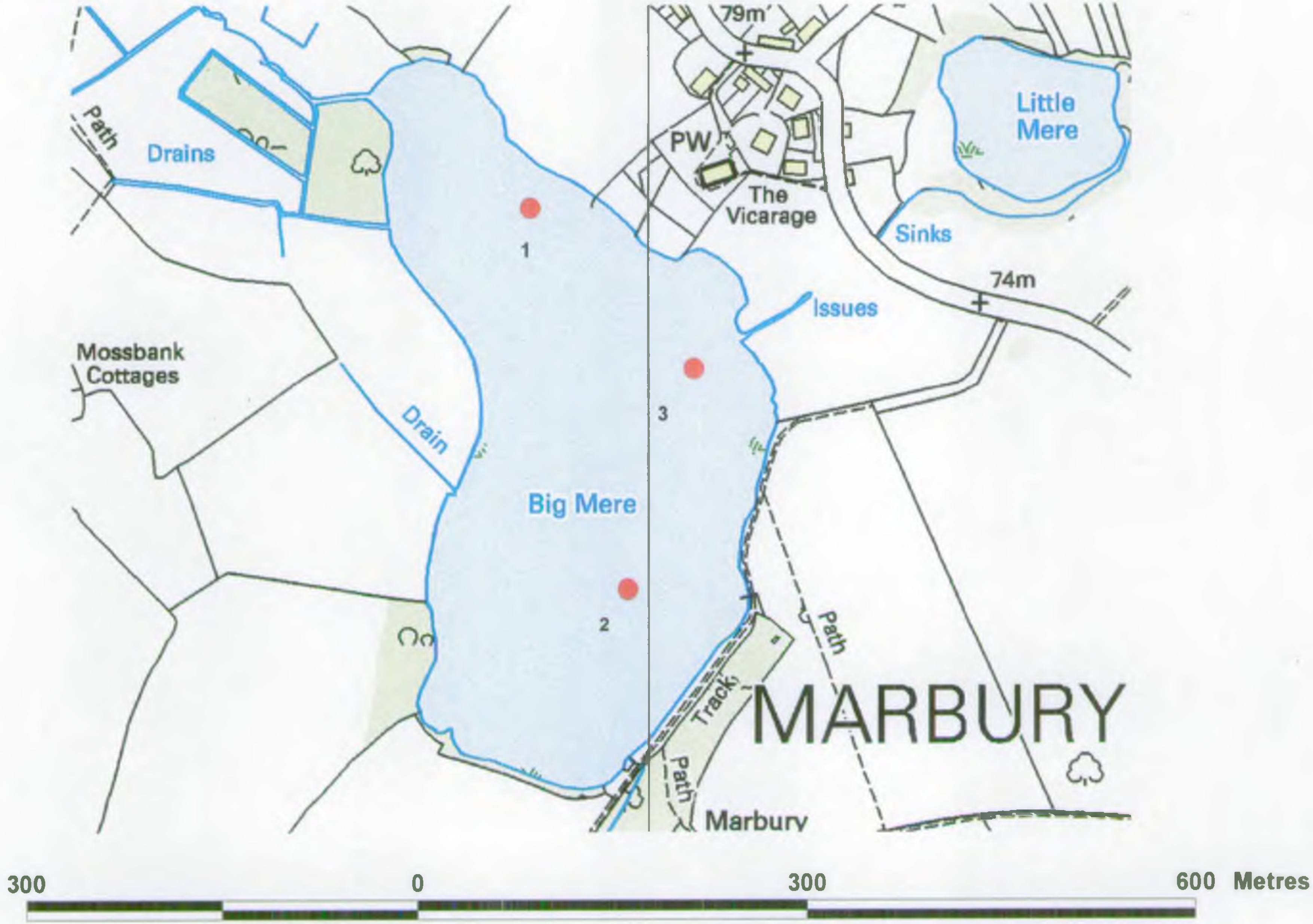
Appendix 1: continued.

Stillwater	Date	Site	NGR	Time	Secchi (m)
Tabley Mere	11/04/00	1	SJ 72513 76736	10:35	1.5
		2	SJ 77153 76769	11:10	0.5
		3	SJ 72314 76957	11:35	0.5
	18/07/00	1	SJ 72301 76803	08:55	1.4(b)
		2	SJ 72215 76787	09:20	0.8
		3	SJ 72312 76807	09:50	0.7
	04/10/00	1	SJ 72480 76831	09:12	1.2
		2	SJ 72201 76788	09:49	0.8
		3	SJ 72303 76887	10:14	0.4 (b)
Melchett Mere	11/04/00	1	SJ 74915 81150	13:30	2.9
		2	SJ 74935 81138	14:00	3.3
		3	SJ 74889 81180	14:25	3.1
	18/07/00	1	SJ 74926 81110	11:35	2.6
		2	SJ 74996 81202	12:05	2.6
		3	SJ 75133 81131	12:30	2.6
	04/10/00	1	SJ 74911 81112	11:58	1.75
		2	SJ 75017 81165	12:38	1.75
		3	SJ 75047 81152	12:55	1.5
Tatton Mere	11/04/00	1	SJ 75580 79837	16:05	5.8
		2	SJ 75574 80028	16:30	6
		3	SJ 75554 80214	16:55	6.6
	18/07/00	1	SJ 75522 79880	14:05	1.5
		2	SJ 75523 80002	14:25	1.6
		3	SJ 75495 80227	15:00	1.6
	04/10/00	1	SJ 75597 79928	14:42	1.3
		2	SJ 75533 80077	15:10	1.3
		3	SJ 75487 80210	15:33	1.3

