An Investigation of Ecological Change in the Rivers Kennet and Lambourn

Progress report for the period April 2001 – March 2002

J. F. Wright, R. J. M. Gunn, J. M. Winder,
N. T. Kneebone. J. Davy-Bowker and H. M. Vincent

Centre for Ecology and Hydrology, Dorset

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ENVIRONMENT AGENCY

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This report presents the results of a repeat survey of invertebrates and plants on the Rivers Kennet and Lambourn. It is intended for use by the Agency's staff and others interested in the ecology and management of chalk rivers and the effects of both low and high flows.

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The study would not have been possible without the active cooperation and help of riparian landowners and river keepers. As in previous years, the team was allowed access to each study site and for this we are most grateful. At Bagnor, we were granted access to the River Lambourn by the Donnington Grove Country Club, at the Littlecote Estate we received help and advice from Head Keeper Mr P Woolnough and at Savernake we received similar assistance from Head Keeper Mr J Hounslow.

Finally, given the widespread outbreak of foot and mouth disease in 2001, we would like to reiterate our thanks to the Agency for advice received and to the riparian landowners and river keepers for their cooperation in allowing access to the study sites.

KEY WORDS

Chalk streams; low flows; discharge; ecological change; macrophytes; macroinvertebrates

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Kennet and Lambourn catchments are important regionally for water supply, fisheries and conservation. There is a need for reliable long-term data on the ecology of these chalk streams to ensure effective management and to fulfil the UK Biodiversity Action Plan. Between 1971 and 1979, an intensive study took place on the macrophytes and macroinvertebrates at a site on the River Lambourn at Bagnor. Between 1974 and 1976, further studies took place at three sites on the River Kennet (Upper and lower sites at Savernake downstream of Marlborough and at Littlecote, upstream of Hungerford).

In 1997, the Environment Agency (Thames Region) commissioned the Institute of Freshwater Ecology (IFE) to re-examine these four sites in summer (June/July) and winter (December) using the 1970s protocols. The macrophytes were mapped and a quantitative sampling programme for macroinvertebrates was undertaken at each site. The objective was to obtain information on long-term ecological change and examine the impact of the 1996-97 drought. The results are reported in Wright *et al.* (1999a), which gives photographs for each site in the mid-1970s and 1997 together with macrophyte and macroinvertebrate data.

The winter of 1997/98 marked the end of the drought and autumn 1997 saw the beginning of phosphate stripping at Marlborough STW. The IFE and the Environment Agency both recognised the need to document long-term consequences of the drought and/or changes in water quality. Because management practices had changed on some sites between the 1970s and 1990s, it was also clear that a long-term study could shed light on this important topic.

As a result, the Environment Agency drew up a Phase 2 contract for a 5-year collaborative project (April 1998 – March 2003) between the Agency and the IFE (now the Centre for Ecology and Hydrology, Dorset). This provided for repeat macrophyte mapping and macroinvertebrate sampling at the four study sites in the summer of 1998, 1999, 2000 and 2001. The basic results of the annual macrophyte mapping and macroinvertebrate sampling are being reported to the Agency each year without any further detailed analysis. The fifth and final year of the contract (April 2002 – March 2003) will not include fieldwork, but will be used to produce a technical report, including an overall analysis of the results and comparison with conditions in the 1970s. In this collaborative project with CEH Dorset, one scientific paper on a given aspect of the results is being written each year.

The results of the June 1998 sampling programme are in Wright *et al.* (1999b) and the scientific paper for that year is Wright *et al.* (2000a). The June 1999 sampling results are in Wright *et al.* (2000b) and the scientific paper is Wright *et al.* (2002). The June/July 2000 results are in Wright *et al.* (2001) and the scientific paper is Wright et al. (in press b). Results for the final sampling operation in June/July 2001 are presented in the current report and the accompanying scientific paper will examine changes in the flora and fauna of the R.Lambourn at Bagnor following the end of management of the site as a trout fishery.

The winter of 2000/2001 was marked by an exceptionally high discharge regime on both the R. Lambourn and R. Kennet, exceeding the high discharge regime of the previous winter. Once again, high water levels in spring and early summer on the Kennet at Savernake and Littlecote resulted in postponement of mapping and sampling until the sites were safe for field work. Littlecote was mapped/sampled in late June and the Savernake sites in early July.

The 50 m site on the River Lambourn at Bagnor is heavily shaded by trees on one bank and by tall marginal vegetation on the other through recent lack of management as a trout fishery. When mapping recommenced in 1997, submerged macrophytes occupied a smaller area of the riverbed than in the 1970s, whereas silt and marginal emergents were more important. Although these changes were probably an initial response to the 1996/97 drought and lack of management, the area of silt has remained substantial throughout the recent high discharge regime and the area of instream macrophytes has remained below the percentage cover routinely observed during the 1970s.

Despite this, there is evidence of long-term stability in macroinvertebrate family richness between the 1970s and 1997-2001. During the 1970s, quantitative sampling of five habitats yielded between 42 and 47 families in June each year and family richness also varied from 42 to 47 families in 1997-2001.

The densities of some important families of macroinvertebrates in chalk streams such as Baetidae (mayflies) and Simuliidae (blackflies) show a strong relationship to discharge regime, with available habitat as another relevant factor (Wright *et al.* 2000a). An analysis of macroinvertebrate response to drought events in 1976 and 1997 based on quantitative family level data revealed an extreme response during the drought itself but fairly rapid recovery after the event (Wright *et al.* in press). Nevertheless, some subtle changes in (mainly) faunal abundances have occurred between the 1970s and late 1990s, probably due to changes in management practices and this will be the subject of the next scientific paper.

The 100 m site on the Kennet at Littlecote remains an important trout fishery, as in the 1970s. The river is allowed to run freely, and even in the 1996/97 drought, *Ranunculus* (Water crowfoot) covered 44.2% of the site in July 1997, supplemented by emergent marginal vegetation. In the four years since then, *Ranunculus* has occupied between 60 and 77.5% of the river-bed at the time of sampling, depending on whether bar-cutting took place before field work. Macroinvertebrate family richness on gravel and *Ranunculus* has remained fairly stable through the mid-1970s and over the past five years although, interestingly, family richness peaked in June 2001, after two winters of very high discharge. Some modest changes in family composition occurred between the 1970s and 1990s (Wright *et al.* 2002).

The two 50 m sites on the Kennet at Savernake suffered progressive loss of macrophytes during the 1990s and attempts at promoting re-growth failed. The drought ended in the winter of 1997/98 and phosphate stripping commenced at Marlborough STW in autumn 1997. June 1998 mapping saw spectacular re-growth of *Ranunculus* and this has been maintained in all subsequent years of mapping. However, the concurrent change in water quality and quantity has made it difficult to disentangle the role of these two factors (Wright *et al.* 2002). Despite major changes in habitats for macroinvertebrates between the 1970s and 1997, and between 1997 and later years when *Ranunculus* assumed its former role, overall changes in family richness have been quite small, although once again, family richness peaked in 2001 on both sites, as at Littlecote. Changes in family composition between the 1970s and 1990s have been modest but there have been major changes in the density of some families between the 1970s and 1990s and also between July 1997 and the later years. (Wright *et al.* 2002). These changes give some insights into the role of water quality and discharge regime.

1. INTRODUCTION

1.1 Background

In 1997, the Environment Agency, Thames Region, commissioned the Institute of Freshwater Ecology River Laboratory (now the Centre for Ecology and Hydrology, Dorset) to undertake studies on the macrophytes and macroinvertebrate assemblages at four sites on the Rivers Kennet and Lambourn. These included two sites on the River Kennet (Savernake upper and lower) downstream of Marlborough, a further location on the same river upstream of Hungerford (Littlecote) and a fourth site on the River Lambourn (Bagnor –shaded site). Each one of these sites had been the focus of detailed studies by a team of freshwater ecologists in the 1970s, and valuable historical data were available for each location. The low flows of 1996 and the worsening drought conditions through the spring of 1997 provided the impetus for a re-examination of these sites, starting in summer 1997.

Macrophyte mapping followed by quantitative sampling of the macroinvertebrates on major habitat types took place in June/July 1997 and again in December 1997, using the 1970s protocols in order to ensure compatibility of the data. The results, including a photographic record of visual changes on all four sites in the 1970s and 1997, together with an appraisal of changes in the macrophytes and macroinvertebrate assemblages over the same period were included in a comprehensive report to the Environment Agency (Wright *et al.* 1999a).

There was always an intention that this study would continue beyond the 1996-97 drought. When the drought ended in winter 1997/98, and high rainfall occurred in spring 1998, it was clear that further sampling could provide valuable information on the rate at which the macrophytes and the macroinvertebrates could respond to the end of a prolonged drought. The autumn/winter of 1997/98 also marked the beginning of a programme of phosphate stripping at Marlborough sewage treatment works.

The IFE team undertook repeat mapping and sampling in June 1998, on the understanding that the Environment Agency would attempt to find financial resources to support the collection, processing and reporting on these samples. Financial help was secured, and information on the mapping and macroinvertebrate sampling programme at the four sites, together with a brief appraisal of the response of the biota to the end of the drought and recommendations for further work were presented to the Environment Agency in Wright *et al.* (1999b).

The Environment Agency recognised that natural variation occurs between years in the flora and fauna of chalk streams and that it is essential to document the scale of this variation in order to demonstrate the scale of response to extreme events such droughts. Only by detailed studies over a number of years would it be possible to determine whether the prolonged droughts of the 1990s had lead to long-term changes in the chalk stream ecosystem. With this in mind, a Phase 2 contract was drawn up as a collaborative project between the Agency and the Institute of Freshwater Ecology. This includes the mapping and sampling programme at all four sites each summer until June 2001, thereby providing a five-year run of data (1997 – 2001). Annual reports which present the macrophyte and macroinvertebrate data for the year will be produced and, in addition, a Technical Report incorporating an overall analysis of the results and a comparison with conditions in the 1970s will be produced at the end of the contract in March 2003. As its contribution to this collaborative project, the Institute of

Freshwater Ecology (now CEH Dorset) will produce one scientific paper in each of five years (1999-2003) on one or more aspects of this series of surveys.

