PBA APPLIED ECOLOGY

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Baseline Survey of Diatoms, Macroinvertebrates and Water Quality

SEMER WATER

2012



Natural England

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31st January 2013

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Report title:	Baseline survey of diatoms, macroinvertebrates and water quality Semer Water, 2012
Edition:	3
Report date:	31st January 2013
Client:	Natural England
Originated by:	Neil Wilkinson, Martyn Kelly, Andy Blincow and Joseph Kelly
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Approved by:	P. Bradley (*Director*)
Circulation:	Natural England
Status:	Final

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1. Introduction

This project was delivered jointly by PBA Applied Ecology Ltd and Bowburn Consultancy.

The project specification was designed by Natural England (NE). The main aim of this project is to improve evidence of anthropogenic inputs to receiving watercourses. To achieve the aim, the project investigated water chemistry, diatoms and macroinvertebrate communities, and calculated biological indices at multiple sites throughout the sub-catchment of Semer Water Lake SSSI, in the Raydale catchment, in the Yorkshire Dales National Park. Diatoms are a useful indicator of inorganic nutrients and macroinvertebrates can be a useful indicator of organic pollution.

It is known that the Raydale catchment (in which Semer Water is placed) maybe subject to a range of point and diffuse sources of pollution. However, the source, timing and extent of the impacts had not been quantified. The project set out to identify of catchment components that are most in need of agricultural support in this context.

2. Site Description

Semer Water SSSI is one of only two natural lakes in the Yorkshire Dales National Park. It is located about 2.5km southwest of Bainbridge village. The lake is mostly very shallow with a mean depth of less than 1.0m. The lake is approx. 800m long, covers 31.71ha and lies at the heart of Raydale, opposite England's shortest river, the River Bain. Semer Water attracts canoes, windsurfers, yachtsmen and fishermen. The settlements of Stalling Busk, Marsett and Countersett are located within the catchment. Ownership of the lake lies with the landowner of the adjoining land; the lake is divided from its centre, radiating to the edge of the respective landowners boundary. There is a pay and display 'car park' on the shore of the eastern end of the lake. Otherwise, public rights of way in the locality do not get close to the shore line. The SSSI incorporates the lake and some surrounding land. The site incorporates two WFD water bodies, the lake itself and the River Bain. The status of the River Bain and Raydale Beck water body is currently moderate status according to the WFD cycle 1 classification, with good status targeted by 2027. Likewise, Semer Water is currently classified in moderate status with good status targeted by 2027.

The land use of the catchment is split between moorland, forestry and agriculture. The forestry is mainly in the upper catchment above Raydale, agriculture is generally in the lower land of the catchment with sheep on the higher ground and cattle on the lower ground, and finally moorland frames the catchment on three sides covering the highest land. The lake and surrounding areas are frequently visited by tourists; for walking and also for activities on the lake itself.

3. Approach

The methodology was based upon the specification set out in the project brief, additional detail and scheduling was agreed with Natural England (NE). The process of site selection methods of sampling and analysis, (including the parameters and indices used for water chemistry, macroinvertebrates and diatoms) are described below.

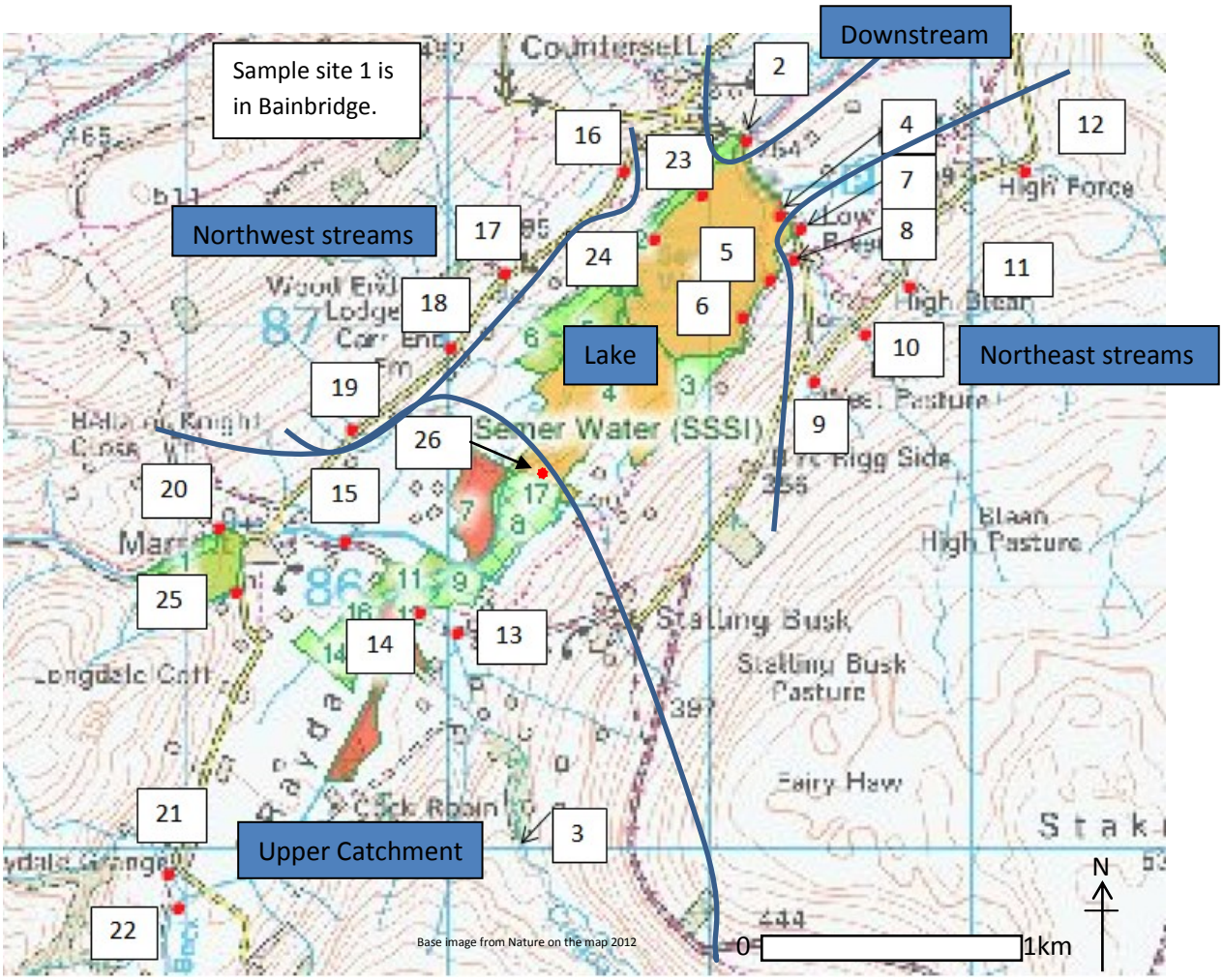
3.1 Sample Site Selection

Maps of the lake and sub-catchment were used to identify 26 potential sample areas and location of sample sites; selection of sample sites was based upon isolating either individual tributaries or inputs to the system, or isolating sections of the catchment. Where possible an upstream and downstream sample was located and taken around potential pollution sources.

Initial scoping by Neil Wilkinson and Martyn Kelly during January 2012 involved visiting proposed sampling sites to assess access and viability for sampling.

The chosen locations of sample sites were agreed with NE Project Manager, Ruth Bull (Figure 1).

Figure 1. Sampling locations



3.2 Sample Site Description

A field survey pro-forma was drafted and agreed with NE, to allow all required environmental variables and location information to be recorded. This pro-forma was completed at each sample site. Laboratory results and biological index results were added later. Completed pro-formas for each sample site for each season are presented in Appendix 1-3 to this report (MS Excel file).

To assist interpretation, five geographical sampling units are recognised, as set out below in Table 1.

Table 1. Sampling units

	Sampling Area	Sample sites	SSSI units	WFD ID	Grid ref
A	**Upstream of the Lake**	3		GB104027069400	SD 91259 85355
		13		GB104027069400	SD 91009 85825
		14	12	GB104027069400	SD 90839 85965
		15		GB104027069400	SD 90609 86188
		20		GB104027069400	SD 90273 86240
		21		GB104027069400	SD 90005 84810
		22		GB104027069400	SD 89981 84877
		25		GB104027069400	SD 90191 85989
		26	4	GB104027069400	SD 91386 86823
B	**Northeast Streams**	7		GB104027069400	SD 92264 87321
		8		GB104027069400	SD 92251 87204
		9		GB104027069400	SD 92402 86812
		10		GB104027069400	SD 92565 86992
		11		GB104027069400	SD 92734 87171
		12		GB104027069400	SD 93195 87608
C	**Semer Water Lake shore**	4	1	GB30429479	SD 92181 87510
		5	1	GB30429479	SD 92153 87108
		6	1	GB30429479	SD92123 87011
		23	1/2	GB30429479	SD91802 87376
		24	1/2	GB30429479	SD 91761 87317
D	**Northwest Streams of the Lake**	16		GB104027069400	SD 91689 87606
		17		GB104027069400	SD 91206 87207
		18		GB104027069400	SD 91034 86913
		19		GB104027069400	SD 90646 86602
E	**Downstream of the Lake**	1	1	GB104027069400	SD 93469 90156
		2		GB104027069400	SD 92166 87732

3.3 Timing of Sampling

Winter macroinvertebrate, diatom, laboratory and field water quality sampling took place on the 25/01/12, 30/01/12 and 31/01/12. Summer macroinvertebrate, diatom and field water quality sampling took place on 16/08/12 and 17/08/12. Autumn macroinvertebrate, diatom and field water quality sampling took place on 02/10/12 and 03/10/12. Autumn sampling was affected by high flows in the River Bain and high lake levels. The order of site sampling was changed to allow levels to recede. Additionally, four diatom sample (Sites 6, 10, 13 and 18) labels were damaged in transit. These samples were retaken on the 18/10/12; it is not expected that the sampling will have been affected by the time difference. The timing of sampling visits was influenced by Natural England procurement, and by prevailing weather conditions.

3.4 Water Chemistry

A total of 15 parameters were recorded at each sample location.

3.4.1 Field sampling

Temperature, pH, conductivity and TDS were recorded during each sampling season using Hanna HI98129 and HI9416 meters (Table 2). Four replicates were taken and a mean calculated for each site.

Table 2. Parameters recorded in the field

Parameter	Sample Range
Temperature	0.0°C – 60.0°C
pH	pH0.00 – pH14.00
Conductivity	0.00 µS/cm – 3999.00 µS/cm
TDS	0.00ppt – 10.00ppt
Dissolved Oxygen Saturation	0.0% – 300.0%
Turbidity	0.00 – 1000 FTU
Alkalinity(Summer and Autumn)	0.00 – 300 mg/l $CaCO_3$

Four replicates were taken and a mean calculated for each site.

3.4.2 Laboratory sampling (winter sampling season only)

Laboratory analysis was undertaken by Severn Trent Services (STS). Samples were collected in clean bottles supplied by STS. Each water sample was double coded, packaged and chilled. Water samples were collected on the 25/01/2012 and were analysed by STS on 27/01/2012. This complied with the stabilisation interval (2 days) set out by STS for the required determinands and limits of detection. Table 3 lists the determinands and limits of detection reported by laboratory analyses.