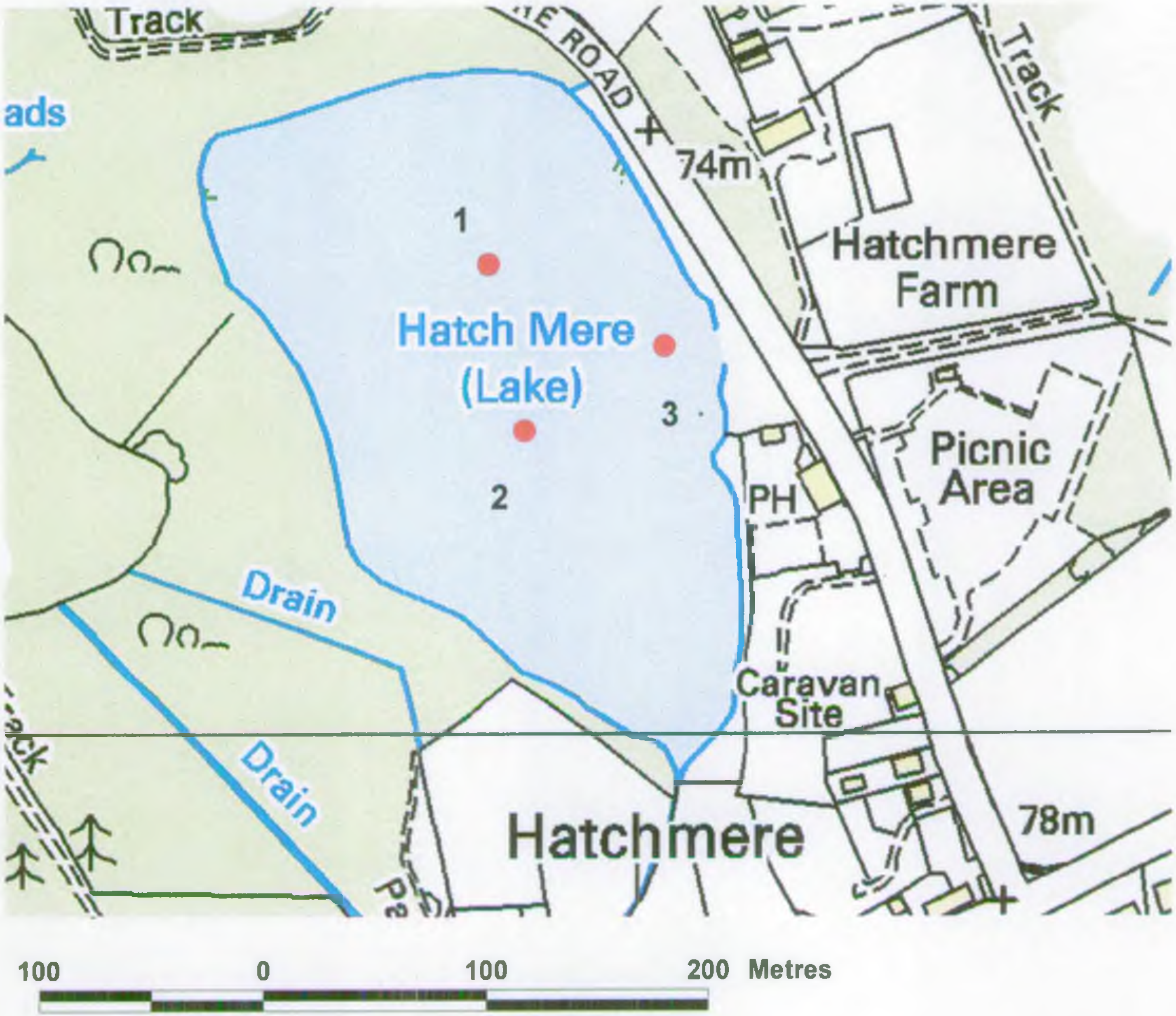
Combermere


Big Wood
Track
Poole's Riding Wood
Duckbay Island
Comber Mere
1
2
3
Summerhouse Island
Gardener's Cottage
Long Walk Covert
Spreads
CG
Steward's Cottage
Stable Cottages
Combermere Abbey and remains of Abbey (Cistercian founded 1133)
Combermere Park
Cocked Hat
Drain
74m
500
0
500
1000
Metres