1.2 Objectives

The overall objective is *'to improve the Environment Agency's knowledge of chalk stream ecology in order to increase our ability to manage chalk streams in a sustainable manner'*

The Phase 2 contract specification also lists twelve specific objectives:

1. To liaise with land agents at Bagnor, Littlecote and Savernake and get agreement to map and sample in June 1998, 1999, 2000 and 2001.

2. To map the sites at Bagnor, Savernake (lower) and Savernake (upper) each year, as in 1997, to determine change in the percentage cover of macrophytes and other habitats.

3. To undertake quantitative sampling of the macroinvertebrate fauna at 4 sites:

Bagnor	– 30 sampling units	Savernake (lower)	– 10 sampling units
Littlecote	– 10 sampling units	Savernake (upper)	– 10 sampling units

4. To take photographs of the sites to document their status and for comparison with summer 1997 and the 1970s.

5. To process the 60 quantitative macroinvertebrate samples at family level each year.

6. To input the June 1998, 1999, 2000 and 2001 macroinvertebrate data from the 4 sites into Access97 and to verify it.

7. To populate the plant database with the mapping data for June 1998, 1999, 2000 and 2001 in order to create maps and cover data for Bagnor, Savernake (lower) and Savernake (upper).

8. To analyse the macrophyte and macroinvertebrate data in relation to the data from the 1970s and 1997.

9. To compile the raw data collected in this survey and collate it so that it can be used by the Agency for future reference.

10. To produce annual progress reports on the work undertaken in each reporting period, together with information on the structure of the results database and a summary of any conclusions and recommendations (to include an evaluation of the desirability of continuing the surveys in the following year).

11. To produce a scientific paper each year (total of five) analysing the results of one or more aspects of this series of surveys.

12. To produce a technical report of this work, including an overall analysis of the results and comparison with conditions in the 1970s.

2. FLOW REGIME

2.1 R. Lambourn at Shaw

Discharge data for the River Lambourn has been supplied by Thames Region of the Environment Agency. The nearest gauging station to Bagnor was at Shaw, approximately 2 km downstream. Note that whereas the river occupies a single channel at Shaw, it is divided into two channels at Bagnor. In the 1970s, two study sites were chosen on the northern channel at Bagnor because it was of wadeable depth and was more typical of the river. The Winterbourne stream also discharges into the northern channel at Bagnor, ~ 100m upstream of the shaded site. Hence, when examining the discharge regime at Shaw it should be borne in mind that discharge through the shaded site at Bagnor is substantially lower than at Shaw, but the seasonal regime in any given year will mimic the picture obtained at Shaw.

The discharge regime on the River Lambourn at Shaw from January 1990 to December 2001 is presented in Figure 2.1. This period included a drought in 1991-92, followed by three years (1993-95) when the characteristic discharge regime resumed with high peak flows early in the year. Then followed another two-year drought (1996-97) with no high flows in the winter of 1996/97. This ended with high rainfall through the winter of 1997/98, but peak flows remained below those experienced between 1993 and 1995. A wet spring resulted in a mean discharge in May 1998 (prior to sampling) approaching the monthly means recorded in 1993-96 and over twice the discharge recorded in May 1997. In 1999, the characteristic discharge regime was observed once more, as in 1993-95. However, in 2000, discharge increased each month between January and May, resulting in a monthly mean discharge for May 2000 of 3.3 cumecs, at the time, the highest discharge observed prior to June sampling in the 1990s or the 1970s.

Even this was exceeded over the winter of 2000/01 when heavy autumn rains resulted in the mean monthly flow exceeding 5 cumecs between December 2000 and April 2001. In May 2001 the mean monthly discharge was 3.81 cumecs, thus exceeding the record value of the previous year. Thereafter, mean monthly discharge decreased quite rapidly through the summer and autumn.

2.2 R. Kennet at Knighton

The Environment Agency also supplied monthly mean flows for the River Kennet at Knighton, which is located approximately 8 km downstream of the Savernake study section and 2 km upstream of Littlecote. Figure 2.2 presents the discharge regime at Knighton between January 1990 and December 2001. The droughts of 1991-92 and 1996-97 are apparent, separated by 1993-95 when the characteristic discharge regime prevailed. As noted on the River Lambourn, winter rains in 1997/98 marked the end of the drought but peak discharge fell short of that recorded in the mid-1990s. In spring 1998, high rainfall resulted in a monthly mean discharge in May 1998 exceeding values recorded in the same month in the earlier years. In particular, mean discharge in May 1998 was almost four times the mean discharge recorded in May 1997. By 1999, the characteristic (1993-95) seasonal discharge regime had resumed. However, in 2000, monthly mean discharge increased progressively from February to May, and the monthly mean value of 7.2 cumecs for May exceeded all previous values for this month in either the 1990s or the 1970s.

As in the R. Lambourn, the winter discharge remained high between December 2000 and April 2001 with mean monthly discharge exceeding 7 cumecs for each of the 5 months. By May 2001, mean monthly discharge was 6.75 cumecs, a little lower than the previous year and thereafter, mean monthly discharge decreased rapidly each month through the summer and autumn.

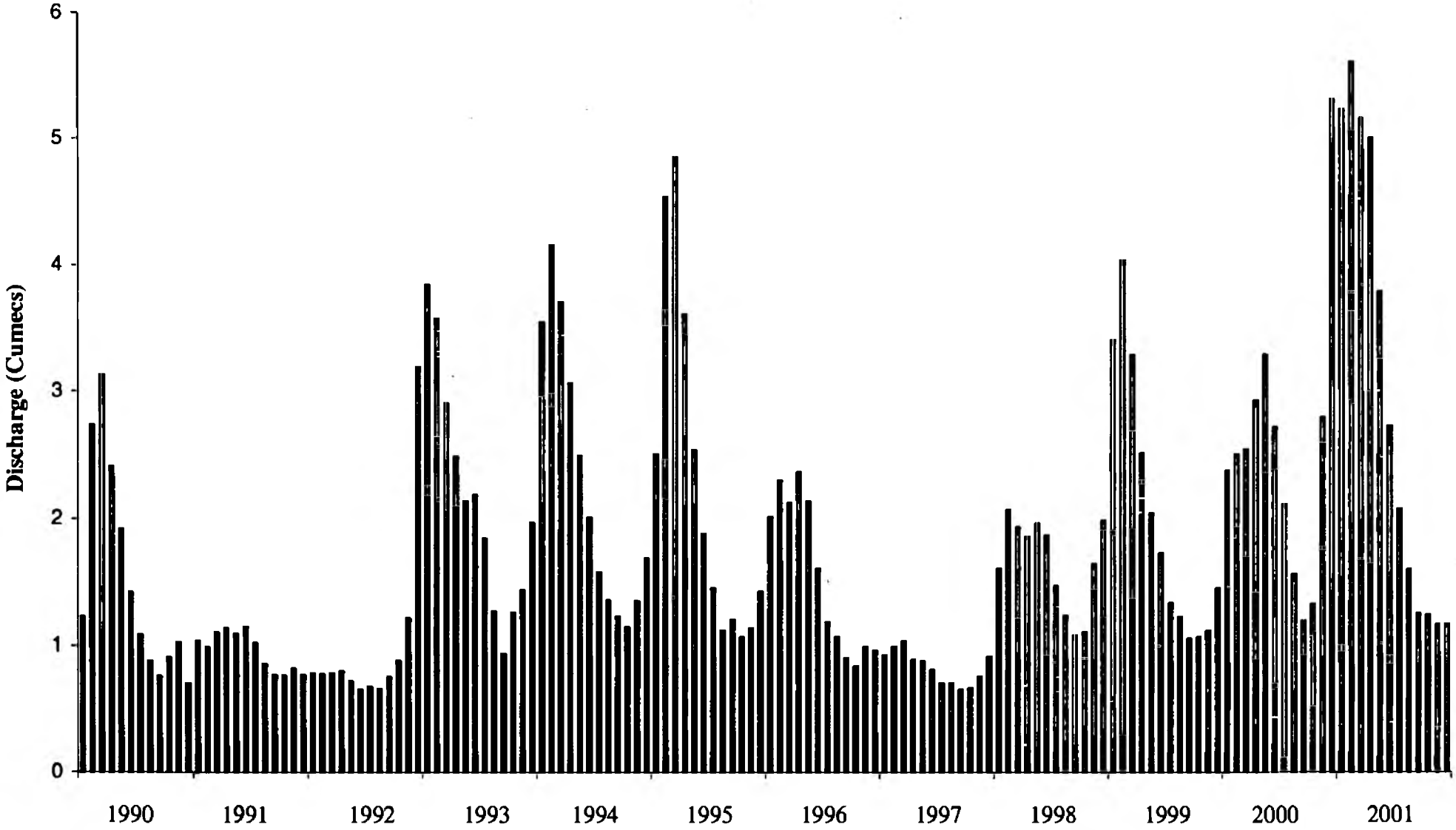

Figure 2.1 **Monthly mean discharge on the River Lambourn at Shaw, January 1990-December 2001**

