Natural England Commissioned Report NECR046

The aquatic ecological status of the rivers of the Upper Dove Catchment in 2009

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

In 2007 the Upper Dove catchment was designated a priority catchment for the English Catchment Sensitive Farming Delivery Initiative (ECSFDI). This initiative provides advice and funding to farmers to help bring English rivers into favourable condition and meet the conditions of the European Union Water Framework Directive (WFD).

With assistance from ECSFDI, the Trent Rivers Trust started a restoration project in the catchment, including a Fishing Passport Scheme to encourage good stewardship of rivers and streams.

Encouraging farmers to improve water management facilities, and looking to improve riparian habitats, many kilometres of watercourse fencing have been installed. Woody debris and brash revetments have been used to improve in-channel habitat and reduce erosion. This survey has been monitoring the changes of invertebrate populations up and down stream of restoration works, fencing and other works carried out to improve farm facilities supported by ECSFDI grants.

This survey was commissioned to start monitoring the condition of the rivers and their catchment; with particular regard to farm management and river protection and restoration work. The results also include presence/absence of BAP species, bullhead, white claw crayfish and brook lamprey in the catchment. This information will contribute towards Condition Assessments of the SSSI river sections within the catchment.

The ECSFDI will use the data to find the source of diffuse and point source pollution, and further selected surveying would allow for detection of improvement in the rivers based on the work carried out on farms. Initial follow-up investigations in 2010 highlighted specific impact of agricultural pollution indicating the environmental stresses and aquatic conservation priorities to target?

Fluvial audit and bed sediment surveys are being carried out on the Upper Dove catchment in 2010, and the findings of both surveys will enable a more structured approach to river restoration.

The information from this survey has been presented in a traffic light map, indicating the key current areas of the catchment to target for remediation and conservation work. The Peak District Biodiversity Action Plan has been updated with data for records on species including water vole, crayfish and red data book macro invertebrates.

In particular the findings will help Natural England focus on:

where to

- target and assess the current investments in agricultural infra-structure with respect to the receiving river quality;
- prioritise the use of watercourse fencing to best effect;
- identify areas for habitat improvement, including riparian tree management;
- rejuvenate wetlands and encourage natural bank side vegetation; and
- improving the condition of the river SSSI's.
- helping Derbyshire Wildlife Trust conserve water voles and other projects.
- set ting up a catchment scale project to co-ordinate work from the numerous interested organisations, thus feeding into the Humber Basin Plan Management Plan and achieving the aims of the EU Water Framework Directive.

This report should be cited as:

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Further information
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Executive Summary

The report herein contained the findings from a large survey of the aquatic ecological status of the River Dove, River Manifold and River Hamps within the Upper Dove Catchment in 2009.

Water vole findings in Upper Dove Catchment

- A water vole (*Arvicola terrestris*) survey across 90 sample sites in the Upper Dove Catchment during the Spring of 2009 revealed no signs of this animal. There remained good water vole habitat at selective locations throughout the catchment but despite trapping efforts there were still signs of predatory mink through all 3 river corridors.

Crayfish findings in Upper Dove Catchment

- Twenty minute net and hand searches at 98 survey sites across the Upper Dove Catchment in the Spring and Autumn of 2009 showed no evidence of native white-clawed crayfish populations (*Austropotambius pallipes*) in the River Dove, River Manifold or River Hamps. Unlike the River Hamps, where there was a marked signal crayfish (*Pacifastacus lenuisculus*) population, there was no evidence of signals in the River Dove or River Manifold in 2009.The continued demise of native crayfish populations in the River Dove and River Manifold appeared to be the result of cross-river transfer of crayfish fungal plague by the movements of domestic animals, livestock and/or anthropogenic activities. The last records of native crayfish in the River Dove in 2005 and the River Manifold in 2008 (Everall, 2009) had both been associated with confirmed outbreaks of fungal crayfish plague.

- There were healthy populations of the invasive signal crayfish in the River Hamps in 2009 from Waterhouses up to a series of large weirs just above Onecote. No signal crayfish were found in the main River Hamps or any tributaries from above Onecote up to Royale edge in the foothills. Following the broad benchmark monitoring in 2009, further crayfish surveys in the River Dove and the River Manifold were desirable to cover any blank survey areas from the 2009 work and better determine if there were any small pockets of signal crayfish or any remaining, hitherto undetected, sentinel native crayfish left in these rivers.

Biological quality in rivers of Upper Dove Catchment

- Standard biometric measures (for example, Biological Monitoring Working Party or BMWP Scores, Average Score Per Taxon's or ASPT and Species Richness) of biological health indicated that ~38% of the River Dove, ~20% of the River Manifold and ~25% of the River Hamps sites produced ecological water quality values below targets set by the Environment Agency (RIVPACS). These watercourse findings in 2009 supported the fact that this catchment was found to be in poor condition by the Environment Agency (EA) while in the process of assessing all English river catchments in 2000.

- On a more positive note, some water quality indices in parts of the Upper Dove Catchment were high although seldom in the very high category. Previous findings from a much more limited number and infrequently sampled set of EA biological monitoring sites had indicated a potential downturn in the general biological quality (for example, BMWP's) at Glutton Bridge and Sprink on the River Dove and Longnor in the River Manifold (Everall, 2009). Marked areas of depressed biological water quality in the present study were:

i. The upper River Dove in various river and stream sites at and above Glutton Bridge.

ii. The River Dove and some associated feeder streams through Beresford Dale and the SSSI in Wolfscote Dale.

iii. The River Manifold from Longnor down to Over Boothlow and the upper River Manifold both below Hardings Booth and above Ball Bank House Farm.

iv. The River Hamps and associated streams in the Winkhill and Onecote areas respectively.

- Quantitative species level analysis of, for example, the full range of riverfly and sentinel shrimp (*Gammarus pulex*) communities revealed a more widespread depression of aquatic faunal levels in limestone stretches of the River Dove and River Manifold compared with nearby rivers from limestone catchments with a lesser intensity of agricultural land use.

Agricultural pollution and siltation in rivers of Upper Dove Catchment

- An agricultural macroinvertebrate pollution indicator key by Rutt *et. al.* (2009) appeared to perform well in the Upper Dove Catchment and demonstrated that in the Spring and, more markedly in the Autumn of 2009, many river and stream sites within the River Dove, River Manifold and River Hamps were adversely affected by organic pollution. The results of this simple field test associated well with the later findings from more in-depth organic pollution indexing using community species Saprobic indicators and more limited water chemistry respectively. It was felt that the agricultural indicator key could potentially be used in the field by skilled hands to isolate specific sources of organic pollution in the Upper Dove Catchment.

- Working with fellow researchers in Germany (the EUROLIMPACS project), extensive organic indexing was undertaken on the River Dove, River Manifold and River Hamps using the species macroinvertebrate community data collected in 2009. The source areas and degrees of organic load in the Upper Dove Catchment were plotted on to OS Environmental Scheme level maps supplied by Natural England across the 70-90 survey sites. These maps were supplied as working reference documents to key Catchment Sensitive Farming (CSF) personnel with DEFRA, the NE project co-ordinator and Trent Rivers Trust staff. CSF, NE and TRT personnel were now in a position to use the organic loading maps to target farm visits, pollution control measures, river habitat restoration work and prioritise associated funding. The maps were also in the process of being upgraded into GPS mapping by Loughborough University for cross-referencing with geomorphological studies planned for 2010.

- Compared with the alternative of continuous chemical monitoring, the ongoing assessment of species macroinvertebrate communities allowed a cost-effective determination of changing organic pollution in the Upper Dove Catchment. Most importantly, it provided a measure of actual organic impact upon the receiving ecology <u>and</u> a quantifiable measure of the success of any agricultural remediation measures applied by CSF/NE.

- All other known sources of organic load to the Upper Dove Catchment (for example, STW final effluents, CSO's and private consented discharges) were mapped against the documented patterns of organic pollution in 2009. All the spatial evidence for organic pollution indicated that the key sources of organic impact in the rivers of the Upper Dove Catchment in 2009 were of agricultural origin.
- Despite the relatively high organic loading evident within the 3 rivers, the biological quality of classified reaches as determined by routine EA monitoring in the Upper Dove Catchment remained high in parts and this was, in all probability, due to the dilution afforded at present. Climate change predictions on seasonal rainfall and flow patterns for the Upper Dove Catchment would therefore be important for future pollution risk assessments in this catchment.

- In collaboration with EA researchers, a recently developed Percentage Siltation Index was applied to all of the species community macroinvertebrate data for the River Dove, River Manifold and River Hamps from 2009. Forty one percent of riffle sites in the Upper Dove Catchment were classified as un-silted or naturally silted, 46% slightly silted, 11% moderately silted and 2% markedly silted. While some degree of siltation can be ecologically desirable in some watercourses the survey sites were all (seasonally) fast-flowing riffle sites and not slack or impounded waters where more marked siltation may have been expected.

- The species siltation indexing data was also mapped onto ESA level OS maps and supplied as reference documents to key CSF, NE and Trent Rivers Trust (TRT) personnel. CSF, NE and TRT personnel were now able to use the proxy siltation maps to assess 'pinch points' of combined environmental stresses (organic plus silt loading) and get an early indication of combined pollution 'hot spots'. Further work in 2010 by personnel from Loughborough University will help to further elucidate the sources, nature and quantum of siltation in the Upper Dove Catchment. While such studies promised to get a better handle on geomorphological aspects of siltation only continued species analysis of the receiving macroinvertebrate communities would measure the actual degree of moulding and impact of silt upon the ecological health of these rivers.

- Following from the work of Paisley *et. al.* (2003) and Everall (2005) a nutrient (total reactive phosphorous or TRP) indexing tool for assessing the degree of nutrient enrichment was further developed using the community macroinvertebrate data from the Upper Dove Catchment in 2009. The results from this indexing were cross-referenced against community nutrient rankings from periphyton communities examined at survey sites through the 3 rivers. There was a good (regression fit) relationship between TRP levels, macroinvertebrate TRP index, Saprobic index and periphyton community nutrient rankings. There was evidence of increasing nutrient enrichment at River Manifold and River Hamps sites from family macroinvertebrate community data over the last 20 years but not in the River Dove.

Aquatic conservation value of rivers in Upper Dove Catchment

- Community Conservation Indexing (CCI) after Chadd and Extence (2004) was undertaken at all macroinvertebrate survey sites in the Upper Dove

Catchment in 2009. In the River Dove in 2009 the 38 overall survey sites were calibrated as 5% Very High, 14% High, 54% Fairly High, 24% Moderate and 3% Low aquatic conservation value. The very high conservation value sites were predominantly a few (2) streams in the upper foothills and the SSSI in Wolfscote Dale had 3 sites ranging from Moderate to Fairly High conservation value. In the River Manifold in 2009 the 27 overall survey sites were calibrated as 33% High, 63% Fairly High and 4% Moderate conservation value. There was no Very High conservation value sites found in the River Manifold during the 2009 survey work. In the River Hamps in 2009 the 25 overall survey sites were calibrated as 28% High, 56% Fairly High, 4% Moderate and 4% Low conservation value. There was no Very High conservation value sites found in the River Hamps during the 2009 survey work.

- It was worth noting that no Red Data Book aquatic fauna were found during the course of the macroinvertebrate surveys in 2009. However, some specimen samples of, for example, Tipulid larvae remained to be interpolated due to the limitations of existing keys. The main investigational drive of the 2009 project was to get a handle on the sources, nature and quantum of pollution and benchmark overall aquatic health respectively in the catchment. Because of this it was not possible to extensively survey some of the upper moorland areas where RDB and rare species were more likely to be found, for example, mayflies like *Potamanthus luteus* and/or *Siphlonorus* sp. and/or *Paraleptophlebia werneri*. Future ecological survey work planned for 2010 was designed to survey further areas of the catchment for conservation and biodiversity assessment purposes per se.

- The (NE) Biodiversity Action Plan mayfly species, *Nigrobaetis niger* (Southern Iron Blue), was found in very low numbers in the River Dove (1 site at: Hollinsclough, Bereseford Dale and Wolfscote Dale), River Manifold (1 site: Blake Brook) and River Hamps (1 site: near Willow Farm) in 2009. In all probability, this BAP mayfly species was at the effective northern limits of current viable population distribution in the U.K. It was therefore clearly important to keep a handle on existing population numbers of this BAP mayfly in the Upper Dove Catchment in future years.

Ecological value of river works in Upper Dove Catchment

- Preliminary investigation of macroinvertebrate communities immediately up and downstream of river improvement work by the Trent Rivers Trust was interesting with some evidence of improved biometric measurements below these sites. For example, BMWP, ASPT and Species Richness were all elevated in the River Manifold at Ludburn Farm downstream of cattle fencing and in-stream bank revetment work. It was hoped to undertake more focussed ecological assessments at Ludburn and a number of other river work improvement sites in the Upper Dove Catchment in 2010. Such ongoing ecological monitoring was critical in providing a quantifiable measure of the success of this environmental improvement work since the good ecological health of receiving watercourses was vital to long-term fishery sustainability.

Development of a multi-metric index of watercourse impacts

- The project has developed a simple (green, amber and red) ‘traffic light’ system to easily identify watercourse sites by their joint conservation value, degree of combined environmental stresses (organic load, nutrient enrichment and siltation) and concomitant evidence of the extent of ecological impact. Overall pollutant stress ranking of sites in the Upper Dove Catchment would provide a more holistic approach to targeting further investigations and remedial actions. It should be noted that all of the multi-metric macroinvertebrate community tests used in the 2009 survey work in the Upper Dove Catchment had shown the same (seasonal) consistent site patterns of environmental stress and ecological impact.

Acknowledgements

There were a number of key people without whose support throughout the project the work would not have been accomplished:

My colleagues Andrew Farmer at Aquascience, Denise Lorne at Natural England, Bob Marsden at Catchment Sensitive Farming, Andrew Heath at the Trent Rivers, Rachel Walker at the National Trust, Dr. Ian Wallace at the Liverpool Natural History Museum, Astrid Scmidt-Kloiber of the EUROLIMPACS Team in Vienna, Dave Ottewell and Alice Chapman at the Environment Agency in Lichfield, Richard Chadd and Chris Extence at the Environment Agency in Lincoln, Tony Bridgett at the Izaak Walton Hotel, Ron Trevis from Derbyshire County Angling Club, the 59'ers FFC, Michael Collins in Beresford Dale, the public and the farming fraternity too numerous to mention who kindly gave us access to the bank sides of the River Dove, Manifold and Hamps.

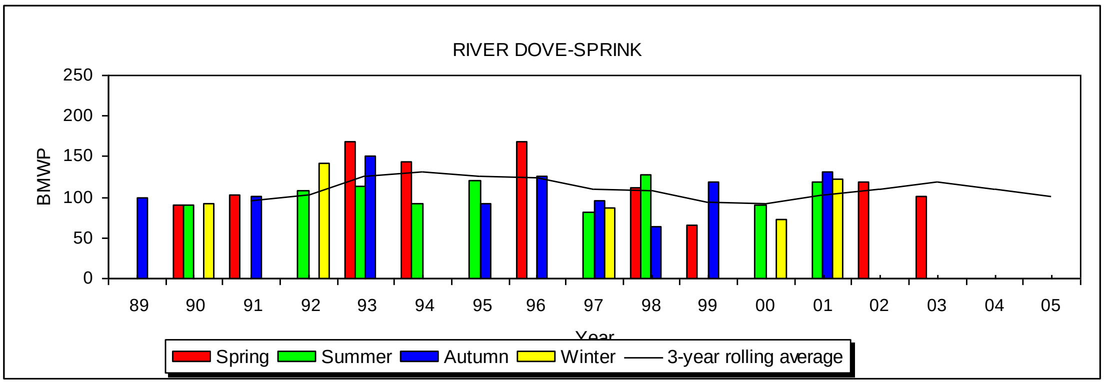
Thanks also to Dr. Cyril Bennett of The National Riverfly Partnership and Aquascience for allowing us to use his excellent river fly nymph photographs throughout this report.

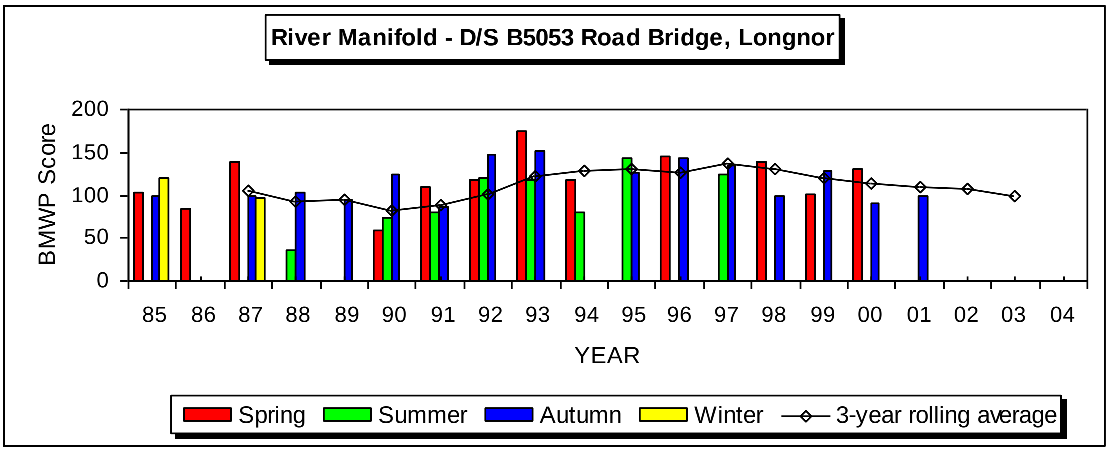
Contents

1. Introduction

The Upper Dove catchment is comprised of the top of the River Dove itself and two major tributaries, the River Hamps and the River Manifold. The Catchment is 232 km^2 in size and lies within the South West Peak (SWP) Natural Area, part of the Peak District National Park (PDNP).

Declines in fish and invertebrate populations in this catchment had been noted by anglers in recent years. It was also found to be in poor condition by the Environment Agency (EA) while in the process of assessing all English river catchments in 2000 and there was evidence of increasing nutrient enrichment in the River Hamps and Manifold catchments respectively (Everall, 2005b). Some of the Environment Agency routine monitoring sites in watercourses in the Upper Dove Catchment had started to show a downturn in biometric measurements of river health like the Biological Monitoring Working Party Score (BMWP) as shown in the graphs below. The graphs below are copyright and courtesy of the Environment Agency.





As such the catchment was designated a priority catchment for the English Catchment Sensitive Farming Delivery Initiative (ECSFDI), a partnership scheme between EA and Natural England (NE) which started in 2007 to provide advice and funding to farmers in order to bring English rivers into favourable condition and meet the conditions of the EU Water Framework Directive (WFD).

The East Midlands ECSFDI team has developed a partnership with the Trent Rivers Trust (TRT) and initiated the Peak District River Restoration Scheme which focuses on the three rivers already mentioned. TRT are now actively engaged in talking with farmers, assisting delivery of the ECSFDI s grant scheme, and practical river improvement works. Although some water sample and invertebrate monitoring had taken place within this catchment in recent years, mainly by EA, the exact scope of the monitoring undertaken and usefulness of the data gathered was unknown. It was proposed that all relevant information should be gathered and a document produced which highlighted any changes in the biological status of these rivers and their current state of ecological health in 2008. A report produced for Natural England benchmarked the current state of knowledge of the native crayfish, water vole and aquatic macroinvertebrate communities in the River Dove, River Hamps and River Manifold in the Upper Dove Catchment up to the end of 2008 (Everall, 2009).

It was important that the reader of this document be familiar with some general principles of biological monitoring, biometric terms used by Agencies and inherent limitations of some biological quality data. The following paragraphs will address these matters before looking at the recent biological survey data for the Upper Dove catchment during 2009 in the later sections of this report.

Unlike chemical samples the aquatic macro-invertebrate communities in a river or stream provide a longer-term ‘biological fingerprint’ of bio-quality and potential pollutant impacts in receiving watercourses. Several biometric indices to describe biological quality and pollution status in rivers are routinely used by organisations like the Environment Agency. For example, the BMWP score system is a commonly used tool to summarise freshwater invertebrate data and it was developed from bio-monitoring tools like the Trent Biotic Index (Woodiwiss, 1964). It was devised to reflect organic pollution and generally higher scores indicate better biological quality and lower scores reflect poorer water quality which could be linked to pollutant impacts.

The BMWP system of biological monitoring takes no account of the abundance of any family fauna merely the presence or absence of taxa, it provides no species richness data and it is affected by natural seasonal variation. The Average Score Per Taxon (ASPT) is also related to the BMWP score. It gives an indication of the aquatic invertebrate community’s sensitivity to pollution. This biotic index is used to give an idea of the diversity of the aquatic invertebrate community. In general, a healthy river will support a diverse community whereas one under stress from pollution, for example, will be less diverse and record a correspondingly lower number of BMWP scoring taxa. Again, it takes no account of the abundance of invertebrates or species richness. ASPT data from the Environment Agency was not summarised in this report on the Dove catchment since the ‘fingerprints’ for ASPT data usually follow the BMWP trends and they suffer from the same data limitations for example, lack of true faunal abundance and species data.

Despite some of the limitations of Environment Agency data with respect to aquatic macro-invertebrate species richness, biodiversity and abundance in watercourses this was sometimes the only biological quality data available for a given watercourse in the Upper Dove Catchment (Everall, 2009). It has been well documented that semi-quantitative and community (family) level monitoring of macro-invertebrates in watercourses can mask underlying changes in the abundance of some species, with for example, sensitive stoneflies and mayflies being lost from aquatic systems impacted by abiotic and/or biotic factors (Hellawell, 1986 and Eyre *et. al.*, 2005).

In the wider context of watercourse monitoring in the U.K. there will be targets or reference macro-invertebrate communities set for reaches of streams in Europe under the terms of the EU Water Framework Directive (2000/60/EC; CEC, 2000). For Britain these targets will be set through a RIVPACS style prediction based on clean-water reference sites (Wright *et al*., 2000). The targets will be set biological indices (BMWP, ASPT, Ntaxa) and lists of taxa that are predicted by the Environment Agency computer model RIVPACS to be present under reference conditions.

RIVPACS (Wright *et al.*, 2000) serves as a moderately robust system for assessing the biological quality of freshwaters but it is not considered to be an appropriate tool for forecasting responses of macroinvertebrate communities to environmental change or localised abiotic factors for example, cattle encroachment impacts on siltation and local slurry or silage liquor incursions (Armitage, 2000). Some knowledge of the whole watershed, particularly upstream sites with respect to re-colonisation potential, was also necessary to enable full diagnosis of these scenarios (Langford *et. al.*, 2009). The influence of land use on biological water quality in agricultural catchments had been shown to be scale-dependent and it varied in time and space (Harding *et. al*., 1999 and Buck et.al., 2004). These temporal and spatial scale effects indicated that any biological (chemical) water-monitoring schemes need to be scale-sensitive to large areas like the Upper Dove Catchment.

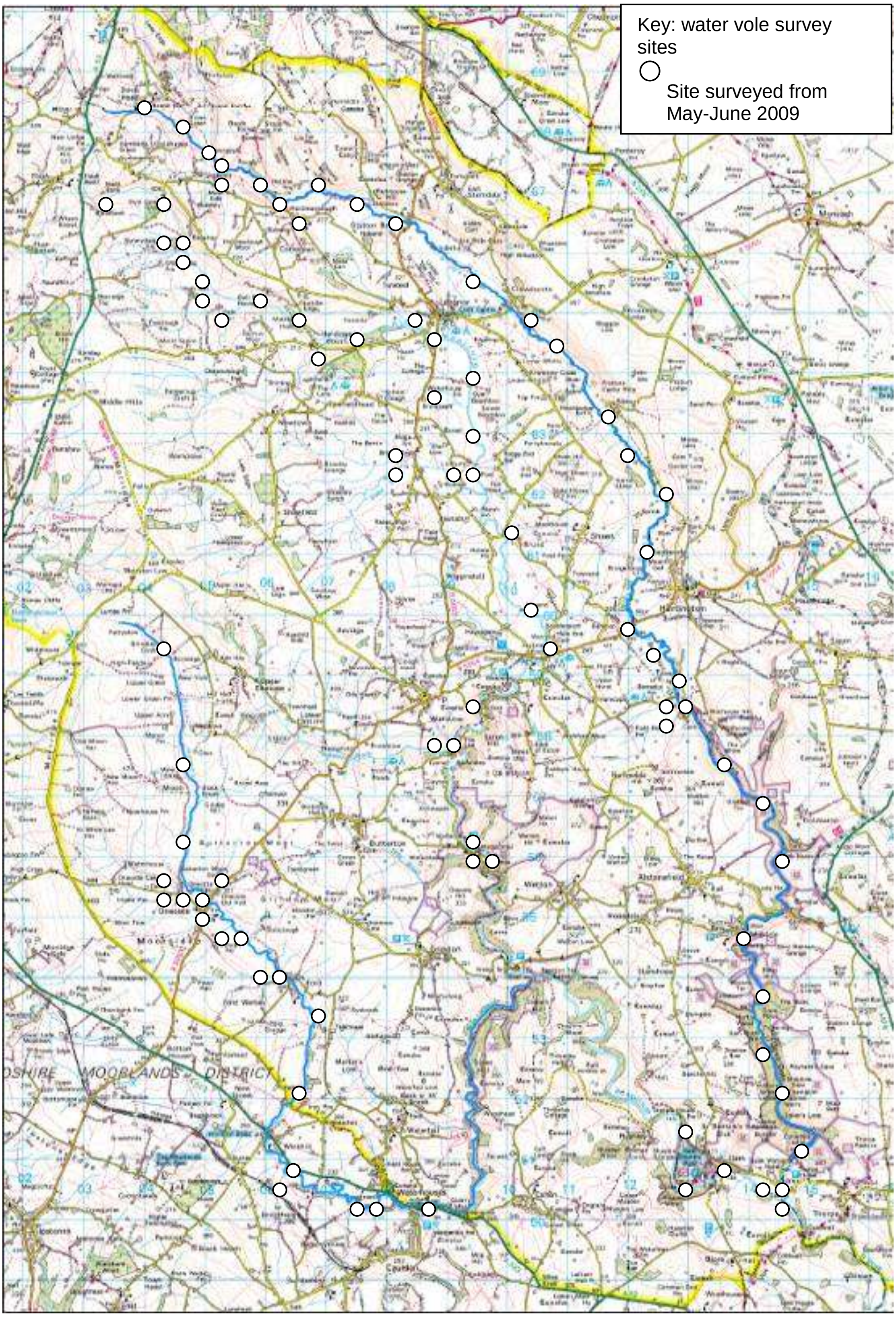
2. Methodology

Water vole surveys

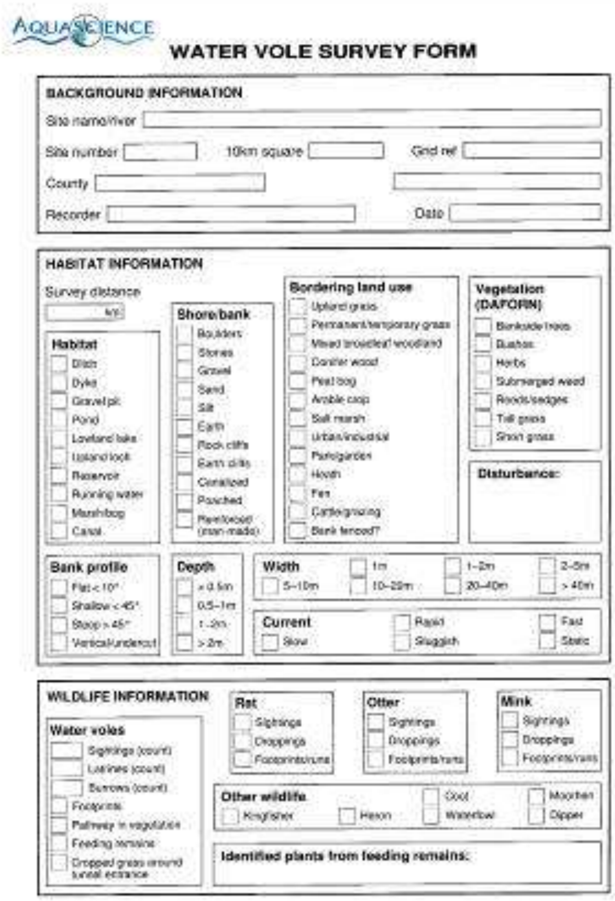
The field survey work was undertaken between the 29th of April and the 1st of June 2009. The weather during this period was mild and there was relatively little rainfall. The left hand (LHS) or right hand (RHS) watercourse bank sites marked in the map overleaf were surveyed over 100m strips moving sequentially upstream from Ilam in the order of the River Dove, River Manifold and River Hamps respectively.

Water vole (*Arvicola terrestris*)

All water vole survey sites in the Upper Dove Catchment in 2009 were shown in overview in the map overleaf.



The survey data collected included basic data on bank structure, slope and vegetation plus recording of any sightings, droppings, feeding stations and burrows of water voles (Strachan, 1998) as shown in the field data form overleaf.


AQUASCIENCE

WATER VOLE SURVEY FORM

BACKGROUND INFORMATION

Site name/river

Site number | 10km square | Grid ref

County

Recorder | Date

HABITAT INFORMATION

Survey distance

Habitat: Ditch, Dyke, Gravel pit, Pond, Lowland lake, Upland loch, Reservoir, Running water, Marsh/bog, Canal

Shore/bank: Boulders, Stones, Gravel, Sand, Silt, Earth, Rock cliffs, Earth cliffs, Canalised, Poached, Reinforced (man-made)

Bordering land use: Upland grass, Permanent/temporary grass, Mixed broadleaf woodland, Conifer wood, Peat bog, Arable crop, Salt marsh, Urban/industrial, Park/garden, Heath, Fen, Cattle/grazing, Bank fenced?

Vegetation (DAFORN): Bankside trees, Bushes, Herbs, Submerged weed, Reeds/sedges, Tall grass, Short grass

Disturbance:

Bank profile: Flat < 10°, Shallow < 45°, Steep > 45°, Vertical/undercut

Depth: < 0.5m, 0.5–1m, 1–2m, > 2m

Width: 1m, 1–2m, 2–5m, 5–10m, 10–20m, 20–40m, > 40m

Current: Rapid, Fast, Slow, Sluggish, Static

WILDLIFE INFORMATION

Water voles: Sightings (count), Latrines (count), Burrows (count), Footprints, Pathway in vegetation, Feeding remains, Cropped grass around tunnel entrance

Rat: Sightings, Droppings, Footprints/runs

Otter: Sightings, Droppings, Footprints/runs

Mink: Sightings, Droppings, Footprints/runs

Other wildlife: Kingfisher, Heron, Coot, Waterfowl, Moorhen, Dipper

Identified plants from feeding remains:

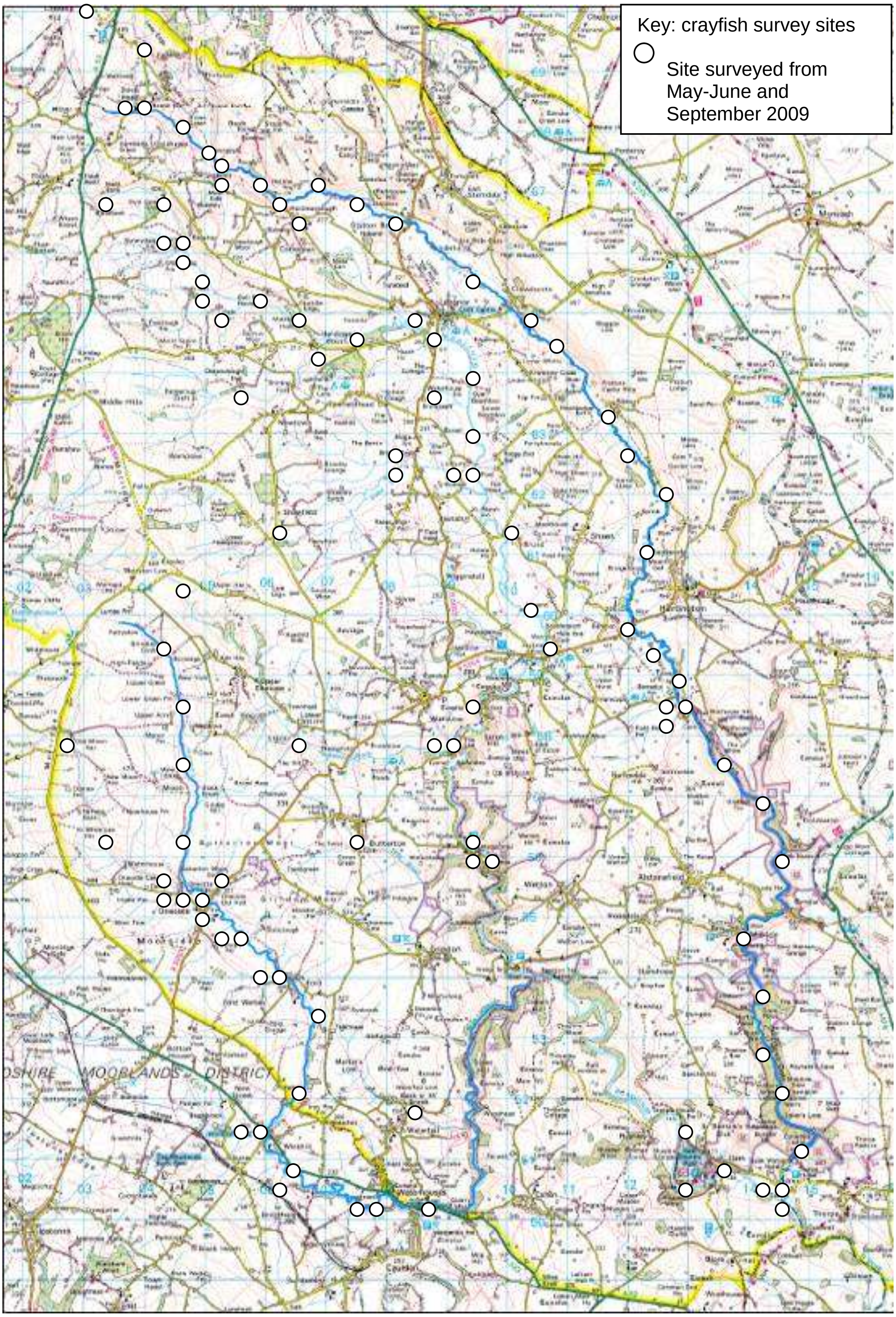
In practice, approximately 20-30 minutes was spent at each survey site in recording the associated water vole data. A total of 90 water vole survey sites were examined across the Upper Dove Catchment in the Spring of 2009. All field ecological observations were grid referenced using a hand held GPS (GARMIN).

Crayfish surveys

The field survey work was undertaken between the 29th of April - 1st of June and 7th - 30th of September 2009 respectively. The weather during these survey periods was mild and there was relatively little rainfall. The field work was only carried out when the watercourse bed visibility was good and water turbidity concomitantly low.

Native white-clawed crayfish (*Austropotambius pallipes*)

The most suitable crayfish habitats were manually searched within a 50m stretch surrounding each of the survey sites highlighted in the map below.



A total of 98 crayfish survey sites were examined across the Upper Dove Catchment in the Spring and Autumn of 2009. Stones and rocks were overturned from the river bed and once any silt had settled, any crayfish present were picked out by hand. A standard DoE approved (1mm^2 mesh) pond net was held downstream of the zone of substrate disturbance to catch any mobile crayfish. Searching amongst tree roots was also undertaken at all relevant sites with a standard DoE approved (1mm^2 mesh) pond net. For the purpose of standardisation and comparison with historic data (Rogers, 2000) the manual crayfish habitat surveying was undertaken for 20 minutes at each site. The latter sample period was either timed for the surveyor by the nominated bank person or by the surveyor at each sample site using a stop watch.

All field survey work was undertaken by moving upstream to the headwaters from Ilam over progressive sample days in the order of the River Dove, River Manifold and River Hamps respectively. Daily disinfection of work wear (boots, waders, gloves and sample nets) and the order of watercourse sampling was particularly important to limit the potential spread of crayfish plague between known problem river corridors and into the upper reaches of these watercourses. All field ecological observations were grid referenced using a hand held GPS (GARMIN).

Ad-hoc otter, mink, dipper and kingfisher observations

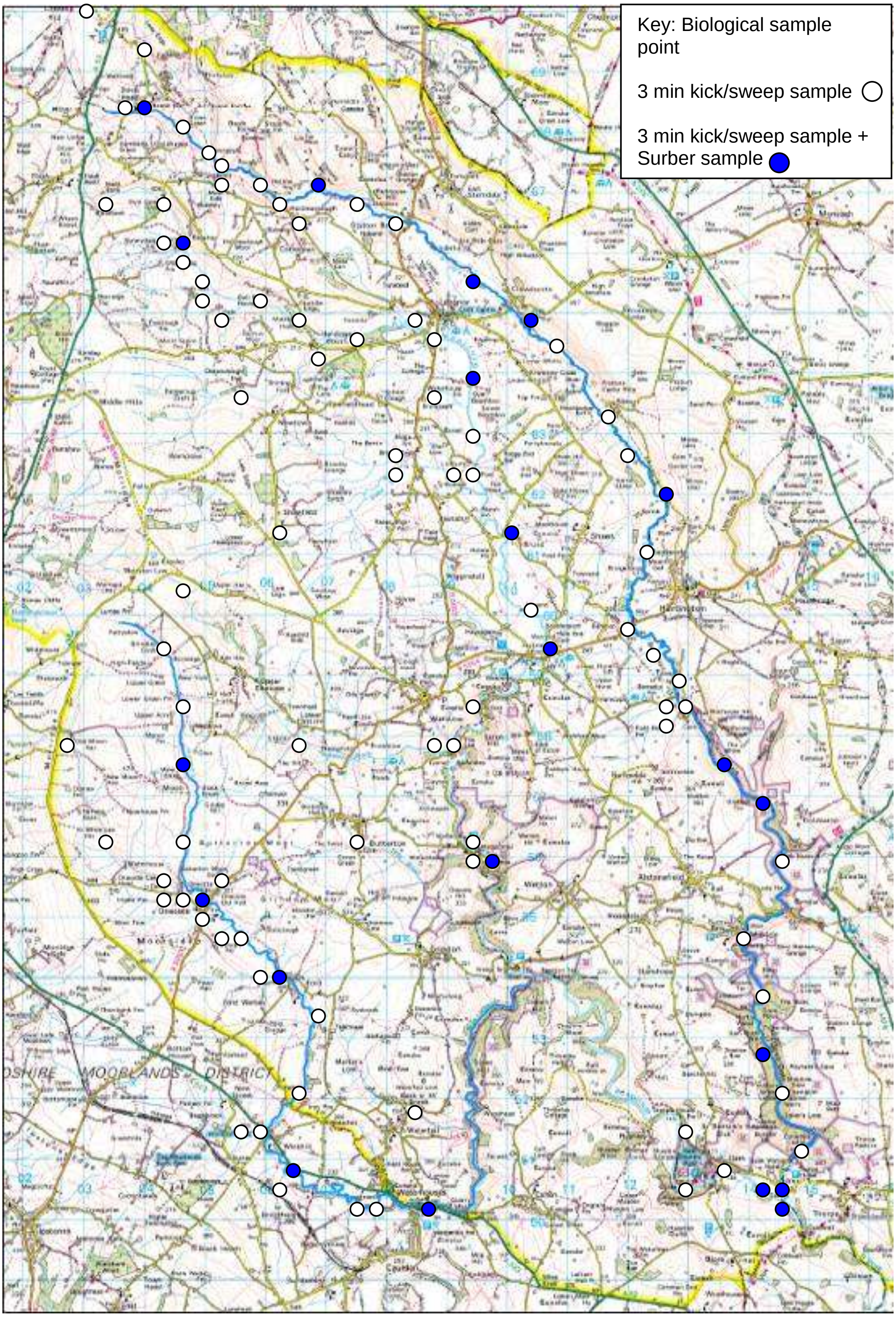
Although not part of the current survey remit, any signs (sightings, droppings, feeding stations or holts/nests) of otter (NRA, 1993 and Chanin, 2003), mink, dipper and kingfisher were noted at all biological sample sites plus any walked sections between sites using the previously highlighted water vole recording forms. All field ecological observations were grid referenced using a hand held GPS (GARMIN).

Aquatic macroinvertebrate surveys

Historic aquatic macroinvertebrate sampling techniques and data was reviewed in Everall (2009) but it was clear that Environment Agency monitoring had not recorded the true abundance of any macro-invertebrates (animals)/m^2 but only the relative abundance of taxa per 3 minute kick/sweep sample on a logarithmic scale and generally only down to a family level of macro-invertebrate identification (Everall, 2009). It was decided to undertake both fully quantitative assessments of macroinvertebrate communities and Environment Agency like 3 minute kick/sweep samples at various sites across the 3 rivers but to genus/species level and actual counts per sampling technique. Such benchmark monitoring allowed a comparison with the more limited historic data sets and other UK river data. These monitoring techniques also facilitated agricultural, organic, nutrient and siltation indexing of the rivers using both established and new modelling techniques respectively. Species data was also required for assessment of the conservation status of the aquatic invertebrate communities in the rivers of the Upper Dove Catchment.

The field survey work was undertaken between the 29th of April - 1st of June and 7th - 30th of September 2009 respectively. The weather during these survey periods was mild and there was relatively little rainfall. The field work was only carried out when the watercourse bed visibility was good and water turbidity was concomitantly low.

Both the fully quantitative (Surber) and 3 minute kick-sweep samples in the 2009 macro-invertebrate surveys of the Upper Dove Catchment are shown in the map overleaf. All field survey sites were grid referenced using a hand held GPS (GARMIN).



Fully quantitative Surber sampling used a $0.1m^2$ CEH type Surber net sampler with a 0.5 mm mesh. Since riffle and pool habitats vary in invertebrate composition, the flow habitat sampled was standardised across sites. Due to the inherent heterogeneity and variability of macro-invertebrate distribution, 5 samples were taken at random from comparably mixed substrate at each site. Great care was taken to ensure that there was good physical, biotic (for example, macrophyte) and flow habitat comparability between all sample sites and watercourses respectively. At any given sample site the substrate was systematically disturbed by hand across the area of the Surber quadrat to allow dislodged animals to be carried into the net. Any slightly larger stones in the quadrat were carefully scraped by hand into the net. The 5 samples were taken from a ca. 10-15m length across all riffle habitats to standardise the flow habitat sampling and the samples were individually analysed. Some samples were pooled to provide a $1m^2$ composite sample and others were left as 5 sub-samples to assess intra-sampling variation. All watercourse riffle samples contained 99% live animals at the time of sampling and this was recorded on the field sample buckets (Everall *pers. obs.*, 2009) prior to sealing sample bucket lids.

If required, the samples were kept cool in transit from field survey sites using car battery driven cooler boxes and processed within 24 hours of collection. All the samples were washed and sorted using stainless steel sieves down to a final retaining sieve of 500um in size. At this first sieving stage any of the tiny macro-invertebrates for example, live water mites and flatworms, were placed in 70% IDA in small sealed and labelled bottles which were placed inside their respective larger preserved sample containers. Water mites and flatworms are particularly difficult to pick out and identify at the later mixed preserved sample stage. All the fresh samples contained live animals but they were 'fixed' in 70% IDA (Industrial Denatured Alcohol) prior to further sorting, counting and identification of macro-invertebrates at a later date i.e. within 2-3 months of sample collection. The order of sorting and identification was alternated between the sample sources to reduce observer drift.

The first stage washed, preserved and sieved samples were then carefully decanted and very gently rinsed with tap water into large (sub-divided) white trays for sorting, counting and identification of the macro-invertebrates. Each of the composite or Surber sub-samples was carefully sorted by hand using 8 sub-divisional areas of a tray into the respective groups of macro-invertebrates for example, cased caddis, caseless caddis, mayflies, stoneflies, etc. These organisms were then placed into compartmental petri-dishes for identification and counting under a low power binocular microscope using FBA keys. Previously, sorted/preserved water mites and flatworms were also identified and counted at this stage. All the sample information and resultant macro-invertebrate identification/counts was entered into the laboratory raw data sheets at that stage. All macro-invertebrate samples were identified to the lowest taxonomic resolution possible and with the exception of some gnat larvae and worms this was to the species and occasionally genus level.

The Environment Agency protocol for 3 minute kick-sweep sampling was strictly adhered to at each of the Upper Dove Catchment watercourse sample sites (Environment Agency, 1997). An additional 1 minute hand search of larger substrate for example, rocks was also undertaken. All representative flow habitats were sampled at each site. All samples contained 99% live animals at the time of sampling and this was recorded on the sealed field sample buckets (Everall *pers. obs.*, 2009). The samples were kept cool in transit and processed within 24 hours of collection.

All the samples were washed and sorted using large stainless steel sieves down to a final retaining sieve of 500um in size within 24 hours of sample collection. At this first sieving stage any of the tiny macro-invertebrates for example, live water mites and flatworms, were placed in 70% IDA in small sealed and labelled bottles which were placed inside their respective larger preserved sample containers. This proved to be a useful interim sorting stage since historically organisms like water mites and flatworms were well documented as being difficult to pick out and identify at later mixed preserved sample stages (Everall *pers. obs*., 1990-2010). All the fresh samples contained live animals but they were 'fixed' in 70% IDA (Industrial Denatured Alcohol) prior to further sorting, counting and identification of macro-invertebrates at a later date i.e. within 2-3 months of sample collection. The order of sorting and identification was alternated between the sample sources to reduce observer drift.

The primary washed, preserved and sieved samples were then carefully decanted and very gently rinsed with tap water into large (sub-divided) white trays for sorting, counting and identification of the sample macro-invertebrates. Each of the 3 minute kick-sweep samples was carefully sorted by hand using 8 sub-divisional areas of a tray into the respective groups of macro-invertebrates for example, cased caddis, caseless caddis, mayflies, stoneflies, etc. These organisms were then placed into compartmental petri-dishes for identification and counting under a low power binocular microscope using FBA level keys. Previously, sorted/preserved water mites and flatworms were also identified and counted at this stage. All the sample information and resultant macro-invertebrate identification/counts was entered into the laboratory raw data sheets at that stage. All macro-invertebrate samples were identified to the lowest taxonomic resolution possible and with the exception of some gnat larvae and worms this was to the species and occasionally genus level.

Benthic algal samples were also taken from mid-stream submerged rocks at a limited number of the watercourse biological sample sites where prolific submerged algae growth was evident during the 2009 Upper Dove Catchment biological surveys. Sampling involved taking a qualitative scrape of ca. 1-2 cm^3 of benthic algae from submerged rocks in the watercourse using a disposable hard edged spatula per site. The sample scrape was placed in a small (60ml) new plastic vial with the *in-situ* watercourse water, labelled and sealed for cooled transportation to the Aquascience laboratory. Benthic algal samples were 'fixed' in Lugols Iodine on the same day as field collection and examined within 24 hours. Examination involved taking 1ml sub-samples of fixed benthic algal material into Sedgwick Rafter cells for algal identification to genus (species) level and a rough assessment of a particular algae's abundance within the sampled algal matt according to Biggs and Kilroy (2000). This work was not part of the remit from Natural England but as Aquascience are experts in algal identification it seemed sensible to gather as much pertinent biotic data as possible with respect to potential nutrient enrichment when prolific algal growths were evident in the field for example, the upper River Manifold in 2009 as shown in the photographs below.

Water chemical sampling

A total of 54 x 1 litre water samples were taken in the Spring and 36 x 1 litre water samples in the Autumn of 2009 across selected macroinvertebrate sample sites in the Upper Dove Catchment to benchmark basic water chemistry in the watercourses. Water samples were collected in the field, stored in car battery driven cool boxes and immediately fridged back at the Aquascience laboratory. Samples were kept on ice and submitted by 24hr courier to the UKAS accredited National Laboratory Service (Environment Agency) within 24-36 hours of collection. All water samples were analysed according to UKAS approved analytical methods for a particular chemical determinand.

The following chemical determinands were analysed in each sample: BOD 5 Day ATU (mg/l), Alkalinity to pH 4.5 as CaCO3 (mg/l), Ammoniacal Nitrogen as N (mg/l), Nitrogen - Total Oxidised as N (mg/l), Nitrite as N (mg/l), Orthophosphate, reactive as P (mg/l), Phosphorus : Total as P (mg/l), Conductivity at 20C (uS/cm), pH, Carbon, Organic : Total as C (mg/l), Solids Suspended (mg/l), Calcium (mg/l), Magnesium (mg/l), Hardness Total CaCO3 (mg/l), Nitrate as N (mg/l), Arsenic (ug/l), Selenium (ug/l), Cadmium (ug/l), Chromium (ug/l), Copper (ug/l), Lead (ug/l), Nickel (ug/l) and Zinc (ug/l).

Heavy metal samples were only taken in the upper catchments of all 3 rivers where elevated levels may have been associated with upland acidification. Alkalinity analysis was only added in the Autumn chemical sampling runs in 2009 to provide data for the Environment Agency at Lichfield by request but in return for all the data and support that they kindly provided to the project.

Data analysis

A fundamental question raised by numerous regulatory authorities and independent experts about the watercourses in the Upper Dove Catchment was whether or not pollution with nutrients-organic matter existed and if so, at what level? In order to get a handle upon this potential issue the raw species macroinvertebrate data from all sites across all 3 rivers sampled in the Spring and Autumn of 2009 was subjected to a number of ecological (water quality) assessment and indexing techniques:

Biological quality and biometric indices

Macroinvertebrate community structure was summarised using a number of routine bio quality and biometric measurements:

1. Biological water quality scores.

Unlike chemical samples the aquatic macro-invertebrate communities in a river or stream provide a longer-term ‘biological fingerprint’ of bio-quality and potential pollutant impacts in receiving watercourses. Several biometric indices to describe biological quality and pollution status in rivers are routinely used by organisations like the Environment Agency. For example, the BMWP score system is a commonly used tool to summarise freshwater invertebrate data and it was originally developed from bio-monitoring tools like the Trent Biotic Index (Woodiwiss, 1964). It was devised to reflect organic pollution and generally higher scores indicate better biological quality and lower scores reflect poorer water quality which could be linked to pollutant impacts.

The BMWP system of biological monitoring takes no account of the abundance of any family fauna merely the presence or absence of taxa, it provides no species richness data and it is affected by natural seasonal variation. The Average Score Per Taxon (ASPT) is also related to the BMWP score. It gives an indication of the aquatic invertebrate community’s sensitivity to pollution. This biotic index is used to give an idea of the diversity of the aquatic invertebrate community. In general, a healthy river will support a diverse community whereas one under stress from pollution, for example, will be less diverse and record a correspondingly lower number of BMWP scoring taxa. Again, it takes no account of the abundance of invertebrates or species richness. ASPT data from the Environment Agency was not summarised in this report on the Dove catchment since the 'fingerprints' for ASPT data invariably follow the BMWP trends and they suffer from the same data limitations for example, lack of true faunal abundance and species data.

Despite the limitations of Environment Agency data with respect to aquatic macro-invertebrate species richness, biodiversity and abundance in watercourses this was sometimes the only biological quality data available for a given watercourse. It has been well documented that semi-quantitative and community (family) level monitoring of macro-invertebrates in watercourses can mask underlying changes in the abundance of some species, with for example, loss of sensitive stoneflies and mayflies or markedly reduced abundances in aquatic ecosystems impacted by abiotic and/or biotic factors (Hellawell, 1986 and Eyre *et. al.*, 2005).

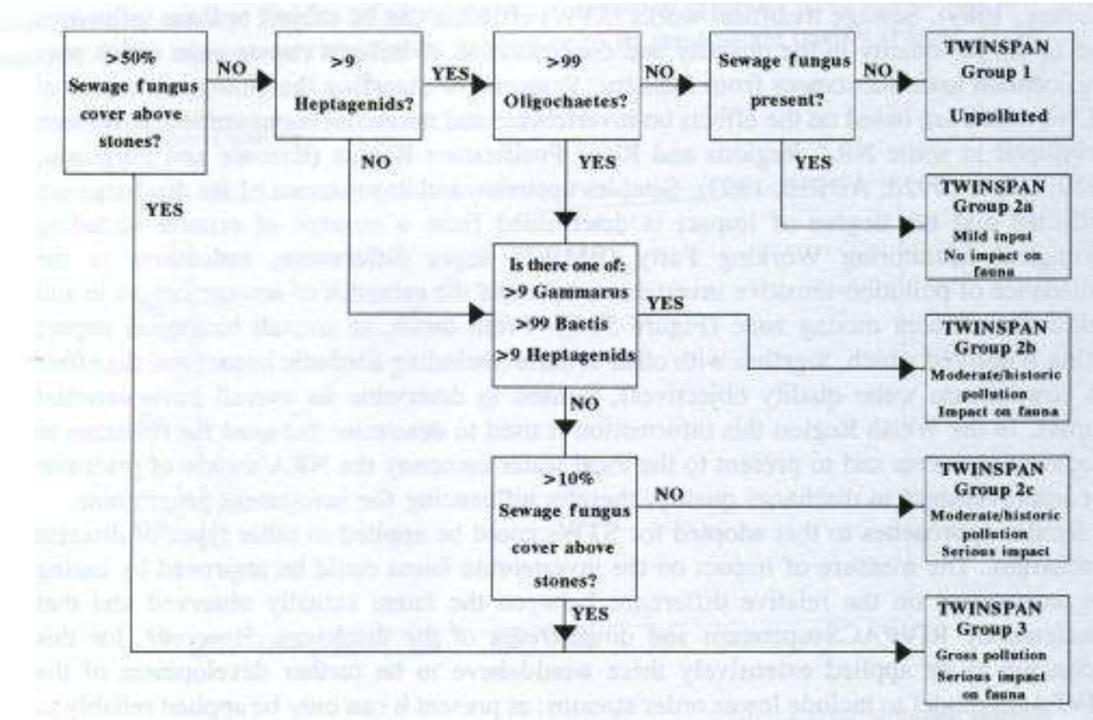
2. Total abundance of macroinvertebrates (number m^{-2}) from net Surber samples and semi-quantitative abundance (number per 3 minute kick-sweep net samples).

3. Taxonomic richness i.e. number of macroinvertebrate species (genus) per sample.

4. Conservation status of the aquatic macroinvertebrate communities (Chadd and Extence, 2002).

Rapid Agricultural Pollution Indicator Key

The use of a rapid indicator key played a key role in the strategy historically employed by the NRA in tackling the problem of farm pollution in areas where there were a large number of farms (Gee and Jones, 1995). All macroinvertebrate data for sites surveyed using 3 minute kick-sweep samples in the Upper Dove Catchment were evaluated using the Agricultural Pollution Indicator Key (Gee and Jones, 1995) and as shown below.



Previous workers (Gee & Jones, 1995) had taken only 1 minute samples and so the 3 minute kick-sweep samples from the Upper Dove Catchment study were a more conservative estimate of farm pollution. For information, Heptagenids are flat bodied mayflies as shown in the photographs below and were well documented to be highly susceptible to organic pollution and the impact of siltation (Hellawell, 1986).

With skilled personnel a relatively large number of sites can be evaluated by applying the indicator key to samples either examined on the bank side or as in this study back at the laboratory and the results were simply presented on catchment maps to highlight the areas of problem farms or other pollution sources.

Macroinvertebrate assessment of organic pollution

Many studies have compared the results of different benthic macroinvertebrate metrics used to assess the impact of organic pollution (Hellawell, 1987, Calow & Petts, 1993, Hauer & Lamberti, 1996 and Eurolimpacs, 2004,). The Average Score Per Taxon (ASPT) used by the Environment Agency with the computer model RIVPACS in the UK has been well correlated with the stress gradient in most stream types but the Saprobic Index worked better than ASPT in those countries (for example, Germany, Austria and the Czech Republic) where macroinvertebrates were generally identified to a lower (species) as opposed to a higher (genus or family) level of identification (Leonard and Daniel, 2004). Saprobic indexing at the species level allowed a greater insight into the nature and quantum of organic pollution in watercourses than other methods since it accounted for species differences in tolerance to organic pollutants (for example, elevated ammonia and lowering dissolved oxygen regimes) as opposed to generic estimates of whole family responses.

The link between biological water quality and the saprobic system of watercourse classification was because benthic invertebrates are important within the stream community as a fundamental link in the food web between organic matter resources and ecosystem fishery health. A standardised method to assess the biological water quality in European watercourses is the saprobic classification system (saprobity = amount of degradable organic material). This classification system is based upon selected index organisms (indicators), whose appearance is related to the impact of degradable organic material.

The saprobic value (s) is a number from 1,0 to 4,0. The category groups of the saprobic values are:

Classification	**s**
oligosaprobic	1,0 - <1,5
oligosaprobic – ß-mesosaprobic	1,5 - <1,8
ß-mesosaprobic	1,8 - <2,3
ß-mesosaprobic – α-mesosaprobic	2,3 - <2,7
α-mesosaprobic	2,7 - <3,2
α-mesosaprobic – polysaprobic	3,2 - <3,5
polysaprobic	3,5 - 4,0

In the calculation of the saprobic classification there are two values that are dedicated to each species:

- the saprobic value (s) and
- the indicator value (G)

The saprobic value shows the appearance of the species in a specific range of water quality. Some species have a narrow tolerance range, this means that they are good indicators. The specific tolerance of the species is expressed by the indication value.

The third term to calculate the saprobic classification is:

- the frequency (A) of a particular species.

Formula for the saprobic index:

$$S = \frac{\sum A*s*G}{\sum A*G}$$

S = saprobic index
A = frequency
s = saprobic value
G = indicator value

The latest Saprobic values (s) and indicator values (G) used throughout Europe were obtained by formal permission in writing from and Dr. Everall was granted (password) access to the EUROLIMPACS database (via www.freshwaterecology.info).

It should also be remembered that the international standard and comparable approach to ecological surveying and water quality assessments using macroinvertebrates was reliant upon the sampling of riffle habitats at all sample sites. Such habitats may or may not reflect the worst scenario for organic pollution within a given stretch of watercourse but were, in all probability, a slightly conservative reflection of pollutant conditions. Slacker and impounded sections of watercourse in the study areas may, if measured, have indicated slightly more organically enriched conditions due to for example, the retention of decomposing particulate organic material.

Macroinvertebrate assessment of siltation

Physical assessment methods have traditionally been used to quantify riverine sedimentation, but Extence *et. al.* (2010, in preparation) have proposed an alternative approach, the use of a sediment-sensitive macro-invertebrate metric, PSI (Proportion of Sediment-sensitive Invertebrates) which can act as a proxy to describe temporal and spatial impacts.

As a benchmark of ecological status and environmental impact it was very important to measure the direct impact of siltation upon the ecology of the receiving watercourses in the Upper Dove Catchment using the latest macroinvertebrate siltation model. However, it was also important to measure the nature, extent and sources of sediment settling in the watercourses of the Upper Dove Catchment via catchment scale fluvial-geomorphological processes and local scale physical habitat features. To this end, geomorphological field studies are being carried out in 2010 by Dr Steve Rice from Loughborough University. The data from the geomorphological field studies will also allow for cross-comparison with the macroinvertebrate siltation results.

Chris Extence and Richard Chadd from the Environment Agency had very kindly allowed Dr Everall at Aquascience to be one of the first independent workers to trial the macroinvertebrate siltation indexing on the data from the 2009 Upper Dove Catchment Project by Natural England.

The PSI score describes the percentage of sediment-sensitive taxa (Table 1 below) present in a sample and the metric is calculated using the matrix shown in Table 2 below and then applying the following formula:

$$\text{PSI } (\Psi) = \frac{\varepsilon \text{ Sediment Scores for Sensitivity Groups A \& B}}{\varepsilon \text{ Sediment Scores for all Sensitivity Groups A, B, C \& D}} \text{ X } 100$$

Table 1

Group	Silt Tolerance Definition
A	Taxa highly sensitive to sedimentation
B	Taxa moderately sensitive to sedimentation
C	Taxa moderately insensitive to sedimentation
D	Taxa highly insensitive to sedimentation
E	Taxa indifferent to sedimentation or excluded from the method for other reasons

Table 2

Group	Sediment Sensitivity Rating (SSR)	Log Abundance 1-9	10-99	100-999	1000+
A	Highly Sensitive	2	3	4	5
B	Moderately Sensitive	1	2	3	4
C	Moderately Insensitive	1	2	3	4
D	Highly Insensitive	2	3	4	5
E	Excluded	-	-	-	-

From the literature review in Extence *et. al.* (2010 in prep.), appropriate abundance and affinity weightings have been incorporated into Table 2 to give the final PSI metric better definition. PSI scores range from 0 (entirely silted river bed) to 100 (entirely silt-free river bed). Extence *et. al.* (2010 in prep.) suggested that when applied to species and family data respectively, the terms PSI (S) and PSI (F) are used. A provisional interpretation scheme for the data is shown in Table 3 below (Extence *et. al.*, 2010 in prep.).