Table 3. Parameters and limits of detection reported from laboratory analysis

Parameters	Limit of Detection	Accreditation
Ammonia	0.27mg/l	UKAS
Nitrogen Total Oxidised	0.29mg/l	UKAS
Nitrogen Nitrate as N	0.29mg/l	UKAS
Alkalinity	2.2mg/l calcium carbonate	UKAS
Total Hardness	2.0mg/l	UKAS
Calcium	0.38mg/l	UKAS
Chlorophyll 'a'	0.05ug/l	None
Total Phosphorus	0.019mg/l – report below	UKAS
Filtered Phosphorus	0.019mg/l – report below	UKAS
BOD	1.00mg/l	UKAS
Suspended Solids	0.5mg/l	UKAS

3.5 Diatoms Sampling

Winter diatom sampling took place on the 30/01/12 and 31/01/12. Summer diatom sampling took place on 16/08/12 and 17/08/12. Autumn diatom sampling took place on 02/10/12 and 03/10/12. Autumn sampling was affected by high flows in the River Bain and high lake levels. The order of site sampling was changed to allow levels to recede. Additionally, four diatom sample (Sites 6, 10, 13 and 18) labels were damaged in transit. These samples were retaken on the 18/10/12, it is not expected this will affect the results. The timing of samples was influenced the NE procurement schedule.

Diatoms were sampled following standard Environment Agency protocols: the upper surface of at least five cobble-sized stones were brushed vigorously with a clean toothbrush in order to remove the biofilm, which was collected in a white plastic tray containing approximately 50 ml of stream or lake water. The resulting suspension was stored in a polypropylene bottle and preserved in 70% ethanol. Sub-samples from each bottle were digested with hydrogen peroxide to remove organic matter and the cleaned suspensions were mounted in Naphrax to give permanent slides. At least 300 diatom valves (standard target number) were identified to

species from each sample and the relative abundances of each taxon were calculated. The main floras used were Krammer and Lange-Bertalot (1986-2004) and Hofmann *et al*. (2009).

A range of metrics were calculated to summarise ecological status at each site: These are based around calculations included in the DARLEQ software, used for classification of freshwaters throughout the UK by statutory agencies. The most important of these metrics is the Trophic Diatom Index (TDI) measures the response of the diatom assemblage to inorganic nutrients; this can be converted to an Ecological Quality Ratio (EQR) by calculation of an expected TDI (eTDI) for each site. The eTDI in use at present will be replaced for the second River Basin Monitoring Programme (M.G.Kelly *pers comms*) and EQRs based on both variants have been computed here (referred to as TDIs and TDI4). The differences between these outcomes are relatively minor, but a few sites change status class as a result of the revised equation. A separate metric is used for lakes; again, the original version (LTDI1) has been updated for RBMP2 (LTDI2) and both variants are reported here.

The Diatom Acidification Metric (DAM) measures the sensitivity of the diatom assemblage to acidity and, like the TDI, can be converted to an EQR by calculation of the expected value for each site (eDAM). The resulting EQR gives an indication of the scale of acidification at a site. EQRs based on DAM are not formally used for classification at this stage; results are presented for information. DAM was developed and calibrated for soft running waters but results should be broadly indicative for other types of water body too.

Finally, the percent motile valves (motility) measures the proportion of diatoms in a sample which belong to motile species. These use their motility to overcome resource (*e.g. light*) limitation. Such limitation may occur for a number of reasons (*competition from other algae, for example*) and, sometimes, follow predictable seasonal patterns. However, part of the signal may be due to anthropogenic factors (*e.g. increased siltation*). In order to assess the extent of this, the relationship between percent motile valves and altitude (as a proxy for stream energy) at high status (*i.e. unimpacted*) sites was used to generate expected values for any site. This metric is still under development, and values are, again, presented here for information only. Table 4 gives boundary values for ecological status classes for each of the metrics used here.

Table 4. Boundary values for WFD ecological status classes derived from diatom assemblages (all based on site-specific predictions, with the exception of the lake TDI, which is a type-specific model; Semer Water belongs to the "high alkalinity" type)

Boundary	River TDI		Lake TDI		DAM	Motility
	TDI3	TDI4	LTD1	LTD2		
High	>0.93	>1.00	>0.90	>0.92	>0.81	>1.00
Good	0.78 - 0.93	0.75 – 1.00	0.63 – 0.90	0.70 – 0.92	0.65 – 0.81	0.75 – 1.00
Moderate	0.52 - 0.78	0.50 – 0.75	0.44 – 0.63	0.47 – 0.70	0.44 – 0.65	0.50 – 0.75
Poor	0.26 - 0.52	0.25 – 0.52	0.22 – 0.44	0.24 – 0.47	0.22 – 0.44	0.25- 0.50
Bad	<0.26	<0.25	<0.22	<0.24	<0.22	<0.25

3.6 Aquatic Macroinvertebrate Community Sampling

Winter macroinvertebrate sampling took place on the 30/01/12 and 31/01/12. Summer macroinvertebrate, sampling took place on 16/08/12 and 17/08/12. Autumn macroinvertebrate, sampling took place on 02/10/12 and 03/10/12. Autumn sampling was affected by high flows in the River Bain and high lake levels and therefore, the order of site sampling was changed to allow levels to recede.

Standard 1 minute look around for macroinvertebrates followed by a 3 minute kick sample using a 250µm net was conducted at all flowing water sites. The method and equipment used was as specified in the WFD UKTAG

River Assessment Methods Benthic Invertebrate Fauna 2008 document (WFD, 2009). Samples were preserved in 70% ethanol, in wide mouthed 250ml HDPE sample bottles.

Identification was completed to family level for the majority of taxa, using a binocular stereo microscope and relevant keys. Individual invertebrate sample id counts were recorded as actual number for <10 individuals, to nearest 10 for <60 individuals and 60-100 and 100+ individuals. A sub-sample was quality assessed by a senior invertebrate taxonomist. Once checks were complete, BMWP, NTAXA and ASPT were recorded for each sample. The samples were then analysed using River Invertebrate Classification Tool (RICT) to gain WFD classifications.

Stillwater samples followed methods set out in the WFD Lake Assessment Methods Benthic Invertebrate Fauna (2008) (as used for LAMM). This comprised 3-minutes kicking with figure of 8 sweeps of the net through the disturbed material. A 1-minute look around was completed before active sampling. Identification followed as for river sample.

3.6.1 BMWP

The Biological monitoring working party (BMWP) Score is an index for assessing water quality by assigning a value to the sensitivity of macroinvertebrate taxa to organic pollution. The development of this method is described in Hawkes (1997). The combined score of identified taxa can then be then interpreted, as in table 5 below. The presence of families of *Plecoptera* (stonefly), *Ephemeroptera* (mayfly) and *Trichoptera* (caddis flies), suggest good water quality. The presence of only Oligochaeta (worms) would suggest possible organic pollution when high scoring taxa are not present. Sites with BMWP scores of 100 and above are usually regarding as exhibiting good water quality (Mason, 2002).

Table 5. BMWP score categories

BMWP Score	Category	Interpretation
0 – 10	Very poor	Heavily polluted
11 – 40	Poor	Polluted or impacted
41 – 70	Moderate	Moderately impacted
71 – 100	Good	Clean but slightly impacted
> 100	Very good	Unpolluted / unimpacted

3.6.2 NTAXA

The number of taxa (NTAXA) is the sum of BMWP scoring families in a sample and provides a simple measure of the diversity of families present in a sample.

3.6.3 ASPT

The Average Score per Taxon (ASPT) is a further index of organic pollution. The index takes the BMWP score and divides by the NTAXA value. The ASPT score is therefore not affected by the diversity of invertebrates present. ASPT shows the sensitivity of the community present at a site to organic pollution and is a good indicator of environmental stress (Armitage *et al*., 1983). Higher ASPT scores show there are high scoring taxa present. Low ASPT scores can show that there are few or no high scoring taxa present.

Table 6. ASPT indication of water quality

Water Quality	ASPT Score
Excellent	> 5.4
Very Good	4.8 – 5.4
Good	4.3 – 4.8
Moderate	3.6 – 4.3
Poor	3.0 – 3.6

(Note: this table is a guide and is not definitive)

3.6.4 PSI (Proportion of Sediment-sensitive Invertebrates)

The proportion of sediment sensitive invertebrates (PSI) indices is a relatively new tool, used to assess the proportion of taxa present in a sample that are sensitive to sediment (Extence *et al*., 2011). Each family is given a sensitivity class and then the abundance of each family is taken into account to generate a value. The total score of sensitive taxa is then divided by the total score of all present taxa, to generate a proportion. Sediment affects sensitive taxa by clogging up gills and mouthparts. The index was calculated for all three sampling seasons. The tool is still relatively new; therefore, these results are given as an indication of siltation and have not been processed using RICT.

Table 7. Interpretation of PSI scores

PSI	River bed condition
81-100	Minimally sedimented/unsedimented
61-80	Slightly sedimented
41-60	Moderately sedimented
21-40	Sedimented
0-20	Heavily sedimented

(Extence *et al.,* 2011)

3.6.5. RICT

The River Invertebrate Classification Tool (RICT) is the newest version of RIVPACS software, designed to be compatible with WFD analysis (WFD 100 Final Report 2010). Environmental and invertebrate indices data were entered into the software. The RICT online software (http://www.sepa.org.uk/science_and_research /what_we_do/monitoring_and_reporting/ecology/rict.aspx) calculates the expected NTAXA and ASPT scores.

To gain a WFD classification for each site, winter, summer and autumn combined samples (of family level identification) were used with environmental data collected in each season. RICT uses the environmental data to calculate reference adjusted expected values. . These expected values were compared against the observed values to gain an Ecological Quality Ratio (EQR). The EQR is calculated by dividing the observed score by the generated expected score. The EQR value was then used to give the site a WFD classification using the RICT tool.

Analysis was also completed on the single season samples to investigate changes between seasons. These indices are described in the results section.

4. Water Chemistry

Water chemistry was subjected to a two-tier analysis, firstly in the field for physical water quality parameters during all seasons, and secondly winter season only water samples sent for detailed chemical analysis by STS Analytical. The results of these analyses are presented in geographical units as outlined in table 1. The raw data for physical and chemical water sampling for each individual site are presented in the field survey pro-formas in Appendix 1-3. The laboratory water chemistry data are summarised in Appendix 4. The UK Technical Advisory Group on the Water Framework Directive (UKTAG) is developing environmental standards and conditions to underpin the implementation of the Directive. The most current standards for physio-chemical water quality developed by the technical group within both rivers and lakes have been utilised within this report and where appropriate are displayed for the associated parameters within tables.

4.1 Field Sampling

Ranges of temperature, pH, conductivity, dissolved oxygen and alkalinity across seasons are displayed within the tables below.

4.1.1 UKTAG waterbody/river typology

In order to determine the biota and water quality of UK rivers a broad typology has been developed, utilising altitude and alkalinity. This basic typology is displayed in Table 8.