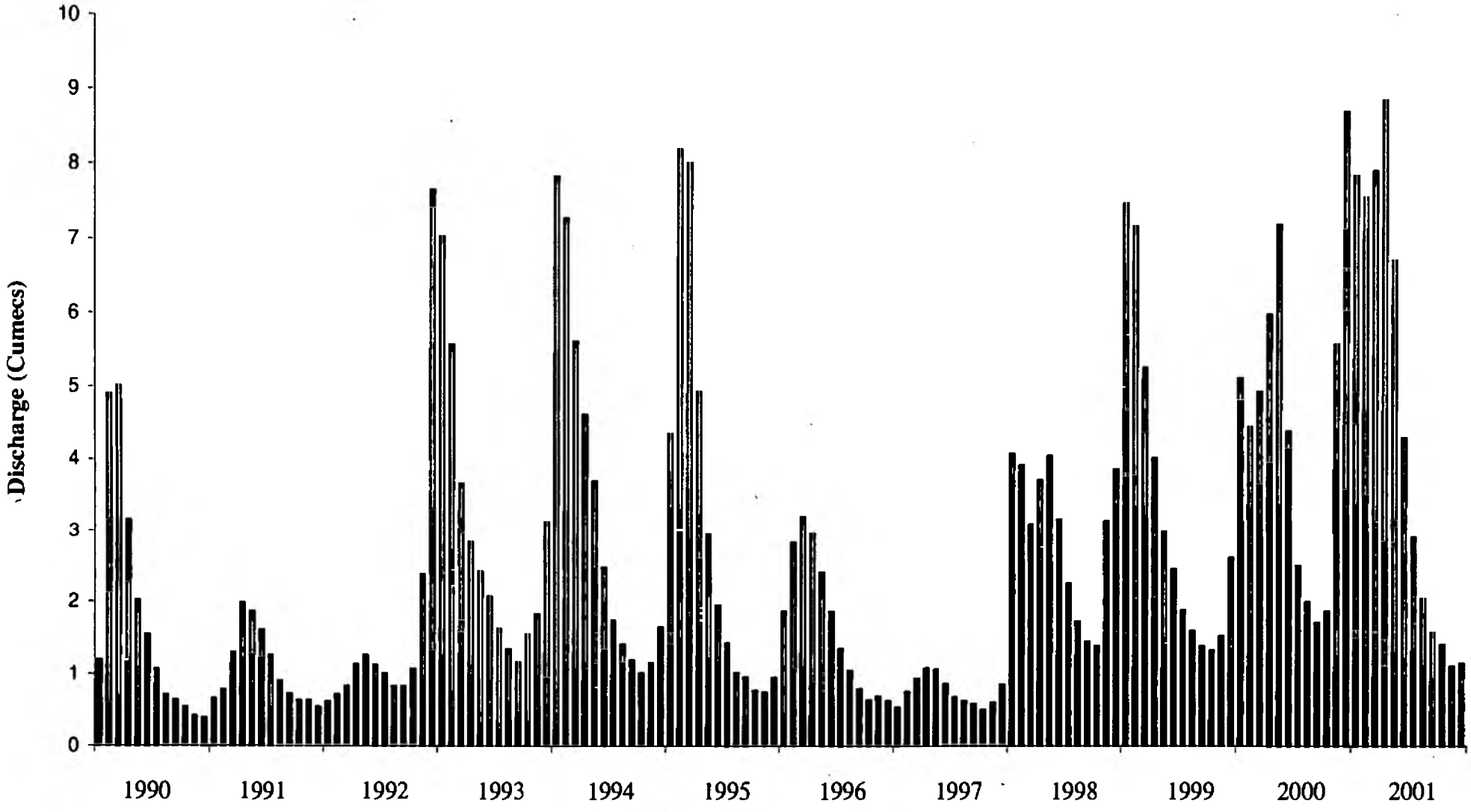

Figure 2.2 **Monthly mean discharge on the River Kennet at Knighton, January 1990-December 2001**

3. THE STUDY SITES

A comprehensive photographic record of the four study sites during the 1970s and in 1997 was given in Wright *et al.* (1999a). Additional photographs taken at each site in June/July of 1998, 1999 and 2000 may be found in Wright *et al.* (1999b), Wright *et al.* (2000b) and Wright *et al.* (2001) respectively. This section provides a photographic record of the sites in June/July 2001.

3.1 The R. Lambourn at Bagnor (shaded site), June 2001

Figure 3.1a is a view looking upstream taken in June 2001. Although the water level at the time of mapping was marginally lower than in June 2000, discharge through the spring has been high. *Ranunculus* is growing well on this open lower section of the study site although it was very sparce elsewhere on the site. As in 1997-2000, the site remains unmanaged with overhanging trees and bushes on the left-hand side of the photograph and emergent marginal vegetation on the right hand side.

Fig.3.1b is a view looking downstream from the middle of the 50 m site. *Berula* forms a very substantial carpet of weed on the river-bed in this area. Note that a tree on the far bank has fallen into the river near the downstream limit of this photograph. This has lead to further deposition of silt along the bank, downstream of this obstruction.

3.2 R. Kennet at Littlecote, June 2001

Fig. 3.2a is a general view of the site in late June 2001 from the upstream limit looking downstream. Prior to mapping and sampling, the keeper had cut a considerable amount of *Ranunculus* in order to reduce water levels and make the river suitable for fishing. Evidence of bar-cutting is apparent.

Fig.3.2b was taken from the downstream limit of this 100 m site looking upstream. In contrast to late June 2000, when the river viewed from this location was choked with *Ranunculus*, the impact of the recent weed-cut is apparent with substantial areas of gravel showing between the remaining weed-beds. In addition, the water is quite coloured.

3.3 R. Kennet at Savernake (lower and upper sites), July 2001

Savernake Lower

Fig.3.3a provides a general view of the site on 4 July 2001, looking upstream. As in the previous year the River Keeper, John Hounslow, reported that the river had been over the banks and an early weed-cut had been necessary. Through June 2001, water levels remained too high for mapping and sampling. However, a second selective cut at the beginning of July helped to lower the water level and enabled mapping and sampling to take place. The photograph shows that some beds of *Ranunculus* were retained, whilst others were cut back.

Fig. 3.3b shows a view looking downstream from the upper limit of the site. Some patches of surface *Ranunculus* have been retained, and although not visible in this photograph, the site still retains limited beds of *Schoenoplectus*. The partially exposed log on the left-hand margin

suggests that the water level in early July is roughly comparable with the (high) level at the same time in 2000.

Savernake Upper

Fig. 3.3c is a view of the upper 50 m site at Savernake on 4 July 2001 looking upstream at the site from the downstream limit. A similar photograph taken on 3 July 2000 indicates only minor changes over the past twelve months. This section of the river was modified during the River Rehabilitation Demonstration Project undertaken in autumn 1999. As mentioned last year, the effective river width under normal discharge conditions has been reduced using branches which have been wired into position. Hence, for several metres width of river on the far side, while discharge remains high, there is currently a very shallow area with very little surface velocity, compared to mid-river. As yet, colonisation of this area by marginal emergents and aquatic macrophytes has been slow, possibly due to the high discharge regime through the winter and spring. As a result of the continuing high water levels, two upstream current deflectors which were clearly visible in summer 1999 (see Fig. 3.3c in Wright *et al.* 2000b) remain under water.

Fig. 3.3d was taken from a location above the upstream limit of the site on 4 July 2001, looking downstream. Again, there is evidence of selective weed-cutting but no sign of the two current deflectors, indicating that the water level remains high.

Figure 3.1a River Lambourn at Bagnor (shaded site). June 2001. View upstream from the bottom of the site showing beds of *Ranunculus*

Figure 3.1b River Lambourn at Bagnor (shaded site). June 2001. View downstream from the middle of the site showing a well-developed carpet of *Berula* and further downstream, a fallen tree partially blocking the river.

Figure 3.2a River Kennet at Littlecote. June 2001. View downstream from the top of the 100 m site

Figure 3.2b River Kennet at Littlecote. June 2001. View upstream from the bottom of the 100 m site. Note the cloudy water.

Figure 3.3a River Kennet at Savernake (Lower). Early July 2001. View upstream

Figure 3.3b River Kennet at Savernake (Lower). Early July 2001. View from upstream limit of the site looking downstream.

Figure 3.3c River Kennet at Savernake (Upper). Early July 2001. Upstream view of the site from the lower site limit

Figure 3.3d River Kennet at Savernake (Upper). Early July 2001. Downstream view of the site from further upstream

4. METHODS

Note: The methods section, as given in Wright *et al.* (1999a), is repeated here with only minor amendment to help readers who are unfamiliar with the procedures used in this study.

4.1 Macrophyte mapping

4.1.1 Field procedures

A detailed account of the field procedures involved in the 'rectangles' method of mapping was given in Wright *et al.* (1981), but a synopsis of the approach is repeated here.

Prior to mapping for the first time, it is essential to establish a straight baseline on one bank and hammer in a series of permanent stakes at 5 m intervals. This is best achieved with a transit compass, ranging poles and a measuring tape. Additional stakes are also required at 5 m intervals on the opposite bank at known distances from the baseline.

When mapping, a temporary grid of mapping strings is set out in order to create a 1 x 1 metre grid over the water surface. First, a 5 m tape, with numbered tags at 1 m intervals is placed between the 0 and 5 m stakes on the baseline, with a similar tape on the opposite bank. Next, a series of longer tapes (often six) which are similarly marked with numbered tags at one metre intervals are positioned across the river at one metre intervals upstream, thus linking successive metre locations on the baseline with the corresponding location on the opposite bank.

The mapping operation may be undertaken by two people, but was normally carried out by a team of three individuals. One person (the caller) stands in the river in order to describe the river-bed whilst a second (the recorder) stands on the baseline bank and marks the prepared mapping sheet with information provided by the caller. A third person normally helps with repositioning the cross-river tapes when they are moved upstream.

Prior to mapping, it is essential to define the features to be distinguished. For example, decisions are required on whether macrophytes can be identified to species at all times or whether species with similar morphology are to be recorded as a single taxon. The range of substrata to be recorded must also be defined. From visual inspection, all particles greater than 2 mm were designated as gravel whilst those of 2 mm or less were termed silt. In practice, this last category included both sand and silt. The term silt was also retained in cases where decaying organic matter such as tree leaves was present at a given location. Note that all categories were as determined visually, irrespective of the composition of the substratum under the visible surface.

At the start of mapping, the caller enters the river downstream of the cross-river tape connecting 0 m on the baseline with 0 m on the opposite bank. The position of the nearside bank is determined to the nearest 0.5 m and relayed to the recorder on the bank who then marks the position of the bank on a blank map consisting of 50 x 100 cm rectangles representing the full 50 m length of river to be mapped. The caller then views the 1 m strip of river between cross-river tapes at 0 and 1 m upstream. The tapes with their numbered tags form a 1 m grid across the river, and each square of the river-bed below can be divided

longitudinally, by eye, into two 1 x 0.5 m rectangles. A metal-tipped pole used by the caller was found to be particularly useful in delimiting the metre square, by holding it vertically at the corners of the square prior to assessing each rectangle. The dominant substratum or macrophyte is then determined for each rectangle, but where a macrophyte and a non-macrophyte each occupy 50%, the macrophyte is given dominance. The substratum underlying the macrophyte is also determined.

For this project the Environment Agency confirmed that only the dominant macrophyte was to be recorded, as this is the only information used in calculating the percentage cover of the habitats on each site. (In the 1970s, additional habitats within the rectangle were also recorded, although in practice this information was not used in later analyses. Collection of this additional information would have increased the time for field mapping).