Marbury Big Mere

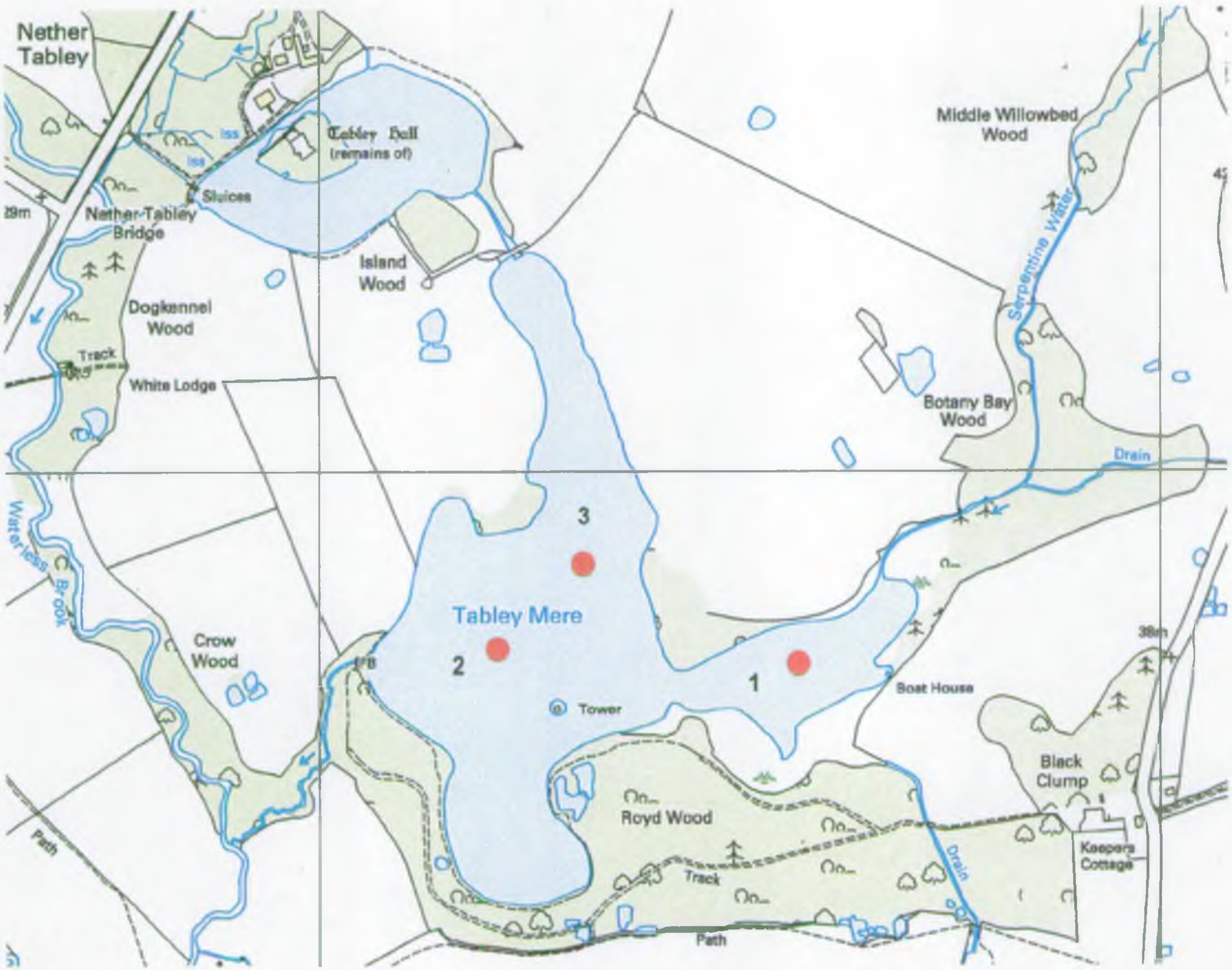


Hatchmere



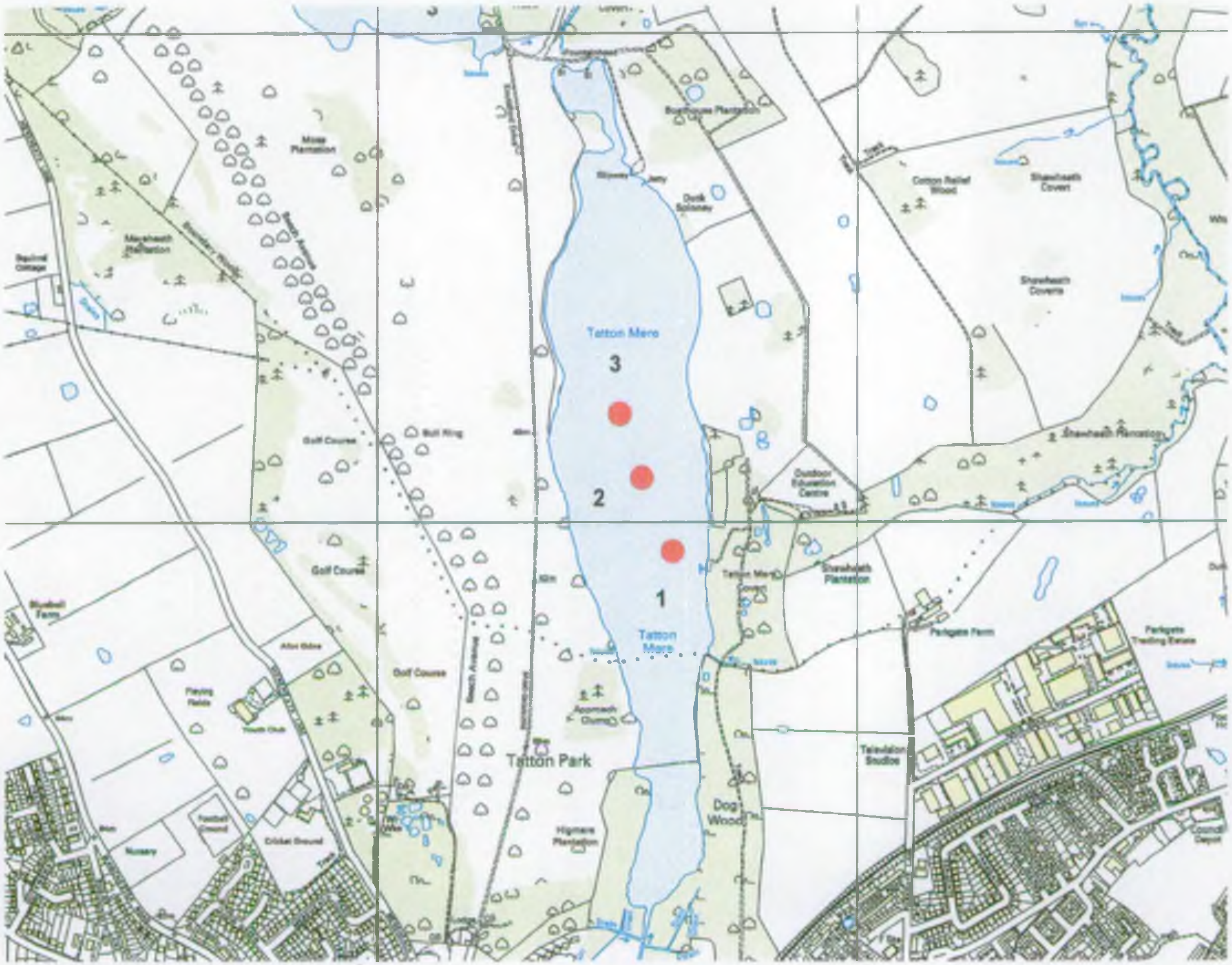
Track
ROAD
ads
74m
Track
Hatchmere Farm
1
Hatch Mere (Lake)
3
2
Picnic Area
PH
Drain
Caravan Site
Drain
Hatchmere
78m
100
0
100
200
Metres