Table 8. UKTAG (2008a) basic typology of rivers

Site Altitude	Alkalinity (as mg/l CaCO3)				
	Less than 10	10 to 50	50 to 100	100 to 200	Over 200
Under 80 metres	Type 1	Type 2	Type 3	Type 5	Type 7
Over 80 metres			Type 4	Type 6	

Where the resulting standards for types are similar, the types are amalgamated. In each case the standards for combined types were then produced by combining their sets of data and performing the analysis on the combined set. This process allows the simplification of the typology into two types, as shown in Table 9 for dissolved oxygen and ammonia in rivers.

Table 9. UKTAG (2008a) final typology for oxygen and ammonia of rivers

Upland and low alkalinity	Types: (1+2), 4 and 6
Lowland and high alkalinity	Types: 3, 5 and 7

4.1.2 Temperature.

Table 10. Temperature results: recorded ranges for each season

	Winter	Summer	Autumn
Upstream of the lake	1.65 – 3.05°C	6.20 – 14.20°C	9-80 – 12.20°C
Northeast streams	2.90 – 4.75°C	13.60 – 15.50°C	9.00 – 9.77°C
Semer Water lake shore	0.80 – 3.48°C	17.10 – 18.40°C	9.30 – 9.60°C
Northwest streams	2.30 – 4.60°C	14.40 – 16.10°C	10.00 – 10.27°C
Downstream of the lake	2.48 – 2.70°C	18.00 – 18.50°C	9.75 – 9.80°C

4.1.3 pH

The effects of anthropogenic acidification are complex and UKTAG has currently retained the original standards for pH and acidity the first cycle of River Basin Management Plans. As pH is a logarithmic index, mean values were not derived. UKTAG status classifications for rivers are shown below (Table 11).

Table 11. UKTAG (2008a) standards for acid conditions in rivers

pH – all river types in England. Wales and Northern Ireland			
High	Good	Moderate	Poor
(5 and 95 percentile)		10 percentile	10 percentile
>=6 to <=9		4.7	4.2

Table 12. pH results: recorded ranges for each season

	Winter	Summer	Autumn
Upstream of the lake	7.38 – 7.59	8.02 – 8.44	7.40 – 7.70
Northeast streams	5.99 – 8.82	8.00 – 8.44	7.00 – 7.70
Semer Water lake shore	7.36 – 8.13	8.12 – 8.49	7.40 – 7.53
Northwest streams	7.12 – 7.43	8.25 – 8.30	7.25 – 7.69
Downstream of the lake	7.30 – 7.61	8.06 – 8.49	7.40 – 7.63

All bar one reading are within the good/high status boundary. The winter reading for SW11 was slightly below 6.

4.1.4 Conductivity

Electrical conductivity estimates the amount of total dissolved salts or ions dissolved in water. It is influenced by geology, the size of the watershed relative to the area of a lake, and a broad range of factors including agricultural runoff.

Table 13. Conductivity results: recorded ranges for each season

	Winter	Summer	Autumn
Upstream of the lake	220 – 300 µS/cm	70 – 210 µS/cm	50 - 120 µS/cm
Northeast streams	20 – 200 µS/cm	80 – 280 µS/cm	50 - 220 µS/cm
Semer Water lake shore	200 – 240 µS/cm	180 - 220 µS/cm	120 - 160 µS/cm
Northwest streams	260 – 380 µS/cm	247 – 320 µS/cm	140 - 250 µS/cm
Downstream of the lake	240 – 260 µS/cm	190 – 210 µS/cm	110 µS/cm

4.1.5 Dissolved Oxygen

Dissolved oxygen (DO) is reduced due to enhanced microbial respiration which may result from additions of organic matter, including; discharges from sewage treatment works and storm overflows and agricultural sources such as slurry and silage liquor. The UKTAG standards for DO in rivers are presented in Table 14.

Table 14. UKTAG (2008a) classification – standards for oxygen in rivers

Dissolved Oxygen (per cent saturation)				
(10 percentile)				
Type*	High	Good	Moderate	Poor
Upland and low alkalinity	80	75	64	50
Lowland and high alkalinity	70	60	54	45

Table 15. Dissolved Oxygen results: recorded ranges for each season

	Winter	Summer	Autumn
Upstream of the lake	68.0 – 89.3%	95.4 – 109.0%	86.3 – 113.0%
Northeast streams	65.3 – 99.7%	93.0 – 112.0%	76.0 – 100.0%
Semer Water lake shore	63.6 – 85.5%	101.0 – 120.0%	62.0 – 85.0%
Northwest streams	65.4- 78.6%	96.8 – 98.7%	88.3 – 97.4%
Downstream of the lake	69.9 – 77.0%	97.9 – 104.2%	103.2 – 104.4%

4.1.6 Alkalinity as $CaCO_3$

Alkalinity for winter was lab analysed, summer and autumn samples were analysed using Hanna HI3811 portable alkalinity test kit. Alkalinity (mg/l CaCO3) is a measure of the ability of a liquid to neutralise acids, therefore aiding with the maintenance of basic or neutral pH. Alkalinity measures strength of bicarbonate/ carbonate buffering system. .

Table 16. Alkalinity results: recorded ranges for summer and autumn

	Winter (Lab)	Summer	Autumn
Upstream of the lake	34.7 – 95.40mg/l	49 – 120mg/l	42 – 113mg/l
Northeast streams	41.1 – 105.0mg/l	57 – 132mg/l	66 – 125mg/l
Semer Water lake shore	60.2 – 74.8mg/l	105 – 123mg/l	71 – 127mg/l
Northwest streams	72.3 – 125mg/l	126 – 168mg/l	121 – 174mg/l
Downstream of the lake	63.1 – 63.8mg/l	117 - 132mg/l	115 - 128mg/l

4.1.7 Turbidity as FTU

Turbidity for summer and autumn was analysed using Hanna HI93703 portable turbidity meter back in the lab. Turbidity (FTU) measures the concentration of suspended solids within a sample. Turbidity has numerous causes, however human induced sediment run-off or phytoplankton growth indicating eutrophication can be contributory factors. High turbidity can be detrimental to biological organisms including diatom and macroinvertebrates.

Table 17. Turbidity results: recorded ranges for summer and autumn

	Summer	Autumn
Upstream of the lake	1.29 – 9.30	0.00 – 5.60
Northeast streams	2.78 – 13.29	0.90 – 4.45
Semer Water lake shore	4.31 – 15.99	0.38 – 5.69
Northwest streams	0.00 – 2.52	1.86 – 3.39
Downstream of the lake	2.03 – 8.78	2.83

4.2 Winter laboratory analysis

4.2.1 Ammonia

Ammonia forms a major component of fertilizer and excessive amounts in surface waters can contribute to eutrophication, other sources of ammonia include sewage discharges and agriculture runoff from pasture

It also has direct toxic and sub-lethal effects on aquatic invertebrates and fish. The standards for ammonia in UK rivers are displayed in Table 18.

The samples detection level of 0.27mg/l ensures recording to the "good" status if results are below the LOD.

Table 18. UKTAG (2008a) classification – standards for ammonia in rivers

Total ammonia (mg/l)				
(90 percentile)				
Type*	High	Good	Moderate	Poor
Upland and low alkalinity	0.2	0.3	0.75	1.1
Lowland and high alkalinity	0.3	0.6	1.1	2.5

A. **Upstream of the lake.** All sample sites upstream of the lake had ammonia levels below detection.
B. **Northeast Streams of the lake.** All sample sites were below detection.
C. **Semer Water lake shore.** All sample sites were below detection.
D. **Northwest Streams of the lake.** All sample sites were below detection.
E. **Downstream of the lake.** All sample sites were below detection.

4.2.2 Total (Oxidised) Nitrogen

Total oxidised nitrogen measures the type (nitrite and nitrate) that is available immediately to plants in freshwater systems.

A. **Upstream of the lake.** All sample sites were below detection.
B. **Northeast Streams of the lake.** Samples were below detection on 4 out of 6 sampling points. It was however slightly above detection at two sites, Site 7 and site 12, measuring 0.51mg/l and 0.53mg/l respectively.
C. **Semer Water lake shore.** All sample sites were below detection.
D. **Northwest Streams of the lake.** All sample sites were below detection.
E. **Downstream of the lake.** All sample sites were below detection.

4.2.3 Nitrate – N

Nitrate, the end product of the breakdown of ammonia and generally of low toxicity, changes rapidly within a water body and also in a removed sample.

UKTAG has yet to release UK standards for nitrate in rivers, however, it is accepted that a nitrate concentration of 10.00mg/l can adversely affect freshwater invertebrates as a result of long-term exposure (Camargo 2005). The concentration of nitrate is usually higher in winter compared to summer.

A. **Upstream of the lake.** All sample sites were below detection.
B. **Northeast Streams of the lake.** As with the total nitrogen, results four of the six sample points on the northwest streams had nitrate levels below detection; those above detection were again site 7 and site 12 both showing 0.50mg/l of nitrate.
C. **Semer Water lake shore.** All sample sites were below detection.
D. **Northwest Streams of the lake.** All sample sites were below detection.
E. **Downstream of the lake.** All sample sites were below detection.

4.2.4 Total Hardness

Total hardness is the combination of calcium and magnesium hardness in a water sample and is categorised in Table 19 below:

Table 19. Water hardness categories

Concentration mg/l	Indication
0 - 10	Soft water
10 - 60	Moderately hard water
60 - 100	Hard water
>100	Very hard water

A. **Upstream of the lake.** Results ranged from 40.00mg/l to 102.00mg/l, although the majority of results suggest that upstream of the lake has softer water than other sampling zones. The recorded mean of 60.11mg/l reflects this, and is somewhat skewed due to the high reading at site 26, removing this sample gives a mean of 54.88mg/l indicating moderately hard water.
B. **Northeast Streams of the lake.** Results ranged from soft water through to the upper reaches of moderately hard water; 48.00mg/l to 116.00mg/l. The mean hardness of these streams was 86.00mg/l, again indicating mainly hard water.
C. **Semer Water lake shore.** Ranged from 69.00mg/l to 84.00mg/l with the mean hardness 76.6mg/l. Indicating hard water, this can also be split into the east shore and west shore with a mean hardness of 80.70mg/l and 70.50mg/l respectively.
D. **Northwest Streams of the lake.** The range of results was 79.00mg/l to 134.00mg/l, resulting in a mean hardness of 100.75mg/l.
E. **Downstream of the lake.** Ranging from 82.00mg/l to 88.00mg/l, the mean hardness of the samples was 85.00mg/l, indicating hard water.

4.2.5 Calcium

Calcium is naturally occurring in water, with amounts varying due to geology amongst other factors. For example limestone rich areas can show up to 100 times the levels of calcium in a river system of a catchment with igneous geology. Calcium is an important determinant of water hardness and its function as a pH stabiliser due to its buffering qualities.

A. **Upstream of the lake.** Ranging from 14.70mg/l to 36.90mg/l, the mean level of calcium was recorded as 21.19mg/l.
B. **Northeast Streams of the lake.** Results ranged from 17.30mg/l to 43.30mg/l, giving a mean calcium level of 31.45mg/l. Interestingly, the low calcium level (17.30mg/l) was measured at the same point (site 11) as the acidic pH.
C. **Semer Water Lake shore.** Results ranged from 25.60mg/l to 30.10mg/l. Mean results for the lake were 26.70mg/l. The east and west shores of the lake were similar, with the mean results being 27.50mg/l and 25.50mg/l respectively.
D. **Northwest Streams of the lake.** Results ranged from 29.20mg/l to 48.00mg/l; here the mean level of calcium was 36.60mg/l.
E. **Downstream of the lake.** Results were recorded as 26.00mg/l and 25.10mg/l on the River Bain, resulting in a mean value of 25.60mg/l.

