

**River restoration:  
Benefits for integrated catchment management**

**UK monitoring programme  
Year 1 (1994) Interim Report**

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# Summary

## 1. Status of the restoration sites

### River Cole

The River Cole has a clay, chalk and sandy limestone catchment with an area of about 129 sq km. The catchment is flashy: a feature which is exacerbated by urbanisation in the headwaters around Swindon. The river is a low energy system, with sediment transport mainly confined to fine silts and clays. Low energy, combined with the effects of artificial deepening and widening, leads to a mainly depositional environment as the channel attempts to adjust from the effects of dredging and overwidening. The river is not powerful enough to erode a new cross-section or planform.

The restoration site is on the National Trust Buscot and Coleshill Estate on the Oxfordshire/Wiltshire border, and consists of a 2-km reach of the river with approximately 50 ha of floodplain. The former route of the river is shown by the old county boundary. The modern river course is almost entirely artificial. It was probably created in three distinct stages: the first was pre-1650; there was another major phase of straightening in the late 18th century; and, most recently, a 1970s land-drainage scheme deepened the river by about a metre between Coleshill and the Thames, all but eliminating regular flooding downstream of Coleshill Bridge and reducing its frequency above the bridge.

River vegetation is currently of moderate conservation value, with no rare or Nationally Notable wetland plant species. About half of the floodplain is currently under arable agriculture, with most of the remaining half intensively-managed grassland. However, there is a small area of MG5 grassland (a nationally uncommon type), which is traditionally managed by grazing and supports a population of Snake's-head Fritillaries.

The aquatic invertebrate fauna is rich (equivalent in quality to some of the best rivers in the NRA Thames Region), with 14 nationally local species, including the White-legged Damselfly. Fish biomasses in the restoration reach are generally the lowest on the Cole. Birds are fairly typical of intensively-managed farmland: of 19 wetland 'target species' of high conservation priority (mainly waders and waterfowl), only five are currently thought to breed on the site.

### River Skerne

The River Skerne has a clay/alluvium lowland catchment, with an area of about 250 sq km. The Skerne's channel is almost entirely man-made throughout its length. Although both coarse and fine sediments are available (including gravels from glacial materials), the river is not energetic enough to erode a new cross-section.

The 2-km restoration site is in an urban fringe public open space owned by Darlington Borough Council. The site has been greatly modified as a result of industrialisation, and much of the floodplain has been eliminated by spoil-tipping. The river channel on the restoration site is currently trapezoidal and linear, and most instream features have been eliminated. Modification of the river is documented from about 1850 onwards, culminating in modern flood defence schemes which protect Darlington from floods of up to 1 in 100 years frequency.

The Skerne has a long history of pollution, and although water quality is slowly improving, chemical water quality is only moderate to poor. Sediments are contaminated by heavy metals.

River channel vegetation is of moderate conservation value. No nationally scarce or rare plant species have been recorded. Floodplain vegetation is primarily amenity grassland, but the Rockwell Conservation Area is more varied, with ponds that support Great Crested Newts. The aquatic invertebrate fauna of the river is impoverished (perhaps because of heavy metal pollution) and of low conservation value. Until recently, no 'sport' fish species were found in the Skerne above Darlington, but Dace and Brown Trout have been restocked since 1992. The landscape is of low to medium value, with few features of 'conservation' status. Despite this, the area is valued by local residents, who have a strong interest in the proposed restoration works.

## **2. Progress of the monitoring programme**

The first year of the monitoring programme has been concerned with the development of the pre-works baseline. Establishment of baseline data will continue into the summer of 1995, when restoration works begin. Both demonstration sites consist of a restoration reach with upstream 'control' and downstream 'impact' reaches.

The monitoring programme on both sites covers background historical information, geomorphology, landscape, hydrology, chemical water quality, river channel vegetation, invertebrate water quality assessment, birds and fisheries. Special studies, areas of the programme where more detailed information is being collected, are the hydraulics of environmentally-designed channels (in collaboration with MAFF and Hydraulics Research), invertebrate conservation, restoration of plant communities, nutrient budgets, public perception of restoration, and economic benefits of restoration schemes.

### **Site history**

Historical data has been reviewed, including a wide range of maps, aerial photographs, land-use data, NRA archive material and archaeological information.

### **Geomorphology**

Geomorphological audits, using standard NRA techniques, have been undertaken for both catchments, including analysis of sediment composition. A geomorphological baseline survey has been undertaken on the Cole and more detailed works are in preparation. Detailed land surveys (giving contour intervals of 10 cm) have been undertaken on both sites. Recent aerial surveys of both sites have been undertaken.

A soil survey has been undertaken on the Cole as a student project. Site investigations are also proceeding on both sites to describe floodplain soils and geology.

### **Landscape**

Landscape baseline surveys have been completed on the Skerne and are in progress on the Cole. Both sites have been surveyed using standard NRA techniques for river corridors, which combine subjective and objective methods for assessing landscape.

### **Hydraulics and hydrology**

Water-level recorders have been installed at four sites on the Cole and two on the Skerne (where problems with vandalism have been experienced). These are providing a continuous record of water levels (with measurements made every 15 minutes) and are providing information for the Hydraulics Research project on the hydraulics of environmentally-designed channels. Water-level information is also needed for nutrient budget work.

A continuous record of flow data is available for both sites from NRA gauging stations.

### **Water quality**

Water quality data is routinely collected by the NRA at three monitoring stations on the Cole and three stations on the Skerne; one additional station has also been established in the centre of the restoration reach on the Skerne. Sampling of macroinvertebrates at family level is also routinely undertaken by the NRA on both rivers. In addition, two new invertebrate monitoring sites have been established by the NRA on the Skerne restoration site as part of a wider Skerne Action Plan.

Detailed monitoring of nutrient concentrations to develop budgets for the restoration site is taking place on the Cole. Weekly samples are being collected from six stations (four on the main river, two off-river). Storm sampling (using automatic water samplers) will be started shortly. Combined with flow data, this study is measuring changes in overall export of nutrients from the restored reaches.

### **Plant ecology**

River corridor surveys have been carried out for both rivers, and a floodplain NVC survey has been completed for the Cole and is planned in the early summer for the Skerne. Additional work has been undertaken to ensure that the river corridor surveys also provide a full wetland plant species list for each 500-m survey reach. On the Cole, more detailed analysis of changes in river-channel and bank vegetation is being undertaken as part of the special study of the restoration of wetland plant

communities. This study is using permanent quadrats in the upstream control, restoration, and downstream impact reaches.

### **Invertebrate conservation**

Invertebrate conservation is an area of special study within the programme. A detailed study of the conservation value of aquatic macroinvertebrate communities is in progress on the Cole: the sampling programme includes replicated sampling of nine reaches (five in the restoration reach, two upstream and two downstream). Additional sampling using a quick field-searching technique was also undertaken on the restoration site to assess the value to invertebrates of non-river habitats which might be damaged by restoration work. On the Skerne, species-level information has been collected in the course of water quality monitoring to allow conservation assessments to be made (although this study is not intended to be as detailed as the work on the Cole).

A pilot study of sampling techniques for assessing changes in floodplain invertebrate populations has been undertaken on the Cole.

### **Fisheries**

Surveys of fish are building on work previously undertaken by the NRA. Surveys on both the Skerne and the Cole (also to be undertaken by NRA staff) are planned for spring 1995, adding to data which was collected from 1991 to 1994 on the Skerne and in 1992 on the Cole.

### **Birds**

Bird survey work has started on the Cole (which has considerable potential for wetland birds) with a breeding season survey and a survey of overwintering birds. Surveys are being done by transect and compartment counts of birds. Five site visits were made between April and June 1994, and six between December 1994 and February 1995.

A breeding bird survey is planned for the Skerne in spring 1995. The survey will probably use modified Common Bird Census techniques.

### **Public perception**

Public perception studies (one of the monitoring programme special studies) have been initiated on the Skerne, where a pre-works questionnaire survey will shortly be undertaken. Detailed planning of this questionnaire (including a pilot trial of questions to be used) was undertaken in January 1995. This questionnaire survey has been developed in conjunction with a variety of public consultation exercises taken in the course of site design work. Public perceptions of restoration are being assessed informally on the Cole.

### **Benefits to integrated catchment management of river restoration.**

Assessing the benefits of restoration is one of the main aims of the project, and is a special study on both sites. Planning of the areas that will be assessed overall has been started; the data gathering described above will provide most of the data needed for this work, although it is expected that additional economic analysis will be needed.

### **Additional studies**

Overall, this works programme makes the Cole and Skerne two of the most intensively-studied sites in Britain. There are, therefore, considerable opportunities for developing the sites' potential, and a number of additional studies have already been initiated or are under consideration. Student projects (MSc and BSc, with Silsoe College and Oxford Brookes University) are currently in progress on (i) the history of land-use changes in the rivers; (ii) design of reed-beds and wet meadows; (iii) comparison of river conservation assessment techniques (two projects); (iv) the economics of river restoration; and (v) soil survey. Discussions are in progress with the Freshwater Biological Association on the funding of a PhD studentship looking at the role of woody debris in restored channels. A Newcastle University PhD student investigating PHABSIM methodology has undertaken some work on the Skerne as part of a larger project. Finally, there is potential for collaboration with research workers at Cambridge University investigating the effects of floodplain hydrology on woody vegetation, and with the Forestry Authority on the establishment of floodplain forest.

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# 1. Introduction

This report presents the first year results from the UK monitoring programme for the European Union LIFE-funded project "River restoration: benefits for integrated catchment management".

The report describes the results of environmental monitoring on the two UK restoration demonstration sites: the River Cole at Coleshill (Oxfordshire/Wiltshire) and the River Skerne at Darlington (Co. Durham).

## 1.1 About this report

The aims of this report are:

- To provide baseline information to establish the pre-restoration state of the rivers.
- To provide information which can (i) inform the design of the restored reaches, and (ii) ensure that their existing interest and value is protected.

The monitoring results are described separately for the River Cole (Section 1 of this report) and River Skerne (Section 2).

Both rivers are being monitored in terms of physical channel structure, hydrology, water chemistry, plant communities, invertebrate communities, bird communities, fisheries ecology and landscape change. In addition, more detailed special studies are being undertaken on nutrient pollution, invertebrate conservation, and the restoration of plant communities on the Cole, and on the public perception of restoration on the Skerne. Both sites are also part of a detailed economic analysis of the catchment scale benefits of 'soft' engineering techniques (see Table 1.1).

## 1.2 Project aims

The project as a whole forms part of a joint initiative between the United Kingdom and Denmark to encourage the restoration of rivers in Europe. The project aims are:

- To establish three European Demonstration Sites which apply new and state-of-the-art techniques to the restoration of natural habitats in damaged rivers and their floodplains.
- To demonstrate the benefits of river restoration for Integrated Catchment Management, i.e. in terms of nature conservation, water quality, river hydrology, flood prevention and amenity, by monitoring the physical, chemical and biological effects of restoration.
- To involve, motivate and train those who influence or undertake river management work (e.g. water managers, landowners, developers, politicians, environmental organisations).
- To widely disseminate information about river restoration using pan-European networks.

The project is led by South Jutland County (Denmark). The project partners are, in addition to South Jutland County, the Danish National Environmental Research Institute, the River Restoration Project Ltd, the National Rivers Authority, English Nature, the Countryside Commission, Darlington Borough Council and the National Trust. The UK component of the project is co-ordinated by the River Restoration Project Ltd (RRP), a non-profit-making company established to promote the restoration of rivers for conservation, recreation and amenity. Further information about the RRP is summarised in 'Partnerships for River restoration Part 1 (1994)'. Further background information describing the project rationale is given in Box 1.

**Table 1.1 Main sections of the UK monitoring programme on the LIFE river restoration demonstration sites**

	<b>River Cole</b>	<b>River Skerne</b>
<b>Physical and chemical</b>		
Water quality monitoring, including nutrient pollution	Special study	✓
Geomorphological change, including changes in channel stability	✓	✓
Hydrological regime, including hydraulics	✓	✓
Soil survey	✓	•
<b>Biological</b>		
Aquatic invertebrate ecology	Special study	✓
Aquatic plant communities	Special study	✓
Floodplain plant communities	✓	✓
Floodplain invertebrates	✓	•
Birds	✓	✓
Fish	✓	✓
<b>Public perception</b>		
Landscape assessment	✓	✓
Public perception assessment	•	Special study
<b>Catchment management</b>		
Cost-benefit analysis	✓	✓

### 1.3 The LIFE project in the UK and Denmark

The LIFE project involves the restoration and monitoring of three river demonstration sites (stretches of river between two and five km in length and their associated floodplains). The sites have been chosen to typify the problems associated with many lowland European stream and river systems, and include watercourses with a range of sizes within both urban and rural catchments.

The sites are:

- River Cole (United Kingdom): restoration in a clay catchment
- River Skerne (United Kingdom): restoration in an urban environment.
- River Bræde (Denmark): restoration in a sand/peat catchment.

### 1.4 Overall monitoring project aims

The monitoring of these restoration schemes essentially aims to assess the environmental benefits of restoration, and the ability of restoration to provide a low-cost solution to practical river catchment management problems. In particular, the monitoring programme aims to provide information which can be used to assess the value of river restoration for integrated catchment management, including the benefits for:

- (i) flood storage and flood alleviation
- (ii) nutrient reduction or storage
- (iii) river maintenance costs
- (iv) conservation
- (v) recreation and amenity.

### 1.5 The report stages

The monitoring project is currently funded for three years and the reporting schedule for the two United Kingdom sites is as follows:

- Year 1 (1994) Interim Report: provides baseline data to establish the pre-restoration state of the rivers.
- Year 2 (1995) Interim Report: completes the baseline, and provides data about the changes during the physical restoration of the sites, including potentially adverse impacts such as increased downstream sediment loads resulting from the construction work.
- Year 3 (1996) Final Report of LIFE funded work: summarising the three years' work, and providing initial results about the value and success of the restoration.

## **BOX 1 Rationale for the LIFE project.**

### **The problem: the impact of regulation on European rivers**

There has been widespread physical degradation of European rivers. In Denmark, for example, 98.7% of streams and rivers have been straightened and channelled, so that less than 3% still retain their original meandering course. In Britain, 89% of main rivers are regulated, either to control land-drainage or to provide water resources. Rivers in many other European countries are subject to the same impacts and stresses and have also been severely modified (e.g. France, Germany, Holland and, increasingly, southern European countries such as Spain).

The result of this physical degradation has been to severely reduce the natural diversity of river ecosystems. The habitats offered by engineered river channels are, typically, both limited and monotonous, especially when compared to the rich habitat-mosaics of natural watercourses. Even more severely impacted have been floodplain wetlands such as fens, wet woodland and wet meadow, which are now nationally threatened habitats in many EC countries. In addition, river modification is known to have caused a variety of practical management problems. Thus, channelisation for agricultural drainage can disrupt the natural ability of rivers to buffer against pollution. It may also result in considerable erosion and sediment production which necessitates expensive programmes of dredging to maintain channel flood capacity. Likewise, loss of floodplain may increase downstream flood volumes and velocities whilst simultaneously reducing the potential for water interception and storage, which exacerbates low flow problems.

### **Benefits of restoration for Integrated Catchment Management**

There is an increasing awareness that reinstating naturally-functioning river-floodplain systems and 'working with the river, rather than against it' may bring benefits for integrated catchment management. The great strength of restoration is that, as a holistic method, it is particularly effective at reconciling the demands of the different water/river user groups. River restoration may, therefore, bring simultaneous benefits for nature conservation, amenity and recreation, pollution control, flood defence and water resources management.

### **The demonstration sites**

The project has established three demonstration sites (lengths of river and associated floodplain) in the partner countries (UK and Denmark), to illustrate the range of river restoration measures and demonstrate the application of different restoration techniques. The sites have been chosen to typify the problems associated with many lowland European stream and river systems, and include watercourses with a range of sizes within both urban and rural catchments.

### **Objectives of restoration**

Restoration involves establishing both channel and floodplain features (e.g. meanders, riffle-pool sequences, oxbow lakes, undrained floodplain) and the natural habitats associated with these features (e.g. floodplain forest, reed and sedge beds, permanent and temporary standing waters).

The project is focusing on integrating the restoration for nature conservation of rivers and their floodplains with other catchment planning needs. In rural demonstration sites, the project is integrating restoration with low-intensity agricultural use (with potential benefit for water quality and flood storage). In the urban demonstration site, the project is focusing on potential water quality improvements (e.g. urban run-off) and amenity and recreation benefits.

# RIVER COLE

RIVER COLE

## 2. River Cole: background information

### 2.1 Aims

Background information about the restoration site was gathered to provide:

- (i) baseline information needed for the design of the restoration works.
- (ii) background for the monitoring programme.

### 2.2 Methods

Gathering background data involved:

- (i) collecting historical documentary and map information relating to the restoration reach itself. The main sources of information used for this work are listed in Table 2.1.
- (ii) gathering data on the wider catchment of the Cole.

The information in this section has mainly been derived from: (i) a Catchment Audit undertaken for this study by David Sear and Richard White (ii) a review of historical data for this study by Penny Williams.

### 2.3 Catchment information

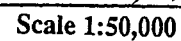
The River Cole flows through a small lowland catchment covering an area of approximately 129 sq km which drains the northern edge of the North Berkshire Downs before flowing north across the clay vale to join the River Thames near Lechlade (see Figure 2.1). The main tributaries of the Cole begin as springs at the foot of the chalk escarpment. Due to the dip of the chalk rock, however, much of the water falling on the Downs flows south as groundwater into the River Kennet catchment. Having risen from chalk rocks, the river flows across a wide expanse of (Kimmeridge) clay before passing between the Corallian Rag Hills to the north-east of Swindon. These hills consist of sand/clay/limestone/sands and silts, and are the only natural source areas for any form of gravel substrate for the river bed before the Thames gravels. The final section of the river flows over Oxford clay before joining the Thames. Catchment data is summarised in Table 2.1 and expanded in the following sections.

### 2.4 Geology

The main regions of the Cole catchment are:

- (i) lowland clay vales on the Kimmeridge and Oxford clays
- (ii) upland areas comprising the chalk escarpment of the Berkshire Downs and the low hills of Corallian sandstone and limestone which separate the clay vales.

The valley of the River Cole is floored with alluvium, which contains an increasingly large proportion of sands and gravels downstream of the Corallian hills. Nevertheless, the alluvium is dominated by fine sands, silts and clays. Extensive basins of alluvium, which demarcate former active floodplains, exist in the upper reaches of the Cole catchment. In the lower reaches of the River Cole, including the restoration area, Thames gravels underlie alluvium, and locally outcrop in the river banks downstream of Coleshill Bridge (NGR SU234935). Elsewhere in the catchment, concentrations of coarse gravel are found only locally at riffles, but it is significant that these are often associated with existing or collapsed structures.



## 2.5 Soils

Soil type is an important control on landuse, vegetation cover and sediment delivery within a catchment. Sediment delivery is largely controlled by clay content in a soil, land use and topography. The soils in the Cole catchment are dominated by clay-based soils up onto the Downs: the soil associations are given in Table 2.1. Using the classification of Evans (1990), it is possible to establish the sensitivity of the Cole catchment to soil erosion. The majority of the catchment soils fall within the categories 'very small risk' or 'small risk from water and wind erosion', though locally the chalk soils on the steeper Berkshire Down escarpment are classified as 'at moderate risk from water erosion' (Evans, 1990; Boardman, 1991). The clay vale landscape is described as being the least susceptible to erosion due to the low gradients associated with this landscape and the cohesiveness of the soil types (Evans, 1990).

<b>Table 2.1      Catchment Characteristics of the River Cole (Oxfordshire/Wiltshire)</b>	
Catchment area	129km <sup>2</sup>
Mainstream length	22.7km
Slope	0.00108
Geology	Chalk, Head, Silts and Fine sands, Mainly clay, Ferruginous sands, Kimmeridge Clay, sand/Clay/Limestone/Sand & Silt, Oxford clay
Drift	Alluvium
Soil	Pelo-Stagnogley/Stagnogley (712&711j/f), Brown Redzina (343h), Gleyic brown calcareous earths (512), Grey Redzinas (342a)
Landuse	Urban, Reservoir, Mixed arable farming. Pasture (rough and improved)

**Table 2.2 Reports and maps relating to the River Cole restoration site**

Author	Date	Title
Great Western Community Forest	1994	<i>Forest plan.</i> Consultation Report.
Hughes, D.P.	1988	<i>Oxfordshire inventory of ancient woodlands.</i> Nature Conservancy Council.
Lansdown, R.	1994	Coleshill River Restoration Project: R. Cole River corridor survey.
National Rivers Authority (Thames Region)	1992	River Cole fisheries survey.
National Trust	Undated	Landscape Plan for Buscot and Coleshill Estate.
National Trust	1986	National Trust biological survey. Buscot and Coleshill, Oxfordshire.
National Trust	1987	Buscot and Coleshill biological survey - farmland.
Rich, T.C.	1994	Coleshill River Restoration Project. Botanical survey.
Sear, D.A. and White, R.A.	1994	Catchment audit of the River Cole (for this study).
Thames Conservancy	Undated	Land drainage fund. Annual accounts for the year ending 31st March 1932 to the year ending 31st March 1949.
Thames Water Authority	1988	River Cole catchment study.
Thamesdown	1991	Thamesdown Local Plan.
Vale of White Horse District Council	1993	Draft Local Plan.
J. Weller	1980	<i>Coleshill model farm, Oxfordshire. Past, present, future.</i> Architects in Agriculture Group: Occasional Paper Number 1. Royal Institute of British Architects.