Tabley Mere



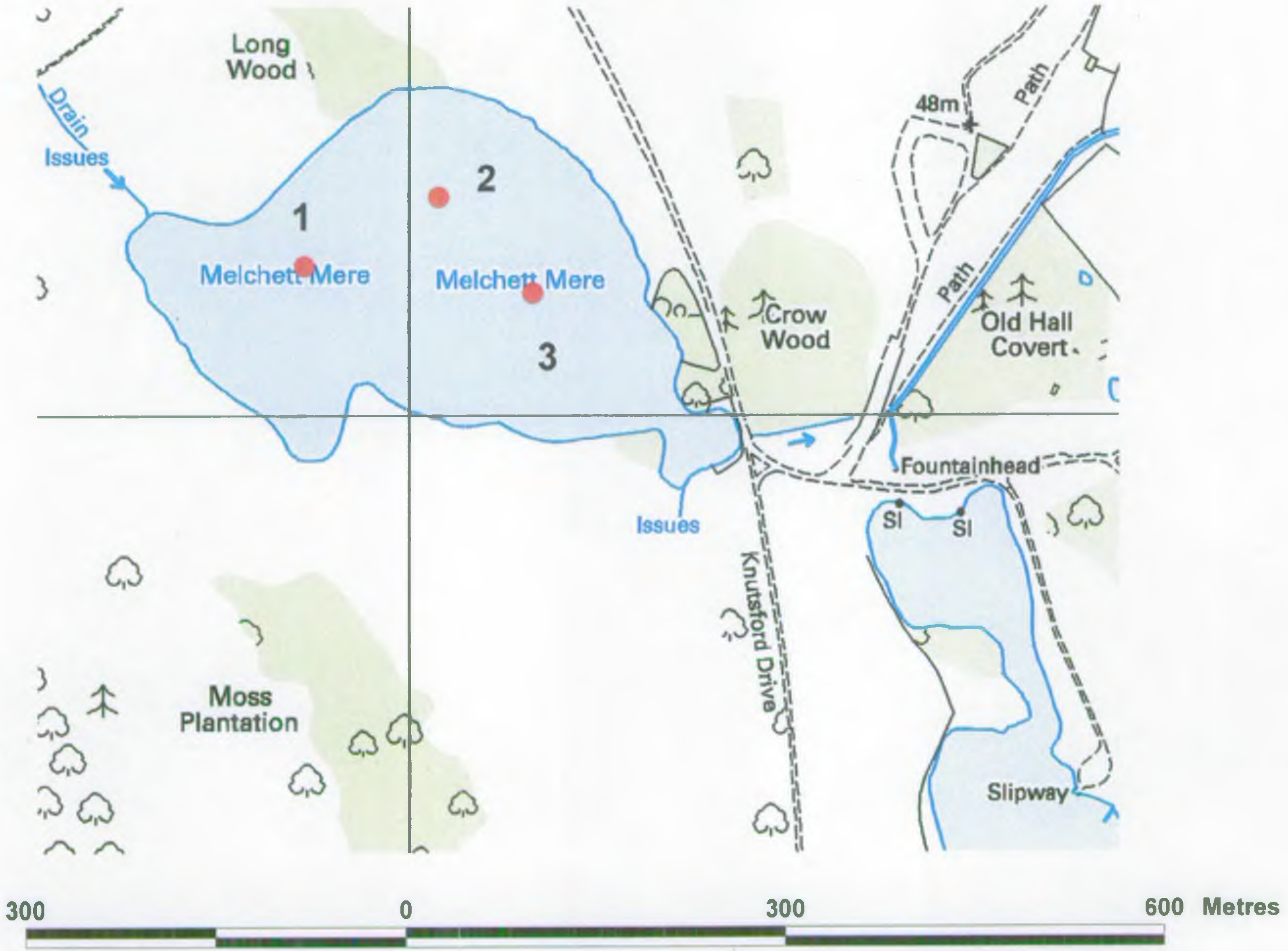
500 0 500 1000 Metres

Tatton Mere



900 0 900 1800 Metres

Melchett Mere



APPENDIX 2: Raw Data - Profiles of physico-chemical parameters

Site	Date/Time	Depth m	Temp °C	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l
Combermere	17/07/00							
1	10:40:26	0.4	18.3	9.18	478	0.31	136.3	12.8
	10:43:48	2	17.7	9.11	484	0.31	119.3	11.35
	10:46:58	4	16.8	8.75	496	0.32	63	6.11
	10:50:43	6	15.2	8.15	546	0.35	5.3	0.53
	10:54:24	8	10.7	7.84	580	0.37	4.7	0.52
	10:57:42	10	9.9	7.66	593	0.38	4.7	0.53
2	11:13:12	0.4	18.6	9.16	483	0.31	135.6	12.65
	11:16:09	2	17.5	9.06	488	0.31	109	10.41
	11:18:56	4	16.7	8.71	499	0.32	60.2	5.85
	11:22:02	6	15.0	8.13	551	0.35	6	0.61
	11:24:11	8	10.9	7.87	581	0.37	5.4	0.6
	11:27:06	9.4	10.3	7.68	591	0.38	5.2	0.58
3	11:40:36	0.4	18.3	9.18	486	0.31	137.7	12.93
	11:44:03	2	17.5	8.98	493	0.32	99.3	9.49
	11:46:00	4	16.7	8.73	498	0.32	64.6	6.27
	11:48:36	6	14.3	8.09	561	0.36	6.9	0.7
	11:50:22	7	12.9	7.96	569	0.36	5.2	0.55
Combermere	02/10/00							
1	105830	0.1	15.1	8.29	467	0.30	89.5	8.99
	110113	2	15.1	8.37	467	0.30	88.6	8.9
	110141	2	15.1	8.39	467	0.30	88.6	8.9
	110357	4	15.1	8.44	467	0.30	87.8	8.82
	110635	6	15.1	8.44	468	0.30	84.8	8.52
	111005	8	12.2	7.64	591	0.38	3.8	0.41
	111240	9.8	10.5	7.34	601	0.38	3.4	0.38
2	112352	0.2	15.1	8.49	468	0.30	88.9	8.94
	112719	2	15.1	8.51	469	0.30	87.8	8.83
	113037	4	15.1	8.52	469	0.30	87.4	8.79
	113232	6	15.1	8.5	469	0.30	84.4	8.49
	113524	8	12.0	7.63	594	0.38	4.6	0.49
	113818	9.1	10.6	7.29	608	0.39	4	0.45
3	115605	0.2	14.9	8.32	471	0.30	75.1	7.58
	115831	2	14.9	8.31	472	0.30	73	7.37
	120010	4	14.9	8.31	472	0.30	72.7	7.34
	120317	5.1	14.9	8.31	472	0.30	72.3	7.3
Hatchmere	19/07/00							
1	10:05:29	0.4	19.2	8.33	408	0.26	110.8	10.22
	10:09:51	1	18.2	8.04	408	0.26	85.5	8.05
	10:14:50	2	16.6	7.53	408	0.26	41.5	4.03
	10:17:55	3.2	15.5	7.35	415	0.27	5.3	0.52
2	10:31:20	0.4	19.4	8.58	405	0.26	117.6	10.81
	10:33:51	1	19.2	8.59	406	0.26	116.4	10.73
	10:38:05	2	15.8	7.61	408	0.26	29.9	2.96
	10:40:31	2.7	15.6	7.47	414	0.27	8.6	0.86
3	10:53:43	0.4	19.5	8.54	406	0.26	116.3	10.67
	10:56:28	1	19.4	8.55	407	0.26	116.2	10.69
	10:59:11	2	16.3	7.72	406	0.26	45.9	4.49
	11:01:50	3	15.5	7.44	415	0.27	6.5	0.65

Hatchmere	03/10/00							
1	14:53:40	0.2	13.6	7.33	386	0.25	74.3	7.71
	14:56:34	1	13.6	7.45	387	0.25	73.5	7.62
	14:59:49	2	13.6	7.53	387	0.25	72.9	7.56
	15:01:40	2.8	13.6	7.54	386	0.25	70.7	7.33
2	15:11:14	0.3	13.8	7.66	386	0.25	76.3	7.9
	15:13:52	1	13.7	7.68	387	0.25	74.7	7.75
	15:17:58	2	13.6	7.71	387	0.25	73.1	7.59
	15:20:55	3	13.6	7.71	387	0.25	70.2	7.29
3	15:31:10	0.2	13.7	7.78	386	0.25	78.5	8.13
	15:34:33	1	13.7	7.8	386	0.25	77	7.98
	15:37:22	2	13.7	7.8	386	0.25	76.5	7.93
	15:40:36	3.4	13.6	7.8	387	0.25	73.8	7.66
Marbury Big Mere	17/07/00						DO ABOVE 200% AT 0.4m	
1	13:58:02	0.4	19.2	9.52	438	0.28		
	14:04:43	1	17.1	9.09	462	0.30	145.4	14
	14:08:55	2	16.8	8.86	470	0.30	111.1	10.76
	14:11:36	3	16.3	8.61	477	0.31	80.2	7.85
	14:14:32	4	15.7	8.39	491	0.32	49.5	4.91
	14:18:15	5	13.5	7.91	573	0.37	6.5	0.68
	14:24:17	6.2	10.7	7.5	621	0.40	5.1	0.56
2	14:40:25	0.4	20.9	9.53	434	0.28		
	14:44:28	1.1	17.4	9.18	454	0.29	150.3	14.4
Marbury Big Mere	02/10/00							
1	14:03:40	0.2	14.5	7.12	489	0.31	51.4	5.23
	14:07:28	2	14.5	7.38	489	0.31	49.7	5.05
	14:18:42	3.9	14.5	7.55	492	0.32		
Melchett Mere	11/04/00							
1	12:49:37	0.1	9.2	7.66	434.7	0.28	103.2	11.85
	12:52:44	1	9.0	7.71	435.1	0.28	102	11.76
	12:55:09	2	8.7	7.75	435.8	0.28	100.6	11.69
	12:57:36	3	8.5	7.76	436.3	0.28	98.4	11.49
	12:59:46	4	8.4	7.77	436.5	0.28	97.5	11.41
2	13:14:35	0.1	9.3	7.93	435.4	0.28	102.3	11.74
	13:16:55	2	9.0	7.93	436	0.28	100.6	11.62
	13:19:46	4	8.0	7.88	436.7	0.28	92.8	10.97
	13:22:27	6	7.4	7.83	436.6	0.28	85.8	10.29
	13:25:58	6.6	7.2	7.75	438	0.28	78.7	9.49
3	13:36:00	0.1	9.3	7.98	436.3	0.28	103.1	11.82
	13:38:17	2	9.0	7.97	434.3	0.28	101.8	11.76
	13:40:55	4	8.2	7.92	436.2	0.28	93.9	11.05
	13:43:26	6	7.3	7.88	435.2	0.28	87.9	10.57
	13:45:58	8	7.1	7.8	437.4	0.28	78	9.43
	13:49:43	9.4	7.1	7.74	440.1	0.28	74.7	9.03