4.2.6 Chlorophyll 'a' (acetone extraction)

Measuring the concentration of chlorophyll 'a' provides an estimate of suspended algal biomass, and can be used as an indicator of a lakes trophic status. However, to estimate trophic class with any confidence sampling needs to be replicated and expanded to cover the whole lake. Tropic class is mentioned here to be descriptive. Carlson's trophic state index (1996) outputs the following table of trophic class.

Table 20. Carlson's TIS (1996) Trophic Classes

TI	Chlorophyll (µg/l)	TIS Trophic Class
<30 – 40	0 – 2.6	Oligotrophic
40 – 50	2.6 – 20	Mesotrophic
50 – 70	20 – 56	Eutrophic
70 – 100	56 – 155+	Hypereutrophic

A. **Upstream of the lake.** Ranged from below detection to 0.63µg/l. Excluding the below detection sample at site 26, the recorded range was 0.31µg/l to 0.63µg/l; with a recorded mean level of 0.44µg/l.
B. **Northeast Streams of the lake.** Ranged from 0.36µg/l to 2.03µg/l. Again the upper end of the range was recorded at a single site, site 7. The recorded mean was 0.75µg/l.
C. **Semer Water lake shore.** Samples from the lake ranged from 0.73µg/l to 9.07µg/l. These results are split east to west, with the eastern shore mean 0.80µg/l. Whereas the western shore recorded a mean 6.28µg/l. Taking the lake as a whole the mean was 2.92µg/l.
D. **Northwest Streams of the lake.** Ranged from 0.36µg/l to 3.18µg/l., with a mean of 1.18µg/.
E. **Downstream of the lake.** Site 1 was below detection, whilst site 2 recorded 0.94µg/l.

4.2.7 Total phosphorus

Phosphorus is present in natural waters as phosphorus, orthophosphorus, polyphosphorus and organically bound phosphorus; total phosphorus is a measure of these. This element is necessary for plant and animal growth and is present in nearly all fertilisers. Phosphorus stimulates the growth of plankton and water plants, providing food for fish. However, too much phosphorus may cause biological and ecological changes, including algal blooms and accelerated eutrophication. UKTAG (2008a) use alkalinity and altitude to determine appropriate concentrations of phosphorus to support GESUK rivers. River phosphorus concentration is dependent on river typology (Table 19), and is classified in four categories (UKTAG, 2008b); presented in Table 20. Lake phosphorus concentration is classified by lake typology and presented as one of two values (UKTAG, 2008a); as displayed in Table 23.

A. **Upstream of the lake.** Ranged from "0.000mg/l" to 0.020mg/l with a mean of 0.005mg/l.
B. **Northeast Streams of the lake. (Type 2n – SW11; n4 – SW8, SW9, SW10; n6 – SW12).** Ranged from 0.000mg/l to 0.030mg/l, with the mean level being 0.011mg/l. All type 4n sites in high status.
C. **Semer Water lake shore.** Ranged from 0.014mg/l to 0.057mg/l. The eastern shore of the lake had less total phosphorus than the western shore; the mean level at the east was 0.019mg/l, whereas the mean level on the western shore was 0.044mg/l.
D. **Northwest Streams of the lake (Type 4n SW16, 18, 19/6n SW17)** Total phosphorus was particularly variable, ranging from 0.0002mg/l at site 19 to 0.093mg/l at site 17. The mean concentration of total phosphorus for the northeast streams was 0.045. However, this mean masks the increased results recorded at site 16 and site 17; these measured 0.072mg/l (good status) and 0.093mg/l.
E. **Downstream of the lake. (Type 4n)** Ranged from 0.020mg/l to 0.022mg/l, with a mean result of 0.021mg/l. Both sites in high status.

4.2.8 Filtered phosphorus

Filtered phosphorus measures both organic phosphorus and inorganic phosphorus after it has been subject to filtration through a 0.45µm membrane filter. The effects are as with total phosphorus, and it is a key indicator of enrichment. Reactive phosphorus within lakes is classified in four status categories (UKTAG, 2008a):

Table 21. UKTAG (2008a) classification typology for nutrient conditions in rivers

Altitude	Annual mean alkalinity (as mg/l calcium carbonate)	
	<50	>50
Under 80 metres	Type 1n	Type 3n
Over 80 metres	Type 2n	Type 4n

Note: Due to a problem with the data for Type 3n, there are concerns that some of the sites thought to be high quality are actually impacted. For the present the standards calculated for Type 4n will be applied also to Type 3n.

Table 22. UKTAG (2008a) classification – reactive phosphorus in rivers

Soluble Reactive Phosphorus (mg/l) (annual mean)				
Type	High	Good	Moderate	Poor
1n	0.030	0.050	0.150	0.500
2n	0.020	0.040	0.150	0.500
3n +4n	0.050	0.120	0.250	1.000

Table 23. UKTAG (2008b) standards for phosphorous in lakes

Type of lake		Reference level of phosphorus		Class boundaries			
				High		Good	
		Range	Type	Range	Type	Range	Type
		Annual (geometric) mean (mg/l)					
High alkalinity shallow	Northern/Atlantic	0.008-0.017	0.013	0.010-0.022	0.016	0.014-0.030	0.023
	Central	0.012-0.027	0.020	0.016-0.034	0.025	0.022-0.046	0.035
High alkalinity very shallow	Northern/Atlantic	0.012-0.029	0.018	0.015-0.036	0.023	0.021-0.048	0.031
	Central	0.018-0.044	0.028	0.023-0.055	0.035	0.033-0.075	0.049

*Based upon table from UKTAG, 2008b.

A. Upstream of the lake. Ranged from "0.000mg/l" to 0.001mg/l, with a mean of 0.0001mg/l. Eight out of the nine samples were recorded as having "0.000mg/l" filtered phosphorus.

B. Northeast Streams of the lake. Ranged from "0.000mg/l" to 0.024mg/l. Of the six sites sampled, four show "zero" filtered phosphorus, and one showed a very low concentration. Only site 7 showed a relatively high concentration of filtered phosphorus (0.024mg/l). Recorded mean: 0.004mg/l.

C. Semer Water lake shore. Ranged from 0.003mg/l to 0.014mg/l, with a mean of 0.0018mg/l. The eastern shore and western shore varied in terms of mean filtered phosphorus, 0.012mg/l and 0.005mg/l respectively. By contrast, highest mean total phosphorus was recorded from the western shore.

D. Northwest Streams of the lake. Like total phosphorus, filtered phosphorus is variable across the northeast streams; results range from "0.000mg/l" to 0.60mg/l, with a mean of 0.016mg/l.

E. Downstream of the lake. Ranged from 0.007mg/l to 0.01mg/l, giving a recorded mean of 0.0085mg/l.

4.2.9 Biochemical oxygen demand (BOD)

Table24 UKTAG (2008a) standards for oxygen conditions (BOD) in rivers

Biological Oxygen Demand (mg/l)				
(90 percentile)				
Type*	High	Good	Moderate	Poor
Upland and low alkalinity	3	4	6	7.5
Lowland and high alkalinity	4	5	6.5	9

BOD is a measure of the quantity of oxygen used by microorganisms and chemical constituents in a range of biological and chemical processes. Natural sources of organic matter include plant decay and leaf litter. However, oxygen demand may also be unnaturally accelerated when nutrients (and sunlight) are overly abundant. The UKTAG (2008a) standards have been developed on the basis of oxygen conditions associated with macro-invertebrate communities (which in reference conditions require higher oxygen levels than those for fish) as these are most sensitive biota to this pressure. The categories are displayed in Table 21.

Only two of the 26 sample points have a recorded BOD above 1.00mg/l. Site 23, on Semer Water, had a BOD of 2.00mg/l (HES) and Site 17 (a northwest stream) recorded BOD of 10.00mg/l (Poor status). The results from two SW17 may indicate enrichment.

4.2.10 Suspended solids

Suspended solids are solid materials, both organic and inorganic, that are suspended in water. They may include silt, plankton agricultural and industrial wastes. High concentrations lower water quality by absorbing light, increasing temperatures and lessening the ability of the water to hold the oxygen necessary for aquatic biodiversity. They can also cause clogging and abrasion of fish gills, reduce growth rates and prevent larval development. The settlement of suspended solids between rocks prevents microhabitats suitable for aquatic invertebrates from being utilised and inhibits respiratory function. Concentrations of 8.00mg/l can cause 3 – 13% reduction in primary productivity and an increased rate of drift in benthic invertebrates, whilst prolonged exposure to 10.00mg/l can cause a 40% reduction in algal biomass (Bilotta and Brazier, 2005).

A. **Upstream of the lake.** Ranged from 0.50mg/l to 17.00mg/l, with a mean of 3.28mg/l.
B. **Northeast Streams of the lake.** Ranged from 1.00mg/l to 9.50mg/l. Recorded mean: 4.08mg/l.
C. **Semer Water lake shore.** Ranged from 0.50mg/l to 270.00mg/l. The mean for the eastern shore was 2.83mg/l, whilst the mean for the western shore was very much higher at 210.50mg/l.
D. **Northwest Streams of the lake.** Ranged between 3.50mg/l and 335.00mg/l, giving a mean of 91.13mg/l. Mean excluding site 16 was 9.83mg/l.
E. **Downstream of the lake.** Ranged between 2.50mg/l and 3.00mg/l, with a mean of 2.75mg/l.

5. Diatoms

5.1 Sampling overview

A total of 217 diatom species were recorded from the 25sites over the three seasons of the study. These were mostly consistent with a moderately hard water catchment with good water quality. Most of the samples were dominated by *Achnanthidium minutissimum*, along with *A. pyrenaicum. A. minutissimum* is an extremely common pioneer species in high/good status streams and, in summer, is dominant in streams subject to heavy grazing by benthic invertebrates. *A. pyrenaicum* has a similar niche but is a better indicator of high status, particularly in calcareous waters. Superficial examination of the data does not suggest a strong seasonal signal in the diatom taxa lists. The dominant and sub-dominant species are listed in Appendix 5.

5.2 River Bain, Downstream of Semer Water

The two sites on the River Bain downstream of Semer Water had floras indicative of good status (following RBMP2 criteria) but with some elements of moderate status also present. The flora is dominated by *Achnanthidium minutissimum*, but numbers of motile taxa (*Navicula gregaria, N. lanceolata* and *N. tripunctata*) are higher than expected and causing an element of moderate status. In addition, DAM is also moderate.

5.3 Semer Water Lake shore

The average status (TDI), calculated across all five sites for three seasons, is good, with floras generally dominated by *Achnanthidium minutissimum*. Individual samples, however, fall into moderate (RBMP2) or even poor (RBMP1) on occasion. Both *Navicula gregaria* and *N. lanceolata* are present in numbers particularly in winter and in the north-east corner of the lakes but a more likely candidate for causing these low EQRs is *Luticola mutica*, which is a desiccation-resistant diatom and which may indicate that some marginal areas are subject to intermittent drying, perhaps reflecting normal lake shore level variations. This hypothesis is supported by abundant *L. mutica* being recorded at all sites around the lake on at least one visit.