Information on each rectangle is passed to the recorder until the location of the opposite bank is given. The caller then moves one metre upstream and continues the mapping process towards the baseline for the strip of river between the tapes positioned 1 to 2 m upstream. This process continues until the entire grid provided by the first positioning of the cross-river tapes has been completed. The tapes are then repositioned upstream for further mapping and this process is continued until the entire site has been mapped.

This account describes the mapping procedure on the River Lambourn at Bagnor, where the river is narrower than the River Kennet. However, the submerged and marginal emergent vegetation at Bagnor include a wide range of species, which increase mapping times. Similarly, the presence of overhanging branches and thick bushes and trees on the far bank makes the positioning of mapping strings more difficult. Once tapes have been repositioned prior to mapping, checks are made that all the 1 m tags on the mapping strings are aligned in order to avoid mapping inaccuracies.

Since the Kennet sites are wider than the River Lambourn, the need to check that tapes are in alignment is even more critical on the River Kennet. At Littlecote, where the site is a full 100 m in length, the baseline itself changes direction at 50 m in order to accommodate a change in alignment of the river. At this site, the baseline established on the mown bank in 1974 was relocated in 1997. However, for ease of mapping on this very wide site, additional stakes were located at the bottom of the bank, just above the water's edge and at known distances from the true baseline. On the River Kennet at Savernake, new stakes were required. Initially, they were positioned on the mown baseline bank and left proud, as requested by Mr Hounslow where they were in full view and could be avoided during mowing operations. More recently, most of these stakes have been removed, but the precise location of each 50 m site can still be defined at the outset of each mapping operation.

On all three Kennet sites (100 m site at Littlecote, two 50 m sites at Savernake) the greater river width coupled with the fact that the habitats on the river-bed were less complex allowed the mapping grid to be increased to 100 x 100 cm squares, as used in the 1970s. Only at the bank did the mapping regime revert to 50 x 100 cm rectangles where necessary, in order to document with greater accuracy the habitats at the waters edge.

Note that from June 1998 onwards, the decision was taken to draw a sketch–map of the weed beds on the Littlecote site, using 5 m metres strings across the river for guidance instead of

undertaking the full mapping procedure outlined above. This avoided the need for three people to spend a whole day mapping a site on which *Ranunculus* was the dominant macrophyte.

4.1.2 Laboratory procedures

Within the laboratory, EXCEL spreadsheets were prepared to represent each of the four mapped sites. The baseline was numbered 0-50 m (0-100 m for Littlecote), whilst rectangles at right-angles to the baseline were numbered 0-0.5, 0.5-1, 1-1.5 m and so on, allowing sufficient space to include the full distance from the baseline to the river, the width of the river itself and the far bank for the full length of the site. Each spreadsheet was then populated with mapping information on the dominant habitat type for each 100 x 50 cm rectangle. In the case of the Kennet sites, where 100 x 100 cm squares had been designated within the river, pairs of rectangles were substituted on the map, although single 100 x 50 cm rectangles were recorded at the river margins where these had been mapped at the site.

An automated procedure was then employed for counting the rectangles of each habitat type, from which the total area (m^2) and the percentage cover of each habitat was derived. The percentage cover data are presented in Chapter 5 of this report.

Please note: The computer maps are being supplied to the Environment Agency as EXCEL files and hence are not included within this report.

4.2 Sampling for macroinvertebrates

4.2.1 Field procedures

The Lambourn sampler (Hiley *et al.* 1981) was used to obtain samples of macroinvertebrates on each of the four study sites, as in the 1970s. The dimensions of the sampler were 20 x 25 cm, resulting in a sampling unit of 0.05 m^2. For each habitat, five sampling units were taken in each season.

In general, the choice of habitats to be sampled on each site was made with a view to maximising the comparisons which could be made with samples taken in the 1970s. There was one exception to this general rule on the River Lambourn at Bagnor. The recent lack of management related to fisheries interests has resulted in the development of both low growing and tall marginal emergent species, at a time when submerged macrophytes were poorly represented. Although no comparisons would be possible with the 1970s, the marginal emergents represented a potentially important habitat and warranted further investigation.

Quantitative sampling for macroinvertebrates on the major habitats took place after the mapping operation and was dependent on the availability of the map. In order to select potential locations for the five sampling units on each habitat, a series of four digit random numbers were used. The first two numbers represented distance along the baseline (0-50 or 0-100 m in the case of Littlecote) and the second two digits represented distance at right angles from the baseline. Thus, most of the four digit numbers represented locations within the mapped site and in this way sampling locations were chosen for each habitat type.

It was normal to obtain not just five sampling locations for each habitat type (representing the five sampling units required) but to have two reserve locations in case any of the original five proved to be inappropriate when sampling was underway. Ideally, mapping and sampling took place on separate days, with selection of the locations for sampling carried out in the laboratory. However, in cases where it was essential to undertake sampling on the same day after mapping, it was feasible to draw on a store of four digit random numbers and undertake the selection of sampling locations in the field.

The field procedure for taking macroinvertebrate samples was as follows. All sampling was carried out from the downstream limit of the site working upstream. Mapping tapes were positioned as required to locate the first sample on the river-bed and the Lambourn sampler was then lowered over the chosen location and forced into the substratum to a depth of 6 cm using both hand and foot pressure. The removal of all plant material and substratum to a depth of approximately 6 cm was carried out by hand, with further help from a small trowel for cutting through weed and removing substratum into the collecting net at the downstream limit of the sampler. The large collecting net was then removed from the frame of the sampler and by careful dipping of the net and its contents into the current, the contents were concentrated into the bottom of the net.

In June/July and December 1997 the following procedure was adopted. Once on the bank, the sample was transferred into a labelled polythene bag. No water or formalin was added at this time as all samples were subjected to an initial clean-up in the laboratory the following day, prior to preservation. Samples were kept cool throughout the period before preservation. This procedure was particularly relevant to the December samples in which there were large numbers of small stone-cased caddis larvae in the family Glossosomatidae that needed careful removal from larger stones. The requirement to move the mapping tapes periodically to collect samples from the river-bed and to transfer the net contents to labelled polythene bags meant that the ideal team for sampling was three or more team members. From June 1998 onwards, the decision was taken to preserve each sample in the field, in order to eliminate the additional step of an initial clean up of each sample in the laboratory. Any large stones were carefully examined and leeches, molluscs and caddis etc. carefully removed and retained with the sample before the stones were discarded.

4.2.2 Laboratory procedures

Each macroinvertebrate sampling unit taken with the Lambourn sampler included macrophyte, mineral material, detritus and macroinvertebrates, except for those taken on gravel and silt, which lacked the macrophyte component.

In 1997 the following procedure was adopted. The macrophytes were removed by flotation and carefully searched for invertebrates. Most of the invertebrates from the mineral fraction of the substratum were separated by elutriation. To achieve this, the sampling unit was placed in a bucket of water, thoroughly stirred by hand and allowed to settle until most of the mineral fraction was no longer in suspension. The water was immediately poured off through a 45 mesh sieve to collect animals and detritus. This process was repeated with clean water until no more animals were washed out. The remaining mineral material frequently contained some stone-cased caddis larvae and molluscs. Large particles were individually examined for attached caddis and molluscs, smaller particles were picked over to remove additional specimens but fine mineral material was retained and added to all previously removed

macroinvertebrates before being fixed and preserved using 5% formalin in a labelled polythene bag. From June 1998 onwards, the samples were fixed and preserved in the field, as previously described.

The sorting and identification procedure for each sampling unit was as follows. The sample was placed in the upper of a pair of 45 and 12 mesh sieves and the formalin removed by thorough washing. The coarse and fine mesh fractions were then processed separately.

First, the coarse fraction was put into a series of trays and, on the basis of the amount of material and abundance of the macroinvertebrate fauna, a decision was reached on the proportion of the coarse fraction to be sorted and identified. This varied from the entire coarse fraction to a half or sometimes a quarter of the fraction. All specimens in the designated fraction were removed and identified to family level. The results were entered on a standard data sheet and a multiplication factor applied to estimate the total number of each family in the fraction.

The fine fraction was subjected to a similar procedure, except that the proportion sorted and identified normally varied from one half to one eighth of the total. Again, the number of individuals in each family were determined and entered on the same data sheet before an appropriate multiplication factor was applied. The totals from the coarse and fine fractions were then added to obtain the estimated number of macroinvertebrates in each family within the sampling unit. All sheets were independently checked for accuracy.

On completion of the processing of all the samples, the data from the five sampling units on each habitat, site and month were entered into a Microsoft Access database and verified. A query was then developed in Access for calculating the mean density of each family from a set of five sampling units on a given habitat type.

The macroinvertebrate data for the shaded site on the River Lambourn in the 1970s had already been transferred to an Access Database in a separate IFE project. However, all the 1974 and 1975 data for the River Kennet at Littlecote and Savernake was also entered in order to be able to undertake selected comparisons with the results from the 1990s sampling programme.

One major group of macroinvertebrates, the Oligochaeta, was treated differently in the 1970s and in the late 1990s research programme. In the 1970s, no attempt was made to count the total number of oligochaetes per sampling unit. During the first twelve months of the study at Bagnor (March 1971 – February 1972), the view was taken that because some oligochaetes undergo fission and others are damaged during the processing of samples, the oligochaetes would be picked out and then weighed as a group. The one exception to this was the Lumbricidae which, being large, were counted individually and kept separate from all other Oligochaeta. In later years at both the River Lambourn and the River Kennet sites, the Lumbricidae were still counted individually, but no numerical information was available on other oligochaetes.

In the late 1990s, the decision was taken to count the Lumbricidae as before, but also to count all other Oligochaeta and input both categories to the database, in order to have more comprehensive information for future reference. However comparison of densities observed in the 1990s and the 1970s were limited to the Lumbricidae and when comparisons were made of

macroinvertebrate 'family' richness between years, the Oligochaeta and Lumbricidae counted as one 'family' and all 1970s samples were assumed to include Oligochaeta.