Melchett Mere	**18/07/00**							
1	12:01:06	0.4	18.2	8.16	430	0.28	110.5	10.41
	12:03:44	1	17.7	8.24	429	0.28	109.7	10.43
	12:06:27	2	17.1	8.1	431	0.28	101.3	9.76
	12:09:31	3	16.1	7.76	434	0.28	71.1	7
	12:14:59	4	15.5	7.39	456	0.29	35	3.49
	12:17:54	5	13.9	7.24	495	0.32	5.2	0.53
2	12:28:30	0.4	18.4	8.31	432	0.28	108	10.14
	12:32:16	1	17.8	8.29	431	0.28	106.2	10.08
	12:34:31	2	16.9	8.17	432	0.28	102.3	9.89
	12:37:52	3	16.2	7.85	434	0.28	76	7.46
	12:41:42	4	15.7	7.56	448	0.29	51.1	5.06
	12:44:39	5	14.2	7.33	498	0.32	6.3	0.65
3	12:51:45	0.4	19.0	8.3	432	0.28	109.6	10.16
	12:55:06	2	17.1	8.22	433	0.28	103.8	10
	12:59:58	4	15.6	7.5	462	0.30	36	3.58
	13:03:27	6	12.3	7.34	495	0.32	4.9	0.52
	13:06:06	7	10.3	7.37	509	0.33	5	0.56
	13:08:37	8	9.8	7.37	524	0.34	4.7	0.53
	13:10:23	8.8	9.6	7.39	536	0.34	4.5	0.51
Melchett Mere	**04/10/00**							
1	12:18:08	0.4	14.1	7.72	436	0.28	87.7	9.01
	12:21:34	1	13.9	7.76	436	0.28	85	8.76
	12:24:01	2	13.8	7.76	437	0.28	82.3	8.51
	12:26:48	3	13.7	7.77	436	0.28	82.6	8.56
	12:30:02	4	13.7	7.79	435	0.28	81.1	8.41
	12:33:04	4.9	13.7	7.79	437	0.28	79.7	8.26
3	13:01:13	0.4	14.0	7.96	436	0.28	90.3	9.29
	13:05:01	2	14.0	7.95	435	0.28	88.5	9.11
	13:07:54	4	14.0	7.95	436	0.28	87.6	9.02
	13:11:07	6	13.7	7.9	436	0.28	82.4	8.55
	13:16:27	7	13.5	7.79	441	0.28	72.9	7.58
	13:20:12	8	10.3	7.47	559	0.36	5.2	0.59
	13:23:00	9	9.9	7.45	580	0.37	4.5	0.51
	13:26:09	10.2	9.6	7.48	606	0.39	4.3	0.49
Tabley Mere	**11/04/00**							
1	09:56:54	0.2	10.1	9.02	794.2	0.51	186.8	21
	10:02:29	0.7	9.8	8.89	865.3	0.55	155.1	17.53
2	10:21:58	0.2	9.7	9.18	720	0.46	155.5	17.63
	10:25:10	1	9.6	9.11	723.8	0.46	146.4	16.65
	10:29:14	2	8.9	8.97	732	0.47	115.4	13.32
	10:32:35	3	8.5	8.87	736.4	0.47	109	12.72
	10:35:48	3.4	8.4	8.83	737.4	0.47	103.4	12.09
3	104609	0.1	9.2	9.22	709	0.45	145.5	16.7
Tabley Mere	**18/07/00**							
1	09:27:35	0.4	18.5	7.47	629	0.40	63.8	5.96
	09:30:53	1.3	18.0	7.45	625	0.40	49.1	4.64
2	09:44:58	0.4	18.4	9.39	572	0.37	150.5	14.1
	09:48:02	1	18.2	9.3	575	0.37	119.7	11.25
	09:51:02	2	16.3	8.6	592	0.38	55.8	5.46
	09:54:24	3	15.5	8.03	601	0.38	6.4	0.64
	09:57:09	3.8	15.2	7.93	606	0.39	4.4	0.44
3	10:11:56	0.4	18.5	9.4	572	0.37	152.5	14.26
	10:14:15	0.8	18.3	9.33	576	0.37	137.2	12.89

Tabley Mere	**04/10/00**							
1	09:31:35	0.4	12.8	7.19	634	0.41	52.8	5.58
	09:34:59	1.3	12.8	7.23	637	0.41	51.1	5.4
2	09:53:36	0.4	13.5	7.69	544	0.35	70.3	7.31
	09:57:19	1	13.4	7.71	544	0.35	69.5	7.25
	10:00:06	2	13.3	7.74	544	0.35	67.8	7.08
	10:02:58	3	13.1	7.73	544	0.35	65.8	6.91
	10:05:58	3.9	13.0	7.71	549	0.35	62.2	6.54
3	10:18:26	0.3	13.2	7.9	543	0.35	81.5	8.54
Tatton Mere	**11/04/00**							
1	15:22:28	0.1	8.7	8.38	494.6	0.32	98.4	11.44
	15:25:22	2	8.6	8.38	494.9	0.32	96.8	11.29
	15:29:08	4	8.5	8.37	494.3	0.32	95.6	11.17
	15:32:51	5.9	8.4	8.36	494.5	0.32	94.5	11.06
2	15:42:05	0.1	9.1	8.4	495.3	0.32	99.7	11.48
	15:45:09	2	8.7	8.4	494.5	0.32	97.6	11.33
	15:47:49	4	8.4	8.38	494.5	0.32	95.6	11.2
	15:50:07	6	8.1	8.37	495.4	0.32	93.2	10.99
	15:53:47	8	7.5	8.28	496.3	0.32	81.1	9.71
	15:55:55	8.8	7.4	8.22	497.4	0.32	74.6	8.94
Tatton Mere	**18/07/00**							
1	14:29:32	0.4	20.0	8.76	477	0.31	128.7	11.69
	14:31:42	2	17.9	8.75	476	0.31	124.9	11.83
	14:35:14	4	16.4	8.06	482	0.31	78.2	7.65
	14:37:56	6	16.1	7.85	485	0.31	57.3	5.64
2	14:50:07	0.4	19.6	8.82	477	0.31	131	11.99
	14:52:24	2	17.9	8.76	477	0.31	122	11.56
	14:55:35	4	16.4	8.17	483	0.31	82.8	8.09
	14:58:45	6	16.1	7.95	485	0.31	64.4	6.33
	15:00:32	8	12.9	7.78	546	0.35	8.1	0.85
	15:14:39	8	12.5	7.84	548	0.35	5.4	0.58
	15:17:59	10	10.7	8.1	565	0.36	5	0.56
3	15:28:54	0.5	19.4	8.85	475	0.30	129.6	11.91
	15:31:27	2	17.4	8.66	478	0.31	111.8	10.7
	15:34:47	4	16.5	8.24	483	0.31	84	8.19
	15:37:39	6	16.1	8.03	483	0.31	68.2	6.71
	15:41:42	8	12.8	7.83	545	0.35	6.3	0.66
	15:45:21	9	10.9	8.13	565	0.36	5	0.55
Tatton Mere	**04/10/00**							
1	14:49:17	0.4	14.1	8.05	475	0.30	73.7	7.57
	14:53:42	2.1	14.1	8.01	475	0.30	71	7.29
	14:57:04	4	14.0	7.99	476	0.30	67.2	6.92
	14:59:57	6	13.9	7.97	477	0.31	67.4	6.95
	15:04:01	7.6	13.9	7.97	477	0.31	65.9	6.81
2	15:16:17	0.4	14.1	8	476	0.30	73.1	7.5
	15:20:49	2	14.1	7.99	476	0.30	72.2	7.41
	15:23:09	4	14.1	7.99	476	0.30	71.8	7.37
	15:26:05	6	14.1	7.97	476	0.31	69.8	7.17
	15:29:26	8	14.0	7.95	476	0.30	68.1	7.01
	15:34:28	10	13.9	7.93	479	0.31	62.9	6.5
	15:39:15	10.5	13.8	7.95	482	0.31	61.8	6.39
	15:44:36	11.2	13.7	7.96	483	0.31	53.7	5.56
3	15:53:56	0.4	14.2	8.04	476	0.30	77.4	7.93
	15:57:08	2	14.2	8.04	476	0.30	76.4	7.83
	15:59:27	4	14.2	8.03	475	0.30	76.4	7.83
	16:02:31	6	14.2	8.02	475	0.30	76.3	7.81
	16:05:27	7.2	14.1	8.01	475	0.30	73.8	7.57
Oak Mere	**19/07/00**							
At Buoy	13:21:09	0.4	19.6	5.71	87	0.06	98.4	9.01
	13:23:55	1	19.7	5.67	87	0.06	97.5	8.93
	13:27:09	2	19.6	5.58	87	0.06	97.4	8.92
	13:31:48	3	17.0	5.39	87	0.06	84.4	8.16
	13:33:24	4	16.2	5.39	86	0.06	82.6	8.11
	13:35:58	5	16.1	5.29	87	0.06	75.2	7.41
	13:38:50	6	16.0	5.23	87	0.06	69.7	6.89
	13:40:51	6.7	16.0	5.28	87	0.06	67.3	6.64