<b>Maps</b>		
1666	Map of the manor and parish of Coleshill (W. Brundell)	
1761	Topographic map of Berkshire (S. Rocque)	
1775	Fresden's Map of Coleshill parish	
1796	Plan of Coleshill	
1809-1818	OS field survey map	
1828	Ordnance Survey First Edition	
1840s	Highworth Tithe Map	
1876 and 1900	Ordnance Survey maps 1st and second edition: 25" = 1 mile	
1914	Ordnance Survey base map with a field survey of land use mapped between 1932 and 1933 (Berkshire VII SE and Wiltshire VI)	
1935/6	Thames Conservancy Land drainage Report for River Cole and Tributaries	
1952	Borough of Swindon map	
1968	OS 1:25000 3rd Edition map	
1974	1:50000 Geology Drift and Solid	
1981/93	Thames down Borough Council Aerial photographs	
	Soil survey of England and Wales 1:250000 soil map	
1987	Thames Water Authority Surveyed Section of River Cole	
1994	Thamesdown Borough Council Draft Local Plan	

Land-use in the catchment is outlined in Section 2.6 below, but is dominated by intensive arable farming for winter cereals, oil-seed rape and flax. These land-use types result in a bare soil surface during the autumn and winter flood season. Evans (1990), Boardman (1991) and Morgan (1985) all indicate that a change in land-use to arable agricultural production increases the erosion of topsoil. This may be more important on clay soils, given the fairly high frequency of overland flow, which can deliver sediments from relatively flat field surfaces to the drainage network (Morgan, 1985). Where arable fields lie on the floodplain, soil erosion can be locally severe during overbank floods.

## 2.6 Land use

### 2.6.1 Catchment land use: current and historical

The Cole catchment is dominated by agriculture, with significant urban development in the headwaters draining Swindon (Table 2.3). The agriculture in the catchment has witnessed significant change over the past 50 years, predominantly from pasture to arable farming. In addition, development has led to an increase in urban area within the catchment as a whole, and specifically in the headwaters of the Cole and Dorcan Brook. The change in land-use can usefully be divided into changes within the whole catchment and those relating specifically to the riparian zone bordering the channel. Table 2.3 summarises the land-use change data collected from the 1936 land-use survey map and a 1993 review obtained from aerial photography. The riparian zone information is derived from data supplied by Thamesdown Borough Council (Bryant, pers comm.). The urban areas are detailed from 1:10,560 scale Ordnance Survey maps.

<b>Table 2.3 Percentage land-use cover in the Cole catchment and riparian zone</b>			
<b>Land-use</b>	<b>1936 Catchment</b>	<b>1993 Catchment</b>	<b>1993 Riparian zone</b>
Urban	5	15	
Pasture/Grassland	70	25	40
Arable Agriculture	25	60	60

Prior to 1950, there was little development within the catchment. Between 1950 and 1980, however, there was a nearly continuous eastward expansion of Swindon which urbanised 13.5 sq km of the upper catchment. Associated with this has been culverting and straightening of the Cole main channel and the Dorcan Brook along their entire lengths within the urban area. The land upon which this expansion took place is low-lying clay vale which was previously meadowland. Consequently, the whole area has been extensively drained. The urban area also contributes one of the main sources of pollution for the Cole, namely oil-spill incidents from industry and road run-off. Most recently, in 1984 Honda began building upon the airfield at Stratton St. Margaret (NGR SU184883), and look set to continue developing over the whole site, creating a new paved area.

Agricultural changes have also been dramatic since the 1950s. The dominant land-use was originally pasture. Arable farming was confined to the higher areas of the Downs (where sheep-grazing also occurred), and the Corallian Rag hills. The river regularly flooded the lowland areas, but this in fact increased the value of the land (by as much as 100%), since late winter/early spring floods protected the bordering meadows and enabled two cuts of hay to be made each year. Post-World War II, with the national drive for increased food production, the vale lowlands began to be extensively drained in order to enable arable crops to be grown. Land-drainage grants from MAFF contributed as much as 70% to the costs of such operations and hence most of the meadowland was lost to the plough.

For example, in 1993 land-use in the riparian corridor was 60% arable, with the main concentration downstream of Coleshill Bridge (Thames Region Water Authority, 1988). Today, crops such as winter cereal and oil-seed rape dominate the catchment. Much of the floodplain land shows evidence of 19th century underdrainage or management for water meadows. Drainage of the floodplain soils was

undertaken in the 1960s and peaked in the period 1965-1975. Downstream of Coleshill, the land drainage scheme of 1976 was accompanied by large-scale underdrainage and arterial drainage of the floodplain.

The Cole catchment upstream of Coleshill Bridge will undergo a land-use change as its woodland cover increases: the Great Western Community Forest (White Horse Forest) covers an area far greater than the Cole catchment, but the proposal for tree-planting aims to increase woodland cover in the catchment to 30% by 2035. Uptake will be achieved through voluntary land-use change under schemes such as Countryside Stewardship. The River Cole is seen as an important wildlife resource in this plan, and Coleshill Estate is an important element within the River Cole project area (Great Western Community Forest, 1994). Newson (1992) highlights the paucity of information on the effects of lowland afforestation on the water quality, sediment yields and hydrology of catchments; however, he cautions that minimising any such effects depends upon proper 'water-minded' management, particularly during planting and felling.

It will be particularly important for the design of the restoration works to review the changing patterns of land-use, the development of land drainage and flood defence schemes and historical modification of river morphology.

## 2.6.2 Details of land-use changes in the restoration area

All early maps and documents which give any indication of land-use suggest that, until the 1930s, the floodplain of the Cole within the restoration area was continually under grassland.

On the 1760s map, the use of terms such as 'meade' and 'pasture' in field names suggests that grassland use was likely to have been a mixture of water-meadow types, i.e. irrigated cut grasslands and grazing. In 1726, William Cobbett noted of Coleshill that

'It is chiefly grazing land; and though the making of cheese and bacon is, I dare say, the most profitable part of farming here, Lord Folkstone fats oxen, and has a stall for it which ought to be shown to foreigners instead of spinning jennies.'

William Cobbett, *Rural Rides*, 1726

Enclosures following two Acts in the late 18th century (1777 and 1780) (Tate 1943) resulted in further subdivision of fields, and almost certainly accompanied channellisation of a number of Cole tributaries (see below). In the early to mid-1800s, farming was biased towards dairying: the 1854 plan for the Model Farm at Coleshill indicates stalls for use by cattle, sheep, horses and pigs, presumably indicating some mixed grazing, at least during parts of the year.

Grazing continued to dominate the floodplain land-use until the 1950s, when, increasingly, drainage allowed a transition to arable cropping. Drainage of the floodplain soils peaked in the period between the mid-1960s and the 1970s and, in the restoration reach, culminated in the land drainage scheme of 1976 which accompanied large-scale underdrainage and arterial drainage of the floodplain. Downstream of Coleshill, land-use in the restoration area is now dominated by crops such as winter cereal and oil-seed rape. Upstream of Coleshill bridge, the land abutting the channel in the restoration reach remains under grassland, but even this area has been much improved by fertilisers and selective herbicides to improve cattle grazing and allow silage production.

The restoration area and its surrounds include very little woodland. Two of the three small woodland areas present (Raglan's Wood and Waterloo Copse) are clearly secondary woods, established in the 19th century. Despite their designation as ancient woodland by the NCC (Hughes 1988) the third area of woodland (including Watchfield Common Wood and Tellhard's Copse) may be secondary plantations. Two sources of evidence support this: (i) map evidence from the 18th century (see Figure 2.2), which shows this area as 'Common'; and (ii) the 1930s land classification survey (Stamp 1936) which classified the woods as new coppice plantation.

Modern land-use is shown in the aerial photograph of the site (Figure 2.5).

## 2.7 Historical development of the channel

### 2.7.1 Changes in the planform of River Cole in the restoration area

The River Cole has a long history of modification in the restoration area. A mill is mentioned in the Domesday Book records of Coleshill (1086), suggesting river impoundment for at least 900 years.

The first map of the area (1666) shows the mill in its present position, with straight (?straightened) sections of stream, both above and below the mill. The downstream section probably reflects a very old straightening of a large river bend downstream of Coleshill Bridge. The county boundary still follows the likely old course (now a ditch) to the west of Coleshill Village.

The 1761 Rocque Map (Figure 2.2) shows that until the late 18th century, the mill was fed only by a small channel which carried water from the R. Cole. Thus the main channel of the Cole was still active at this time, and meandered through the grazing field at NGR SU235930 (see Figure 2.2).

Sequential maps indicate that between 1761 and 1818 the Cole underwent a major modification upstream of the mill to approximately its present configuration (see Figure 2.3). This involved:

- (i) widening, and presumably deepening, the small mill channel to take the entire flow of the Cole;
- (ii) filling, or partial filling, of most of the old river course, until today it remains only as a series of depressions which form temporary pools during part of the year;
- (iii) extending the mill channel (doubled to approximately 1 km) by straightening a meandering reach of the Cole up to what is now Tellhard's Copse;
- (iv) retaining part of the original Cole channel immediately west of the mill to act as an overflow, with a weir and two short channels linking the original river and mill stream.

Immediately outside the restoration area, a number of other changes in the river are worth noting. South (upstream) of the National Trust land, a small bifurcation of the channel below Fresden Farm appears to have been simplified, with the western arm much reduced, by 1818, and narrowed again by 1900 to form a simple drain. The practice of cutting-off meander bends also continued into the 20th century, with a small (100-m) section of meanders immediately north (downstream) of the National Trust land having been straightened between 1936 and 1974.

### 2.7.2 Changes to tributaries and drains

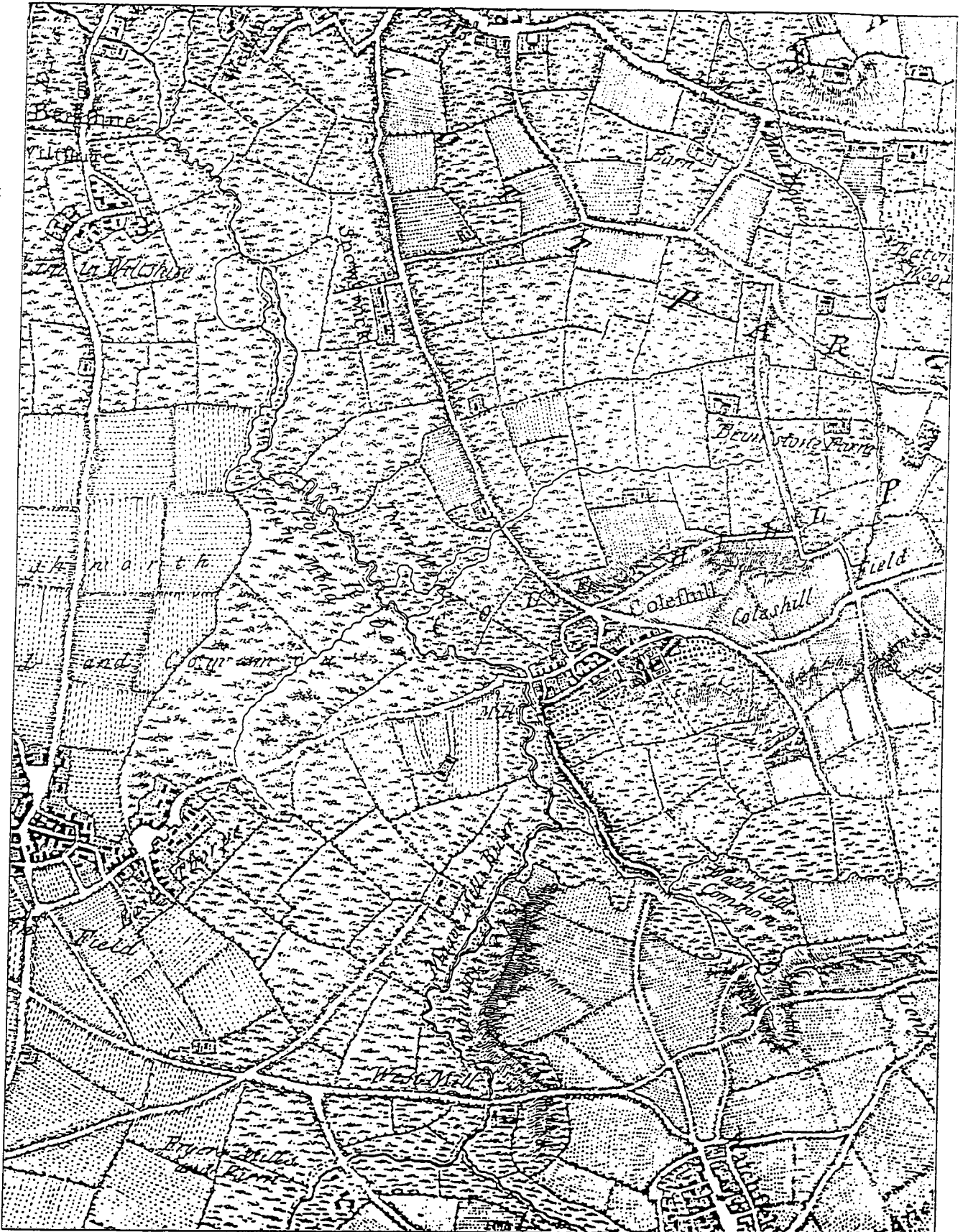
Map evidence suggests that the courses of all the River Cole tributaries have been simplified since the 18th century.

The Waterloo Ditch, which now joins the Cole at SU939223, originally divided into two arms about 300m upstream of its confluence. It was straightened between 1761 and 1818, presumably at the same time as the extension of the mill channel (described in 2.7.1 above).

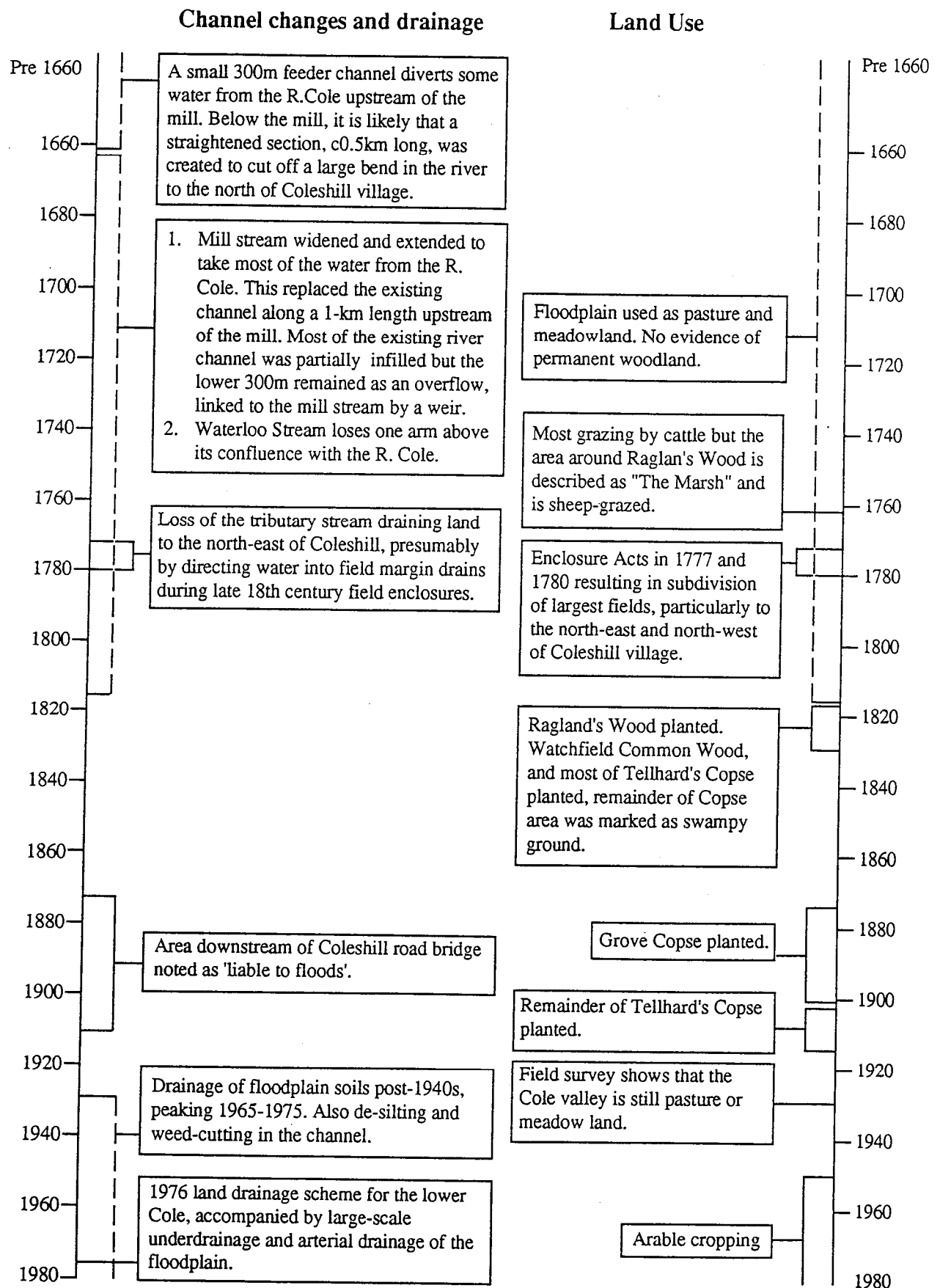
The 1761 Berkshire Topographic map indicates the presence of a bifurcating tributary stream, which is no longer in evidence at all, downstream of Coleshill. This originally drained the north-eastern part of the restoration area; no trace of it is apparent on post-1818 maps, however, and it is likely that it was redirected into field drains during enclosures in the late 18th century.

Finally, the ditch which marks the north-western boundary of the National Trust land was originally a slightly meandering tributary stream to the Cole. It appears to have been much straightened between 1818 and 1876.

Figure 2.2      Roque Map of Berkshire (1761)



**Figure 2.4 Chronology of channel modification, drainage and land use changes on the River Cole around Colehill**



## 2.8      **Flooding and drainage**

Flooding still occurred downstream of Coleshill Bridge in 1914. In 1773 the western end of the field south of Coleshill Road bridge (part of which is now covered by Raglan's Wood) was called The Marsh and used for sheep grazing.

Fields were progressively enclosed between 1761 and 1818, and this presumably included some ditching because enclosure coincided with the disappearance of the stream shown draining the north-east of the restoration area. Drains to the east of the river, south of Coleshill, can be dated to between 1841 and 1883, and there are map records of an 'improvement' drain from the Waterloo Ditch in 1883. The second edition of the Victorian OS maps, however, suggests that most of the existing field boundaries and drains were in place by the 1900s.

### 3. Geomorphology: Cole

#### 3.1 Aims

The aims of the river morphology monitoring programme on the Cole are:

- (i) To compare the morphometry of the old and restored channels.
- (ii) To assess the stability of restored channel sections.
- (iii) To assess channel sediment mobilisation and deposition, including evaluation of sediment release downstream.
- (iv) To provide information relevant to the restoration design.
- (v) To provide topographic information to facilitate plant and invertebrate surveys.

#### 3.2 Methods

##### 3.2.1 River geomorphology

The main components of the geomorphological monitoring programme on the Cole are:

- (i) catchment audit: describes the geomorphological context of the catchment, reviewing the existing geomorphology and factors which influence geomorphology (e.g. sediment sources and land drainage engineering).
- (ii) morphological survey: describes in more detail the individual reaches of the river (including reaches outside the restoration area), and identifies the degree to which reaches have been modified morphologically.

Morphological survey work was undertaken in the course of NRA work on the Upper Thames Catchment Management Plan.

- (iii) site-specific monitoring, including:
  - Sediment sampling to characterise the bed and banks of the old and new channels.
  - Pre-construction geomorphological survey to 'characterise the channel'. The detailed topographic survey compiled for the project will be used as the basis for this, including a detailed map showing pools, riffles, and other morphological features.
  - Transect surveys of the original and restored river channel, which are being undertaken every 100m throughout the restoration reach, and at closer intervals (probably 10m) in selected sections (including up- and downstream control reaches). It is intended that detailed survey sections will coincide with vegetation and invertebrate survey sections.
  - Construction and post-construction monitoring at defined intervals of time. This is likely to include a one-off survey towards the end of construction, with summer and winter surveys together with a contingency for flood events over the period of study. The method will include relocating sections and detailing erosion/deposition of the bed/banks as appropriate. Particular attention will be paid to the short-term adjustment of bed and banks. Patterns of siltation will also be noted, particularly in relation to the growth of vegetation. Erosion pins will be used to evaluate changes to river banks (where appropriate).

Most site-specific monitoring work will be undertaken in Spring 1995 prior to the commencement of construction works.

### **NRA River Habitat Survey**

The NRA has recently introduced a new physical habitat survey monitoring technique known as 'River Habitat Survey' (RHS).

The Cole downstream of Coleshill bridge was selected as a trial site in 1994 and was surveyed using this new technique. It is hoped to make a more detailed investigation of the relationship between RHS results and river conservation assessment methods on the Cole in the course of an MSc Dissertation with a student from Silsoe College.

### **Catchment audit methods**

The catchment audit followed the standard technique developed by the NRA, and was undertaken by David Sear and Richard White (University of Southampton). The audit reviewed a wide variety of existing data (principally maps, aerial photographs, water quality data and photographic archives). Field evidence and site-specific information was then used to assess current channel stability and the operation of the sediment system.

### **Morphological survey methods**

The morphological survey used standard methods developed by the NRA, which have been applied widely in the NRA Thames Region. The main aim of this classification technique is to assess the morphological diversity of river channels and the degree to which they have been modified (for example, by dredging or realignment). The work was undertaken by Sue Reed and Andrew Brookes (NRA Thames Region) as part of the development of the Upper Thames Catchment Management Plan.

A variety of background data, including geological maps, soil-survey data, Thames Conservancy land drainage records from the 1930s and an archive of photographs of the Cole from the 1950s, was reviewed at the outset of the morphological survey. Morphological survey data and further photographs from a survey in 1987 were also reviewed.

The river was surveyed from Friars Mill Bridge to the confluence with the River Thames at Lechlade (this was Part 1 of the survey; further work is planned by the NRA to complete the survey of the full length of the Cole).

Standard morphological data was collected at a representative point in each 500-m river reach. Data was collected on channel form, process, stability, management, previous works and recovery, ecological value, land-use, maintenance requirements, protection value and enhancement opportunities. This information was used to assign a sensitivity rating to each reach. Reaches that are little modified by human activity are regarded as 'highly sensitive', whereas those that have been severely modified are regarded as being of low sensitivity.

### **Site-specific survey work**

Site-specific survey work will begin in spring 1995, and will continue into the post-construction phase.

## **3.2.2 Floodplain geomorphology**

### **Topographic survey**

The topographic survey of the floodplain of the restoration area was undertaken in August 1994 by Maltby Land Survey. Survey contour intervals are in the order of 10-20 cm, giving a very detailed interpretation of surface topography.