5. RESULTS OF MACROPHYTE MAPPING

5.1 R. Lambourn at Bagnor (shaded site)

The results obtained by mapping the site in June 2001 have been inserted into Table 5.1 for comparison with the equivalent results for June 1997-June 2000 plus December 1997. This table also presents the maximum, minimum and mean percentage cover of the major habitat types for the site over the period January 1971 to December 1979 and information on the total wetted area of the study site, expressed in square metres (m^2).

Table 5.1 R. Lambourn at Bagnor (shaded site). Total wetted area of the 50 m site and the % cover of the major habitat types in June and December 1997, plus June 1998, 1999, 2000 and 2001 (latter in bold). Historical data for January 1971 - December 1979 is presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover					
	m^{-2}	Berula	Call	Gravel	Ran	Silt	Other
June 2001	**454.5**	**18.8**	**3.9**	**19.5**	**4.0**	**37.4**	**16.4**
June 2000	475.5	12.8	2.7	30.2	7.5	23.7	23.1
June 1999	397	20.0	3.5	35.8	7.7	22.0	10.9
June 1998	439	9.6	2.3	51.7	1.9	26.8	7.8
Dec 1997	372	9.3	1.6	44.2	2.6	31.2	11.1
June 1997	387	5.8	24.9	29.3	6.2	17.6	16.2
71-79: Max	454	65.9	48.1	79.0	44.2	48.8	16.5
71-79: Min	336	0.5	0.0	5.7	0.1	2.8	0.0
71-79: Mean	409	38.3	10.3	26.3	13.7	9.7	1.5

In June 2001, the total wetted area for the site was 454.5 m^2, a value which was only exceeded in June 2000, when the mean discharge for June was closely similar to June 2001. The total area of aquatic macrophyte (*Berula*, *Ranunculus* and *Callitriche*) in June 2001 was 26.7%, marginally higher than the 23% of June 2000. This was mainly due to an increase in the area of *Berula*. In contrast, *Ranunculus* decreased in area, despite the high discharge and was almost entirely confined to a traditional area at the downstream limit of the site. Also notable was the substantial area of silt (37.4%) which was almost entirely deposited under the tree cover on the far bank. Finally, a fallen tree on the far bank which blocked over half the width of the river 14m from the downstream limit allowed further deposition of silt. Given that the wetted area was slightly lower than in 2000, the area of other riparian vegetation (16.4%) which largely comprised *Oenanthe*, *Mentha* and *Phalaris*, was lower than in June 2000.

As observed in previous years, the site continues to be unmanaged in terms of control of the farside tree cover, nearside emergents or instream macrophytes. Hence, the light reaching the river surface remains less than that typical of the 1970s and the potential for in-stream macrophytes to resume the percentage cover seen during that period is low. *Berula*, the dominant in-stream macrophyte for most of the 1970s, retains that position, but with a much lower percentage cover compared to the mean for the 1970s when it was 38.3%. The very high winter discharge observed in 2000/01 probably resulted in increased runoff from the land

and consequent increases in bedload and suspended sediments. The extent to which the increased area of silt in June 2001 derived from such sources as opposed to *in situ* decaying leaves or collapsing banks is unclear. Under the 1970s management regime, attempts would have been made to remove or reduce the area of silt on the riverbed.

5.2 R. Kennet at Littlecote

Mapping of the 100 m site at Littlecote is a full day's work for a team of three. In view of the fact that, under high discharge conditions, the riverbed is largely *Ranunculus* and gravel, it was apparent that a good approximation of percentage cover could be obtained by making a sketch map on the date of sampling, thereby saving valuable time. Hence, in Table 5.2, the estimate for the total area of the site and percentage cover of the major habitat types for June of 1998 to 2001 is given within brackets.

Table 5.2 R. Kennet at Littlecote. Total wetted area of the 100m site and the % cover of the major habitat types in July and December 1997. Estimated values for June 1998, 1999, 2000 and 2001 are given within brackets. Historical data for April 1974 - June 1976 is presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover			
	m^{-2}	Gravel	Ran	Silt	Others
June 2001	**(1383.5)**	**(34.8)**	**(60.0)**	**(2.1)**	**(3.2)**
June 2000	(1363)	(18.6)	(77.5)	(0.1)	(3.8)
June 1999	(1362)	(37.9)	(61.2)	(0.5)	(0.4)
June 1998	(1245.5)	(27.7)	(71.5)	(0.0)	(0.7)
Dec 1997	1310	30.5	38.9	0.9	29.7
July 1997	1244.5	35.9	44.2	3.1	16.8
74-76: Max	1395	71.7	84.0	11.6	3.4
74-76: Min	926	12.2	16.2	0.3	0.0
74-76: Mean	1225	38.8	57.2	2.4	1.6

The estimate for the total area of the site was made on 27 June 2001, after consulting with the River Keeper, Peter Woolnough, who advised that the very high discharge regime over the past few months had resulted in high velocities and water levels earlier that month. Some time before our sampling operation, the keeper managed to get into the river and undertake a substantial weed cut, which also helped to reduce water levels. Nevertheless, the total area of the site was higher than in June 2000. *Ranunculus* remained dominant with 60.0% cover, but this was substantially lower than in June 2000 as a result of the recent weed cut.

As on the R. Lambourn, the area of silt had increased slightly this year. The 'others' category was dominated by marginal *Carex*, which had been flooded out by the high water levels.

5.3 R. Kennet at Savernake (lower and upper sites)

5.3.1 Savernake (Lower site)

Mapping on this site had to be postponed until 4 July 2001, due to the high discharge regime and consequent high water levels. Following an early summer weedcut, a second cut was made by the River Keeper, John Hounslow, on the 2 July resulting in a modest fall in water level and the opportunity to map and sample soon afterwards. The results obtained by the 4 July mapping are given in bold in Table 5.3 for comparison with the equivalent information for early July2000 and June of 1999, 1998 and 1997 (also December 1997). The summarised data for the period from April 1974 to April 1976 provides a broader context.

The total wetted area of the site remained very high, as in July 2000, despite the recent weedcut.

Table 5.3 R. Kennet at Savernake (Lower). Total wetted area of the 50 m site and the % cover of the major habitat types in July and December 1997, June 1998, June 1999, July 2000 and July 2001 (latter in bold). Historical data for April 1974 - April 1976 is presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover				
	m^{-2}	Gravel	Ran	Schoen	Silt	Other
July 2001	**674.5**	**33.7**	**44.0**	**3.0**	**9.8**	**9.5**
July 2000	676	28.9	43.6	5.2	3.0	19.3
June 1999	653.5	23.6	53.7	6.3	9.3	7.2
June 1998	617.5	26.8	43.6	7.3	5.6	16.7
Dec 1997	536.0	53.6	0.2	11.8	14.1	20.3
July 1997	569.5	61.2	0.9	17.4	18.2	2.5
74-76: Max	686.0	38.6	19.3	66.5	23.5	3.2
74-76: Min	553.0	14.5	0.0	55.0	1.0	0.0
74-76: Mean	661.3	25.9	4.3	60.0	8.6	1.2

Although the area of *Ranunculus* was relatively modest as a result of the very recent weedcut, it nevertheless retained the dominant position first observed in spring and summer 1998 after the 1996/97 drought.

Schoenoplectus, which occupied 17.4% of the site in July 1997 during the drought, continued it's progressive decrease in area, probably as a result of the dominance of *Ranunculus*, following the end of the 1996-97 drought. As in 2000, it was decided to take macroinvertebrate samples on *Ranunculus* rather than *Schoenoplectus*, given the restricted growth of this macrophyte.

The total area of 'other' macrophytes decreased from the high value of July 2000, mainly as a result of the very limited growth of marginal *Callitriche* in July 2001 compared to the previous summer.

As a consequence of the limited growth of some macrophytes and the recent weedcut, the area of gravel increased again in July 2001 compared with the previous mapping in July 2001. In

contrast, the area of silt increased, as previously observed on the R. Lambourn at Bagnor and to a lesser extent on the R. Kennet at Littlecote.

5.3.2 Savernake (Upper site)

Table 5.4 presents information on the total area and percentage cover of the major habitats on the upper site at Savernake on 4 July 2001, together with the equivalent information for July 2000, June 1999 & 1998, July and December 1997, plus summary data for 1974-76.

In July 2001, as in July 2000, the total wetted area of the site was substantially lower than in June 1999 as a result of the autumn 1999 rehabilitation demonstration project which involved a narrowing of the channel. Because of the very high water levels in both 2000 and 2001, there was some standing water on the far side of the river overlying a berm which would normally be above water level under typical discharge conditions. This was not included in the area mapped and sampled.

Table 5.4 **R. Kennet at Savernake (Upper). Total wetted area of the 50 m site and the % cover of the major habitat types in July and December 1997, June 1998, June 1999, July 2000 and July 2001 (latter in bold). Historical data for April 1974 - April 1976 is presented as maximum, minimum and mean values.**

Date(s)	Total Area	Percentage Cover				
	m^{-2}	Gravel	Ran	Schoen	Silt	Other
July 2001	**528**	**29.8**	**57.5**	**1.1**	**6.4**	**5.1**
July 2000	513	33.4	41.4	1.8	5.0	18.4
June 1999	605	23.1	56.5	2.1	15.0	3.2
June 1998	604.5	36.2	48.8	1.7	4.1	9.2
Dec 1997	541.5	52.5	8.1	2.2	19.2	17.9
July 1997	551.0	64.5	6.5	2.7	22.0	4.4
74-76: Max	806.0	70.9	45.2	28.5	28.3	9.1
74-76: Min	597.0	23.4	0.0	12.5	1.4	0.0
74-76: Mean	766.0	49.5	19.1	21.8	7.0	2.5

Despite some very recent weedcutting, the area of *Ranunculus* was 57.5% and the total area of the site exceeded that recorded in July 2000.

The area of *Schoenoplectus* continued to decline (now just 1.1%) and is limited to a small area at the downstream limit of the site. The area of 'other' macrophytes also decreased, as on the lower site at Savernake, again largely due to a reduction in the area of marginal *Callitriche*.

Finally, the percentage cover of silt increased marginally over the value recorded in July 2000.

6. RESULTS OF MACROINVERTEBRATE SAMPLING

Please note: Information on the abundance of each macroinvertebrate family in each of the five sampling units for each habitat and study site is held in an Access Database being made available to the Environment Agency. In consequence, the raw data will not be presented within this report. As in previous years, information on family richness, composition and abundance is given in a series of tables with a brief commentary only. Detailed analyses are beyond the remit for this report and are being undertaken in a series of scientific papers.