APPENDIX 2: RAW DATA - NUTRIENT AND ALGAL CONCENTRATIONS

Stillwater	Date/Time	Site	Secchi m	Susp. Solids mg/l	Chlorophyll µg/l	Phaeophytin µg/l	Alkalinity mg/l	Total P µg/l	Ortho - µg/l
Hatchmere	10-Apr-00								
	1400	Top1	0.8	9	42.1	22.4	87.6		4.2
	1401	Bot1							8.7
	1415	Top 2	0.9	8	39.4	36.4	88.2		3.9
	1416	Bot 2							< 1
	1430	Top 3	0.9	6	37.7	28.4	78.6		4.6
	1431	Bot 3							4.2
	19-Jul-00								
	935	Top 1	1.1	14	46.1	37.9	119	51	
	936	Bot 1							< 1
	1005	Top 2	1.1	10	45.4	31.5	118	57	
	1006	Bot 2							< 1
	1030	Top 3	1.1	14	51	30.4	116	54	
	1032	Bot 3							< 1
	03-Oct-00								
	1420	Top 1	0.9	11	52.2		135	88	4.18
	1421	Bot 1							2.73
	1445	Top2	0.95	10	57.5		135	98	< 1
	1446	Bot 2							2.16
	1510	Top 3	0.9	11	67.5		135	93	3.13
	1511	Bot 3							2.66
Marbury Big Mere	10-Apr-00								
	910	Top1	2.4						122
	911	Bot 1							116
	940	Top 2	2.2						120
	941	Bot 2							128
	955	Top 3	2.4						124
	956	Bot 3							148
	17-Jul-00								
	1330	Top 1	0.4	34	136	97.5	158	221	
	1331	Bot 1							671
	1415	Top 2	0.35	58	109	86.2	147	200	
	1416	Bot 2							450
	1445	Top 3	0.4	48	93.4	70.4	156	196	
	1446	Bot 3							150
	02-Oct-00								
	1330	Top 1	1.2	8	37.4	27.2	173	366	323
	1331	Bot 1							509
	1405	Top 2	1.2	10	37.5	28	173	338	315
	1406	Bot 2							341
	1420	Top 3	1.1	8	32.4	22.2	173	373	327
	1421	Bot 3							328

P	Total N µg/l	Nitrate µg/l	Nitrite µg/l	Ammonia µg/l	Silicate µg/l
	6160	6150	14.8	51.8	4530
	6240	6230	13.6	106	4500
	6010	6000	14.1	50.3	4580
	6220	6210	14.3	96	4520
	6120	6110	14	51.6	200
	6170	6160	13.8	71.7	4370
	2010	1990	27.2	25.4	374
	2200	2170	29.8	21.8	324
	2050	2030	27.2	31.2	373
	2140	2110	30.3	30.3	456
	2010	1980	27.9	39.8	356
	1990	1970	28.1	10.2	390
	596	583	13.2	84.6	1110
	558	546	11.8	82	1160
	599	587	12.5	66.5	1160
	570	557	13.4	80	1120
	596	584	12.2	58.7	1080
	586	574	12.3	62.8	1120
	4820	4780	44.3	43.7	388
	4790	4750	45	76.5	294
	4770	4730	43.7	46.5	201
	4830	4790	45.4	140	587
	4850	4810	44.3	46.3	380
	4740	4690	45.5	70.9	288
			< 1	6.98	1130
	88.2	79	8.73	2100	5330
	< 2.5	< 2.5	< 1	6.7	1240
	504	490	13.9	1440	3680
	< 2.5	< 2.5	< 1	6.47	1230
	403	373	29.5	423	1980
	560	516	43.7	737	3910
	394	346	48	1530	4660
	583	542	41.4	671	3810
	570	529	40.9	781	3860
	545	502	43.1	731	3840
	590	546	43.8	720	3860

Stillwater	Date/Time	Site	Secchi m	Susp. Solids mg/l	Chlorophyll µg/l	Phaeophytin µg/l	Alkalinity mg/l	Total P µg/l	Ortho µg/l
Combermere	10-Apr-00								
	1115	Top 1	1.8						73.2
	1116	Bot 1							84.3
	1140	Top 2	1.8						76.5
	1141	Bot 2							84.5
	1200	Top 3	1.7						73.4
	1201	Bot 3							72.7
	17-Jul-00								
	1000	Top 1	1.2	11	41	31.5	163	89	6.05
	1001	Bot 1							734
	1050	Top 2	1.2	9	29.7	21.9	163	78	10.4
	1051	Bot 2							648
	1120	Top 3	1.4	20	35.8	26.5	165	85	11.6
	1121	Bot 3							320
	02-Oct-00								
	1025	Top 1	1.4	10	66.6	44.5	158	193	148
	1026	Bot 1							1230
	1055	Top 2	1.5	19	54.7	25.9	157	187	144
	1056	Bot 2							1160
	1120	Top 3	1.6	7	36.3	28.1.	159	190	165
	1121	Bot 3							168
Tabley Mere	11-Apr-00								
	1035	Top 1	0.58						19.6
	1036	Bot 1							90.1
	1110	Top 2	0.5						8.6
	1111	Bot 2							8.5
	1137	Top 3	0.5	21	87.8		117		4.4
	1135	Bot 3							7.9
	18-Jul-00								
	855	Top 1	1.4	5	3.66	1.92	138	352	302
	856	Bot 1							301
	920	Top 2	0.8	17	162	22	101	261	4.01
	921	Bot 2							197
	950	Top 3	0.7	18	164	19	101	261	1.08
	951	Bot 3							11.5
	04-Oct-00								
	912	Top 1	1.2	b 5	13.3	10.5	156	198	138
	913	Bot 1						196	159
	949	Top 2	0.8	10	33.3	22.9	140	191	133
	950	Bot 2						182	159
	1040	Top 3	0.4	b 7	27.7	20.6	137	185	158
	1041	Bot 3							109

P	Total N µg/l	Nitrate µg/l	Nitrite µg/l	Ammonia µg/l	Silicate µg/l
	1100	1090	10.2	44.4	417
	1280	1270	9.8	105	1230
	1090	1080	10.1	51.6	154
	1220	1210	10.1	101	1110
	1120	1110	10.6	57.2	175
	1230	1220	10.1	73.7	525
	< 2.5	< 2.5	1.64	4.52	394
	< 2.5	< 2.5	2.39	1620	9510
			1.94	8.44	409
	< 2.5	< 2.5	1.66	1390	9070
	< 2.5	< 2.5	1.11	4.73	445
	< 2.5	< 2.5	< 1	580	4610
	105	96	8.53	84.8	1960
	12.2	8.23	3.97	3500	11000
	129	119	10.4	104	2090
	< 3	< 2.5	2.75	3140	1070
	190	179	10.9	168	2330
	178	167	10.8	176	2400
	6790	5870	919		107
			80.3	646	286
	4420	4380	43.7		446
			41.4		
	2530	2490	38.4	39.3	346
	3520	3480	37.8		327
	3840	3170	669	1070	1910
	3700	3020	682	1020	1790
	3.09	< 2.5	5.41	698	2410
	45.6	31.8	13.8	86.3	4940
	< 2.5	< 2.5	3.05	219	2360
	6.21	3.4	2.8	681	2410
	7000	6500	498	563	9900
	7000	6780	220	571	9540
	2790	2680	104	212	5530
	2750	2640	108	186	5330
	2720	2600	117	130	5220
	2810	2690	120	129	5290