### Aerial photographs

Recent and historical aerial photographs have been inspected to review floodplain morphology.

## 3.3 Catchment audit

### 3.3.1 Catchment characteristics

Information about the geology, soils, land-use and historical change in the Cole catchment are given in Chapter 2 (Background).

Catchment hydrology is described in Chapter 5 (Hydrology and hydraulics).

### 3.3.2 Channel sediment transport

The Cole sediment transport system is dominated by fine silts and clays. This is probably a reflection of both urbanisation and the dramatic change in agricultural practice within the catchment which led to the production of large quantities of silt. Evidence of the influence of agricultural practices on sediment loads is clearest in some of the rural tributaries of the Cole, where silt deposition is similar to, and sometimes greater than, that in streams draining the urban area. Values for suspended solids transport also exhibit wide fluctuations between baseflows and flood peaks (Table 3.1).

Silt and clay are, therefore, the dominant components of the sediment load of the contemporary River Cole, though there is evidence that sand and gravel have been more extensive and will still comprise the bedload. Silt covers much of the bed material, and locally reaches depths of 1.0m. Transport of sediment will be dominated by suspended sediment loads during floods. These have been sporadically monitored for 20 years by the relevant water authorities. The suspended solids load varies dramatically, from 1.2 mg/l during base flows up to 447mg/l during flooding. Table 3.1 documents the average suspended solids loads for two periods during which levels have risen for sampling stations downstream of the Dorcan Brook. This may reflect catchment land-use changes, which have been dominated by a change to arable cropping in the Cole downstream of the Dorcan Brook. The decrease in suspended solids levels in the Dorcan Brook probably reflects the slowing-down in the rate of urban development in this sub-catchment.

**Table 3.1 Average suspended solids loads in the River Cole: 1970-79 and 1980-89, corrected for sample size.**

Reach	1970-79 (mg/l)	1980-89 (mg/l)
Dorcan Brook	53.2	27.9
Cole: A419	20.4	24.7
Cole: Acorn Bridge	27.2	33.6
Cole: Coleshill Bridge	14.5	24.5
Cole: Inglesham weir	14.5	24.5

Geochemical analysis of fine sediment samples returned from 12 sites along the River Cole, from its headwater in Swindon to downstream of Inglesham weir, confirmed that sediment quality is generally good, though with higher concentrations of heavy metals associated with urban channels draining Swindon. All values, with the exception of one located at NGR SU181858 (Swindon), have heavy metal

levels below those specified as problematic by the ICRCL. Overbank siltation will not pose a pollution problem in the RRP reach.

### 3.3.3 Current channel typology

The following section draws on a variety of historical sources, contemporary field observation, and recent channel surveys in order to reconstruct the sequence of channel modification and to quantify the geomorphology of the channel and floodplain. Values for sinuosity were taken from Ordnance Survey 1:10,560 and 1:10,000 scale maps. Values of catchment characteristics were derived from 1:25,000 map analysis after the Flood Studies Report recommendation.

The River Cole at Coleshill is a fourth order (after Strahler) tributary of the Thames. The drainage network totals 166 km, giving a drainage density of 1.29 km/km<sup>2</sup>, which is relatively high for British river catchments and is considered to reflect the impervious nature of the catchment and the probable extension of this network by drain construction. The drainage network of the River Cole is dominated by the first order tributary and drain system which constitutes over 57% of the total stream length. Sinuosity values for these streams are low, reflecting their management for land-drainage (Table 3.2). As the stream order increases sinuosity values increase, reflecting the change from straightened agricultural drains to the more natural planform of the main river. The low values for sinuosity associated with the fourth order main river reflect the straightening of the channel downstream of Acorn Bridge and downstream of Coleshill Bridge. The main River Cole downstream of Swindon constitutes only 16% of the total channel network.

**Table 3.2 Sinuosity and channel length on the basis of stream order in the catchment of the River Cole.**

Stream Order (Strahler)	Length (km)	%	Sinuosity
1	94.3	57	1.02
2	44.3	27	1.14
3	10	6	1.60
4	17.4	10	1.08
<b>Total</b>	<b>166.0</b>	<b>100</b>	

For most of its length, the River Cole is bounded by banks of cohesive alluvium with a high silt and clay content. The cohesive nature of the bank material permits maintenance of steep banks and a sinuous course with little planform instability.

The morphology of the river-bed is difficult to determine, since all of the Cole has at some point in the past 50 years been dredged to improve drainage. The contemporary channel does not display a well-developed pool-riffle sequence, except in short reaches downstream of Inglesham weir where gravels are locally abundant. Isolated riffles are a feature of the reach upstream of Inglesham weir, but in general they do not conform to the predicted location of riffles within the river system. Instead, they are often associated with bridges, collapsed structures, or downstream of mill-weir scour pools. Exceptions include the two riffles downstream of Coleshill Bridge, which may result from river restoration works or from a local outcrop of gravel within the underlying clay bedrock. Water-levels in the River Cole upstream of Coleshill bridge are maintained by Coleshill Mill, which, together with widening and deepening of the channel, has created a long pool which extends throughout the length of the restoration reach. Water-levels during the summer appear to be controlled by emergent macrophyte growth and by the presence of bridge footings and occasional riffles. Downstream of Coleshill Mill, water-levels are controlled by fisheries improvement weirs, isolated riffles, macrophyte growth and the weir at Inglesham.

A feature of the channel morphology throughout the river is the presence of marginal macrophyte-covered berms (locally termed 'flams'). Some are associated with the insides of meander apices where deposition is expected, although not all meanders possess these point bars. Other features include berms along the margins of the channel in areas that have been widened or in the slackwater areas found in wide deep pools.

Upstream of Coleshill bridge, floodplain gravels are rarely evident in the channel banks, and, though locally abundant at isolated riffles, comprise less than 50% of the bed material. Bed sediments are dominated by particles <4mm diameter, and upon disturbance release large clouds of fine sediments into suspension. In the chalk streams draining the Berkshire Downs, calcium carbonate granules and fine gravels are found mixed with silts and clays. Riffle surface sediments are considerably coarser than the general bed material ( $D_{50}$  14-19mm,  $D_{84}$  39-56mm), but do contain significant levels of fine sands, silts and clays. Macrophyte growth on these riffles traps sands and silts, producing a carpet of organic-rich fines, which locally cloak the gravel substrate. Downstream of Coleshill Bridge, the land drainage scheme has cut into clay bedrock, removing most of the former gravels.

Evidence for riffles in the old River Cole comes from descriptions of the removal of hardened bed sediments and gravels from dredged reaches throughout the main River Cole. The existence of a hardened riffle was found at NGR SU229907 in a recently recut abandoned reach of the old River Cole. The landowners have cut through the former riffle surface to permit a low flow to fill the recut channel. Bed material is coarse, and is stuck into the clay substrate. The gravels are of local Corallian Rag.

In its natural state, the River Cole maintained a sinuous course, with sinuosity values ranging between 1.31 - 2.08. Old maps, photographs and contemporary field evidence of the old course of the River Cole reveal a tree-lined riparian zone, which, together with the cohesive nature of the bank material, would have the effect of stabilising the bank line. Sequential analysis of historical maps and aerial photography for the period 1775 - 1993 confirms the lateral stability in areas where channelization has not affected the course.

### 3.3.4 River deepening and channelization

The River Cole and its tributaries have been subject to regrading in order to facilitate the gravity drainage of floodplain fields and to accommodate storm-water runoff from the urban areas of Swindon. This has altered the cross-section morphology of the channel, and casts doubt on the existence of a suitable analogue for the river restoration project reach. Some evidence may be obtained from measurements taken in 1935 during a land drainage survey and from surveys of the abandoned course of the River Cole where this is clearly not part of a farm drainage system. The problems with the latter relate to the unknown depth of infilling since abandonment.

Downstream of Coleshill Bridge, the channel has been regraded as part of the 1976 Lower Cole land drainage scheme. This scheme lowered the bed by at least 1m for 9.5 km, removing any gravel substrate, and destroyed the herb-rich meadows on either side of the channel. Interestingly, the planform and dimensions of this reach had been previously altered during drainage attempts pre-dating the 1912 OS 1:2500 map.

The effects of channelization may be gauged by comparing estimates of sinuosity derived from 1:2500 scale OS maps for the old channel planform and new channel planforms. Table 3.3 documents the changes in sinuosity as a result of channelization which may broadly be seen in the restoration reach.

Planforms have been straightened with a corresponding increase in channel slope as stream length is reduced.

**Table 3.3** Changes in channel planform as revealed in sinuosity values for the River Cole. Straight channels have sinuosity values of 1.00.

Reach	Pre-1912 sinuosity	1993 sinuosity
Lower Tuckmill Brook	2.08	2.08
Dorcan Brook (Urban)	----	1.06
River Cole, Nythe B. - Acorn B.	----	1.21
River Cole, Acorn B. - Hill Farm	1.94	1.12
RRP Site (u/s)	1.52	1.05
RRP Site (d/s)	1.44	1.15
RRP - Inglesham	1.47 (some straightening)	1.10

The values in Table 3.4 illustrate the scale of morphological change that has occurred throughout the length of the River Cole. Bankfull channel width has been increased by up to 255% and bankfull depth by up to 328%. Stream power values are typically low, and even after channelisation remain below the  $35\text{W/m}^2$  threshold identified by Brookes as separating erosional and depositional adjustments. This is supported by the field evidence, which reveals a lack of bank erosion and the development of berms and silted riffles.

**Table 3.4** Values of width, depth, slope and stream power calculated for five reaches of the modern River Cole and, where possible, the old River Cole (figures in brackets).

Reach	Width (m)	Depth (m)	Slope	Power ( $\text{W/m}^2$ )	w:d ratio
Swindon - A419	10.3	2.1	0.00170	6.6	4.9
A419 - Acorn Bridge	10.2 (4.0)	2.1 (1.3)	0.00134	7.2	4.9 (3.1)
Acorn Bridge. - Friars Mill	8.5 (6.4)	1.8 (0.7)	0.00078	3.0 (4.3)	4.7 (9.3)
Friars Mill - Coleshill	13.6 (7.2)	2.3 (0.7)	0.00069	4.7 (5.4)	5.9 (10.7)
Coleshill - Inglesham	15.5 (4.0) (7.3)	2.8 (1.60)	0.00052	11.0 (5.5)	5.5 (2.5) (4.5)

### 3.3.5 Contemporary management

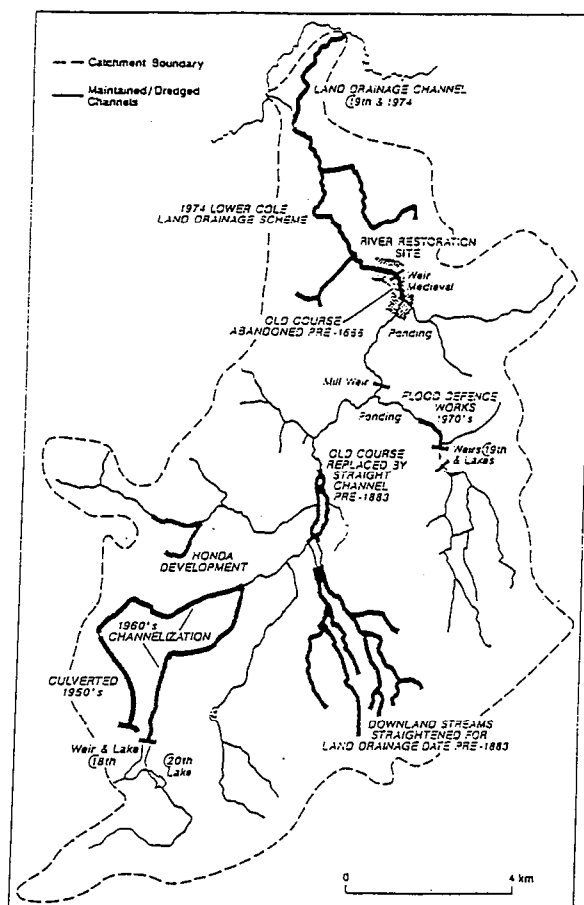
The contemporary maintenance programme on the River Cole is dominated by urban refuse clearance from the urban flood-relief channels through Swindon and by light weed-cutting in the agricultural main river. Periodic desilting of drainage channels is conducted by landowners. This contrasts with the past regimes, when silt bars (flams) and obstructions caused by overhanging trees were removed.

### 3.3.6 Geomorphological Interpretation

The River Cole is a heavily managed and modified stream throughout its catchment. There is no evidence of any reaches which have not either been deepened and/or straightened at some point over the past 500 years. Geomorphologically, the most natural feature of the Cole is the channel planform, which in places is almost exactly the same as that recorded in maps as long ago as 1775. A catchment 'timechart' (Figure 3.1) reveals two attributes: the long management history of the Cole, and the recent and large-scale changes in both channel and catchment. The period 1930-1950 witnessed a change in floodplain use from valuable water meadows (water encouraged to spill overbank) to drainage (water encouraged off land into channel). At the same time, urban development of the headwaters increased runoff into the channel network. The same period up to 1976 witnessed large-scale deepening and widening of the channel and a loss of morphological diversity. The geomorphological implications are:

- (i) The contemporary channel is managed, and although analogues for planform may be derived from old maps, the correct width/depth ratio is difficult to establish. The channel was undoubtedly narrower and shallower than at present, with a floodplain which was more frequently inundated. Local evidence suggests that water was never far from the bank top during low flows.
- (ii) Removal of gravel substrates during dredging has eradicated the pool-riffle sequence, with the exception of isolated reaches. Largely because of the lack of replacement of coarse sediment, new pool-riffle sequences have not developed. It was not possible to confirm whether a regular and extensive pool-riffle sequence existed before extensive dredging and deepening occurred, although it is likely that downstream of the Corallian Rag hills there was sufficient gravel to form a sequence. Upstream of the weir at Coleshill, the ponding effect drowns out any pool-riffle sequence. Similarly, the fisheries enhancement weirs downstream of Coleshill bridge have the effect of drowning out pool-riffles that may be locally be developing.
- (iii) Vegetation (and debris) once played a more important role in the River Cole. The banks were lined with trees, and debris dams are recorded in land drainage surveys of 1935. These feature may have had a pronounced effect on the morphology of the River Cole, effectively forming series of pools and dams.
- (iv) The Cole floodplain was an important store of water and fine sediments, a situation which has effectively been reversed in the reach downstream of Coleshill so that all but the largest floods (>1:25 year recurrence interval) are contained in bank.
- (v) The hydrology and sediment supply and delivery from the Cole catchment has changed, so that in all probability the sediment loads are now greater and flood peaks steeper than in the past. Despite this, the energy for erosion and wholesale bed mobilisation is not achieved, creating a depositional system characterised by suspended load transport.

**Figure 3.1** River channel modifications and impacts on the riverine environment in the catchment of the R.Cole



Time		Pre 1600	1800-1900	1900-1930	1930's	1940's	1950's	1960's	1970's	1980's	1990's	Future
Climate	Floods						1959	1968	1971 1979	1984	1993	
	Droughts								1978			
Capital Works							Urban Flood Storage Areas					?
									1974 Lower Cole Land Drainage Scheme			
									Land Drainage			
River Maintenance		Drain Clearance / Pollarding									Light Weedcut	
							Desilting / Weed Cutting /					
Channel Change					Natural Planform Stability							
					Piecemeal Channelization / Mill Structures			Urban Culverting / Land Drainage Dredge				
											River Restoration	
Land Use Change		Water Meadows / Livestock Farming						Urbanization (Swindon)			(Honda)	
									Arable Cropping		Community Forest	
											Stewardship & Setaside	
Water Quality Change									Oil & Urban Runoff			
					Removal of STW				Increasing Suspended Solids			
Fisheries Change			'Good' Course Fishery							Fish Stocks 'Decimated'		
											Stocking	

### **3.4 Morphological survey**

#### **3.4.1 Morphology of the three reaches in the study (restoration, upstream control, downstream impact)**

##### **Morphology of the restoration reach**

Most of the restoration site reach is highly-modified channel of low geomorphological 'sensitivity'. (see Figure 3.2). This area is, morphologically, suitable for restoration (but note that the channel may itself be a feature of historical interest).

##### **Morphology of the upstream control reach**

Upstream of the restoration site, the channel retains a more sinuous course, and a more natural profile, which has not been deep-dredged. This area is therefore 'sensitive' to channel engineering works. Minor improvements may be appropriate.

##### **Morphology of the downstream impact reach**

In the downstream control reach, the channel retains most of its original sinuosity but has been deep dredged. This section is therefore of moderate sensitivity.

#### **3.4.2 Overview of channel morphology between Friars Mill Bridge and the River Thames**

The greater part of the channel of the River Cole between Friars Mill Bridge and the River Thames has been subjected to some form of channel works in the past. In its present state, the channel is a series of backwaters interspersed with local controls at bridges and weirs. The channel has little gravel substrate remaining, mainly as a result of land-drainage engineering works which removed the (presumably) armoured gravel bed.

Land-drainage reports from the mid-1930s suggest that channel modifications for land-drainage were routine at that time. This work involved removal of berms (known locally as flams) and debris clearance

The modern river is a primarily depositional environment. The geology of the catchment gives low slopes and low stream power. This means that the potential for the channel to recover from modification by eroding a new channel form is very limited. Consequently, natural processes are not likely to lead to the channel recovering an asymmetric cross-section, except in very limited areas.

The abundance of fine sediment combined with the low stream power and slopes mean that the Cole is now providing an essentially depositional environment. This is leading to channel readjustment by deposition (and associated colonisation by vegetation). This process will, eventually, lead to a new stable state for the river, although the environment of this new state will be very different from that of the more 'natural' Cole.

## 4 Landscape assessment: Cole

### 4.1 Aims

The main aim of the landscape assessment was to provide baseline data for the monitoring programme. This consisted of:

- (i) describing and classifying the landscape of the restoration sections into elements or character areas
- (ii) undertaking an evaluation which identified individual management needs of each area, noting whether landscape areas/features in the river restoration section should be conserved in their current forms or modified.

Landscape assessment is being undertaken by W.S. Atkins Ltd. This work is currently in progress and the information presented here draws on their preliminary report.

### 4.2 Methodology

The strategic and detailed landscape assessments are based on the NRA methodology for river landscape assessment, which was developed in part to fulfil the environmental duties of the NRA. The process of assessment in the standard methodology is divided into four main stages.

- Step 1: Definition of Purpose. The purpose of assessment as defined in the brief indicates what the study will be used for and relates to the level of study.
- Step 2: Desk Study. The study is defined and background information gathered and processed to provide a basis for the field study (Step 3). A comprehensive review of literature, articles and planning policies is undertaken in order to examine the physical and human influences on the riparian landscape of the catchment.
- Step 3: Field Study. The river valley/corridor is surveyed using field recording forms and photography to record specific features.
- Step 4: Analysis. The field records and desk study are collated, reviewed and analysed; conclusions are presented in a report form, with maps.

The standard methodology was simplified for this study, because of the relatively short section of river assessed, and analytical information is therefore shown on 1:10,000 and 1:5,000 plans.

### 4.3 Landscape types

#### 4.3.1 Macro river landscape types

The 'macro river landscape' refers to the wider landscape of the river valley defined by the 'visual envelope' of the river. Within the visual envelope, the following Macro River Landscape Types have been identified.

#### **Coleshill Village**

Value Class: 1

Management Strategy: Conservation

The River Cole is bridged at the foot of Coleshill, an historic 17th-century planned village owned by the National Trust. Buildings are constructed mostly of stone with, stone or slate pitched roofs. The gardens

to residential properties are typically contained by neat clipped box or holly hedges, with well maintained front lawns and planted beds. Topiary is noted in some gardens.

All Saints Church is prominent on the skyline in the centre of the village. The existing Estate Farm is surrounded by a high stone wall which is also conspicuous.

#### **Coleshill Parkland**

Value Class: 1/2

Management Strategy: Restoration/Conservation

The River Cole runs at the bottom of the Coleshill Park, south of Coleshill village. The Parkland is distinguished by gently undulating grassland with single-specimen tree-planting, varying in age from mature oak trees to young saplings. Young trees are protected from grazing by timber tree-guards (which are conspicuous where newly erected in the western section of the park). The parkland is bounded on the higher ground by Flamborough Woodland and Long Shrubbery. The parkland is currently being restored to a National Trust restoration plan.

#### **Clay Vale Farmland**

Value Class: 2/3

Management Strategy: Restoration

The River Cole runs in a broadly clay catchment. Oxford Clay is found on the shallow valley slopes, giving way to alluvial deposits in the valley floodplain and Corallian limestone on the higher ground at Coleshill and north of Fresden Farm. The farmland here is mixed, although generally arable with some unmanaged pasture fields. Field boundaries are characterised by hedgerows in various stages of management, resulting in an open and semi-enclosed character depending on their condition. Some older hedgerows are gappy and may have large hedgerow trees.

#### **Alluvial Mixed farmland**

Value Class: 2

Management Strategy: Restoration

Locally prominent limestone hill outcrops are found at Coleshill and above Fresden Barn. These represent part of the Corallian Hills, and create a distinctive character in this part of the Cole Valley.

#### **Wooded Limestone Valley**

Value Class 1/2

Management Strategy: Conservation/restoration

The River Cole meanders in a relatively narrow valley. This valley is dominated, as it passes through the Corallian ridge by Tellhard's Copse, Grove Copse and Watchfield Common Wood. Parts of the woodland have been felled. Fresden Farm and Strattenborough Castle farm are conspicuous on either side of the valley.

## **4.4 The Planning Context**

### **4.4.1 Introduction**

The River Cole forms the boundary between the Vale of White Horse district in Oxfordshire and the borough of Thamesdown in Wiltshire. Relevant planning policy designations have been extracted from the following Local Plans:

- Vale of White Horse Local Plan, Draft Consultation, Vale of White Horse District Council, November 1993. (This plan was current at the time of writing in January 1995).
- Thamesdown Local Plan (1991-1996), Consultation Draft, Thamesdown Borough Council, May 1991. This plan had been replaced by the 1994 Deposit Draft Version of the Local Plan at the time of writing. The Deposit Draft is likely to be subject to further review at Inquiry in 1995.