A similar explanation may explain the overall classification (i.e. combining all samples from all sites) of Semer Water as moderate status, although *Navicula tripunctata* and *Nitzschia dissipata*, also both motile, are more abundant here than *Navicula lanceolata*. SW05 contains 10% *Luticola mutica*, which is desiccation-tolerant and may indicate that the substrata had been exposed shortly before the sampling trip.

5.4 Northwest Tributaries

The average status of these streams is high, with both *Achnanthidium minutissimum* and the more sensitive *A. pyrenaicum* present in numbers at all sites.

5.5 Uppercatchment (Southwest tributaries)

The average status of these was, again, high, with *Achnanthidium minutissimum* and *A. pyrenaicum* present in numbers at all sites and quite well consistentbetween seasons

Only one sample, SW26, classifies as less than good status for the acidification metric (DAM-EQR); this is the only sample where *Achnanthidim pyrenaicum* is more abundant than *A. minutissimum* and, whilst A. pyrenaicum is reported as slightly more acid-sensitive than *A. minutissimum*, there are no other indicators of low pH conditions in this sample, which should also be treated as a “false negative” until more data are available (the calcareous nature of the catchment suggests that truly acid waters are extremely unlikely here).

All stream sites have percentages of motile taxa within the expected ranges and are classified as "high status" using the motile/siltation metric (the lake sites have not been classified using this tool.).

5.6 Northeast Tributaries

The average status of these sites was high status (RBMP2) and good status (RBMP1). Again, *Achnanthidium minutissimum* was abundant along with *A. pyrenaicum* at some sites, but also a mix of other taxa some of which (*Cocconeis placentula* var. *euglypta, Nitzschia palea*) may suggest some enrichment. Scores show overall consistency between seasons.

5.7 Results

Table 25. Summary of results for diatom analyses for samples collected 2012 from Semer Water catchment. TDI-EQR and DAM-EQR are EQRs calculated from TDI (nutrient-sensitive) and DAM (acid-sensitive) respectively; MO-EQR is an EQR calculated from the percent motile valves. Astricks on resample autumn

River	Local ref	Date	TDI3-EQR	RBMP1	TDI4-EQR	RBMP2	DAM-EQR	Acid-status	MO-EQR	Motile-status
Downstream of Semer Water										
Bain, River	SW01	30/01/2012	0.62	M	0.68	M	0.69	G	0.5	M
Bain, River	SW01	16/08/2012	0.86	G	1.2	H	0.72	G	0.96	G
Bain, River	SW01	02/10/2012	0.69	M	0.86	G	0.69	G	0.62	M
Bain, River	SW02	30/01/2012	0.64	M	0.68	M	0.58	M	0.82	G
Bain, River	SW02	16/08/2012	0.83	G	1.01	H	0.56	M	0.92	G
Bain, River	SW02	02/10/2012	0.67	M	0.74	M	0.55	M	0.65	M
Average			**0.72**	**M**	**0.86**	**G**	**0.63**	**M**	**0.75**	**M**
Semer Water lake shore										
Semer Water	SW04	30/01/2012	0.43	P	0.5	M			0.63	M
Semer Water	SW04	16/08/2012	0.67	G	0.79	G			1.09	H
Semer Water	SW04	02/10/2012	0.78	G	0.63	M			0.5	M
Semer Water	SW05	30/01/2012	0.53	M	0.6	M			0.66	M
Semer Water	SW05	16/08/2012	0.83	G	1.07	H			1.11	H
Semer Water	SW05	02/10/2012	0.7	G	0.77	G			0.8	G
Semer Water	SW06	30/01/2012	0.79	G	0.75	G			0.66	M
Semer Water	SW06	16/08/2012	0.68	G	0.63	M			0.85	G
Semer Water	SW06	18/10/2012*	0.72	G	0.75	G			0.87	G
Semer Water	SW23	30/01/2012	0.57	M	0.65	M			0.86	G
Semer Water	SW23	17/08/2012	0.68	G	0.8	G			1.03	H
Semer Water	SW23	03/10/2012	0.79	G	0.88	G			0.8	G
Semer Water	SW24	30/01/2012	0.6	M	0.72	G			0.89	G
Semer Water	SW24	17/08/2012	0.86	G	1.08	H			1.11	H
Semer Water	SW24	03/10/2012	0.8	G	0.85	G			0.94	G
Average			**0.70**	**M**	**0.76**	**G**			**0.86**	**G**
Northwest Tributaries										
Semer Water NE inflows	SW16	30/01/2012	0.83	G	1.04	H	0.87	H	0.99	G

River	Local ref	Date	TDI3-EQR	RBMP1	TDI4-EQR	RBMP2	DAM-EQR	Acid-status	MO-EQR	Motile-status
Semer Water NE inflows	SW16	17/08/2012	0.83	G	1.13	H	0.83	H	0.95	G
Semer Water NE inflows	SW16	03/10/2012	0.91	G	1.05	H	0.81	G	0.92	G
Semer Water NE inflows	SW17	30/01/2012	0.88	G	1.20	H	0.83	H	1.04	H
Semer Water NE inflows	SW17	17/08/2012	0.88	G	1.37	H	0.83	H	1.00	H
Semer Water NE inflows	SW17	03/10/2012	0.71	M	1.09	H	0.54	M	0.35	M
Semer Water NE inflows	SW18	30/01/2012	0.82	G	0.99	G	0.91	H	0.99	G
Semer Water NE inflows	SW18	17/08/2012	1.04	H	1.48	H	0.95	H	1.13	H
Semer Water NE inflows	SW18	18/10/2012*	0.87	G	1.09	H	0.92	H	1.08	H
Semer Water NE inflows	SW19	30/01/2012	1.05	H	1.21	H	0.92	H	1.10	H
Semer Water NE inflows	SW19	17/08/2012	1.00	H	1.42	H	0.87	H	1.05	H
Semer Water NE inflows	SW19	03/10/2012	1.03	H	1.36	H	0.88	H	1.03	H
Average			**0.9**	**G**	**1.20**	**H**	**0.85**	**H**	**0.97**	**G**
Northeast Tributaries										
Semer Water NW inflows	SW10	30/01/2012	1.05	H	1.25	H	0.77	G	1.13	H
Semer Water NW inflows	SW10	16/08/2012	1.02	H	1.17	H	0.81	H	1.18	H
Semer Water NW inflows	SW10	18/10/2012*	1.13	H	1.23	H	0.83	H	1.15	H
Semer Water NW inflows	SW11	30/01/2012	0.99	H	1.06	H	0.93	H	1.16	H
Semer Water NW inflows	SW11	16/08/2012	1.12	H	1.20	H	0.89	H	1.18	H
Semer Water NW inflows	SW11	02/10/2012	1.09	H	1.12	H	0.90	H	1.08	H
Semer Water NW inflows	SW12	30/01/2012	0.96	H	1.24	H	0.91	H	1.15	H
Semer Water NW inflows	SW12	16/08/2012	1.08	H	1.43	H	0.81	G	1.13	H
Semer Water NW inflows	SW12	02/10/2012	1.20	H	1.32	H	0.92	H	1.17	H
Semer Water NW inflows	SW07	30/01/2012	0.63	M	0.77	G	0.87	H	0.97	G
Semer Water NW inflows	SW07	16/08/2012	0.81	G	1.08	H	0.73	G	0.90	G
Semer Water NW inflows	SW07	02/10/2012	0.96	H	1.12	H	0.77	G	0.88	G
Semer Water NW inflows	SW08	30/01/2012	0.92	G	1.06	H	0.91	H	1.09	H
Semer Water NW inflows	SW08	16/08/2012	1.02	H	1.30	H	0.88	H	1.09	H
Semer Water NW inflows	SW08	02/10/2012	1.07	H	1.32	H	0.86	H	1.00	G
Average			**1.00**	**H**	**1.18**	**H**	**0.85**	**H**	**1.08**	**H**
Upper Catchment										
Semer Water SW inflows	SW13	30/01/2012	1.07	H	1.15	H	0.86	H	1.11	H
Semer Water SW inflows	SW13	16/08/2012	1.17	H	1.36	H	0.86	H	1.17	H
Semer Water SW inflows	SW13	18/10/2012*	1.23	H	1.46	H	0.86	H	1.16	H
Semer Water SW inflows	SW14	30/01/2012	1.02	H	1.10	H	0.86	H	1.11	H
Semer Water SW inflows	SW14	17/08/2012	1.15	H	1.38	H	0.95	H	1.16	H
Semer Water SW inflows	SW14	03/10/2012	1.17	H	1.37	H	0.82	H	1.12	H
Semer Water SW inflows	SW15	30/01/2012	1.04	H	1.13	H	0.81	H	1.05	H
Semer Water SW inflows	SW15	17/08/2012	1.19	H	1.54	H	0.89	H	1.13	H
Semer Water SW inflows	SW15	03/10/2012	1.23	H	1.55	H	0.81	G	1.15	H
Semer Water SW inflows	SW20	30/01/2012	1.03	H	1.11	H	0.84	H	1.15	H
Semer Water SW inflows	SW20	17/08/2012	1.13	H	1.42	H	0.90	H	1.11	H
Semer Water SW inflows	SW20	03/10/2012	1.09	H	1.20	H	0.86	H	1.13	H

River	Local ref	Date	TDI3-EQR	RBMP1	TDI4-EQR	RBMP2	DAM-EQR	Acid-status	MO-EQR	Motile-status
Semer Water SW inflows	SW21	30/01/2012	1.06	H	1.17	H	0.86	H	1.17	H
Semer Water SW inflows	SW21	17/08/2012	1.20	H	1.45	H	0.80	G	1.17	H
Semer Water SW inflows	SW21	03/10/2012	1.20	H	1.48	H	0.80	G	1.11	H
Semer Water SW inflows	SW22	30/01/2012	1.09	H	1.13	H	0.93	H	1.16	H
Semer Water SW inflows	SW22	17/08/2012	1.01	H	1.22	H	0.90	H	1.15	H
Semer Water SW inflows	SW22	03/10/2012	1.22	H	1.45	H	0.81	G	1.17	H
Semer Water SW inflows	SW25	30/01/2012	0.82	G	0.89	G	0.83	H	1.00	G
Semer Water SW inflows	SW25	17/08/2012	0.90	G	1.18	H	0.89	H	1.00	H
Semer Water SW inflows	SW25	03/10/2012	1.21	H	1.48	H	0.76	G	1.05	H
Semer Water SW inflows	SW26	30/01/2012	1.12	H	1.40	H	0.69	G	1.09	H
Semer Water SW inflows	SW26	17/08/2012	1.15	H	1.37	H	0.90	H	1.16	H
Semer Water SW inflows	SW26	03/10/2012	1.15	H	1.31	H	0.83	H	1.07	H
Semer Water SW inflows	SW03	30/01/2012	1.11	H	1.19	H	0.75	G	1.19	H
Semer Water SW inflows	SW03	16/08/2012	1.19	H	1.23	H	0.75	G	1.17	H
Semer Water SW inflows	SW03	02/10/2012	1.08	H	1.06	H	0.79	G	1.12	H
Average			**1.11**	**H**	**1.29**	**H**	**0.84**	**H**	**1.12**	**H**

P = poor, M = moderate, G = good, H= high status

Diatom samples which were retaken on the 18/10/12 marked *

6. Aquatic Macroinvertebrates

6.1 Sampling Overview (general overview across and between seasons)

6.1.1 Winter

Macroinvertebrate sampling was conducted on 30th and 31st January 2012. This is outside the normal sampling period for aquatic macroinvertebrate sampling, but was required to fit in with NE project schedule. A total of 25 kick samples were completed across 26 locations. Site 9 was not sampled due to insufficient flow. The samples were preserved in 70% ethanol solution and were processed and identified during the week commencing 27th February.