Table 3

PSI	River Bed Condition
81 -100	Naturally sedimented/Unsedimented
61 - 80	Slightly sedimented
41 - 60	Moderately sedimented
21 - 40	Sedimented
0 - 20	Heavily sedimented

In the study of the watercourses in the Upper Dove Catchment during 2009 the macroinvertebrate results for siltation are expressed as PSI (S) as the data was analysed to species level.

Macroinvertebrate assessment of eutrophication

Organic pollution, as previously highlighted, refers to excessive amounts of nutritive substances (organic matter, including nutrients) in an aquatic ecosystem. When the river drift of nutritive substances is progressive yet still within the assimilation capacity of the system, eutrophication (i.e., complexation of the biological structure) can, albeit only temporarily, accelerated. When the amount of river drift presumed to be nutritive exceeds the assimilation capability of the receiving water then this condition results in the gradual development of a pollution condition characterized by the accentuated simplification of the consuming biological structure.

Pollution of an aquatic system is manifested at the macroinvertebrate population level by a number of ecological changes. For example, a modification of the structure of the initial population resulting in the development of a few saprophage or euryoeces invertebrate populations, such as Oligochetes (worms) or the Hydropsychidae (caseless caddis), and/or the decrease in abundance of other more sensitive organisms, such as certain Heptageniidae (flat bodied mayflies) or stoneflies. The process of eutrophication $\rightarrow$ organic pollution often results in the appearance, then proliferation, of species elective of specific river drift; for example, this may occur because of intense development of certain algae, bacteria, and fungi (Cladophoraceae, Spirogyra, Sphaerotilus, Leptomitus, Fusarium, Cellolobacteria, Ferrobacteria, and Sulphobacteria) downstream from diffuse or point source organic incursions. Gradual disappearance in a specified order of all or part of the initial invertebrate population then follows.

Eutrophication (nutrient enrichment) can initially correspond to an increase in biodiversity, and the opposite of the adverse effect of pollution or of the general system degradation phenomena which produces a decrease in the biodiversity of consuming organisms. Dependent upon the nature of the pollutants entering a watercourse, the biological fingerprints of nutrient enrichment and organic pollution can both be detected in receiving watercourses.

The Trophic Diatom Index (TDI) is now a recognised diagnostic tool used in the benchmarking of nutrient enrichment in UK rivers and has been used in the assessment of watercourses under the Water Framework Directive. However, there are a great many UK watercourses which for a variety of reasons lack TDI data but may be subject to nutrient enrichment. Many of these watercourses do have some varying degrees of semi-quantitative macro-invertebrate data from routine Environment Agency biological sample sites.

It has been well documented that phosphorus rather than nitrogen was the key limiting nutrient to the process of eutrophication in European waters (OECD, 1982, Reynolds, 1980). The pioneering work of Paisley *et. al.* (2003) suggested that the consumer level of the ecosystem did show some significant association with Total Reactive Phosphorous (TRP) levels. The author had worked on a number of independent and Environment Agency associated pollution investigations potentially involving nutrient enrichment in the cocktail of pollutants impacting watercourses (Everall, 2004, 2005a, 2005b and 2006). During the course of these investigations the author has developed a simple method to look at whether or not the macro-invertebrate community showed any evidence of the influence of nutrient enrichment (phosphate).

Nutrient enrichment indicator taxa and their associated Rankings were taken from Paisley *et. al.* (2003) and the top 38 of the 78 BMWP taxa weightings are shown in the table below.

	Average TRP			
Taxon	Spring	Autumn	Ann Avg	Rank
Rhyacophilidae	0.0471	0.0385	0.0428	1
Elmidae	0.0332	0.0491	0.0412	2
Heptageniidae	0.0388	0.0321	0.0355	3
Asellidae	0.0378	0.0329	0.0353	4
Calopterygidae	0.0265	0.0399	0.0332	5
Ephemerellidae	0.0451	0.0205	0.0328	6
Tipulidae	0.0292	0.0361	0.0327	7
Gammaridae	0.0309	0.0318	0.0313	8
Erpobdellidae	0.0333	0.0292	0.0313	9
Caenidae	0.0309	0.0314	0.0311	10
Hydrobiidae	0.0254	0.0368	0.0311	11
Sericostomatidae	0.0274	0.0346	0.0310	12
Leuctridae	0.0306	0.0306	0.0306	13
Coenagriidae	0.0190	0.0392	0.0291	14
Nemouridae	0.0199	0.0370	0.0284	15
Ancylidae	0.0237	0.0321	0.0279	16
Limnephilidae	0.0215	0.0333	0.0274	17
Hydropsychidae	0.0220	0.0325	0.0272	18
Sphaeriidae	0.0255	0.0289	0.0272	19
Baetidae	0.0328	0.0215	0.0272	20
Planorbidae	0.0207	0.0318	0.0263	21
Planariidae	0.0292	0.0230	0.0261	22
Leptophlebiidae	0.0236	0.0286	0.0261	23
Goeridae	0.0237	0.0272	0.0255	24
Lepidostomatidae	0.0246	0.0250	0.0248	25
Perlodidae	0.0280	0.0211	0.0245	26
Leptoceridae	0.0218	0.0270	0.0244	27
Simuliidae	0.0223	0.0260	0.0241	28
Oligochaeta	0.0229	0.0248	0.0239	29
Chironomidae	0.0245	0.0223	0.0234	30
Ephemeridae	0.0196	0.0267	0.0232	31
Brachycentridae	0.0169	0.0291	0.0230	32
Gyrinidae	0.0194	0.0259	0.0227	33
Aphelocheiridae	0.0135	0.0303	0.0219	34
Psychomyiidae	0.0182	0.0229	0.0205	35
Neritidae	0.0170	0.0240	0.0205	36
Hydroptilidae	0.0221	0.0188	0.0205	37
Glossiphoniidae	0.0226	0.0171	0.0198	38

Only the top 20 rankings or upper quartile of nutrient enrichment taxa were treated as significant indicators of eutrophication in this study. Similarly, for the given top 20 taxa to be classified as a nutrient indicator within a given study period the representative BMWP family had to be dominant during that time period. Taxa dominance was taken as ≥ 60% of the samples containing 10-99 or greater numbers of indicator species per sample within a given study period.

The %TRP (Total Reactive Phosphorous) indicator score describes the percentage of phosphorous-sensitive (family) taxa present in a sample and the metric is calculated by applying the following formula:

No. top 20 TRP indicator taxa (upper quartile) x 100 = % TRP (total reactive phosphorous) in pop'n
Mean no. of taxa/sample in study period

In the study of the watercourses in the Upper Dove Catchment during 2009 the macroinvertebrate results for nutrient enrichment are expressed as TRP values from family level data. It was also important, at this stage, to make the data analysis comparable with historic TRP calculations for River Hamps and River Manifold data analyses (Everall, 2005b). Chris Extence, Richard Chadd and the author are currently looking at developing the index further to incorporate all 78 BMWP macroinvertebrate family TRP tolerances and community family abundance weightings.

Semi-quantitative periphyton community surveys

Predominant periphyton community types were delineated after adapting the Biggs and Kilroy (2000) methodology for determining benthic algal communities commonly found in upland watercourses from New Zealand and their corresponding habitat descriptors (with secondary and filamentous taxa listed in decreasing order of abundance that they were usually found in the communities).

River Hamps benthic algal growth Autumn 2009

River Manifold benthic algal growth Autumn 2009

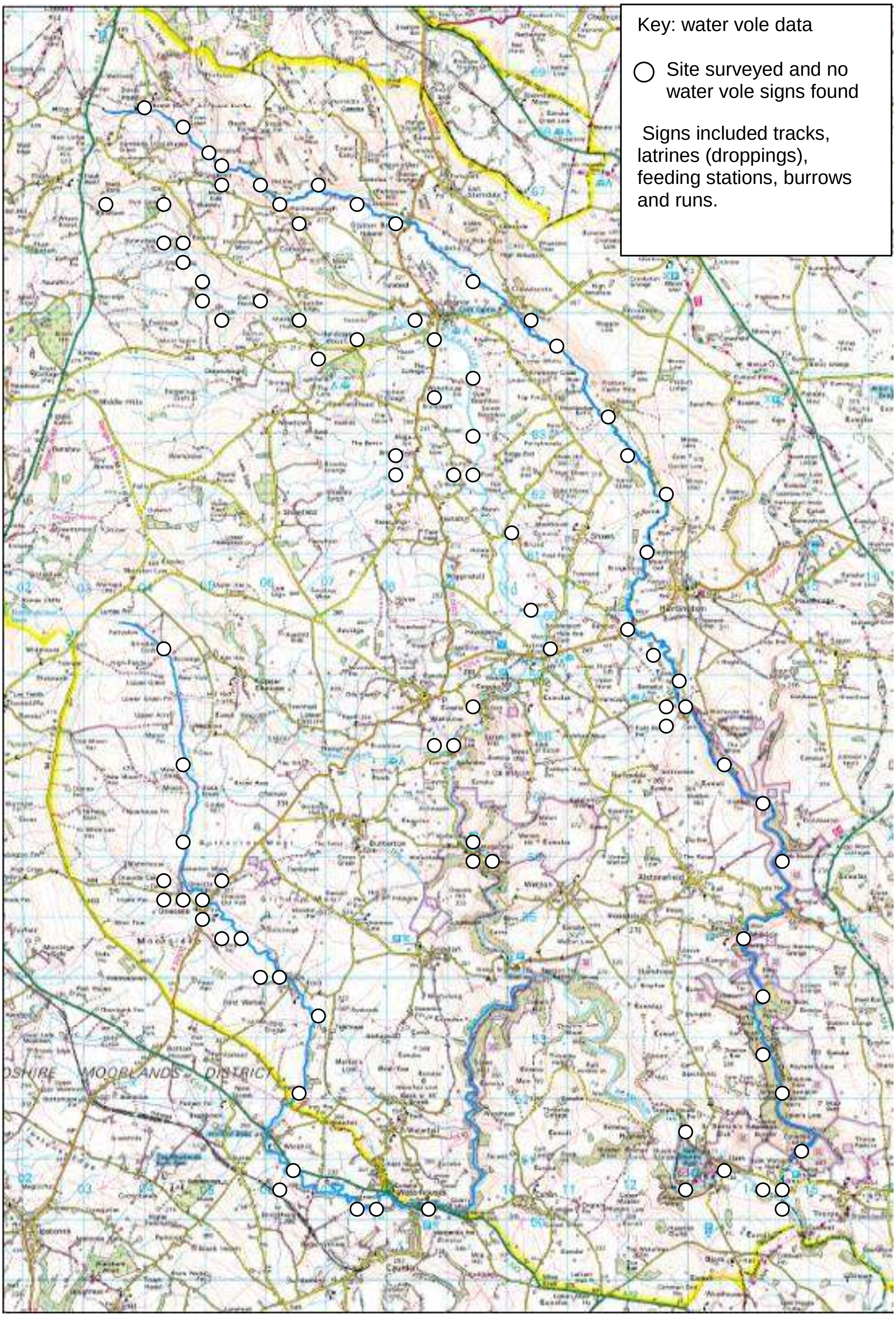
The periphyton communities were assigned simple trophic or Nutrient Enrichment Indicator (NEI) rankings as shown in the table below.

Algal community description (dominant taxa and relative abundances)	Typical habitat	NEI Rank
Batrachospermum sp *et.al.*	Upland watercourses with good flow. Often Batrachospermum abundant in Spring in soft and partly shaded waters	1
Cladophora sp. and Spirogyra sp. *et.al.*	Ubiquitous community most commonly dominates moderately enriched to unenriched habitats	2
Microspora sp. and Cladophora *et.al.* or Batrachospermum sp., Cladophora and Stigeoclonium *et.al.*	Conspicuous in moderately enriched foothills and Springs or Upland watercourses with good flow and some nutrient enrichment	3
Melosira varians and Stigeoclonium sp. *et.al.*	Intensively developed pastoral agricultural catchments with hard sediment geology	4
Cladophora sp. and aquatic hyphomycetes-fungi *et.al.*	Intensively developed pastoral catchments and/or catchments with a high proportion of organic sediments	5

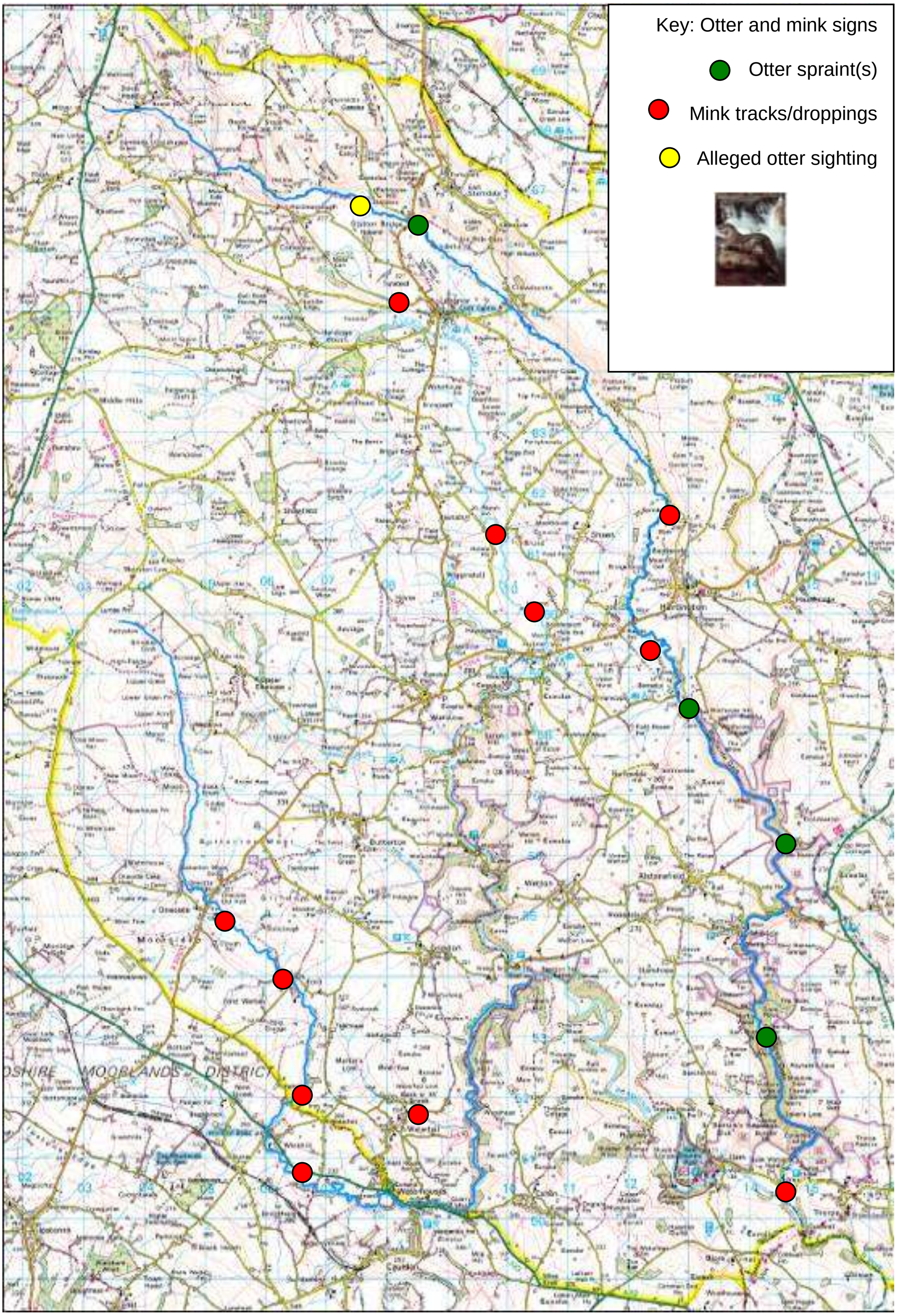
3. Findings

Water vole surveys

No signs of water vole were found at any of the 87 sample sites surveyed in the Upper Dove Catchment between May and June 2009 as highlighted in the map overleaf.



Although not a part of the current survey remit there were signs of mink (droppings and tracks) and otter (spraints) noted at a number of sites throughout the 3 river corridors as shown in the map overleaf.



In all probability, the predation of water voles by mink had been the key factor in the demise of water vole populations throughout the Upper Dove Catchment. The more recent active trapping of mink and the evident return of otters to all 3 river corridors (C. Horsford *pers. comm.*, and N. Everall *pers. obs.*, 2009) may create favourable conditions for the re-introduction or natural re-colonisation of water vole over time.

There remained favourable habitat (flood plain, bank structure and feeding ground) for water vole adjacent to or at numerous of the survey sites examined throughout the Upper Dove Catchment (N. Everall *pers. obs.*, 2009) for example, in the River Dove:

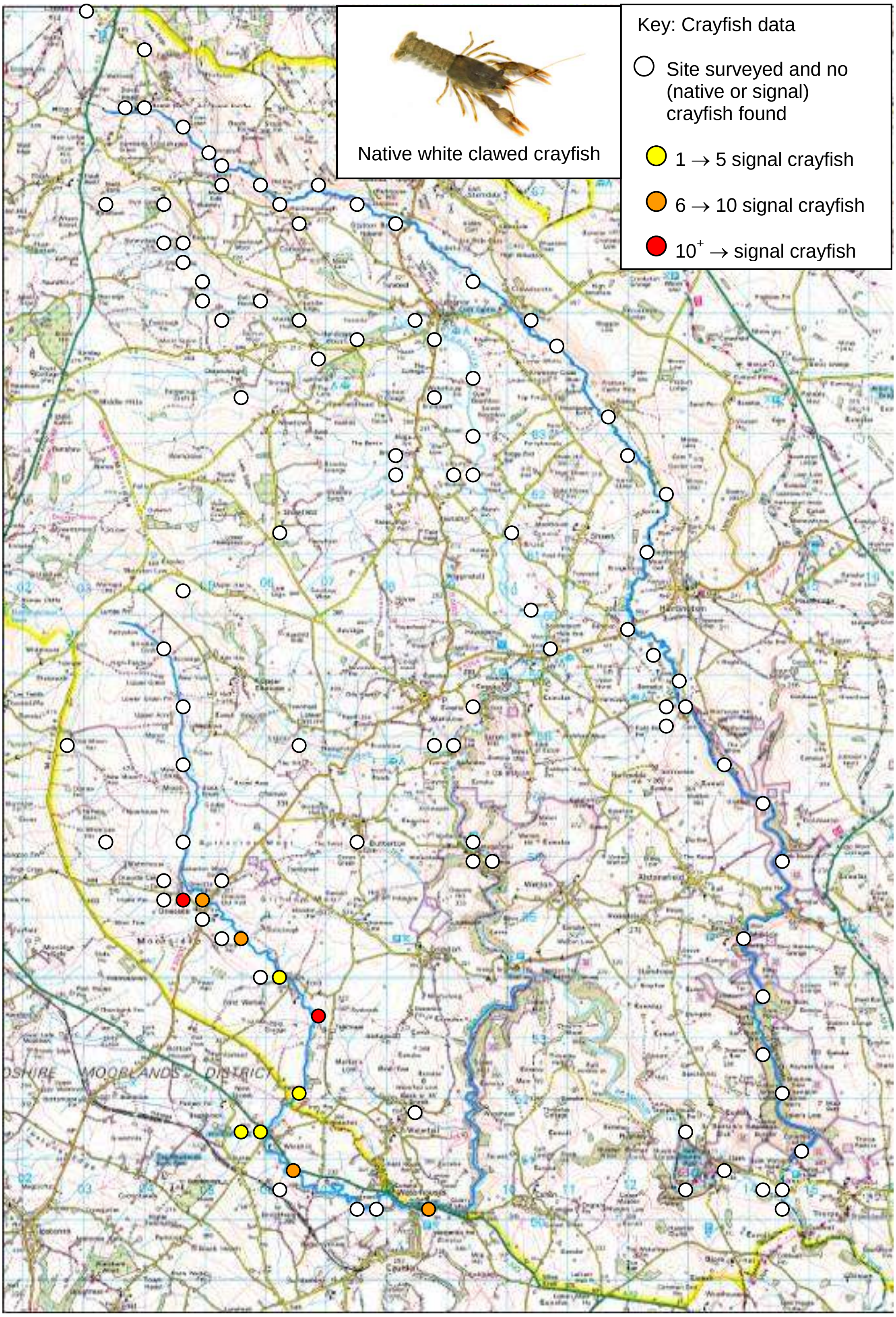
Potential water vole habitat in River Dove at Dovedale

Potential water vole habitat in River Dove at Milldale


Potential water vole habitat in River Dove in Wolfscote Dale and near Hollinsclough


Crayfish surveys

No signs of native white clawed crayfish were found at any of the 97 sample sites surveyed in the Upper Dove Catchment between May-June and in September 2009 as highlighted in the map overleaf.



The native white clawed crayfish was classified as Vulnerable (VU) on the IUCN Red List (1). Listed in Appendix III of the Bern Convention, Annexes II and V of the EC Habitats Directive and protected under Schedule 5 of the Wildlife and Countryside Act 1981. Native white clawed crayfish were last recorded in the Upper Dove Catchment at Wetton Mill on the River Manifold in 2008 and in the River Dove at

Milldale in 2005 (Everall, 2009). The recent survey appeared to indicate a continued demise and potential extinction of the white clawed crayfish populations in the River Dove, River Manifold and River Hamps upstream of Ilam.

The American signal crayfish was found throughout the River Hamps river corridor in variable but generally marked numbers from Waterhouses up to Onecote in 2009.

Photograph above of signal crayfish captured from the River Hamps in the Spring of 2009. All signal crayfish captured were removed from the river and euthanized at the request of NE with any remains disposed of to land fill away from any watercourses.

No signal crayfish were found at the relatively smaller number of sites from Onecote up to the headwaters of the River Hamps. Although no native crayfish were found through the upper reaches of the River Manifold or River Dove either, it was interesting that no signal crayfish were found in either of these rivers during the 2009 crayfish surveys. The last sightings of native crayfish in these rivers coincided with reports of outbreaks of fungal plague (Everall, 2009) and it remained a possibility that these historic impacts had been ephemeral incursions of the plague via humans or animals but not necessarily signal crayfish invasions. If this scenario proved to be the case with further monitoring then there remained some scope for re-introduction work with native white clawed crayfish. However, it was evident from later sections of this report (pages 95-97) that siltation appeared to be variably above natural levels in large sections of the River Dove and Manifold such that localised water quality would have to be carefully considered in the scoping of any re-introduction work.

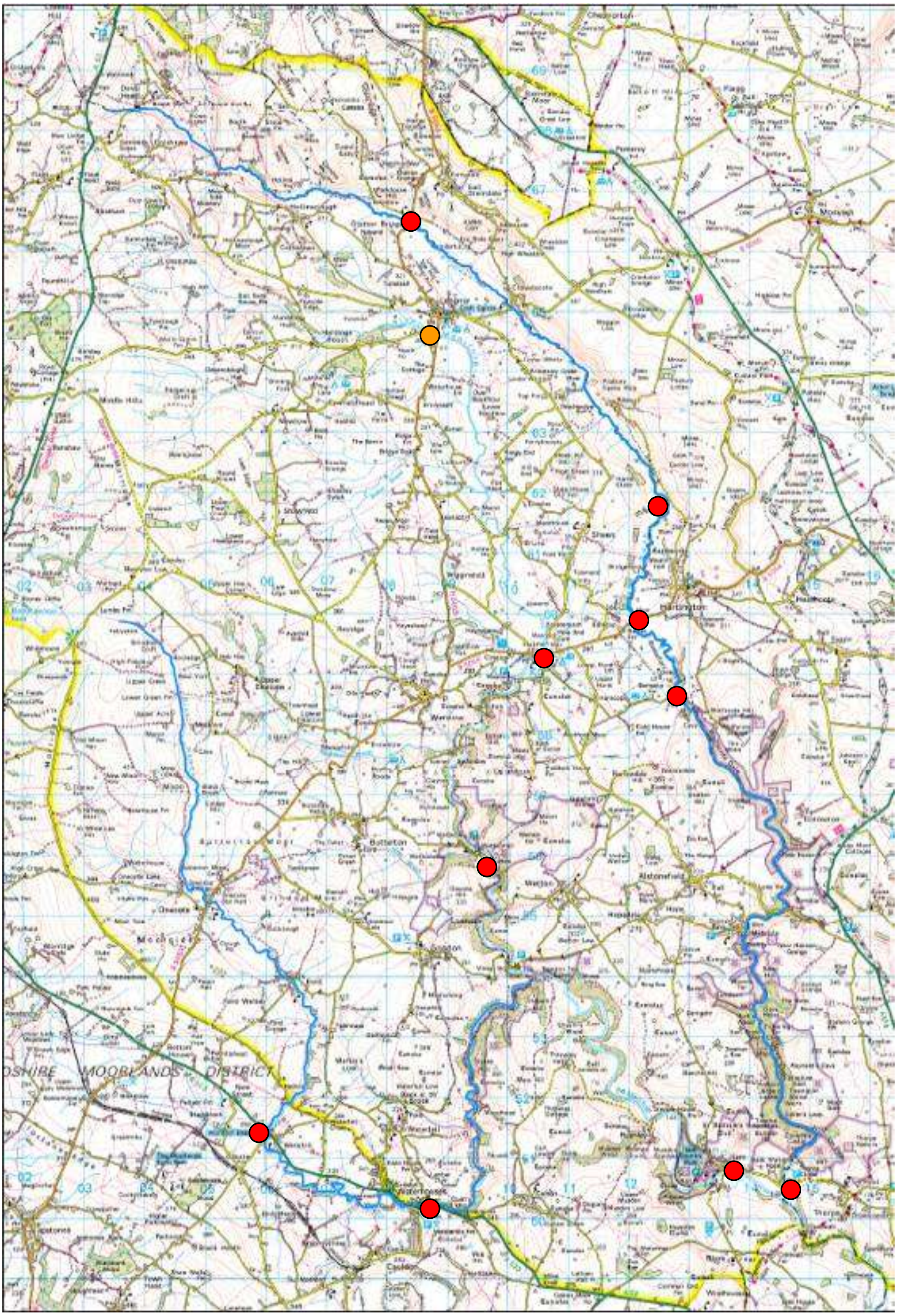
Ad-hoc fish data

A number of fish (lamprey) species of varying conservation value were inadvertently captured, recorded and released as part of the macroinvertebrate sampling programme. The records for these animals were summarised in Appendix 1 but were not part of the survey remit and reporting.

Biological quality indices

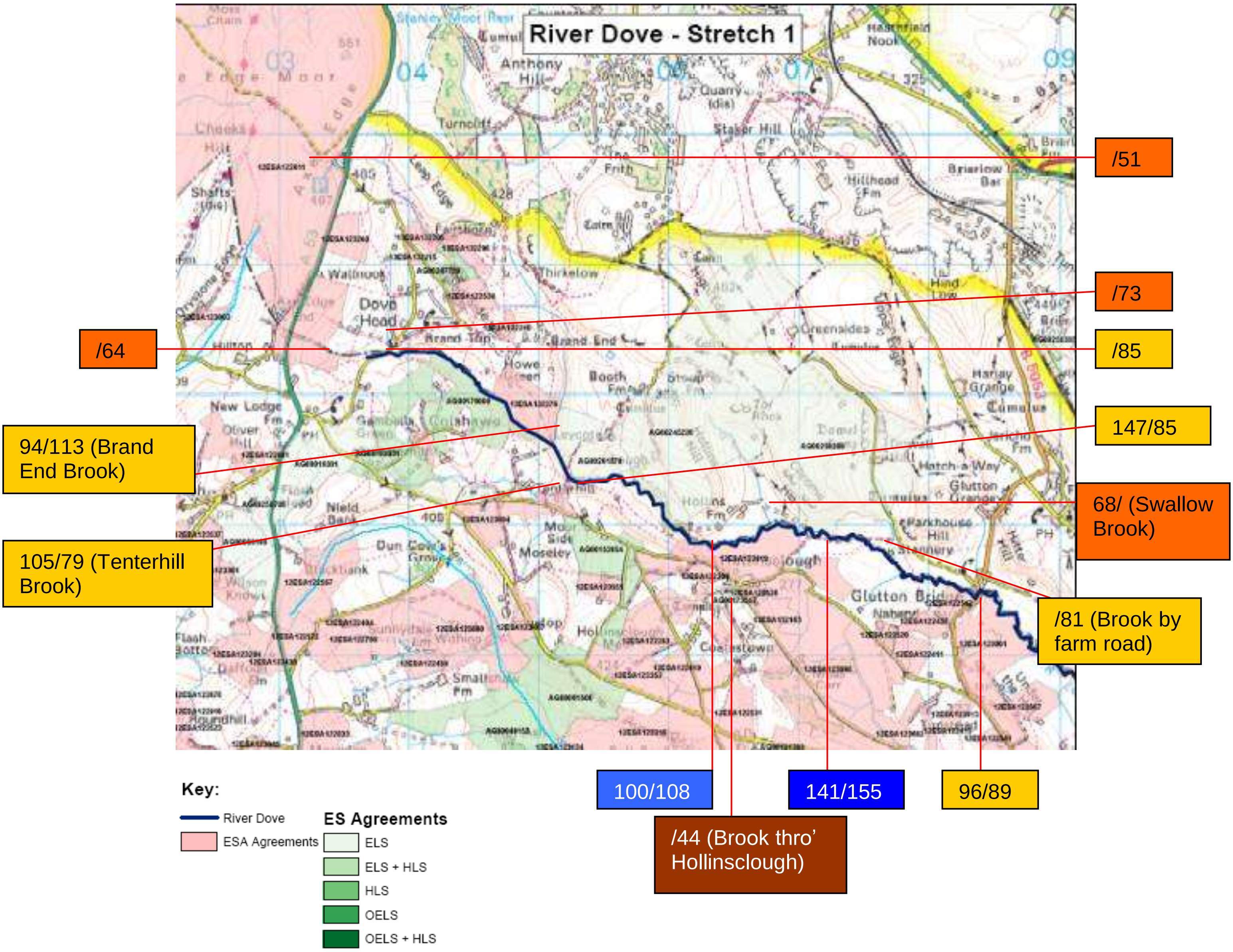
All the species listings and macroinvertebrate abundance data for all ~90 study sites across the River Dove, Manifold and Hamps sampled in the Spring and Autumn of 2009 are presented in Appendix 2a and 2b respectively.

Environment Agency monitoring sites for biological quality (for example, BMWP and ASPT scores) were at a limited number of sites in the Upper Dove Catchment as shown in the map below (routine ● and ad-hoc ● monitoring sites).



The last trends in gross biological quality at a relatively limited number of EA monitoring sites showed some general compliance with expected BMWP and ASPT values in the lower sections of the River Dove, Manifold and Hamps. However, there was evidence of a potential downturn in biological quality at EA monitoring sites in the middle-upper reaches of the 3 rivers in the Upper Dove Catchment from the last available data prior to the 2009 Natural England surveys and as highlighted in the introduction section of this report and Everall (2009). The more extensive biological surveillance of the upper reaches of the River Dove, River Manifold and River Hamps by Aquascience for Natural England in 2009 revealed a more detailed picture.

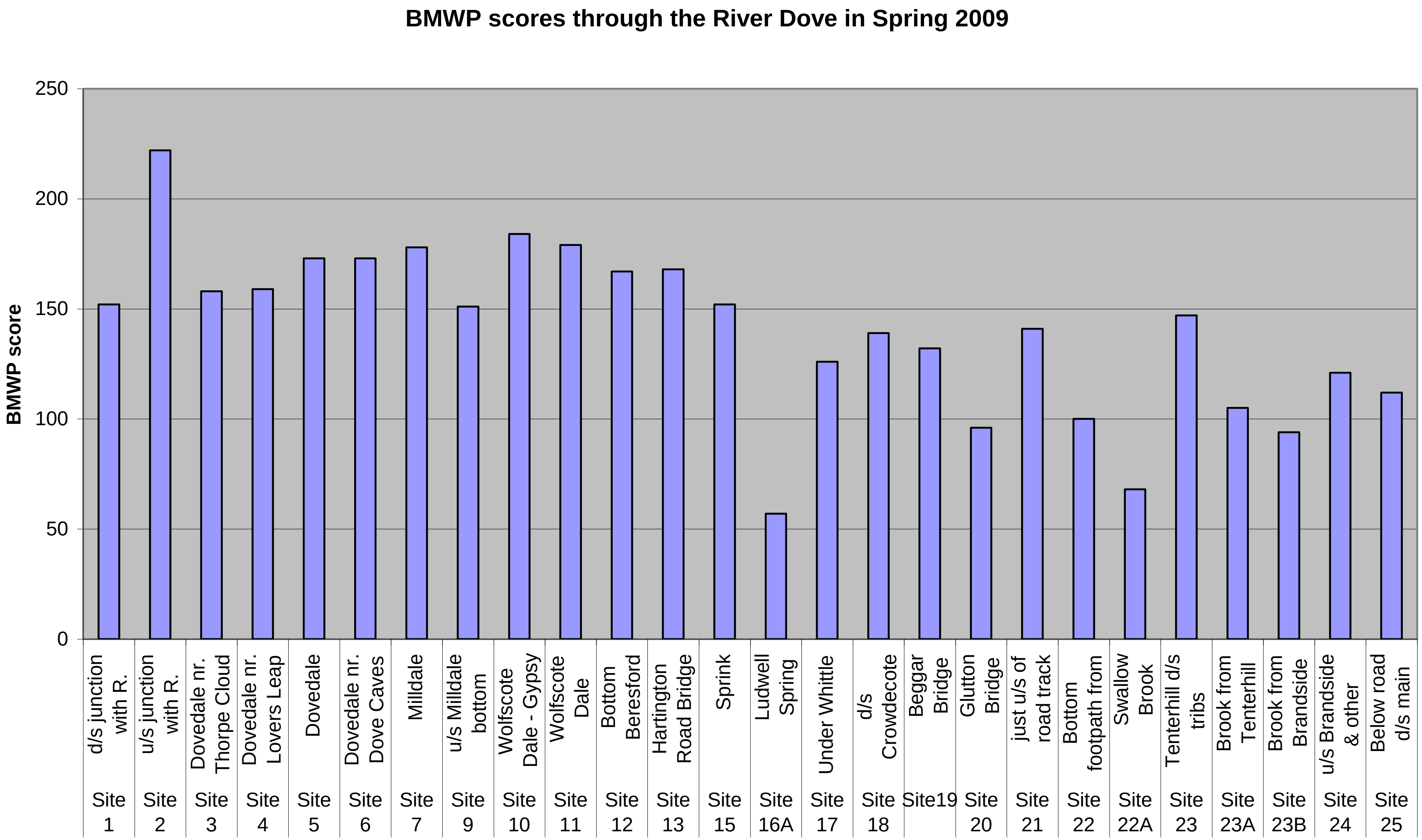
The Biological Monitoring Working Party (BMWP) Scores for survey sites in the River Dove, River Manifold and River Hamps in the Spring and Autumn of 2009 were listed in the data in Appendix 2a and 2b. Mapped seasonal BMWP data by site through all 3 river corridors of the Upper Dove Catchment during 2009 was provided to CSF, NE and TRT personnel. An example of the detailed mapped data was shown in the map below in for example, the upper River Dove (Spring/Autumn data).



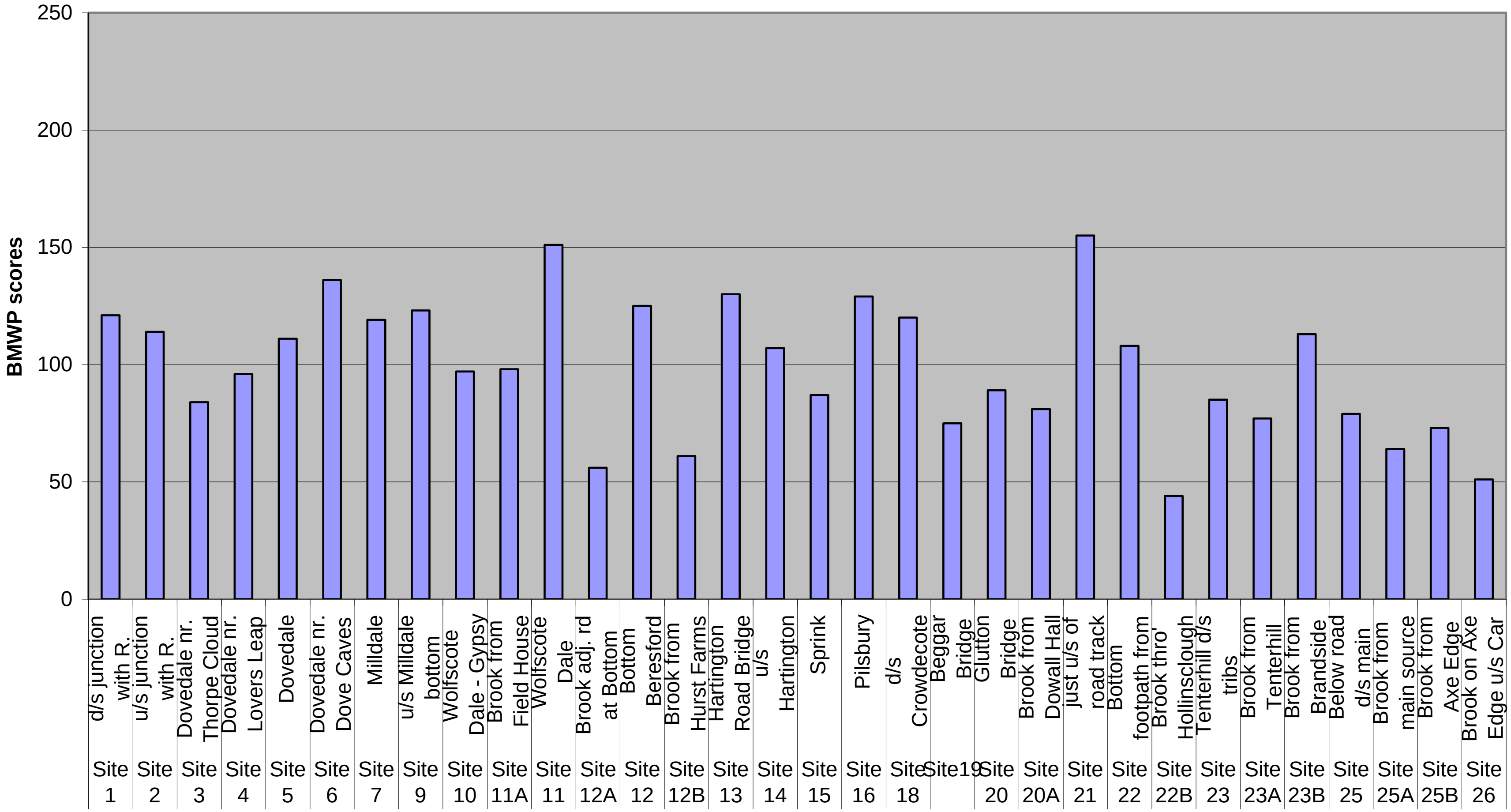
BMWP scores provide a direct and long-term indicator of river quality from which EA Ecosystem Classifications can be inferred and the following table can be used as a key to the data provided on the previous page.

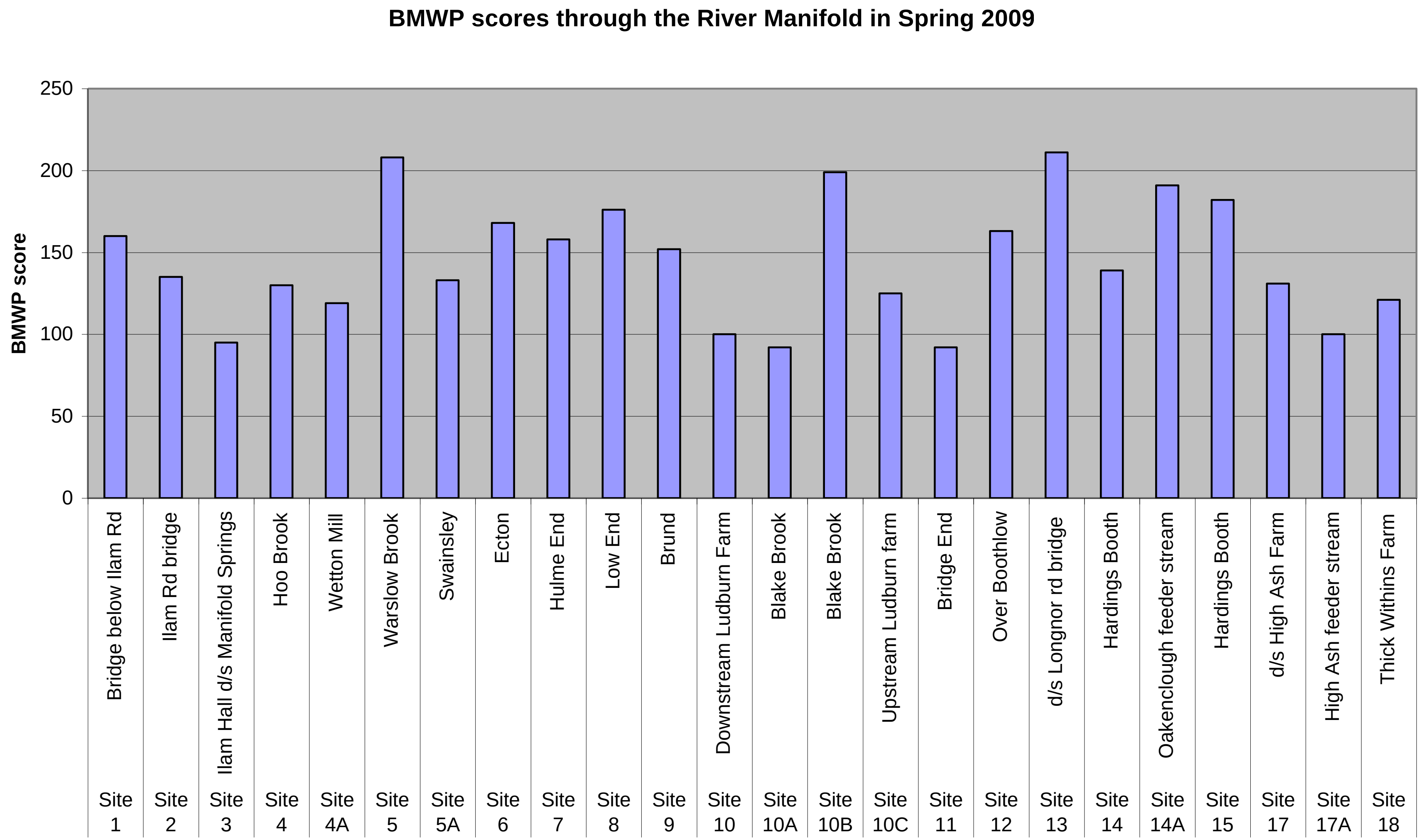
BMWP Score	River Ecosystem Class	Quality comment	Status
>96	RE 1	Very good	Game (salmon) fishery
71-95	RE 2	Good	Game Fishery
51-70	RE 3	Moderate	Coarse Fishery
36-50	RE 4	Fair	No Fishery
13-35	RE 5	Poor	Polluted
0-12	-	Unclassified	Grossly polluted

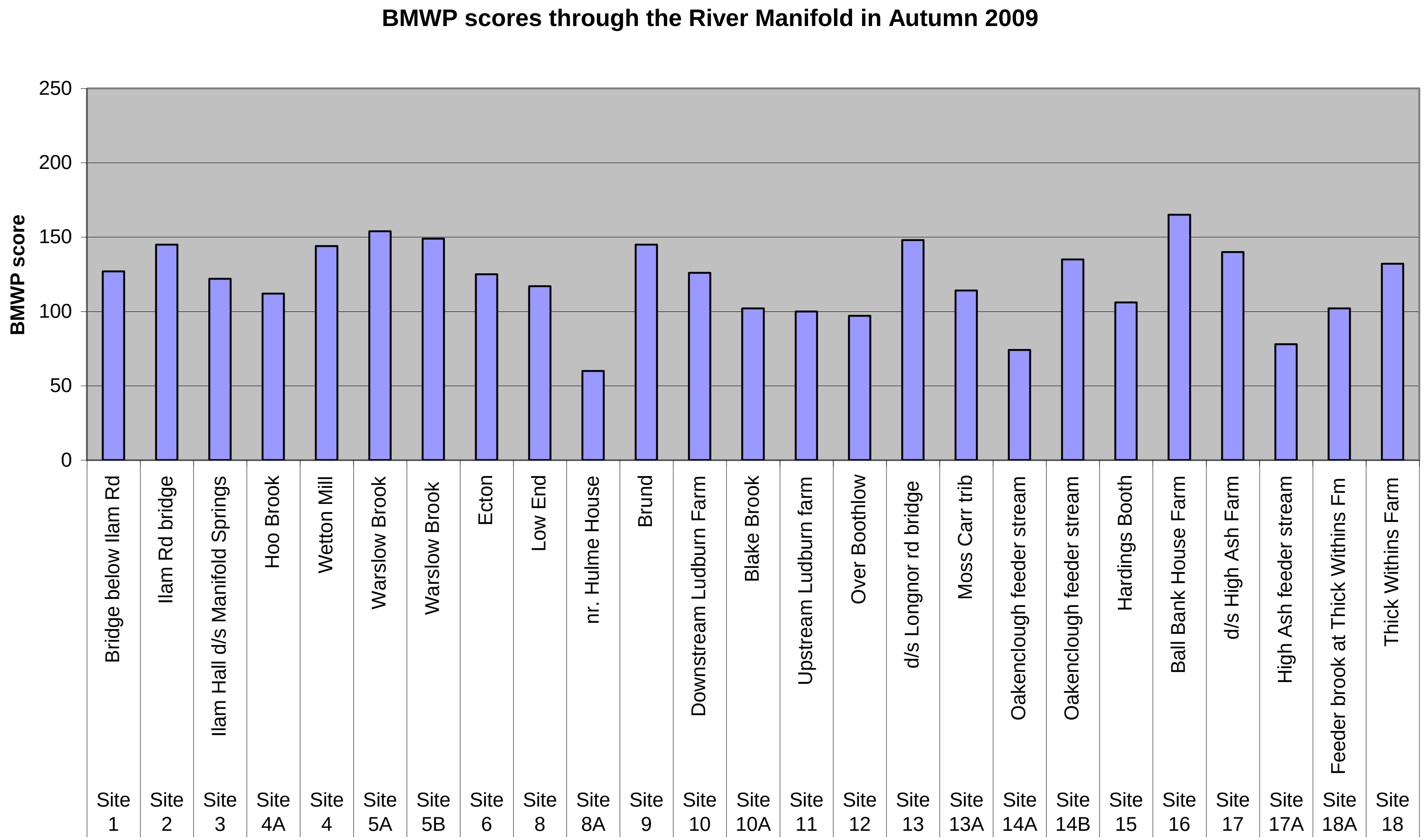
The BMWP scores for all survey sites in the River Dove, River Manifold and River Hamps in the Spring and Autumn of 2009 were summarised in the following graphs.


BMWP scores through the River Dove in Spring 2009
BMWP score
0
50
100
150
200
250
d/s junction with R.
u/s junction with R.
Dovedale nr. Thorpe Cloud
Dovedale nr. Lovers Leap
Dovedale
Dovedale nr. Dove Caves
Milldale
u/s Milldale bottom
Wolfscote Dale - Gypsy
Wolfscote Dale
Bottom Beresford
Hartington Road Bridge
Sprink
Ludwell Spring
Under Whittle
d/s Crowdecote
Beggar Bridge
Glutton Bridge
just u/s of road track
Bottom footpath from
Swallow Brook
Tenterhill d/s tribs
Brook from Tenterhill
Brook from Brandside
u/s Brandside & other
Below road d/s main
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 9
Site 10
Site 11
Site 12
Site 13
Site 15
Site 16A
Site 17
Site 18
Site19
Site 20
Site 21
Site 22
Site 22A
Site 23
Site 23A
Site 23B
Site 24
Site 25

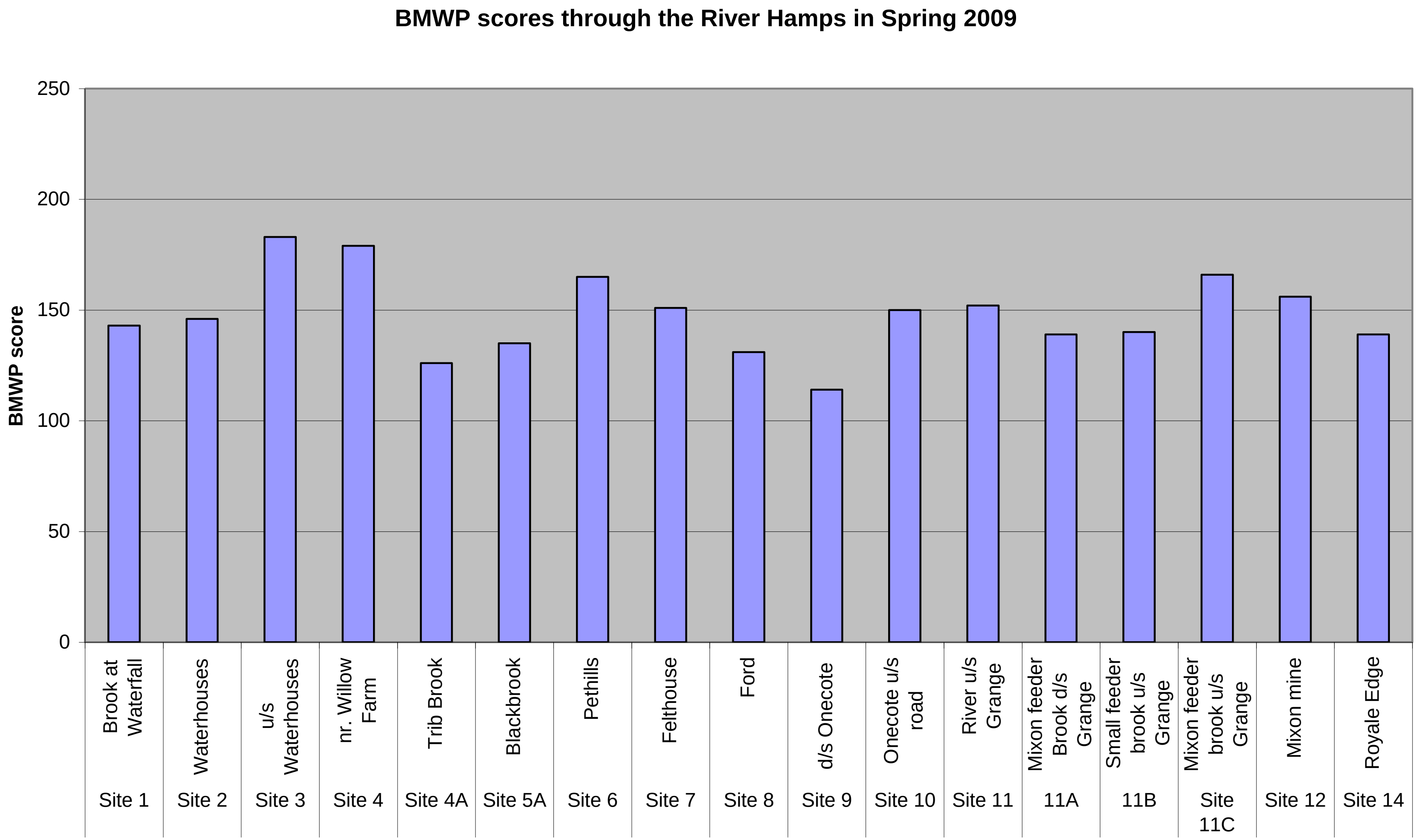
BMWP scores through the River Dove in Autumn 2009




BMWP scores through the River Manifold in Spring 2009
BMWP score
250
200
150
100
50
0
Bridge below Ilam Rd
Ilam Rd bridge
Ilam Hall d/s Manifold Springs
Hoo Brook
Wetton Mill
Warslow Brook
Swainsley
Ecton
Hulme End
Low End
Brund
Downstream Ludburn Farm
Blake Brook
Blake Brook
Upstream Ludburn farm
Bridge End
Over Boothlow
d/s Longnor rd bridge
Hardings Booth
Oakenclough feeder stream
Hardings Booth
d/s High Ash Farm
High Ash feeder stream
Thick Withins Farm
Site 1
Site 2
Site 3
Site 4
Site 4A
Site 5
Site 5A
Site 6
Site 7
Site 8
Site 9
Site 10
Site 10A
Site 10B
Site 10C
Site 11
Site 12
Site 13
Site 14
Site 14A
Site 15
Site 17
Site 17A
Site 18

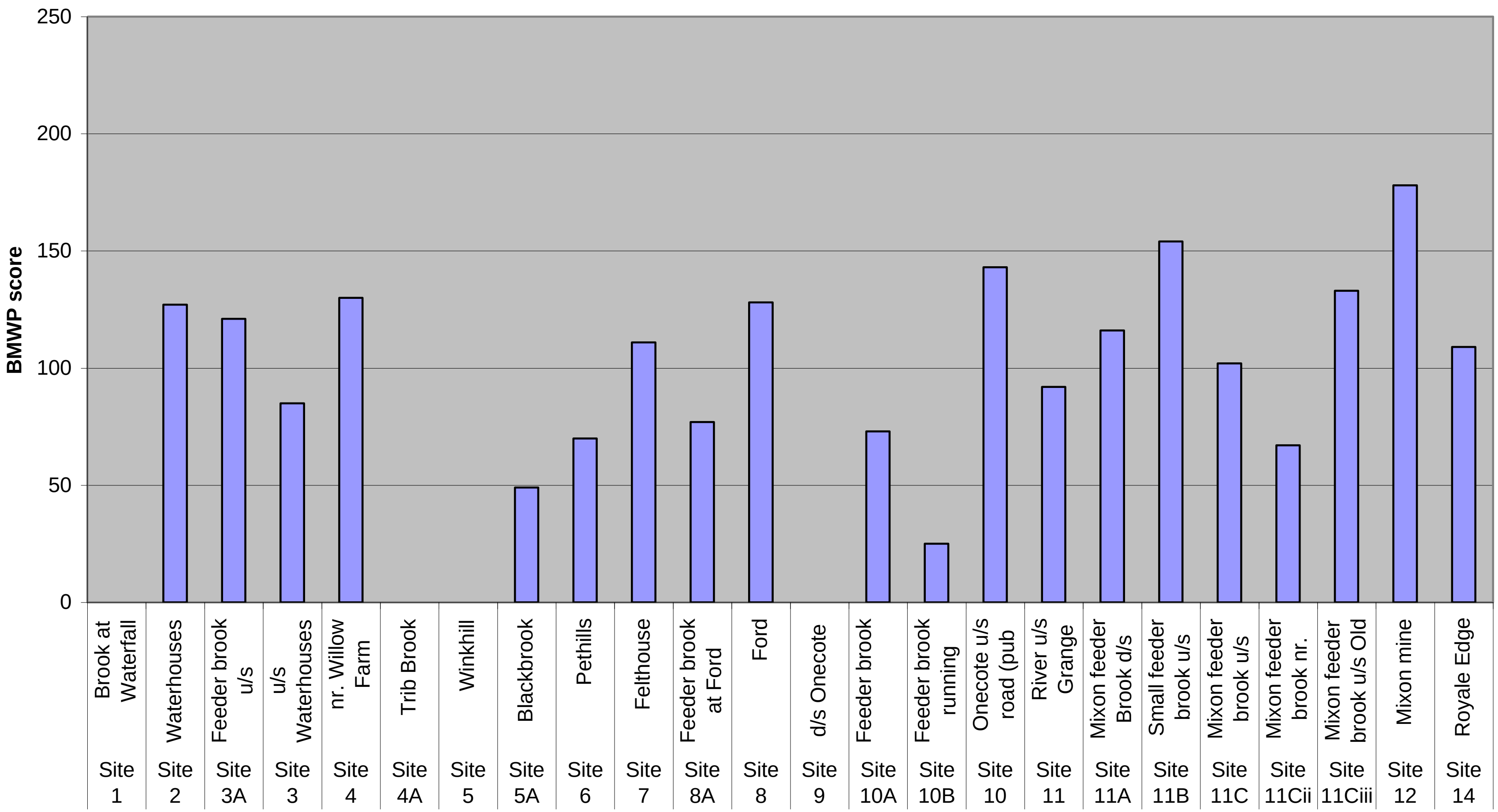


BMWP scores through the River Manifold in Autumn 2009
BMWP score
250
200
150
100
50
0
Bridge below Ilam Rd
Ilam Rd bridge
Ilam Hall d/s Manifold Springs
Hoo Brook
Wetton Mill
Warslow Brook
Warslow Brook
Ecton
Low End
nr. Hulme House
Brund
Downstream Ludburn Farm
Blake Brook
Upstream Ludburn farm
Over Boothlow
d/s Longnor rd bridge
Moss Carr trib
Oakenclough feeder stream
Oakenclough feeder stream
Hardings Booth
Ball Bank House Farm
d/s High Ash Farm
High Ash feeder stream
Feeder brook at Thick Withins Fm
Thick Withins Farm
Site 1
Site 2
Site 3
Site 4A
Site 4
Site 5A
Site 5B
Site 6
Site 8
Site 8A
Site 9
Site 10
Site 10A
Site 11
Site 12
Site 13
Site 13A
Site 14A
Site 14B
Site 15
Site 16
Site 17
Site 17A
Site 18A
Site 18



BMWP scores through the River Hamps in Spring 2009
BMWP score
250
200
150
100
50
0
Brook at Waterfall
Site 1
Waterhouses
Site 2
u/s Waterhouses
Site 3
nr. Willow Farm
Site 4
Trib Brook
Site 4A
Blackbrook
Site 5A
Pethills
Site 6
Felthouse
Site 7
Ford
Site 8
d/s Onecote
Site 9
Onecote u/s road
Site 10
River u/s Grange
Site 11
Mixon feeder Brook d/s Grange
11A
Small feeder brook u/s Grange
11B
Mixon feeder brook u/s Grange
Site 11C
Mixon mine
Site 12
Royale Edge
Site 14

BMWP scores through the River Hamps in 2009



There were several key findings with respect to the general biological quality of the River Dove in 2009 and these were:

- Biological quality showed evidence of a marked deterioration above Sprink in the Spring of 2009.
- Biological quality showed evidence of a marked deterioration above Hartington in the Autumn of 2009 and additionally in the feeder streams entering Beresford Dale.
- There was a marked drop in biological quality down the length of the River Dove in the Autumn versus the Spring of 2009 which at many lower Dove sites was greater than that expected from ‘natural’ seasonal variation.