This section summarises the relevant local planning policies in the two plans.

#### **4.4.2 Relevant Planning Policy Designations**

##### **The North Vale Area of High Landscape Value**

Coleshill and the eastern banks of the River Cole lie within the North Vale Area of High Landscape Value. The designation emphasises the quality and importance of the landscape of the Corallian Ridge and the need for special care when assessing the visual impact of development proposals.

Vale of White Horse District Council seeks to conserve and enhance the quality of the landscape within the AHLV. Therefore, restoration proposals should be sympathetic to the character and appearance of the landscape.

##### **Area of Local Landscape Importance**

The countryside to the west of the River Cole is designated as an Area of Local Landscape Importance by Thamesdown Borough Council. The river cuts through the Corallian ridge east of Highworth, and the council considers that the quality of the landscape should be conserved and enhanced. Therefore, restoration proposals should recognise the character of the rural landscape.

##### **Coleshill Conservation Area**

The River Cole forms the western boundary of the Coleshill Conservation Area. The council aims to preserve and enhance the special character and appearance of the village, and would not permit development which could detract from the skyline, landscape or views into and out of the Conservation Area. Restoration proposals should enhance the visual impact both into and from the Conservation Area.

##### **Ancient Woodland**

Flamborough Wood and Grove Copse have been identified as ancient woodland by English Nature. The Vale of White Horse District Council would not normally permit the loss or significant alteration of these woodlands. However, these woods are not shown on early maps eg the Rocque Map of Berkshire 1766, suggesting that they are not ancient woodland.

##### **Great Western Community Forest**

A community forest is being created in parts of Thamesdown Borough and Vale of White Horse District Council with the support of the Countryside Commission and the Local Authorities. A significant part of the western end of the Vale would be included within the proposals, although the boundary shown in the Vale of White Horse Local Plan is provisional. Subject to general planning policies, the District Council intends to promote the community forest in countryside east of the River Cole.

## 5. Hydrology and channel hydraulics: Cole

### 5.1 Aims

The aims of hydrological monitoring on the Cole are:

- (i) to provide detailed river channel water-level data to validate hydraulic modelling of the site before and after restoration.
- (ii) to provide data on river channel water-levels and flows needed for the calculation of nutrient and sediment budgets in the control and restoration reaches.
- (iii) to assess the impact of restoration on floodplain groundwater/surfacewater levels.
- (iv) to provide data for interpretation of floodplain vegetation change.
- (v) to provide information which will help project design.

Hydrological data has mainly been used during the first year to (i) describe the current hydrological regime of the site, and (ii) to provide the basis for modelling of the proposed restoration design. This report deals with the current features of the site and does not contain further information about the proposed design of the restoration scheme.

This section of the report is based mainly on hydraulic modelling undertaken for the study by Hydraulics Research Limited. It uses data collected routinely by the NRA at Inglesham Weir, data collected specifically for this project by the River Restoration Project, and the results of land survey work.

### 5.2 Methods

#### 5.2.1 River channel hydraulics

##### Land survey

Channel dimensions and floodplain levels were obtained from the land survey undertaken in summer 1994. Some cross-sections from a previous land survey, undertaken in 1986, were used.

The most detailed topographic information was collected on the restoration site, where survey work was undertaken to give contours of 10-20cm interval.

##### Discharge data

The volume of water discharged by the River Cole is measured continuously by the NRA at Inglesham Weir (5km downstream of Coleshill). This provides a continuous record back to 1976.

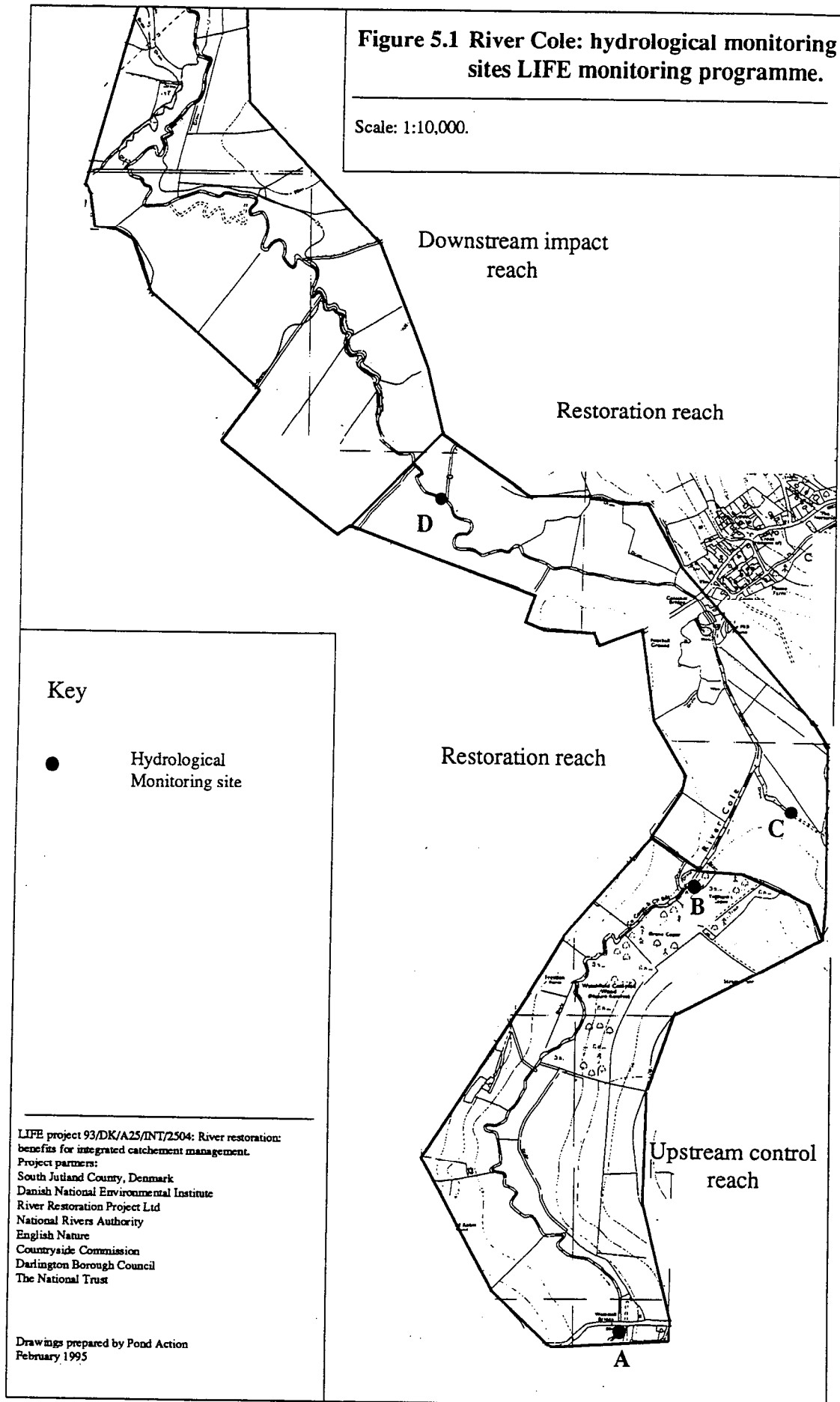
##### Water-level monitoring

Four continuous monitoring stations were established on the River Cole and its tributary, the Waterloo Ditch (see Figure 5.1). Water-level recorders were placed at the beginning and end of the restoration reach and at the upstream end of the 'control' reach. The weir at Inglesham, where water levels are continuously monitored, was used as the downstream limit of 'impact' reach. Dataloggers record this information continuously, and are downloaded at fortnightly intervals.

One water-level recorder was installed on the Waterloo Ditch to monitor its sub-catchment.

**Figure 5.1 River Cole: hydrological monitoring sites LIFE monitoring programme.**

Scale: 1:10,000.



## 5.2.2 Groundwater and surfacewater levels on the floodplain

### Groundwater levels

Groundwater monitoring stations will be installed during site investigations in spring 1995.

It is intended to install piezometers in three or four transects across the river valley. One each will be installed in the upstream control reach and downstream impacts reach, and one or two will be installed in the restored sections.

### Observations of floods

Flood events will be observed directly when they occur and the extent of flooding mapped.

## 5.2.3 Modelling methods

Hydraulic modelling is being undertaken for the project by Hydraulics Research Ltd, as part of a Ministry of Agriculture, Fisheries and Food (MAFF) research project on the hydraulics of environmentally designed channels.

Data from the catchment and the Inglesham gauging station were used to create hydrographs for various flood events (1 in 2 year through to 1 in 100 year). These hydrographs were developed using a computerised version of the Flood Studies Report (micro-FSR).

The most extreme event was on the 28th December 1979, when the discharge was the highest recorded in 18 years of continuous monitoring. Flood outlines for the site based on the hydrographs of 1 in 2 year to 1 in 100 year floods were prepared.

## 5.3 Results

### 5.3.1 General characteristics of the Cole catchment

The River Cole rises in chalk which sustains a modest baseflow throughout the year, but the catchment has a rapid response to rainfall because more than 55% of the catchment is underlain by clay. The mean annual flood, based on the 18-year record from the gauging station at Inglesham, is  $15.5\text{m}^3\text{ s}^{-1}$ , rising to  $26.3\text{m}^3\text{ s}^{-1}$  during the highest recorded flood in December 1979. Although no sewage effluent from Swindon itself enters the Cole, there are large amounts of urban runoff that have necessitated the gradual construction and continuous upgrading of 12 flood storage areas in the urban area of the headwater catchment in order to regulate the flashy flood flows. Licensed discharges amount to 7% of the Mean Annual Flow (MAF) and licensed abstractions 1% of MAF. Over 50% of the flow in the Pennyhooks Brook may be treated sewage during low flows.

Up to 1950, the floodplain was only partially drained and much of it was operated as a water-meadow system, which encouraged inundation. Downstream of Coleshill Bridge, the floodplain was regularly inundated and land-use was dominated by permanent pasture. The Land Drainage report of 1935 describes much of the floodplain as waterlogged and prone to frequent flooding (Thames Conservancy, 1935). Overall, the hydrology of the catchment has been altered by urbanisation, large-scale underdrainage (both in the 19th century and more recently) and arterial drainage schemes, culminating in the 1974 Cole Stage 1 works which effectively eliminated inundation of the floodplain downstream of Coleshill Bridge. Robinson (1990), in a review of the impacts of drainage on catchment hydrology, records a decrease in discharge magnitude associated with the underdrainage of impermeable soils, but an increased flood magnitude and decreased time to peak associated with improved efficiency of the arterial drainage network. It is perhaps significant that farmers downstream of Swindon complained of an increase in overbank flooding during the expansion of the town.

### 5.3.2 Flood events

Most flood events occur on the Cole in winter. Between 1976 and 1993, discharges of 7.5 cumecs or more (half the mean annual flood) were recorded most frequently between November and March. Flows of this size occurred occasionally in May and June (six times in 17 years), but never in July and August (see Table 5.1).

The 1 in 2 year flood event currently floods the site, mainly upstream of Coleshill Bridge, with little flooding downstream. Figure 5.2 shows the predicted extent of this flood. The 1 in 100 year flood event (Figure 5.3) is predicted to flood most of the site both up- and downstream of Coleshill Bridge.

Following a period of several dry years, late January 1995 saw a flood with a return period of between 1 in 10 years and 1 in 25 years (full data from the flood has not yet been analysed). This led to extensive flooding of the site (see Figure 5.4), including the reach downstream of Coleshill Bridge. The route of floodwater downstream of the bridge gave a clear indication of the former channel route.

**Table 5.1      Frequency of floods of more than 7.5 cumecs (half the mean annual flood) on the River Cole: 1976-1993**

Month	Number of floods greater than 7.5 cumecs (half the mean annual flood) in this month
January	11
February	7
March	9
April	5
May	3
June	3
July	0
August	0
September	1
October	2
November	6
December	8

## **6. Water quality and sediment monitoring**

### **6.1 Overall aims of water quality monitoring**

The aims of water quality and sediment monitoring on the Cole are:

- (i) to assess the effect of river restoration on general river water quality in the Cole (see Section 6.2.1)
- (ii) to assess the effects of river restoration on nutrient budgets in the Cole (see Section 6.2.2)
- (iii) to assess the change in floodplain soil chemistry following restoration: this is an optional aim of the monitoring programme

The monitoring of general water quality makes use of existing NRA water quality monitoring programmes in the Cole catchment. Interpretation of this data was undertaken by Dave Walker and Penny Williams.

Nutrient budgets are being established as part of a special study for the LIFE programme. Sample analysis up to January 1995 has been undertaken by Silsoe College in a specially commissioned study under the guidance of Nick Haycock and Peter Leeds-Harrisson. Interpretation of data was undertaken by Dave Walker. Field sample collection has been undertaken by Antony Corfield.

### **6.2 General water quality monitoring**

#### **6.2.1 Aims**

The aims of general water quality monitoring are:

- (i) to provide data on the water quality of the sites before and after restoration
- (ii) to monitor water quality effects from the construction process

#### **6.2.2 Methods**

##### **Chemical sampling**

Table 6.1 lists the standard chemical water-quality measurements that are being made on the River Cole. The monitoring is based on the existing programme of routine monitoring undertaken by the NRA, with water quality measured in the upstream control reach and in the restored reach.

##### **Biological sampling**

The NRA also conducts biological water-quality assessments at several locations on the Cole on a less frequent basis. These include one site within the restoration section at Coleshill and several others above and below the control sections. Additional data on biological water quality is being collected by Pond Action within both the restorations section and the control sections. Biological water-quality assessment uses standard macroinvertebrate methodology based on the Biological Monitoring Working Party (BMWP) system and the River Invertebrate Prediction and Classification System (RIVPACS)

**Table 6.1 Basic water quality monitoring on the River Cole. Determinands measured and sampling stations**

Determinand	Frequency of measurement	Determinand	Frequency of measurement
pH	Monthly	Chloride	Monthly
Conductivity	Annual	Sulphate as SO <sub>4</sub>	Annual
Suspended solids (105C)	Monthly	Orthophosphate as P	Monthly
BOD (5 day using ATU)	Monthly	Synthetic detergents, anionic	Annual
Temperature (field)	Monthly	Hardness, total as CaCO <sub>3</sub>	Monthly
Dissolved oxygen	Monthly	Zinc	Monthly
Ammoniacal nitrogen	Monthly	Copper	Monthly
Ammonia, un-ionised as N	Monthly	Copper, dissolved	Monthly
Nitrogen, total oxidised	Monthly	Boron	Annual
Nitrite as N	Monthly		
<b>Sampling locations</b>			
River Cole	Cole at B4000, Sevenhampton		
	Cole at B4019, Coleshill		

## 6.3 Nutrient budget special study

### 6.3.1 Aims

The aims of the nutrient budget monitoring programme are:

- (i) to establish a net nutrient budget for the restored river, with control sections of river upstream of and downstream of the restoration site
- (ii) to provide data for cost-benefit analyses to assess the overall water-quality benefits of river restoration for integrated catchment management.

The monitoring programme will assess whether quantities of nutrients exported from the restored reach have changed relative to the control reaches. Estimates of total nutrient export from the reaches (measured in kg/year) will be calculated.

Nutrient budgets will take into account nutrients (a) in solution; (b) associated with suspended sediment; and (c) associated with stream bedload. Monitoring will not take account of nutrients transported in floatation load (e.g. woody material).

Samples for bedload nutrient analysis will be collected as part of the geomorphology programme (in which samples will be collected for sediment size analysis).

### 6.3.2 Methods

#### Determinands measured

It is intended to develop budgets for the following determinands, depending on the final cost of analyses:

- (i) Total nitrogen
- (ii) Inorganic nitrogen species (nitrate, nitrite, ionised and unionised ammonia)
- (iii) Particulate organic nitrogen
- (iv) Dissolved organic nitrogen
- (v) Total phosphorus
- (vi) Soluble (molybdate) reactive phosphorus
- (vii) Particulate phosphorus
- (viii) Soluble unreactive phosphorus

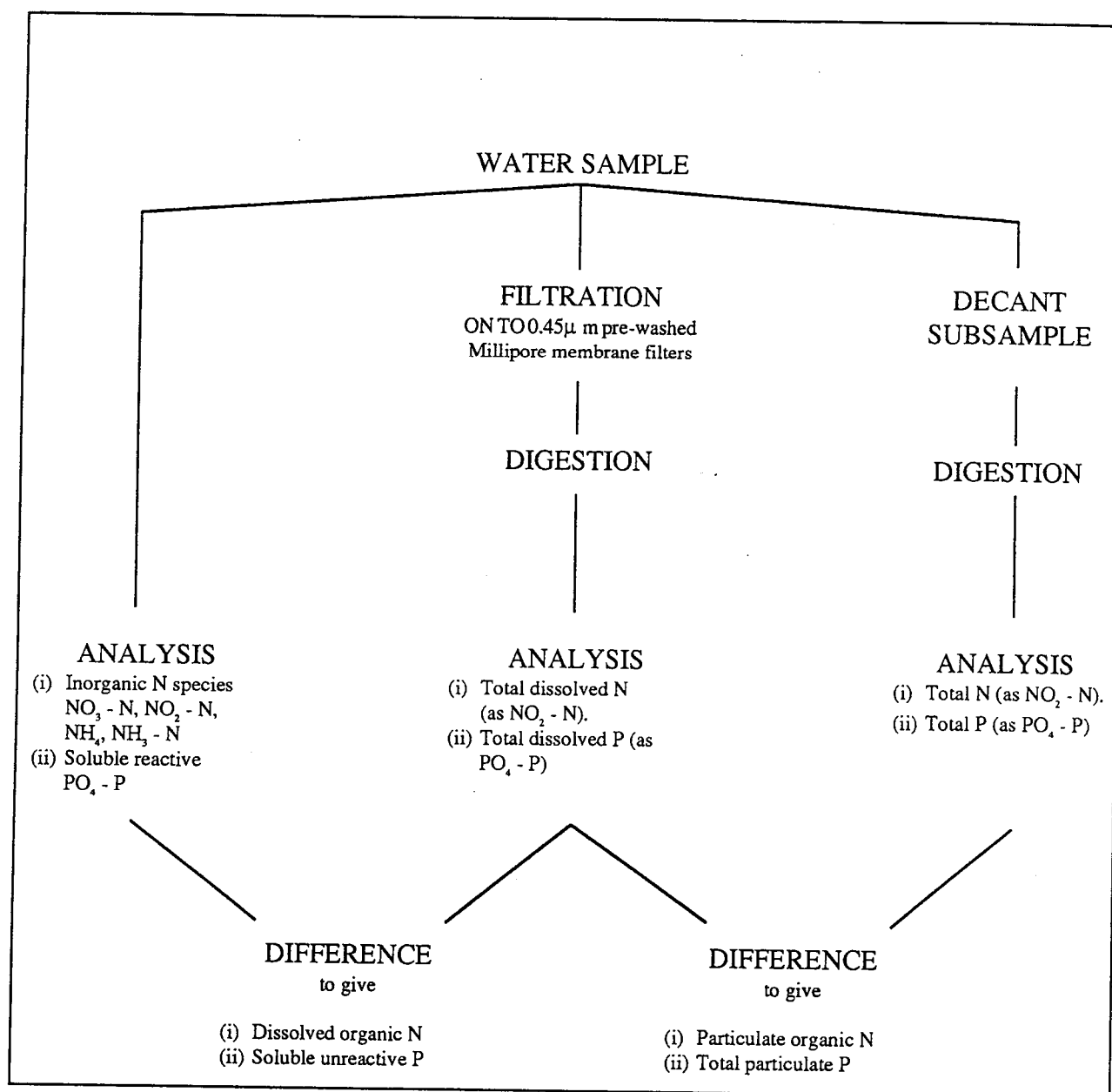
#### Water sampling methods

Samples for the Cole special study are collected at weekly intervals from 6 sampling stations. Sample stations are located 1-3 km upstream of the restored section, at the start and end of the restored section and close to the confluence with the River Thames (at Inglesham weir). A sample station has also been established on the Waterloo Ditch and, within the restoration reach, immediately below the outfall of the Thames Water sewage treatment works.

On each sampling occasion, one sample is collected by hand at each site, except during floods when the automatic samplers will operate (see below). During flood events, additional samples will be collected by an automatic sampler programmed to collect samples as the hydrograph rises. It is anticipated that this will provide additional data on five to ten flood events annually, with a maximum of 40 samples at each event. Concurrently, water level and discharge monitoring data will also be collected.

Laboratory analysis will follow the pathway shown in Figure 6.1.

Annual sampling frequency is shown in Table 6.2

**Figure 6.1** Analytical pathways for nutrient budget study

**Table 6.2      Number of samples collected annually for nutrient budget monitoring programme (total expected)**

<b>Weekly sample collection</b>	
Sampling stations	6
Sampling periods	52
Number of samples	312
<b>Storm water sample collection</b>	
Sampling stations	4
Sampling events	10
Samples per event	40
Number of samples	1600

#### **Bedload nutrients**

Nutrient concentrations carried in stream bedload will be estimated from grab/core samples collected for sediment size analysis. Bedload should be a fairly small component of total sediment moved, so this should represent a small portion of the sediment budget. Movement of bedload will be calculated using standard models (see Section 4).

#### **Floodplain nutrients**

Sediment samples collected on the floodplain (see below) will be analysed for total nitrogen and total phosphorus to investigate the importance of the floodplain as nutrient sink.

#### **Analysis**

Net nutrient budgets will be calculated in association with water quality data and discharge data.

### **6.3.3 Optional project: change in floodplain soil chemistry following restoration**

This optional section may be undertaken as an MSc Project with Oxford Brookes University.

#### **Aims**

- (i) To monitor the development of a more organic soil type following restoration
- (ii) To aid interpretation of the changes in the flora of the floodplain
- (iii) To assess any possible detrimental effects of overbank deposition on the floodplain.

#### **Methods**

Soil samples should be collected along three transects in the floodplain. Soil would be fractionated and analysed for organic content, nitrogen and phosphorus.

River sediment samples will be collected from various sections of the Cole and its tributaries and analysed for possible polluting heavy metals, including lead, zinc, copper, cadmium, manganese and iron.