6.1 R. Lambourn at Bagnor (shaded site)

6.1.1 Family richness

The number of families of macroinvertebrates recorded on each habitat type (i.e. total number of families from 5 sampling units) in June 2001 is shown in Table 6.1 in bold. This table also gives the equivalent information for June 1997-2000 and the maximum, minimum and mean number of families recorded per habitat during the detailed studies undertaken in the 1970s. (**Note**: the 1970s data-set is restricted to seven years data comprising 1971 plus 1974-79 when the laboratory processing technique was the same as that used in 1997 and 1998. In 1972 and 1973, it was necessary to pool and then sub-sample the five sampling units from a given habitat). No macroinvertebrate samples were taken from emergent macrophytes during the 1970s because they rarely occupied a significant area of the river-bed. However, from 1997 onwards, they did warrant additional sampling to determine their characteristic fauna.

Table 6.1 **R. Lambourn at Bagnor (shaded site) in June 1997 to June 2001 (latter in bold). Number of families of macroinvertebrates recorded on each habitat (total from 5 sampling units). Maximum, minimum and mean values derived from 7 years (1971+1974 to 1979) are also given.**

Date(s)	Ber	Call	Grav	Ran	Silt	Emerg.
June 2001	**36**	**27**	**27**	**32**	**24**	**27**
June 2000	34	33	31	21	24	25
June 1999	40	34	24	31	28	35
June 1998	37	32	24	26	27	34
June 1997	30	32	25	31	24	33
1970s: Max	41	39	36	41	33	No data
1970s: Min	22	30	27	29	23	No data
1970s: Mean	33.1	33.0	31.9	33.9	28.2	No data

The June 2001 sampling took place after a very wet winter and spring in which discharge had been remarkably high. The consequences of this extreme event were therefore anticipated with considerable interest. Family richness on *Berula*, which had itself increased in area since June 2000, increased marginally to 36 families, based on the five replicates. In contrast, on both *Callitriche* (just 3.9% in area) and also on gravel, family richness decreased to 27 families in each case. However, 32 families were recorded on *Ranunculus* (which only occupied 4% of the site), a substantial increase in richness from the unexpected low value of just 21 families recorded in June 2000. Family richness on the emergent vegetation was marginally higher at 27 families than in June 2000 (25 families), but these two years have supported substantially

lower numbers of families than in June 1997-99, when the discharge regime was less extreme and less riparian vegetation was flooded. Finally, family richness on silt remained low at 24 families, as in June 2000.

It is also important to assess overall family richness on the site, by pooling the information from all habitats. The total number of families recorded on all six habitats (i.e. including the emergents) has varied as follows: June 1997- 46 families, June 1998 - 52, June 1999 – 48, June 2000 - 45 and June 2001 – 46 families. The years with the lowest richness values have therefore been years of hydrological extremes i.e. in the 1997 drought (46 families) and the very high discharge recorded in 2000 and 2001 (45 & 46 families respectively). If just the five habitats originally sampled in the 1970s are considered, then family richness varies as follows: June 1997- 42 families, June 1998 - 45, June 1999 – 47, June 2000 - 43 and June 2001 – 44 families. Thus once more, the lowest richness values are recorded under drought (1997) and high discharge (2000/2001) conditions. Note that in the seven years 1971 plus 1974-79, the total number of families from five habitats varied from 42 to 47, and hence the values obtained in the last five years have not varied beyond these boundaries.

6.1.2 Family composition and abundance data for June 2001

Table 6.2 presents a list of the 46 families of macroinvertebrates and their mean densities on each of the six habitat types sampled in June 2001. Note that the Oligochaeta and Lumbricidae, although presented separately, are counted as a single 'family' in this report. See section 4.2.2 for an explanation of the need for this protocol. The faunal list for June 2001 includes 17 'families' of non-insects and 29 families of insects compared to 17 and 28 in June 2000, 17 and 31 in June 1999, 17 and 35 in June 1998 and 16 and 30 in June 1997.

Overall, 41 families of macroinvertebrates were recorded at this site in both June 2000 and June 2001. However, the following differences were noted between the families recorded in these two years.

June 2000 only		**June 2001 only**	
Ephemeroptera:	Heptageniidae	Mollusca:	Valvatidae
Plecoptera:	Nemouridae	Megaloptera:	Sialidae
Hemiptera:	Corixidae	Trichoptera:	Lepidostomatidae
Trichoptera:	Beraeidae	Diptera:	Psychodidae
		Diptera:	Ptychopteridae

All the above families that occurred in either June 2000 or June 2001 were present at low density on the site. Hence their apparent absence in a given year may simply indicate that they were not picked up by the sampling programme in one particular year. Thus, the five families listed as present in June 2001 but absent in June 2000 were, nevertheless, recorded in June 1999.

Table 6.2 **R. Lambourn at Bagnor (shaded site), June 2001. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat type**

Family name	Berula	Callitriche	Gravel	Emergents	Ranunculus	Silt
Planariidae	10.20	12.40	4.20	2.40	2.40	0.60
Dendrocoelidae	2.80	1.20	0.00	1.20	0.80	0.20
Valvatidae	4.80	1.60	0.00	0.00	2.80	1.20
Hydrobiidae	87.00	100.40	61.40	22.40	58.40	66.00
Physidae	4.00	0.40	0.00	6.80	0.40	0.00
Lymnaeidae	0.40	0.00	0.00	0.00	0.00	0.00
Planorbidae	10.60	0.00	1.00	1.60	2.00	0.00
Ancylidae	4.80	1.20	9.80	3.20	3.60	0.20
Sphaeriidae	11.20	28.00	1.00	19.20	3.60	11.60
Oligochaeta	677.60	866.40	52.00	203.60	81.60	173.40
Lumbricidae	3.00	0.00	1.00	0.00	3.60	0.00
Piscicolidae	1.00	2.00	0.60	0.00	0.80	0.00
Glossiphoniidae	1.20	1.20	0.00	0.00	2.00	0.20
Erpobdellidae	0.80	0.40	0.00	0.80	0.40	0.00
Hydracarina	33.60	52.00	2.40	28.80	50.40	1.20
Astacidae	0.00	0.40	0.00	0.00	0.00	0.00
Asellidae	1.80	8.00	0.60	3.20	3.60	0.20
Gammaridae	319.60	155.20	331.40	334.40	172.40	74.60
Niphargidae	0.00	0.00	0.40	0.00	0.00	0.00
Baetidae	86.20	91.20	44.40	8.00	82.00	1.60
Leptophlebiidae	0.00	0.00	0.00	2.80	0.00	0.00
Ephemeridae	10.20	3.20	1.60	4.40	3.20	8.20
Ephemerellidae	43.40	105.20	5.60	25.60	112.00	0.40
Caenidae	10.40	4.40	1.20	6.80	8.00	1.40
Leuctridae	1.80	0.00	2.00	0.00	0.00	0.00
Veliidae	0.00	0.00	0.00	0.40	0.00	0.00
Elmidae	0.80	1.60	2.40	2.00	3.20	0.00
Sialidae	0.00	0.00	0.00	0.00	0.40	0.00
Rhyacophilidae	0.80	0.00	1.80	0.00	0.80	0.00
Glossosomatidae	7.00	0.00	30.60	0.00	7.60	0.20
Hydroptilidae	0.40	0.00	0.00	0.00	1.20	0.00
Psychomyiidae	0.00	0.00	1.20	0.00	0.00	0.00
Polycentropodidae	0.20	0.00	0.00	0.00	0.00	0.00
Lepidostomatidae	0.20	0.00	0.00	0.00	0.00	0.00
Limnephilidae	8.80	3.20	1.80	5.20	5.60	0.00
Goeridae	0.00	0.00	7.80	0.00	0.00	0.00
Sericostomatidae	0.00	0.00	0.00	0.00	0.00	0.20
Odontoceridae	0.00	0.00	0.00	0.00	0.00	0.20
Leptoceridae	3.20	0.40	5.20	0.00	3.20	4.20
Tipulidae	1.80	4.80	2.20	2.80	2.00	4.20
Psychodidae	0.20	0.00	0.00	0.40	0.00	0.00
Ptychopteridae	0.80	0.00	0.00	0.00	0.00	0.00
Dixidae	0.00	0.00	0.00	0.40	0.40	0.00
Ceratopogonidae	44.00	38.40	1.40	34.40	14.00	5.60
Simuliidae	53.00	22.40	1.00	2.00	13.60	0.20
Chironomidae	162.20	160.80	17.00	310.80	205.60	37.60
Empididae	1.00	0.40	0.00	0.40	2.40	1.60

6.2 R. Kennet at Littlecote

6.2.1 Family richness

The River Kennet at Littlecote is characterised by *Ranunculus* growing on a gravel substratum and hence the results for the 1970s and the more recent sampling programme has been confined to these habitat types. In Table 6.3, the June 2001 results (in bold) have been placed alongside the data for June 2000, 1999, 1998 and July and December 1997 plus the available data for 1975 and 1974.

Table 6.3 R. Kennet at Littlecote. Number of families of macroinvertebrates on *Ranunculus* and gravel in July and December 1997 and June 1998 to June 2001 (latter in bold). Historical data for 1975 (June and December) and 1974 (June only) are also given.

Year	June/July		December		Total for Year
	Ranunculus	Gravel	Ranunculus	Gravel	(Ran + Grav)
2001	**33**	**36**	No data	No data	No data
2000	30	32	No data	No data	No data
1999	30	34	No data	No data	No data
1998	31	29	No data	No data	No data
1997	32	31	43	34	47
1975	30	33	35	33	42
1974	30 (29)*	28	No data	No data	-

* Figure in brackets refers to data from 5 replicate samples taken on recently cut *Ranunculus*.

In June 2001, the number of families recorded on each of *Ranunculus* and gravel was higher than at any time during the mid-1970s or the more recent five-year study period. In view of the high discharge regimes experienced over the past two winters, this is a very interesting result and demonstrates that high discharge was not detrimental to the maintainance of high family richness on each of these two habitats.