There were several key findings with respect to the general biological quality of the River Manifold in 2009 in the graphs on pages 32 and 33 and these were:

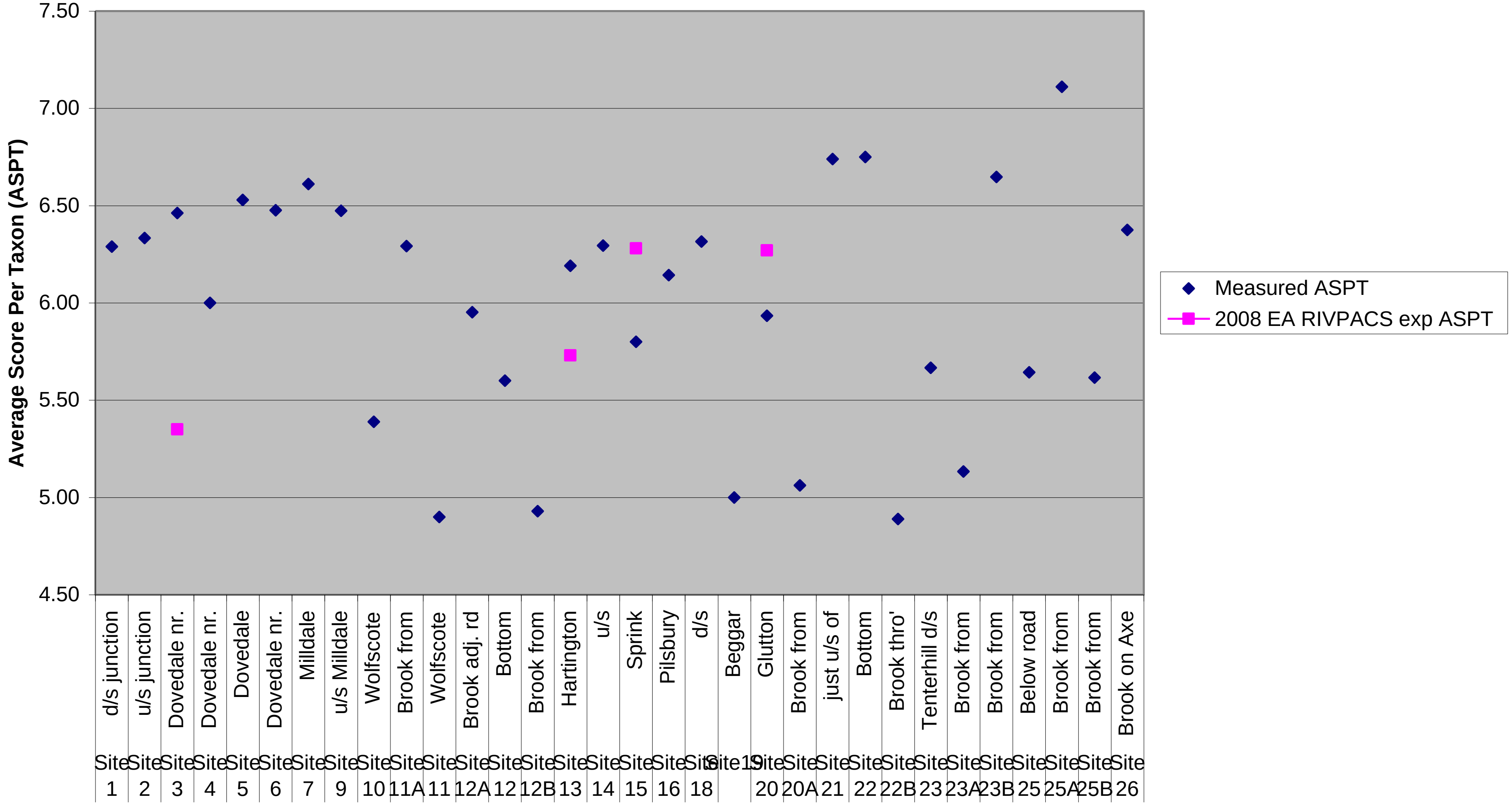
- An overall lesser biological quality in the River Manifold when compared to similar habitat reaches of the River Dove in the Spring and Autumn of 2009.
- A general deterioration in biological quality in the section of the river between Brund and Longnor Bridge in the Spring and Autumn of 2009.
- An additional deterioration in biological quality further upstream in the section of the river from Thick Withins Farm down to below the feeder stream near High Ash Farm in the Spring and Autumn of 2009. It should be noted that no biological samples were taken upstream of Thick Withins Farm in 2009 due to refused land (watercourse) access by the landowner at Dun Cow Grange.

There were several key findings with respect to the general biological quality of the River Hamps in 2009 in the graphs on pages 34 and 35 and these were:

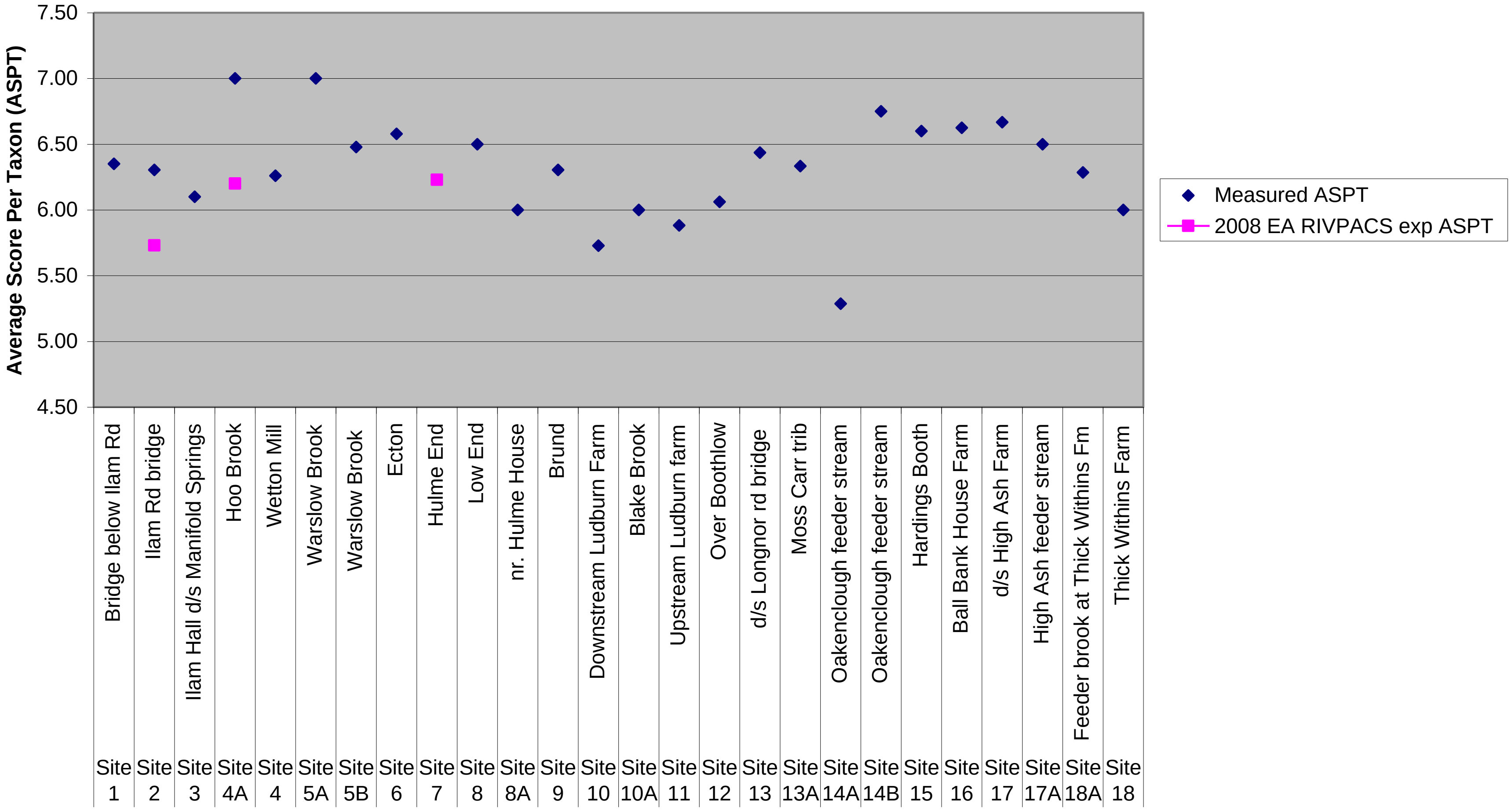
- A similar profile for overall biological quality scores to the River Manifold when compared to similar habitat reaches of the River Hamps in the Spring and Autumn of 2009.
- A general deterioration in biological quality in the sections of the River Hamps around Winkhill and Onecote respectively in the Spring and Autumn of 2009.

The BMWP score system was fine as a general broad brush approach to measuring overall biological water quality in watercourses but the powers of interpretation were limited to overall family taxa responses to environmental pressures and takes no account of individual taxa variations between sites or abundance of fauna. Similarly, the BMWP scoring system can flatter to deceive, in that, the presence of only one individual organism from one or two water quality scoring groups can significantly elevate BMWP scores by 10’s of units. For this and other reasons the Environment Agency have based their ecological predictive modelling more around the Average Score Per Taxon (ASPT) and their computer model (RIVPACS) can predict expected ASPT values for a given watercourse site based upon measured physico-chemical conditions under non-polluted conditions. It was possible for the EA to calculate expected ASPT’s for a number of routine EA sampling sites in 2008 but there was only sufficient historic data to facilitate Autumn data calculations (data courtesy of the Environment Agency). The expected ASPT’s for un-polluted EA sites has been plotted with the 2009 Upper Dove Catchment data in the following graphs.

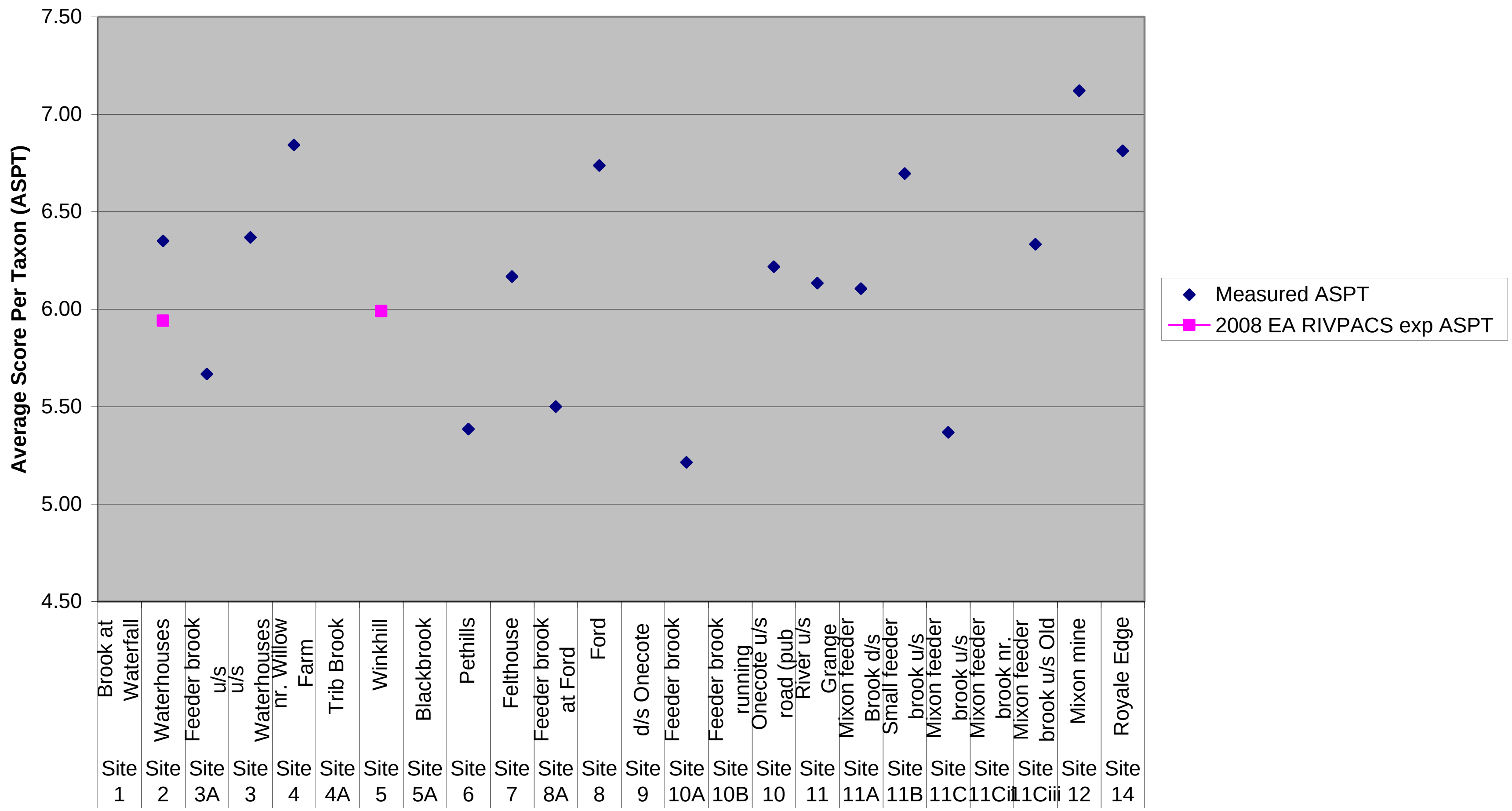
Maesured ASPT at R. Dove sites in Autumn 2009 versus expected RIVPAC ASPT's in 2008



Measured ASPT at R. Manifold sites in Autumn 2009 versus expected RIVPAC ASPT's for 2008



Measured ASPT at R. Hamps sites in Autumn 2009 versus expected RIVPAC ASPT's for 2008



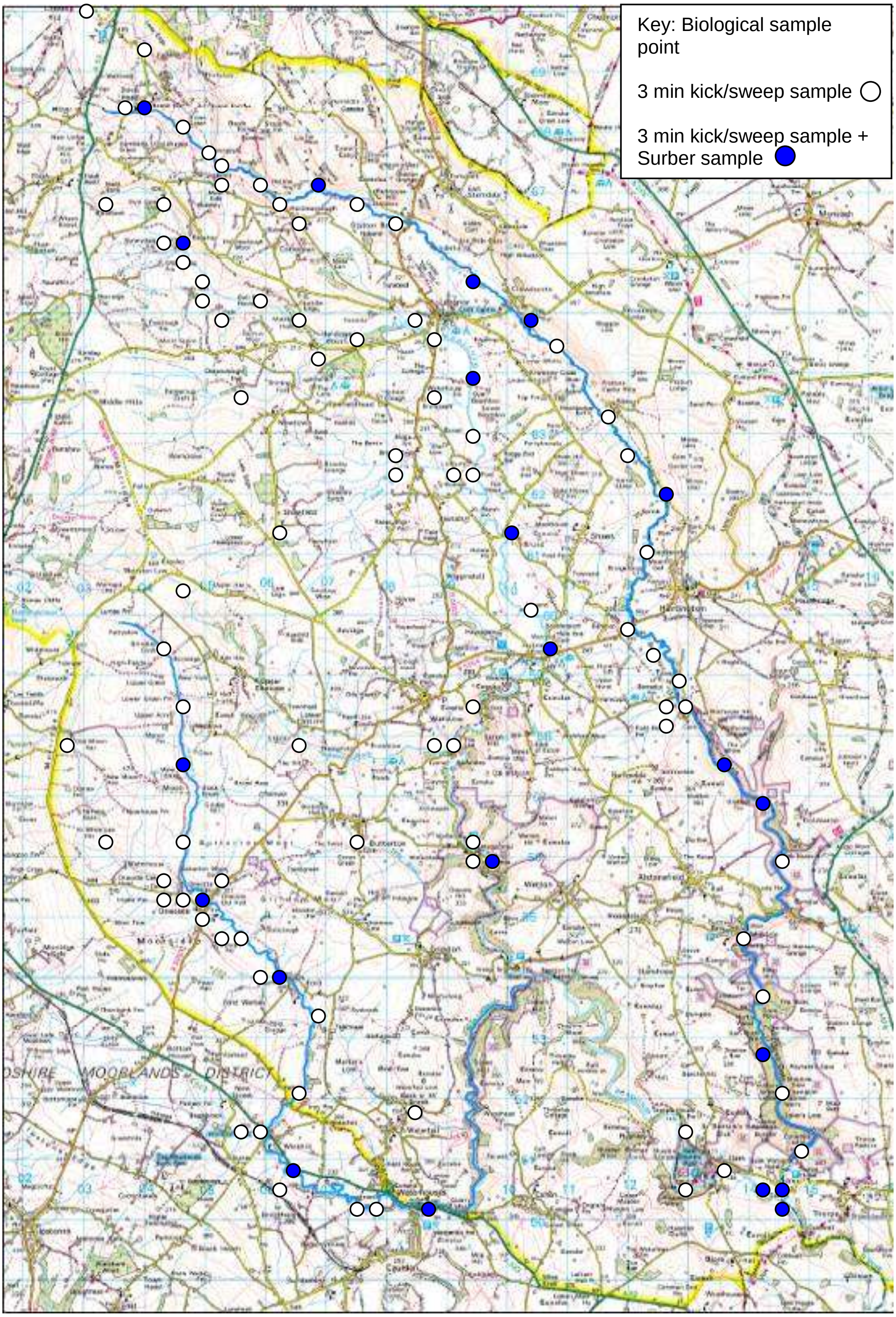
The ASPT data for the River Dove in the graph above showed that in the Autumn of 2009 many of the aquatic macroinvertebrate communities in the watercourses above Sprink were registering ASPT values below those expected for un-polluted sites for example, Sprink, Beggars Bridge, Tenterhill and just downstream of the source of the Dove. Conversely there were a number of watercourses that appeared to be healthy in terms of ASPT measurements for example, some feeder streams in the upper reaches. Furthermore, some of the aquatic ecological monitoring sites in Wolfscote Dale, Beresford Dale and associated Beresford feeder streams appeared to be below par in the Autumn of 2009.

It was a similar story for the ASPT data in the River Manifold in the graph above which showed that in the Autumn of 2009 many of the aquatic macroinvertebrate communities in the watercourses between Low End and the tributary of the Oakenclough feeder stream were registering ASPT values below those expected for un-polluted sites. Conversely there were a number of watercourses from below Ilam to Low End and in some of the upper reaches of the River Manifold appeared to be ‘healthy’ in terms of ASPT measurements. However, expected ASPT’s could not be calculated for non-EA sample sites in the upper reaches but predicted ASPT’s would be expected to rise slightly with increasing watercourse gradient and improving water quality associated with clean upland feeder streams. Later pollution indexing in this report would shed more light upon this matter.

The ASPT data for the River Hamps above was impossible to interpret since there was no expected ASPT data from RIVPACS above Winkhill and therefore no benchmark standard to measure observed ASPT’s against for much of this river. Again, later pollution indexing in this report would shed more light upon this matter.

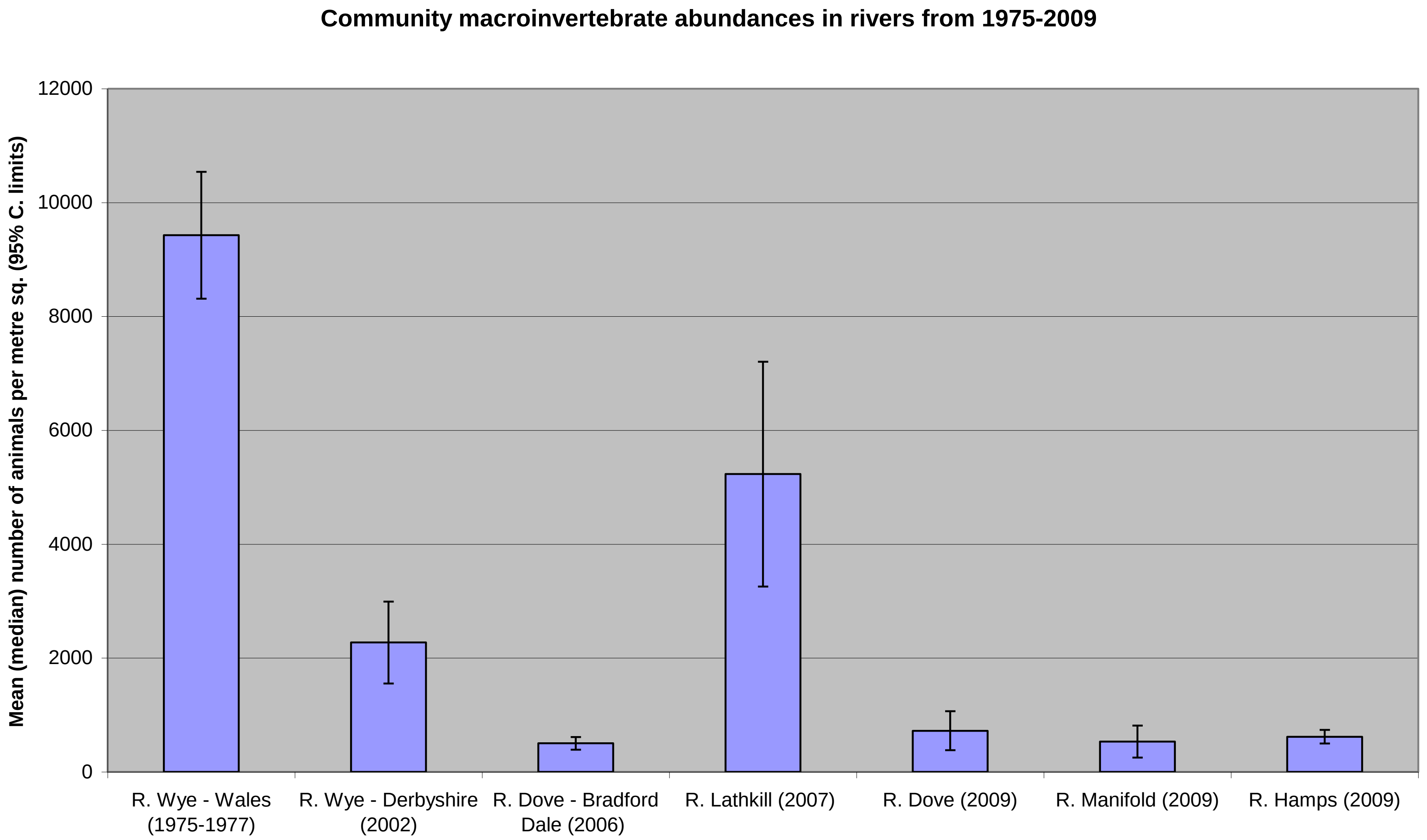
Macroinvertebrate abundance data

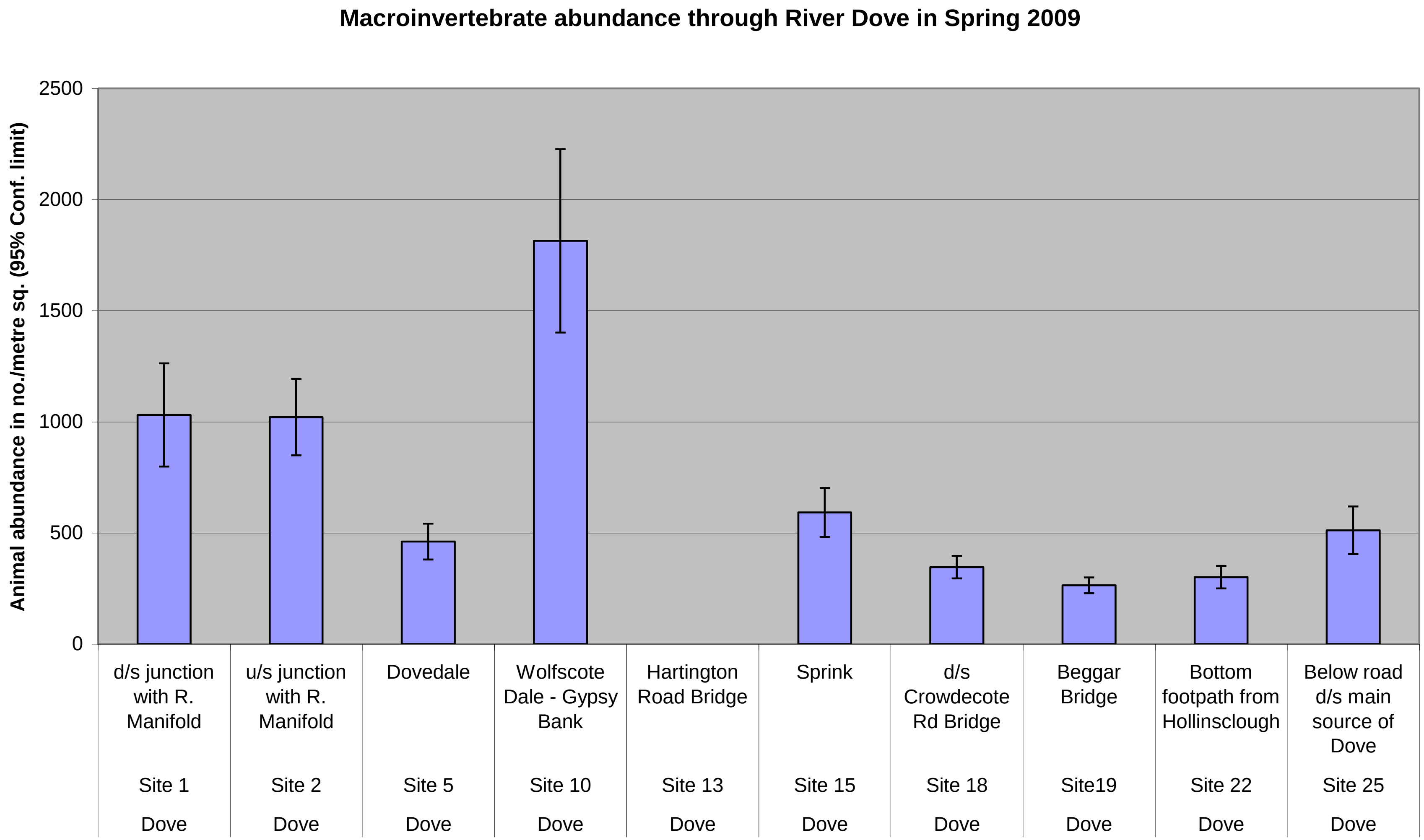
All the species listings and macroinvertebrate abundance data for all ~90 study sites across the River Dove, Manifold and Hamps sampled in the Spring and Autumn of 2009 were presented in Appendix 2a and 2b and shown in the map below.



A backbone of quantitative net-Surber ($0.1m^2$) sample sites was distributed through the 3 studied rivers where comparable riffle sites were available as highlighted in the previous map on page 41. Any measurements of total aquatic faunal abundances at sites in the Upper Dove Catchment may not, in themselves, reflect some types of pollution if sensitive species are simply replaced by tolerant species but depressed or similar population numbers compared to other relatively un-polluted ‘reference’ rivers would provide some global benchmark of watercourse health. Because sensitivity to contaminants often varies among species, a complimentary assessment of the relative abundances of sensitive and tolerant species in a community should then be employed to assess the degree of any contamination and this was undertaken in the later sections of this report on pollution indexing.

The graph below provides some historic and ‘reference’ river context for the 3 rivers in the Upper Dove Catchment in 2009. For comparative purposes the ‘reference’ data used was for watercourse riffles sampled by net-Surbers ($0.1m^2$), in the same season (Spring), from upland river (not stream) stretches, with comparable geology and where samples sizes were ≥ 5 samples (data shown has mean or median values with 95% Confidence Limits).


Community macroinvertebrate abundances in rivers from 1975-2009
Mean (median) number of animals per metre sq. (95% C. limits)
12000
10000
8000
6000
4000
2000
0
R. Wye - Wales (1975-1977)
R. Wye - Derbyshire (2002)
R. Dove - Bradford Dale (2006)
R. Lathkill (2007)
R. Dove (2009)
R. Manifold (2009)
R. Hamps (2009)


Macroinvertebrate abundance through River Dove in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limit)
2500
2000
1500
1000
500
0
d/s junction with R. Manifold
u/s junction with R. Manifold
Dovedale
Wolfscote Dale - Gypsy Bank
Hartington Road Bridge
Sprink
d/s Crowdecote Rd Bridge
Beggar Bridge
Bottom footpath from Hollinsclough
Below road d/s main source of Dove
Site 1
Site 2
Site 5
Site 10
Site 13
Site 15
Site 18
Site19
Site 22
Site 25
Dove
Dove
Dove
Dove
Dove
Dove
Dove
Dove
Dove
Dove

True quantitative faunal data from comparable watercourses using comparable sampling techniques was not that easy to find and virtually non-existent for the 3 Upper Dove Catchment rivers. The River Wye and River Lathkill in Derbyshire had most geological and hydro-morphological similarities to the River Dove and River Manifold. The middle-upper River Wye in Wales had geological and hydro-morphological similarities to parts of all 3 Upper Dove Catchment rivers. It appeared that the River Dove, Manifold and Hamps had relatively depressed faunal abundance (biomass) compared to the nearby Derbyshire River Wye (Wood *et.al*., 2005) and River Lathkill (Smith & Wood, 2002 and Smith *et.al*., 2003) plus some historic River Wye (Wales) data (Goch, 1977). Previous more isolated faunal abundance data for the River Dove (Everall, 2006) suggested the river at Beresford Dale was in a similar macroinvertebrate abundance status in 2006 to that found variably throughout the river in 2009. It was, in all probability, salient that the River Wye and River Lathkill in Derbyshire did not have the same intensity of dairying and cattle rearing prevalent in the 3 rivers of the Upper Dove Catchment.

The patterns of community macroinvertebrate abundance through the 3 rivers of the Upper Dove Catchment in the Spring and Autumn of 2009 are shown in the graphs above. The Spring 2009 sampling included 10 sub-Surber ($0.1m^2$) net samples and allowed a calculation of intra-sample confidence limits for the mean abundance value at each site as shown in the graphs.

Since measures of total aquatic faunal abundances at sites in the Upper Dove Catchment may not, in themselves, reflect anthropogenic inputs because pollutant sensitive species may simply be replaced by tolerant species then this data would serve as a benchmark data set against which to examine future trends. It was worth mentioning that a reduction in the general community macroinvertebrate abundances in the upper reaches did not indicate in itself a significant pollutant impact (for example, pesticides) and that the abundance levels were fairly typical of Moorland areas from Pennine watercourse catchments (Brown *et. al*, 2008). The Upper Dove has historically been subject to marked pesticide incursions (Williams, 2003 and Everall, 2004) but that does not mean that this section of the Dove river corridor or the referenced Pennine study area were not subject to other anthropogenic impacts.

In looking at watercourse sites in the Upper reaches of the Dove one should, in the absence of marked anthropogenic inputs, be effectively examining reference un-polluted sites. Much of this report looks at the potential types and effects of pollution on the aquatic macroinvertebrate communities in the rivers of the Upper Dove Catchment through sites dominated by pollution tolerant species. In a similar vein, communities with moderate to high levels of species that are sensitive to a particular chemical provide reasonable evidence for the absence of that chemical. The freshwater shrimp (*Gammarus pulex*) is well documented in the literature to be highly sensitive to insecticides at very low environmental levels (Williams, 2003 and Everall, 2003) and such levels usually result in a near complete decimation of this fauna in impacted watercourses (Everall, 2003). Presence but depressed population numbers were usually the result of other often ephemeral anthropogenic inputs for example, organic pollution, habitat availability and water chemistry (Hellawell, 1989 and Crane, 1994). Typical abundances for pertinent reference rivers are shown in the table below.

River	***Gammarus* abundance**	**Reference**
Bourne - chalk stream (Hampshire, n>10 samples) 2007	4796/m^2	Everall, 2007
Crags stream Derbyshire	2297/m^2	Crane, 1994
Wye (length, > 50 samples) 1998	>250/3 min kick sample	Smith and Wood, 2002
Wye (Millers Dale, n =5 samples) 2009	354/3 min kick sample	National Riverfly Partnership
Wye (Millers Dale, n =7 samples) 2008-2009	517/3 min kick sample	National Riverfly Partnership
Wye (Monsal Dale, n =8 samples) 2008-2009	507/3 min kick sample	National Riverfly Partnership
Lathkill 2005	> 1000m^2	Wood *et. al.*, 2005
Wye 2005	> 350m^2	Wood *et. al.*, 2005
Dove (Beresford Dale n =40 samples) 2006	35/m^2	Everall, 2006

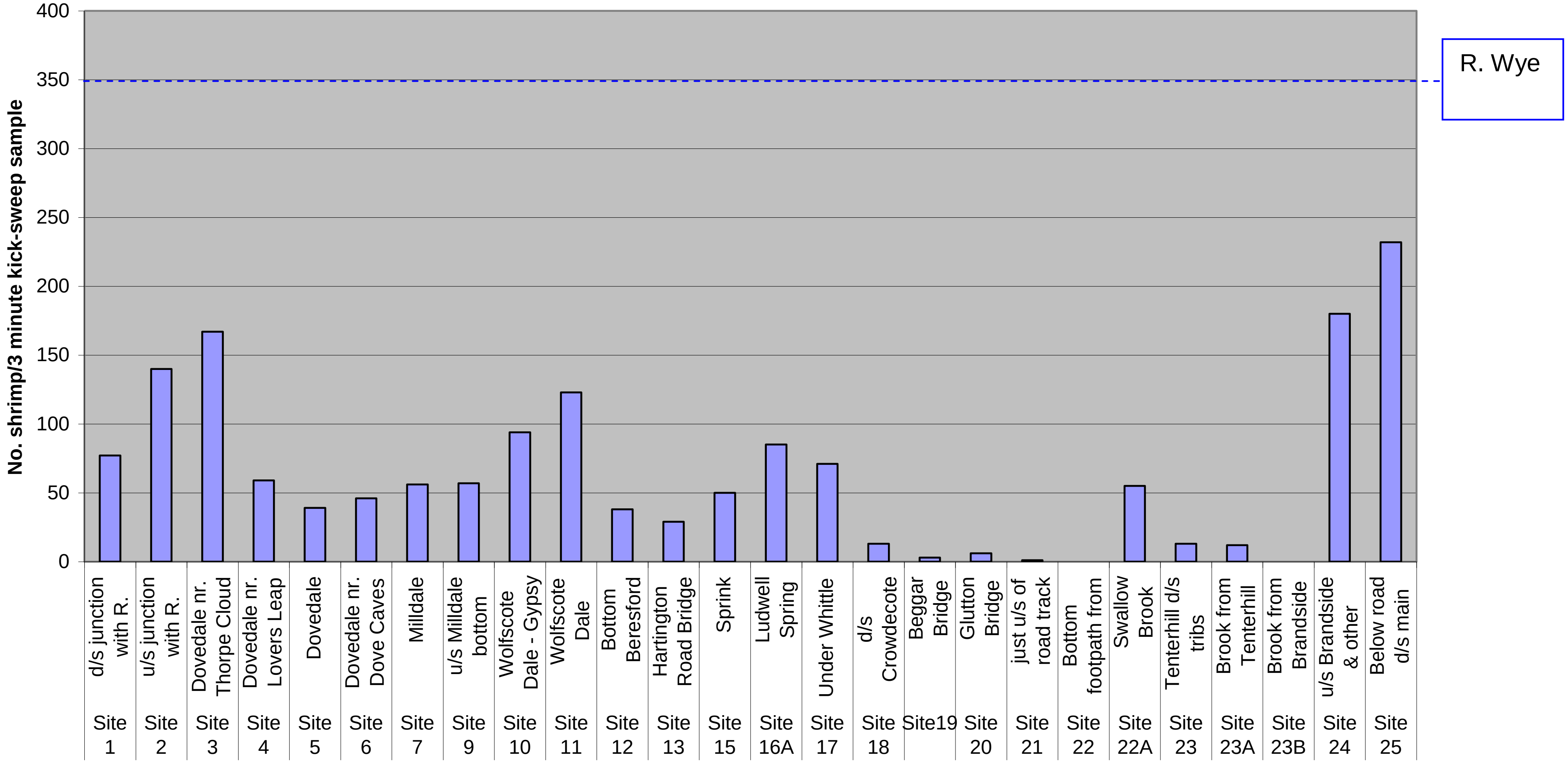
Freshwater shrimp (*Gammarus pulex*)

The most conservative estimates of *Gammarus* levels for these reference limestone rivers in recent years were plotted on the River Dove graphs below for reference (---) with the 2009 Upper Dove Catchment data.

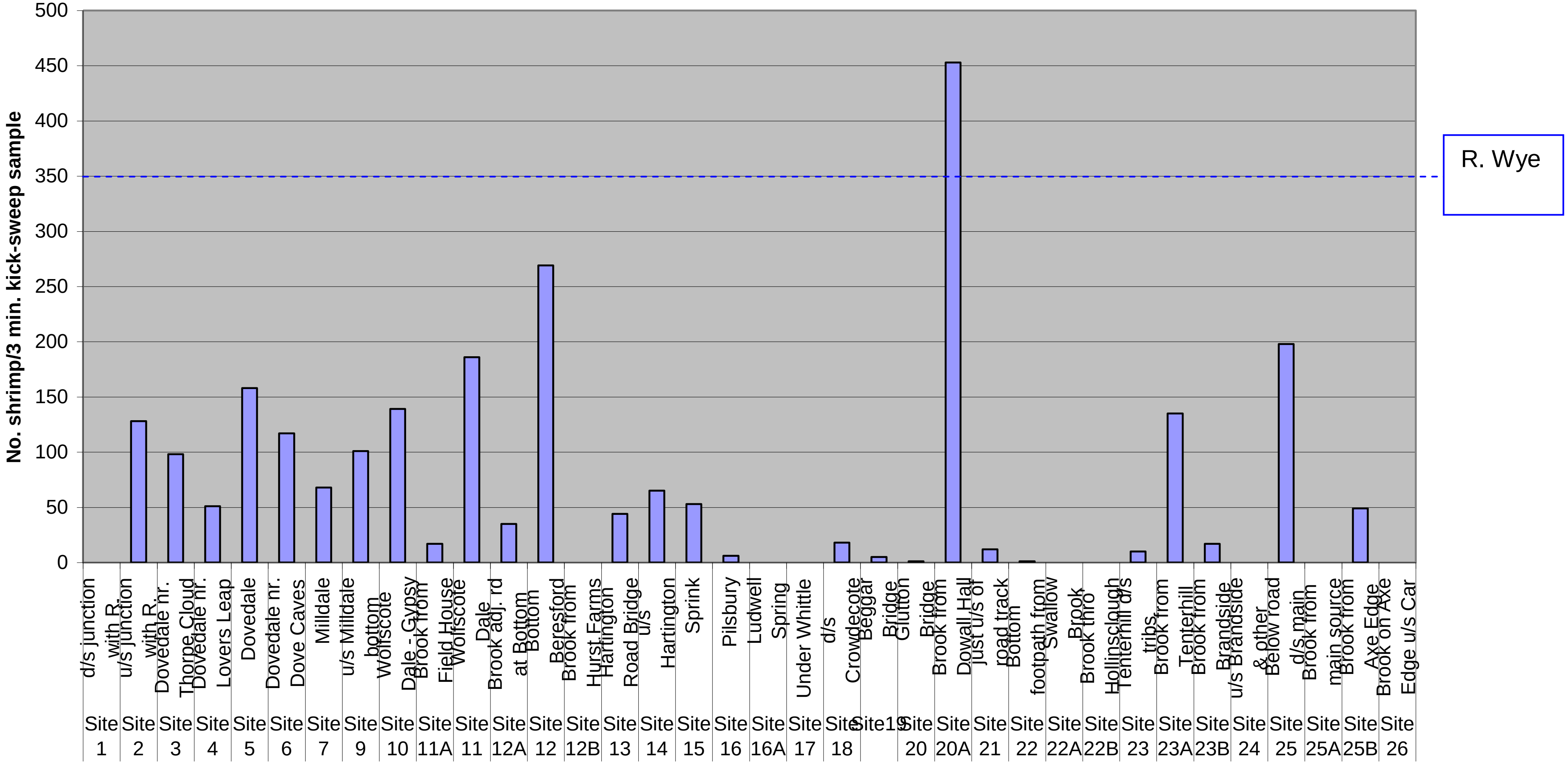
The Spring 2009 macroinvertebrate abundance sampling included 10 sub-Surber (0.1m^2) net samples and allowed a calculation of intra-sample confidence limits for the mean *Gammarus* abundance value at each site as shown in the graphs overleaf.

The Autumn 2009 macroinvertebrate abundance sampling included 10 sub-Surber (0.1m^2) net samples which were pooled in the field because additional survey site coverage in the autumn reduced analytical time to look at individual sub-samples in the laboratory. The mean *Gammarus* abundance values for each quantitative survey site in the Autumn of 2009 were shown in the graph below.

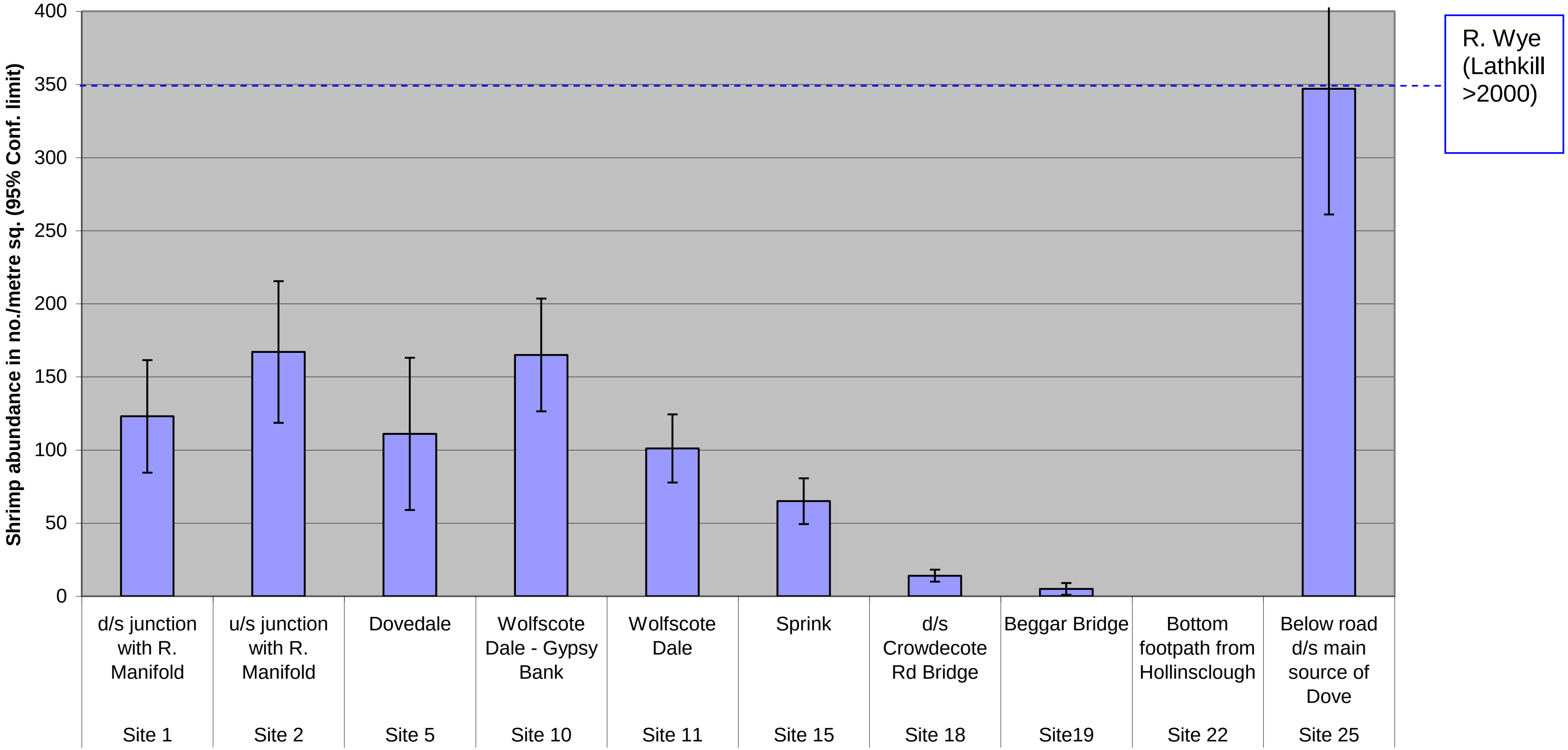
Shrimp (*Gammarus pulex*) numbers through River Dove in Spring 2009

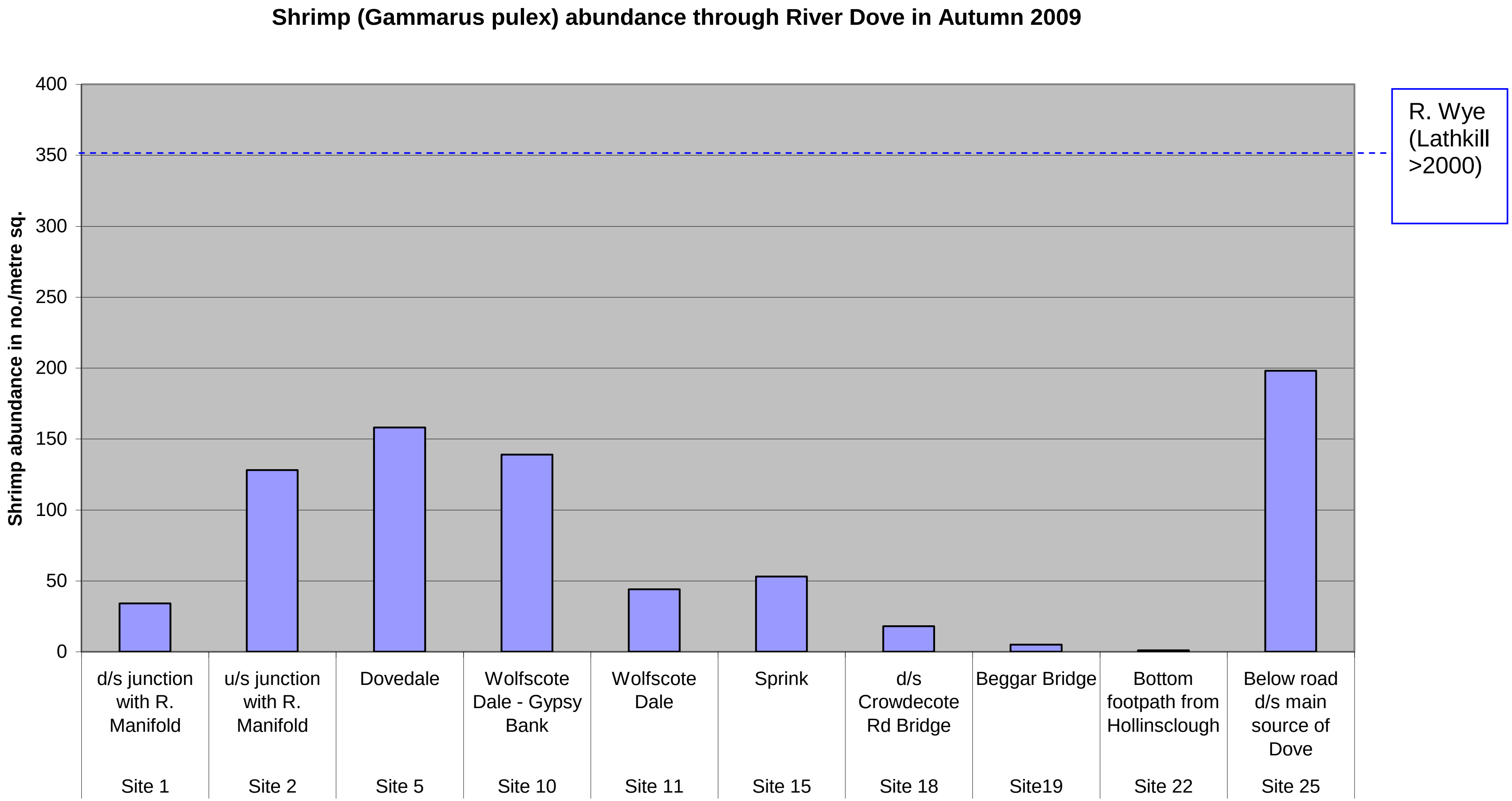


Shrimp (*Gammarus pulex*) abundance through River Dove in Autumn 2009



Shrimp (*Gammarus pulex*) abundance through River Dove in Spring 2009



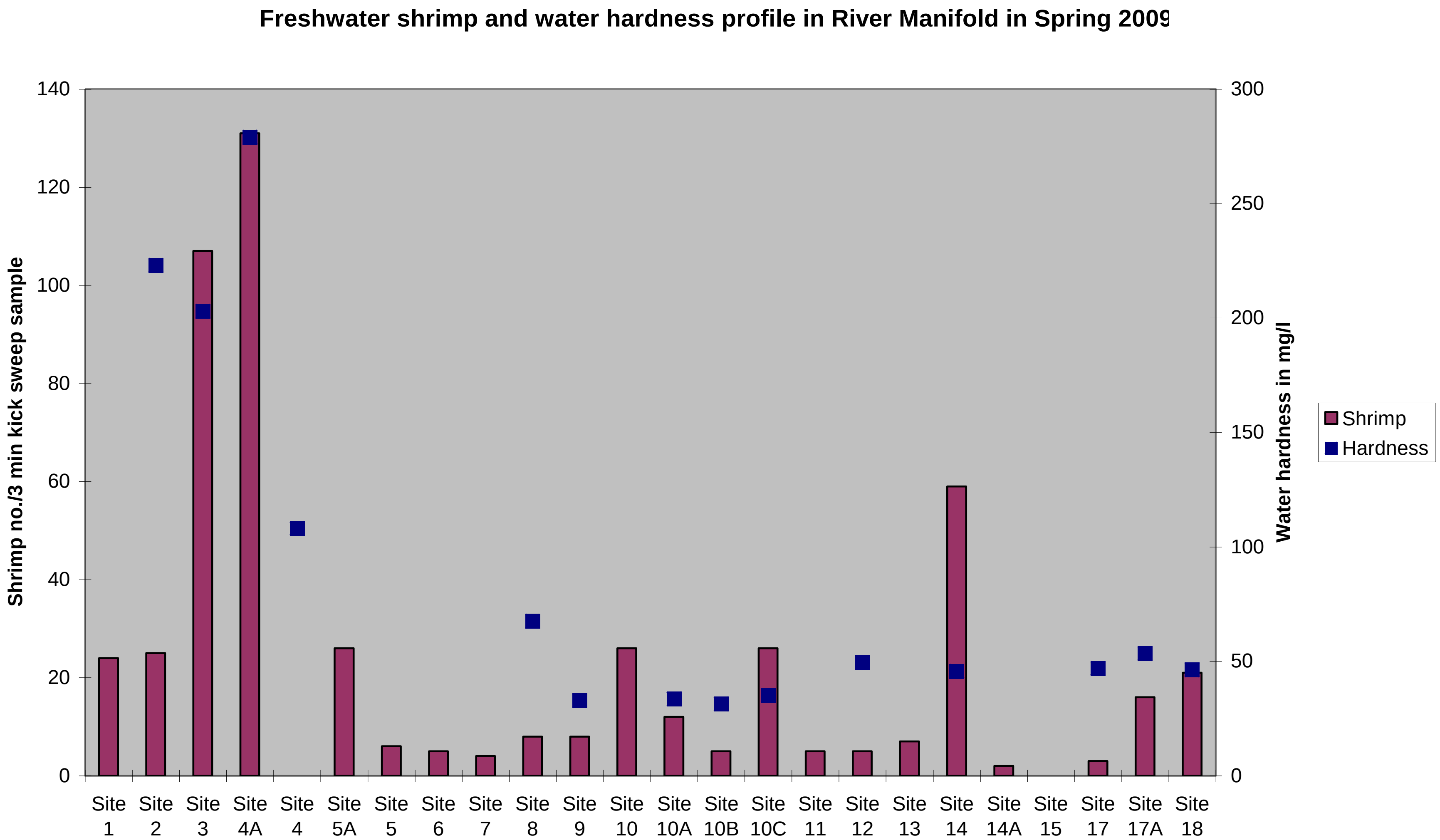


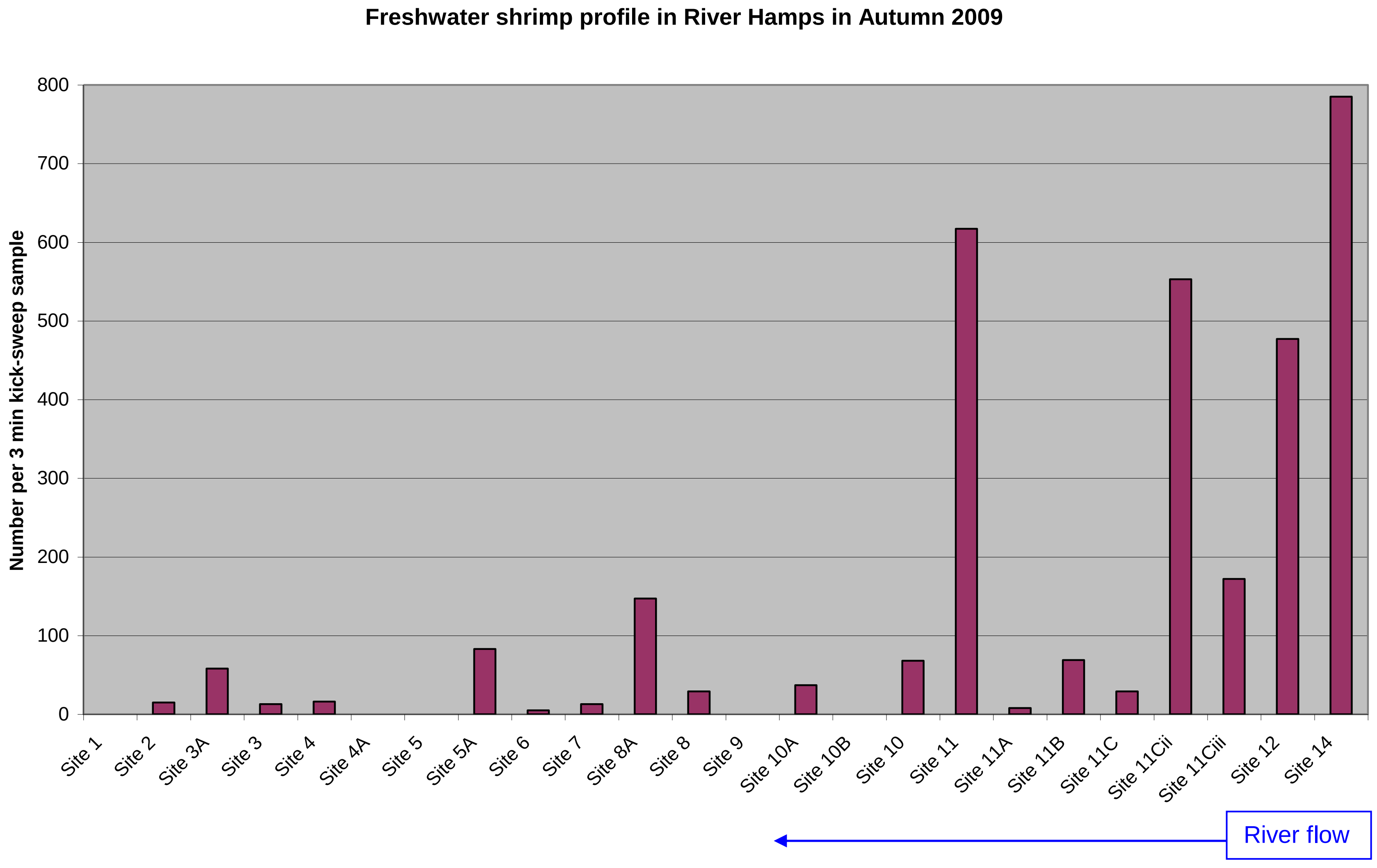
Shrimp (Gammarus pulex) abundance through River Dove in Autumn 2009
Shrimp abundance in no./metre sq.
400
350
300
250
200
150
100
50
0
R. Wye (Lathkill >2000)
d/s junction with R. Manifold
Site 1
u/s junction with R. Manifold
Site 2
Dovedale
Site 5
Wolfscote Dale - Gypsy Bank
Site 10
Wolfscote Dale
Site 11
Sprink
Site 15
d/s Crowdecote Rd Bridge
Site 18
Beggar Bridge
Site19
Bottom footpath from Hollinsclough
Site 22
Below road d/s main source of Dove
Site 25

Both semi-quantitative and quantitative assessments of shrimp (*Gammarus pulex*) populations through the River Dove in 2009 suggested that population levels were below those typically associated with nearby limestone rivers where there was less land use associated with dairying and cattle rearing. In the upper reaches in the foot hills of the Dove catchment there was evidence of modest *Gammarus* populations or at least some presence which suggested that historic pesticide incursions had reduced or abated by 2009. The depressed levels of *Gammarus* between the source of the Dove and Sprink may have been due to a combination of a lack of supportive water hardness as shown with some similar River Manifold pattern data in the graph below and/or (intermittent) organic loads as shown later in this report and/or a legacy of pesticide impact plus potentially associated residual sediment levels of insecticide.

In the limestone sections of the River Dove and River Manifold and in common with many studies of perennial rivers the amphipod crustacean (*Gammarus pulex*) was an important pollution sentinel which should under relatively un-polluted conditions have been recorded as a very abundant species in concordance with data from the River Lathkill and Wye (Wood et.al., 2005 and National Riverfly Partnership data 2008-2009). Interestingly, the best *Gammarus* numbers recorded from 3 minute kick-sweep samples were in the upper reaches of the River Hamps in the Autumn of 2009 and not the concomitant stretches of the R. Dove or the R. Manifold, which suggested that pollution in the latter watercourses may have been overriding ‘habitat’ effects upon shrimp populations.

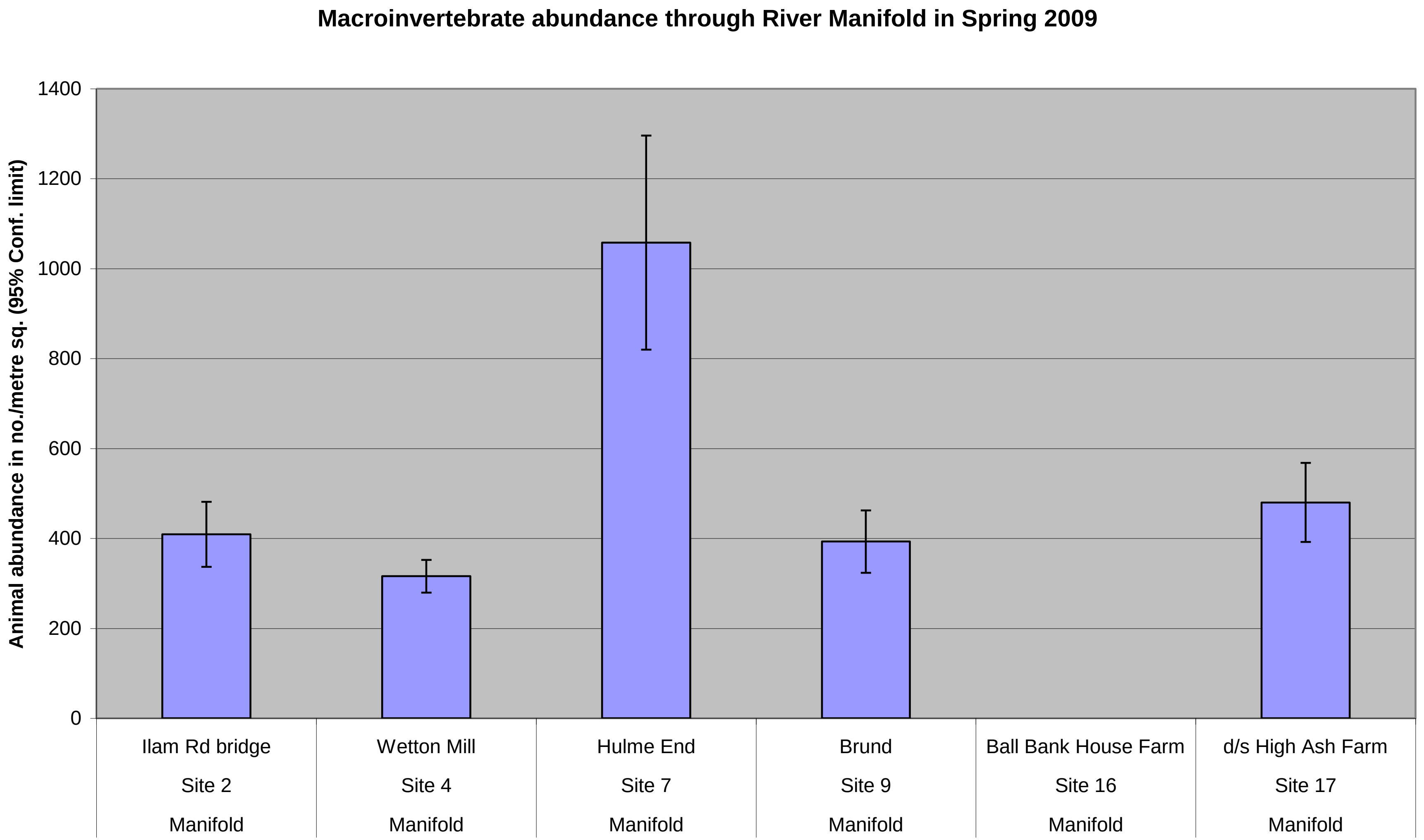
It was planned to undertake some quantitative (Surber) samples from the River Wye around Monsal Dale in 2010 to obtain some more reference data to aid further benchmarking of both riverfly and *Gammarus* levels in the Upper Dove Catchment.