## 6.4 Results

### 6.4.1 General water quality monitoring

#### General quality of the Cole within the restored section

The Cole at Coleshill is fairly typical of many small rural rivers in lowland Britain. See Table 6.3 for average concentrations of selected determinands between 1990 and 1993.

**Table 6.3** Values of selected determinands at B4109, Coleshill between 1990 and 1993.

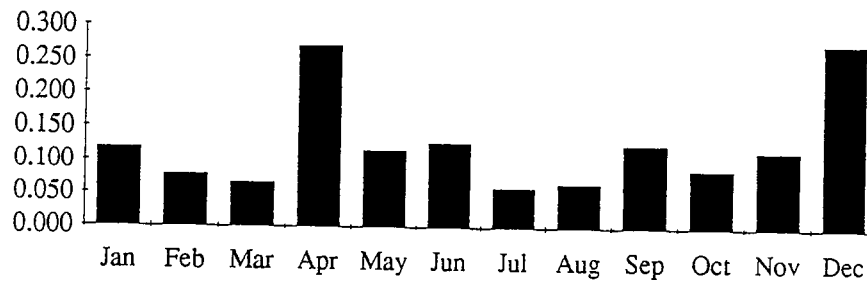
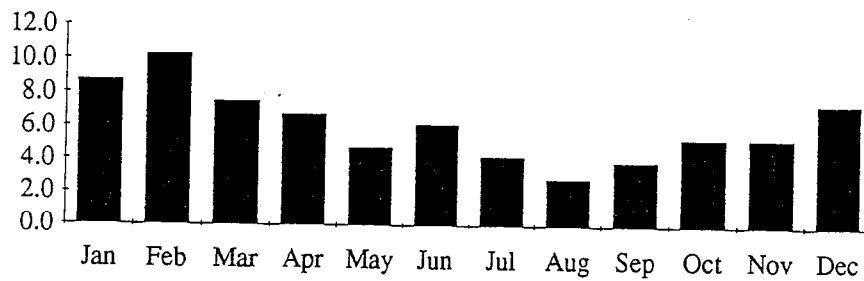
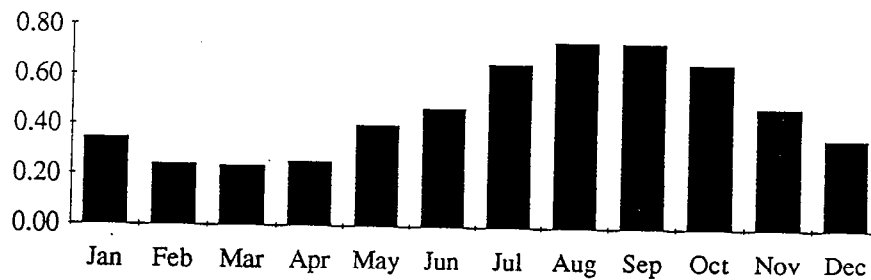
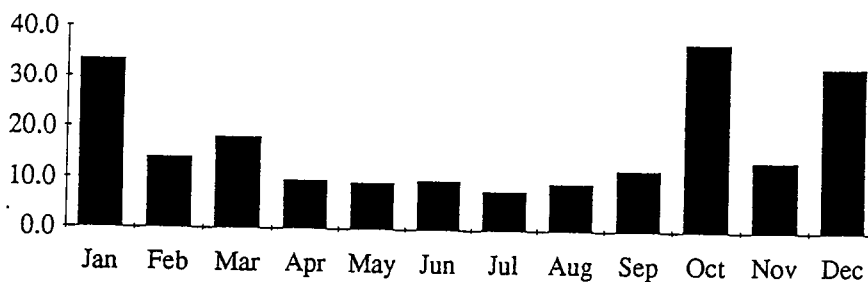
Determinand	Mean	Range
pH	7.9	7.4 - 8.4
Suspended solids (mg/l)	15.4	2.5 - 72.4
Biochemical Oxygen Demand (mg/l)	1.54	1.0 - 5.1
Dissolved oxygen (%)	92.1	69 - 118
Ammoniacal nitrogen (mg/l)	0.046	<0.05 - 0.28
Total oxidised nitrogen (mg/l)	6.32	2.1 - 17.9
Chloride (mg/l)	43.3	19 - 83
Soluble reactive phosphorus (mg/l)	0.55	<0.06 - 1.46
Alkalinity (as CaCO <sub>3</sub> ) (mg/l)	186	128 - 242
Copper (dissolved) (µg/l)	0.14	<5 - 6
Zinc (µg/l)	9.4	<8 - 91

Values falling below the detection limit are treated as zero for means.

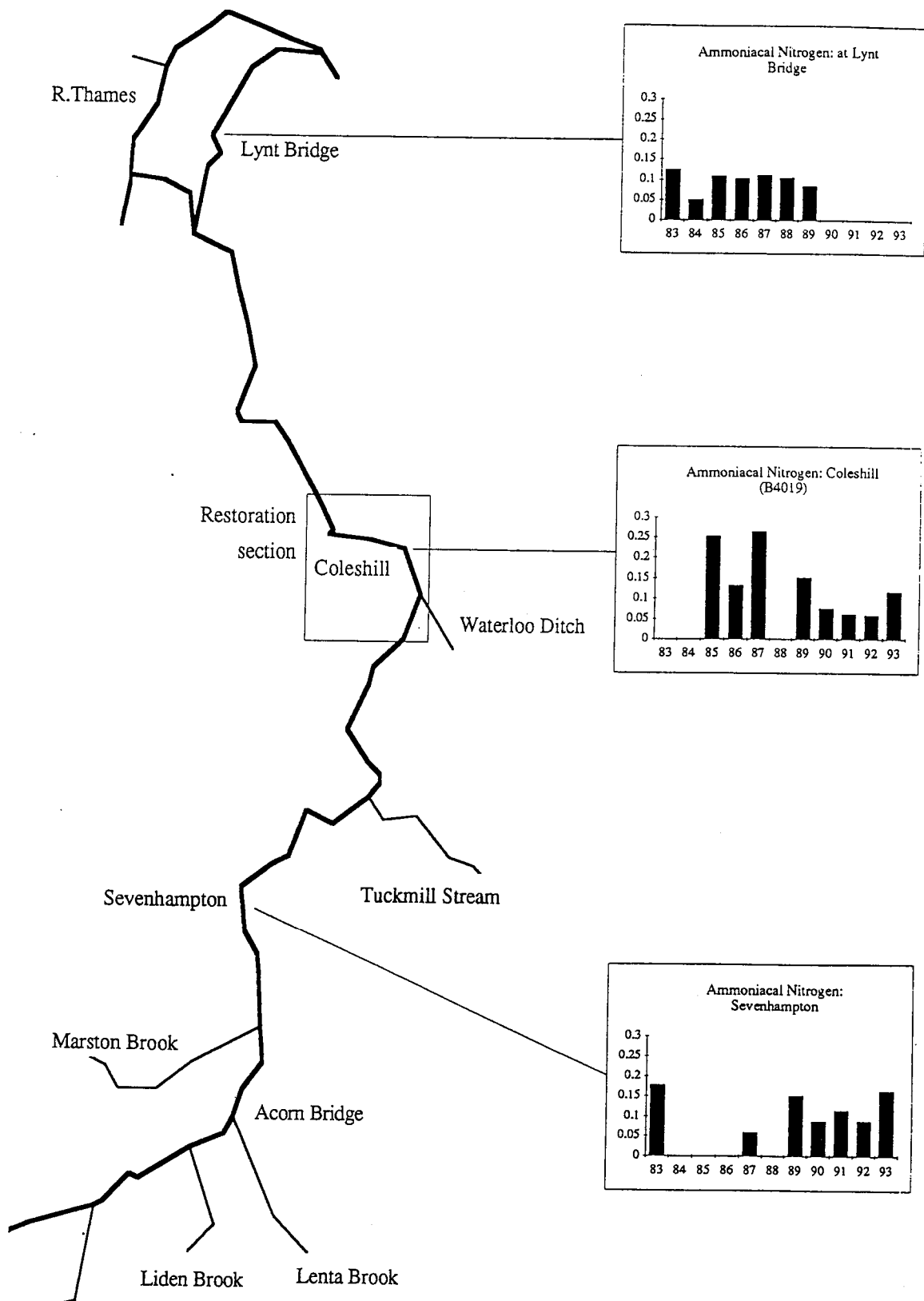
The water has high alkalinity, with a pH consistently above neutral. In general, the water quality is good, well-saturated with oxygen and usually with a low Biochemical Oxygen Demand and only moderate levels of ammonia.

Suspended sediment loads tend to be rather high, and the range of values reflects the rather spaty nature of the catchment. Nutrient loadings also tend to be high, with total oxidised nitrogen peaking well above the EC drinking water guidelines. Phosphate, too, is much higher than would be expected for an undisturbed catchment. The high nitrate levels reflect the largely agricultural nature of the catchment, and the phosphate levels reflect sewage discharges: possibly from the small sewage treatment works (STW) at Coleshill and possibly from the larger STW at Shrivenham, further upstream. Levels of copper in the water are generally low, though levels of zinc are high at times, possibly reflecting the close proximity of the Coleshill STW.

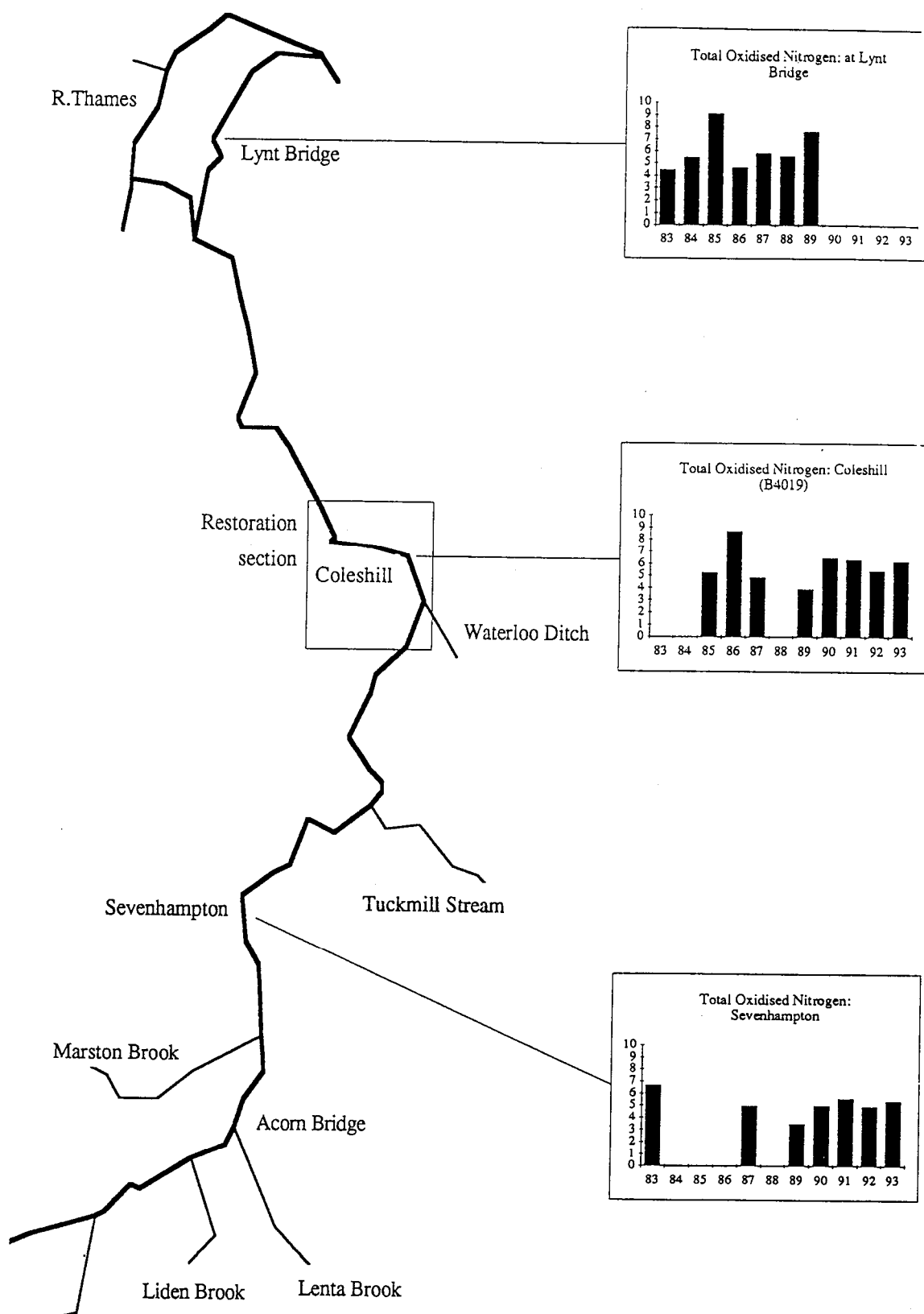
Biological monitoring of the site between 1990 and 1993 has also shown good water quality in terms of organic load. BMWP.EQIs (a measure of the biological diversity of clean-water fauna) ranged from 0.88 to 1.66, with an average of 1.11. (A value of 1.00 represents the fauna associated with rivers in good

**Figure 6.2: Seasonal variation in ammoniacal nitrogen (mg/l): Coleshill****Figure 6.3: Seasonal variation in total oxidised nitrogen (mg/l) at Coleshill****Figure 6.4: Seasonal variation in soluble reactive phosphorus (mg/l) at Coleshill****Figure 6.5: Seasonal variation in suspended solids (mg/l) at Coleshill**

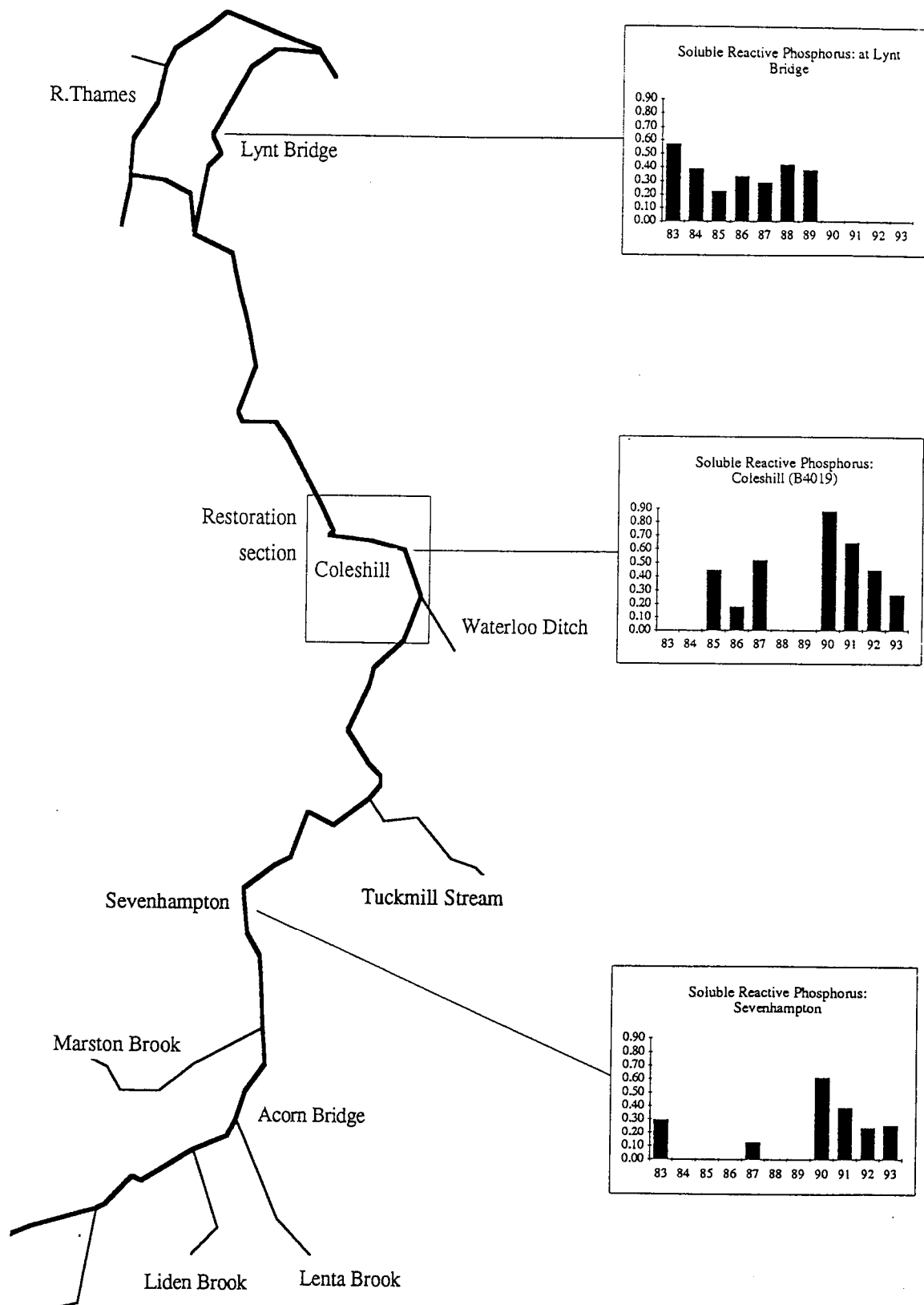
**Figure 6.6** Variation in ammoniacal nitrogen (mg/l) in the River Cole



**Figure 6.7** Variation in total oxidised nitrogen (mg/l) in the River Cole



**Figure 6.8** Variation in soluble reactive phosphorus (mg/l) in the River Cole



**Figure 6.9** Variation in suspended solids (mg/l) in the River Cole

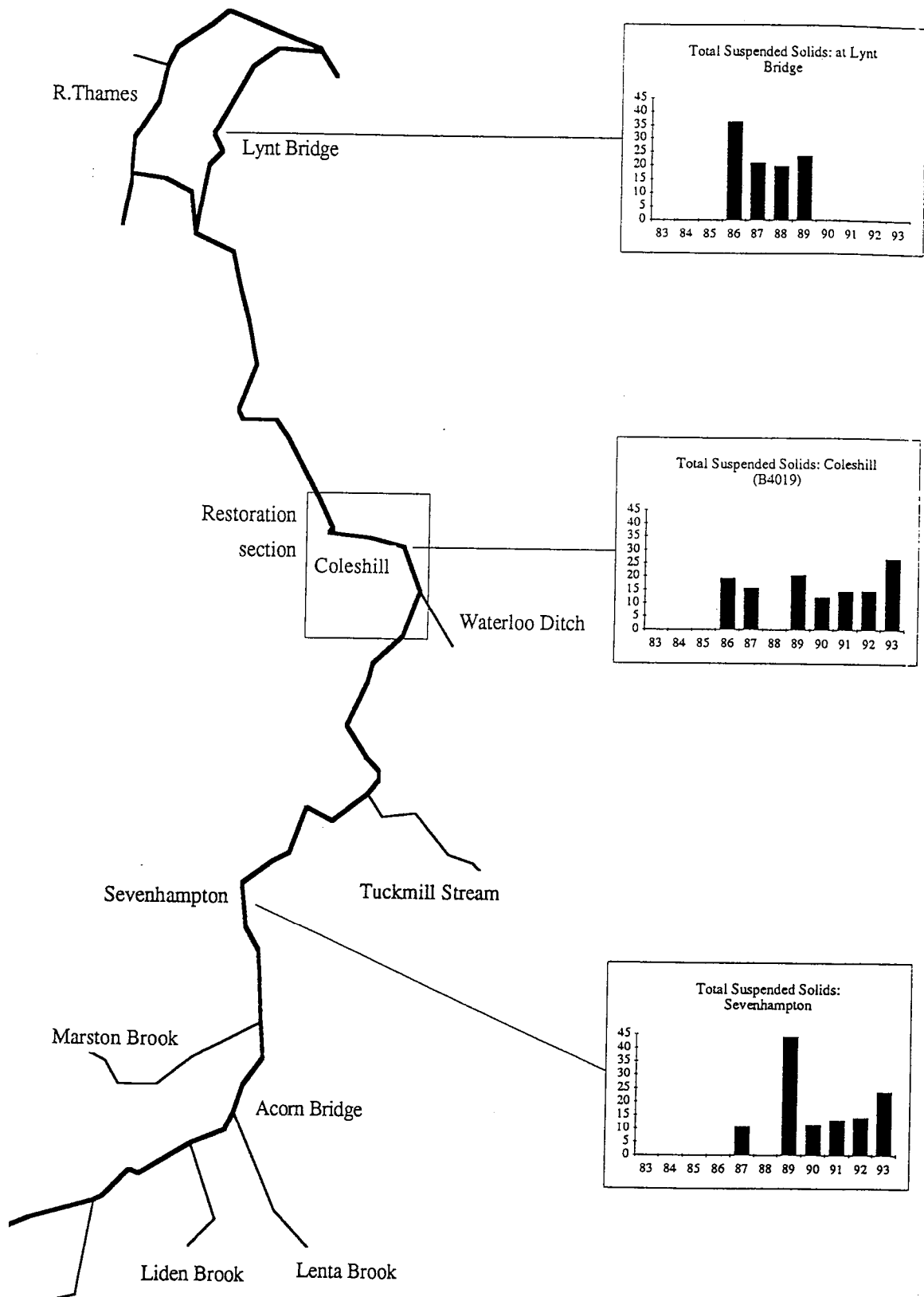
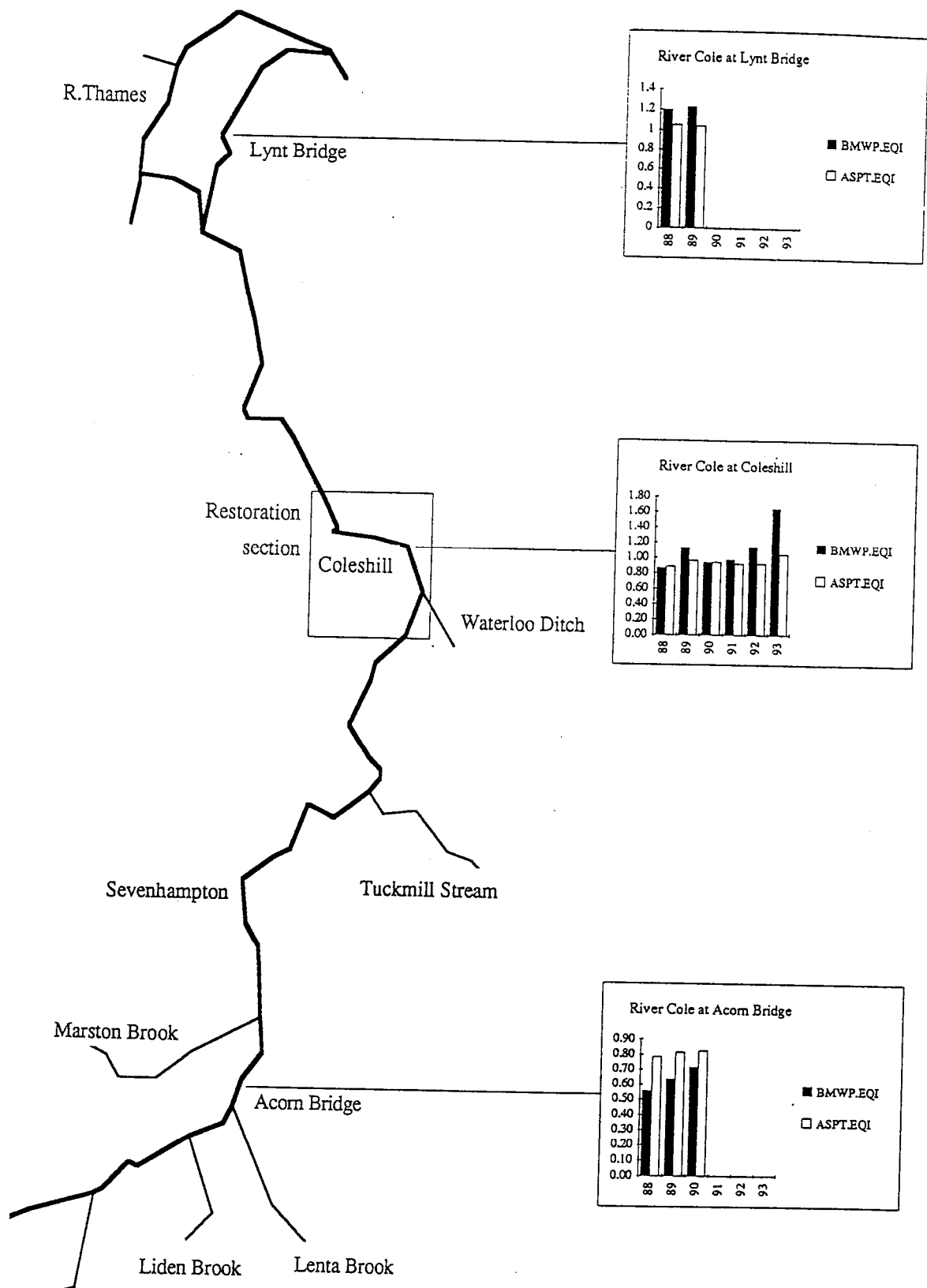