Stillwater	Date/Time	Site	Secchi m	Susp. Solids mg/l	Chlorophyll µg/l	Phaeophytin µg/l	Alkalinity mg/l	Total P µg/l	Ortho - µg/l
Melchett Mere	11-Apr-00								
	1330	Top 1	2.9	3	4.28	4.28	143		< 1
	1331	Bot 1							1.7
	1400	Top 2	3.3	3	3.12	3.12	142		< 1
	1401	Bot 2							< 1
	1425	Top 3	3.1	6	5.09	4.22	143		< 1
	1426	Bot 3							1.3
	18-Jul-00								
	1135	Top 1	2.6	4	7.85		138	18	
	1136	Bot 1							< 1
	1205	Top 2	2.6	6	8.66	1.72	102	18	
	1206	Bot 2							< 1
	1230	Top 3	2.6	3	7.14	1.72	101	13	
	1231	Bot 3							< 1
	04-Oct-00								
	1158	Top 1	1.75	5	38.3	28.1	145	43	
	1159	Bot 1							
	1238	Top 2	1.75	5	42.3	25.8	146	24	< 1
	1239	Bot 2							5.94
	1255	Top 3	1.5	5	42.4	26.4	145	37	< 1
	1256	Bot 3							22.2
Tatton Mere	11-Apr-00								
	1605	Top 1	5.8	< 3	3.39	3.39	140		25.7
	1606	Bot 1							25.1
	1630	Top 2	6	3	2.68	2.68	140		26.4
	1631	Bot 2							27.2
	1655	Top 3	5.4	4	3.39	3.39	146		31.4
	1656	Bot 3							25.1
	18-Jul-00								
	1405	Top 1	1.5	6	17.3	3	102	68	19.1
	1406	Bot 1							42.4
	1425	Top 2	1.6	5	18.7	3.5	102	68	16.2
	1426	Bot 2							189
	1500	Top 3	1.6						168
	1501	Bot 3							23.9
	04-Oct-00								
	1442	Top 1	1.3	6	24	17.3	134	133	88.1
	1443	Bot 1							92.3
	1510	Top2	1.3	6	34.4	12.7	135	123	88.8
	1511	Bot 2							98.6
	1553	Top 3	1.3	6	38.8	22.5	134	134	91.3
	1554	Bot 3							84.8

P	Total N µg/l	Nitrate µg/l	Nitrite µg/l	Ammonia µg/l	Silicate µg/l
	379	375	4.3	26.7	7010
	403	398	5.33	36.4	7120
	397	392	4.77	30	7060
	373	369	4.42	34.4	7640
	364	360	3.6	28	7290
	424	420	4.48	66.3	8000
	< 3	< 2.5	< 1	8.36	3570
	16.3	12.4	3.92	46.6	6870
	< 2.5	< 2.5	< 1	3.9	3620
	< 2.5	< 2.5	1.26	121	6750
	< 2.5	< 2.5	< 1	< 3	3790
	3.13	< 2.5	1.5	535	10100
	15.6	12.6	2.97	55	6860
	16.5	13.9	2.56	62.9	6900
	17.5	14.5	3.04	52	6590
	6.39	3.49	2.9	1100	13500
	14.4	11.7	2.67	43	6780
	< 3	< 2.5	4.02	1410	14600
	246	240	5.79	92	1080
	284	279	4.68	89.4	1050
	292	287	4.6	94.5	998
	286	281	4.69	95.3	1380
	230	225	4.7	114	1140
	298	294	4.46	92.7	1060
	< 2.5	< 2.5	< 1	< 3	2730
	9.63	4.9	4.74	9.56	4170
	< 2.5	< 2.5	< 1	4.45	2740
	< 2.5	< 2.5	1.37	1100	11600
	10.3	< 2.5	7.87	703	9400
	< 2.5	< 2.5	1.01	< 3	2860
	118	112	6.07	174	6530
	115	109	5.92	213	6380
	111	106	5.09	163	6170
	112	106	5.68	327	6810
	113	107	5.65	158	6340
	111	106	5.39	152	6450

APPENDIX 3: RAW DATA - OAKMERE CONTINUOUS MONITORING, NUTRIENT AND ALGAL CONCENTRATIONS FOR 2000

Date	Time	Position	Secchi (m)	Sus.solids (mg/l)	Chlorophy (µg/l)	Phaeophyti (µg/l)	Total P (µg/l)	Ortho-P (µg/l)	Ammonia (µg/l)	Nitrate (µg/l)	Nitrite (µg/l)	Silicate (µg/l)
06/01/00	11:00	Top	2.7	< 3	17.7	16.2		6.3	16	33.8	1.7	647
	10:36	Bottom						6.7	38.2	56.6	1.8	651
02/02/00	11:00	Top	1.9	4	28.2	26.3		3.3	15.2	< 3	1.4	351
	11:01	Bottom						4	12	15.1	1.5	385
09/03/00	10:30	Top	1.9	8	20.3	17.9		3.7	22.1	< 3	1.1	289
	10:31	Bottom						3.5	26.2	< 3	1.3	292
12/04/00	10:45	Top	1.8	8	34.4	24.2		8.3	29.2	< 2.5	1.96	69.7
	10:46	Bottom						7.06	31.3	6.57	< 1	78.4
02/05/00	09:50	Top	3.2	< 3	3.75	3.75		4.79	14.7	< 2.5	1.68	78.1
	09:51	Bottom						7.51	110	15	2.5	160
31/05/00	09:20	Top	2.3	4	9.1	9.1		4.94	4.02	< 3	1.61	45.1
	09:21	Bottom						6.6	5	< 3	1.35	62.8
23/06/00	09:00	Top		< 3	4.46	3.38		16.6	23.1	< 2.5	1.56	123
	09:01	Bottom						96	43.8	< 2.5	3.62	253
19/07/00	12:50	Top	3.6	4	5.36	4.93		3.78	4.74	< 2.5	2.3	167
	12:51	Bottom						11.2	24.2	< 2.5	2.12	244
23/08/00	12:45	Top	3	< 3	8.03	6.29		< 1	25.2	< 2.5	2.34	332
	12:46	Bottom						53.2	172	6.42	2.34	496
11/09/00	1350	Top		< 3	13	10.8			13.2	< 2.5	2.09	432
	1352	Bottom							43.2	< 2.5	2.09	491
31/10/00	12:30	Top	2	< 3	26	0	40	< 1	12.9	< 2.5	1.21	17.1
	12:31	Bottom						< 1	11.9	< 2.5	< 1	< 1
00/11/00	12:15	Top	2	4	14.9	13	39	9.27	85.6	43.1	2.22	574
	12:16	Bottom					48	10.6	94	45.1	2.28	580
13/12/00	10:00	Top	2	< 3	7.32	6.89	47	1.54	201	89.7	2.4	773
	10:01	Bottom					67	1.24	193	89	2.75	754

Appendix 1: Table 2: Density estimates for single targets within Tatton Mere from 600 ping subsets (- indicates insufficient volume sampled).

a) First horizontal run (21:31 – 22:43)

Pings:		4 – 20 m Range		20 - 35 m Range		35 – 50 m Range	
From	To	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}
0	600	151	18.13	-	-	-	-
600	1200	142	33.79	167	3.84	-	-
1200	1800	397	52.02	1259	37.70	1379	16.64
1800	2400	581	48.50	1474	48.06	879	10.53
2400	3000	489	46.58	1052	40.96	1001	11.74
3000	3600	650	62.17	1756	50.78	1254	14.42
3600	4200	694	56.66	239	10.41	-	-
4200	4800	1224	128.63	1361	38.68	600	6.04
4800	5400	848	143.41	1331	38.51	646	7.13
5400	6000	1418	129.35	1441	49.77	610	7.17
6000	6600	1168	102.20	862	28.44	220	3.01
6600	7200	-	-	-	-	-	-
7200	7800	-	-	-	-	-	-
7800	8400	750	69.06	861	22.77	429	4.87
8400	9000	281	21.49	666	21.07	327	3.40
9000	9600	250	27.07	225	6.66	-	-
9600	10200	484	55.53	-	-	-	-
10200	10800	1160	135.40	538	12.89	159	1.54
10800	11400	787	73.29	868	19.61	238	2.17
11400	12000	1241	132.42	873	21.17	102	0.87
12000	12600	1375	157.05	1709	42.02	398	3.95
12600	13200	630	80.55	251	6.12	-	-
13200	13800	1473	142.23	1784	48.47	313	3.17
13800	14400	491	43.31	-	-	-	-
14400	15000	398	40.41	-	-	-	-
15000	15155	-	-	-	-	-	-
	Min:		18.13		3.84		0.87
	Max:		157.05		50.78		16.64
	Mean:		78.23		28.84		6.44
	SD:		44.97		16.21		4.84
	CI (95%):		18.38		7.29		2.45

b) Second horizontal run (22:49 – 23:56)