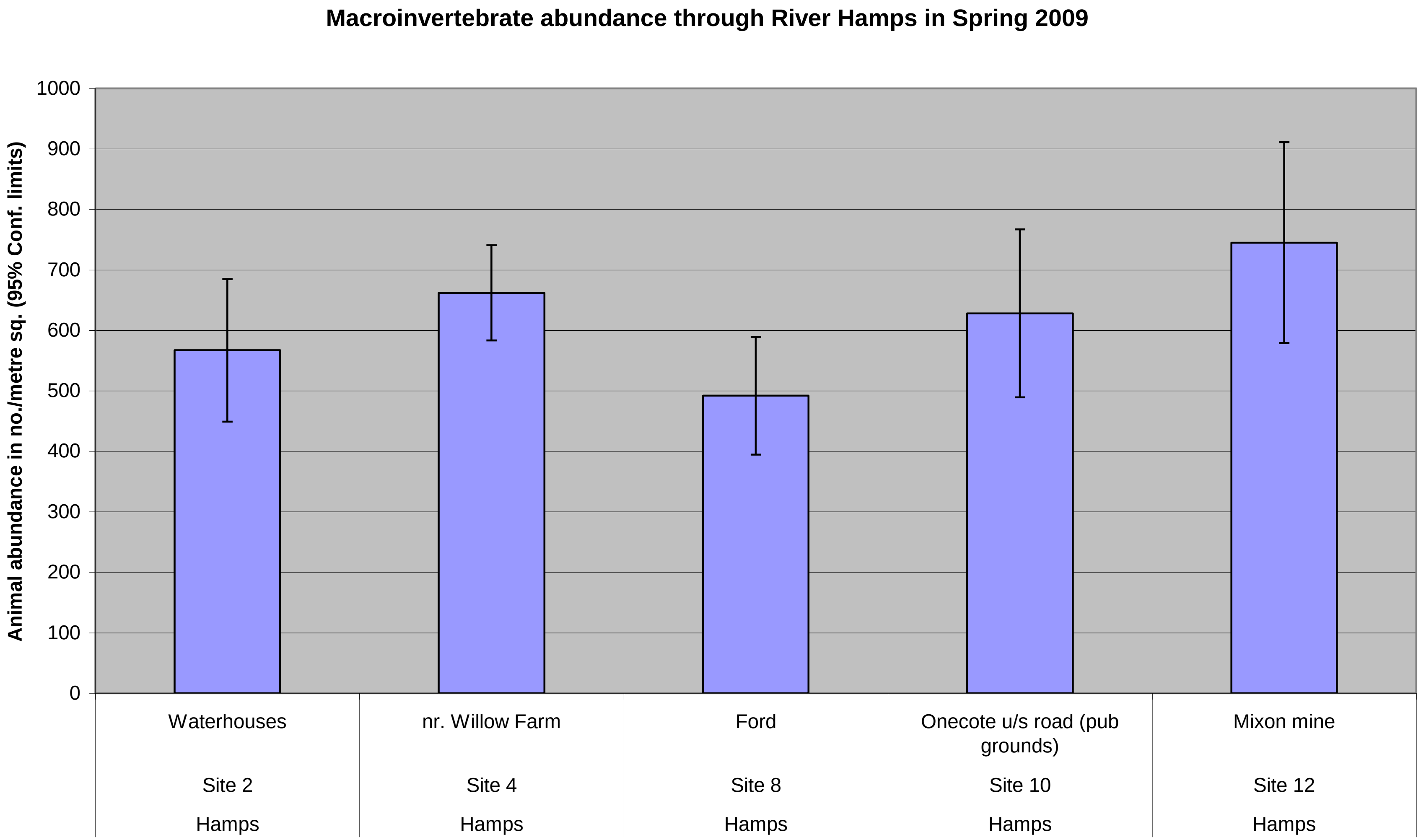

Freshwater shrimp and water hardness profile in River Manifold in Spring 2009
Shrimp no./3 min kick sweep sample
Water hardness in mg/l
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
Site 1
Site 2
Site 3
Site 4A
Site 4
Site 5A
Site 5
Site 6
Site 7
Site 8
Site 9
Site 10
Site 10A
Site 10B
Site 10C
Site 11
Site 12
Site 13
Site 14
Site 14A
Site 15
Site 17
Site 17A
Site 18
Shrimp
Hardness


Freshwater shrimp profile in River Hamps in Autumn 2009
Number per 3 min kick-sweep sample
0
100
200
300
400
500
600
700
800
Site 1
Site 2
Site 3A
Site 3
Site 4
Site 4A
Site 5
Site 5A
Site 6
Site 7
Site 8A
Site 8
Site 9
Site 10A
Site 10B
Site 10
Site 11
Site 11A
Site 11B
Site 11C
Site 11Cii
Site 11Ciii
Site 12
Site 14
River flow

As previously discussed, measurements of total aquatic faunal abundances at remaining survey sites in the Upper Dove Catchment may not, in themselves, reflect anthropogenic inputs because pollutant sensitive species may simply be replaced by tolerant species and so the data for the River Manifold and Hamps below was merely to provide a benchmark to monitor future trends.

There was generally remarkable consistency in the total aquatic macroinvertebrate abundances through the Surber survey sites in the River Manifold and River Hamps in the Spring of 2009.


Macroinvertebrate abundance through River Manifold in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limit)
0
200
400
600
800
1000
1200
1400
Ilam Rd bridge Site 2 Manifold
Wetton Mill Site 4 Manifold
Hulme End Site 7 Manifold
Brund Site 9 Manifold
Ball Bank House Farm Site 16 Manifold
d/s High Ash Farm Site 17 Manifold

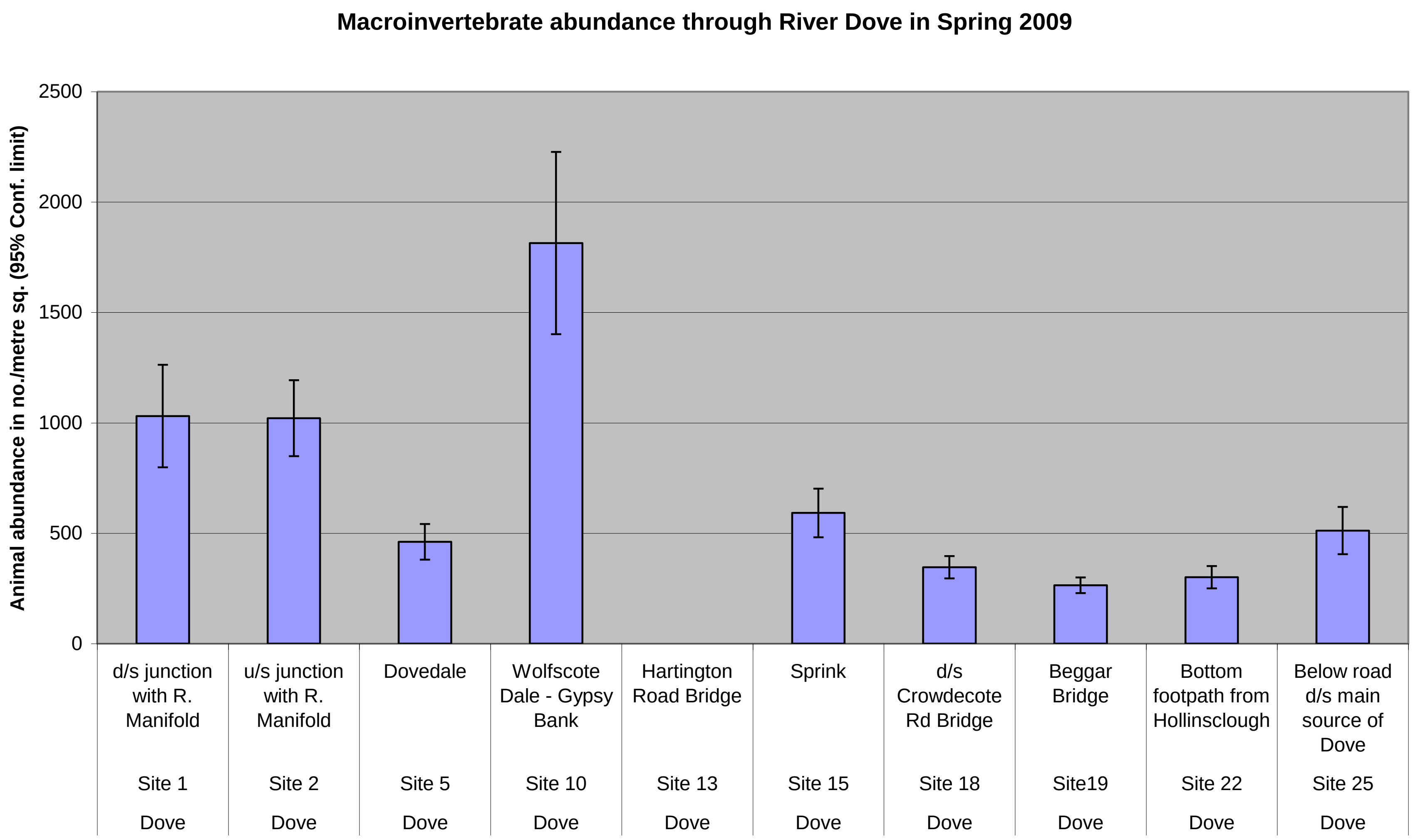

Macroinvertebrate abundance through River Hamps in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limits)
0
100
200
300
400
500
600
700
800
900
1000
Waterhouses
Site 2
Hamps
nr. Willow Farm
Site 4
Hamps
Ford
Site 8
Hamps
Onecote u/s road (pub grounds)
Site 10
Hamps
Mixon mine
Site 12
Hamps

Spring and Autumn faunal abundance data for the Upper Dove Catchment in 2009 was plotted on the same scale axes in the graphs below.

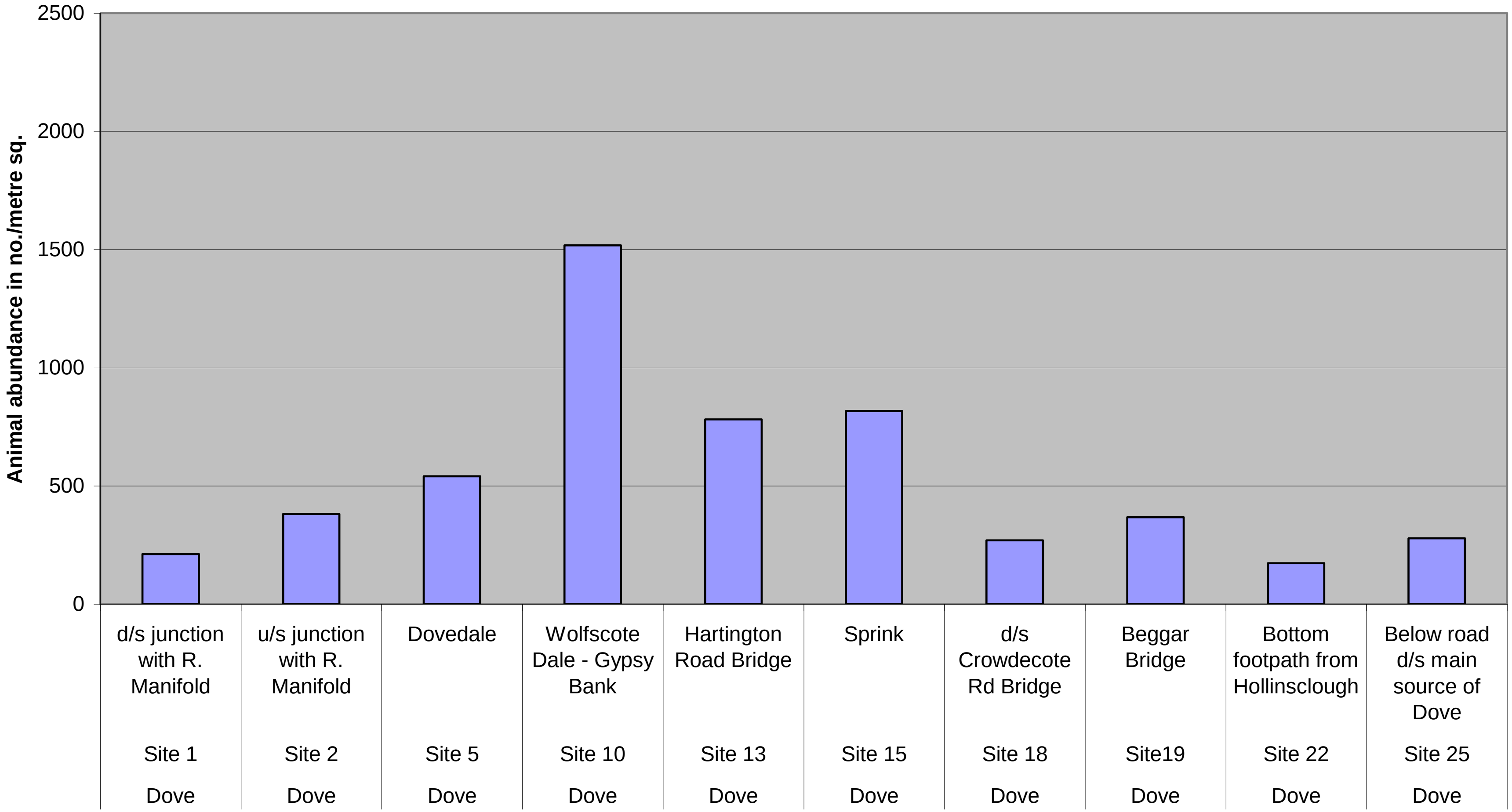
There was some tentative evidence of a loss of macroinvertebrate abundance at the surveyed lower Dove sites (up and downstream of the junction with the River Manifold) and from the source of the river down to Sprink in the autumn of 2009. At some sites, this appeared to be too large an effect to attribute to seasonal changes in the faunal communities and suggested anthropogenic impacts.

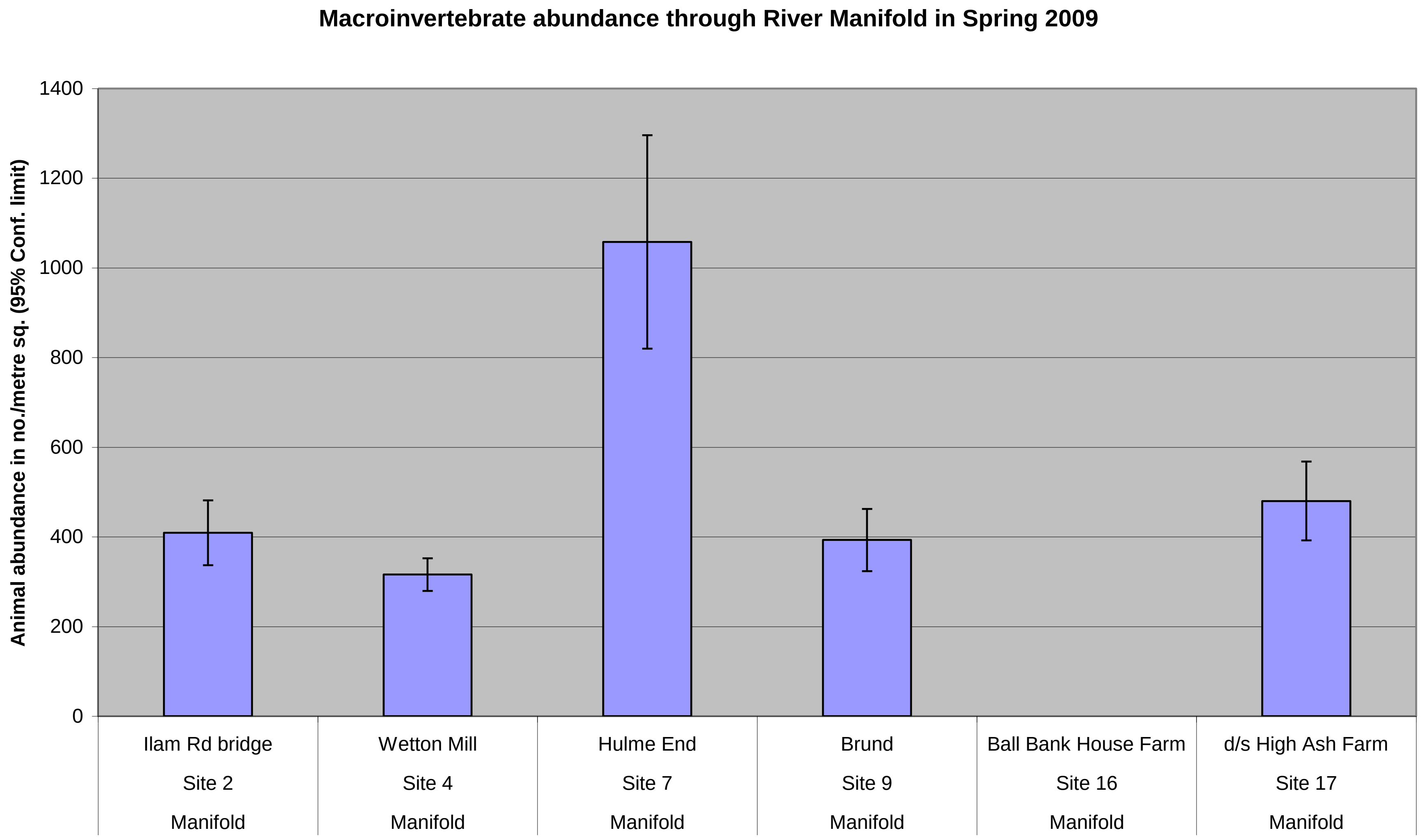
There was no evidence of any marked changes in faunal abundances at survey sites in the River Manifold between the Spring and Autumn of 2009.

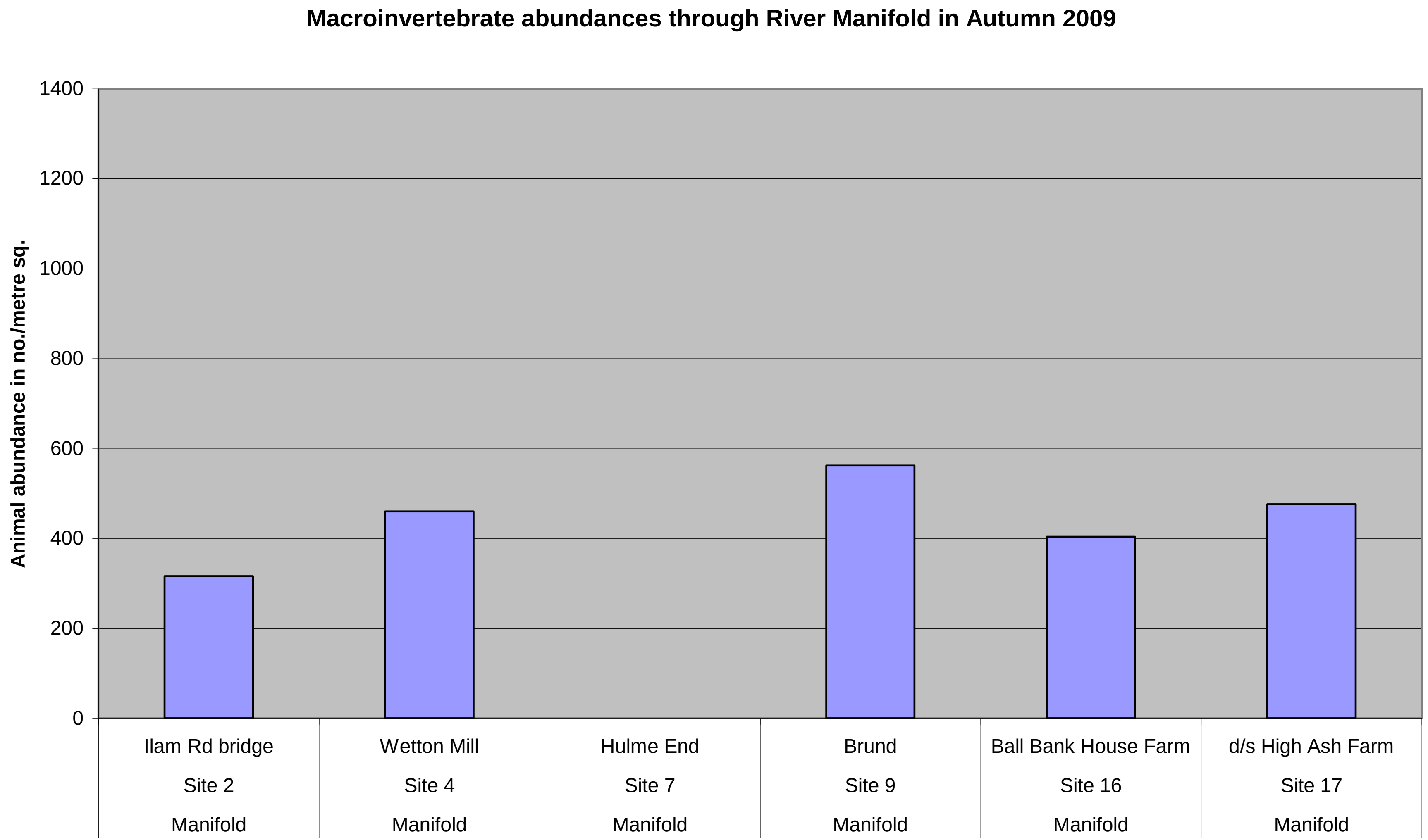
There was no evidence of any marked changes in faunal abundances at survey sites in the River Hamps between the Spring and Autumn of 2009.

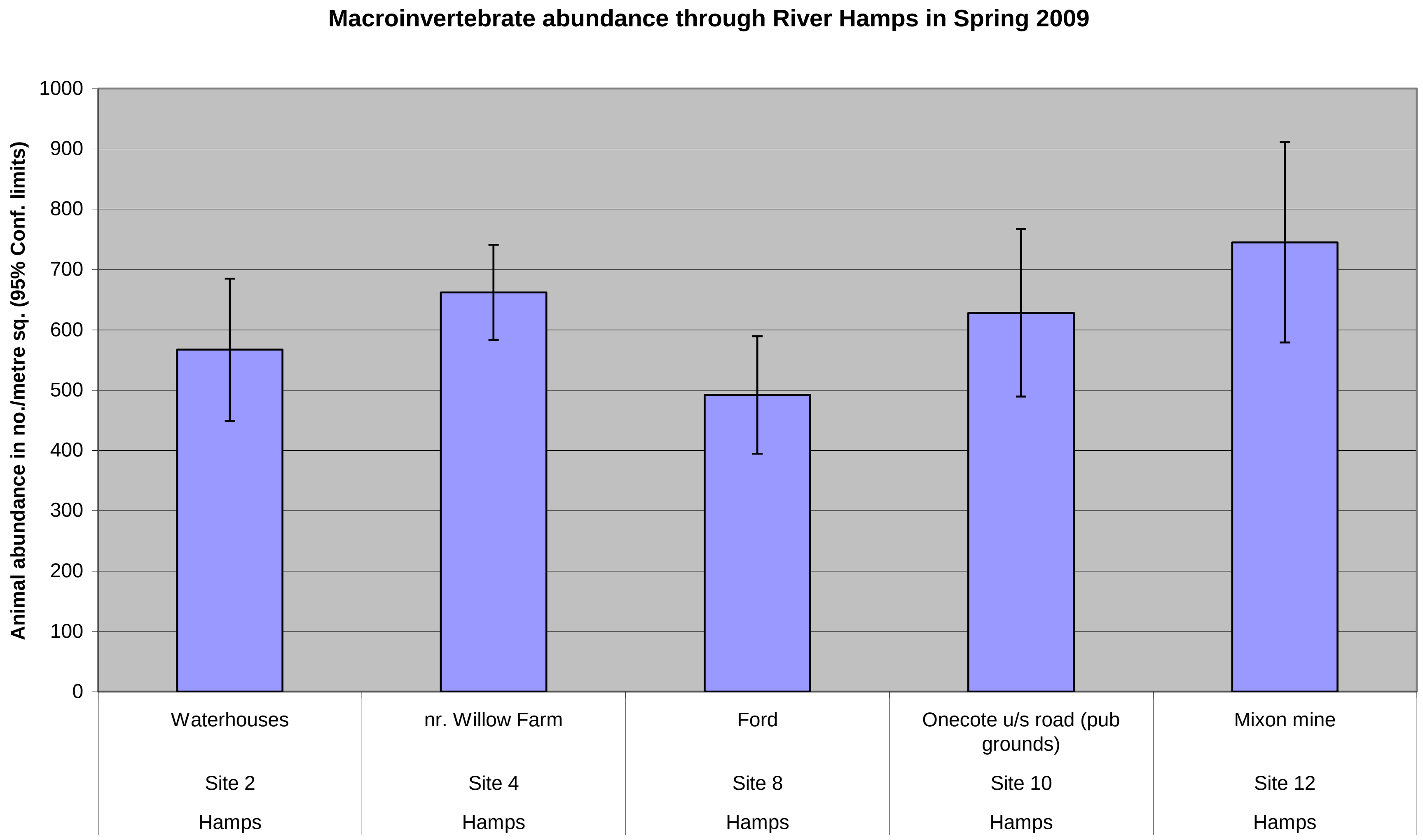

Macroinvertebrate abundance through River Dove in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limit)
2500
2000
1500
1000
500
0
d/s junction with R. Manifold
Site 1
Dove
u/s junction with R. Manifold
Site 2
Dove
Dovedale
Site 5
Dove
Wolfscote Dale - Gypsy Bank
Site 10
Dove
Hartington Road Bridge
Site 13
Dove
Sprink
Site 15
Dove
d/s Crowdecote Rd Bridge
Site 18
Dove
Beggar Bridge
Site19
Dove
Bottom footpath from Hollinsclough
Site 22
Dove
Below road d/s main source of Dove
Site 25
Dove

Macroinvertebrate abundances through River Dove in Autumn 2009



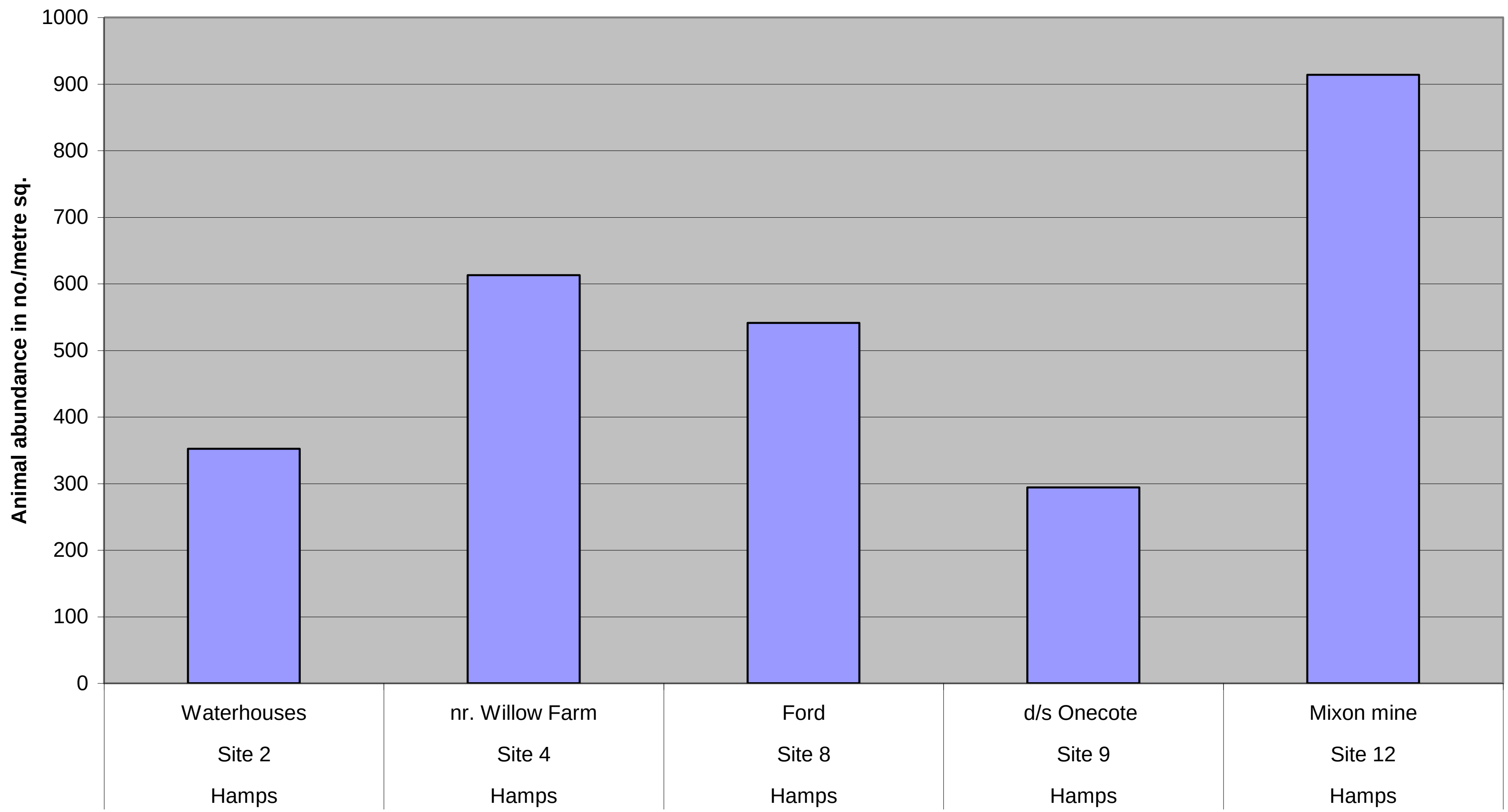

Macroinvertebrate abundance through River Manifold in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limit)
1400
1200
1000
800
600
400
200
0
Ilam Rd bridge
Site 2
Manifold
Wetton Mill
Site 4
Manifold
Hulme End
Site 7
Manifold
Brund
Site 9
Manifold
Ball Bank House Farm
Site 16
Manifold
d/s High Ash Farm
Site 17
Manifold


Macroinvertebrate abundances through River Manifold in Autumn 2009
Animal abundance in no./metre sq.
1400
1200
1000
800
600
400
200
0
Ilam Rd bridge Site 2 Manifold
Wetton Mill Site 4 Manifold
Hulme End Site 7 Manifold
Brund Site 9 Manifold
Ball Bank House Farm Site 16 Manifold
d/s High Ash Farm Site 17 Manifold



Macroinvertebrate abundance through River Hamps in Spring 2009
Animal abundance in no./metre sq. (95% Conf. limits)
1000
900
800
700
600
500
400
300
200
100
0
Waterhouses
Site 2
Hamps
nr. Willow Farm
Site 4
Hamps
Ford
Site 8
Hamps
Onecote u/s road (pub grounds)
Site 10
Hamps
Mixon mine
Site 12
Hamps

Macroinvertebrate abundances through River Hamps in Autumn 2009

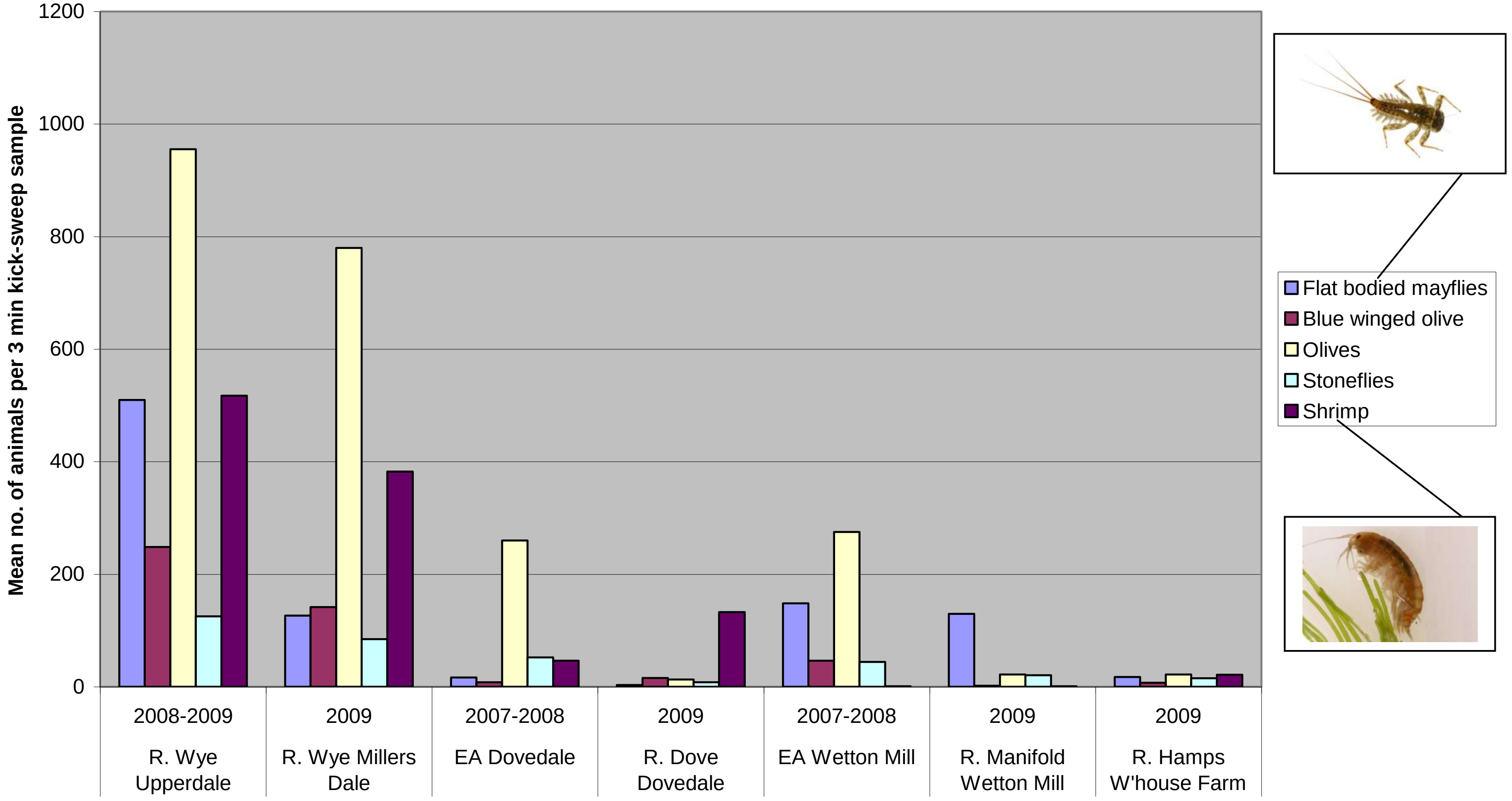


More specific differences in faunal abundance between limestone (gritstone) rivers in the Derbyshire and Staffordshire area were evident from semi-quantitative abundance data for riverfly groups as shown in the graph overleaf.

All data was from 3 min kick-sweep samples from comparable in-stream habitats at the same seasonal sampling times (Spring and Autumn 2007-2009). R. Wye data was courtesy of the National Riverfly Partnership, EA routine biological monitoring data and the 2009 R. Dove, Manifold and Hamps data was from the most abundant macroinvertebrate river sites in comparable limestone areas that were recorded in the Upper Dove Catchment Survey for Natural England in 2009.

It appeared that riverfly numbers in the River Wye were markedly higher than the best sites found in the River Dove, Manifold and Hamps during the 2007-2009 study period. With little difference in main river geology, habitat and flow characteristics between the Wye, Manifold and Dove sites (Everall *pers.obs*., 2007-2009) any differences in faunal communities were, in all probability, likely to be due to differences in land use and associated anthropogenic inputs. It has been well established that mayflies, caddis flies and stoneflies are relatively sensitive to organic enrichment (Clements and Newman, 2002) and their depressed numbers in the Upper Dove catchment appeared to be potentially associated with the literature findings upon this matter.

Abundance of key water quality indicator macroinvertebrates in Upper Dove catchment in 2007-2009

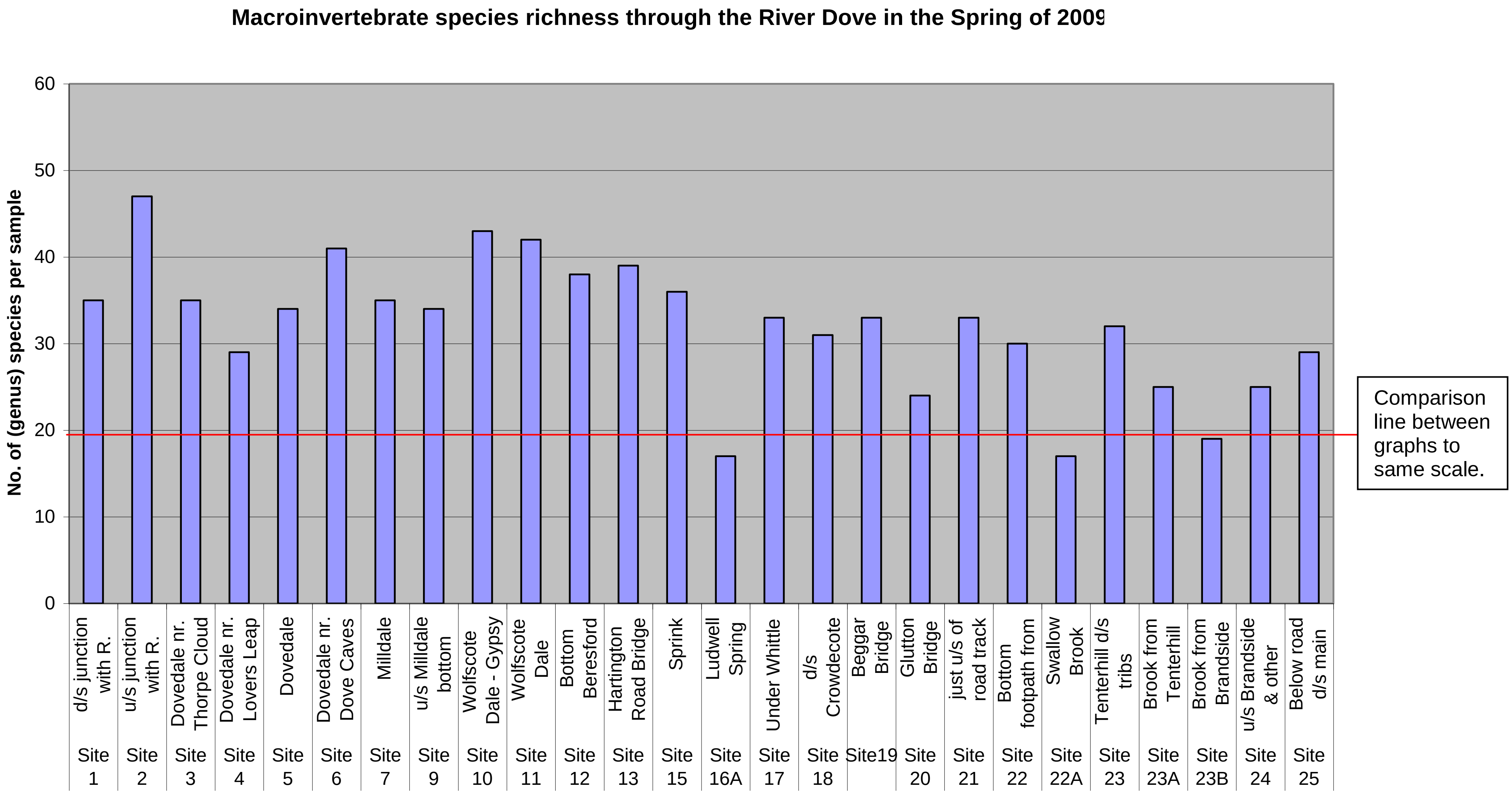


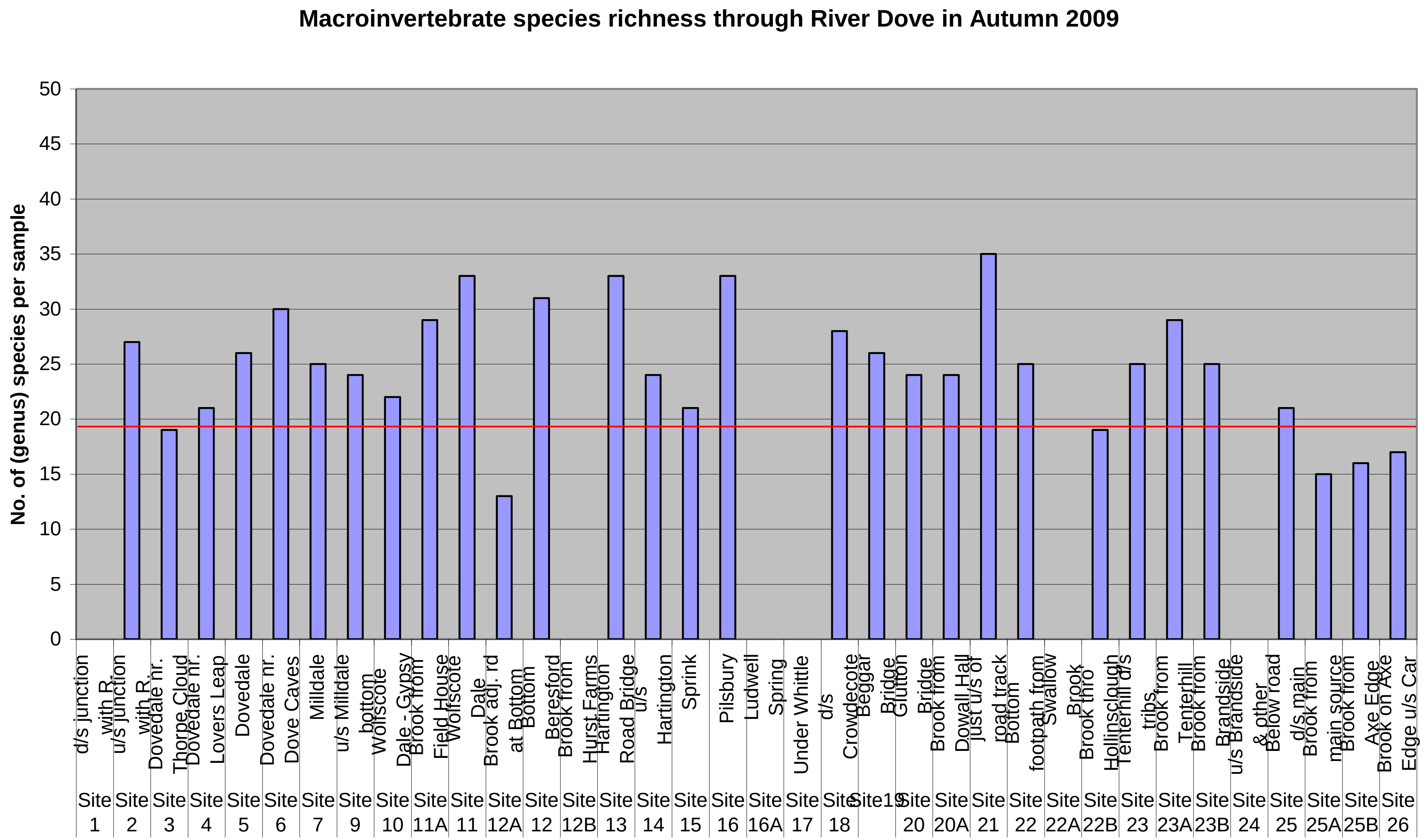
Species richness

Rapport *et. al.* (1985) highlighted reduced species richness as a key indicator of the ‘ecosystem distress syndrome’. Among the scores of measures used by community ecotoxicologists to assess the effects of contaminants reduced species richness is probably the most consistent response.

The species richness data presented below was from 3 minute kick-sweep (1 minute hand search) samples since this type of sampling, in skilled hands, provided a much wider habitat search across riffle survey sites than Surber sampling and thus enabled a better indication of species richness at any given site.

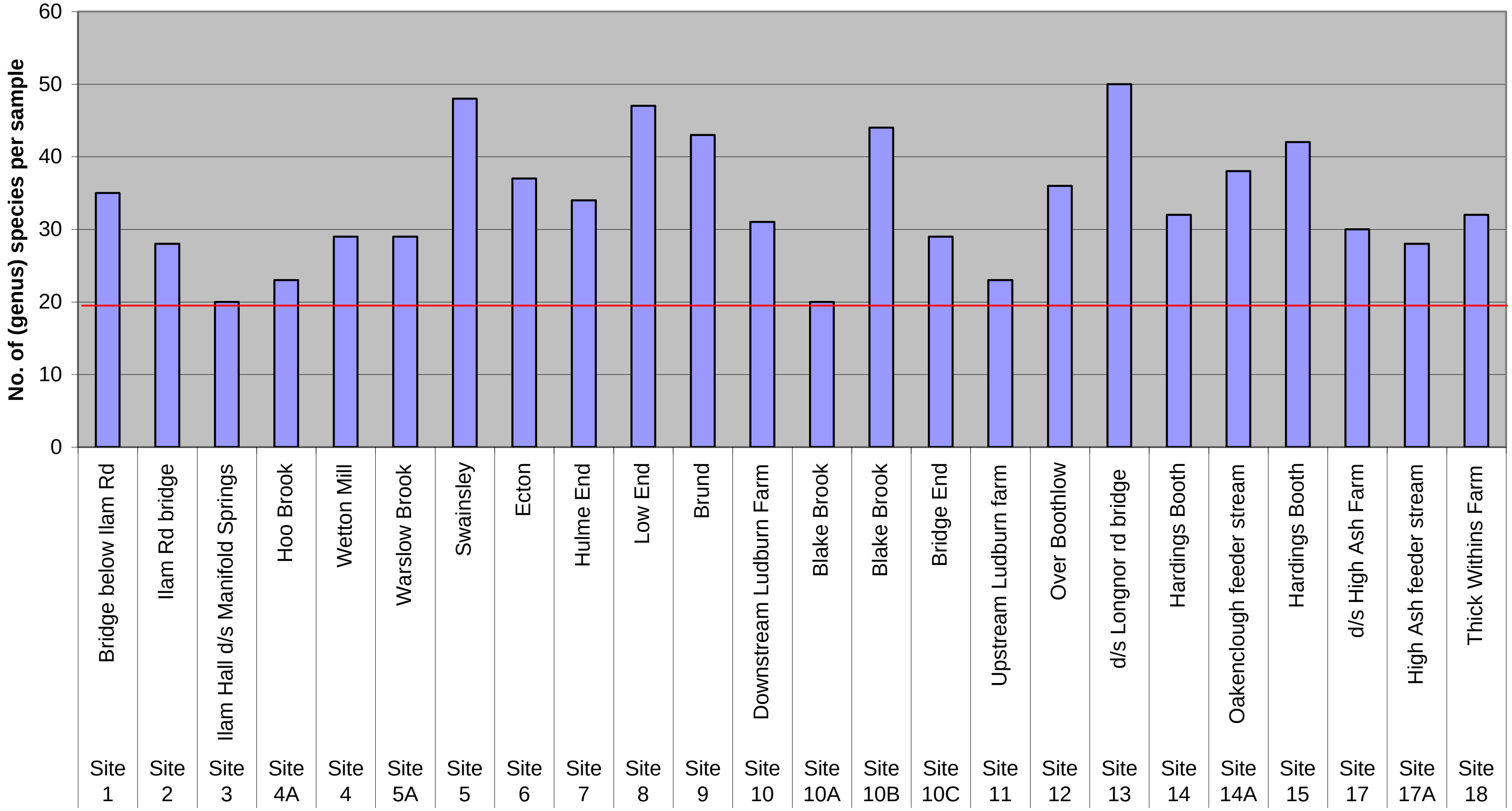
Depressed species richness was apparent at a number of sites throughout the Upper Dove Catchment in 2009 when compared with average species richness at sites like Moor House NNR in the Pennine River Tees catchment ranging from 23-33 species per sample (Brown and Holden, 2009). However, species richness was one biometric measure heavily affected by sampling effort and it was prudent to review this parameter in future years when more routine monitoring data had been collected.

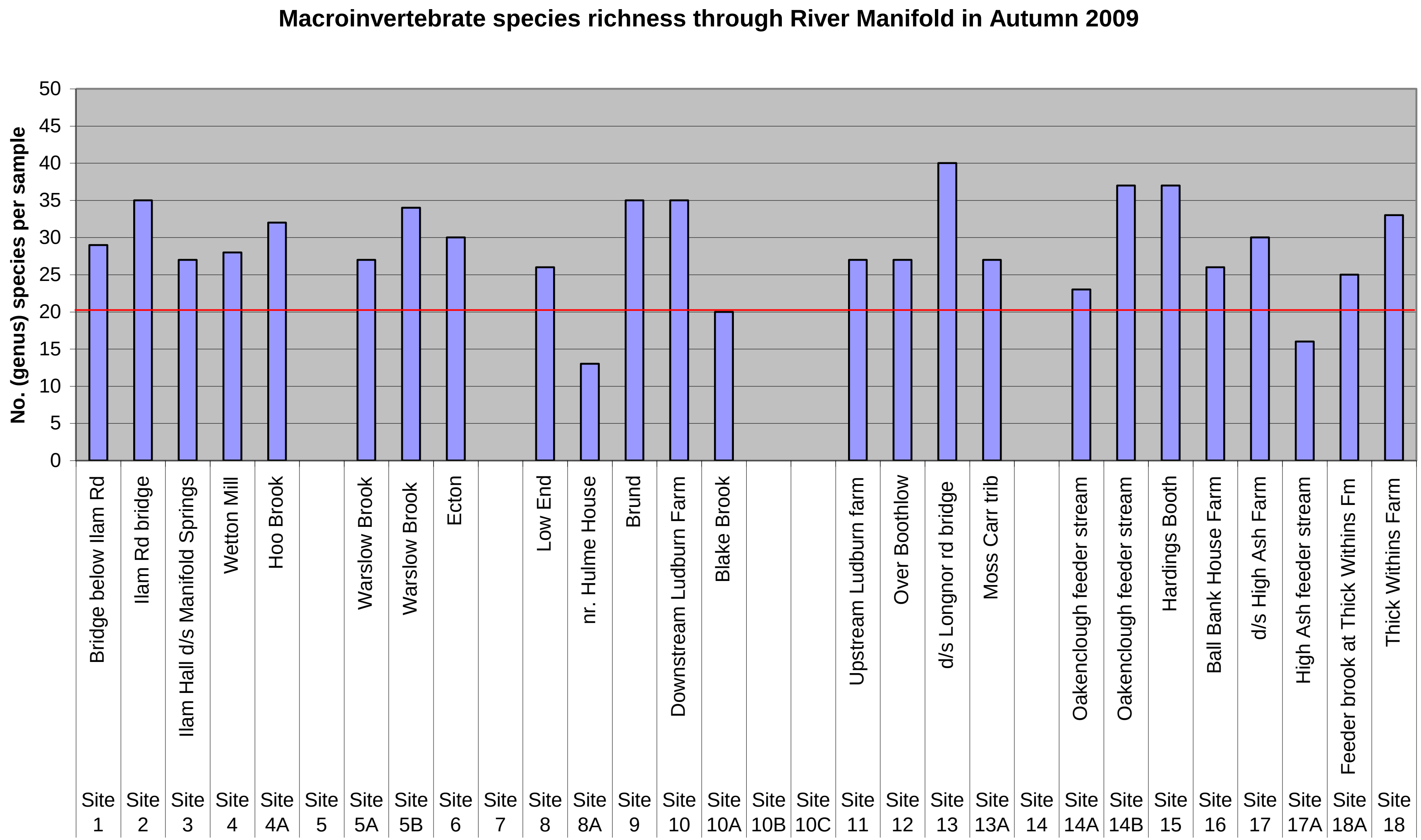

Macroinvertebrate species richness through the River Dove in the Spring of 2009
No. of (genus) species per sample
0
10
20
30
40
50
60
d/s junction with R. Site 1
u/s junction with R. Site 2
Dovedale nr. Thorpe Cloud Site 3
Dovedale nr. Lovers Leap Site 4
Dovedale Site 5
Dovedale nr. Dove Caves Site 6
Milldale Site 7
u/s Milldale bottom Site 9
Wolfscote Dale - Gypsy Site 10
Wolfscote Dale Site 11
Bottom Beresford Site 12
Hartington Road Bridge Site 13
Sprink Site 15
Ludwell Spring Site 16A
Under Whittle Site 17
d/s Crowdecote Site 18
Beggar Bridge Site19
Glutton Bridge Site 20
just u/s of road track Site 21
Bottom footpath from Site 22
Swallow Brook Site 22A
Tenterhill d/s tribs Site 23
Brook from Tenterhill Site 23A
Brook from Brandside Site 23B
u/s Brandside & other Site 24
Below road d/s main Site 25
Comparison line between graphs to same scale.

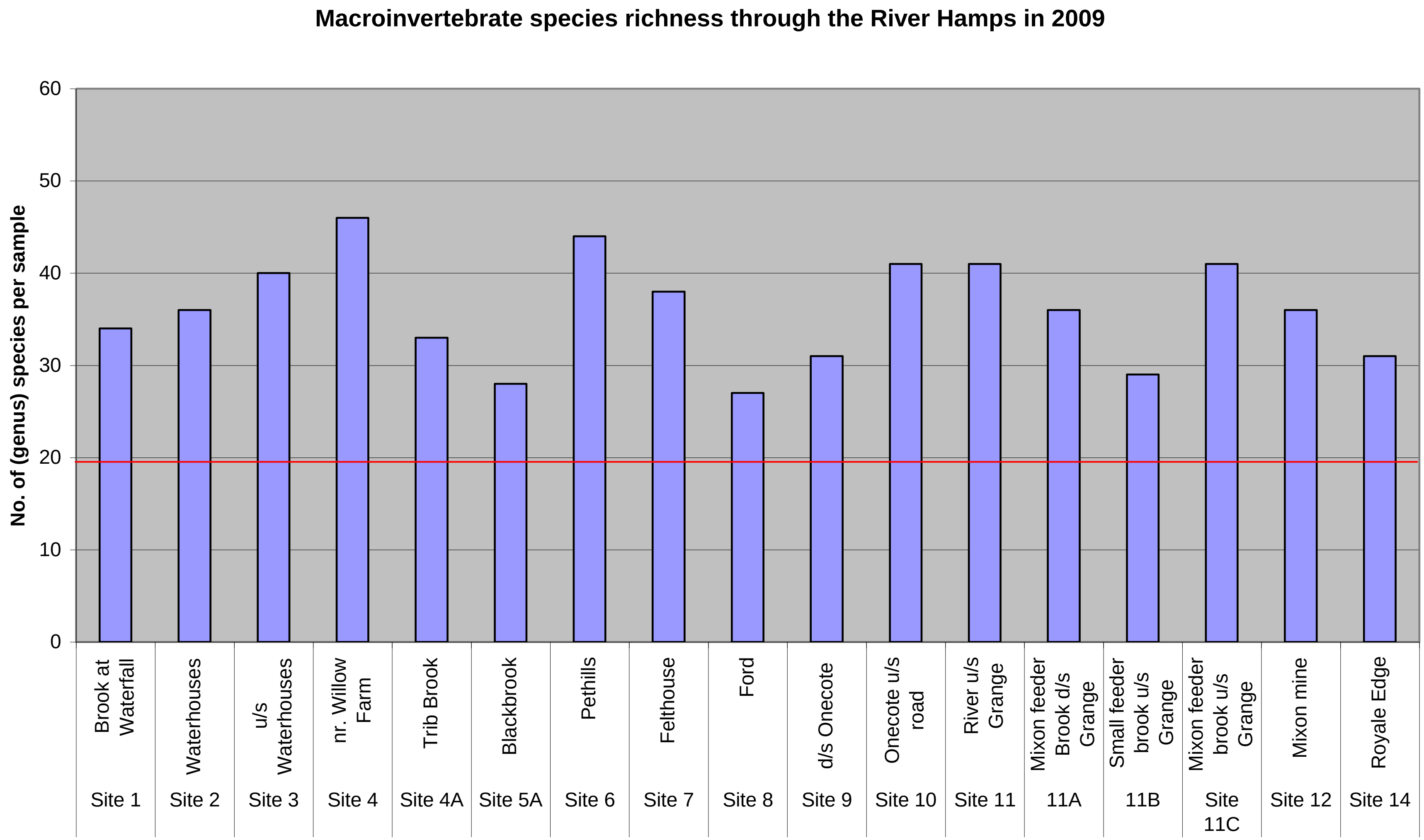


Macroinvertebrate species richness through River Dove in Autumn 2009
No. of (genus) species per sample
0
5
10
15
20
25
30
35
40
45
50

Macroinvertebrate species richness through the River Manifold in the Spring of 2009

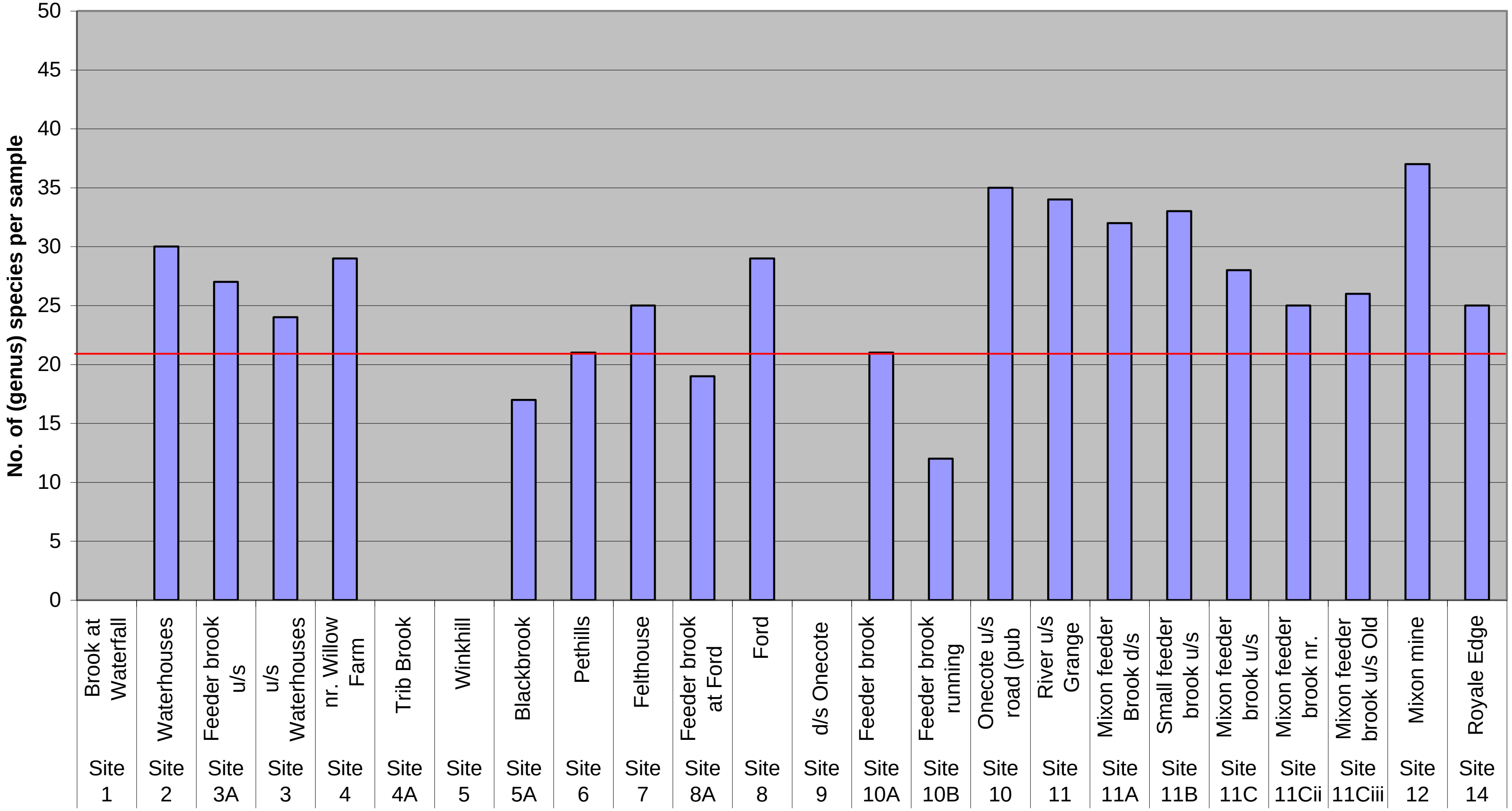



Macroinvertebrate species richness through River Manifold in Autumn 2009
No. (genus) species per sample
0
5
10
15
20
25
30
35
40
45
50
Bridge below Ilam Rd
Ilam Rd bridge
Ilam Hall d/s Manifold Springs
Wetton Mill
Hoo Brook
Warslow Brook
Warslow Brook
Ecton
Low End
nr. Hulme House
Brund
Downstream Ludburn Farm
Blake Brook
Upstream Ludburn farm
Over Boothlow
d/s Longnor rd bridge
Moss Carr trib
Oakenclough feeder stream
Oakenclough feeder stream
Hardings Booth
Ball Bank House Farm
d/s High Ash Farm
High Ash feeder stream
Feeder brook at Thick Withins Fm
Thick Withins Farm
Site 1
Site 2
Site 3
Site 4
Site 4A
Site 5
Site 5A
Site 5B
Site 6
Site 7
Site 8
Site 8A
Site 9
Site 10
Site 10A
Site 10B
Site 10C
Site 11
Site 12
Site 13
Site 13A
Site 14
Site 14A
Site 14B
Site 15
Site 16
Site 17
Site 17A
Site 18A
Site 18



Macroinvertebrate species richness through the River Hamps in 2009
No. of (genus) species per sample
0
10
20
30
40
50
60
Brook at Waterfall
Site 1
Waterhouses
Site 2
u/s Waterhouses
Site 3
nr. Willow Farm
Site 4
Trib Brook
Site 4A
Blackbrook
Site 5A
Pethills
Site 6
Felthouse
Site 7
Ford
Site 8
d/s Onecote
Site 9
Onecote u/s road
Site 10
River u/s Grange
Site 11
Mixon feeder Brook d/s Grange
11A
Small feeder brook u/s Grange
11B
Mixon feeder brook u/s Grange
Site 11C
Mixon mine
Site 12
Royale Edge
Site 14

Macroinvertebrate species richness through River Hamps in Autumn 2009



Rapid Agricultural Pollution Indicator Key

The 3 minute kick-sweep data for aquatic macroinvertebrate communities in the Upper Dove Catchment was run through the agricultural pollution indicator key of Gee and Jones (1995) to help detect any watercourses affected by organic pollution. The Spring and Autumn results for 2009 were tabulated in Appendix 3 and presented in the maps overleaf.