6.2.2 Family composition and abundance data for 2001

Table 6.4 lists the 40 families of macroinvertebrates captured at Littlecote in June 2001 together with their mean densities on gravel and *Ranunculus*. These 40 families include 16 non-insect and 24 insect families, compared to 35 families (14/21) in June 2000, 36 families (14/22) in June 1999, 32 families (12/20) in June 1998 and 35 families (12/23) in July 1997. Overall, there were 35 families recorded at the site in both June 2000 and June 2001. The following additional families were recorded in June 2001 only:

June 2001 only

Mollusca:	Hydrobiidae; Lymnaeidae	Megaloptera:	Sialidae
Odonata:	Calopterygidae	Trichoptera:	Psychomyiidae

Thus, the high discharge regime over a second winter/spring was associated with an overall increase in family richness.

Table 6.4 **R. Kennet at Littlecote, June 2001. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Gravel	Ranunculus
Planariidae	5.80	7.60
Dendrocoelidae	0.80	1.60
Hydrobiidae	1.20	0.40
Physidae	0.20	4.80
Lymnaeidae	0.40	0.00
Planorbidae	0.80	2.80
Ancylidae	41.80	0.00
Sphaeriidae	13.60	23.60
Oligochaeta	87.20	75.60
Lumbricidae	1.20	1.60
Piscicolidae	0.40	1.60
Glossiphoniidae	5.00	15.60
Erpobdellidae	0.80	2.80
Hydracarina	19.00	46.00
Asellidae	0.00	1.60
Gammaridae	802.60	840.80
Niphargidae	0.80	0.00
Baetidae	170.00	94.00
Heptageniidae	0.40	0.00
Ephemerellidae	31.80	456.40
Caenidae	0.60	26.00
Leuctridae	15.00	2.40
Calopterygidae	0.00	0.80
Dytiscidae	0.20	0.00
Elmidae	27.20	22.00
Sialidae	0.00	1.60
Rhyacophilidae	8.00	4.80
Glossosomatidae	9.00	0.00
Psychomyiidae	1.20	0.00
Polycentropodidae	0.80	2.00
Hydropsychidae	5.00	0.80
Lepidostomatidae	0.00	68.00
Limnephilidae	3.40	12.40
Goeridae	17.00	0.80
Sericostomatidae	1.60	6.00
Leptoceridae	5.20	11.60
Tipulidae	9.80	3.20
Ceratopogonidae	4.60	24.80
Simuliidae	8.40	563.60
Chironomidae	52.00	903.20
Empididae	2.40	1.60

6.3 R. Kennet at Savernake (lower and upper sites)

6.3.1 Family richness

At the lower site at Savernake, it was again necessary to abandon the earlier procedure of sampling *Schoenoplectus* because very little of this macrophyte remains at the site. Instead, five replicates were taken on *Ranunculus*, the macrophyte which was probably outcompeting *Schoenoplectus* in the present discharge and current velocity regime. Gravel was also sampled in early July 2001, for comparison with results obtained in early July 2000, June 1999 and 1998, July and December 1997 and in the 1970s (Table 6.5).

Table 6.5 **R. Kennet at Savernake (Lower site). Number of families of macroinvertebrates captured on *Schoenoplectus* (or *Ranunculus*) and gravel in July and December 1997, June 1998 & 1999 and July 2000 & 2001 (latter in bold). Historical data for 1975 (June + December) and 1974 (June) is also given.**

Year	June/July		December		Total for Year
	Schoenoplectus	Gravel	Schoenoplectus	Gravel	(Schoen+Grav)
2001	**32***	**32**	No data	No data	-
2000	25*	27	No data	No data	-
1999	31	31	No data	No data	-
1998	26	30	No data	No data	-
1997	31	27	33	32	39
1975	27	24	32	29	35
1974	26	28	No data	No data	-

Ranunculus rather than ***Schoenoplectus*** sampled in July 2000 and 2001.

In July 2001, the number of families recorded on *Ranunculus* and on Gravel was 32 in each case, marginally higher than in any previous year of study.

Table 6.6 **R. Kennet at Savernake (Upper site). Number of families of macroinvertebrates captured on *Ranunculus* and gravel in July and December 1997, June 1998 and 1999 and July 2000 and 2001 (the latter in bold). Historical data for these habitats plus *Schoenoplectus* is also given.**

Year	June/July			December			Total for Year
	Schoen	Ran	Gravel	Schoen	Ran	Gravel	(All habitats)
2001	No data	**30**	**33**	No data	No data	No data	-
2000	No data	28	29	No data	No data	No data	-
1999	No data	28	29	No data	No data	No data	-
1998	No data	27	23	No data	No data	No data	-
1997	No data	28	29	No data	32	27	38
1975	29	No data	29	32	31	31	37
1974	No data	29	27	No data	No data	No data	-

Data on family richness for the upper site at Savernake is presented in Table 6.6. In July 2001 family richness on each of *Ranunculus* and gravel was higher than in any previous year of study, as previously observed at the lower site at Savernake and also at Littlecote.

6.3.2 Family composition and abundance data for 2001

A list of the 37 families of macroinvertebrates recorded on the lower site at Savernake in July 2001, together with their mean densities on gravel and *Ranunculus* is presented in Table 6.7. These 37 families include 16 non-insects and 21 insect families compared to 31 families (14/17) in July 2000, 34 families (14/20) in June 1999, 32 families (13/19) in June 1998 and 33 families (14/19) in July 1997.Overall, there were 29 families recorded at this site in both July 2000 and July 2001. However, the following differences were noted between the listings for the two years:

Lower Savernake – July 2000 only		**Lower Savernake – July 2001 only**	
Mollusca:	Hydrobiidae	Tricladida:	Dendrocoelidae
Crustacea:	Niphargidae	Mollusca:	Valvatidae
		Mollusca:	Physidae
		Crustacea:	Astacidae
		Coleoptera:	Haliplidae
		Coleoptera:	Hydrophilidae
		Megaloptera:	Sialidae
		Trichoptera:	Hydropsychidae

As in previous years, it is important to emphasise that the absence of a family in the samples for a given year does not necessarily imply that the family was absent from the site, merely that it was sufficiently uncommon to be absent from the samples.

A listing of the 36 families of macroinvertebrates and their mean densities on gravel and *Ranunculus* on the upper site at Savernake in early July 2001 is given in Table 6.8. It includes 16 non-insect and 20 insect families compared to the 13/20 families in early July 2000, 13/21 families in June 1999, 15/17 families in June 1998 and 15/18 families in July 1997. Overall, there were 31 families recorded at this site in both July 2000 and July 2001. However, the following additional families were recorded on one sampling occasion only.

Upper Savernake – July 2000 only		**Upper Savernake – July 2001 only**	
Ephemeroptera:	Caenidae	Mollusca:	Valvatidae
Trichoptera:	Hydropsychidae	Mollusca:	Physidae
		Crustacea:	Astacidae
		Coleoptera:	Hydrophilidae
		Trichoptera:	Lepidostomatidae

Several of the additional families recorded on the lower Savernake site in July 2001 (Valvatidae, Physidae, Astacidae and Hydrophilidae) are repeated here on the upper Savernake site.

Table 6.7 **R. Kennet at Savernake (Lower site) July 2001. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Gravel	Ranunculus
Planariidae	1.6	1.6
Dendrocoelidae	0.6	0.8
Valvatidae	0.2	3.2
Physidae	1.6	6
Lymnaeidae	0.8	0.8
Planorbidae	0.2	0
Ancylidae	345.6	72
Sphaeriidae	4	8.4
Oligochaeta	35.6	102.8
Piscicolidae	3.8	6.8
Glossiphoniidae	10.4	9.6
Erpobdellidae	2.6	2.8
Hydracarina	13.4	76
Astacidae	0	0.6
Asellidae	1.4	7.2
Gammaridae	419.4	342.4
Baetidae	32	182.8
Ephemerellidae	63.4	275.2
Leuctridae	0.4	0
Caenidae	0	1.6
Haliplidae	0	0.4
Dytiscidae	14.6	6
Hydrophilidae	0	0.4
Elmidae	19	18.8
Sialidae	0	4
Rhyacophilidae	4.2	8.4
Glossosomatidae	2.8	0
Polycentropodidae	6	0
Hydropsychidae	1.8	0
Limnephilidae	3.8	8.8
Sericostomatidae	0.6	2
Leptoceridae	0.2	0.4
Tipulidae	0.8	4
Ceratopogonidae	8.2	23.2
Simuliidae	5.4	197.6
Chironomidae	307.8	458.4
Empididae	2.8	7.2

Table 6.8 **R. Kennet at Savernake (Upper site), July 2001. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Gravel	Ranunculus
Planariidae	7.6	0.4
Dendrocoelidae	2.8	2
Valvatidae	0	0.4
Physidae	1	0.4
Lymnaeidae	0.2	0
Ancylidae	88.4	2.4
Sphaeriidae	1.8	3.2
Oligochaeta	65.8	50
Lumbricidae	2.2	0.4
Piscicolidae	0.2	7.2
Glossiphoniidae	2.2	1.2
Erpobdellidae	1.4	3.2
Hydracarina	0	17.6
Astacidae	0.2	0
Asellidae	1	1.6
Gammaridae	256	317.6
Niphargidae	1.8	0
Baetidae	36.2	284.8
Ephemerellidae	73.6	346.8
Leuctridae	0.2	0
Dytiscidae	4.6	3.6
Hydrophilidae	0	0.8
Elmidae	14.2	11.2
Sialidae	0.2	1.2
Rhyacophilidae	5.8	5.2
Glossosomatidae	1.6	0
Polycentropodidae	3.4	4.8
Lepidostomatidae	0.2	1.2
Limnephilidae	4	6
Goeridae	2.8	0.8
Sericostomatidae	3	5.2
Leptoceridae	3.2	0.8
Tipulidae	1.8	0
Ceratopogonidae	5.2	4
Simuliidae	20.2	356.4
Chironomidae	126.8	378.8
Empididae	7.2	3.6

7. CONCLUSIONS

7.1 Introduction

This five-year sampling programme (1997-2001) at the four study sites is now complete. It was initiated during the second year of the major drought of 1996-97 when there was concern that a succession of droughts may have had a detrimental impact on the flora and fauna of these chalk streams. These data provide a firm basis from which to compare the current flora/fauna with that recorded using the same procedures in the 1970s. The 1997-2001 dataset may also be used to document changes in the aftermath of the 1996-97 drought. In practice, the discharge regime over the winter/spring periods of both 1999/2000 and 2000/2001 has been unusually high and therefore the sampling programme has provided further information on the response of the biota to these extreme hydrological events.