Figure 6.10 Variation in BMWP.EQI and ASPT.EQI in the River Cole



**Table 6.4 Pollution incidents reported to NRA TR (1988 - 1993)**

Incidents	1988	1989	1990	1991	1992	1993
Number of incidents	22	46	25	21	34	35
Number of pollution incidents	18	22	11	9	19	23
<b>Incident class</b>						
Major category (1)	4	1	0	0	0	0
Significant category (2)	9	4	2	0	3	1
Minor category (3)	9	41	23	21	31	34
<b>Incident type</b>						
Oil	10	22	15	11	17	12
Chemical	1	2	6	2	3	2
Sewage	5	10	1	0	2	10
Natural	1	4	2	2	3	1
Agricultural	4	2	0	1	2	4
General	0	3	1	2	7	6
Urban runoff	0	1	0	0	0	0
Not known	1	2	0	3	0	0

#### Water quality trends in the River Cole catchment

Figures 6.11 to 6.14 show the trends in four determinands (ammoniacal nitrogen, total oxidised nitrogen, soluble reactive phosphorus and total suspended solids) within the catchment. Between the Sevenhampton and Coleshill stations there are two significant tributaries, the Tuckmill Brook and the Waterloo Ditch. Ammoniacal nitrogen levels appear to decrease with distance downstream. There is also a decrease between Sevenhampton and Coleshill, despite a relatively heavy input from the Tuckmill Brook which carries the effluent from Shrivenham STW.

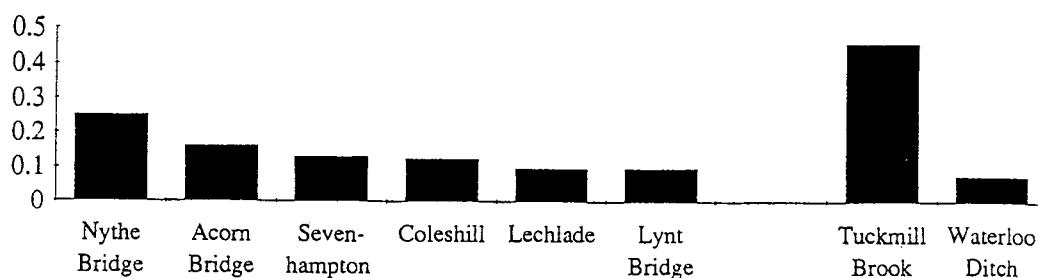
Total oxidised nitrogen shows a general increase with distance downstream, as might be expected with an increasing area of agricultural land drained. Both the Tuckmill Brook and the Waterloo Ditch carry higher concentrations of total oxidised nitrogen than the Cole itself. The Waterloo ditch flows into the Cole within the restored reach, and for this reason is being specifically monitored in the nutrient budget study.

Soluble reactive phosphorus shows no particular trend in the catchment, presumably reflecting the point source nature of this determinand and its ability either to be taken up by plants or to fall out of solution. Between Sevenhampton and Coleshill, the rise in soluble reactive phosphorus could be due either to the heavy input from the Tuckmill Brook or to a local effect of the small STW at Coleshill.

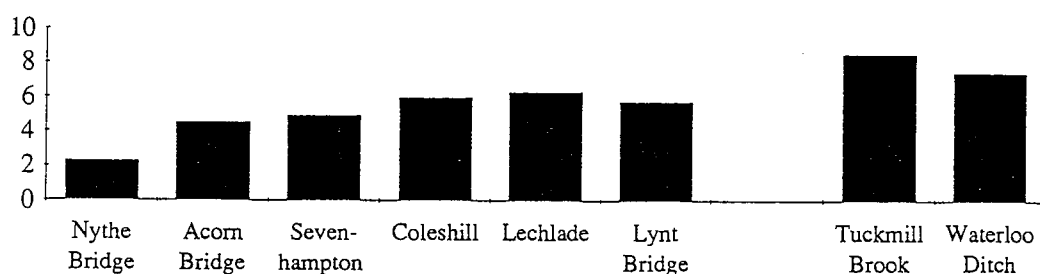
There is no obvious trend in total suspended solids in the catchment. The amounts in the restored reach and the local tributaries would appear to be below average for the catchment.

There are few routine monitoring sites for biological water quality on the Cole. BMWP and ASPT.EQIs for these sites (averaged between 1988 and 1994) are shown in Figure 6.15. There is an apparent trend for biological water quality to increase with distance downstream. There is an increase in both BMWP.EQI and ASPT.EQI between Acorn Bridge and Coleshill, despite the input of slightly lower-quality water from the Tuckmill Brook and Waterloo Ditch and the very low-quality water from the Marston Stream. The water quality in the tributaries above Acorn Bridge appears to be similar to that of the main river in terms of ASPT.EQI, and variable in terms of BMWP.EQI.

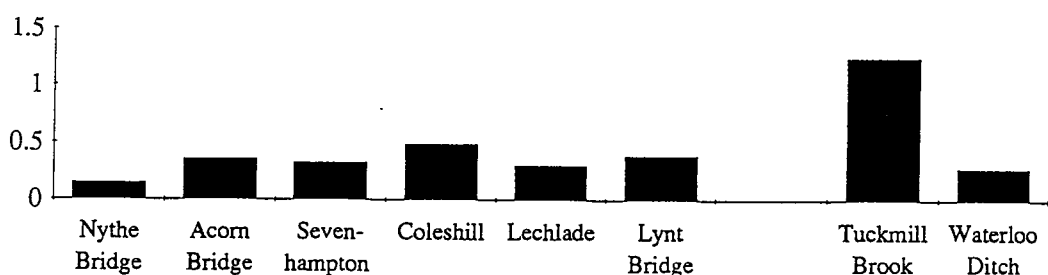
**Figure 6.11 Ammoniacal nitrogen (mg/l) in the Cole catchment**



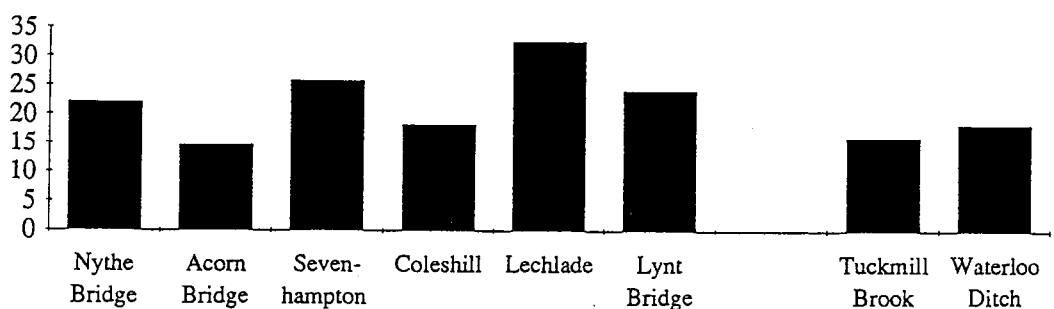
**Figure 6.12 Total oxidised nitrogen (mg/l) in the Cole catchment**

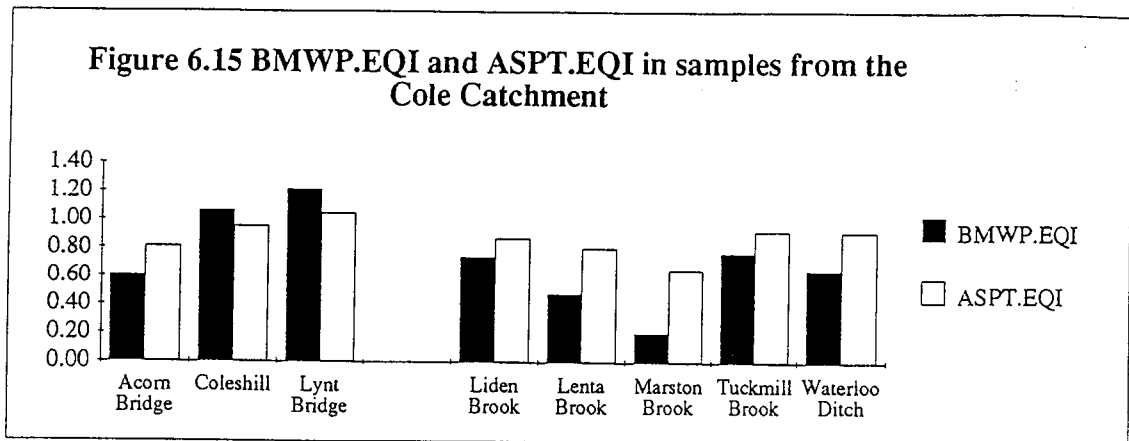


**Figure 6.13 Soluble reactive phosphorus (mg/l) in the Cole catchment**



**Figure 6.14 Suspended solids (mg/l) in the Cole catchment**





### 6.4.2 Nutrient special budget study: River Cole

The results for ammoniacal nitrogen, total oxidised nitrogen, soluble reactive phosphorus and total suspended solids already presented in Section 6.4.1 form a useful background to this study, and highlight the need to monitor inputs from the Waterloo Ditch and the need for automatic flood recording. They are also useful in setting detection limits for some of the determinands of interest in the special nutrient budget study.

Monitoring of nutrients in the River Cole began on 18 November 1994, with weekly samples being taken from the river at five sites. On 2 December 1994 a sixth site was added. Table 6.5 gives the locations of the six sites.

These weekly samples will be supplemented in the future by automatic flood monitoring equipment.

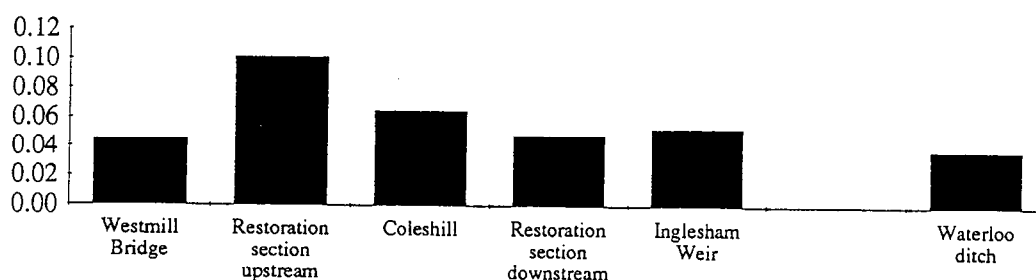
<b>Table 6.5 Locations of water sampling sites for nutrient special study.</b>	
Reference section at Westmill Bridge	SU23169090
Restoration section (upstream)	SU23439249
Coleshill	SU23419348
Restoration section (downstream)	SU22469384
Lower reference section at Inglesham Weir	SU20159886
Waterloo ditch	SU23909262

To date, samples from the six sites have been taken and analysed on eight occasions. Figures 6.16 to 6.19 show the average concentrations of ammoniacal nitrogen, total oxidised nitrogen, soluble reactive phosphorus and suspended solids in each site over the six occasions when measurements were made at all sites. Figures 6.20 to 6.23 show average concentrations of the four determinands on eight occasions averaged over all sites.

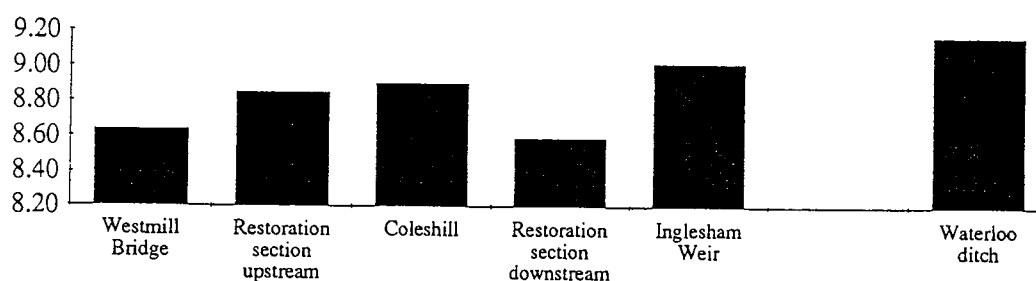
With respect to differences between sampling stations, first results suggest that total oxidised nitrogen varies only slightly between sites, being highest in the Waterloo Ditch and lowest at the downstream station in the restoration section. Ammoniacal nitrogen varies twofold, being highest at the upstream end of the restoration section (just after the river runs through woodland), and lowest in the Waterloo ditch. Soluble reactive phosphorus is relatively constant in the main river, and noticeably lower in the Waterloo ditch. Suspended solids, again, vary twofold, being highest at the Coleshill station and lowest at the upper control station (Westmill bridge).

In terms of temporal variation, there appears to be a clear correlation between total oxidised nitrogen and suspended solids. This presumably reflects agricultural run-off during periods of high flows. The relationship between ammoniacal nitrogen and suspended solids is not particularly strong, with some occasions having high ammoniacal nitrogen and low suspended solids. Soluble reactive phosphorus appears to decrease gradually over the period of study.

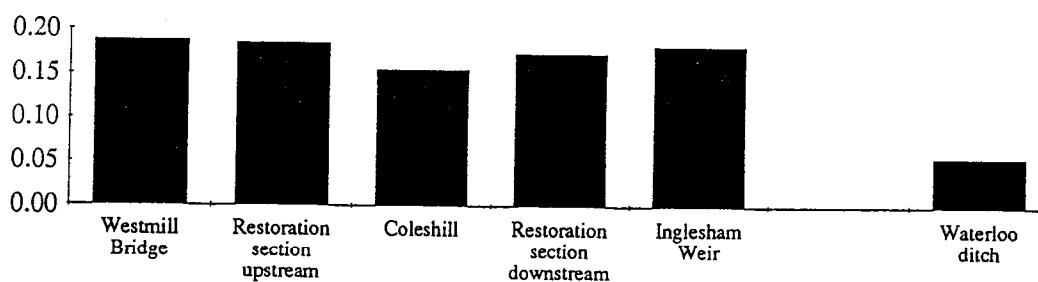
**Figure 6.16 Variation in ammoniacal nitrogen (mg/l) in special nutrient study sites**



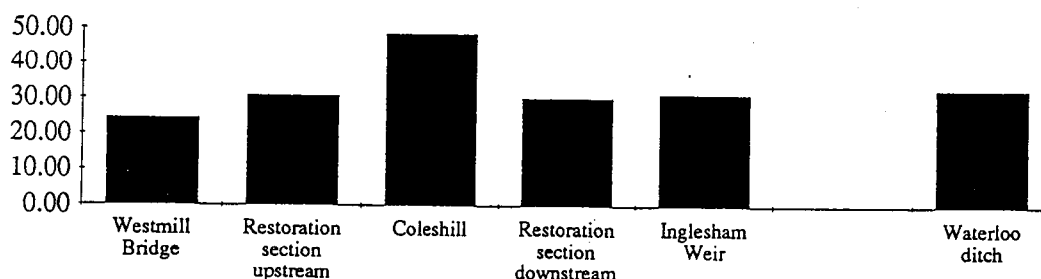
**Figure 6.17 Variation in nitrate nitrogen (mg/l) in special nutrient study sites**



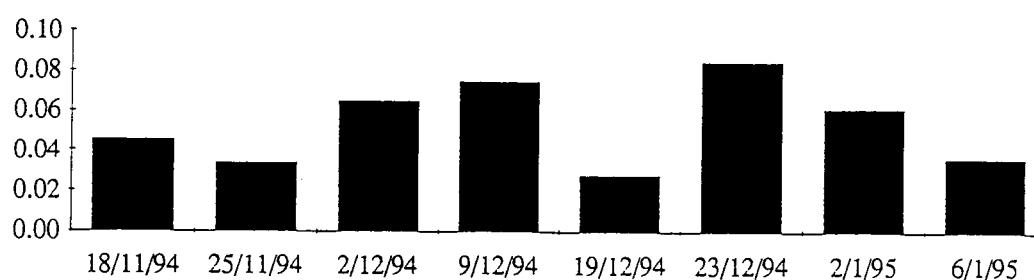
**Figure 6.18 Variation in soluble reactive phosphorus (mg/l) in special nutrient study sites**



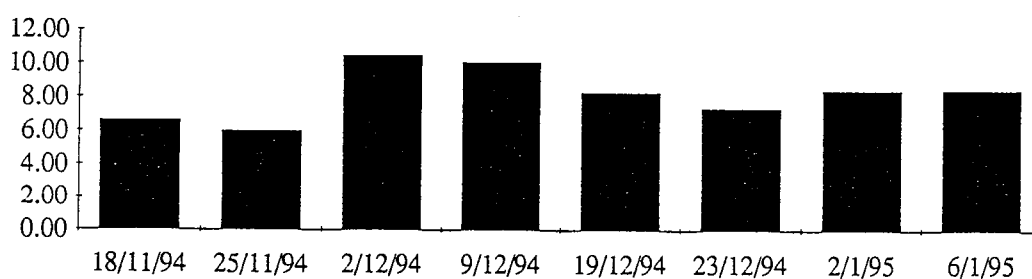
**Figure 6.19 Variation in suspended solids (mg/l) in special nutrient study sites**



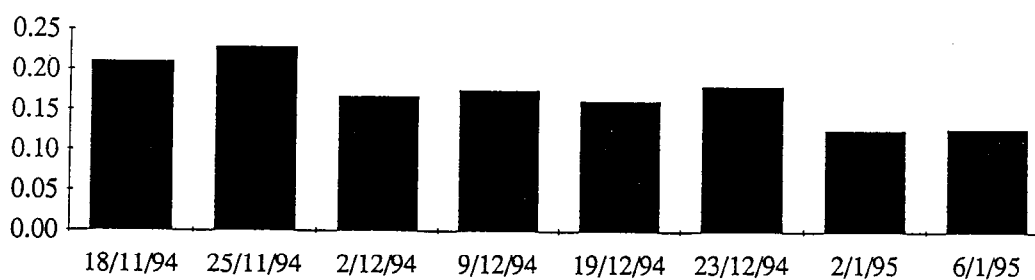
**Figure 6.20 Variation in ammoniacal nitrogen (mg/l) with time in all six special nutrient study sites**



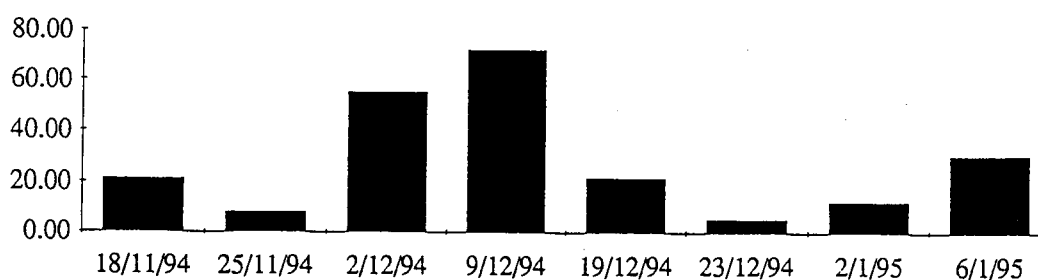
**Figure 6.21 Variation in total oxidised nitrogen (mg/l) with time in all six special nutrient study sites**



**Figure 6.22 Variation in soluble reactive phosphorus (mg/l) with time in all six special nutrient study sites**



**Figure 6.23 Variation in suspended solids (mg/l) with time in all six special nutrient study sites**



### 6.4.3 Optional project: change in floodplain soil chemistry following restoration

Soil samples have been collected in the course of an Oxford Brookes University undergraduate student project by Nicola Bailey. Results from this study will be reported later.