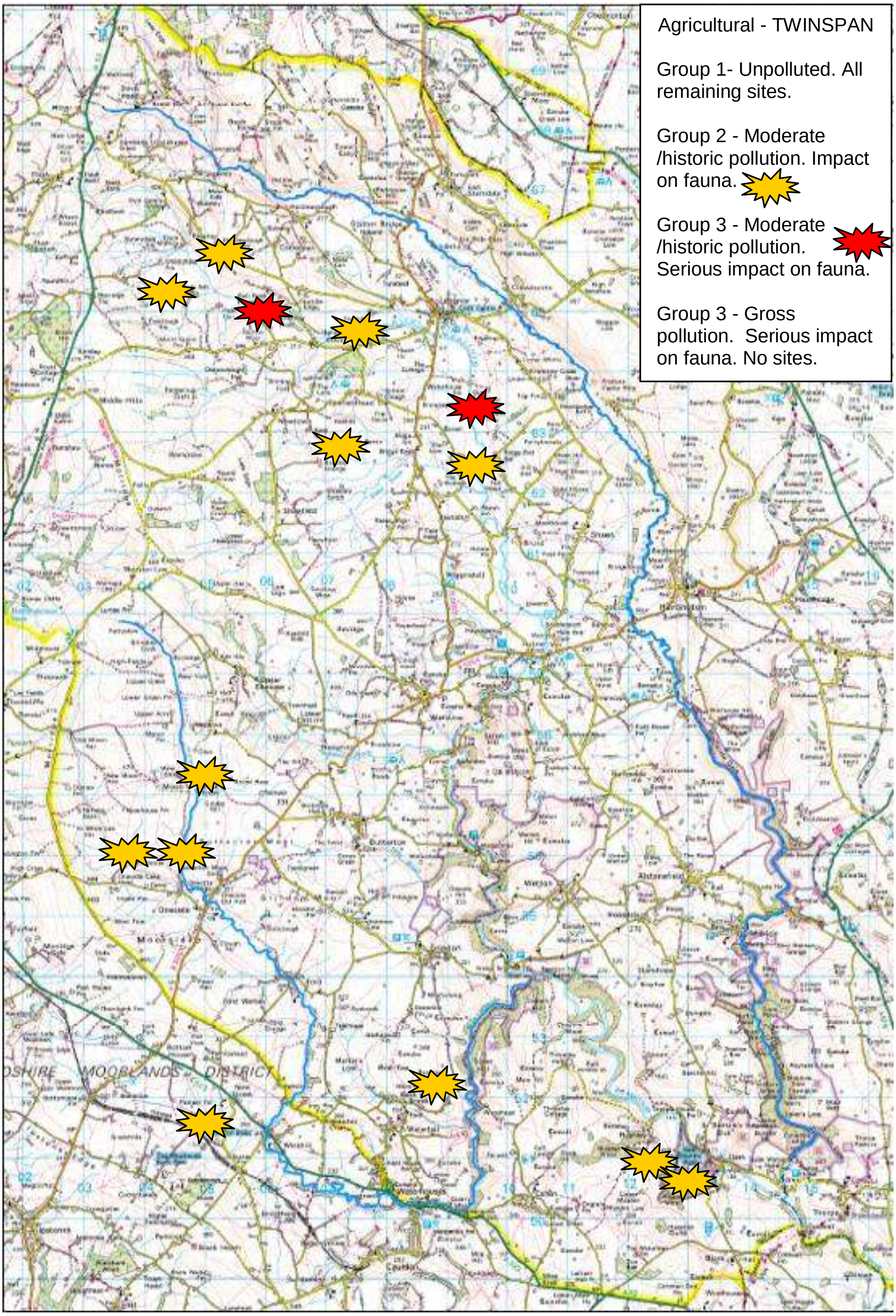
The first rapid assessment stage of the agricultural pollution indicator key relies heavily on the presence or absence of >9 heptagenids (flat bodied mayflies) in a 1 minute kick-sweep sample (Gee and Jones, 1995). The fact that many of the sample results in Appendix 3 reflected this level of depressed flat bodied mayfly numbers from 3 minute kick-sweep samples was an indication of how environmentally stressed many of these watercourses appeared to be. The fact that comparable habitat sampling through these rivers also revealed sites with a modest presence of flat bodied mayflies in the same time sampling window during both the Spring and Autumn sampling windows also meant that recorded differences in mayfly populations between sites was, in all probability, not due to habitat or seasonal influences.

Flat bodied mayflies like *Ecydonorus* and/or *Rhithrogena* species have long been regarded as stable taxa of upland northern watercourses (Percival and Whitehead, 1929 and Hynes, 1970).

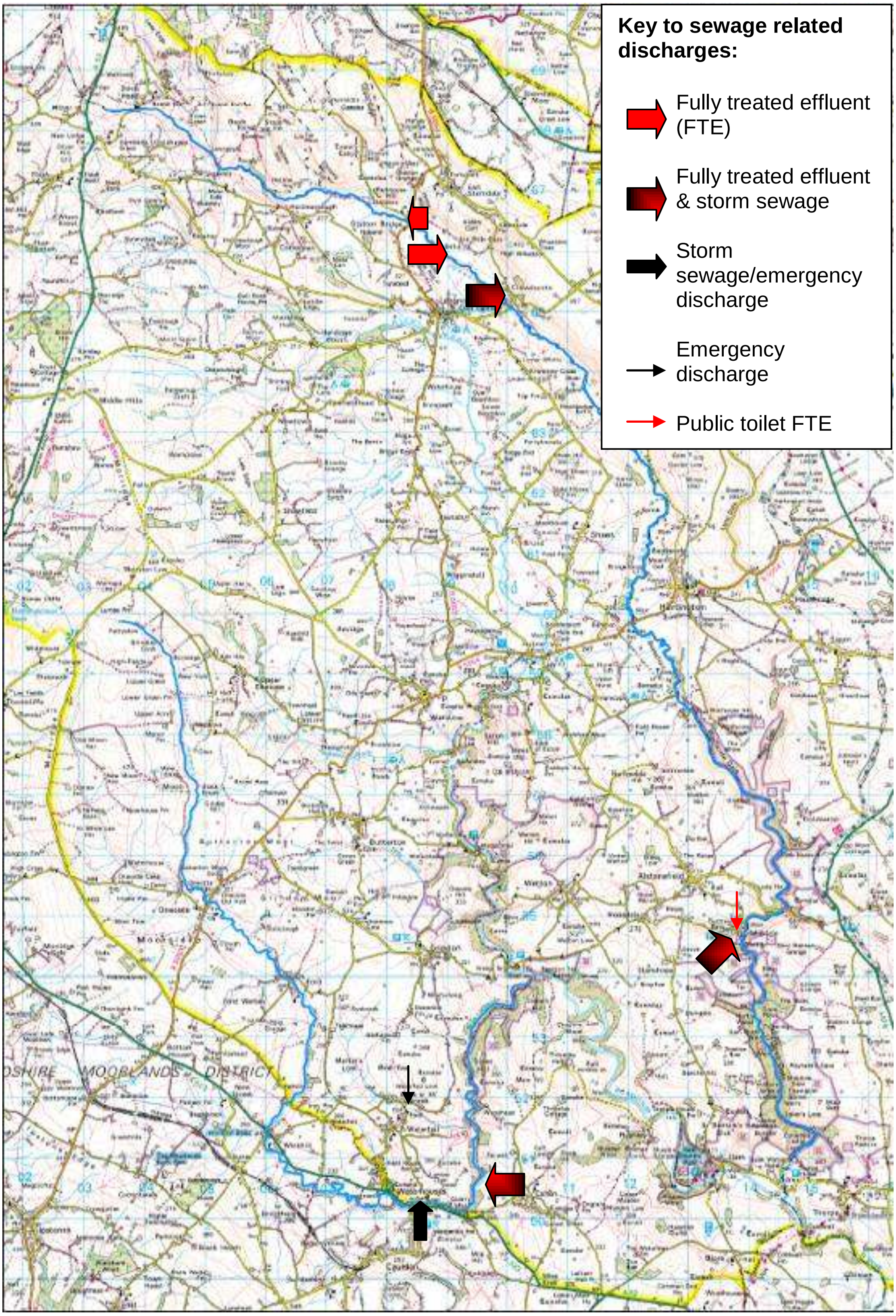
Ecydonorus species

Rhithrogena semicolorata

Flat bodied mayflies were also a good pollution sentinel since they are well documented to be very sensitive to for example, organic pollution and/or siltation (Hellawell, 1989). The map overleaf showed some of the potential agricultural pollution hotspots using the rapid assessment indicator key in the Spring (May) of 2009.



During the Spring of 2009, there were therefore a number of sites in the Upper Dove Catchment showing evidence of varying degrees of either current or historic agricultural pollution according to the rapid assessment macroinvertebrate key of Gee and Jones (1995). These appeared to be confined in the Spring to the main tributaries of the River Dove i.e. The River Manifold and River Hamps. Before commenting further upon these findings it was important to understand the location of other potential sources of organic pollution in the catchment. The only known sources of organic (siltation) inputs to these rivers other than the ‘diffuse’ (sometimes effectively point-source with for example, cattle slurry) agricultural sources were consented discharges and these were marked on the map below.

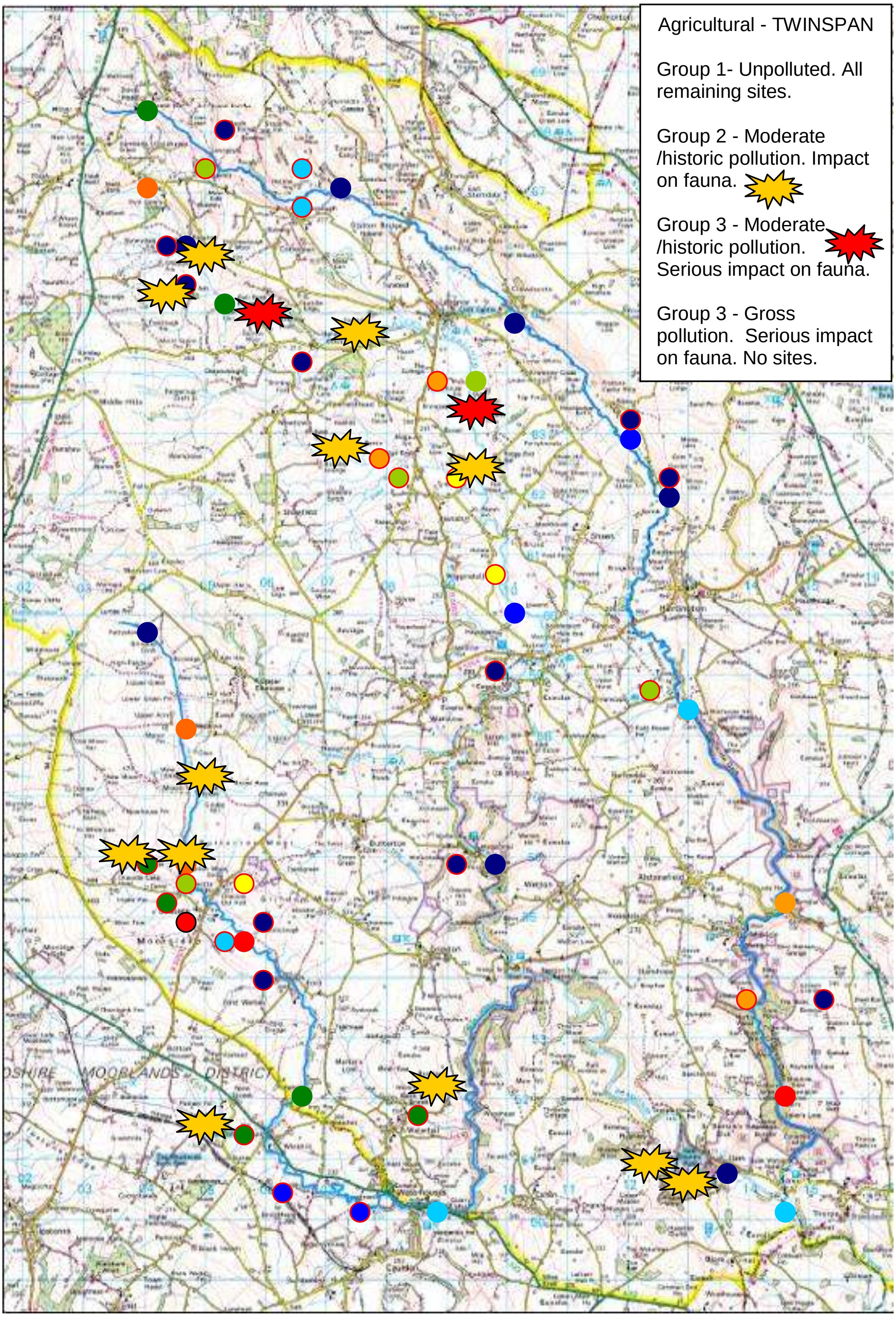


It was clear from the previous map and the map on page 74 that consented non-agricultural organic discharges did not associate well with downstream areas of receiving watercourse where impacted macroinvertebrate fauna had been recorded in the Spring of 2009. There was also macroinvertebrate evidence in Appendix 3 that agricultural pollution had potentially increased through these river systems by the Autumn of 2009 such that the River Dove also showed areas of agricultural pollution. The reasons for an apparent increase in agricultural pollution on all 3 rivers between May and September were, in all probability, quite variable. However, on the River Dove in the Autumn of 2009 there was evidence of strong agricultural pollution at the top end of the river (Appendix 3 Site 25A) and feeder streams entering the watercourse through Hollinsclough (Appendix 3 Site 22B) and in Beresford Dale (Appendix 3 Site 11A). During the Autumn sampling runs the River Dove and the River Manifold often smelled in parts of silage following rainfall (Everall and Farmer *pers. obs.*, 2009). Similarly, many of the macroinvertebrate samples from the worst fauna impacted areas contained large amounts of 'grass-cutting' like material when analysed back at the laboratory.

The impacts of agricultural pollution would be expected to be manifested through the often combined impact of organic pollution (elevated ammonia, lowered dissolved oxygen regimes …), nutrient enrichment (elevated phosphate and eutrophication effects like prolific 'choking' benthic algal growth) and siltation. Although some chemical spot-sampling was undertaken in the Spring and Autumn to get a handle on basic water chemistry such analyses were very unlikely to detect intermittent pollution events. Indeed, some basic regression analysis of water chemistry parameters (for example, ammonia, orthophosphate and nitrate) against biological measurements (for example, ASPT, Saprobic indices and siltation indexes) were undertaken out with and later in this report and only a few correlations were found. This was not a surprise given the very limited and ephemeral nature of the water chemistry sampling alone. In watercourses subject to intermittent and ephemeral pollution inputs, an annual or at best bi-annual monitoring regime employing daylight and weekday sampling is not a reliable method of detecting pollutant incursions. It has been well documented that the true pollutant regime in a river was likely to be shown not by infrequent sampling during daylight hours but only where automatic monitoring was employed (Alabaster and Lloyd, 1980). This reasoning was the very ethos behind concentrating on biological fingerprinting techniques in this benchmarking phase of the project. Having said that there appeared to be some associations between some of the suspended solids measurements taken and the fauna impacted areas as shown in the map overleaf.

Key: S.S. levels in mg/l

●	< 4
●	4 → 6
●	6 → 8
●	8 → 10
●	10 → 12
●	12 → 14
●	14 → 16
●	16 → 18
○ ●	Tributaries



However, siltation was only one environmental stressor likely to be impacting the aquatic fauna and ecology of these rivers so it was important to look at the results from more in-depth biological fingerprinting of macroinvertebrate species community structures in the following sections.

Macroinvertebrate assessment of organic pollution

The benthic invertebrates are important within the stream community as a fundamental link in the food web between organic matter resources and fishes. Partly because of their diversity and ubiquity, the study of macro invertebrates is a central part of stream ecology. A standardised method to assess the biological water quality is the saprobic classification system (saprobity = amount of degradable organic material). This classification system is based on selected index species (indicators), whose appearance is related to the impact of degradable organic material.

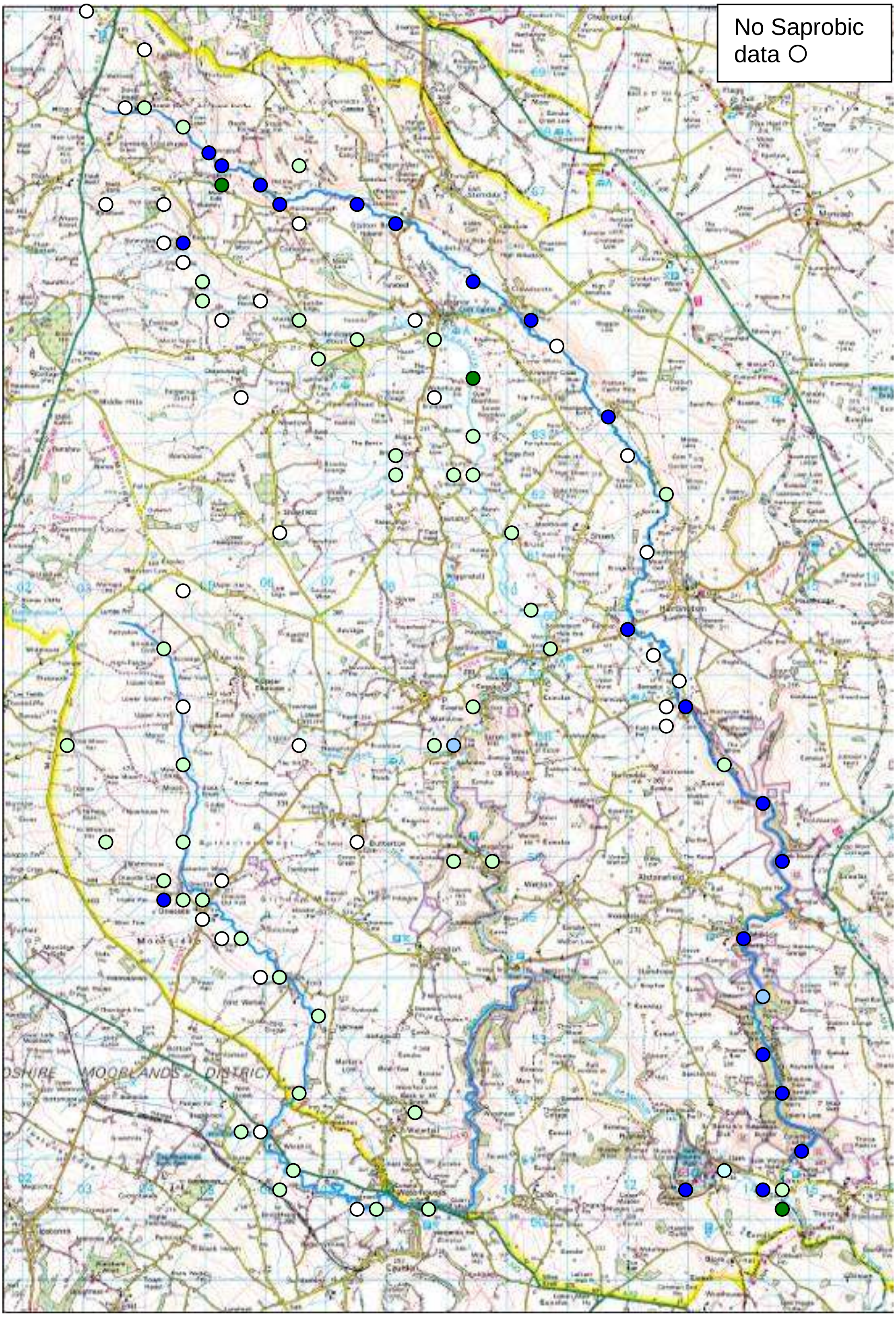
The Saprobic indexes for macroinvertebrate species communities at all sites in the 3 study rivers of the Upper Dove Catchment were presented for the Spring and Autumn of 2009 in the maps overleaf. The table below provides a pollution interpretation of Saprobic indices but these measurements were also important in understanding the relative degrees of organic enrichment at different points in a watercourse as additive environmental stressors in these watercourses.

After: Laenderarbeitsgemeinschaft Wasser (LAWA), Mainz, Germany, 1976 (showing colours used for mapping)

Quality class & colours as used in the maps	Symbol	Degree of organic load	Saprobic state	Saprobic index	Usual BOD5 in mg/L	Usual NH4-N in mg/L	Usual O2-minima in mg/L
I	●	**no or minimal**	**oligosaprobic**	**1,0-<1,5**	**1**	**<0,1**	**8**
I-II	●	small	oligo-betamesosaprobic	1,5-<1,8	1-2	~0,1	8
II	●	medium	betamesosaprob	1,8-<2,3	2-6	<0,3	6
II-III	●	critical	beta-alphamesosaprobic	2,3-<2,7	5-10	<1	4
III	●	strongly polluted	alphamesosaprobic	2,7-<3,2	7-13	0,5-several mg/L	2
III-IV	●	very strongly polluted	alphamesosaprobic transition zone	3,2-<3,5	10-20	several mg/L	<2
IV	●	**extremely polluted**	**polysaprobic**	**3,5-<4,0**	**15**	**several mg/L**	**<2**

In simple terms, any organic pollution values at or above the light green circle (●) highlighted in the table above and found in the following 2 maps of riffle sample sites indicated potential environmental impact in these upland watercourses.

Organic pollution in the Upper Dove Catchment in Spring 2009



Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

Organic enrichment →

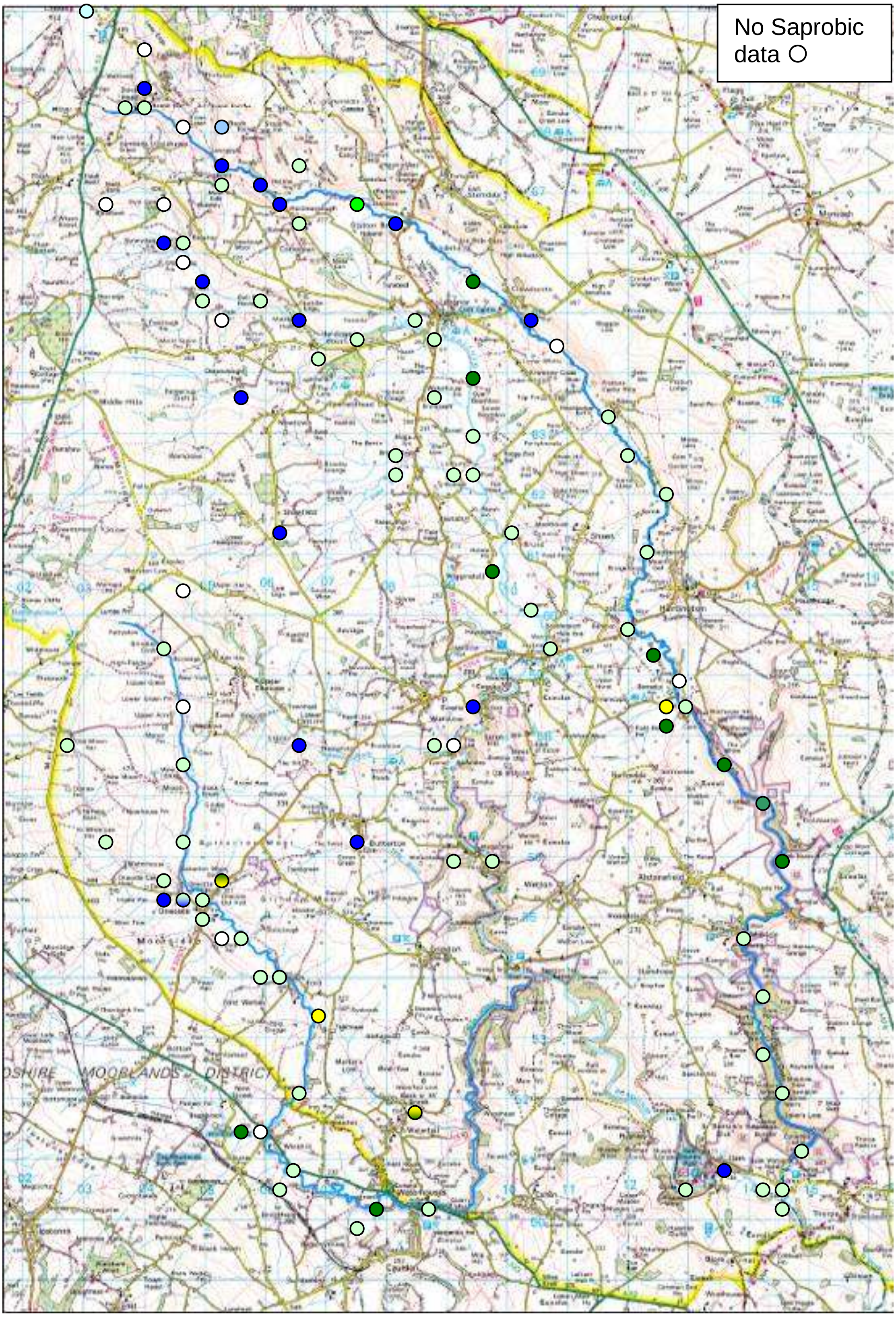
There was variable organic input into and through the main rivers of the Upper Dove Catchment during 2009 with the River Manifold and River Hamps showing more evidence of organic impact than the River Dove in the Spring of 2009. In the Spring of 2009, the top end of the River Dove below Dove Head and the bottom end of the river below the Izaak Walton Hotel showed more evidence of organic enrichment than other areas. The River Manifold showed more universal evidence of moderate organic loads with a potential 'hotspot' at Over Boothlow below Longnor. The River Hamps exhibited a more widespread distribution of organic load in the Spring of 2009.

There was variable organic input into and through the main rivers of the Upper Dove Catchment during 2009 with all 3 rivers showing evidence of organic impact in the Autumn of 2009 in the map overleaf. In the Autumn of 2009, there was fairly universal evidence of organic impact through the River Dove with more marked impact upstream of Crowdecote and in Beresford Dale down through Wolfscote Dale. Feeder stream data suggested that the key sources of organics in this stretch of the river were the brooks draining nearby agricultural land. However, it was also possible that a proportion of the organic impact recorded in this section of the River Dove in the Autumn may have been from the disturbance of a residual legacy of organic material impounded through Beresford Dale after the documented Creamery inputs at Hartington (Everall, 2006 and 2007) and following late summer rainfall (spate) events. The lower elevation of organic impact recorded through Dovedale at this time was, in all probability, a watered down effect from upstream following further groundwater dilution and self-purification by the ecosystem with the passage of flow down the river.

The River Manifold showed a continued evidence of universal organic loads with the continuing organics 'hotspot' at Over Boothlow below Longnor. The photograph below showed field slurry from a cattle area draining into the River Manifold at Over Boothlow in the Spring of 2009.

Like the Dove, The River Hamps showed an elevated organic loading profile during the Autumn of 2009 with marked organic 'hotspots' at Waterfall, above Waterhouses, in the Blackbrook, at Felthouse and around Onecote (various feeder streams)

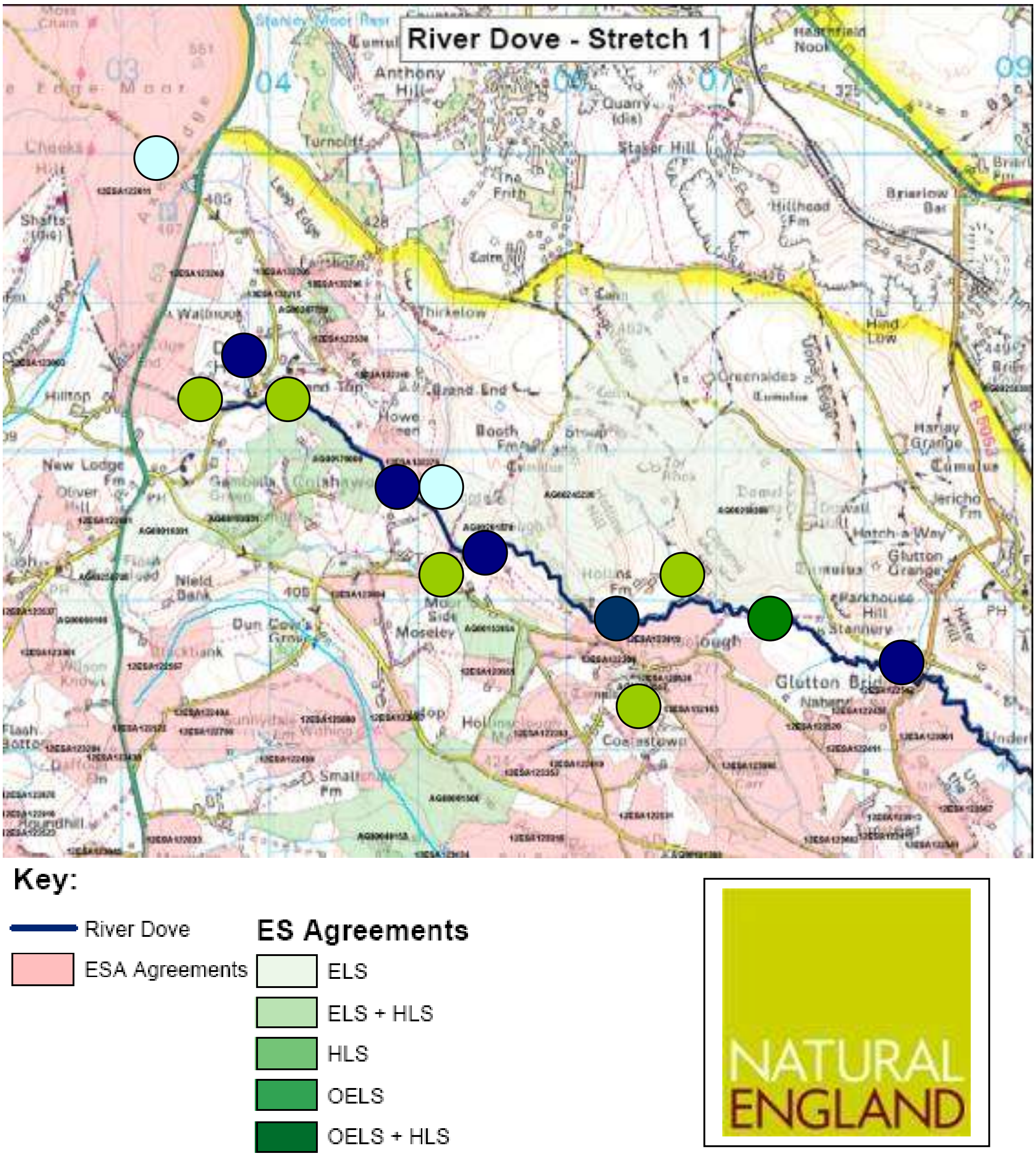
Organic pollution in the Upper Dove Catchment in Autumn 2009



Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

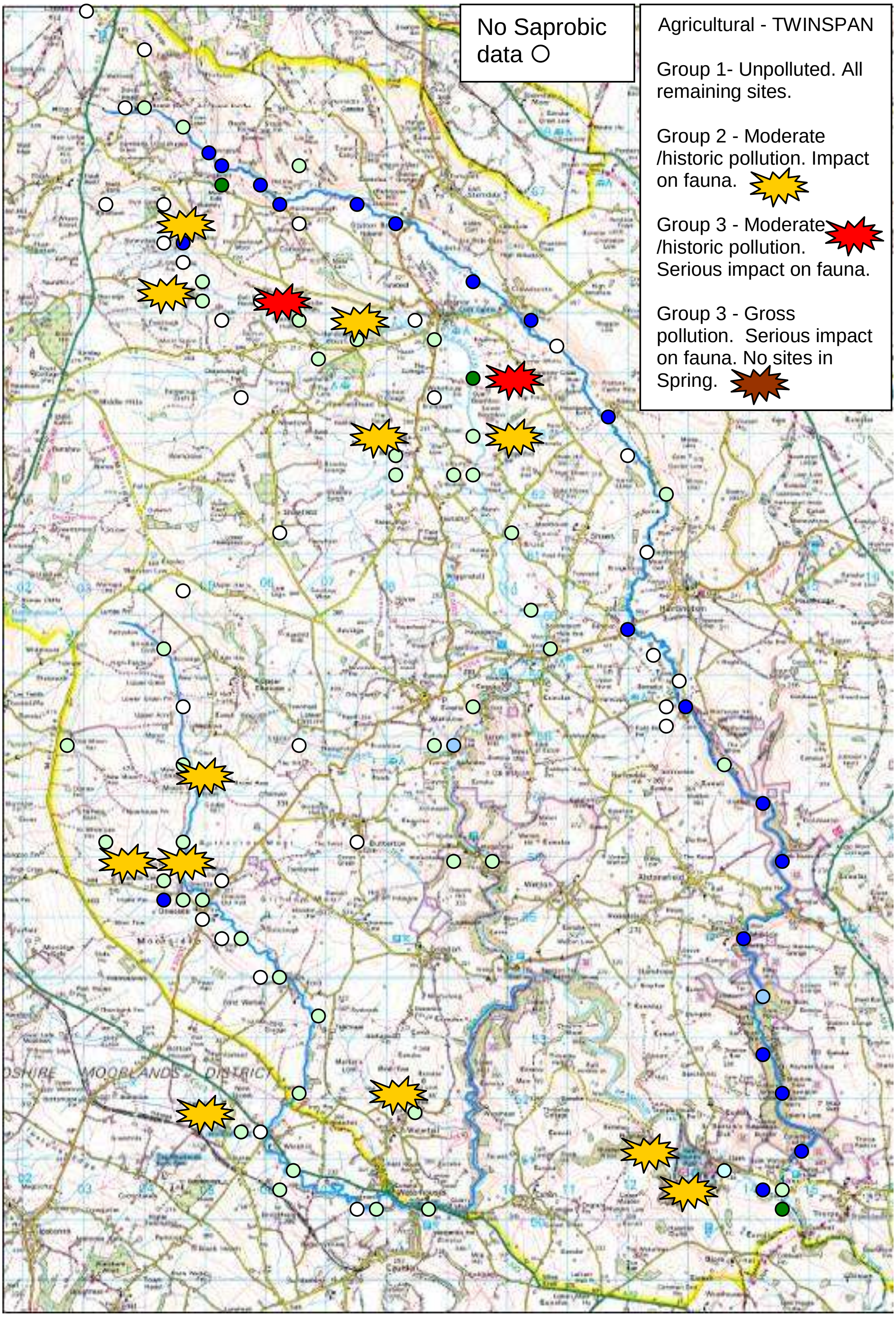
Organic enrichment →

More detailed maps of organic pollution for all stretches of these watercourses were available from CSF and NE at Bakewell in Derbyshire with local Environmental Stewardship schemes highlighted and an example was shown below.



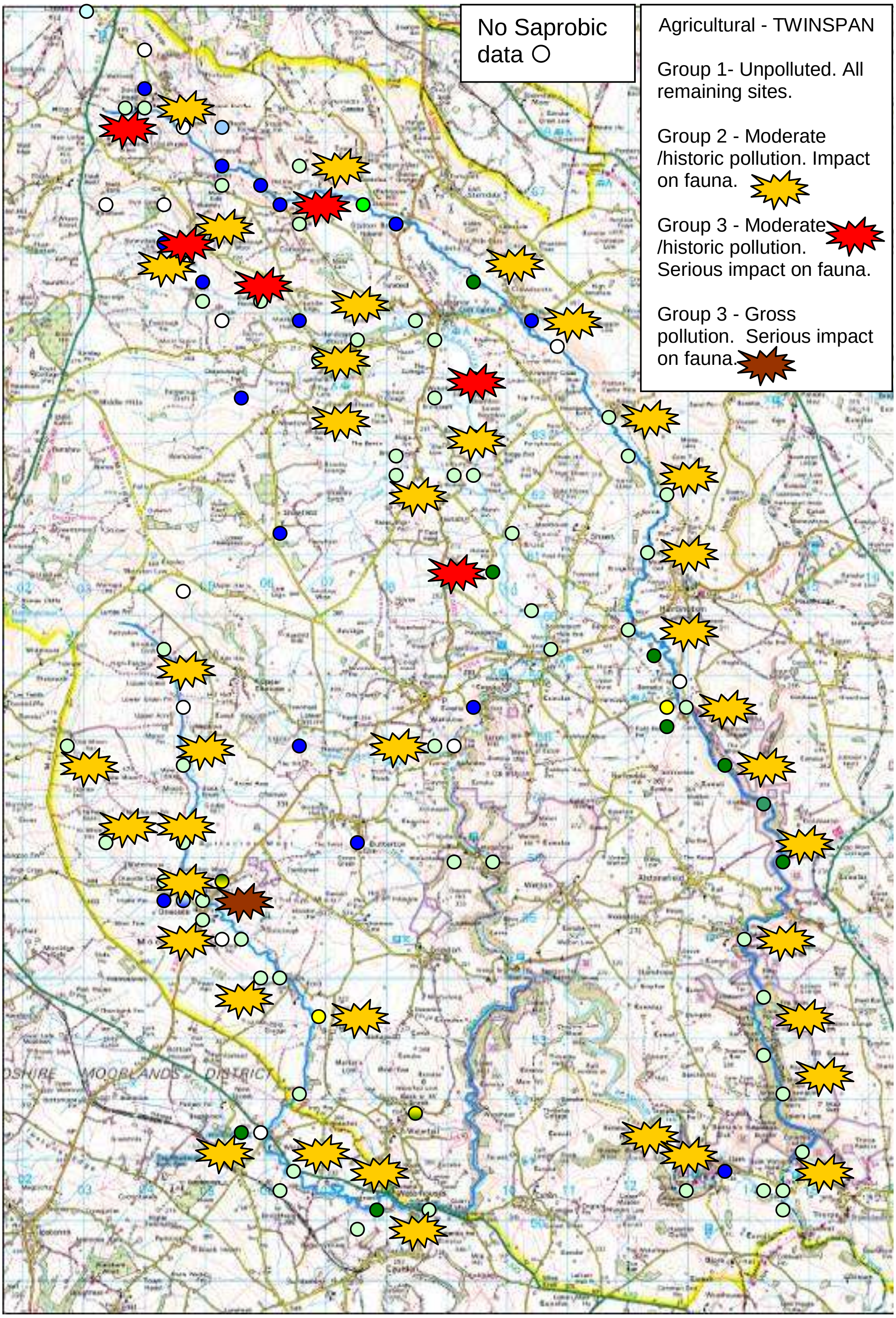
These detailed organic pollution maps and others highlighting siltation from later sections of this report were provided to Natural England, the DEFRA Catchment Sensitive Farming Scheme and the Trent Rivers Trust in December 2009 to help appropriate personnel to determine the source, nature and quantum of agricultural inputs. The data therefore served as a means of prioritising remedial management actions and targeting any associated river remediation work. In the longer-term such data would provide, one of many, quantitative ecological measures of the success of any pollution remediation and river improvement work

There was a strong association between increasing organic indicators in the survey site macroinvertebrate communities and a recorded environmental impact upon the fauna as highlighted in the Spring of 2009 in the map overleaf.



Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

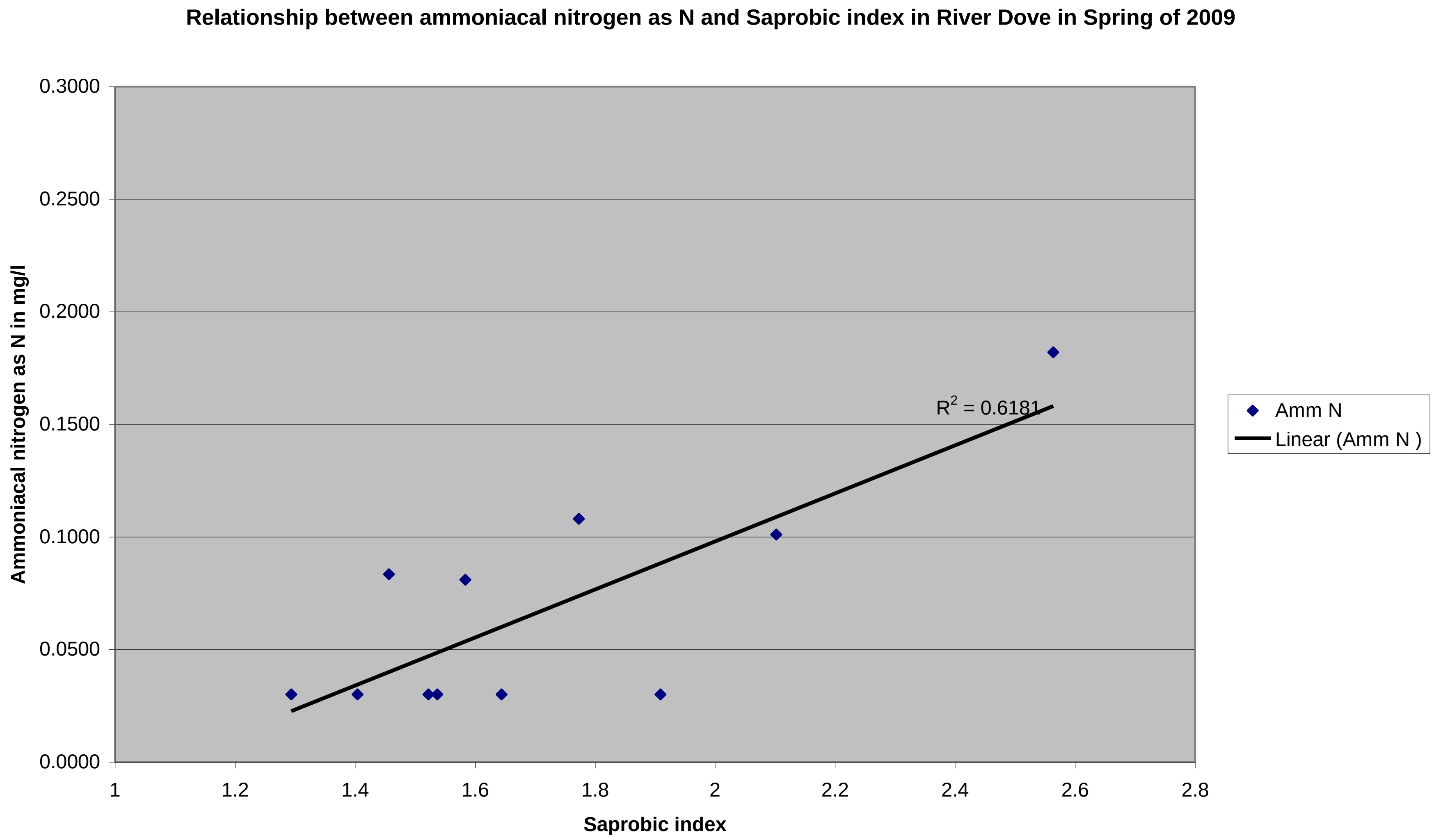
There was also a similar strong association between increasing organic indicators and an impact upon the fauna as highlighted in the Autumn of 2009 in the map overleaf.



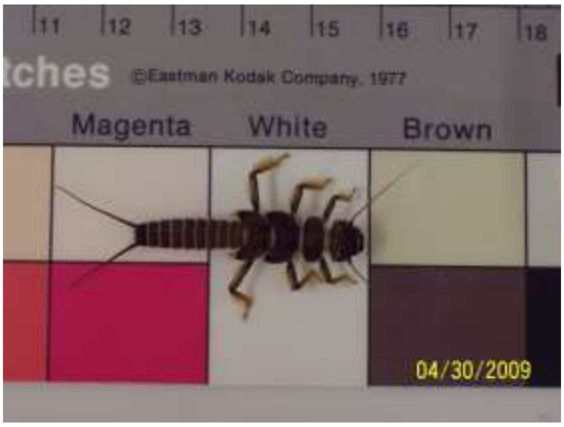
Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

Organic enrichment →

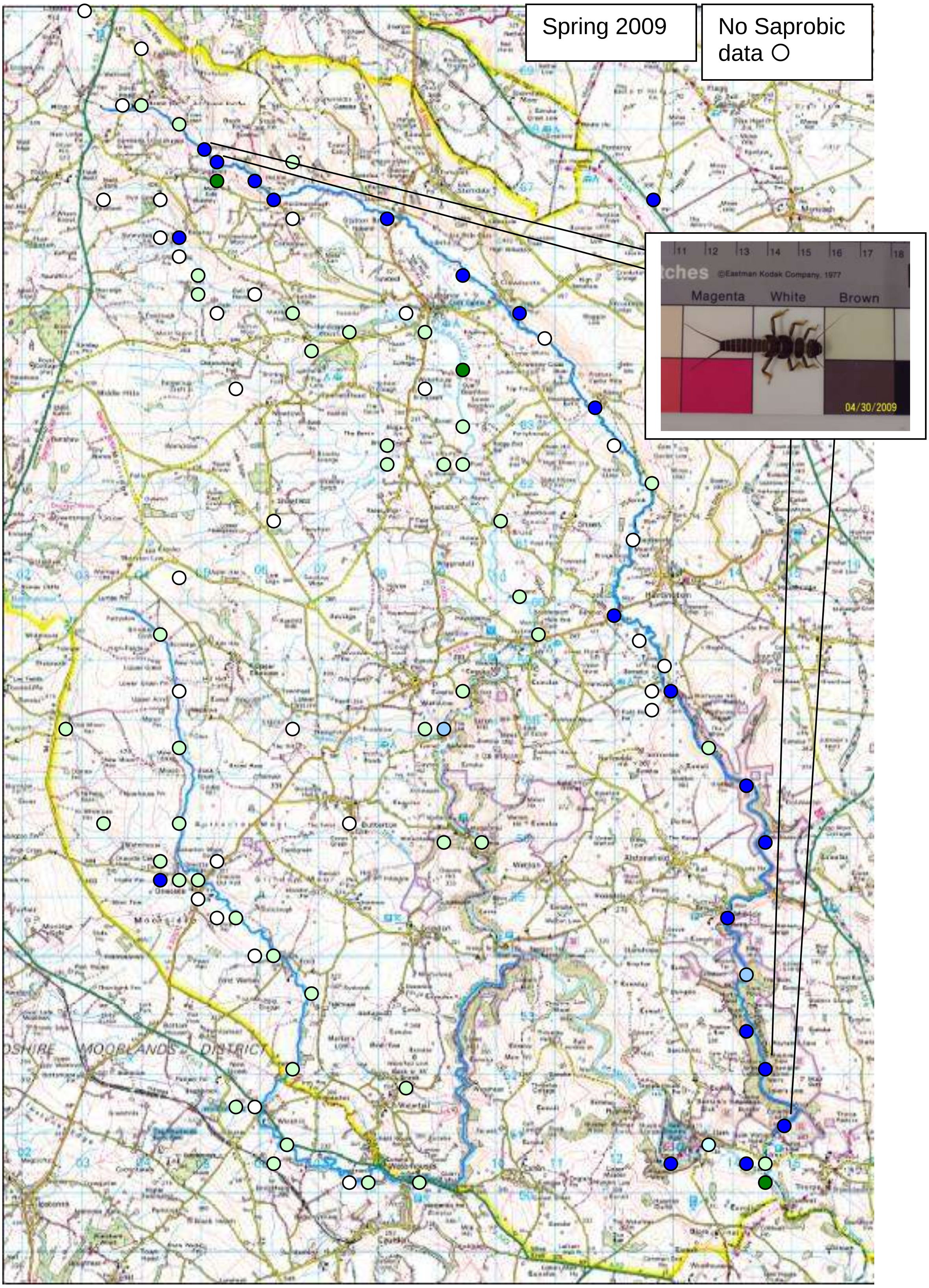
Despite the very limited water chemistry sampling in 2009 there was some evidence of an association between organic determinands (for example, total ammonia concentration) and increasing Saprobic response of the receiving macroinvertebrate communities in these watercourses as shown in the graph below and documented in the literature from larger datasets (Hellawell, 1986).


Relationship between ammoniacal nitrogen as N and Saprobic index in River Dove in Spring of 2009
Ammoniacal nitrogen as N in mg/l
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
Saprobic index
R^2 = 0.6181
Amm N
Linear (Amm N)

Finally, although there is a good argument that one should not use the absence of a single 'indicator' species as a measure of any pollutant impact the presence of a species sensitive to a particular type of pollutant was often regarded as a better indicator of 'reference' i.e. clean water conditions. The large predatory stonefly *Dinocras cephalotes,* shown in the photograph below from the Dove in 2009, had been shown in other studies to be highly sensitive to low levels of organic pollution (Frutiger, 1987).

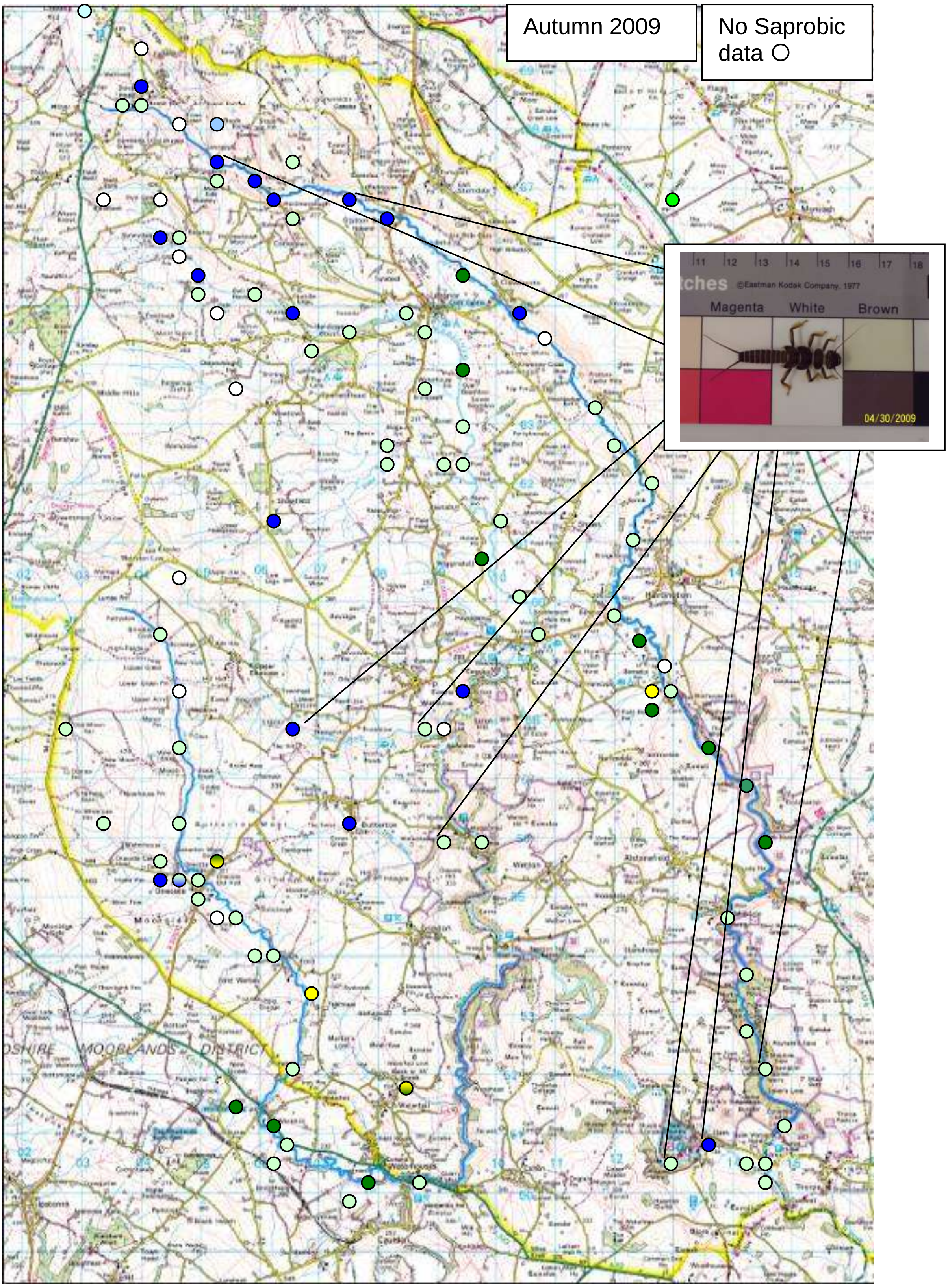


It was, in all probability, no coincidence that this large sentinel stonefly only occurred in the River Dove and River Manifold where Saprobic indexing from macroinvertebrate community profiles indicated low organic loading as shown in the following maps.



Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

Organic enrichment →



Quality Class	I	I - II	II	II - III	III	III - IV	IV
Saprobic index	1.0-1.4	1.5-1.7	1.8-2.2	2.3-2.6	2.7-3.1	3.2-3.4	3.5-4.0

Organic enrichment →

Macroinvertebrate assessment of siltation

Rivers naturally receive and transport variable amounts of sediment of various forms and these materials are deposited in areas of lower current speed to create cobble, shingle, gravel, sand and silt beds. Trout and grayling are adapted to live in certain habitat types, for instance using cobbles and shingle as cover and gravels for spawning and early juvenile life stages. Relatively high concentrations of fine suspended solids are, however, known to have potentially damaging impacts on all life stages of these fish (Alabaster and Lloyd, 1980). Fine sediments can be drawn down into gravel beds at locations where trout and grayling spawn, leaving an apparently-clean gravel surface, but a sediment-saturated lower zone (where the incubating fish eggs lie). The degree to which sediments settle upon and penetrate into a natural river bed will depend upon both local environmental conditions and on the exact nature and quantity of the sediment load.

The impact of fine sediment on benthic macro-invertebrate communities has long been recognised (Cordone & Kelley 1961, Chutter 1969, Hynes 1971, Richards & Bacon 1994 and Richards *et al*. 1997). Sediment deposited in eroding reaches of rivers inevitably results in altered invertebrate community structures, as a direct result of smothering of the substratum and the clogging of interstices (Ryan 1991, Wood *et al.* 1999) and as a consequence of indirect effects, such as changes in macrophyte and algal communities (Hynes 1973, Graham 1990, Ryan 1991, Davies-Colley *et al.*1992, Parkhill & Gulliver 2002, Wood *et al*. 2005). Suspended solids tolerance limits for fish and higher macroinvertebrates vary according to species and are poorly understood but a guideline annual mean of <25 mg l-1 has been proposed for bullhead, white-clawed crayfish and all three species of lamprey.

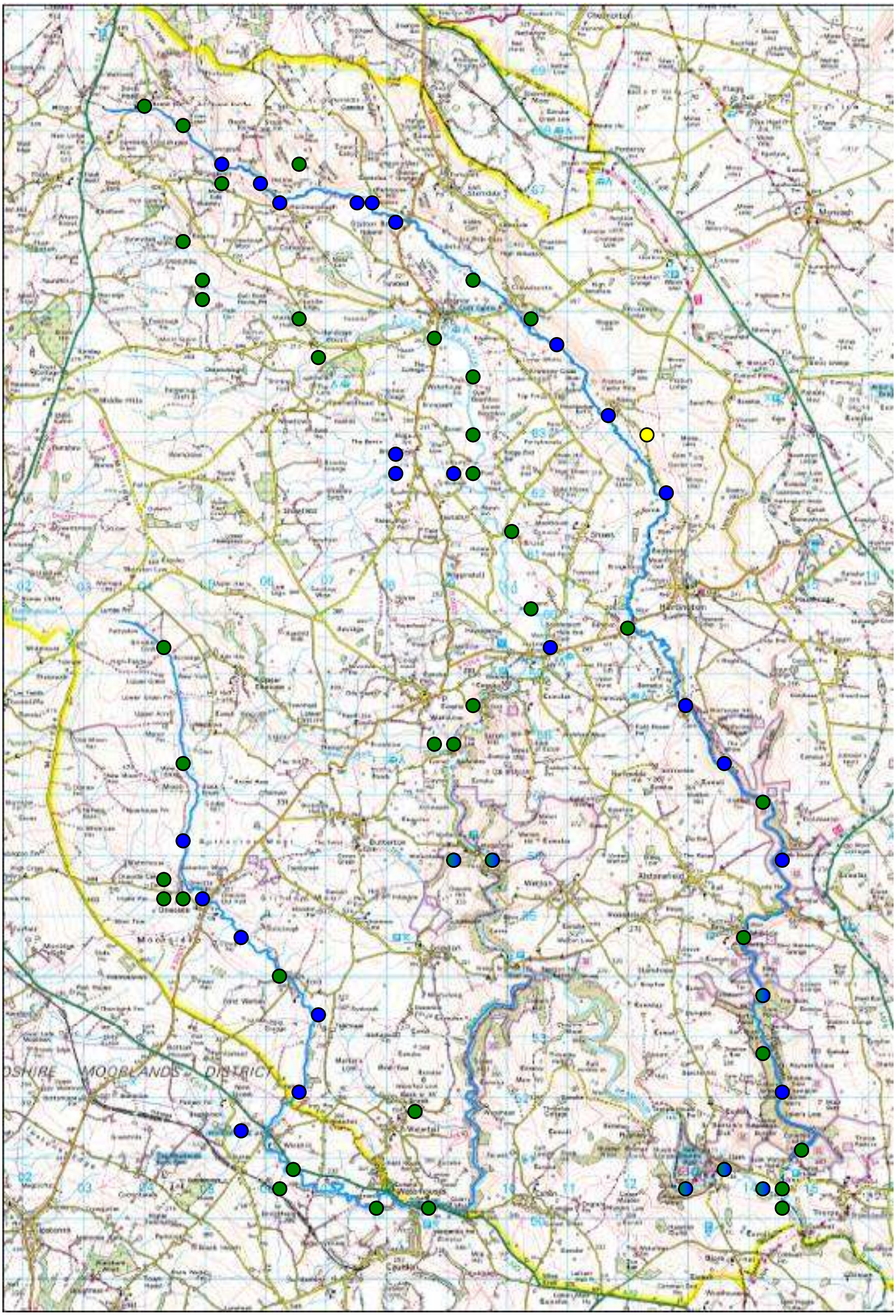
Much effort has been devoted in the past to the physical quantification of settled solids in rivers and direct measurement techniques range from bulk and freeze coring, to the use of baskets/traps and disturbance techniques.