In general, samples were dominated by *Baetidae* (olives), *Gammaridae* (freshwater shrimps) and *Heptageniidae* (flat bodies). With *Simuliidae* and *Chironomidae* also found in the majority of samples often at fairly high abundance.

Representatives of six *Plecoptera* (stonefly) families were found across the 26 Semer Water sites, and all six were found within one sample (SW21). *Taeniopterygidae,* the winter stonefly, was present in three samples with one sample containing two different species; *Taeniopteryx nebulosa* and *Brachyptera risi*. In the *Perlidae* family several noticeably large specimens of *Perla bipunctata* were present.

Two sites, Site 2 and Site 15 contained *Austropotamobius pallipes* (white-clawed crayfish), which are sensitive to poor water quality *e.g.* agricultural runoff and seasonal flow derogation. Both individuals had carapace lengths between 15 and 20mm. These were returned to the water and not preserved with the rest of the sample.

Trichoptera (cased caddis) were relatively under-represented in the Semer Water stream sites, *Limnephillidae* was present at eight sites in small numbers and *Glossomatidae* were found at site 25 in reasonable numbers during the 1-minute look-see.

Notably, Site 7 contained no *Plecoptera* (stonefly) families, however upstream on Little Ings Sike three families were recorded (SW12 – *Nemouridae*, *Perlidae* and *Perlodidae*). This possibly indicates organic pollution in the lower reaches of the stream. However, levels are likely to be low to moderate due to the presence of one sensitive *Ephemeroptera* family and *Gammaridae*. Site 2 also shows a reduced number of *Plecoptera* families suggesting some degree of impact.

The abundance of individuals within families generally fell within the 1-10 or 10-100 categories. *Baetidae*, *Heptageniidae*, *Gammaridae* and *Chironomidae* abundance reached the 100-1000 category in at least one sample, though this was uncommon.

Lake sites on average contained less taxon than the flowing water sites. Each sample, with the exception of SW23, contained taxa which are sensitive pollution. *Gammaridae, Oligochaeta* and *Chironomidae* were often the most abundant families.

6.1.2 Summer

Summer macroinvertebrate sampling was conducted on 16th and 17th August 2012. A total of 25 kick samples were taken across 26 sites. Ephemeral site 9 was not sampled. The samples were preserved in 70% ethanol and identified the week commencing 3rd September. The revised counting method was used, sample id counts were recorded as actual number for <10 individuals, to nearest 10 for <60 individuals and then 60-100 and 100+ individuals.

Samples were dominated by *Diptera*, *Baetidae*, and *Leuctridae* families, with *Heptageniidae* and *Elmidae* present in the majority of samples.

Perlidae were present in 11 of the 25 samples and abundance was often high at these sites where they're present. Both species of *Perlidae* (*Perla bipunctata and Dinocras cephalotes*) were present in two or three samples; though most only contained one species. As seen in winter several large specimens of *Perla bipunctata* were found. *Leuctridae spp* were also often present at relatively high abundances of between 20 and 60.

No *Plecoptera* families were present at site 16. At three sites, SW2, SW7 (similar to winter) and SW17 only one stonefly family (*Leuctridae*) was present. However, samples from SW11 and SW12 up steam of SW7, contained three and four families respectively. *Plecoptera* are known to be the most sensitive taxa to organic pollution.

A. pallipes were recorded at seven sites (1, 2, 8, 13, 14, 15, 26) at Semer water. Juveniles were abundant at Site 13. The recruiting population at Site 13 suggests the water quality has remained stable over recent months.

Trichoptera families were present at most sites. *Rhyacophilidae* and *Polycentropodidae* were the most commonly recorded families. *Philopotamidae* (SW1, 11, 13, 18, 19 and 25) and *Psychomyiidae* (SW 6 and 24) were present at a limited number of sites, at low abundance. Cased caddis were sparsely distributed across sites (SW3, 10, 11, 12, 13, 14, 19 and 21) or not present at all. Three separate families were represented; *Limnephilidae, Sericostomatidae* and the species *Odontoceridae* (*Odontocerum albicorne*).

6.1.3 Autumn

Autumn macroinvertebrate sampling was conducted on 2nd and 3rd October 2012. A total of 25 kick samples were taken across 26 sites. Ephemeral Site 9 was not sampled. The samples were preserved in 70% ethanol and identified the week commencing 15th October.

As in the previous seasons, mayfly (*Ephemeroptera*) and *Gammaridae* dominated samples. *Baetidae, Heptageniidae*, *Gammaridae* and *Elmidae* were the most commonly recorded and abundant families. *Baetidae* were recorded in all flowing water sites. Other mayfly were present, *Ephemerellidae, Ephemeridae* and *Leptophlebiidae* were recorded, but rarely and at low abundance.

Plecoptera families were present at most flowing sites, but none were recorded in lake shore samples.. Abundance was generally low for all five families recorded. Remaining consistent with the previous seasons, several samples contained both species of *Perlidae* (*Perla bipunctata* and *Dinocras cephalotes*). Following low diversity of Plecoptera at SW2, 7 and 17, no families were recorded at these sites in autumn.

The diversity of caddis (*Trichoptera*) in samples improved compared to previous seasons. Four families of cased caddis and five families of caseless caddis were recorded. Similar to previous seasons, abundance of families of caseless and cased caddis were relatively low in all samples.

Four beetle (*Coleoptera*) families were recorded in the autumn samples (*Scirtidae, Hydrophilidae*, *Dytiscidae* and *Elmidae*). At least two of these families were recorded in the majority of samples from flowing sites; however, no *Coleoptera* were recorded in lake samples.

6.2 River Bain Downstream of Semer Water

6.2.1 BMWP results

The winter samples downstream of Semer Water SW1 and SW2 scored 99 and 73 respectively. This suggests that good water quality, but slightly impacted. In summer the BMWP score at SW2 fell to 55 and in autumn the site scored the lowest of all flowing sites. The high flows and nature of the substratum at this site are likely to have accentuated the low score. The BMWP scores for SW1 declined slightly throughout the year, though only as low as good water quality.

6.2.2 NTAXA results

The sites downstream of the lake contained numbers of taxa comparable to elsewhere in the catchment during winter and summer. However, in autumn SW2 only contained four taxa.

6.2.3 ASPT results

ASPT results fluctuated slightly over the year at SW2 and declined slightly through the year at SW1, but remained above 5.4 (excellent water quality) in each season. This suggests limited organic impacts.

6.2.4 PSI results

The PSI result suggested bed conditions at site SW2 were slightly sedimented in summer and a score of 55% in autumn, suggested sedimentation. However, the substrate at site 2 consisted mainly of sediment, which may account for the low score. SW1 showed little or no signs of sedimentation.

6.2.5 RICT results

Both downstream sites, observed ASPT scores were better than the expected values in winter. In winter , summer and autumn, SW2 was classified as in bad ecological status In summer and autumn, this was due to lower than expected NTAXA results. SW1 classified in moderate status throughout the year.

6.3 Lake Semer Water (Lake shore)

6.3.1 BMWP results

Overall lake samples scores were lower than lotic sites. Throughout the year, SW4 often scored higher than the other lake samples. The majority of winter and summer samples were comparable. However, the sample at SW6 on the eastern shore was notably low scoring in summer (7).

Scores for lake samples declined heavily in autumn, though this was likely due to some extent to the higher water level of the lake (immediately preceding sampling days) and possible fluctuations in water level over the summer.

6.3.2 NTAXA results

Lake samples ranged from 5 to 13 taxa in winter. On average, there were less taxa per site than lotic sites and there was little difference between areas of the lake in winter. In summer Lake samples showed marginally higher taxa counts on the west shore compared to the east shore. The number of taxa present in the samples declined significantly in autumn at all sites.

6.3.3 ASPT results

Lake ASPT scores were comparable to the flowing water sites, indicating good water quality in winter. Lake site SW6 recorded the lowest score of 3.5 in summer. Lake samples scores were otherwise stable around 4. However, samples on the east shore were lower than those on the west shore (East 3.5-4.67 and West 4-5.11). Site 4 on the northeast shore consistently recorded the highest scores in both summer and autumn (7.67 in summer and 6.25 in autumn) showing stability throughout the year.

6.4 Northwest Tributaries of Semer Water

6.4.1 BMWP results

Site 17 (46) and site 19 (57) were two of the worst scoring flowing water sites in winter and SW16 (102) was one of the highest. The lowest scoring sites fell in to the moderate water quality band suggesting moderate water quality was affecting the biodiversity of the site. Sites 16 and 17 scored poorly in summer: with scores in the 50's. These scores suggest moderate impacts at the sites in summer, and show a large decrease in the score at SW16.

The lowest scoring sites in autumn, SW17 and 18, scored below 60 suggesting the sites may have been impacted. The majority of sites scores in autumn fell compared to both winter and summer.

6.4.2 NTAXA results

The NTAXA results showed that in general sites contained at least ten taxa. Only one sample contained less in winter; site SW17 contained 9 taxa. Site 16 contained the greatest diversity of taxa in winter. The number of taxa per site remained relatively similar in all samples from summer. However, in summer, Sites 16 declined to contain less than 10 taxa, recovering in autumn to 15 taxa. With the exception of SW2 where the number of taxa varied, the number of taxa in each sample was relatively stable across all stream sites in autumn.

6.4.3 ASPT results

The results put almost all the sites within the excellent water quality category, with SW17 falling into the good water quality category, on the provided scale. The ASPT results do not class any of the sites as being heavily subjected to organic pollution in winter. Site 17 was the most likely to have been impacted, with the lowest ASPT score of 5.11, though this still falls within the good water quality category, so any impact in winter was likely to be minor. The lowest ASPT scores were recorded at site 16(4) and 17(4.9) in summer. The scores suggest the water quality has been impacted, but not seriously in summer. All ASPT scores recorded were 5.1 or above in autumn. Site 17 was consistently low scoring compared to the other sites in the sub-catchment, indicating slight impacts.

6.4.4 PSI results

On the whole, PSI scores showed sites were not impacted by siltation. SW18 scored 79% in autumn, suggesting slight sedimentation.

6.4.5 RICT results

Three of the ASPT scores were below and one above expected in winter. Site 16 contained more taxa than was predicted by RICT. SW16 was classified in good status during winter and summer, and in high status in Autumn, though individual indices suggested the site declined in summer. Two sites SW17 and 19 were classified in bad ecological status in winter. However, SW19 classified in high status in summer and good status in autumn.