Stream bed samples have been taken from various points in the Cole catchment to assess any possible detrimental effects of overbank deposition of silt. This work was done by David Sear and Richard White in the course of the Catchment Audit. Results of this section of the special study are presented in Table 6.6.

Site	Sediment type	%	Pb	Zn	Cd	Cu	Mn	Fe
Dorcan Brook	Sand	60.14	62	120.8	<1	16.9	110	4783
	Silt	39.86	191.6	261.8	<1	64.9	18	5009
Cole at Nythe	Sand	40.76	81.3	223.7	<1	22.7	138	4618
	Silt	59.24	290.9	507.3	<1	131.6	258	5232
Cole at Acorn Bridge (A420)	Sand	87.03	81.5	134.4	<1	6.3	399	5441
	Silt	12.97	74.7	104.5	<1	17.9	202	4770
Cole at Friars Farm	Sand	91.31	97.2	110.2	<1	2.2	340	5324
	Silt	8.69	137.6	186.6	<1	21.4	362	5079
Cole at Westmill Farm	Sand	92.19	115.8	100	<1	1	405	5147
	Silt	7.81	130.3	146.4	<1	19.7	444	4550
Cole at Fresden Farm	Sand	75.94	113.3	62.5	<1	1	149	4826
	Silt	24.06	153.6	170.7	<1	28.6	262	4629
Restoration site: downstream	Sand	58.15	114.6	103.4	<1	6.2	167	4851
	Silt	41.85	129.8	180.4	<1	21.8	260	5244
Restoration site: upstream	Sand	85.98	104.6	104.7	<1	18.1	385	4795
	Silt	14.02	139.3	123.7	<1	9.2	276	5482
Cole d/s of Inglesham Weir	Sand	93.39	118.8	86.5	<1	1	289	5230
	Silt	6.61	109.9	101.1	<1	17.4	347	4746

From Sear and White(1994)

Geochemical analysis of fine sediment samples returned from 12 sites along the River Cole, from its headwater in Swindon to downstream of Inglesham Weir, confirmed that sediment quality is generally good, though with higher concentrations of heavy metals associated with urban channels draining Swindon. All values, with the exception of one - from the Cole at Nythe Bridge, Swindon (SU189858) - have heavy metal levels below those specified as problematic by the ICRCL. The Swindon site is sufficiently far upstream of the restoration reach that overbank siltation will not pose a pollution problem.

## 7. Vegetation

Vegetation monitoring of the River Cole involved surveys within (a) the river channel and corridor (see Section 7.1 below) and (b) the floodplain (see Section 7.2 below).

For both areas, the broad aim of ecological survey work has been to enable an assessment of the vegetation changes resulting from the restoration of the river and floodplain to be made. This is an area of special (i.e. more detailed) study within the monitoring programme, which has involved the establishment of monitoring stations within:

- i) The restoration habitat (river and floodplain).
- ii) An upstream length of channel/floodplain to act as a control.
- iii) A downstream area to ensure that the restoration works do not have adverse downstream impacts (eg excess sediment deposition).

In addition to providing a baseline from which future change can be measured, the first year of survey work has provided data describing the current conservation status of the riparian and floodplain community. This information has been essential in order to ensure that the restoration design does as little damage as possible to species and areas of existing conservation interest.

### 7.1 River corridor surveys

Surveys of the river corridor have involved: (i) a River Corridor Survey (ii) quantitative monitoring of quadrats along the river channel and banks.

- **River Corridor Survey**

The aim of the River Corridor Survey has been to provide information about the conservation value of the riparian plant community. Conservation value has been measured principally in terms of changes in wetland plant species-richness and rarity. Maps marking the extent of vegetation stands have also been produced in order to enable an assessment of broad changes in vegetation abundance to be made.

- **Quantitative monitoring**

The aim of quantitative monitoring has been to provide more detailed information about vegetation associated with the river channel, which could be used to quantify any changes in species abundance and community type resulting from river restoration. The monitoring also provides information which complements and can be used to help interpret data from aquatic invertebrate surveys.

#### 7.1.1 Methods

##### **River Corridor Survey rationale and methods**

The River Corridor Survey was undertaken over (a) the existing 2km of channel within the restoration area, and (b) 1-km lengths up and downstream (see Figure 7.1). In future years, both new and old sections of channel (where separately excavated and retained) will be re-surveyed to assess change in species richness and rarity.

The detailed methodology for the river corridor survey has, broadly, followed the standard NRA methodology given in *River Corridor Surveys, Conservation Technical Handbook No. 1* (NRA 1992). The main additions have been (i) the provision of wetland plant species lists for every 0.5-km length surveyed and (ii) the annual undertaking of two surveys, in order to ensure that plant species lists are as

complete as possible. The boundaries for the 0.5-km river reaches used for the plant survey were consistent with those used for the aquatic invertebrate pre-construction survey (see Figure 7.1).

River Corridor Surveys were undertaken by Richard Lansdown in August and October 1994. Wetland plant species present in each 500-m survey length were double-checked by Penny Williams in October 1994. Critical specimens of mosses were identified by Nigel Holmes.

### **Assessing the conservation value of the plant community**

The conservation value of the River Cole's plant community was also assessed on the basis of the presence of the number of wetland species and the number of nationally uncommon (i.e. local, nationally scarce or Red Data Book) wetland plants in the river corridor.

A Species Rarity Index (SRI) was used in order to achieve a relatively objective comparison of the reaches surveyed with sites in other areas. The SRI as described below should be regarded as an aid to assessing conservation value, and not as an **absolute** measure of conservation value without further consideration of all available information.

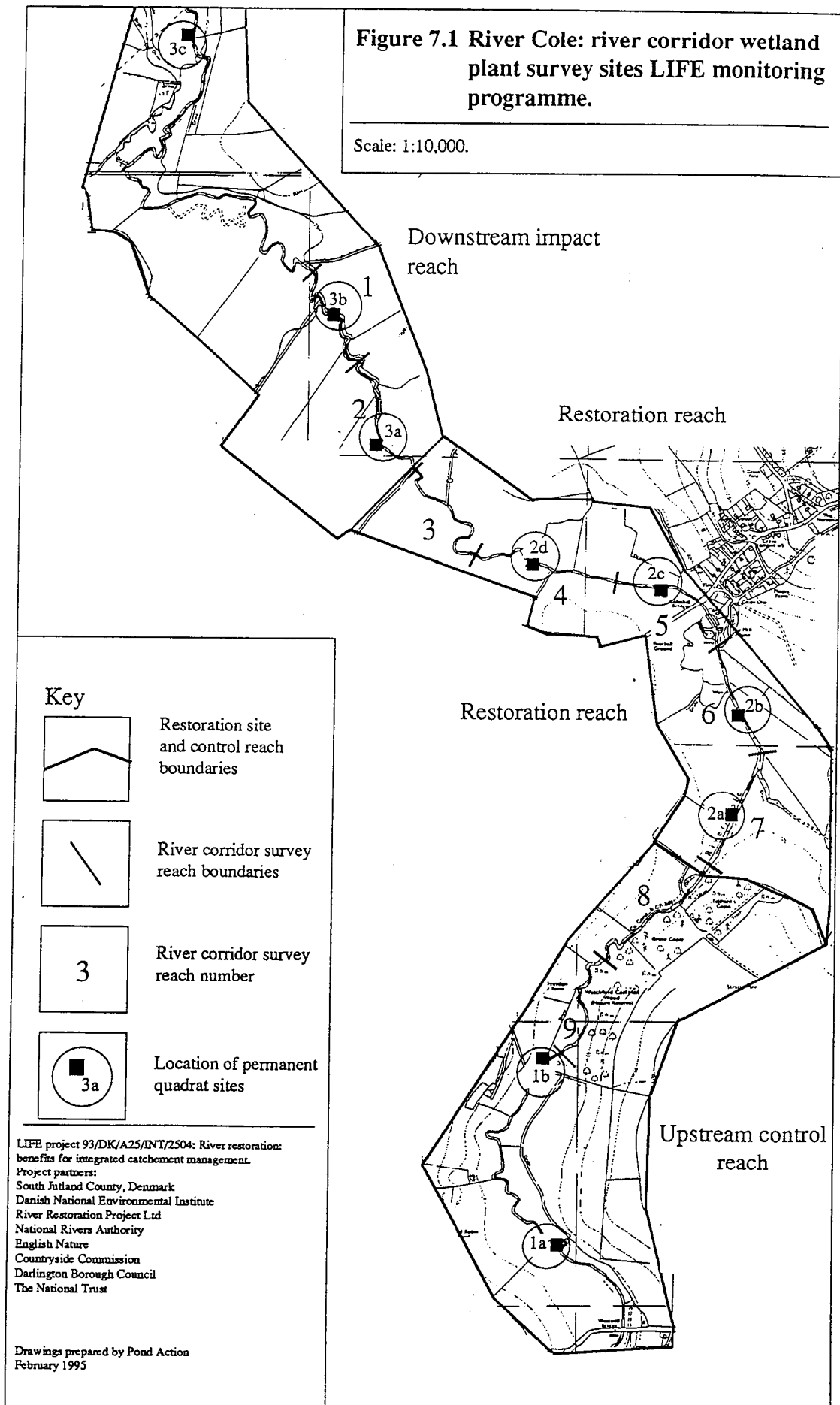
The SRI is a measure of the 'average rarity' of the species in a community and is derived in the following way:

- (i) All species present are given a numerical value from 1 to 64, depending on their rarity (i.e. common species = 1, local species = 2, Nationally Scarce B = 4, Nationally Scarce A = 8, Red Data Book 3 (rare) = 16, RDB 2 (vulnerable) = 32, RDB 1 (endangered), =64).
- (ii) The values of all the species present are totalled to give a Species Rarity Score (SRS).
- (iii) The SRS is divided by the number of species present to give the SRI.

Species-richness and SRI information was then used to place each of the Colehill reaches in one of four national conservation categories: low, moderate, high or very high (see Section 7.1.4)

**Figure 7.1 River Cole: river corridor wetland plant survey sites LIFE monitoring programme.**

Scale: 1:10,000.



### **Quantitative monitoring of changes in river channel vegetation**

Quantitative monitoring of changes in river channel vegetation has involved the establishment of a total of 36 permanent 2-m<sup>2</sup> quadrats which provide transects along nine sections of the R. Cole. Four of these transects lie within the restoration area, with two control transects upstream and three downstream of the restoration area. Where possible, the location of the transects was chosen to correspond with the 100-m sections surveyed for the aquatic macroinvertebrate monitoring.

Along each of the nine river monitoring transects, a permanent quadrat was established in four areas of the river channel: (i) mid bank; (ii) lower bank; (iii) shallow river/river edge; and (iv) central channel (see Figure 7.2). Transects were located to typify areas of the river, and quadrats were more precisely located to include plant-stand edges so that changes in stand size as well as composition can be evaluated. The position of quadrats was established using either permanent ground markers or by taking accurate measurements from permanent landscape features.

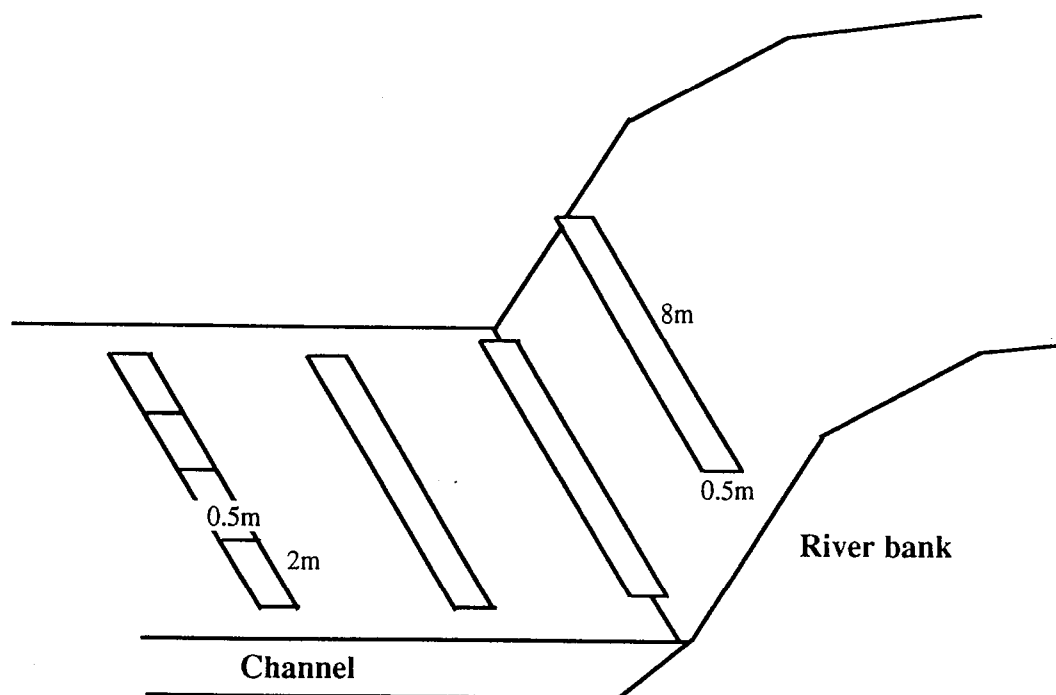
Within each river transect, the four 2-m<sup>2</sup> monitoring quadrats were constructed as an 8m x 0.5m rectangle, which was positioned along the river with the long axis of the quadrat oriented parallel to the hydrosere (see Figure 7.2). Each of these quadrats was subdivided into four 0.5m x 1m subquadrats (replicates) to facilitate statistical comparisons within and between monitoring sections. The 2-m<sup>2</sup> quadrat as a whole allows the survey results to be classified using the National Vegetation Classification scheme. The plant species present and their percentage cover were recorded in each quadrat.

The quadrats were established and monitored by Penny Williams in August 1994. In Year Two (1995) monitoring will involve more restricted surveying of upstream (control) and downstream (possibly impacted) sections only. Year Three monitoring (1996) will involve full survey monitoring to the level undertaken in 1994.

### **Analytical methods**

The results of quadrat monitoring will be analysed to establish whether there are quantitatively significant changes in vegetation composition and quality as a result of the restoration work. Analysis of change within and between quadrats and habitats thorough time will be undertaken using Analysis of Variance.

**Figure 7.2** Location of plant monitoring quadrats used for quantitative assessment of vegetation change



### 7.1.2 Results of the River Corridor Survey

The River Corridor Survey report (Lansdown 1994) provides a description and a species list for each 500-m reach of the River Cole within the survey area, together with photographs and annotated maps for each reach (see Figure 7.3).

The following description provides a summary of the findings from

- (i) Richard Lansdown's report
- (ii) Additional data and further analysis of the conservation value of the river communities undertaken by P. Williams.

#### Description of the vegetation types in the Restoration section prior to the physical works.

The channel and channel margin vegetation of the River Cole in the restoration area can be divided into three sections: (i) vegetation in the impounded section upstream of Coleshill Mill and weir (ii) vegetation in the river immediately downstream of the Mill, and (iii) the remaining 1km section below Coleshill road bridge.

- (i) The impounded and ponded section of river upstream of Coleshill Mill (see Figure 7.4)

This was the most botanically diverse section of the river in the survey area. The channel itself was deep and canalised with little variation, and although riffle vegetation was absent, the

channel supported more aquatic species than any other reach, including good stands of Floating Bur-reed (*Sparganium emersum*) and Yellow Waterlily (*Nuphar lutea*), together with a number of aquatics which were uncommon or absent from other reaches surveyed, including Arrowhead (*Sagittaria sagittifolia*), Canadian Waterweed (*Elodea canadensis*), Water Starwort (*Callitriche* sp.) and Common Duckweed (*Lemna minor*).

The channel margins were cattle-grazed, creating a low marsh berm along the left bank. This supported a diverse marginal plant community, including extensive stands of Reed Sweet-grass (*Glyceria maxima*) and a rich wet herb community, including species uncommon or absent elsewhere in the surveyed sections e.g. Narrow-leaved Water-plantain (*Alisma lanceolatum*), Skullcap (*Scutellaria galericulata*), Tufted Forget-me-not (*Myosotis laxa*), and Marsh Woundwort (*Stachys palustris*).

(ii) Vegetation in the river immediately downstream of the Mill

The section of river which ran from Coleshill Mill to just below Coleshill road bridge was anomalous in that it had a number of shallow riffles and runs which supported good stands of Stream Water-crowfoot (*Ranunculus penicillatus* var. *pseudofluitans*) and Willow Moss (*Fontinalis antipyretica*). The flow management structures associated with the mill and road bridge also provided a moderately diverse channel structure for tall marginal emergents and wetland herbs.

(iii) The 1-km section below Coleshill road bridge (see Figure 7.5)

Below Coleshill road bridge, the river was characterised by steep banks covered by a dense growth of ruderals. The most significant species present was Flowering Rush (*Butomus umbellatus*), which occurred as small stands along the channel margin where shallows were locally present. Immediately below the road bridge, shallow riffles supported locally dense growth of Water-milfoil (*Myriophyllum spicatum*), Stream Water-crowfoot (*Ranunculus penicillatus*), Willow Moss (*Fontinalis antipyretica*) and Fennel Pondweed (*Potamogeton pectinatus*). Downstream, the channel progressively deepened with loss of aquatic plant diversity.

#### **Vegetation in the upstream Control Reach**

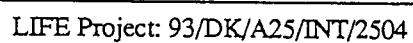
The reaches up to 1km above the restoration area were heavily shaded by bankside trees and ruderals, the lower part of the banks were nearly vertical throughout and the channel was deep. As a result, the reach supported about half the numbers of species present in the adjacent restoration reaches.

#### **Vegetation in the downstream Impact Reach**

Downstream of the restoration area, the river was characterised by steep banks both above and below the water, and a progressively deepening channel. As in the restoration area itself, the banks were covered by a dense growth of ruderals, with stands of Reed Sweet-grass (*Glyceria maxima*) and Reed Canary-grass (*Phalaris arundinacea*) along some edges. The channel was, in general, too deep to support rooted aquatic vegetation.

### **7.1.3 Results of the quantitative plant survey**

1994 monitoring results from the 144 quadrat surveys (4 subquadrats in each of the 36 x 2m<sup>2</sup> quadrats) are given in Appendix 1.



### 7.1.4 Conclusions

#### Species-richness

As a whole, the reaches of the River Cole on National Trust land (i.e. within the restoration area) were:

- (i) moderately rich in wetland plant species
- (ii) significantly richer in wetland plants than the control reaches both up- and downstream of the restoration area.

The ponded area above the Mill supported the richest wetland flora in the reaches surveyed, including a diverse wetland herb community on the low cattle-poached banks (see Table 7.1). Despite the considerable depth of the channel in this section, the aquatic plant community was also diverse. Both the emergent and aquatic floras of this section included species which were not recorded elsewhere in the survey (including Arrowhead, Narrow-leaved Water-plantain, Skullcap, Tufted Forget-me-not and Marsh Woundwort).

The other main areas of interest, both of which are associated with shallows below Coleshill Mill and the road bridge, are the aquatic communities (dominated by Stream Water-crowfoot) and, locally, the marginals (particularly Flowering Rush).

Elsewhere within the restoration area, particularly along the northerly reaches (downstream), the high steep banks and progressively increasing water depths significantly inhibit the development of a diverse marginal and aquatic flora.

**Table 7.1 Summary data for wetland plant species recorded from the River Cole (1994)**

Reach	Downstream control			Restoration reach				Upstream control	
	1	2	3	4	5	6	7	8	9
Number of plant species	2	2	2	3	3	4	3	1	2
	8	0	5	6	4	3	5	4	0
Number of uncommon species	2	2	4	4	5	5	3	1	1
Species Rarity Score	3	2	2	4	3	4	3	1	2
	0	2	9	0	9	8	8	5	1
Species Rarity Index	1.07	1.1	1.16	1.1	1.15	1.12	1.08	1.07	1.05
Conservation category (Mod = moderate conservation value)	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod

#### Uncommon species

No rare or nationally notable wetland plant species were recorded from any of the survey reaches, and the occurrence of local species was generally poor. In all, seven nationally uncommon species (i.e. species present in less than 600 10-km grid squares in Britain) were recorded (see Table 7.1 and 7.2): most of these species, however, have a predominantly southern distribution. Only *Ranunculus penicillatus* and *Alisma lanceolatum* could be considered to be both nationally and regionally uncommon, and in the case of both of these species there is some doubt about the accuracy with which their distribution has been

recorded.

Of the nationally uncommon species recorded, there was a tendency for more to be recorded in the restoration area than in the adjacent control areas.

#### **Overall conservation value**

Using the Species Rarity Index (SRI) to assess the overall conservation value of the reaches (see Table 7.3 below ), all reaches surveyed are considered to have a wetland plant community of moderate conservation value (on a four-point scale: low, moderate, high, very high).

**Table 7.2 Uncommon (local and nationally scarce) wetland plant species recorded in the study area**

***Alisma lanceolatum* (ALISMATACEAE). Narrow-leaved Water-plantain.**

Native: a species generally found on muddy substrata beside slow-flowing rivers, ponds, ditches and canals. The national distribution of *A. lanceolatum* is imperfectly known, but it appears to be much less frequent than *A. plantago-aquatica*. Scattered in England, Wales and Ireland. (Clapham *et al.* 1989; Stace 1991.)

On the R. Cole, it was recorded from the impounded section of the river (Reach 6).

***Butomus umbellatus* (ALISMATALES: Butomaceae). Flowering Rush.**

Found in ditches, ponds and canals; also on river-margins. Overall, the species is rather local in England, rare in Wales, and not native in Scotland. (Clapham *et al.* 1989; Stace 1991.)

On the River Cole, a small number of plants were recorded on the western edge of the river, within 100m downstream of Coleshill Bridge.

***Carex riparia* (CYPERALES). Greater Pond Sedge.**

Nationally, the species is typically found by slow-flowing rivers, in ditches and ponds, and (though more rarely) on drier ground. From its national distribution, it only just deserves the status 'uncommon' (i.e. recorded from less than 600 10-km grid squares in the UK). Overall, the species is very generally distributed in the south of England and the Midlands, but more local in the west and north as far as Fife. (Clapham *et al.* 1989; Stace 1991.)