Regarding ecological assessment, macro-invertebrate indices have historically been formulated in the U.K. to describe and respond to a range of environmental pressures and attributes but not siltation. In the UK there was no generally accepted methodology for assessing the impact of sedimentation on benthic invertebrate communities until recently (Extence *et. al.*, 2010).

In a European context, the Water Framework Directive -WFD (European Commission 2000) requires the attainment of good ecological status or potential, on prescribed time scales, and the UK Technical Advisory Group (UK TAG, 2006) has recently concluded that suspended and deposited solids have the potential to threaten the ecological status of water bodies and their resident species.

Overleaf were the relative degrees of siltation impact upon the receiving macroinvertebrates and the proxy measures of siltation at all survey sites in the Upper Dove Catchment in the Spring and Autumn of 2009.

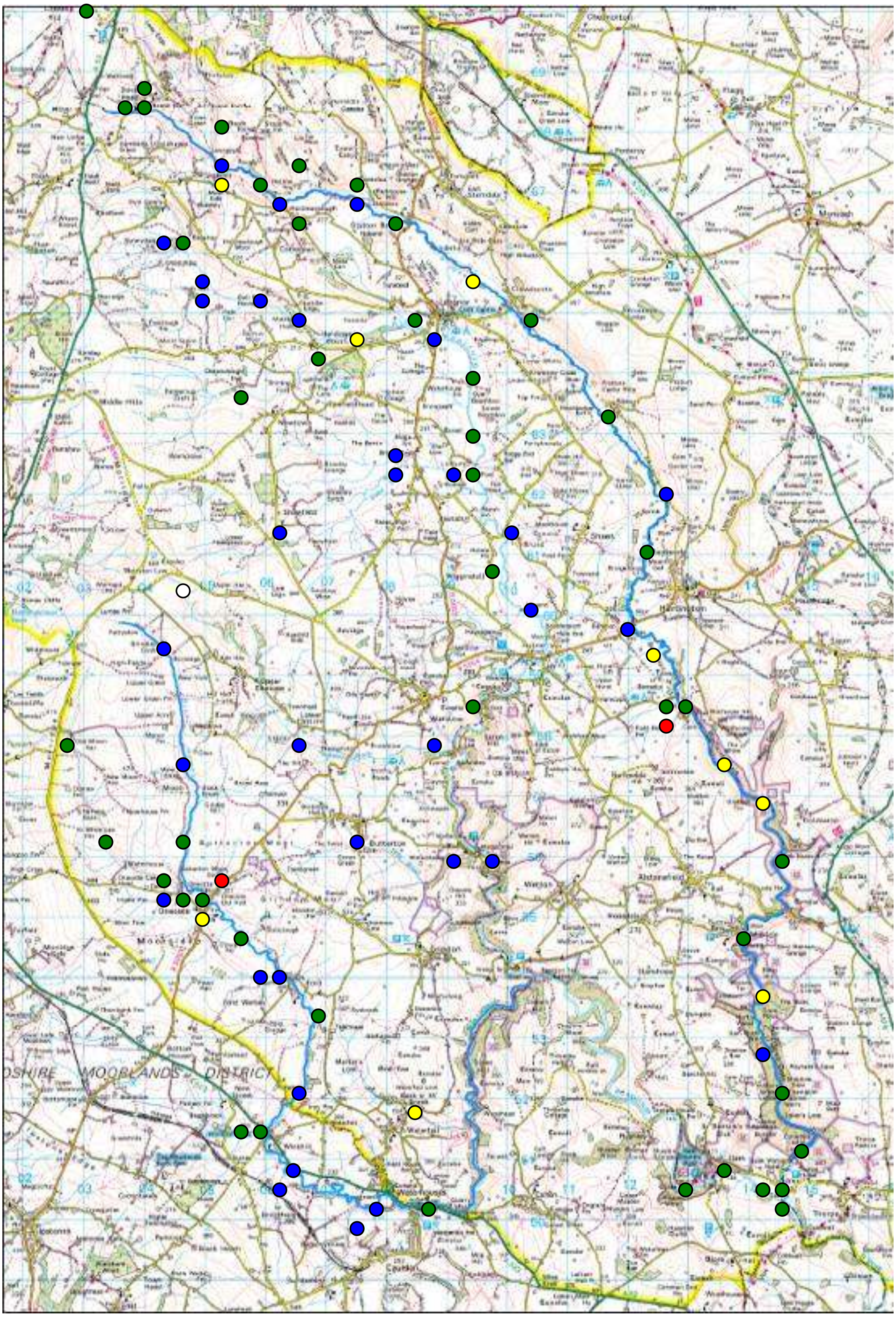
Siltation in the Upper Dove Catchment in Spring 2009



PSI Score	81-100	61-80	41-60	21-40	0-20
River status	Naturally silted/unsilted	Slightly silted	Moderately silted	Silted	Heavily silted

Siltation →

Siltation in the Upper Dove Catchment in Autumn 2009



PSI Score	81-100	61-80	41-60	21-40	0-20
River status	Naturally silted/unsilted	Slightly silted	Moderately silted	Silted	Heavily silted

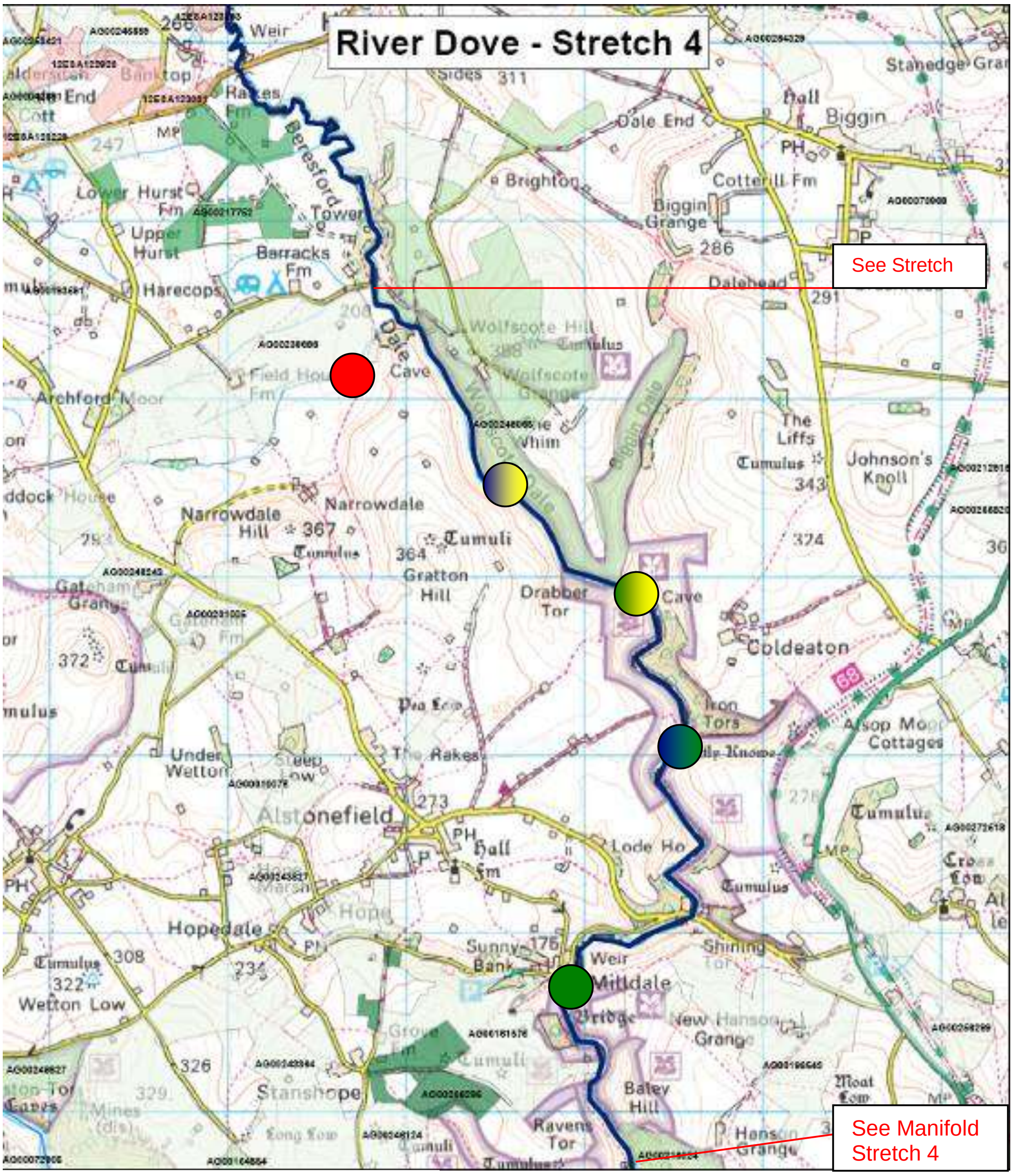
Siltation →

The extent to which sediment settles on river beds is determined by catchment scale fluvial and geomorphological processes and local scale physical habitat features. Close concordance between PSI and flow/velocity sensitive invertebrate indices such as LIFE (Lotic-invertebrate Index for Flow Evaluation) was expected and PSI and LIFE were strongly correlated in the study of Extence *et. al.* (2010). We have not calculated LIFE scores for the study sites in this report at present but great care was taken to carefully choose comparable survey sites in terms of habitat flow characteristics and so, all of the surveyed riffle sites would have relative comparability through and between these watercourses respectively. The results of actual measured sedimentation from field studies will be contrasted with the PSI (Proportion of Sediment-sensitive Invertebrates) findings at a later date when the geomorphological and sediment studies have been completed in 2010 by Loughborough University. Riffle sites used in the current study of macroinvertebrate communities would be strongly subject to seasonal flushing and would, in all probability, not reflect some of the worst siltation scenarios in the more impounded or lower flow areas of the study watercourses. However, the study sites served all of the water quality studies better and they would potentially allow analysis of spatial differences in sediment impacts in the short-term. Such studies may also provide valuable information on flow interdependencies and diffuse sources of fine sediment to rivers i.e. the lighter more mobile sedimentary material.

It appeared from the PSI (Proportion of Sediment-sensitive Invertebrates) findings that all of the rivers in the Upper Dove Catchment were subject to seasonally variable degrees of siltation and few study areas of the main rivers could be classified as ‘un-silted’ or ‘naturally silted’. These results should be of some concern for the ecological well being of these watercourses and particularly because the chosen study areas were riffles which were potentially subject to the most ameliorative actions of seasonal flushing.

Sections of the upper and lower River Dove, upper River Manifold and most of the River Hamps appeared to be showing signs of siltation moulding the receiving aquatic macroinvertebrate communities. Both the degree and spatial extent of siltation appeared to be worse during the Autumn surveys versus the Spring data. The compounding measures of siltation in the Autumn of 2009 may have been due to the sampling proceeding a moderate period of dry weather followed by short bursts of heavy rains. Perhaps of greatest concern was the shift to moderate and silted conditions recorded through Beresford and Wolfscote Dale (down to Milldale) during the Autumn of 2009 which may or may not correlate with a similar pattern of organic enrichment associated with both the feeder stream in Beresford Dale and potential for flow related mobilisation of impounded sediments through Beresford Dale. Many of the feeder streams in the Onecote area of the River Hamps also showed marked degrees of siltation in 2009.

More detailed maps of the proxy siltation determinations for all stretches of these watercourses were available from CSF and NE at Bakewell in Derbyshire with local Environmental Stewardship schemes highlighted and an example was shown overleaf.



Key:

River Dove

ESA Agreements

ES Agreements

- ELS
- ELS + HLS
- HLS
- OELS
- OELS + HLS

Key to Percentage Siltation (Macroinvertebrate) Indicators at species level PSI(S) data:

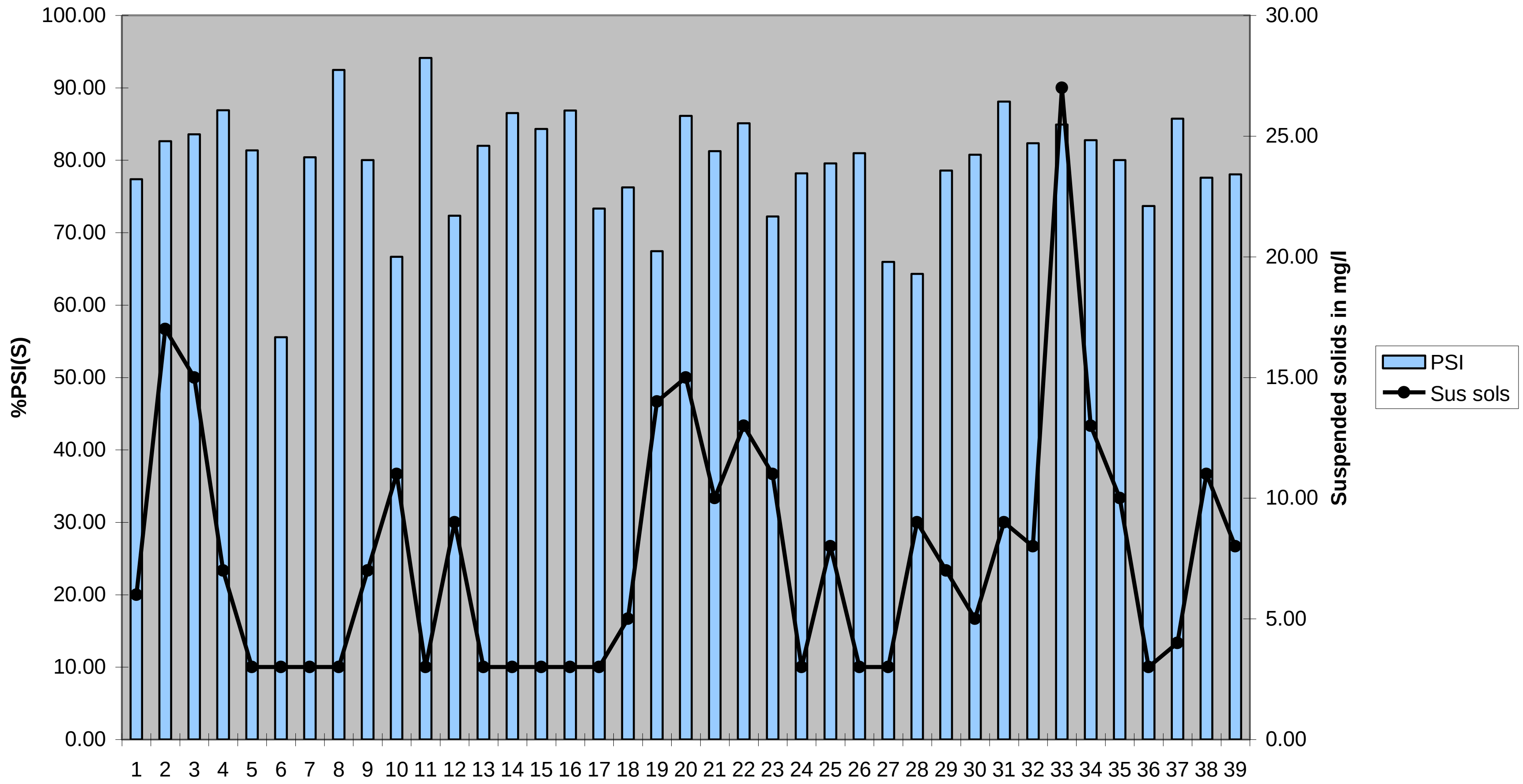
PSI Score	81-100	61-80	41-60	21-40	0-20
River status	Naturally silted/unsilted	Slightly silted	Moderately silted	Silted	Heavily silted

Siltation →

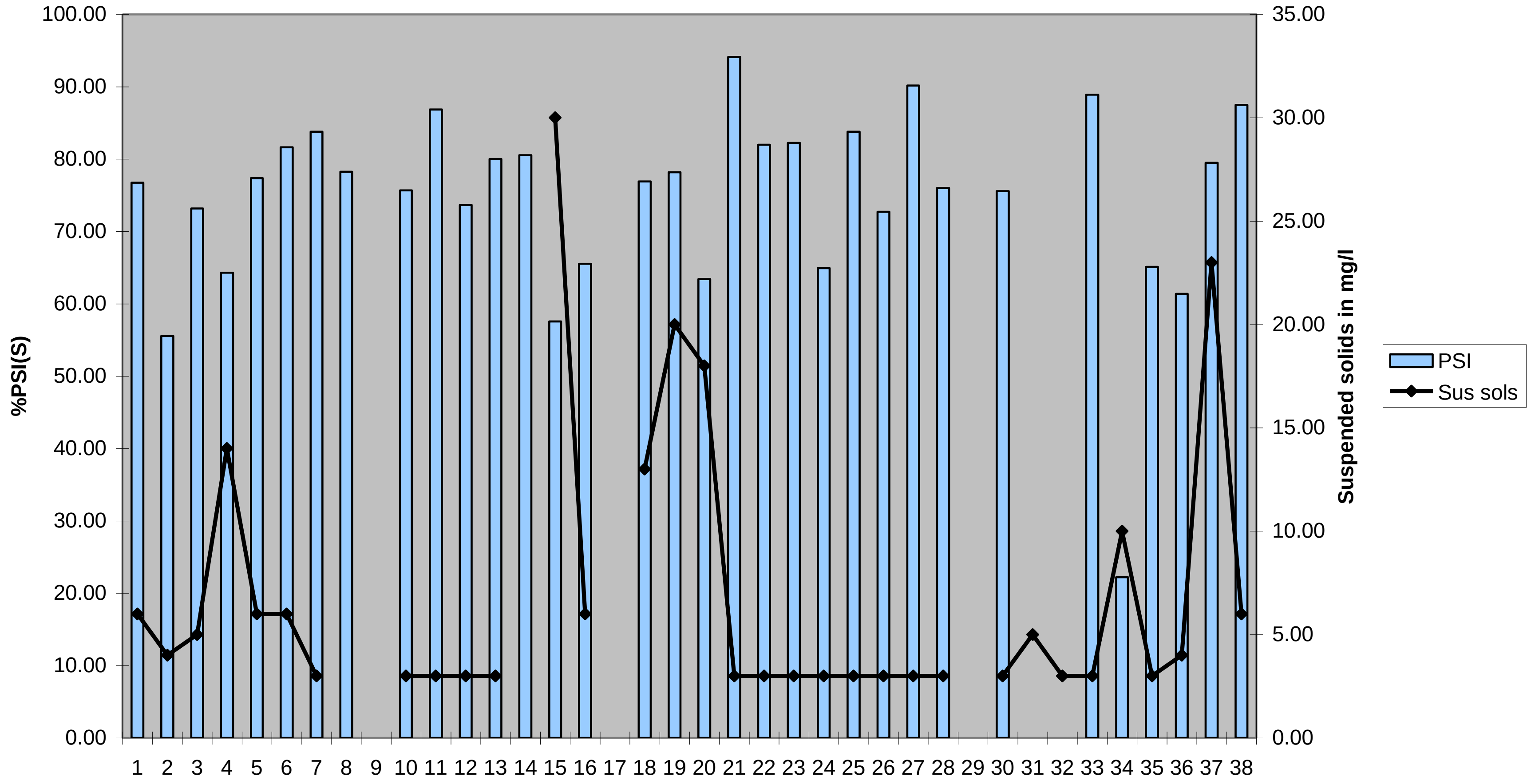
The detailed proxy siltation maps were provided to Natural England, the DEFRA Catchment Sensitive Farming Scheme, the Trent Rivers Trust and the geomorphologists from Loughborough University in December 2009 to help the appropriate personnel to start to understand the impact of siltation upon the ecology of these rivers. The sources and associated physico-chemical nature of sediments in the rivers of the Upper Dove Catchment would only be fully determined by the geo-morphological studies in progress in 2010. The current data would still serve as a means of prioritising remedial management actions and targeting any associated river remediation work. In the longer-term such data would provide, one of many, quantitative ecological measures of the success of any pollution remediation and river improvement work

Despite the very limited water chemistry sampling in 2009 there was some evidence of the associations expected between suspended solid levels and increasing PSI(S) (Proportion of Sediment-sensitive Invertebrate Species) of the receiving macroinvertebrate communities in these watercourses as shown in the graphs below.

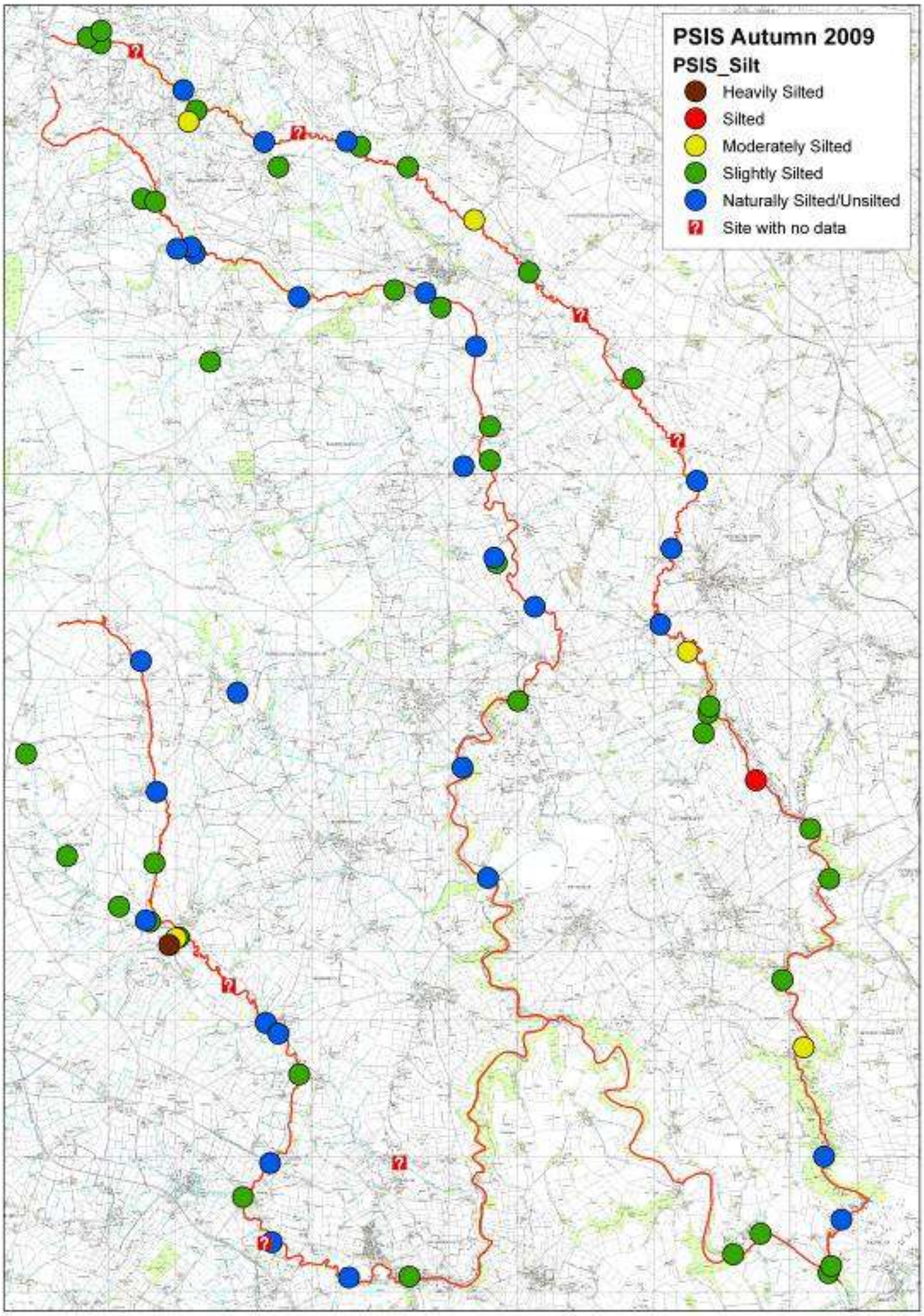
Relationship between PSI(S) and suspended solids levels in rivers of Upper Dove Catchment in Spring 2009



Relationship between PSI(S) and suspended solids in rivers from Upper Dove Catchment in Autumn 2009



In collaboration with Aquascience, more detailed maps of all the macroinvertebrate indexing data were being drafted into ARC view by Jules Toone at Loughborough University and a DRAFT example of these detailed maps was highlighted below.



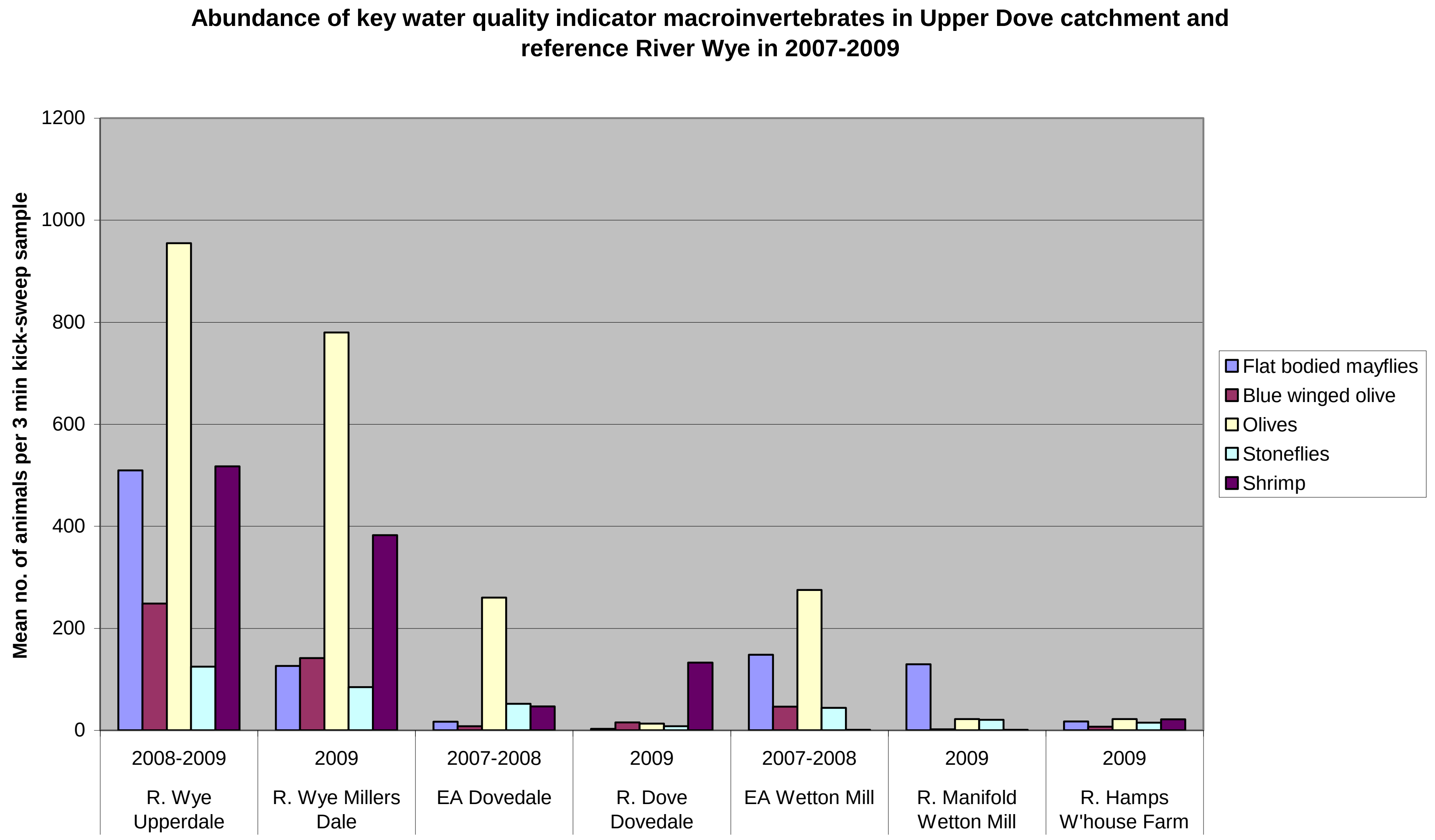
Macroinvertebrate assessment of eutrophication

Increased phosphorus levels are a problem in watercourses because generally, there is a link between phosphorus enrichment and detrimental ecological change. The primary impact can be enhanced plant and algal production, which in extreme cases can lead to the physical blockage of river channels. Secondary impacts can include reduced dissolved oxygen at night caused by overnight respiration of macrophytes and benthic algae, which in extreme cases can lead to fish kills.

Currently there is no phosphate limit defined in the River Ecosystem Classification. Under the Water Framework Directive the limit proposed for High status waters (RE1) is 0.05 mg/l Soluble Reactive Phosphate (SRP) and 0.12 mg/l SRP for Good status waters (RE2) of under 80m altitude and >50 mg/l hardness (UKTAG, 2006). However, where a watercourse was classified as a Headwater then these proposed limits would have to be reviewed under the Habitats Directive and a more stringent standard of 0.06 mg/l could be applied to the RE2 stretches as derived from Pitt *et. al.* (2002). For reference, the term Soluble Reactive Phosphorous (SRP) is effectively the same measure as orthophosphate.

Secondly, when phosphorus is in short supply, then an increase in the supply will influence both the composition of the macrophyte/benthic periphyton (algae) communities and the total biomass. The proliferation of macrophyte/benthic periphyton encourages the deposition of organic silts from the seasonal die-off of the associated algae/plants and can undermine the stability of macrophytes like *Ranunculus* (water crowfoot species). The orthophosphate related plant/periphyton proliferation also serves to aid the process of physical entrapment and deposition of particulate material from the passing water. Benthic food (algal) composition and habitat availability are therefore critically associated with what macro-invertebrate taxa are able to thrive in a given watercourse.

In enriched, mildly polluted waters, plant/periphyton induced changes in the nature of the substratum may have as great an influence on the fauna as any mild organic pollution and therefore orthophosphate can be linked to macro-invertebrate community structure. In practice, nutrient enrichment and chronic organic pollution would not favour the diversity of up-winged flies and may select against some macro-invertebrate species regarded as stable taxa of given watercourses. Both the historic EA biological data sets (1996-2006) and associated data from the current surveys in the graph overleaf showed a fairly impoverished population of up-winged flies through the rivers of the Upper Dove Catchment when compared to nearby rivers with comparable reference physico-chemical and flow conditions.

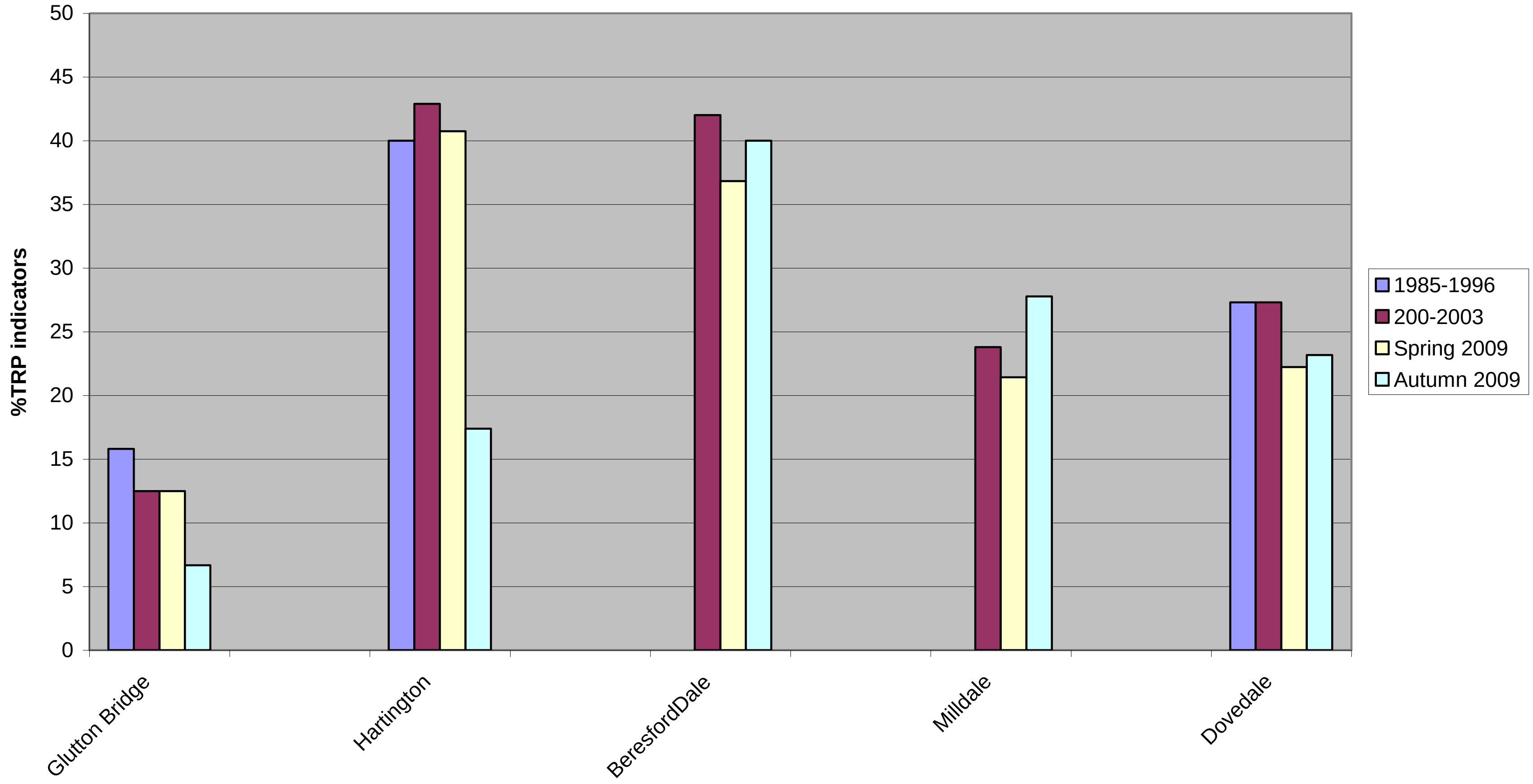

Abundance of key water quality indicator macroinvertebrates in Upper Dove catchment and reference River Wye in 2007-2009
Mean no. of animals per 3 min kick-sweep sample
1200
1000
800
600
400
200
0
2008-2009
R. Wye Upperdale
2009
R. Wye Millers Dale
2007-2008
EA Dovedale
2009
R. Dove Dovedale
2007-2008
EA Wetton Mill
2009
R. Manifold Wetton Mill
2009
R. Hamps W'house Farm
Flat bodied mayflies
Blue winged olive
Olives
Stoneflies
Shrimp

Previous studies of nutrient enrichment in the River Dove (Everall, 2004) and the River Manifold and River Hamps (Everall, 2005) respectively had shown some evidence of escalating nutrient enrichment in the latter two Dove tributaries between 1985 and 2003. The 2009 survey data was analysed for the percentage composition of the macroinvertebrate communities tolerant to elevated soluble phosphorous loadings (%TRP indicators) and all of the data was summarised for historically comparable survey sites in the graphs below.

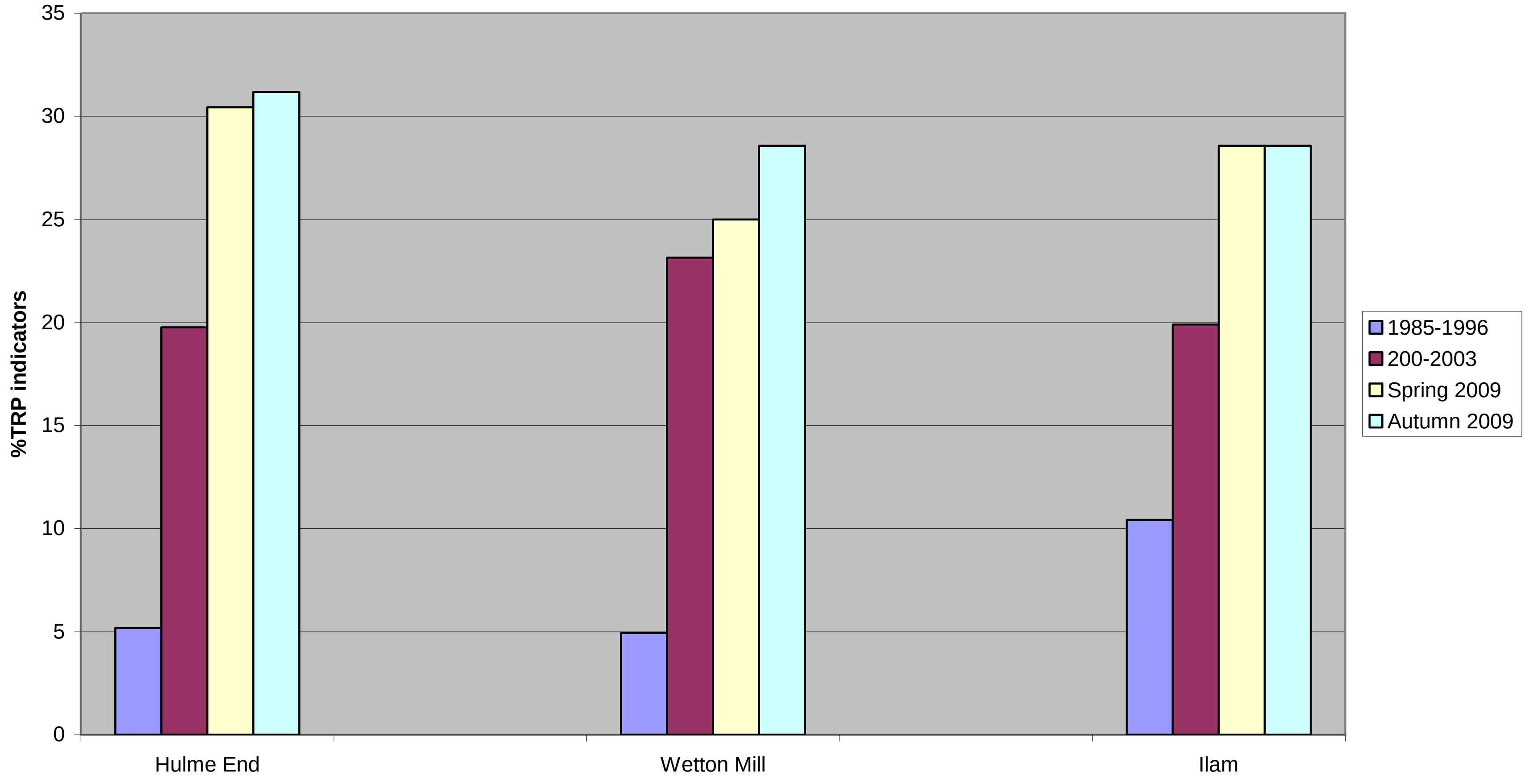
Allowing for standard error in these type of calculations (see Everall, 2005) there was, in all probability, little significant change in the impact of nutrient enrichment upon the receiving macroinvertebrate communities at the measured sites in the River Dove between 1985 and 2009. The possible exception to this hypothesis was the apparent downturn in nutrient enrichment effects at Glutton Bridge and Hartington in the Autumn of 2009. However, the more sensitive macroinvertebrate species interpretations of organic pollution (Saprobic analysis) had indicated more marked organic pollution at these sites during the Autumn of 2009. Both Paisley *et. al.* (2003) and Everall (2005) had suggested that organic pollution effects upon macroinvertebrate community structure would mask the observation of any effects expected from high phosphorous loads alone i.e. many macroinvertebrate [P] indicators would disappear due to the toxic effects of organic pollution like elevated ammonia and depressed dissolved oxygen levels.

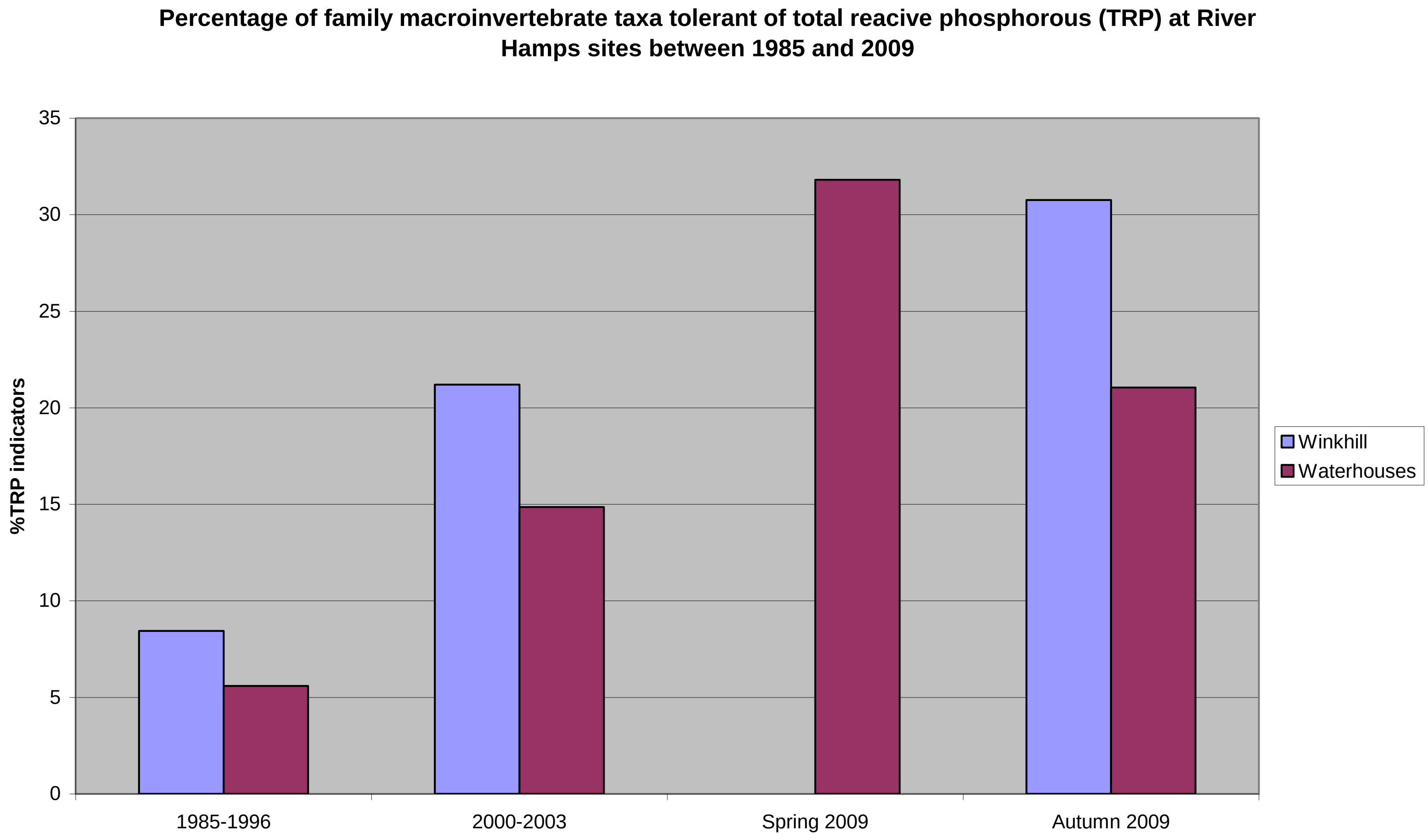
There was clear evidence of increasing nutrient enrichment effects upon the macroinvertebrate communities of the River Manifold at all comparable survey sites between 1985 and 2009.

Percentage of family macroinvertebrate taxa tolerant of elevated total reactive phosphorous (TRP) at River Dove sites between 1985-1996



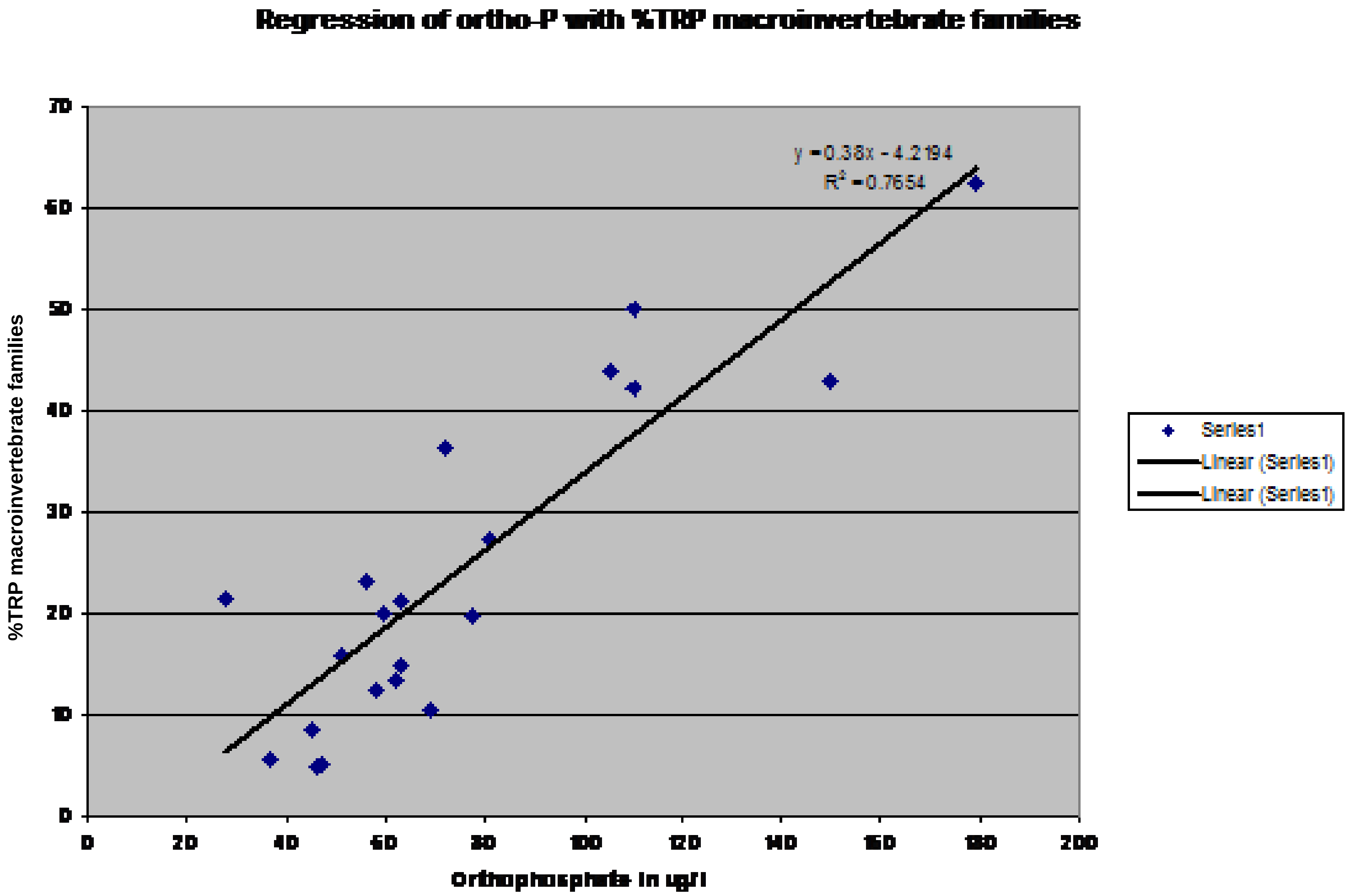
Percentage of family macroinvertebrate taxa tolerant of elevated total reactive phosphorous (TRP) AT River Manifold sites between 1985 and 2009




Percentage of family macroinvertebrate taxa tolerant of total reacive phosphorous (TRP) at River Hamps sites between 1985 and 2009
%TRP indicators
35
30
25
20
15
10
5
0
1985-1996
2000-2003
Spring 2009
Autumn 2009
Winkhill
Waterhouses

There was also clear evidence of increasing nutrient enrichment effects upon the macroinvertebrate communities of the River Hamps at all comparable survey sites between 1985 and 2009. The author was going to work with Richard Chadd and Chris Extence at the Environment Agency to refine the current TRP indicator indexing based upon macroinvertebrate community analysis of family taxa compositions to include lower TRP ranking groups and abundance weightings. At this stage, it appeared possible to devise a nutrient [P] indexing system with macroinvertebrates which would work as effectively as for example, the Trophic Diatom Index. Indeed, previous studies had shown as strong a relationship between [P] and macroinvertebrate families in the graph below (from Everall, 2005) as that for diatoms in Kelly and Whitton (1995).

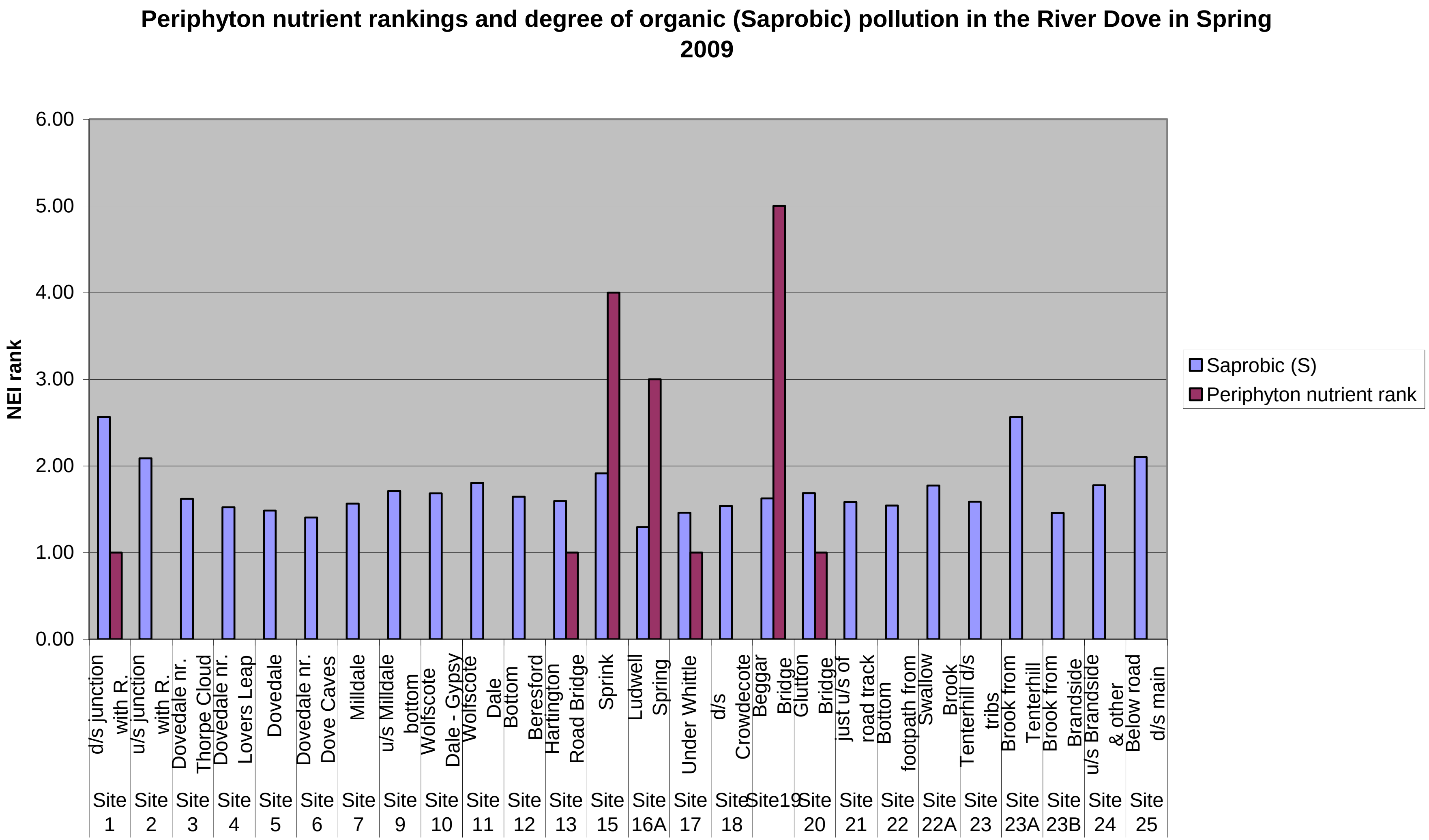
As in this and previous reports, macroinvertebrate indicators appeared to be useful in the design of diagnostic or predictive models applied to diffuse agricultural pollution. Similarly, a very significant finding from the paper of Paisley *et. al.* (2003) was that macrophytes did not turn out to be better indicators of TRP or TON than the invertebrates. Depending upon your viewpoint this either challenged or supplemented the current biological monitoring approach whereby phytoplankton or macrophytes are preferentially used as a means of investigating nutrient-biological response relationships.


Regression of ortho-P with %TRP macroinvertebrate families
y = 0.38x - 4.2194
R² = 0.7654
%TRP macroinvertebrate families
Orthophosphate in ug/l
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140
160
180
200
Series1
Linear (Series1)
Linear (Series1)

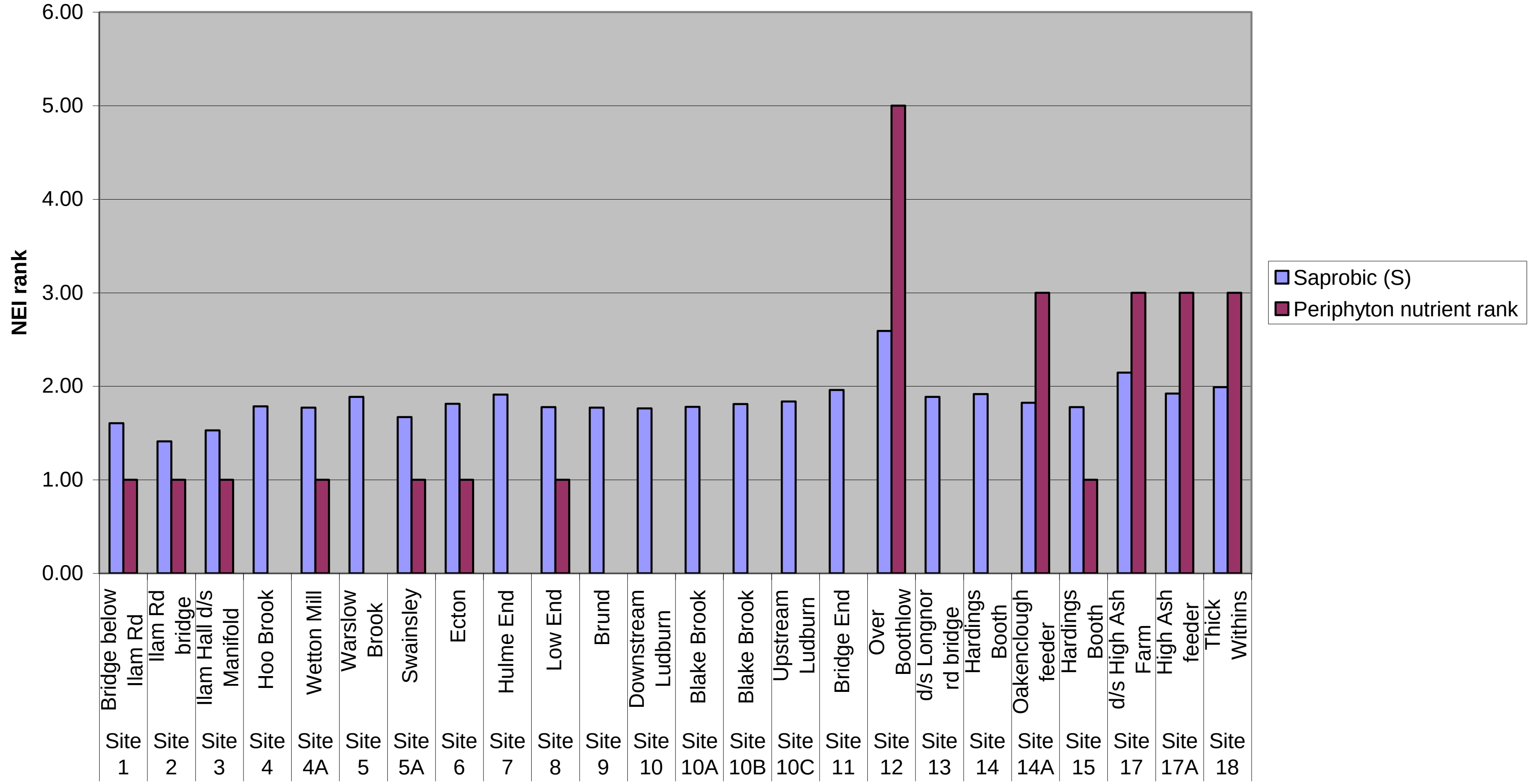
Periphyton community structures and nutrient enrichment rankings (NEI)

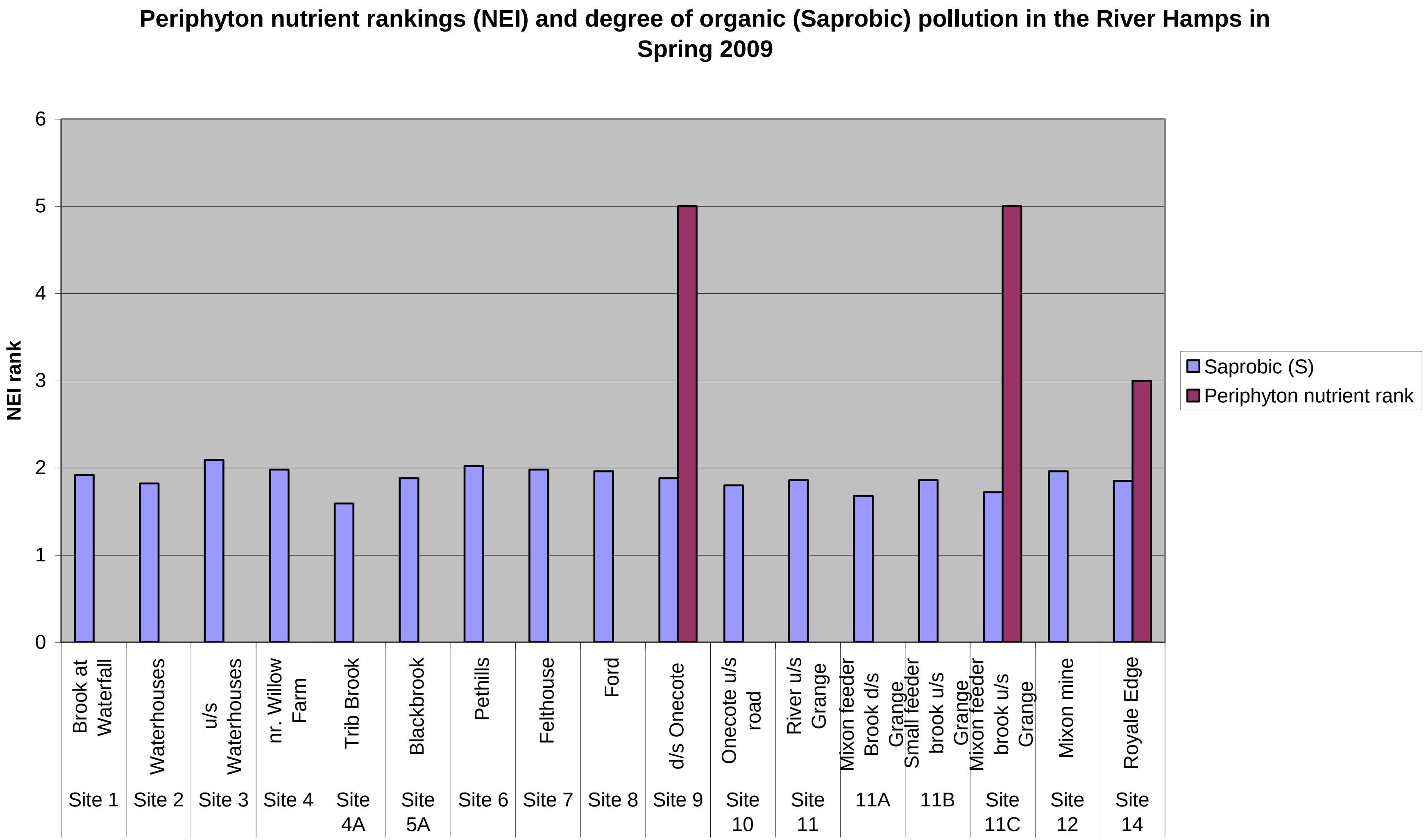
The semi-quantitative periphyton community data for all sites surveyed in the Upper Dove Catchment in the Spring of 2009 was presented in Appendix 4a and 4b.