Some individual sites have provided further insights into the response of the macroinvertebrate fauna to changes in management (Lambourn at Bagnor) or the return of *Ranunculus* as the dominant macrophyte at a site (Savernake). In contrast, Littlecote appears to have changed little from the 1970s and has been viewed as a valuable control site.

Thus, the information collated over the past five years should form the basis for achieving the overall objective of the project. That is, to improve the Environment Agency's knowledge of chalk stream ecology in order to increase ability to manage chalk streams in a sustainable manner. The annual reports produced to date have provided an indication of the type of data available and also a commentary on general changes from one year to the next, without any detailed analyses. In the final year of the present contract (April 2002 – March 2003) a technical report will be produced, to include an overall analysis of the results and comparison with conditions in the 1970s. In addition, in this collaborative project, one scientific paper is being written on a specific aspect of the dataset each year in order to ensure that the results reach a wider audience.

In the following sections, a general commentary is provided on each of the study sites.

7.2 R. Lambourn at Bagnor

Background information on this site throughout the 1970s and during the first year of resampling in 1997 was given in Wright *et al.* (1999a). In 1997, it was apparent that the shaded site had undergone substantial change since the 1970s due to the lack of the river management for trout fishing and also due to the effects of the prolonged drought of 1996-97. Lack of management allowed the initial encroachment of marginal emergents on the baseline bank, and this process increased during the drought. In addition, lack of control of the bank-side trees and bushes on the far bank increased shading with some potential for restricting the growth of submerged vegetation.

In 1997, the poor growth of *Ranunculus* and the progressive build-up of silt was thought to be largely due to the drought. The reason for the limited area of *Berula* was less clear, but in view of the large areas of clean gravel, it was anticipated that both macrophytes would increase in area quite rapidly following the end of the drought. Although the discharge over the winter of 1997/98 was unexceptional, heavy rainfall in spring 1998 provided what

appeared to be favourable conditions for the progressive recovery of the macrophytes and macroinvertebrate assemblages.

The results of the mapping programme in June 1998 (Wright *et al.* 1999b), June 1999 (Wright *et al.* 2000b), June 2000 (Wright *et al.* 2001) and June 2001 (this report) demonstrate that, there is no sign of the site returning to the high macrophyte cover of the 1970s. Although *Berula* remains the dominant macrophyte with *Ranunculus* subdominant, the overall percentage cover of macrophytes is substantially lower than in the 1970s, most likely as a result of limited light penetration through the water surface due to the present cover of trees, bushes and marginal vegetation. Also notable is the high percentage cover of silt recorded each year from June 1997 onwards, and which reached the high value of 37.4% following the exceptionally high discharge regime observed over the winter and spring of 2000/2001. This silt is largely associated with the far bank where trees, bushes and associated trailing vegetation influence the pattern of water flow through the site. In June 2001, a fallen tree within the river also altered the pattern of flow in the lower 15m of the river and resulted in further deposition of silt. (Note: On a brief visit to the site in early March 2002, it was apparent that this tree had been sawn up and largely removed from the river).

The long-term macroinvertebrate sampling programme is also a unique record which is now starting to provide answers to a number of important questions. These are currently being addressed in a series of scientific publications and the reader is referred to these for detailed information. Only a brief synopsis is provided below.

When considering ecosystem functioning it is very important to take account of the densities of macroinvertebrates on the various habitat types. Some characteristic families of fast-flowing chalk streams such as mayflies in the Baetidae and blackfly larvae (Simuliidae) are very sensitive to the prevailing discharge regime. In a recent paper, Wright *et al.* (2000a) calculated the 'weighted' mean densities of these families on the site in June for the period 1971-79 and also for 1997. Weighted mean densities take account of the densities of the families on each habitat but also the area of each habitat on the site, thereby giving the best estimate of the density of the family on the site as a whole. In general, low discharge for the three-month period March to May prior to sampling resulted in low densities of Baetidae and Simuliidae but in years of progressively higher discharge, densities increased.

In another paper, Wright *et al.* (in press b) examined the response not just of individual families but of the entire macroinvertebrate assemblage to the prevailing discharge regime. The particular focus was on the drought of 1976 (using data for 1974-79) and the drought of 1997 (using data for 1997-2000). Macroinvertebrate family richness was shown to be significantly lower on *Berula* in the year of each drought and recovery was only partial in the following year. On *Berula* during the 1976 drought (but not in the 1997 drought) the total numbers of individuals were significantly higher than in other years. Thus there were more individuals of fewer taxa (i.e. diversity decreased) during the drought. Ordinations based on abundance data at family level demonstrated very effectively the manner in which the fauna changed in each of the drought years 1976 and 1997 in relation to all non-drought years.

These same ordination diagrams also illustrated that there had been some subtle changes in the fauna between the 1970s and the 1990s. Preliminary analyses suggest that changes in family composition are of very minor significance. In contrast, it appears that there a number of important changes in the densities of many macroinvertebrate families. These changes are

believed to be related to the move from management of the site as a trout fishery in the 1970s to the current lack of management on the site. Thus, in addition to flow regime as a major factor affecting macroinvertebrate abundances, available habitat is also very important. This topic is of considerable interest in the context of river management and conservation and will be examined in the next scientific paper.

7.3 R. Kennet at Littlecote

This site appears to be very much as it was in the 1970s and the same regime of bar-cutting and bankside maintenance has continued with the interests of the trout fishery in mind. In summer 1997, the discharge regime at Littlecote was greater than in the severe drought of 1976 and although the growth of *Ranunculus* was slower than normal, nevertheless, it covered 44.2% of the 100 m site in July 1997. In subsequent years growth of *Ranunculus* has been good, as expected under conditions of high discharge (Wright *et al.* 2002).

Changes in family composition at Littlecote between the 1970s and 1990s have been relatively minor (Wright *et al.* 2002). The macroinvertebrate sampling programme on *Ranunculus* and gravel in the mid-1970s and from 1997 onwards has also demonstrated that family richness has remained relatively stable under a range of different discharge regimes. Nevertheless, the highest number of families recorded on *Ranunculus* and gravel combined during the 1997-2001 sampling programme occurred in the recent June 2001 sampling programme, in the aftermath of the exceptional discharge regime of the previous few months.

This site is of considerable value as a 'control' against which to assess the more substantial changes in the flora and fauna observed further upstream at Savernake.

7.4 R. Kennet at Savernake

The River Kennet at Savernake suffered progressive loss of *Ranunculus* below Marlborough for some years and in an attempt to promote regrowth, a combination of management techniques were used by the River Keeper in the 1990s. These included allowing the river to run freely, use of current deflectors, removal of vertical boarding and reduction of channel width through the planting of marginal emergents etc. Despite his best efforts, these procedures were largely unsuccessful.

At sites on the River Lambourn, there is observational evidence that in years of low discharge, growth of *Ranunculus* is restricted by the accumulation of epiphytic algae and associated detritus on the surface of the plants (Ham *et al.* 1981, Wright and Berrie 1987). At Savernake, the potential for this problem to be compounded in low flow years by the presence of nutrients from Marlborough STW, and other diffuse sources resulting from agricultural activities within the catchment was raised in Wright *et al.*(1999a). In the same report it was noted that in summer 1997, the Littlecote study site was capable of supporting good growth of *Ranunculus* but a relatively similar discharge regime failed to promote growth of *Ranunculus* at Savernake, despite the various management protocols listed above. The question therefore arose as to whether water quality, in addition to water quantity, was relevant to this problem.

In 1997, *Schoenoplectus* was dominant at the lower site, as it had been in the mid-1970s but the total area of this macrophyte (17.4%) was much reduced compared to the 1970s. On the

upper site *Ranunculus* occupied just 6.5% cover and *Schoenoplectus* only 2.7%. On each site silt occupied around 20% of the riverbed.

Prior to mapping in June 1998, some significant changes occurred. First, phosphate stripping commenced in autumn 1997 at Marlborough sewage treatment works. Second, the two-year drought came to an end and although winter discharge was not unusually high, the month before mapping in June 1998 was notable for heavy rain and increased discharge.

In June 1998, it was apparent that a remarkable change had taken place on this section of river. *Ranunculus* had undergone spectacular growth on both study sites and this, in combination with the discharge regime meant that water levels were very high. In 1999 and subsequent years this position has been maintained and *Ranunculus* has often dominated with percentage cover values exceeding those recorded in the mid-1970s. In contrast, *Schoenoplectus*, has continued its slow decline in area, probably because it cannot compete with *Ranunculus* on sites where discharge is high and the river is now allowed to run free.

A full account of changes in the cover of in-stream habitats (including the macrophytes) at Littlecote and both Savernake sites through the mid-1970s and since mapping recommenced in summer 1997 is given in Wright et al. (2002).

A superficial examination of macroinvertebrate family richness on the gravel and macrophyte habitats at the two Savernake sites in the mid 1970s and the late 1990s suggests a high level of stability. Interestingly, each of the two Savernake sites recorded highest family richness for the period 1997-2001 in early July 2001, in the aftermath of the exceptionally high discharge regime, as previously observed at Littlecote.

There have been some relatively minor changes in family composition between these two sampling periods. Ordination techniques using information on family composition and abundance demonstrate this feature (Wright *et al.* 2002). Ordination also indicates that on both Savernake sites the fauna underwent a notable change between summer 1997, when macrophyte growth was poor, and the following two years after the end of the drought, and the start of phosphate stripping. Further analysis showed that this was mainly due to changes in faunal abundance and that, for example, in 1997 there were high densities of three families of leeches, Asellidae and Chironomidae. In 1998, under high flow conditions these families normally occurred at significantly lower densities, whereas in the case of Baetidae, the high densities were associated with the high flow conditions. Unfortunately, the relative roles of flow regime and changes in water quality, as influences on the density of particular macroinvertebrates, are sometimes difficult to disentangle in that they operated over the same winter period of 1997/98 (Wright *et al.* 2002).

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