Pings:		4 – 20 m Range		20 - 35 m Range		35 – 50 m Range	
From	To	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}	Number of Traces	Volume Density (Single Targets) fish.1000m^{-3}
0	600	192	17.09	-	-	-	-
600	1200	297	37.79	163	4.37	-	-
1200	1800	950	69.24	1366	32.39	642	5.22
1800	2400	570	58.04	862	13.99	321	2.32
2400	3000	866	69.62	951	21.83	220	1.42
3000	3600	989	101.20	860	19.99	158	1.23
3600	4200	548	47.58	399	12.58	36	0.33
4200	4800	790	126.65	379	9.33	66	0.45
4800	5400	1082	141.11	891	23.16	352	3.04
5400	6000	360	70.40	762	19.41	399	3.52
6000	6600	914	98.67	974	24.81	357	2.66
6600	7200	1064	64.72	909	21.01	280	2.07
7200	7800	297	40.96	47	1.09	-	-
7800	8400	92	13.55	-	-	-	-
8400	9000	655	56.43	275	5.71	151	1.11
9000	9600	1059	90.90	1199	34.99	172	1.75
9600	10200	568	53.05	239	4.94	-	-
10200	10800	836	104.63	637	16.48	160	1.44
10800	11400	1380	161.71	863	22.98	244	2.21
11400	12000	962	104.68	713	16.45	224	1.94
12000	12600	1241	152.42	877	21.90	160	1.41
12600	13200	1174	127.98	1413	31.34	380	3.16
13200	13800	495	42.68	196	5.04	-	-
13800	14400	905	75.60	1132	29.09	144	1.34
14400	15000	719	70.79	187	4.62	-	-
15000	15600	332	20.77	62	1.59	-	-
	Min:		13.55		1.09		0.33
	Max:		161.71		34.99		5.22
	Mean:		77.63		16.63		2.03
	SD:		41.07		10.28		1.18
	CI (95%):		15.79		4.11		0.55

Appendix 1: Table 3: Density estimates for single targets within Combermere from 600 ping subsets (- indicates insufficient volume sampled).

Pings:		4 – 20 m Range		20 - 35 m Range		35 – 50 m Range	
From	To	Number of Traces	Volume Density (Single Targets) fish.1000m⁻³	Number of Traces	Volume Density (Single Targets) fish.1000m⁻³	Number of Traces	Volume Density (Single Targets) fish.1000m⁻³
West – East Run							
0	600	-	-	-	-	-	-
600	1200	357	49.67	99	4.63	-	-
1200	1800	232	38.04	57	2.26	45	0.57
1800	2400	498	53.96	206	7.96	150	1.99
2400	3000	352	40.26	149	6.21	144	1.97
3000	3600	344	47.74	144	5.21	71	1.01
3600	4200	298	52.94	120	5.09	86	1.21
4200	4800	287	48.60	148	5.48	92	1.35
4800	5400	256	51.12	117	4.42	99	1.38
5400	6000	331	26.56	136	4.45	103	1.54
6000	6600	362	45.45	156	4.67	47	0.54
6600	7200	342	48.22	143	5.74	60	0.71
7200	7800	515	46.31	314	9.84	196	2.78
7800	8400	576	82.11	313	11.93	197	2.62
8400	9000	576	80.94	289	11.12	138	2.20
9000	9600	508	78.30	213	9.09	44	0.67
9600	10200	318	43.57	179	6.57	62	0.92
10200	10800	426	51.57	178	6.56	93	1.26
10800	11400	373	47.29	215	7.71	83	1.16
11400	12000	459	48.53	270	9.42	133	1.66
12000	12321	160	29.30	79	5.26	36	0.98
East – West Run							
0	600	433	80.93	158	4.95	58	0.74
600	1200	434	43.66	189	5.92	73	0.82
1200	1800	556	83.94	77	2.54	28	0.28
1800	2400	464	42.73	156	4.54	69	0.76
2400	3000	617	88.79	105	2.71	77	0.62
3000	3600	687	115.48	218	6.09	115	0.83
3600	4200	800	93.38	259	6.67	158	1.15
4200	4800	1029	124.19	295	10.49	162	1.22
4800	5400	506	68.90	150	4.37	63	0.72
5400	6000	379	53.91	130	4.59	82	1.04
6000	6600	509	59.26	230	8.92	188	2.46
6600	7200	352	47.96	153	5.08	70	0.87
7200	7800	358	41.64	178	5.95	87	1.00
7800	8400	347	77.41	156	5.77	65	0.94
8400	9000	267	36.61	139	4.27	113	1.73
9000	9600	337	47.60	136	4.15	115	1.50
9600	10200	379	68.22	238	8.15	141	1.68
10200	10800	350	49.55	214	7.57	75	0.70
10800	11400	244	35.54	157	5.32	114	1.52
11400	12000	215	30.47	144	5.46	106	1.48
12000	12504	181	29.58	86	3.59	30	0.37
	Min:		*26.56*		*2.26*		*0.28*
	Max:		*124.19*		*11.93*		*2.78*
	Mean:		***56.83***		***6.12***		***1.22***
	SD:		*22.58*		*2.29*		*0.60*
	CI (95%):		*6.91*		*0.70*		*0.19*

Appendix 2: Conversion of acoustic size (dB) to real size (fork length, FL) for all species.

(From Duncan and Kubecka, (1995) based on a mixed coarse stillwater fishery, 200kHz transducer, mean all aspect; TS = 22.5811.LogFL – 93.617)

Target Strength (dB)	Fish Length (cm)
50	8.54
47	11.6
44	15.75
41	21.39
38	29.04
35	39.43
32	53.54
29	72.7
26	98.72
23	134.05
20	182.02
17	247.16

Appendix 3: Glossary of terms

Transducer	Device for transmitting and receiving sound waves.
Echosounder	Device for controlling the characteristics of transmitted sound and transducer and returning echoes.
Single target	A single fish detected due to good separation form other fish in the water column.
Target strength (TS)	The reflected echo strength from a single fish in decibels (dB). The strength of the signal relates to the size of the fish.
No. of traces found	The number of fish that could be identified as single targets.
Volume density f/1000m^3	Estimate of the total number of fish per 1000m^3 of water.
Area density (trace)	A minimum estimate of fish density (in units of number of fish per hectare). This value is based on the detection of targets which the echosounder could identify as separate fish, those fish that were too close together are not counted here.
Area density (f/h)	Estimated total fish density (fish per hectare). This is calculated by a process of echo integration. The target strength of those fish that were detected as single targets are used to calculate total fish density. (i.e. this includes those fish that could not be separated as single targets.)
sa.	Total area back-scattering coefficient (sa in dB) "Relative energy received from all echoes by area"
sa.(tr)	Sa/sa for traces only, the area back-scattering coefficient for accepted single targets "Energy received from single fish targets by area"
sv	Sv/sv total, volume back-scattering strength (Sv in dB) "Relative energy received from all echoes by volume"
sv (tr)	Sv/sv for traces only, volume back-scattering strength for accepted single targets.
Trace	Accepted single target