The results from this indexing were cross-referenced against community nutrient rankings from periphyton communities examined at survey sites through the 3 rivers and listed in Appendix 4a and 4b. There was evidence of a (regression fit) relationship between TRP levels, macroinvertebrate TRP index, Saprobic index and periphyton community nutrient rankings. The relationship between Saprobic index and periphyton community nutrient rankings was shown for all 3 rivers in the Upper Dove Catchment in the graphs below.


Periphyton nutrient rankings and degree of organic (Saprobic) pollution in the River Dove in Spring 2009
NEI rank
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Saprobic (S)
Periphyton nutrient rank
d/s junction with R.
u/s junction with R.
Dovedale nr. Thorpe Cloud
Dovedale nr. Lovers Leap
Dovedale
Dovedale nr. Dove Caves
Milldale
u/s Milldale
bottom Wolfscote Dale - Gypsy
Wolfscote Dale Bottom
Beresford
Hartington Road Bridge
Sprink
Ludwell Spring
Under Whittle
d/s Crowdecote
Beggar Bridge
Glutton Bridge
just u/s of road track
Bottom footpath from
Swallow Brook
Tenterhill d/s tribs
Brook from Tenterhill
Brook from Brandside
u/s Brandside & other
Below road d/s main
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 9
Site 10
Site 11
Site 12
Site 13
Site 15
Site 16A
Site 17
Site 18
Site19
Site 20
Site 21
Site 22
Site 22A
Site 23
Site 23A
Site 23B
Site 24
Site 25

Periphyton nutrient rankings (NEI) and degree of organic (Saprobic) pollution in the River Manifold in Spring 2009




Periphyton nutrient rankings (NEI) and degree of organic (Saprobic) pollution in the River Hamps in Spring 2009
NEI rank
0
1
2
3
4
5
6
Saprobic (S)
Periphyton nutrient rank
Brook at Waterfall
Waterhouses
u/s Waterhouses
nr. Willow Farm
Trib Brook
Blackbrook
Pethills
Felthouse
Ford
d/s Onecote
Onecote u/s road
River u/s Grange
Mixon feeder Brook d/s Grange
Small feeder brook u/s Grange
Mixon feeder brook u/s Grange
Mixon mine
Royale Edge
Site 1
Site 2
Site 3
Site 4
Site 4A
Site 5A
Site 6
Site 7
Site 8
Site 9
Site 10
Site 11
11A
11B
Site 11C
Site 12
Site 14

Across the 3 rivers where there was an increase in organic load (Saprobic index) and there was matching periphyton community ranking data, the Nutrient Enrichment Indicator (periphyton community) rank increased down the scale shown in the table below.

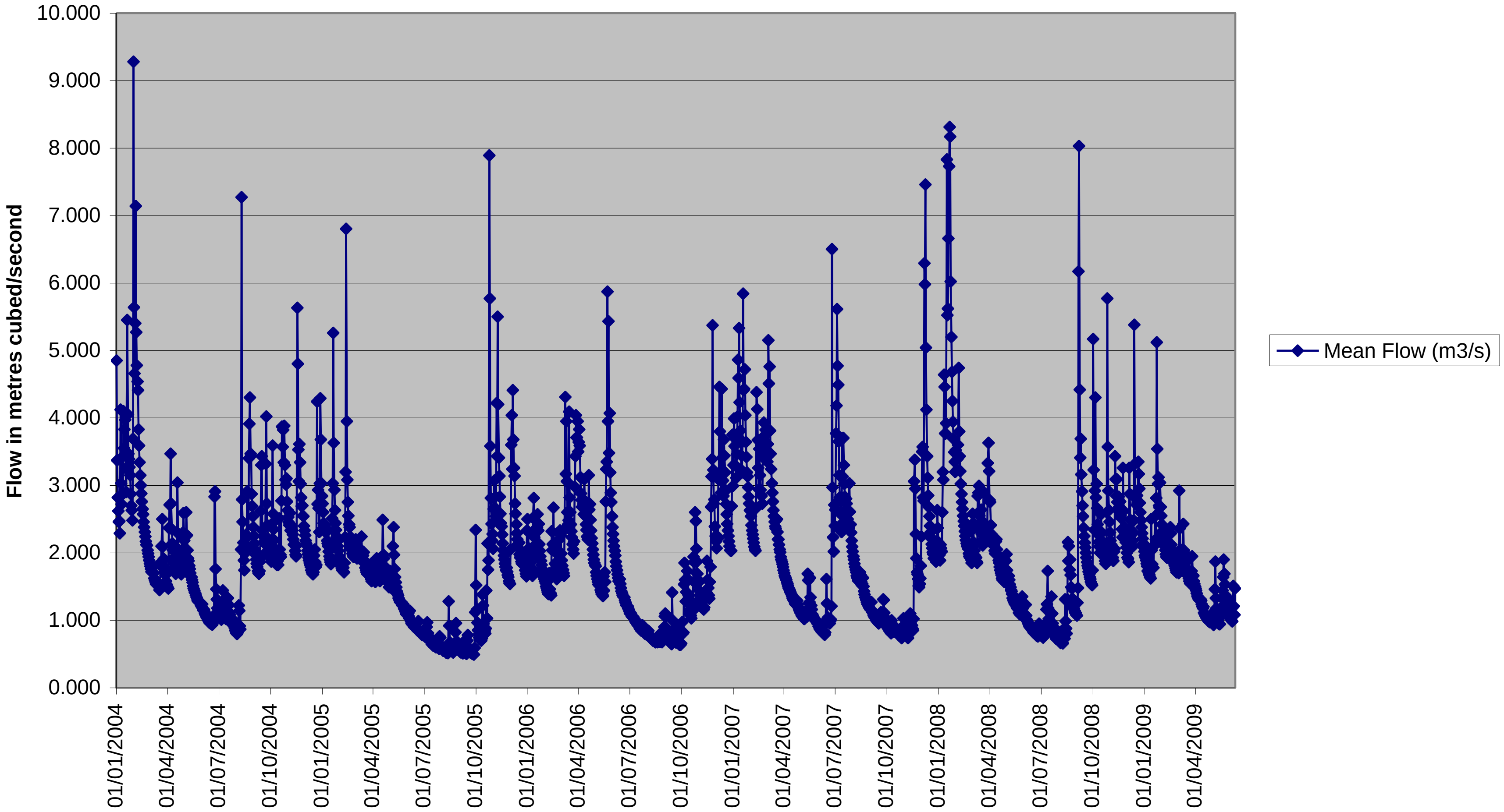
Algal community description (dominant taxa and relative abundances)	**Typical habitat**	**NEI Rank**
Batrachospermum sp *et.al.*	Upland watercourses with good flow. Often Batrachospermum abundant in Spring in soft and partly shaded waters	1
Cladophora sp. and Spirogyra sp. *et.al.*	Ubiquitous community most commonly dominates moderately enriched to unenriched habitats	2
Microspora sp. and Cladophora *et.al.* or Batrachospermum sp., Cladophora and Stigeoclonium *et.al.*	Conspicuous in moderately enriched foothills and Springs or Upland watercourses with good flow and some nutrient enrichment	3
Melosira varians and Stigeoclonium sp. *et.al.*	Intensively developed pastoral agricultural catchments with hard sediment geology	4
Cladophora sp. and aquatic hyphomycetes-fungi *et.al.*	Intensively developed pastoral catchments and/or catchments with a high proportion of organic sediments	5

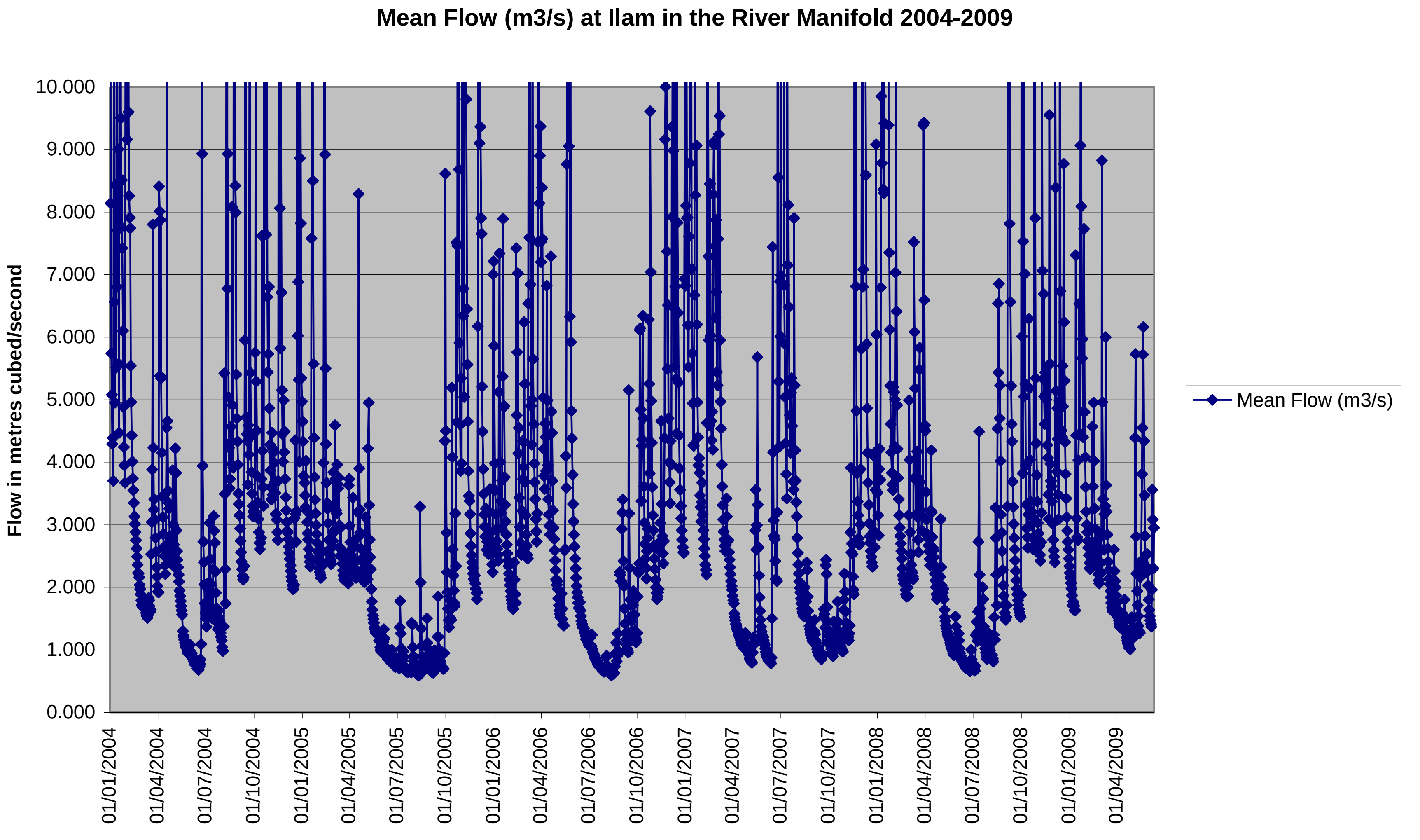
The findings from the unplanned data investigation on periphyton communities were interesting and it was planned to undertake some Trophic Diatom Indexing at 30 sites across the Upper Dove Catchment in 2010.

River flows

Flow studies on other watercourses of similar topography have suggested that flows $\geq 0.3\ m^3 s^{-1}$ from November through to the end of May should maintain habitat for trout and dace at about 50% of potential and discharges $\geq 1.0\ m^3 s^{-1}$ would provide optimum fish habitat (Petts *et. al.*, 1995).

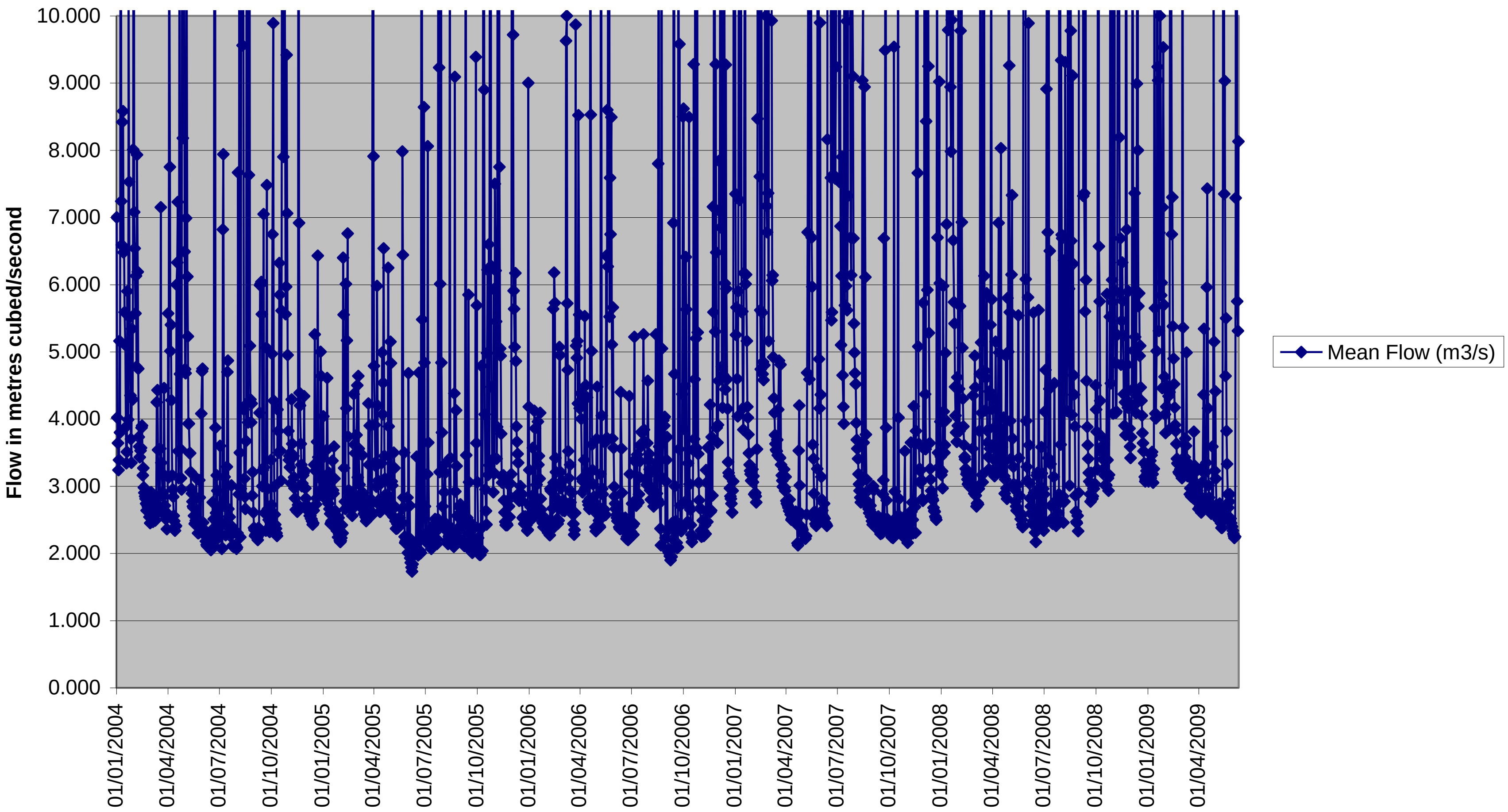
Mean Flow (m3/s) at Izaak Walton Hotel in River Dove 2004-2009





Mean Flow (m3/s) at Ilam in the River Manifold 2004-2009
Flow in metres cubed/second
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
01/01/2004
01/04/2004
01/07/2004
01/10/2004
01/01/2005
01/04/2005
01/07/2005
01/10/2005
01/01/2006
01/04/2006
01/07/2006
01/10/2006
01/01/2007
01/04/2007
01/07/2007
01/10/2007
01/01/2008
01/04/2008
01/07/2008
01/10/2008
01/01/2009
01/04/2009
Mean Flow (m3/s)

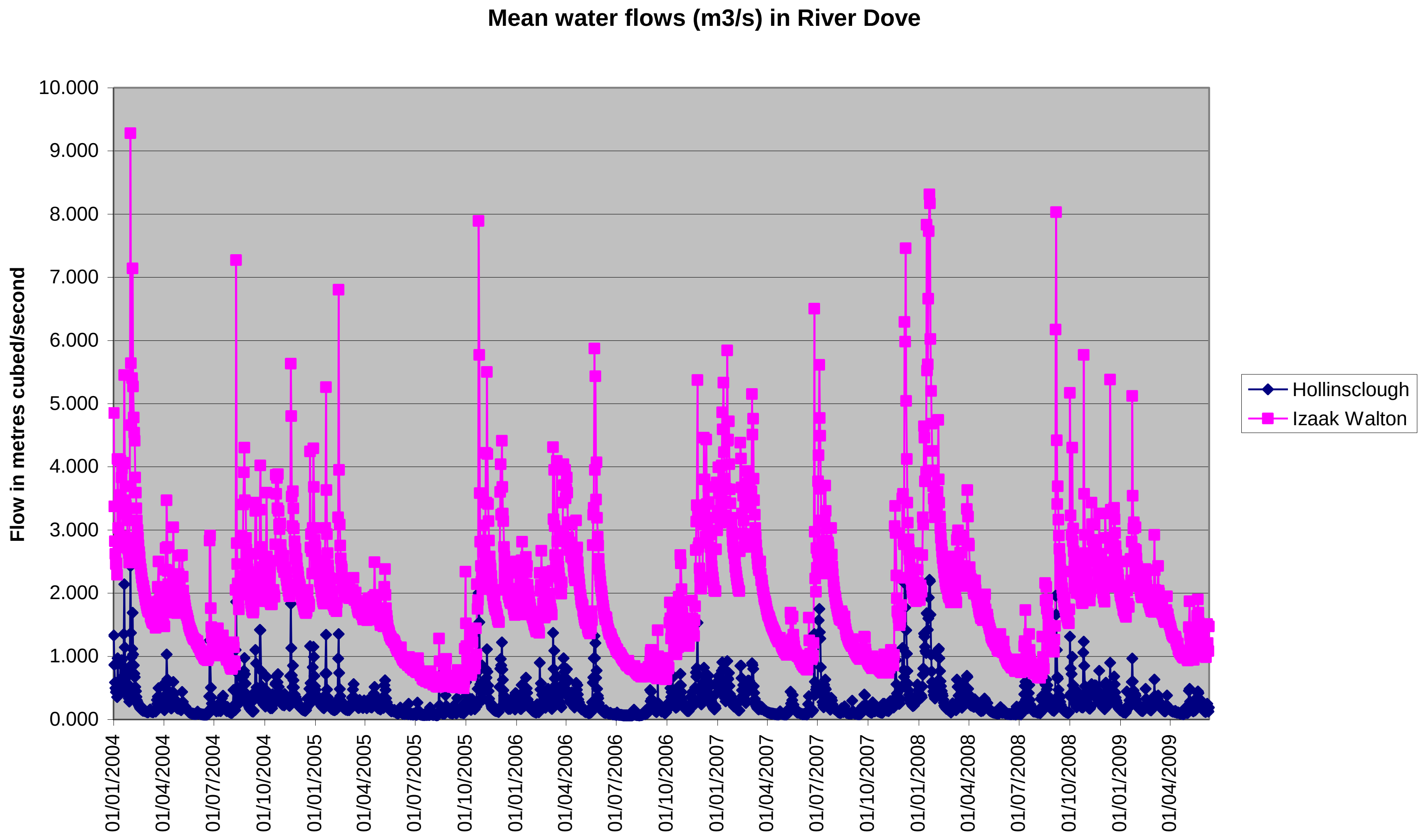
Mean Flow (m3/s) at Waterhouses in River Hamps 2004-2009



Flows in all 3 rivers of the Upper Dove Catchment were generally at or above optimal for salmonid fishery survival over the last 5 years to June 2009 (data courtesy of Environment Agency). Flow patterns in individual years were very important and unfortunately by the time of completing this report the flow data for all 3 rivers between June 2009 and December 2009 had not been completed by the Agency. The flow, rainfall and land fertiliser applications during the Autumn of 2009 would, in all probability, shed some insight into the measured step change in organic load upon the macroinvertebrate communities measured in parts of the catchment during this time.

What was clearly apparent from the existing flow data was the augmentation of water flow down the River Dove in the graph below and this was thought to be from mainly limestone spring sources.

In all probability, it was mainly the high dilution currently afforded by the spring augmentation of flow in the upper River Dove that was tempering any greater organic impact evident than that already evident in the receiving macroinvertebrate communities.



Mean water flows (m3/s) in River Dove
Flow in metres cubed/second
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
01/01/2004
01/04/2004
01/07/2004
01/10/2004
01/01/2005
01/04/2005
01/07/2005
01/10/2005
01/01/2006
01/04/2006
01/07/2006
01/10/2006
01/01/2007
01/04/2007
01/07/2007
01/10/2007
01/01/2008
01/04/2008
01/07/2008
01/10/2008
01/01/2009
01/04/2009
Hollinsclough
Izaak Walton

Despite the relatively high organic loading evident within the 3 rivers, the biological quality of classified reaches as determined by routine EA monitoring in the Upper Dove Catchment remained high in parts and this was, in all probability, due to the dilution afforded at present. Climate change predictions on seasonal rainfall and flow patterns for the Upper Dove Catchment would therefore be important for future pollution risk and load assessments in this catchment.

Aquatic Community Conservation Index (CCI)

Community Conservation Indexing (CCI) after Chadd and Extence (2004) was undertaken at all macroinvertebrate survey sites in the Upper Dove Catchment in 2009. The results of the Community Conservation Indexing for the macroinvertebrate species community data in Appendix 2 was shown in the tables below for each river corridor surveyed in 2009.

River Dove 2009

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 1	Dove	SK14568-50292	d/s junction with R. Manifold	12.00	-	Fairly high
Site 2	Dove	SK14604-50394	u/s junction with R. Manifold	11.21	17.68	High
Site 3	Dove	SK14756-51075	Dovedale nr. Thorpe Cloud	17.36	10.33	High
Site 4	Dove	SK145520	Dovedale nr. Lovers Leap	16.69	9.67	High
Site 5	Dove	SK145520	Dovedale	11.46	10.00	Fairly high
Site 6	Dove	SK142536	Dovedale nr. Dove Caves	11.41	11.74	Fairly high
Site 7	Dove	SK13892-54589	Milldale	10.60	10.59	Fairly high
Site 9	Dove	SK14578-56070	u/s Milldale bottom Wolfscote Dale	12.32	13.42	Fairly high
Site 10	Dove	SK143568	Wolfscote Dale – Gypsy Bank	8.44	8.82	Moderate
Site 11A	Dove	SK12735-58205	Brook from Field House Farm	-	8.00	Moderate
Site 11	Dove	SK13503-57515	Wolfscote Dale	9.70	16.23	High
Site 12A	Dove	SK128585	Brook adj. rd at Bottom Beresford Dale	-	9.38	Moderate
Site 12	Dove	SK12823-58596	Bottom Beresford Dale	11.07	9.57	Fairly high
Site 12B	Dove	SK125594	Brook from Hurst Farms	-	5.35	Low-Moderate
Site 13	Dove	SK12100-59800	Hartington Road Bridge	8.21	9.52	Moderate
Site 14	Dove	SK12264-60910	u/s Hartington Creamery	-	9.74	Moderate
Site 15	Dove	SK12637-61902	Sprink	9.79	10.59	Fairly high
Site 16	Dove	SK117634	Pilsbury	-	11.04	Fairly high
Site 16A	Dove	SK12358-62496	Ludwell Spring	12.08	-	Fairly high
Site 17	Dove	SK10935-64328	Under Whittle	10.87	-	Fairly high
Site 18	Dove	SK10173-64960	d/s Crowdecote Rd Bridge	9.29	10.00	Fairly high
Site 19	Dove	SK09370-65728	Beggar Bridge	9.55	8.57	Moderate
Site 20	Dove	SK08400-66500	Glutton Bridge	6.19	8.67	Moderate
Site 20A	Dove	SK077668	Brook from Dowall Hall	-	12.06	Fairly high
Site 21	Dove	SK07502-66877	just u/s of road track ford crossing river	6.11	12.12	Fairly high
Site 22	Dove	SK06290-66869	Bottom footpath from Hollinsclough	17.50	10.00	High
Site 22A	Dove	SK06794-67002	Swallow Brook	9.62	-	Moderate

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 22B	Dove	SK065665	Brook thro' Hollinsclough	-	12.22	Fairly high
Site 23	Dove	SK05298-67333	Tenterhill d/s tribs	15.96	21.78	Very high
Site 23A	Dove	SK05181-67166	Brook from Tenterhill	11.67	10.33	Fairly high
Site 23B	Dove	SK05106-67630	Brook from Brandside	12.33	12.06	Fairly high
Site 24	Dove	SK04411-68202	u/s Brandside & other brooks	10.33	-	Fairly high
Site 25	Dove	SK03894-68312	Below road d/s main source of Dove	12.25	12.31	Fairly high
Site 25A	Dove	SK037684	Brook from main source Dove	-	14.50	Fairly high
Site 25B	Dove	SK039685	Brook from Axe Edge Car Park	-	12.69	Fairly high
Site 26	Dove	SK033698	Brook on Axe Edge u/s Car Park	-	23.55	Very high

River Manifold 2009

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 1	Manifold	SK14568-50292	Bridge below Ilam Rd	10.63	10.68	Fairly high
Site 2	Manifold	SK13572-50867	Ilam Rd bridge	10.91	11.60	Fairly high
Site 3	Manifold	SK13168-50566	Ilam Hall d/s Manifold Springs	10.83	5.83	Fairly high
Site 4A	Manifold	SK09573-56084	Hoo Brook	8.33	15.75	High
Site 4	Manifold	SK09573-56084	Wetton Mill	16.67	12.61	High
Site 5A	Manifold	SK092577	Warslow Brook	6.15	11.05	Fairly high
Site 5B	Manifold	SK059588	Warslow Brook	-	12.27	Fairly high
Site 5	Manifold		Swainsley	10.42		Fairly high
Site 6	Manifold	SK10013-58676	Ecton	5.77	10.23	Fairly high
Site 7	Manifold		Hulme End	9.17		Moderate
Site 8	Manifold	SK10257-60057	Low End	15.31	14.39	High
Site 8A	Manifold	SK097607	nr. Hulme House	-	21.88	Very high
Site 9	Manifold	SK09665-60775	Brund	10.93	18.85	High
Site 10	Manifold	SK096622	Downstream Ludburn Farm	13.67	16.10	High
Site 10A	Manifold	SK09217-62118	Blake Brook	5.75	10.00	Fairly high
Site 10B	Manifold		Blake Brook	10.91	-	Fairly high
Site 10C	Manifold		Bridge End	11.74	-	Fairly high
Site 11	Manifold	SK096627	Upstream Ludburn farm	4.64	11.47	Fairly high
Site 12	Manifold	SK09399-63872	Over Boothlow	10.22	10.79	Fairly high

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 13	Manifold	SK08657-64657	d/s Longnor rd bridge	10.14	11.48	Fairly high
Site 13A	Manifold	SK082647	Oakenclough feeder stream	-	9.75	Moderate
Site 14A	Manifold	SK08879-64443	Oakenclough feeder stream	10.80	6.25	Fairly high
Site 14	Manifold	SK05500-63647	Hardings Booth	9.35	10.45	Fairly high
Site 15	Manifold	SK06797-64597	Hardings Booth	17.39	19.19	High
Site 16	Manifold	SK05276-65239	Ball Bank House Farm	-	19.16	High
Site 17	Manifold	SK05221-65329	d/s High Ash Farm	11.59	17.15	High
Site 17A	Manifold	SK05016-65303	High Ash feeder stream	11.11	10.63	Fairly high
Site 18A	Manifold	SK04507-66035	Feeder brook at Thick Withins Fm	-	17.32	High
Site 18	Manifold	SK04695-65994	Thick Withins Farm	10.45	13.60	Fairly high

River Hamps

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 1	Hamps	SK08276-51905	Brook at Waterfall	16.41	-	High
Site 2	Hamps	SK08422-50239	Waterhouses	5.65	10.56	Fairly high
Site 3A	Hamps	SK07535-50225	Feeder brook u/s Waterhouses	-	10.00	Fairly high
Site 3	Hamps	SK07535-50225	u/s Waterhouses	10.33	10.00	Fairly high
Site 4	Hamps	SK06403-50744	nr. Willow Farm	11.45	10.53	Fairly high
Site 4A	Hamps	SK06298-50731	Trib Brook	10.40		Fairly high
Site 5	Hamps	SK-06000-51400	Winkhill			
Site 5A	Hamps	SK05980-51405	Blackbrook	11.58	10.56	Fairly high
Site 6	Hamps	SK06379-51904	Pethills	17.50	10.83	High
Site 7	Hamps	SK06805-53204	Felthouse	11.30	8.57	Fairly high
Site 8A	Hamps	SK06314-53957	Feeder brook at Ford	-	15.62	High
Site 8	Hamps	SK065538	Ford	10.88	10.71	Fairly high
Site 9	Hamps	SK05772-54505	d/s Onecote	11.67		Fairly high
Site 10A	Hamps	SK05040-55211	Feeder brook	-	4.36	Low
Site 10B	Hamps	SK050552	Feeder brook running alongside main road	-	10.00	Fairly high

Site no.	River	Grid ref	Site description	Spring	Autumn	Overall conservation value
Site 10	Hamps	SK049551	Onecote u/s road	5.59	10.25	Fairly high
Site 11	Hamps	SK04680-56299	River u/s Grange	12.93	16.80	High
11A	Hamps	SK04617-55441	Mixon feeder Brook d/s Grange	10.71	11.67	Fairly high
11B	Hamps	SK04556-55459	Small feeder brook u/s Grange	16.10	11.59	High
Site 11C	Hamps	SK04164-55663	Mixon feeder brook u/s Grange	15.17	13.22	High
Site 11Cii	Hamps	SK034564	Mixon feeder brook nr. White Lea Farm	-	5.08	Moderate
Site 11Ciii	Hamps	SK028759	Mixon feeder brook u/s Old Mixon Hay Fram	-	14.37	Fairly high
Site 12	Hamps	SK04716-57345	Mixon mine	14.00	10.15	Fairly high
Site 14	Hamps	SK04484-59261	Royledge	10.23	15.65	High

Key to tables:

0.0 to 5.0 } sites supporting only common species and/or a community of low taxon richness. Low conservation value.

>5.0 to 10.0 } sites supporting at least one species of restricted distribution and/or a community of moderate taxon richness. Moderate conservation value.

>10.0 to 15.0 } sites supporting at least one uncommon species, or several species of restricted distribution and/or a community of high taxon richness. Fairly high conservation value.

>15.0 to 20.0} sites supporting several uncommon species, at least one of which may be nationally rare and/or a community of high taxon richness. High conservation value.

>20.0 } sites supporting several rarities, including species of national importance, or at least one extreme rarity (for example, taxa included in the British RDBs) and/or a community of very high taxon richness. Very high conservation value (potentially of national significance and may merit statutory protection).

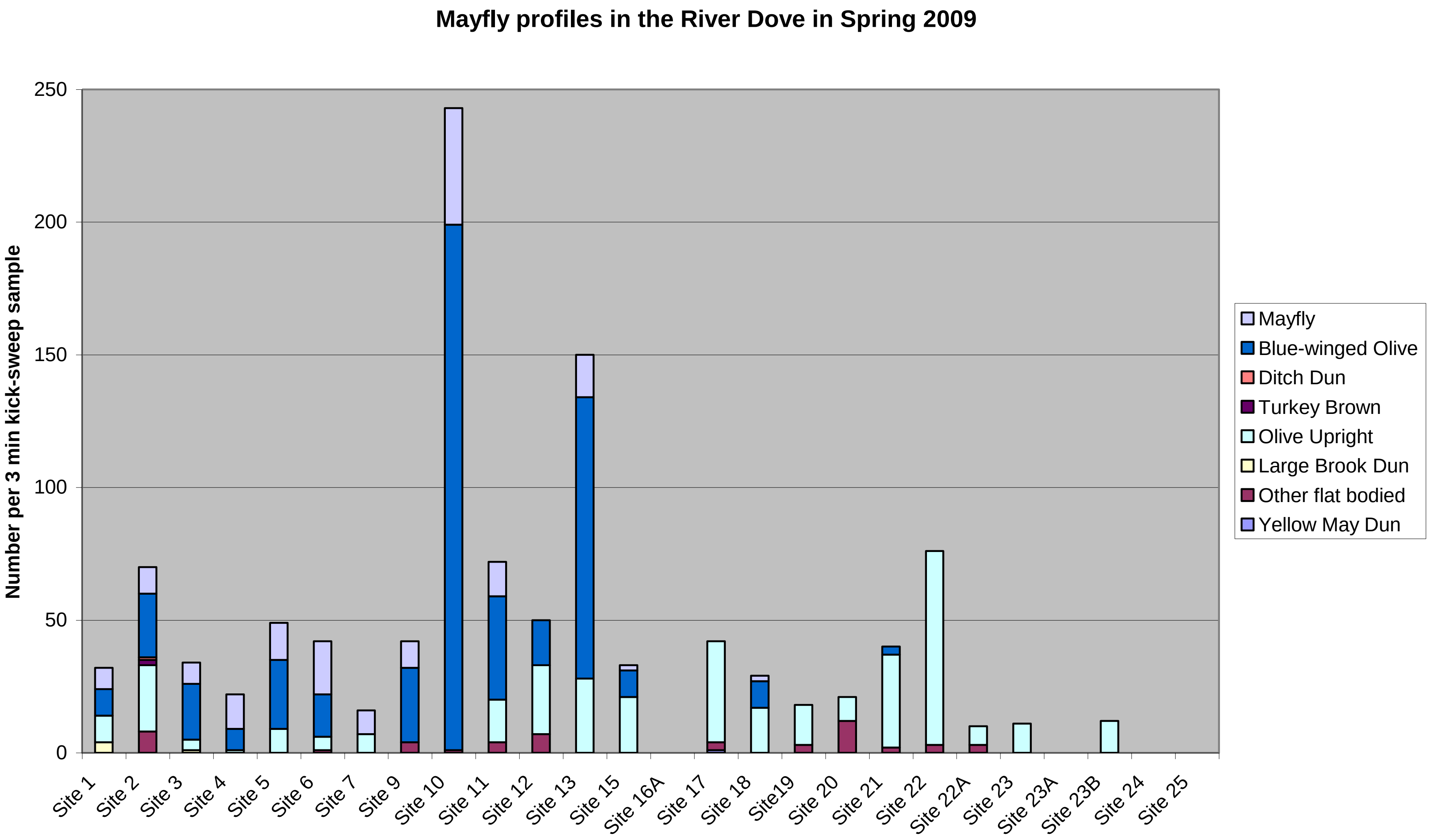
These classifications of CCI were derived by testing the index over a 10 yr period. As with any set of generalized rules, there will inevitably be some drift at the boundaries of these ranges. Overall conservation values were weighted towards the higher values between the Spring and Autumn sampling in 2009 since the appearance or disappearance of rarer species can obviously have seasonal variations irrespective of other factors.

In the River Dove in 2009 the 38 overall survey sites were shown to be 5% Very High, 14% High, 54% Fairly High, 24% Moderate and 3% Low aquatic conservation value. The very high conservation value sites were predominantly a few (2) streams in the upper foothills and the SSSI in Wolfscote Dale had 3 sites ranging from Moderate to Fairly High conservation value. In the River Manifold in 2009 the 27 overall survey sites were calibrated as 33% High, 63% Fairly High and 4% Moderate conservation value. There was no Very High conservation value sites found in the River Manifold during the 2009 survey work. In the River Hamps in 2009 the 25 overall survey sites were calibrated as 28% High, 56% Fairly High, 4% Moderate and 4% Low conservation value. There was no Very High conservation value sites found in the River Hamps during the 2009 survey work.

Up-winged fly populations

The riverfly population structures and numbers at different survey points on the R. Dove, R. Manifold and R. Hamps were of both practical interest to anglers and a direct ecological measure of watercourse health. Many anglers on the River Manifold and the River Dove had commented on dwindling numbers of up-winged flies over the last 40 years but we were unable to find any quantifiable historic data to date to scientifically validate these observations. However, nearby rivers from catchments experiencing less agricultural activity appeared to have much healthier up-winged fly populations in terms of diversity and abundance levels. It was evident that riverfly profiles in the Upper Dove Catchment in 2009 needed to be viewed against a backdrop of a number of key environmental stresses including eutrophication, organic pollution and siltation.

There were clearly also seasonal differences in the structure of up-winged fly populations as would be expected from the literature and some interesting specific species patterns. None of the rarer RDB status species up-winged flies were found in the rivers of the Upper Dove Catchment in 2009 like *Ameletus* and *Siphlonorus* species:

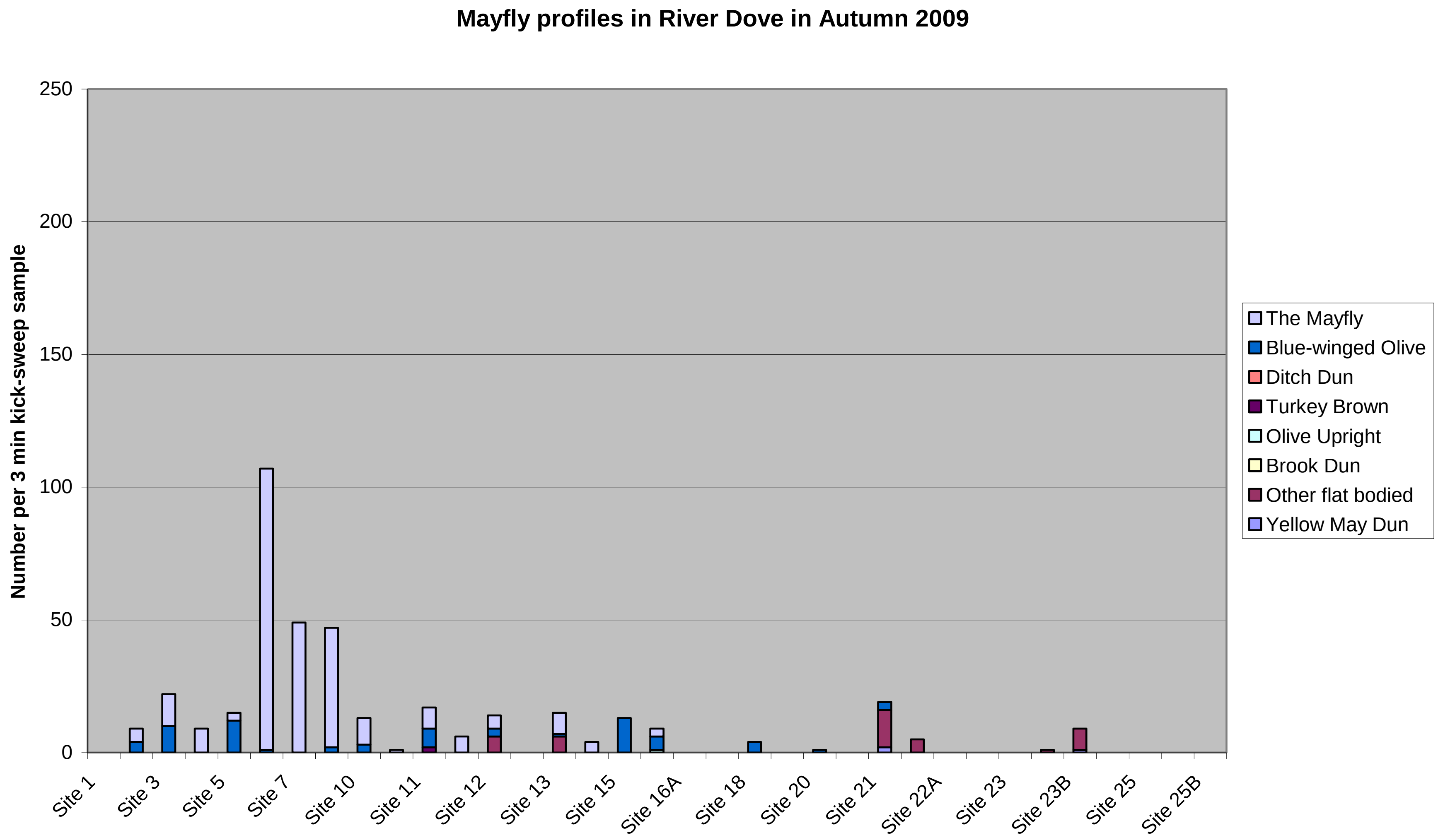

Mayfly profiles in the River Dove in Spring 2009
Number per 3 min kick-sweep sample
250
200
150
100
50
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 9
Site 10
Site 11
Site 12
Site 13
Site 15
Site 16A
Site 17
Site 18
Site19
Site 20
Site 21
Site 22
Site 22A
Site 23
Site 23A
Site 23B
Site 24
Site 25
Mayfly
Blue-winged Olive
Ditch Dun
Turkey Brown
Olive Upright
Large Brook Dun
Other flat bodied
Yellow May Dun

The mayfly (*Ephemera danica*) and the blue-winged olive (*Seratella ignita*) were dominant through the R. Dove in May 2009 but they were replaced in dominance by the olive upright (*Rhithrogena semicolorata*) in the upper reaches of the river.

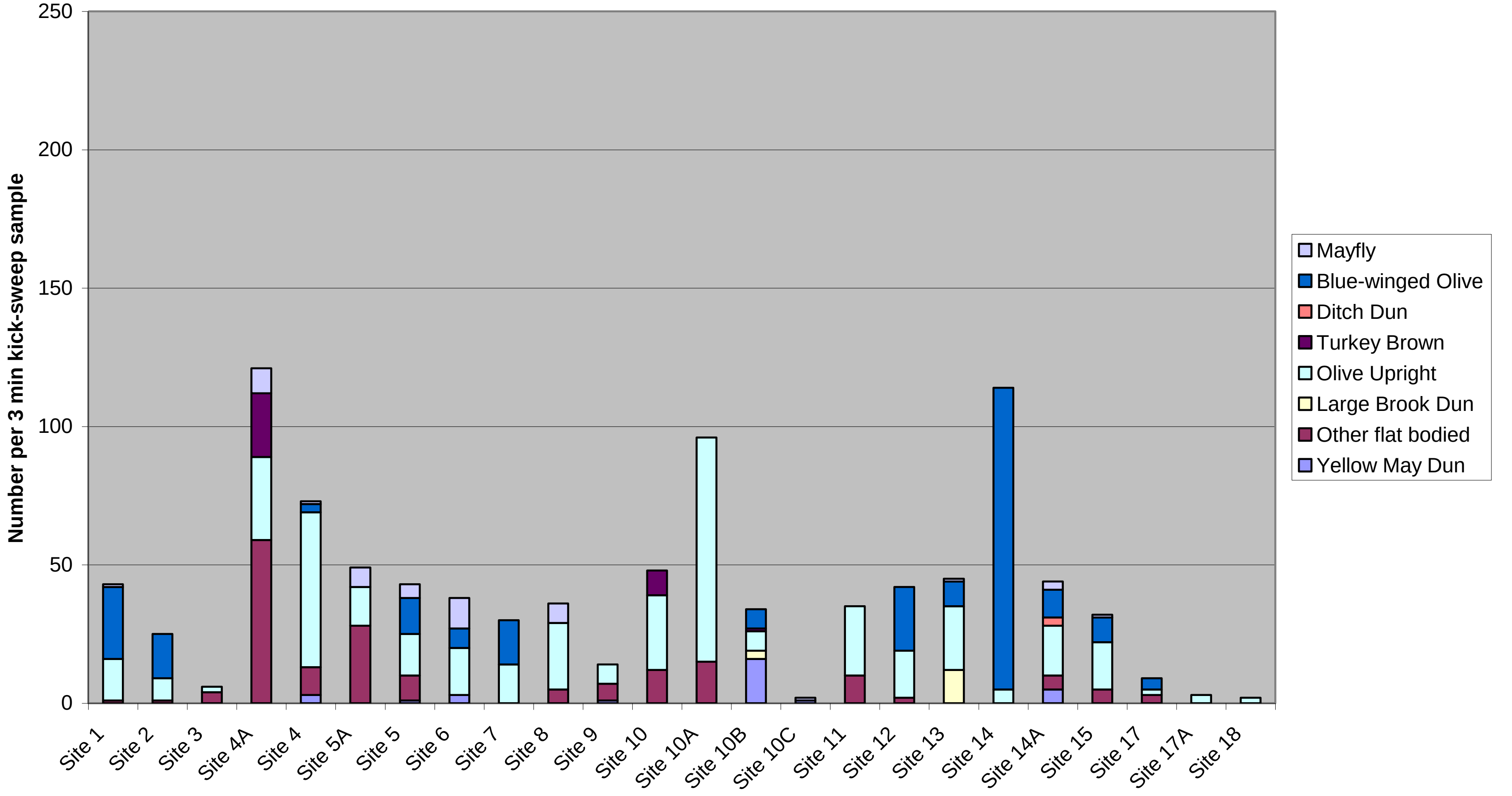
Ephemera danica

Seratella ignita

Rhithrogena semicolorata


Mayfly profiles in River Dove in Autumn 2009
Number per 3 min kick-sweep sample
250
200
150
100
50
0
Site 1
Site 3
Site 5
Site 7
Site 10
Site 11
Site 12
Site 13
Site 15
Site 16A
Site 18
Site 20
Site 21
Site 22A
Site 23
Site 23B
Site 25
Site 25B
The Mayfly
Blue-winged Olive
Ditch Dun
Turkey Brown
Olive Upright
Brook Dun
Other flat bodied
Yellow May Dun

Mayfly profile in the River Manifold in Spring 2009

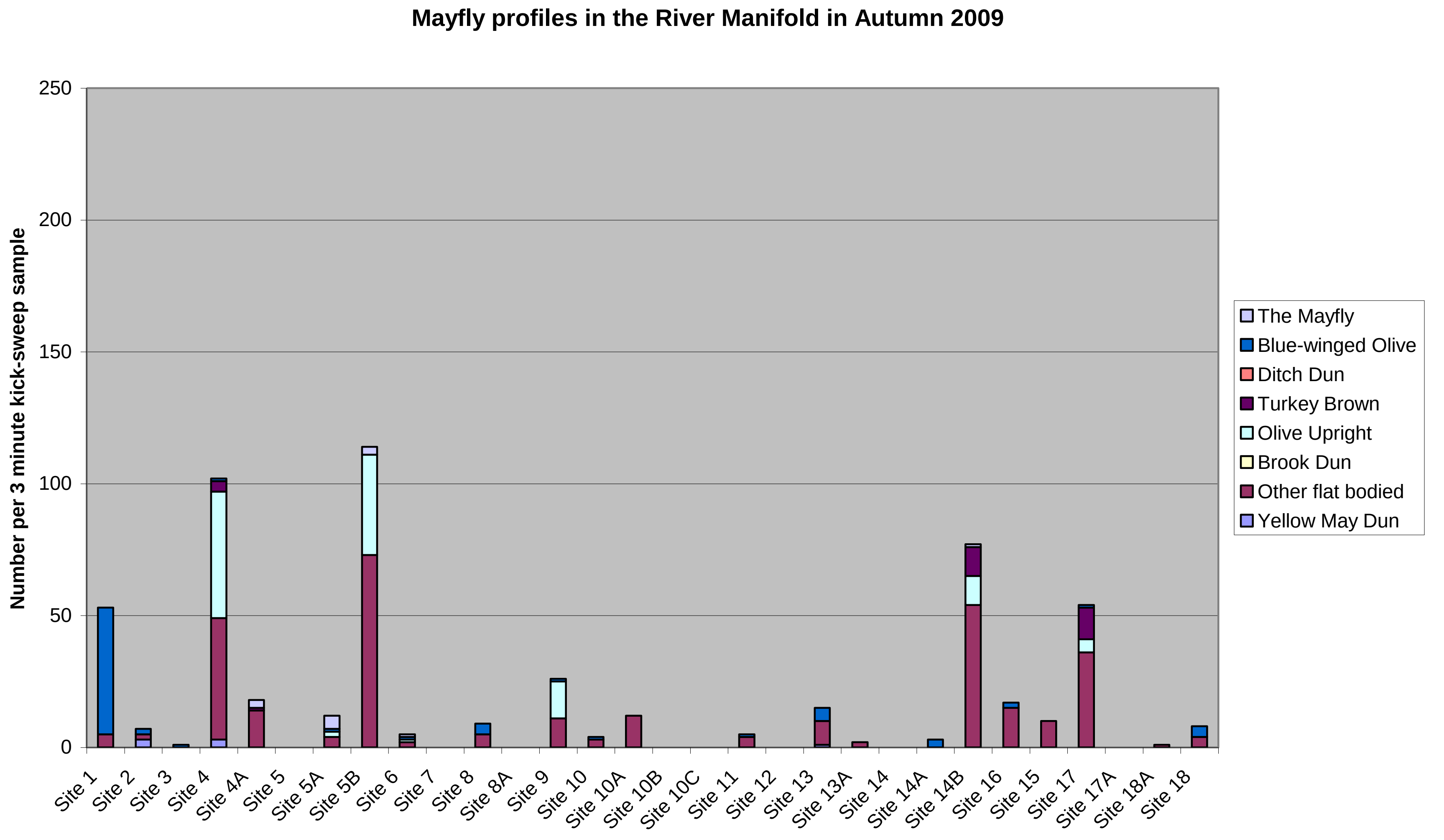


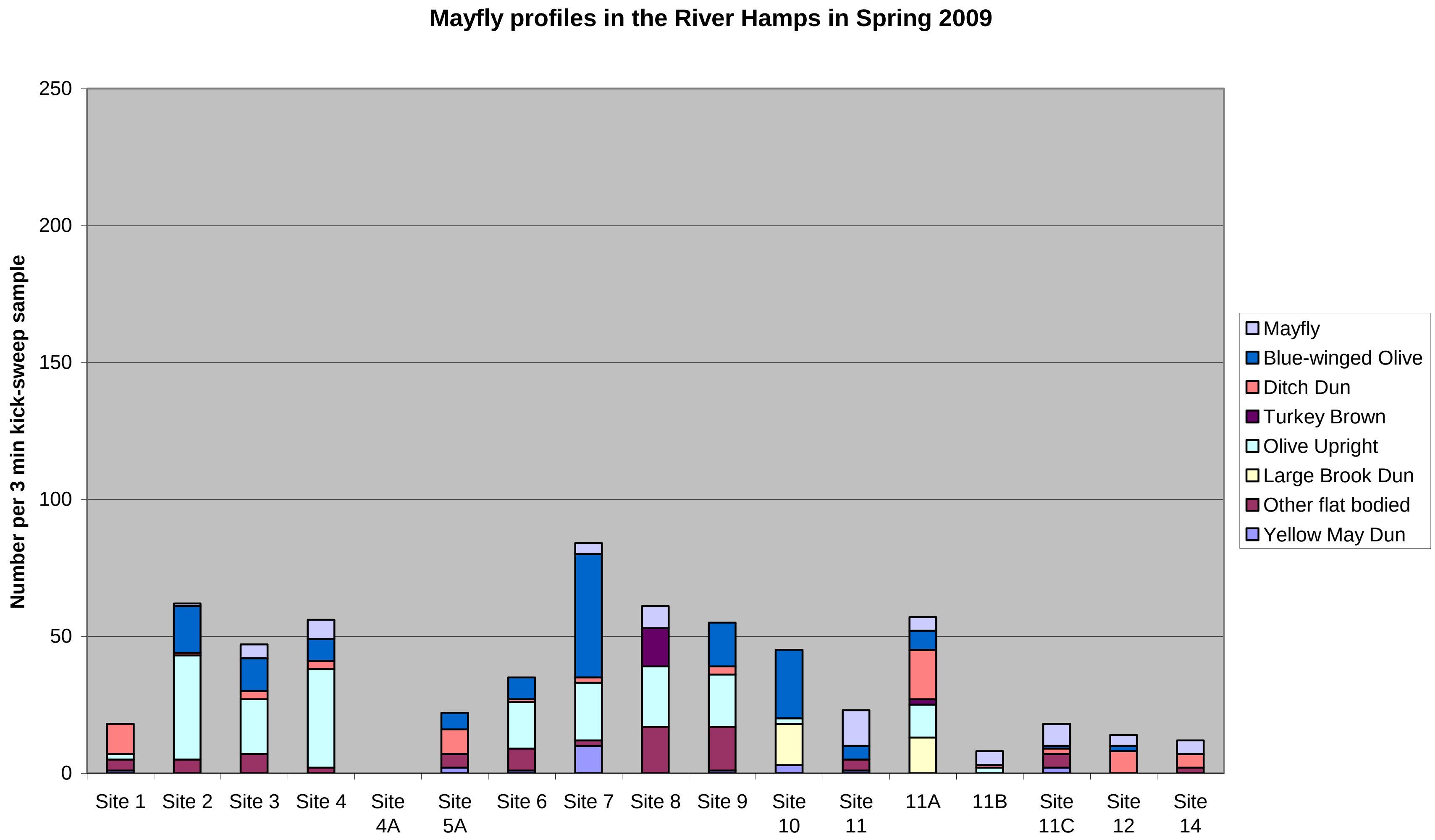
Flat bodied mayflies (*Ecydonorus* species and *Rhithrogena semicolorata*) were dominant through the R. Manifold in May 2009 and were complimented in dominance by the blue-winged olive (*Seratella ignita*) towards the upper reaches of the river.

Ecydonorus venosus/dispar/torrentis

Rhithrogena semicolorata

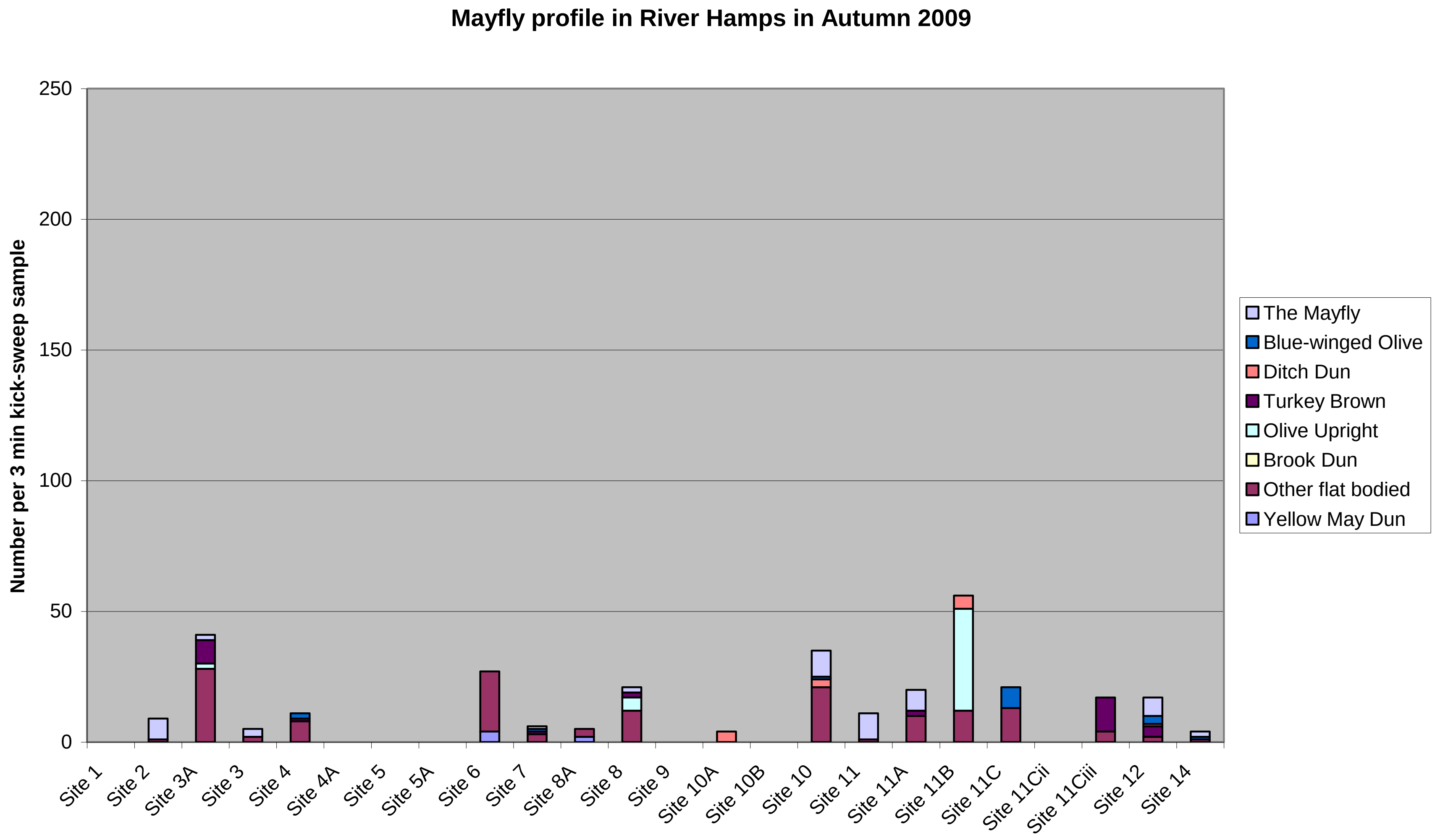
Seratella ignita


Mayfly profiles in the River Manifold in Autumn 2009
Number per 3 minute kick-sweep sample
250
200
150
100
50
0
Site 1
Site 2
Site 3
Site 4
Site 4A
Site 5
Site 5A
Site 5B
Site 6
Site 7
Site 8
Site 8A
Site 9
Site 10
Site 10A
Site 10B
Site 10C
Site 11
Site 12
Site 13
Site 13A
Site 14
Site 14A
Site 14B
Site 16
Site 15
Site 17
Site 17A
Site 18A
Site 18
The Mayfly
Blue-winged Olive
Ditch Dun
Turkey Brown
Olive Upright
Brook Dun
Other flat bodied
Yellow May Dun


Mayfly profiles in the River Hamps in Spring 2009
Number per 3 min kick-sweep sample
250
200
150
100
50
0
Site 1
Site 2
Site 3
Site 4
Site 4A
Site 5A
Site 6
Site 7
Site 8
Site 9
Site 10
Site 11
11A
11B
Site 11C
Site 12
Site 14
Mayfly
Blue-winged Olive
Ditch Dun
Turkey Brown
Olive Upright
Large Brook Dun
Other flat bodied
Yellow May Dun

The R. Hamps had comparable mayfly numbers to the River Manifold but dominated by the blue-winged olive (*Seratella ignita*) and the olive upright (*Rhithrogena semicolorata*) plus a marked presence of the Ditch Dun (*Haprophlebia fusca*) at various main river sites in May (September) 2009.

Habrophlebia fusca
Ditch Dun


Mayfly profile in River Hamps in Autumn 2009
Number per 3 min kick-sweep sample
250
200
150
100
50
0
Site 1
Site 2
Site 3A
Site 3
Site 4
Site 4A
Site 5
Site 5A
Site 6
Site 7
Site 8A
Site 8
Site 9
Site 10A
Site 10B
Site 10
Site 11
Site 11A
Site 11B
Site 11C
Site 11Cii
Site 11Ciii
Site 12
Site 14
The Mayfly
Blue-winged Olive
Ditch Dun
Turkey Brown
Olive Upright
Brook Dun
Other flat bodied
Yellow May Dun

The (NE) Biodiversity Action Plan mayfly species, *Nigrobaetis niger* (Southern Iron Blue), was found in very low numbers in the River Dove (1 site at: Hollinsclough, Beresford Dale and Wolfscote Dale), River Manifold (1 site: Blake Brook) and River Hamps (1 site: near Willow Farm) in 2009.