6.5 Upper Catchment (Southwest) of Semer Water

6.5.1 BMWP results

In winter, SW20 (58) upstream of Marsett was the worst scoring site, though scores recovered through the year. The lower scoring sites in winter fell in to the moderate water quality band suggesting a moderate water quality was affecting the biodiversity of the site. SW26 (105) was the top scoring site in the upper catchment in winter. Winter results were slightly higher than both summer and autumn.

Sites 25 scored poorly in summer: with a BMWP score in the 50's. The score suggests moderate impacts at the site.

SW26 scored below 60 in autumn, which was notable lower than in previous seasons and followed a general trend of declining BMWP scores at this site. In autumn, the majority of other sites scores fell slightly compared to both winter and summer.

6.5.2 NTAXA results

The NTAXA results showed that in general sites contained at least ten taxa. In winter, only site SW20 contained less (9 taxa). Site 26 contained the greatest diversity of taxa in winter, also reflected in the BMWP score. SW26 showed a decline in diversity through the year to only nine taxa in autumn. Sites 25 (summer) and site 2 (autumn) also contained less than 10 taxa. The average number of taxa per site otherwise remained fairly stable over the year.

6.5.3 ASPT results

The results put all the sites within the excellent water quality category throughout the year. Scores varied slightly at sites between seasons.

6.5.4 PSI results

Results from the three seasons indicated that there was little or no siltation during the sampling periods.

6.5.5 RICT results

In the upstream sub-catchment, ASPT scores at three sites were below expected and six were above expected in winter. Based on the winter samples, only two sites met the target of good ecological status due to lower than expected NTAXA values. However, the timing of the sampling may have affected the result. SW14 scored relatively well in all three seasons (NTAXA and ASPT); however, the observed NTAXA values were below expected leading to reduced classifications.

In summer, the majority of sites showed improvement compared to winter and were classified as either in good or moderate status. SW3 and 25 were classified in the high ecological status category. The improvements contradicted the downward trend in BMWP scores, but agreed with the other indices.

The decline in indices scores highlight at SW26 was reflected in the decline in RICT classification through the year. SW26 declined from Good status in winter to bad status in autumn, averaging in moderate status. The majority of sites were classed as in moderate condition in autumn. As in summer, Site 25 classified in high status.

6.6 Northeast Tributaries of Semer Water

6.6.1 BMWP results

Site 8 was the worst scoring site in winter (58), but improved in summer (88), before declining slightly in autumn (67). The top scoring site in winter was SW11 (126), though the BMWP scores declined in the following seasons.

SW7 scored 62 in winter and below 60 in autumn, which were considerably lower than upstream, suggesting water quality issues. The majority of sites scores fell in autumn compared to both winter and summer. However, the lowest scoring sites (SW7 & 8) fell no lower than the moderate water quality category.

6.6.2 NTAXA results

Northeast streams contained on average more taxa than sample locations elsewhere, in all three seasons. All sites had 10 taxa or greater, with little variation between seasons. Sites 11 contained the greatest diversity of taxa of all sites in winter.

6.6.3 ASPT results

The results put almost all the sites within the excellent water quality category and one site (SW7) in to the good water quality category in winter. Site 7 was again one of the lower scoring sites in autumn; indicating water quality was slightly impacted. All other ASPT scores in summer and autumn were above 5.4 indicative of excellent water quality.

6.6.4 PSI results

The PSI results for sites SW7 taxa showed signs of slight sedimentation in summer, but the autumn results did not highlight any issues. All other sites were classed as minimally sedimented or unsedimented over both summer and autumn.

6.6.5 RICT results

SW7 and 8 classified as in moderate status or below in winter and autumn. However, both sites classified as good status in summer. The sites (SW11 & 12) upstream of SW7 and 8 generally classified in higher status categories, but did show variation between seasons.

SW11 was classified in the high ecological status category in both winter and summer. SW12 was also classified in high status in summer.

Table 26. Summary of macroinvertebrate indices

Semer Water	BMWP		ASPT		NTAXA		PSI	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Winter								
Lake								
Downstream	73-99	86.0	6.6-6.6	6.62	13	13		
Northwest streams	46-102	70.3	6.6-7.4	5.67	12.25	12.25		
Northeast streams	58-126	77.4	5.1-6.3	6.36	12	12		
Upper catchment	58-105	74.9	5.3-7.3	6.32	13.5	13.5		
Summer								
Lake	7-46	29.2	3.5-7.7	4.99	2-9	6		
Downstream	55-88	71.5	5.5-6.2	5.85	10-14	12	73.3-84.6%	78.90%
Northwest streams	32-73	54.8	4.7-6.4	5.50	8-13	10.5	79.0-100%	91.26%
Northeast streams	80-119	93.4	5.1-6.4	5.86	12-17	14.5	71.4-100%	84.50%
Upper catchment	65-119	85.1	5.8-6.8	6.32	10-17	12.7	91.6-100%	98.60%
Autumn								
Lake	13-25	18.2	3.0-6.2	4.10	4-6	4.46		
Downstream	24-76	62.0	5.9-6.0	5.93	4-13	5.93	55.0-94.1%	70.35%
Northwest streams	51-72	60.8	5.1-6.4	5.86	9-13	10.4	91.6-100%	94.60%
Northeast streams	51-96	71.5	4.7-6.4	5.50	10-15	12.75	85.7-91.6%	86.10%
Upper catchment	52-92	72.3	5.5-6.8	6.30	9-15	11.4	81.3-94.7%	91.20%

6.7 Combined Season RICT Analysis and Classification (Macroinvertebrates)

The combined seasons samples provide a WFD classification for each surveyed site, shown in figure 2.

Five lotic sites at Semer Water were classified in high ecological status (SW 16, 17, 18, 19, and 25). A further eight sites were classified in good ecological status (SW3, 8, 10, 11, 12, 13, 21 and 22).

6.7.1 River Bain downstream of Semer Water

SW2 on the River Bain classified in Bad status throughout the sampling year. The very high proportion of sediment in the substrate is likely to limit the diversity of microhabitats available to macroinvertebrates at this site. This sample point (SW2) would be more reliable if moved 50m downstream. SW1 in Bainbridge classified moderately throughout the year.

6.7.2 Northwest tributaries of Semer Water

All four northwest streams were classified in high ecological status. However, SW17 was generally sub-standard throughout the year; therefore, this site's high ecological status classification should be interpreted with caution.

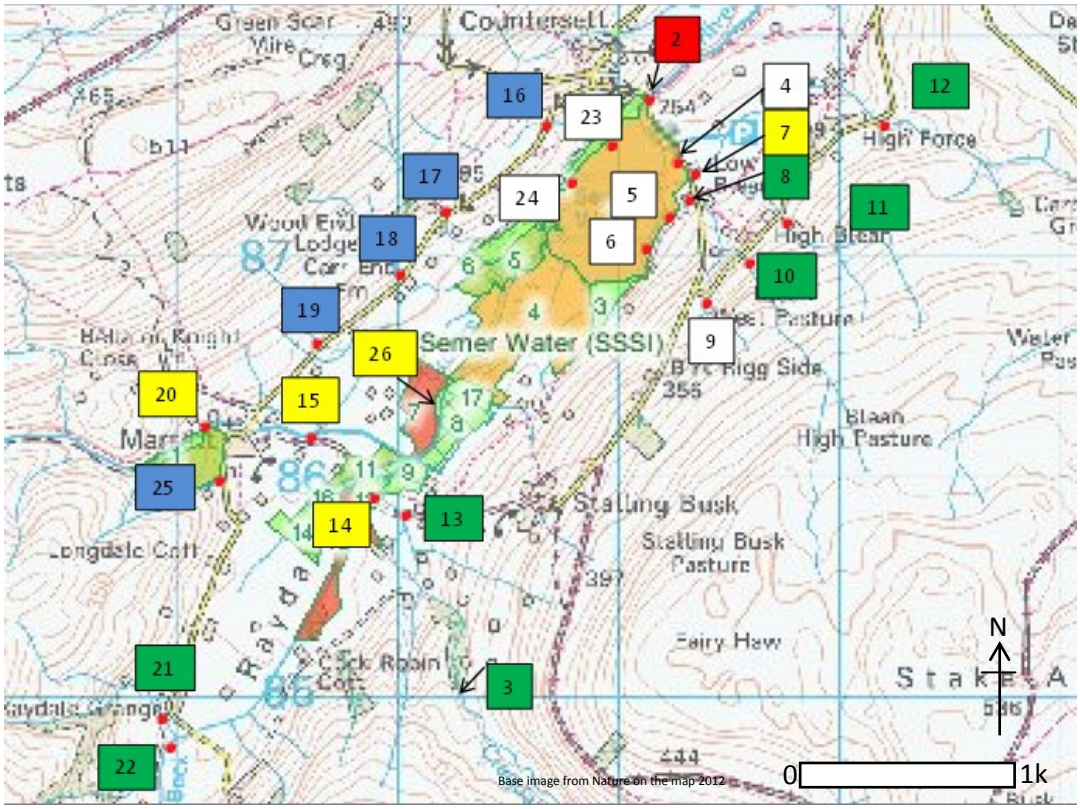
6.7.3 Upper catchment (southwest) of Semer Water

In the upper catchment, Marsett Beck was classified in moderate ecological condition upstream and downstream of Marsett. Suggesting sites further upstream should be investigated to locate potential pollution sources. On Raydale Beck, the upstream sites (SW21 and 22) were classed in Good ecological status. However, the downstream site SW14 was moderately classed; showing a reduction in water quality downstream. The combined upper catchment streams then flow into Crooks Beck (SW26) which also classified in moderate condition. SW26 was likely impacted by water quality from upstream.

6.7.4 Northeast tributaries of Semer Water

The northeast sites upstream of Low Blean farm all were classified in Good status. The downstream site SW8 also gained good ecological status; however the individual seasons BMWP scores suggest the water quality at this site may fluctuate slightly over the year. SW7 located downstream of SW11 and 12 was classified in moderate condition across all seasons; suggesting a decline in water quality between the upstream and downstream samples.

Figure 2. Sampling site RICT classifications mapped



SW1 at the bridge in Bainbridge classified in moderate status

Key – Water Framework Directive Bands:

- High Standard
- Good Standard
- Moderate
- Poor
- Bad

6.7.5 Macroinvertebrate results overview

Based on combined seasons (within year), a breakdown of the sites likely to require improvement are shown in the table below. (note that results suggest some additional temporal issues in individual indices at SW8 and 17)

Table 27. Sites classified as sub-standard under WFD (RICT)

Site	Class	Site	Class
SW2	Bad	SW1	Moderate
		SW7	Moderate
		SW14	Moderate
		SW15	Moderate
		SW20	Moderate

7. Overall Discussion

The combined results from winter water chemistry and three seasons of macroinvertebrate and diatom sampling are discussed below in the catchment areas described in section 3.2.

At almost all sites, biological index scores and RICT results showed considerable variation between seasons. This variation can be attributed in part to seasonal variation in community composition (macroinvertebrates, Hynes, 1972). Several indices (i.e BMWP) have been shown to vary significantly with season, especially in headwater streams (Callanan *et al.,* 2008). However, changes in water quality throughout the year are the major driver behind indices variation shown by the results of this study (Zamora-Munoz *et al.,* 1995). Scatter plots of macroinvertebrate indices vs. the diatom index TDI.4 are displayed within Appendix 8.