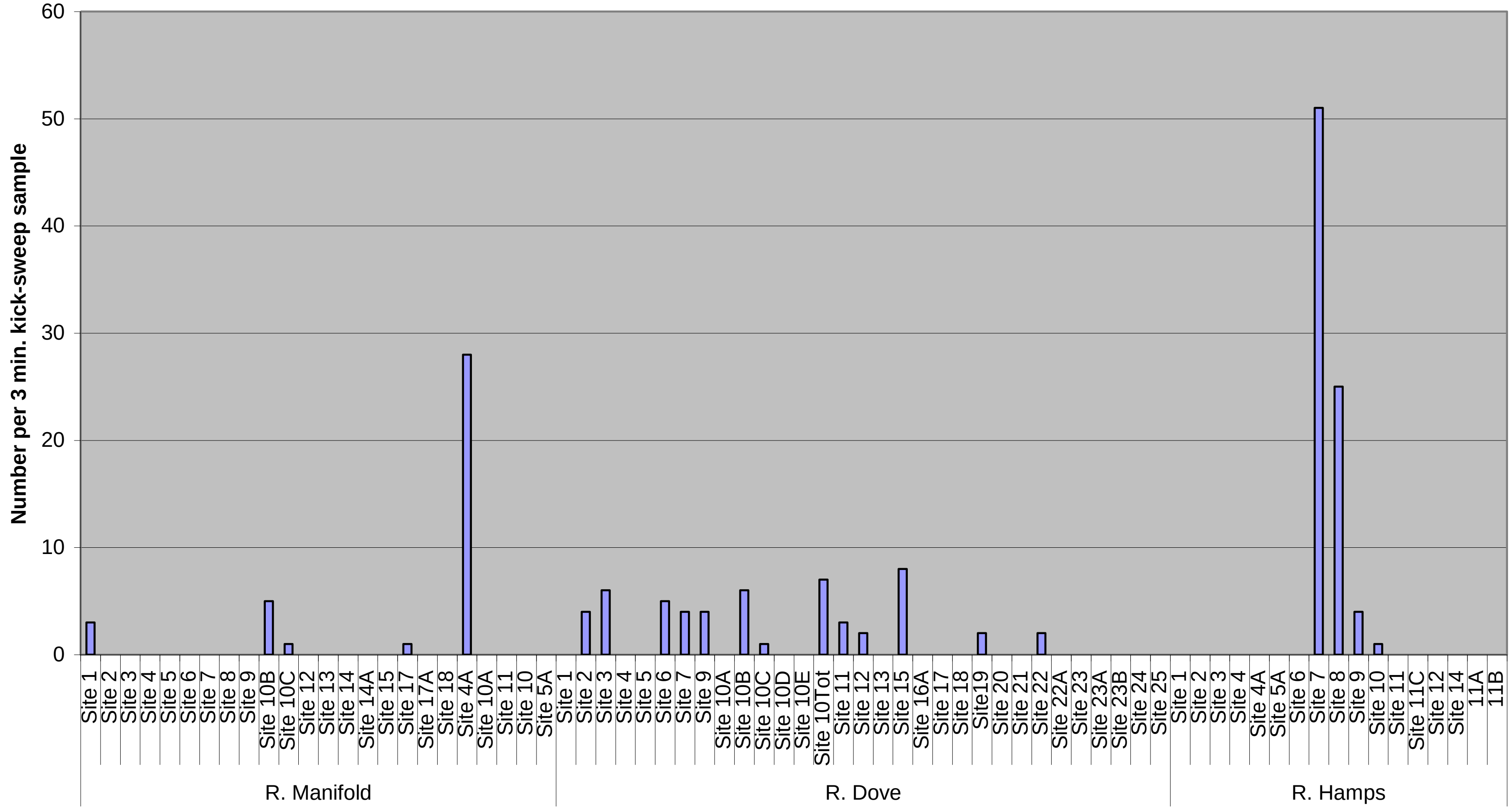
Nigrobaetis niger
Southern Iron Blue

In all probability, this BAP mayfly species was at the effective northern limits of current viable population distribution in the U.K. It was therefore clearly important to keep a handle on existing population numbers of this BAP mayfly in the Upper Dove Catchment in future years.

The Iron Blue Dun (*Alainetes muticus*) was another sentinel up-winged fly which has had a documented population decline in a number of U.K. rivers over the last 20 years (National Riverfly Partnership Co-ordinator C.J. Bennett *pers. comm.*, 2010) and their numbers through the rivers of the Upper Dove Catchment in the Spring of 2009 were of concern.

Alainites muticus
(Iron Blue)

***Alainetes muticus* (Iron Blue Dun) abundance through Upper Dove Catchment rivers in Spring 2009**



Preliminary results from the aquatic ecological assessments of river restoration and improvement work by the Trent Rivers Trust

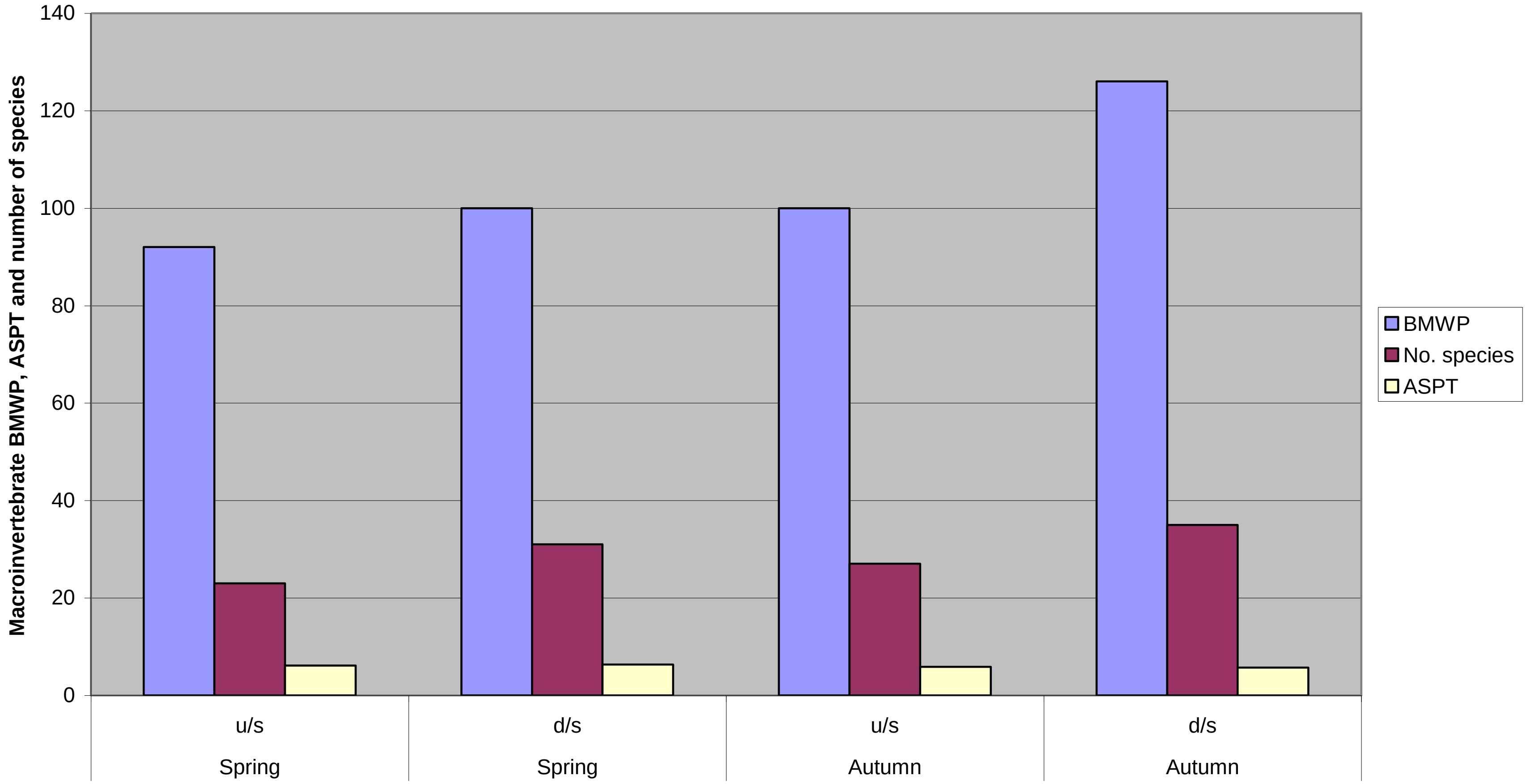
The seasonal biometric measures from the River Manifold at Ludburn Farm in 2009 were tentatively very encouraging as shown in the graphs below.

With only 2 sets of upstream (u/s) and downstream (d/s) data some caution should be applied to any interpretation of the data and another two years monitoring was required to undertake some statistical analysis of the results. However, there appeared to be a seasonal increase in both the BMWP and species richness downstream or river works in the River Manifold at Ludburn Farm in 2009. Increased species richness at the downstream site was, in all probability, accounted for by the proliferation of caddis and snail biodiversity which appeared to be afforded by the in-stream and fine woody debris revetments (Everall *pers. obs.*, 2009 of woody debris *in-situ* at Ludburn).

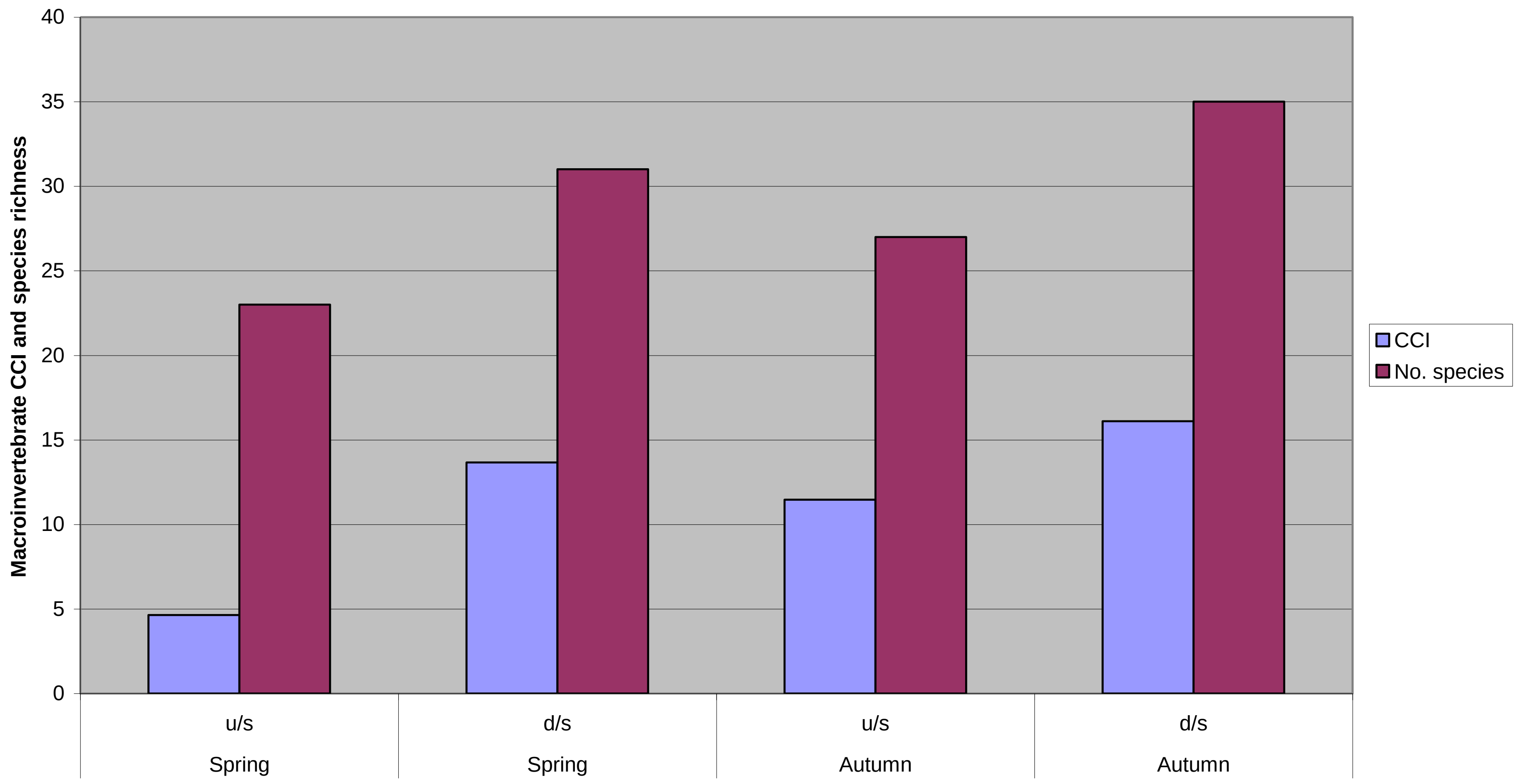
As a result of the measured increase in caddis and snail biodiversity there was a complimentary increase in the CCI or aquatic conservation value of the river works downstream site compared to the upstream area of watercourse.

It was also noted that both organic pollution and siltation impacts appeared less marked downstream of the TRT works in both 2009 survey seasons. It was possible that bank stabilisation from the cattle fencing may have been exerting some effects upon these parameters but it was prudent to look at a longer-term data set before postulating any further upon these findings.

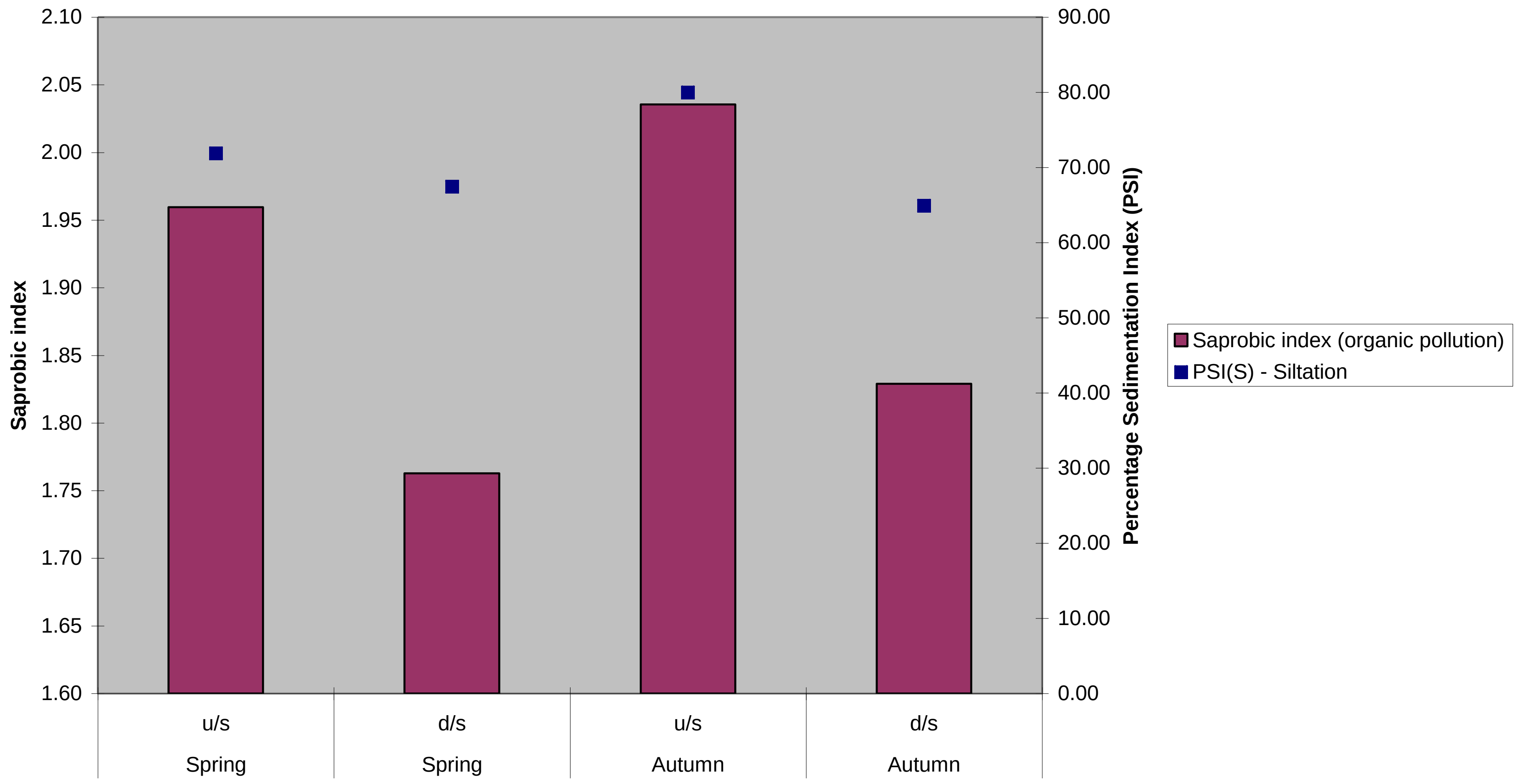
Aquatic macroinvertebrate community changes in the River Manifold up and downstream of cattle fencing and in-stream bankside habitat creation at Ludburn Farm in 2009



Macroinvertebrate Community Conservation Index (CCI) and species richness up and downstream of TRT work at Ludburn Farm in the River Manifold in 2009

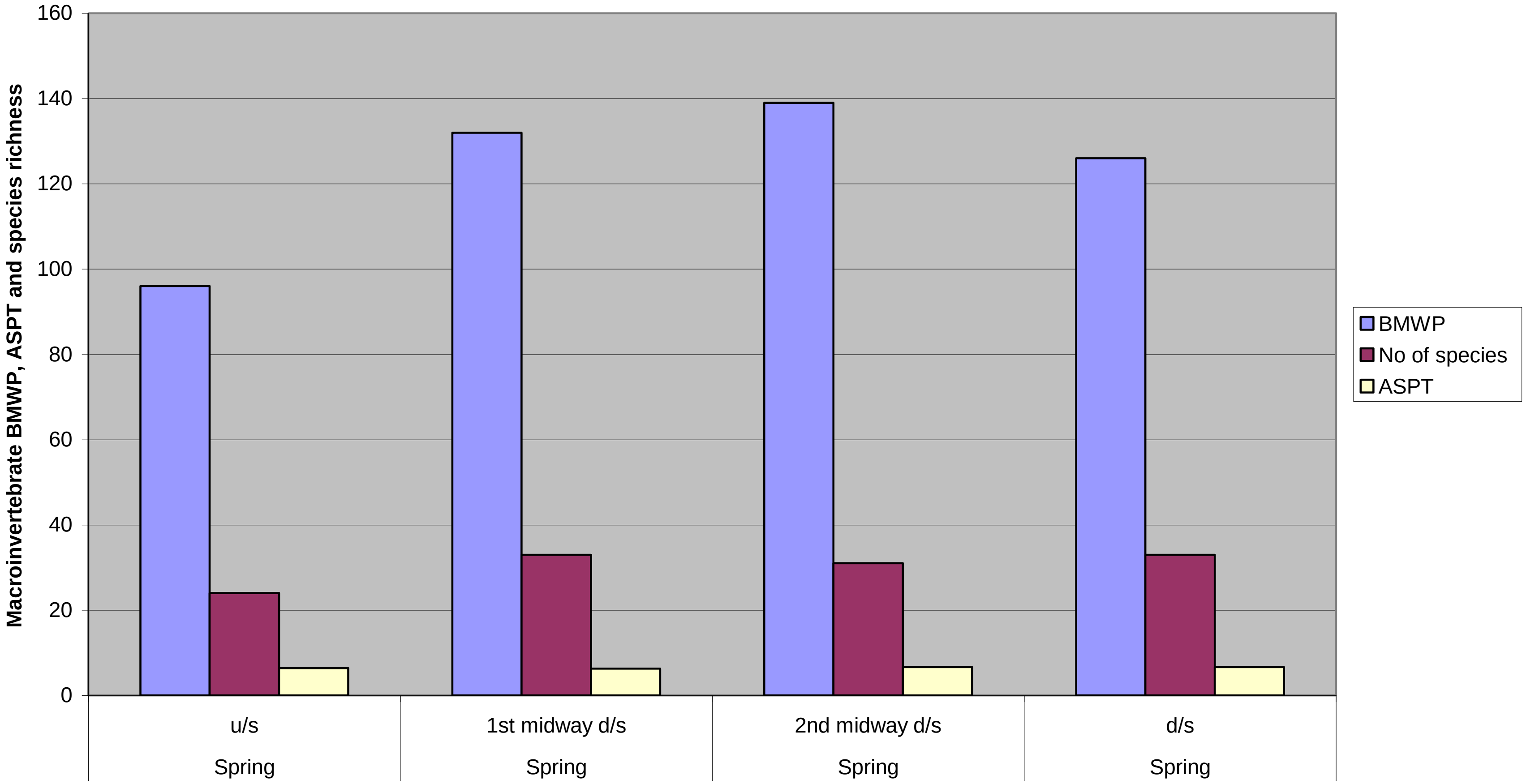


Organic (Saprobic) and siltation (PSI) index from macroinvertebrates up and downstream of cattle fencing and bank work in the River Manifold at Ludburn Farm in 2009

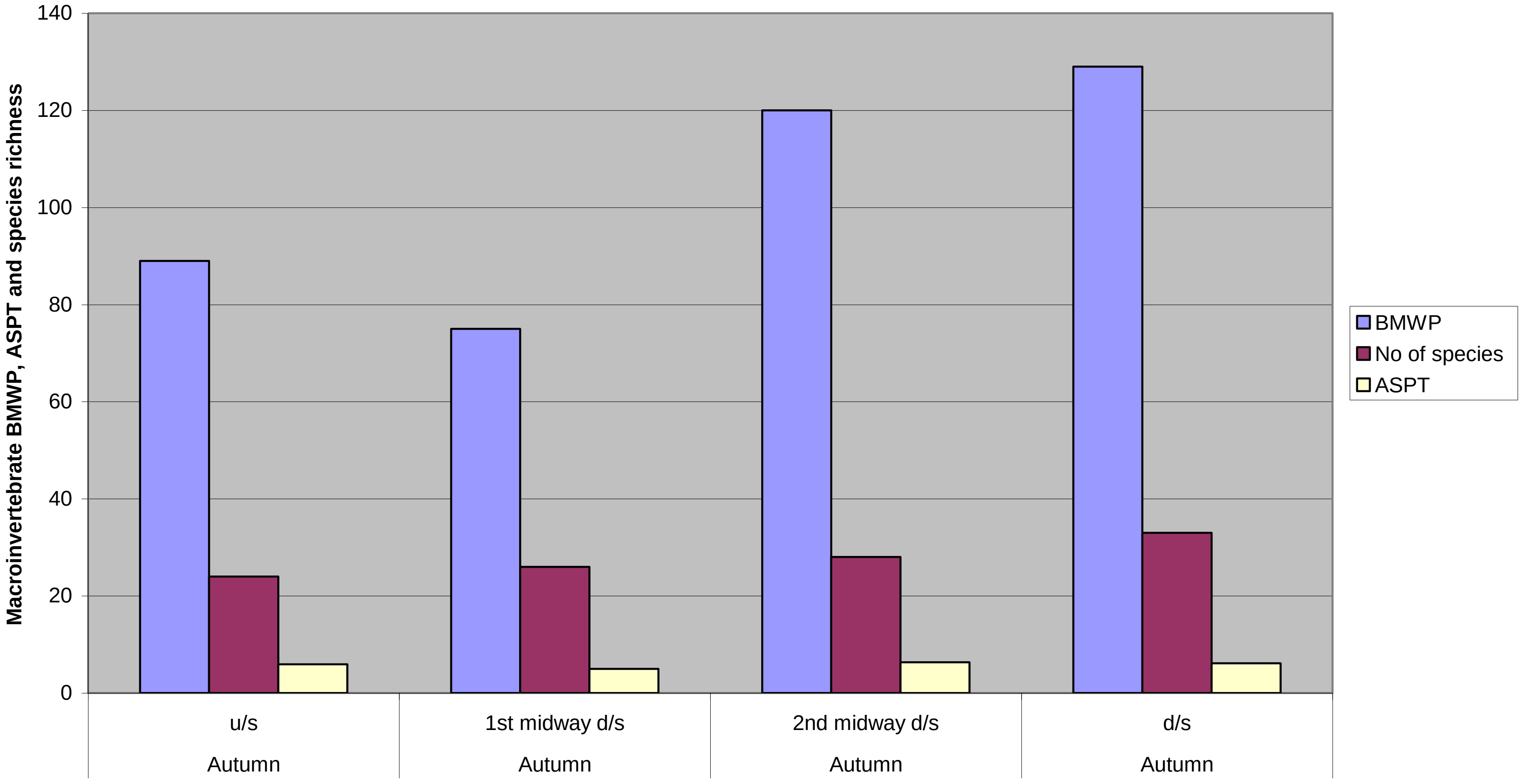


The preliminary results for assessments of river work at Crowdecote on the River Dove in 2009 and shown in the graphs below were less equivocal but understandable.

Aquatic macroinvertebrate community changes in the River Dove up and downstream of cattle fencing and pollarding around Crowdecote from Spring 2009

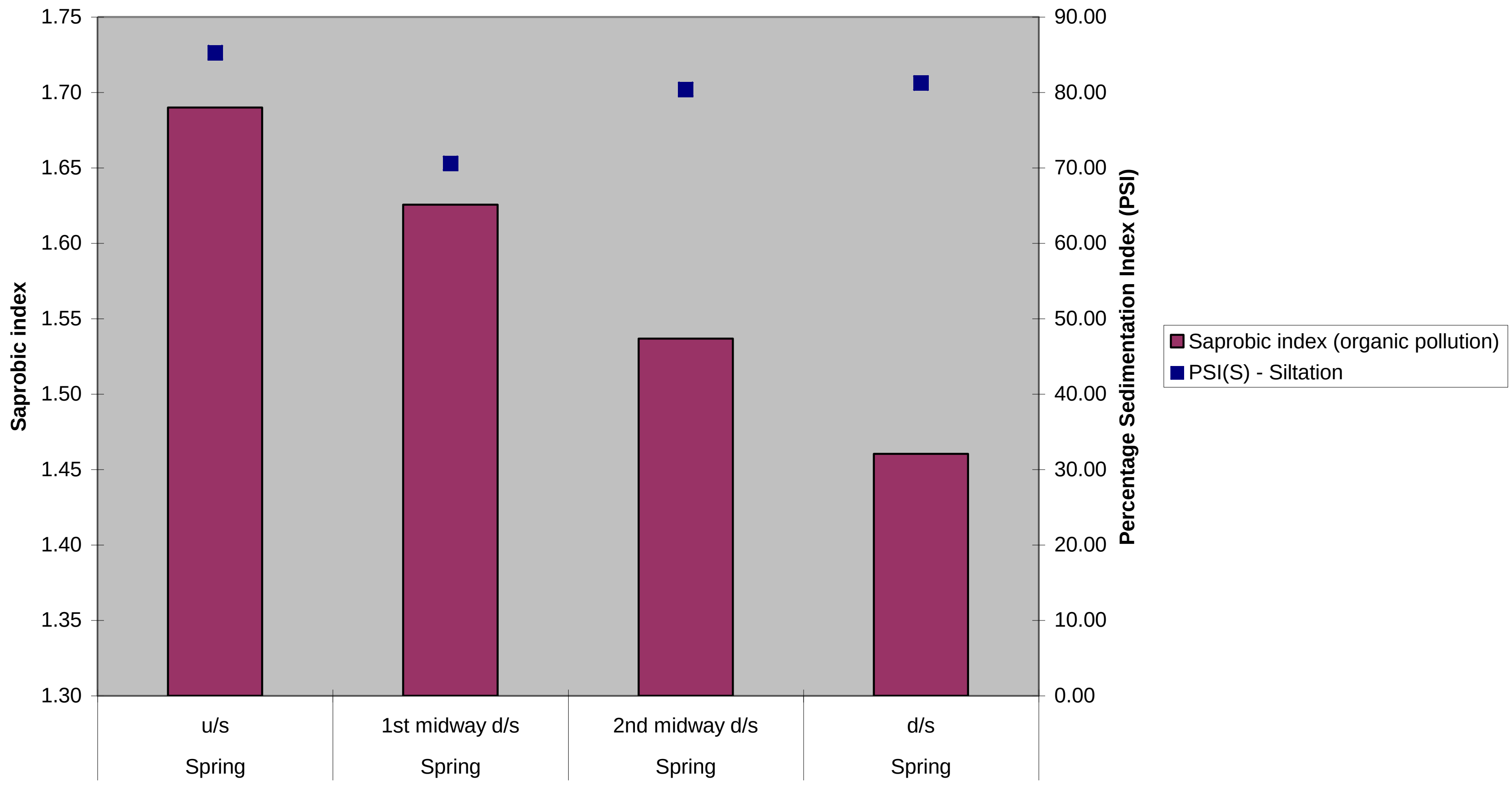


Aquatic macroinvertebrate community changes in the River Dove up and downstream of cattle fencing, coppicing and pollarding around Crowdecote from Autumn 2009 data

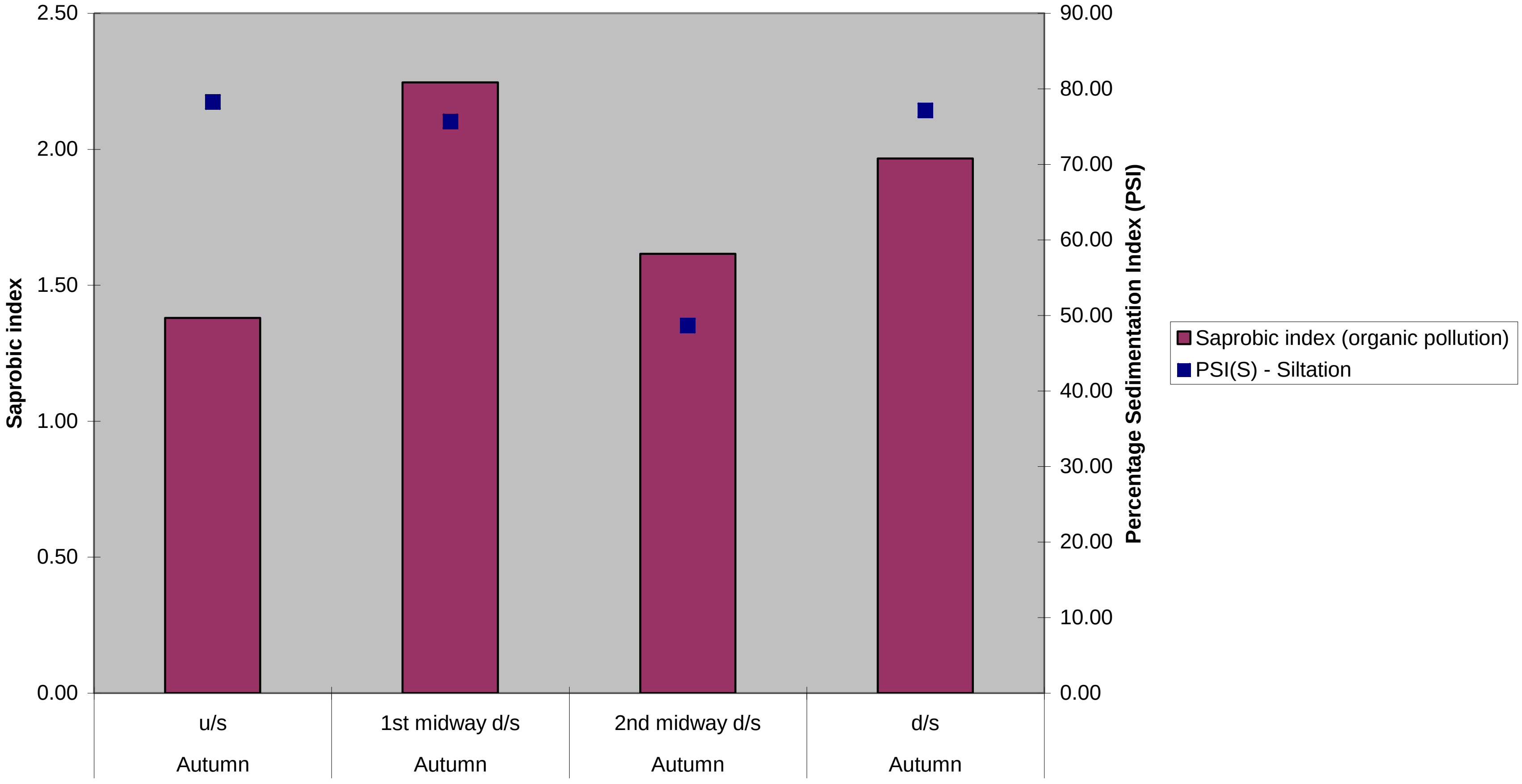


Again with only 2 sets of upstream and downstream data some caution should be applied to any interpretation of the data and another two years monitoring was required to undertake some statistical analysis of the results. However, there appeared to be a seasonal increase in both the BMWP and species richness downstream of river works in the River Dove at Crowdecote in the Spring and Autumn of 2009. The bank side cattle fencing down this section of the River Dove was so extensive that it covered four of the projects macroinvertebrate survey sites and in doing so was more prone to localised anthopogenic or geomorphological impacts than the discrete area of the River Manifold studied at Ludburn in 2009. In all probability, such localised impacts over time may have accounted for the dip in biometrics in the graph above and the evidence of variable organic responses of the macroinvertebrates at the downstream monitoring sites in the Autumn of 2009 in the graphs below.

Organic (Saprobic) and siltation (PSI) index from macroinvertebrates up and downstream of cattle fencing, coppicing and pollarding in the River Dove around Crowdecote from Spring 2009 data



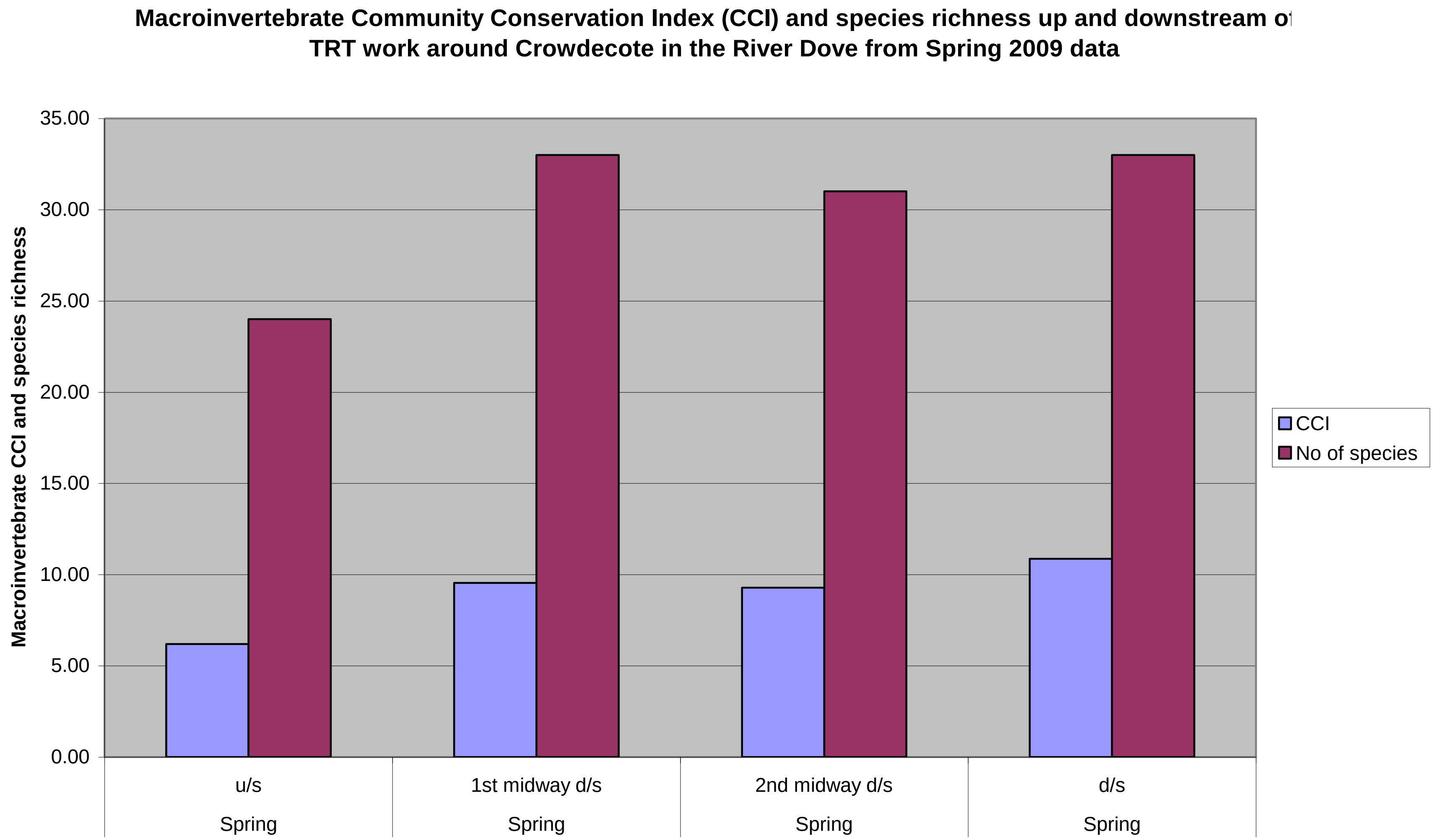
Organic (Saprobic) and siltation (PSI) from macroinvertebrates up and downstream of cattle fencing, coppicing and pollarding work in the River Dove from 2009 Autumn data



Localised and variable siltation effects would also have been likely over such a large study area and may have been highlighted in the previous graphs. It was proposed that other more discretely demarcated sections of watercourse subject to river works were chosen for study in future years and they would provide the opportunity for pre-works benchmarking of the macroinvertebrate community status.

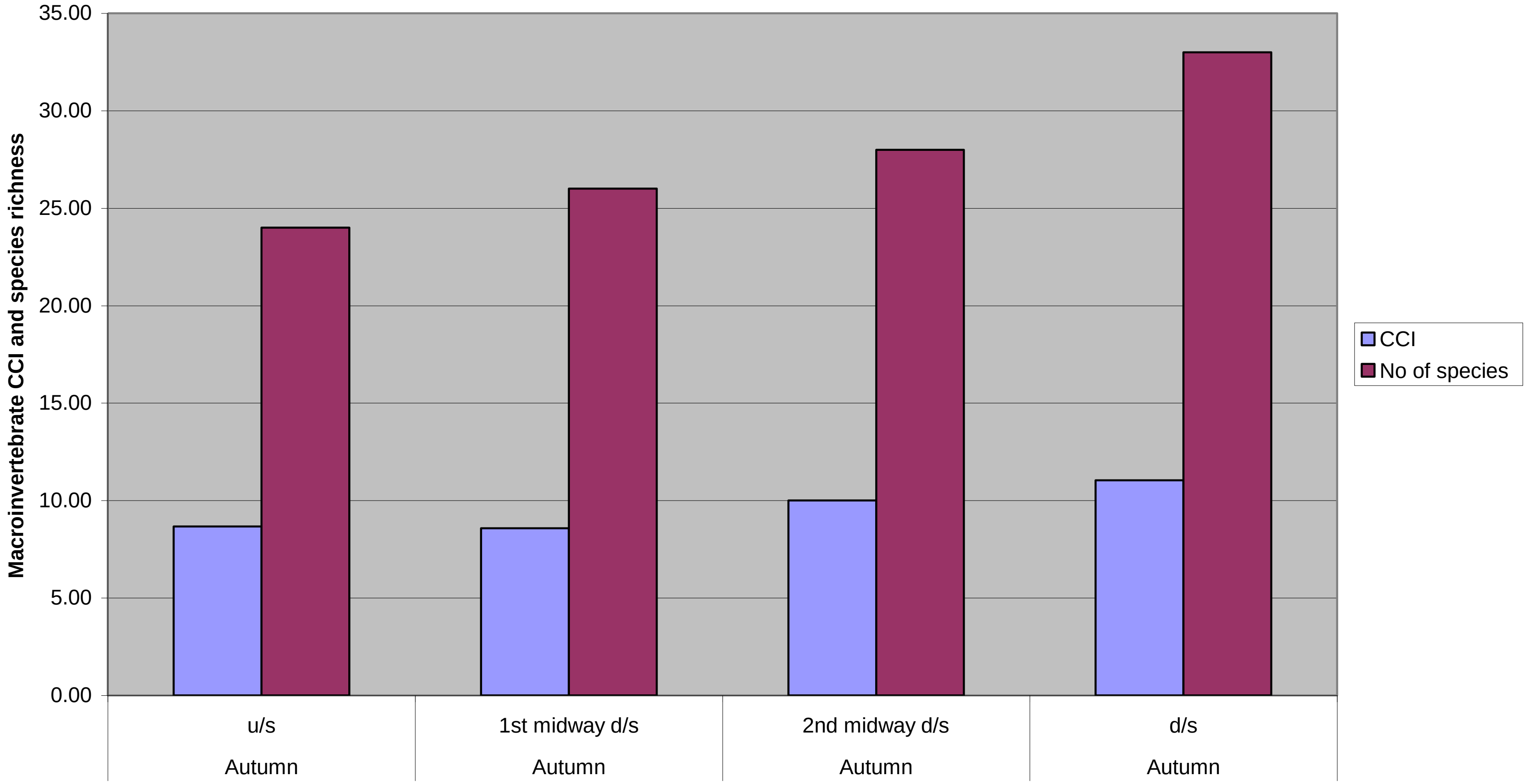
On that basis, the CCI and species richness data for the Crowdecote river works in 2009 was included in the graphs below for completeness and the results appeared encouraging subject to all the previous caveats applied to the existing data.

Habitat can be as important as water quality in encouraging good ecological health in watercourses. However, in all probability, the full benefits of the varied river restoration and improvement work undertaken by the Trent Rivers Trust would not peak until the identified water quality stresses identified in this report were resolved.



Macroinvertebrate Community Conservation Index (CCI) and species richness up and downstream of
TRT work around Crowdecote in the River Dove from Spring 2009 data
Macroinvertebrate CCI and species richness
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
u/s
1st midway d/s
2nd midway d/s
d/s
Spring
CCI
No of species

Macroinvertebrate Community Conservation Index (CCI) and species richness up and downstream of Crowdecote in River Dove from 2009 Autumn data



Traffic light environmental management system

To simplify the interpretation of multiple contamination impacts and to aid the prioritisation of remediation measures, a simple ‘traffic light’ management system was devised for this project. However, such a system could be readily adopted by other agricultural catchments designated a priority for the English Catchment Sensitive Farming Delivery Initiative (ECSFDI) where similar temporal and scale appropriate monitoring schemes have been implemented.

The tables below show a look up matrix by river where any survey site can be assessed for remedial action in terms of the current benchmarked aquatic conservation value, the degree and nature of key of pollutant stressors against the immediate presence or absence of actual ecological impact. While the other (CCI, Saprobic and PSI) indices at river sites in the Upper Dove Catchment had been outlined in this report the current ecological impact was taken as significantly depressed BMWP, ASPT and/or species richness at a site. A key was provided below each table but the transition from fluorescent/dark green through straw/amber to red indicated a worsening condition in each assessed category.

The example below from the River Dove in 2009 indicated a site with currently good conservation status remaining but significant concerns over organic and silt impacts upon a stressed ecology. Such a site would clearly warrant further investigation, appropriate remedial action and impact trend monitoring.

Site 11	Dove	SK13503 -57515	Wolfscote Dale				

A photograph of this survey site in the River Dove was shown below.

The overall ‘traffic light’ assessment of the 2009 data from watercourse sites in the Upper Dove Catchment was presented in the tables overleaf.

River Dove 2009 (Synopsis of Spring and Autumn data)

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI$_S$)	Current ecological impact
Site 1	Dove	SK14568-50292	d/s junction with R. Manifold	light green	orange	light green	dark green
Site 2	Dove	SK14604-50394	u/s junction with R. Manifold	dark green	light green	light green	dark green
Site 3	Dove	SK14756-51075	Dovedale nr. Thorpe Cloud	dark green	light green	light green	light green
Site 4	Dove	SK145520	Dovedale nr. Lovers Leap	dark green	light green	light green	light green
Site 5	Dove	SK145520	Dovedale	light green	light green	light green	
Site 6	Dove	SK142536	Dovedale nr. Dove Caves	light green	light green	orange	light green
Site 7	Dove	SK13892-54589	Milldale	light green	light green	light green	light green
Site 9	Dove	SK14578-56070	u/s Milldale bottom Wolfscote Dale	light green	light green	light green	light green
Site 10	Dove	SK143568	Wolfscote Dale – Gypsy Bank	orange	light green	orange	dark green
Site 11A	Dove	SK12735-58205	Brook from Field House Farm	orange	orange	red	yellow
Site 11	Dove	SK13503-57515	Wolfscote Dale	dark green	orange	orange	orange
Site 12A	Dove	SK128585	Brook adj. rd at Bottom Beresford Dale	dark green	dark orange	orange	orange
Site 12	Dove	SK12823-58596	Bottom Beresford Dale	light green	orange	light green	yellow
Site 12B	Dove	SK125594	Brook from Hurst Farms	red	orange	orange	yellow
Site 13	Dove	SK12100-59800	Hartington Road Bridge	orange	light green	light green	light green
Site 14	Dove	SK12264-60910	u/s Hartington Creamery	orange	light green	light green	light green
Site 15	Dove	SK12637-61902	Sprink	light green	light green	dark green	light green
Site 16	Dove	SK117634	Pilsbury	light green	dark green	light green	dark green
Site 16A	Dove	SK12358-62496	Ludwell Spring	light green	light green	orange	light green
Site 17	Dove	SK10935-64328	Under Whittle	light green	dark green	dark green	dark green

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI_S)	Current ecological impact
Site 18	Dove	SK10173-64960	d/s Crowdecote Rd Bridge	Of some concern in category	Good in category	Of marked concern in category	Of some concern in category
Site19	Dove	SK09370-65728	Beggar Bridge	Significant concern	Significant concern	Significant concern	Significant concern
Site 20	Dove	SK08400-66500	Glutton Bridge	Significant concern	Good in category	Of some concern in category	Significant concern
Site 20A	Dove	SK077668	Brook from Dowall Hall	Of some concern in category	Of some concern in category	Of some concern in category	Of marked concern in category
Site 21	Dove	SK07502-66877	just u/s of road track ford crossing river	Of some concern in category	Of some concern in category	Good in category	Good in category
Site 22	Dove	SK06290-66869	Bottom footpath from Hollinsclough	Good in category	Good in category	Significant concern	Good in category
Site 22A	Dove	SK06794-67002	Swallow Brook	Significant concern	Of marked concern in category	Of some concern in category	Significant concern
Site 22B	Dove	SK065665	Brook thro' Hollinsclough	Of some concern in category	Of marked concern in category	Of some concern in category	Serious problem
Site 23	Dove	SK05298-67333	Tenterhill d/s tribs	Exceptionally good in category	Good in category	Of some concern in category	Exceptionally good in category
Site 23A	Dove	SK05181-67166	Brook from Tenterhill	Of some concern in category	Significant concern	Significant concern	Good in category
Site 23B	Dove	SK05106-67630	Brook from Brandside	Of some concern in category	Good in category	Of some concern in category	Good in category
Site 24	Dove	SK04411-68202	u/s Brandside & other brooks	Of some concern in category	Of some concern in category	Of some concern in category	Good in category
Site 25	Dove	SK03894-68312	Below road d/s main source of Dove	Of some concern in category	Of marked concern in category	Of some concern in category	Good in category
Site 25A	Dove	SK037684	Brook from main source Dove	Of some concern in category	Of marked concern in category	Of some concern in category	Serious problem
Site 25B	Dove	SK039685	Brook from Axe Edge Car Park	Of some concern in category	Good in category	Of some concern in category	Significant concern
Site 26	Dove	SK033698	Brook on Axe Edge u/s Car Park	Exceptionally good in category	Good in category	Of some concern in category	Good in category

- **Exceptionally good in category**
- **Good in category**
- **Of some concern in category**
- **Of marked concern in category**
- **Significant concern**
- **Serious problem**

River Manifold 2009 (Synopsis of Spring and Autumn data)

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI_s)	Current ecological impact
Site 1	Manifold	SK14568-50292	Below Ilam Rd bridge	(light green)	(dark green)	(light green)	(dark green)
Site 2	Manifold	SK13572-50867	Ilam Rd bridge	(light green)	(dark green)	(light green)	(yellow)
Site 3	Manifold	SK13168-50566	Ilam Hall d/s Manifold Springs	(light green)	(dark green)	(light green)	(yellow)
Site 4A	Manifold	SK09573-56084	Hoo Brook	(dark green)	(light green)	(dark green)	(dark green)
Site 4B	Manifold	SK09593-56156	Hoo Brook (Butterton)	(dark green)	(dark green)	(dark green)	(dark green)
Site 4	Manifold	SK09573-56084	Wetton Mill	(dark green)	(light green)	(dark green)	(dark green)
Site 5A	Manifold	SK092577	Warslow Brook	(light green)	(light green)	(light green)	(yellow)
Site 5B	Manifold	SK059588	Warslow Brook	(light green)	(dark green)	(dark green)	(dark green)
Site 5	Manifold		Swainsley	(light green)	(dark green)	(light green)	(dark green)
Site 6	Manifold	SK10013-58676	Ecton	(light green)	(dark green)	(light green)	(dark green)
Site 7	Manifold		Hulme End	(yellow)	(light green)	(light green)	(dark green)
Site 8	Manifold	SK10257-60057	Low End	(dark green)	(light green)	(light green)	(dark green)
Site 8A	Manifold	SK097607	nr. Hulme House	(bright green)	(yellow)	(light green)	(orange)
Site 9	Manifold	SK09665-60775	Brund	(dark green)	(light green)	(light green)	(dark green)
Site 10	Manifold	SK096622	Downstream Ludburn Farm	(dark green)	(light green)	(light green)	(dark green)
Site 10A	Manifold	SK09217-62118	Blake Brook	(light green)	(light green)	(dark green)	(yellow)
Site 10B	Manifold		Blake Brook	(light green)	(light green)	(dark green)	(dark green)
Site 10C	Manifold		Blake Brook Bridge End	(light green)	(light green)	(dark green)	(dark green)
Site 11	Manifold	SK096627	Upstream Ludburn farm	(light green)	(light green)	(light green)	(yellow)
Site 12	Manifold	SK09399-63872	Over Boothlow	(light green)	(orange)	(orange)	(red)

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI_S)	Current ecological impact
Site 13	Manifold	SK08657-64657	d/s Longnor rd bridge	Of some concern	Of some concern	Of some concern	Of some concern
Site 13A	Manifold	SK082647	Oakenclough feeder stream	Of marked concern	Of some concern	Of some concern	Of marked concern
Site 14A	Manifold	SK08879-64443	Oakenclough feeder stream	Of some concern	Good	Of some concern	Good
Site 14	Manifold	SK05500-63647	Hardings Booth	Good	Of some concern	Significant concern	Of marked concern
Site 15	Manifold	SK06797-64597	Hardings Booth	Of some concern	Of some concern	Significant concern	Of marked concern
Site 16	Manifold	SK05276-65239	Ball Bank House Farm	Good	Of some concern	Good	Good
Site 17	Manifold	SK05221-65329	d/s High Ash Farm	Good	Of some concern	Of some concern	Significant concern
Site 17A	Manifold	SK05016-65303	High Ash feeder stream	Of some concern	Good	Good	Significant concern
Site 18A	Manifold	SK04507-66035	Feeder brook at Thick Withins Fm	Good	Good	Good	Significant concern
Site 18	Manifold	SK04695-65994	Thick Withins Farm	Of some concern	Good	Of some concern	Significant concern

- **Exceptionally good in category** (bright green)
- **Good in category** (dark green)
- **Of some concern in category** (pale green)
- **Of marked concern in category** (yellow)
- **Significant concern** (orange)
- **Serious problem** (red)

River Hamps 2009 (Synopsis of Spring and Autumn data)

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI_S)	Current ecological impact
Site 1	Hamps	SK08276-51905	Brook at Waterfall	dark green	orange	orange	light green
Site 2	Hamps	SK08422-50239	Waterhouses	light green	light green	yellow	light green
Site 3A	Hamps	SK07535-50225	Feeder brook u/s Waterhouses	light green	dark green	light green	dark green
Site 3	Hamps	SK07535-50225	u/s Waterhouses	light green	yellow	dark green	light green
Site 4	Hamps	SK06403-50744	nr. Willow Farm	dark green	light green	light green	light green
Site 4A	Hamps	SK06298-50731	Trib Brook	light green	light green	light green	light green
Site 5	Hamps	SK-06000-51400	Winkhill	Awaiting Autumn data analysis			
Site 5A	Hamps	SK05980-51405	Blackbrook	light green	orange	light green	yellow
Site 6	Hamps	SK06379-51904	Pethills	dark green	light green	dark green	dark green
Site 7	Hamps	SK06805-53204	Felthouse	light green	yellow	light green	light green
Site 8A	Hamps	SK06314-53957	Feeder brook at Ford	dark green	dark green	dark green	light green
Site 8	Hamps	SK065538	Ford	light green	light green	light green	dark green
Site 9	Hamps	SK05772-54505	d/s Onecote	light green	light green	light green	light green
Site 10A	Hamps	SK05040-55211	Feeder brook	light green	light green	orange	light green
Site 10B	Hamps	SK050552	Feeder brook running alongside main road	red	orange	red	red
Site 10	Hamps	SK049551	Onecote u/s road	light green	light green	light green	light green
Site 11	Hamps	SK04680-56299	River u/s Grange	dark green	light green	light green	light green
11A	Hamps	SK04617-55441	Mixon feeder Brook d/s Grange	light green	light green	light green	light green
11B	Hamps	SK04556-55459	Small feeder brook u/s Grange	dark green	dark green	light green	dark green
Site 11C	Hamps	SK04164-55663	Mixon feeder brook u/s Grange	dark green	light green	light green	light green

Site no.	River	Grid ref	Site description	Overall conservation value	Organic pollution (Saprobic index)	Siltation (PSI_S)	Current ecological impact
Site 11Cii	Hamps	SK034564	Mixon feeder brook nr. White Lea Farm	Significant concern	Of some concern in category	Of some concern in category	Of some concern in category
Site 11Ciii	Hamps	SK028759	Mixon feeder brook u/s Old Mixon Hay Fram	Of some concern in category	Of some concern in category	Of some concern in category	Of some concern in category
Site 12	Hamps	SK04716-57345	Mixon mine	Of some concern in category	Of some concern in category	Of some concern in category	Of some concern in category
Site 14	Hamps	SK04484-59261	Royledge	Good in category	Of some concern in category	Of some concern in category	Of some concern in category

Exceptionally good in category

Good in category

Of some concern in category

Of marked concern in category

Significant concern

Serious problem

It should be noted that all of the multi-metric macroinvertebrate community tests used in the 2009 survey work in the Upper Dove Catchment had shown the same consistent (seasonal) site patterns of environmental stress and ecological impact.

In the next phase of the project the data was being plotted onto ARC maps by Aquascience/Loughborough University personnel to provide a topographically visual summary of this data to aid CSF, NE and TRT personnel with the English Catchment Sensitive Farming Delivery Initiative (ECSFDI).

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Appendix 1 - Ad hoc fish data from Upper Dove Catchment surveys in 2009

A number of fish (lamprey) species of varying conservation value were inadvertently captured, recorded and released as part of the macroinvertebrate sampling programme. The records for these animals were summarised in the map below.

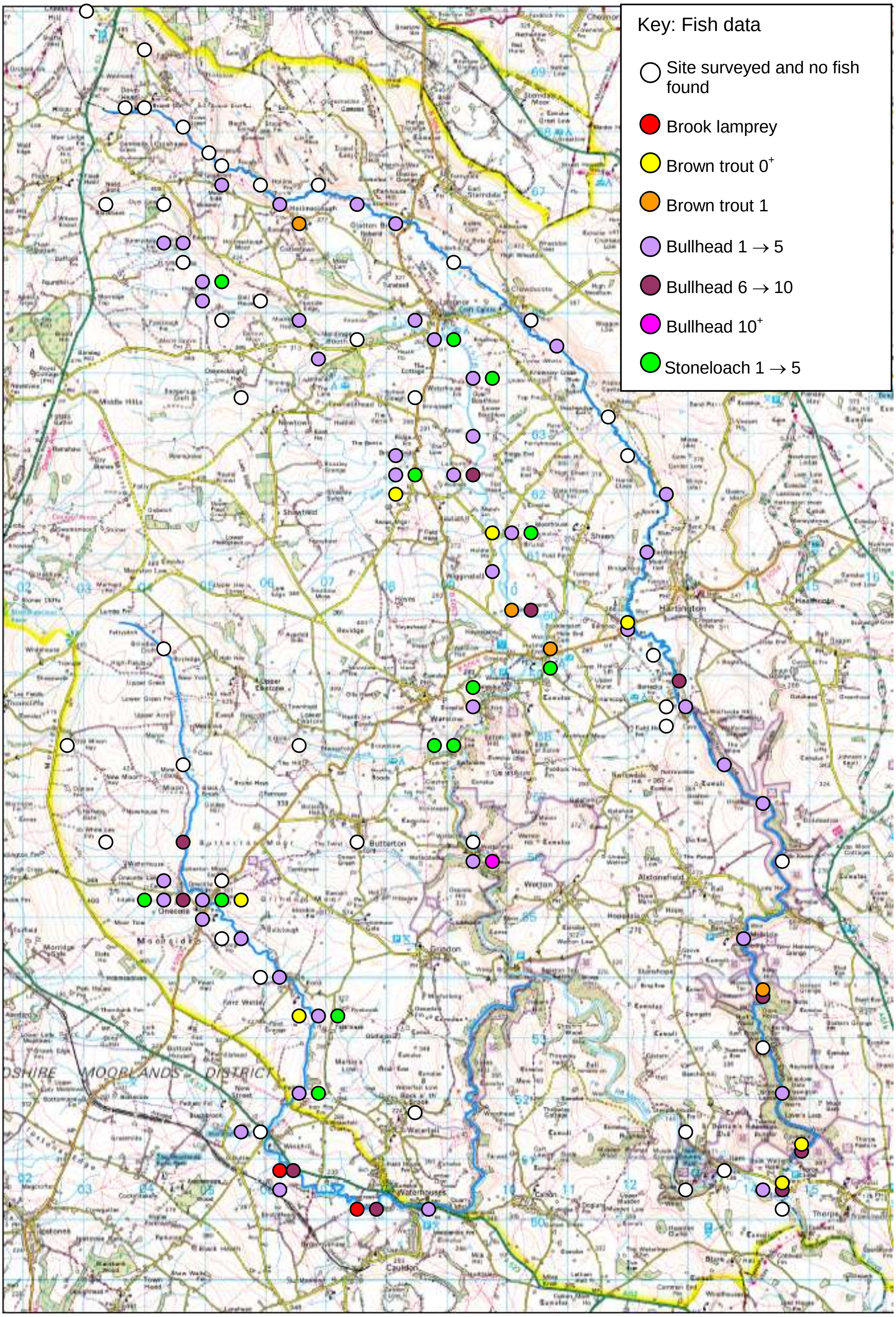
The macroinvertebrate survey technique was designed to monitor sedentary animals and so the bullhead recordings were the only fish data with any reliability for reflections of fish presence and absence through these rivers. The survey techniques would not and were not required to provide any estimates of the size of bullhead populations. The bullhead is listed on Annex II of the EC Habitats Directive.

The river lamprey was classified as Least Concern (LC) on the IUCN Red List (3) but listed on Annex III of the Bern Convention, Annexes II and V of the EC Habitats Directive and Schedule 3 of the Conservation Regulations (1994). River lampreys were only recorded in two feeder streams off the River Hamps but these macroinvertebrate sampling techniques did not preclude the possibility of their presence throughout all of these river systems.

Brook lamprey

Brown trout

Bullhead



Key: Fish data
Site surveyed and no fish found
Brook lamprey
Brown trout 0+
Brown trout 1
Bullhead 1 → 5
Bullhead 6 → 10
Bullhead 10+
Stoneloach 1 → 5

Other Appendices

Appendix 2a All macroinvertebrate data from Upper Dove Catchment from Spring 2009 (EXCEL doc) - Available on request by contacting enquiries@naturalengland.org.uk

Appendix 2b All macroinvertebrate data from Upper Dove Catchment from Autumn 2009 (EXCEL doc) - Available on request by contacting enquiries@naturalengland.org.uk

Appendix 3 Agriculture Pollution Index results 2009 from Upper Dove Catchment surveys in 2009 - Available on request by contacting enquiries@naturalengland.org.uk

Appendix 4a Predominant periphyton communities found in the Upper Dove Catchment Spring surveys in 2009 - Available on request by contacting enquiries@naturalengland.org.uk

Appendix 4b Predominant periphyton communities found in the Upper Dove Catchment Autumn surveys in 2009 - Available on request by contacting enquiries@naturalengland.org.uk