7.1 River Bain Downstream of Semer Water

The outflow of Semer Water was sampled 150m downstream from the lake. Diatom results showed SW2 to be in moderate status, whilst the macroinvertebrates suggested bad status throughout the year. The indices and classifications suggest possible pollution and/or poor habitat/substrate at this site. The substrate at SW2 was predominantly silt, suggesting high silt accumulation and therefore poor habitat, which may account for the low scores. Further downstream in Bainbridge, SW1 classified as in moderate/good status, and the macroinvertebrate indices scores were significantly improved.

7.2 Semer Water (Lake shore)

The lake diatom EQR were generally classified in good status. However, as with the macroinvertebrates (BMWP and ASPT), individual samples fell into lower classifications. In all three seasons, the west shore of Semer Water scored marginally better than the east. Individual samples highlighted greater issues at the eastern sites. It is unclear if this was due to field runoff at individual sites or if circulation of nutrients was affecting the eastern area. The macroinvertebrate samples at the car park site on the north shore scored highest in all seasons, but the diatom results suggest the site was in poor/good status, lower than the other lake sites. The proximity to tributaries SW7 and 8 may influence this site, alternatively the use of the upper shore as a car park may lead to additional anthropogenic influences at this part of the lake.

Perlodidae are reported as one of the few families which showed a consistent association with oligotrophic conditions in still waters (O'Toole *et al.,* 2008). *Perlodidae* were present in several winter samples and one the repeat samples at SW23 in summer. However, Site 23 on the west shore did show a moderate level of total phosphorus and Site 24 on the eastern shore also showed a high level of suspended solids, though these appear to have had only a small effect on the winter samples.

7.3 Northwest Tributaries of Semer Water

The Northwest streams were classified in high status from the macroinvertebrates combined samples. However, the diatom results and macroinvertebrate individual indices suggest the combined sample may be masking changes in water quality. SW17 macroinvertebrate samples scored relatively poorly in all three seasons and diatom results indicated moderate status in winter. The results suggest intermittent water quality issues or habitat degradation at the site. SW16 macroinvertebrate samples showed a significant decline in the summer sample alone, though the diatom results remained stable. The only notable variation in water quality was a moderate pH increase in summer, but this was consistent with all northwest sites. Macroinvertebrate results for SW18 declines in autumn (BMWP 56 and ASPT 4.7) compare to the relatively consistent score observed in winter (BMWP 76, ASPT 6.33) and summer (BMWP 73, ASPT 5.62). However, diatom indices did not indicate issues were significant.

In terms of water chemistry, in winter, SW17 recorded raised phosphorus levels compared to other sites in the catchment, which could be attributed to agricultural runoff. This site also recorded very high BOD (10.00mg/l), which places the site within the UKTAG standards poor category. At this sustained level of BOD, the aquatic ecosystem is highly likely to be impacted upon.

7.4 Upper Catchment (Southwest) of Semer Water

Diatom EQR classified the majority of the upper catchment in high status. In contrast to this, the invertebrate results for the upper catchment contained the highest concentration of moderately classified sites in the combined season analysis. On Marsett Beck, both sample site locations (SW15 and SW20) followed similar patterns, and were classified in moderate status for macroinvertebrates and high status for diatoms. The upstream site contained diatom taxa suggestive of enrichment, which combined with the invertebrate classification suggests investigation upstream is required. These results suggest Marsett hamlet has relatively limited effect on the water quality. Further investigation upstream would be required to identify potential sources of pollution.

SW14 in the upper catchment was classified in moderate ecological status from macroinvertebrate data. However, the diatom results classified the site and both upstream sites in high ecological status. The high ASPT invertebrate scores at the upstream sites and SW14 limits the possibility of organic pollution as the cause of the moderate status invertebrate classification. The lower than expected number of taxa recorded suggests possible microhabitat degradation, though no evidence to support this was observed. Winter water quality was generally good in the upper catchment. A slight increase in pH was recorded in summer corresponding with increased temperature. Water chemistry data, or further biological sampling is needed to allow futher interpretation at this site.

The upper catchment streams flow into Crooks Beck (SW26). The diatom EQR showed the site to be in high status throughout the year, but the macroinvertebrates classified the site in moderate condition. Of the indices, BMWP and the number of taxa declined throughout the year; to a level that suggested the site was moderately impacted. ASPT scores suggest organic pollution was limited; with the scores only falling below 6 in the autumn.

Water quality above Site 26 was generally good in winter. The winter results showed that water in the upper catchment (sites 3, 13, 14, 15, 21,22) was softer on average than the other sub-catchments and had lower alkalinity. The Diatom DAM EQR classified SW26 in less than good status for acidification, though more evidence is needed to confirm the result. In winter, there was little phosphorus recorded upstream of Semer Water, with all sites bar Site 3 recording below the standard detection level. Other indicators of pollutants were not detected, with each of the nitrogen related parameters below detection across this grouping.

7.5 Northeast Tributaries of Semer Water

The northeast tributaries can be split in to two sections; upstream of the farming infrastructure (SW9, 10, 11 and 12) and downstream of the farming infrastructure (SW7 and 8). For macroinvertebrates SW7 classified in moderate status and for diatom in good/moderate status across the three seasons. However, both upstream sites (SW11 and 12) classified in good status (invertebrate) and high status (diatom). The macroinvertebrate indices results were also significantly reduced downstream in all seasons. These results suggest the water quality declines downstream. Site 7 did show a moderate level of phosphorus and also a raised level of nitrate and total oxidised nitrogen in winter. SW8 was classified in good status for macroinvertebrates (RICT) and in high status for diatom (TDI3). Macroinvertebrate BMWP results did vary for SW8 but ASPT remained high throughout the year suggesting no/little organic pollution.

7.6 Limitations

Water chemistry can change rapidly; results fluctuate with seasonal cycle and pulses of nutrients delivered to streams can cause large peaks in certain parameters (*e.g.* following rainfall or fertilisation). Therefore, sampling replication must occur across the year. Monthly sampling would pick-up seasonal cycle, but might miss peaks in key parameters. Weekly water sampling would be much more effective at detecting any peaks in key nutrient parameters throughout the year.

The extreme rainfall observed during winter, summer and autumn of 2012 further complicate the analysis of results. Increased drift of macroinvertebrates due to the high flows had the potential to alter community composition and corresponding indices. Four diatom samples were repeated in autumn, this was as a result of damage to labels in transit. It is not believed that the time delay will have affected the results.

Replication across the year will allow water quality standards to be expressed as mean or percentiles. It also allows meaningful comparison with UKTAG standards. With one temporal snapshot sampling, comparisons made to these standards are purely descriptive of the point in time that sampling occurred, and confident conclusions cannot be drawn using the single water chemistry sample results. The higher the rate of replication of sampling the more significance can be taken from the data that are produced and conclusions that are drawn.

Lake invertebrate data should be interpreted with caution. Research has shown that the tolerances of some macroinvertebrate taxa to conditions in standing water differ greatly to their tolerances in flowing waters. An example being *Baetidae* scored as the least sensitive family of mayfly in flowing waters. However, research has shown it to be a good indicator of oligotrophic conditions in standing waters. Likewise the use of flowing water indices in standing waters has been shown to be unreliable, with alkalinity playing an important role in the composition and tolerance of taxa (O'Toole *et al.,* 2008). This would require a similar index to the Lake TDI which has different versions for different alkalinity type lakes.

8. Conclusions and Recommendations

8.1 Conclusions

The results indicate low-levels of enrichment in the upper catchment (southwest) of Semer Water, although locating the likely sources would require further investigation. Samples from two streams; SW7 and 17 were also indicative of enrichment. The source of the enrichment was likely agricultural due to the surrounding land use. SW17 would benefit from fencing as protection from poaching and direct input from cattle.

The RICT analysis classified the Semer Water sites at their lowest in winter similar to the majority of diatom EQR. The majority of sites showed significant improvements into summer and autumn. The ASPT score varied slightly at the majority of sites between seasons and BMWP scores were often more variable between seasons (Zamora-Munoz *et al.,* 1995)

Samples from the lake generally exhibited good water quality indicators, but water quality issues were indicated by individual samples. Identifying sources in standing waters is difficult due to factors such as water circulation as well as runoff.

The changeable nature of water chemistry data makes sampling replication essential. The data produced are potentially extremely powerful, if the most is made of the opportunity to sample. Sampling at monthly or weekly intervals would be required to record fluctuations with seasonal cycle, and allow comparisons with water quality standards. Weekly sampling is much more likely to detect peaks in key parameters such as total phosphorus, and provide a detailed insight into what is mixing in the lake and work towards identifying sources of the diffuse pollution.

This data set provides a year-long baseline, which allows for monitoring of gains or losses in status as issues in the catchments are addressed.

8.2 Recommendations

Further investigation in to Marsett Beck is recommended. Furthermore, sampling at sites SW7, SW11 and SW12 (on Little Ings Sike), and additional sites on the beck are recommended to monitor impacts downstream of the farming infrastructure. Likewise, at SW17 further samples above and below the possible impact would confirm the source and timing of pollution.

Water chemistry must be replicated at least monthly, preferably weekly, at sites of concern is required to draw more meaningful conclusions from the data. A monthly/weekly sample programme is important in order to detect peaks in key determinands, which will lead a more detailed understanding of diffuse pollution sources in the catchment.

Additionally, further exploration of the biological status of Semer Water lake itself would be helpful, expanding water chemistry analysis from the littoral zone to include samples across the lake would allow for estimations of trophic status to be achieved. The inclusion of the chironomid pupal exuviae technique (CPET) would allow WFD classification of the lake for invertebrates.

9. References

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Appendices

(Excel and Word files)

Appendix 1a. Proforma: winter upstream of the lake
Appendix 1b. Proforma: winter northeast streams
Appendix 1c. Proforma: winter Semer Water
Appendix 1d. Proforma: winter northwest streams
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APPENDIX 1

Appendix 1a. Proforma: Winter Upstream of the lake
Appendix 1b. Proforma: Winter Northeast streams
Appendix 1c. Proforma: Winter Semer Water
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APPENDIX 2

Appendix 2a. Proforma: Summer Upstream of the lake
Appendix 2b. Proforma: Summer Northeast streams
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APPENDIX 3

Appendix 3a. Proforma: Autumn Upstream of the lake
Appendix 3b. Proforma: Autumn Northeast streams
Appendix 3c. Proforma: Autumn Semer Water
Appendix 3d. Proforma: Autumn Northwest streams
Appendix 3e. Proforma: Autumn Downstream of the lake

APPENDIX 4

Appendix 4. Summary Water Quality

APPENDIX 5

Appendix 5. Diatom Dominant Species

APPENDIX 6

Appendix 6. Diatom Raw Data
Excel Spreadsheet

APPENDIX 7

Appendix 7a. Macroinvertebrate Winter Raw Data
Appendix 7b. Macroinvertebrate Summer Raw Data
Appendix 7c. Macroinvertebrate Autumn Raw Data

APPENDIX 8

Appendix 8. Macroinvertebrate Indices

APPENDIX 9

Appendix 9. TDI4 EQR vs RICT EQR