***Myosoton aquaticum* (CARYOPHYLLACEAE). Water Chickweed.**

Native: occurs nationally in marshes and fens, stream-sides, ditches and damp woods at low altitudes. Through England and Wales, northwards to Durham. (Clapham *et al.* 1989.)

On the River Cole, it was frequently recorded as scattered plants along the more shaded lower bank sections.

***Potamogeton pectinatus* (POTAMOGETONACEAE). Fennel Pondweed.**

Widespread throughout Britain in base-rich water of the lowlands, but absent from mountainous districts of Wales, N. England and Scotland. Found in eutrophic or brackish water in a wide range of lowland habitats: one of the most pollution-tolerant *Potamogeton* species. (Clapham *et al.* 1989; Croft *et al.* 1991.)

On the River Cole, this species was found sparsely in the shallower sections of channel within the restoration area, particularly in reach 5 below Coleshill Mill and the road bridge.

***Sagittaria sagittifolia* (ALISMATACEAE). Arrowhead.**

Found nationally in at least moderately nutrient-rich ponds, ditches and slow streams, usually in highly calcareous, even brackish water. Overall, the species occurs throughout Britain where it is not uncommon, but it is most frequent in south-east England and is at present becoming very local in the west and north. (Clapham *et al.* 1989; Stace 1991.)

On the River Cole, it was found in the main channel within the impounded sections of Reaches 6 and 7 above Coleshill Mill.

***Ranunculus penicillatus* ssp. *pseudofluitans* (RANUNCULACEAE). Stream Water-crowfoot.**

Often the dominant macrophyte in base-rich rivers and streams; also recorded from ditches, pools and lakes. Overall, the species has a predominantly southern distribution, becoming scarce in Scotland. (Clapham *et al.* 1989; Croft *et al.* 1991.)

On the River Cole, this species was most common in Reach 5 below the Mill. It also occurred sparsely in other lengths within the restoration area, but was absent from the deeper reaches of the Control sections.

Table 7.3	Provisional system for assessing the nature conservation value of plant and aquatic macroinvertebrate communities
CATEGORY	DESCRIPTION OF TYPE OF COMMUNITY
<b>VERY HIGH</b>	Typically supporting a very rich community of plant and/or macroinvertebrate species, including local and rare (RDB) species (though note that some sites with rare species can be relatively species-poor). Sites in this category would normally have Species Rarity Indices in excess of 1.5.
<b>HIGH</b>	Supporting a rich community of common plants and/or macroinvertebrate species. Generally an above-average number of local species recorded. No RDB species. Sites in this category would normally have Species Rarity Indices between 1.2 and 1.5.
<b>MODERATE</b>	Supporting a moderately rich or rich community of common plant and/or macroinvertebrate species with at least one local species. Sites in this category would normally have Species Rarity Indices between 1.01 and 1.19.
<b>LOW</b>	Supporting a species-poor community of common plants and macroinvertebrates. No rare or local species. Sites in this category will have Species Rarity Indices of 1.00.

**Table 7.4 Wetland plant species recorded from the River Cole (1994)**

National Rarity Score			Downstream Control			Restoration Reach				Upstream Control		
Aquatics			1	2	3	4	5	6	7	8	9	
		<i>Callitriche</i> sp. (undet.)	Starwort Sp.	+	-	-	-	-	+	+	-	-
1		<i>Elodea canadensis</i>	Canadian Waterweed	-	-	-	-	-	+	-	-	-
1		<i>Elodea nuttallii</i>	Nuttall's Waterweed	-	-	-	+	+	+	-	-	-
1		<i>Lemna minor</i>	Common Duckweed	-	-	-	-	-	+	+	-	-
1		<i>Myriophyllum spicatum</i>	Spiked Water-milfoil	+	+	+	+	+	+	+	-	-
1		<i>Nuphar lutea</i>	Yellow Water-lily	-	+	+	+	+	+	+	+	+
2		<i>Potamogeton pectinatus</i>	Fennel Pondweed	-	-	-	+	+	+	-	-	-
2		<i>Ranunculus penicillatus</i>	Stream Water-crowfoot	-	-	+	+	+	+	-	-	-
2		<i>Sagittaria sagittifolia</i>	Arrowhead	-	-	-	-	-	+	+	-	-
1		<i>Sparganium emersum</i>	Unbranched Bur-reed	-	-	-	+	+	+	+	-	-
1		<i>Fontinalis antipyretica</i>	Willow Moss	-	-	+	+	+	-	-	-	-
Emergents												
1		<i>Agrostis stolonifera</i>	Creeping Bent	+	+	+	+	+	+	+	-	+
2		<i>Alisma lanceolatum</i>	Narrow-leaved Water-plantain	-	-	-	-	-	+	-	-	-
1		<i>Alisma plantago-aquatica</i>	Water- plantain	+	-	-	+	+	+	+	-	-
1		<i>Angelica sylvestris</i>	Wild Angelica	-	+	-	-	+	+	-	-	-
1		<i>Apium nodiflorum</i>	Fool's Water-cress	+	-	+	+	+	+	+	-	+
1		<i>Barbarea vulgaris</i>	Winter-cress	-	-	-	+	+	+	+	-	+
2		<i>Butomus umbellatus</i>	Flowering-rush	-	-	+	-	+	-	-	-	-
2		<i>Carex riparia</i>	Greater Pond-sedge	+	+	+	+	+	+	+	-	-
1		<i>Cirsium palustre</i>	Marsh Thistle	-	-	-	-	-	-	-	+	-
1		<i>Conium maculatum</i>	Hemlock	-	-	-	-	-	-	-	-	+
1		<i>Deschampsia caespitosa</i>	Tufted Hair-grass	+	-	-	-	-	-	-	+	-
1		<i>Epilobium hirsutum</i>	Great Willow-herb	+	+	+	+	+	+	+	+	+
1		<i>Eupatorium cannabinum</i>	Hemp-agrimony	-	+	+	+	-	+	+	-	+
1		<i>Filipendula ulmaria</i>	Meadowsweet	+	+	+	+	+	+	+	+	+
1		<i>Glyceria maxima</i>	Reed Sweet-grass	+	+	+	+	+	+	+	-	-
1		<i>Juncus inflexus</i>	Hard Rush	-	-	-	-	+	+	+	-	-
1		<i>Juncus effusus</i>	Soft-rush	-	-	-	-	+	+	+	-	-
1		<i>Lycopus europaeus</i>	Gipsywort	+	+	-	+	+	+	+	+	+
1		<i>Mentha aquatica</i>	Water Mint	-	-	-	-	+	+	+	-	-
1		<i>Myosotis laxa</i>	Tufted Forget-me-not	-	-	-	-	-	+	-	-	-
1		<i>Myosotis scorpioides</i>	Water Forget-me-not	+	-	-	+	+	+	+	+	+
2		<i>Myosoton aquaticum</i>	Water Chickweed	+	+	+	+	+	+	+	+	+
1		<i>Nasturtium officinale</i>	Water-cress	-	-	-	+	-	+	-	-	-
1		<i>Phalaris arundinacea</i>	Reed Canary-grass	+	+	+	+	+	+	-	+	+
1		<i>Phragmites australis</i>	Common Reed	+	-	-	-	-	-	-	-	-
1		<i>Polygonum amphibium</i>	Amphibious Bistort	+	+	+	-	-	+	+	-	-
1		<i>Polygonum hydropiper</i>	Water-pepper	+	-	-	+	+	+	+	+	+
1		<i>Polygonum persicaria</i>	Redshank	-	-	-	+	+	-	+	-	+
1		<i>Ranunculus sceleratus</i>	Celery-leaved Buttercup	+	-	-	+	-	+	-	-	-

**Table 7.4 Wetland plant species recorded from the River Cole 1994 (continued)**

National Rarity Score			Downstream Control			Restoration Reach				Upstream Control	
			1	2	3	4	5	6	7	8	9
1	<i>Rorippa palustris</i>	Marsh Yellow-cress	-	-	-	-	-	+	+	-	-
1	<i>Schoenoplectus lacustris</i>	Common Club-rush	+	+	+	+	+	+	+	-	+
1	<i>Scrophularia auriculata</i>	Water Figwort	-	-	+	+	+	+	+	-	+
1	<i>Scutellaria galericulata</i>	Skullcap	-	-	-	-	-	-	+	-	-
1	<i>Solanum dulcamara</i>	Bittersweet	+	+	+	+	+	+	+	+	-
1	<i>Sparganium erectum</i>	Branched Bur-reed	+	+	+	+	+	+	+	-	+
1	<i>Stachys palustris</i>	Marsh Woundwort	-	-	+	-	-	+	+	-	-
1	<i>Symphytum officinale</i>	Common Comfrey	+	+	+	+	+	+	-	+	+
1	<i>Typha latifolia</i>	Bulrush	-	-	-	-	-	-	+	-	-
1	<i>Veronica anagallis-aquatica</i>	Blue Water-speedwell	-	-	-	+	-	+	+	-	-
1	<i>Veronica beccabunga</i>	Brooklime	+	-	+	+	+	+	+	-	+
<b>Trees and shrubs:</b>											
1	<i>Alnus glutinosa</i>	Alder	+	-	-	+	-	-	-	-	-
1	<i>Salix alba</i>	White Willow	-	-	-	-	+	-	-	-	-
1	<i>Salix caprea</i>	Goat Willow	+	-	+	+	-	-	-	-	-
1	<i>Salix cinerea</i>	Grey Willow	+	+	+	+	-	-	-	+	+
1	<i>Salix fragilis</i>	Crack Willow	+	+	+	+	+	+	+	+	+
1	<i>Salix triandra</i>	Almond Willow	-	-	-	+	-	-	-	-	-
1	<i>Salix viminalis</i>	Osier	+	+	-	-	-	-	-	-	-
Number of plant species			28	20	25	36	34	43	35	14	20
Number of uncommon species			2	2	4	4	5	5	3	1	1
National conservation score			30	22	29	40	39	48	38	15	21
Species Rarity Index and conservation category			1.07 Mod	1.1 Mod	1.16 Mod	1.1 Mod	1.15 Mod	1.12 Mod	1.08 Mod	1.07 Mod	1.05 Mod

## 7.2 Floodplain survey

### 7.2.1 General aims

The aim of the floodplain survey has been to describe the character and conservation value of floodplain habitats before and after restoration, and any changes that occur. Conservation value is here measured in terms of:

- (i) Changes in the number/rarity of plant species in different habitat compartments
- (ii) Changes in landscape/community complexity.

More detailed studies aimed:

- (i) To describe changes in grassland habitats with water-level change
- (ii) To assess the value of creating microtopographic complexity on the floodplain.

### 7.2.2 Description of floodplain survey methods

The basis for floodplain monitoring has been:

- (i) A background literature study
- (ii) A Phase 1 habitat survey of the area to be restored with vegetation assigned to National Vegetation Classification (NVC) community types
- (iii) Species list compilation for every major habitat or compartment type.

The survey area includes (i) the area of floodplain to be restored, together with (ii) a 1-km upstream control section, and (iii) a 1-km downstream section, which could possibly be impacted by the restoration scheme. Information has been maintained on GIS.

#### 1994 floodplain survey methods

Each major compartment or habitat type was surveyed on the 8 and 9 July 1994 by Tim Rich. Species lists were compiled by walking along, recording all vascular plant species seen. Frequencies of species were recorded using the DAFOR scale. This is a crude scale giving a subjective estimate of frequency as follows:

D = dominant  
A = abundant  
F = frequent  
O = occasional  
R = rare

(qualified with L = 'locally' and V = 'very', as appropriate.)

The length of time taken to record each site was noted to give an estimate of effort. Note, however, that it is very difficult when surveying many areas composed of similar species and habitats to ensure that every species was recorded each time.

Many meadows had been cut before the survey, and it was impossible to produce a representative species list. For these sites, the species present were simply listed without DAFOR frequencies.

Plant nomenclature follows Stace (1991).

To test the recording method, Site 14 was recorded twice. The first survey on 8 July found 20 species.

When the survey was repeated on the 9 July, one species noted on the previous day was not found, but two further species were recorded. The frequencies noted were largely agreeable on both days, the main discrepancies being between 'frequent' and 'occasional'. The method should thus give a crude impression of changes in species resulting from the restoration, and seems to be largely repeatable.

### **NVC mapping**

The survey method and classification were consistent with the National Vegetation Classification (NVC). Each distinct vegetation type was identified and mapped in the field, but no quadrat samples were taken. The survey concentrated on the inner study area, with only areas of interest outside noted in detail.

The River Cole was not recorded, as this was mapped separately in the River Corridor Survey.

### **Special floodplain monitoring methods**

In addition, as part of a special study to provide more detailed, quantitative information about vegetation changes on the floodplain of the R Cole, the NVC classification will be supplemented by fixed quadrat monitoring both within and outside the restoration areas. The first monitoring of these quadrats will be undertaken in June/July 1995, prior to the first silage/hay cuts. Monitoring plots will include:

- (i) Grassland which will experience a changed hydrological regime following restoration
- (ii) Grassland which will have a more diverse microtopography
- (iii) Control plots

Quadrats will be established using a stratified random method, using transects running across existing meadow vegetation perpendicular to the new river course.

### **Additional information**

Additional material describing floodplain vegetation has been provided by Catherine Hearn (National Trust) and gathered from previous National Trust reports (e.g. National Trust 1986, 1987).

## **7.2.3 Floodplain plant communities: results**

The results of the Phase 1 vegetation survey are described in full in Rich (1994). The report includes:

- (i) A habitat map of the study area with NVC types.
- (ii) Species lists with estimated frequencies for compartments in the restoration area

An abbreviated summary of the results of this floodplain survey, together with data from other sources, is given below. A summary map showing the major habitats is given in Figure 7.6.

## Floodplain communities - results

Habitats within the restoration area were broadly divided into two areas: arable land to the north of Coleshill Bridge, and grasslands to the south. The main exception was a small, relatively unimproved, meadow on the eastern bank of the Cole, located amongst arable fields. This area, formerly a Site of Special Scientific Interest (SSSI) but now de-notified, holds a moderate population of Snake's-head Fritillary (see below). Other habitats of note included a number of hedges and riverside woodland, and small areas of swamp vegetation.

### Arable fields

The distribution of arable land adjacent to the Cole was limited to the area north of Coleshill Bridge. In 1994, most arable fields were growing rape. All fields on the western side of the river had broad (10m) buffer-strip areas, supporting a variety of common ruderals, between the arable crop and the river edge.

### Grassland communities

Four NVC grassland types were recorded from the survey area: MG1(b,c), MG5(a), MG6(a) and MG7.

The grassland community of greatest species-richness and conservation value recorded from the restoration area belonged to the **MG5 Crested Dog's-tail - Common Knapweed meadow and pasture community**. This community type is widely scattered throughout the British lowlands, but has its main concentration in Worcestershire. It is one of the grassland types noted by Croft and Jefferson (1994) to be of high botanical interest.

Two fields held MG5 communities:

- (i) the ex-SSSI Fritillary field downstream of Coleshill Bridge, which, whilst it had the best examples, still appears to have been somewhat improved.
- (ii) the football ground upstream of Coleshill bridge, which supported a very species-poor version of this community.

The MG5 community is characterised by Red Fescue, Crested Dog's-tail, Bird's-foot Trefoil (*Lotus corniculatus*), Ribwort Plantain (*Plantago lanceolata*), Yorkshire Fog, Cock's-foot, White Clover, Common Knapweed, Creeping Bent, Sweet Vernal Grass (*Anthoxanthum odoratum*), and Red Clover. Locally there may be Rye Grass, or Ladies' Bedstraw (*Galium verum*), Yellow Oat-grass (*Trisetum flavescens*) and Yarrow (*Achillea millefolium*), or Self-heal (*Prunella vulgaris*), Autumn Hawkbit (*Leontodon autumnalis*), Field Woodrush (*Luzula campestris*), Heath-grass (*Danthonia decumbens*), Tormentil (*Potentilla erecta*), Devil's-bit Scabious (*Succisa pratensis*) and Meadow Buttercup (*Ranunculus bulbosus*). They are, typically, species-rich pastures. They can be quite variable in composition. They occur on soils which are not high in nutrients, neither acid or alkali, and freely-drained. The pastures have usually not been sprayed with herbicide, and receive little or no fertiliser. They are usually cut for hay, and are ungrazed in summer but may be grazed in winter.

Three sub-communities are recognised in Britain, and the most variable of these, the MG5a Meadow Vetchling sub-community, occurred at Coleshill. This sub-community has Rye Grass, Daisy, Meadow Vetchling and Ox-eye Daisy in addition to the community constants: it has often received some fertiliser or manure.

### Coleshill fritillary meadow

This is a moderately species-rich site, which has been partly improved but still retains a number of old wet meadow species, including Snake's-head Fritillary, Dropwort, Sweet Vernal-grass, Meadowsweet, Meadow Vetchling, Lady's Smock, Knapweed, Common Woodrush and Common Vetch.

The location of fritillary plants in the field varies between years, but they appear to be centred towards the middle of the field (see 1989 distribution in Figure 7.7).

Katherine Hearn's site records suggest that there has been a very significant increase in the Snake's-head Fritillary population since 1989, with flowering heads spreading much more over the field than previously (See Table 7.5 below).

Records for the site suggest that prior to 1988 the management was hay-cutting (after 1st July), with no grazing until September. After September there was heavy grazing by sheep to produce a very short sward by the end of the year. There was flooding in patches in Spring 1988.

Katherine Hearn's advice in 1989 for management of a similar field in Kelmscott was:

- Ensure that the field is never ploughed.
- Stop the application of any fertilisers and farmyard manure.
- Prevent a hay-cut until 1st July.
- Late summer/autumn grazing of stock.

She suggests that it would be worthwhile to consider whether it would be better to dig out the old drains in the Kelmscott fields again, adding that in the better 'fritillary years' they seem to occur nearer the old drain lines. Fritillaries do not like permanent water-logging, and may occur round drains at present. She notes that 'if we ever had the chance to sow a Cricklade Meadow mix (or even a Grafton Lock mix) on the adjacent enclosure, that would be marvellous'.

An account of the fritillary in Wiltshire is given in Gillham (1993).

**Table 7.5      Coleshill Fritillary Meadow data**

Date	Flower-head counts	Notes
1977	Carpets	After hot summer of 1976
1980	100	
1981	70	
1983	12	
1984	80	
1985	130	Farmyard manure spreading stopped in 1985
1986	c. 12	
1987	446	
1988	300	
1989	589	
1990	480	12.04.90. Sward short, only 10-15cm. Looks herb-rich. A lot of flowers frosted or eaten. Many more flowering plants.
1991	487	Sward very short: hardly grown. (Recently been topped?) Much <i>Heracleum</i> in sward.
1992	608	04.05.92. Sward thick and rather littery. Was it grazed last autumn or this spring? Despite this, looked rich and good.
1993	429	24.04.93. Lots eaten, well past best.
1994	782	23.4.94. Grass short, 10cm, well poached and open, no litter. Fritillaries standing well above the sward. Not many eaten. Past best at this date. Some 8 only 10-12m from far west hedge - new patch? 18 on north side of ditch.
Source: Catherine Hearn (National Trust).		

### Other grasslands

Most of the remaining grassland within the restoration area was improved (**MG7 Rye Grass Ley**), with little botanical interest. This included all the fields to the east of the river in Coleshill Park, upstream of the Mill, and the two fields immediately west of the Mill (see Figure 7.6). Rye Grass leys are characterised by dominant Rye Grass, associated variably with Timothy, Rough Meadow Grass (*Poa trivialis*), White Clover, Cock's-foot, Meadow Foxtail (*Alopecurus pratensis*), plantains (*Plantago* species), dandelions (*Taraxacum* species), and other nitrophilous herbaceous plants. They are typically very species-poor communities, and are characteristic of the more nutrient-rich and heavily improved soils of medium pH, which are usually well-drained. They are either heavily grazed, or are cut for hay or silage. This is the predominant, modern agricultural pasture in lowland Britain.

The most significant feature of this community at Coleshill was the occasional occurrence of *Filipendula vulgaris* - a species usually thought of as a plant of chalk and limestone, but which does occur on water meadows. It was seen on improved pasture in Coleshill Park, south of the Waterloo ditch, and indicates that the interest of the pastures may not all be completely destroyed.

The second largest area of grassland, the grazed field located to the west of the R. Cole upstream of the Mill, classifies as **MG6 Rye Grass - Crested Dog's-tail pasture**. This community is typically characterised by Rye Grass, Crested Dog's-tail, White Clover, Yorkshire Fog, Mouse-ear, and Red Fescue. It is often a relatively species-poor community, but is often very variable in composition, depending on the precise type of grazing and soil. It occurs on fairly nutrient-rich soils of medium pH which are well-drained, but these range from weakly acid to weakly basic. The pastures are typically heavily grazed for most of the year, and have often received fertiliser or slurry. They are the commonest partly improved grazing pastures in Britain.

Three sub-communities are recognised in Britain, of which the MG6a sub-community occurred at Coleshill. This sub-community is the typical Rye Grass - Crested Dog's-tail pasture, characterised by the species which define the community as a whole. It is often fairly improved through fertiliser application, and occurs on the richer soils. It is common in Britain.

The margins of many ditches in the restoration area are characterised as **MG1 False Oat-grass grasslands**. These are, typically, dominated by False Oat-grass, Cock's-foot, Yorkshire Fog and Hogweed (*Heracleum sphondylium*). They occur on freely draining to seasonally moist soils which are weakly acidic to calcareous, and which are often moderately or strongly nutrient-rich. They are usually ungrazed, but may be mown. They are widespread in lowland Britain on roadsides, banks, neglected pastures, etc. Five sub-communities are recognised in Britain, of which two occurred at Coleshill.

The MG1b Common Nettle sub-community, which has abundant nettles in addition to the community constants, was widespread at Coleshill. It typically occurs on nutrient-rich soils. It is typical of roadsides, neglected and disturbed pastures, and waste ground. The River Cole bankside vegetation was also ascribed to this community, although some areas had purer stands of nettles.

The MG1c Meadowsweet sub-community occurred in some of the wetter areas, usually associated with the MG1b Common Nettle sub-community. In this sub-community, in addition to False Oat-grass, Common Nettle and Hogweed, Meadowsweet becomes a prominent component of the vegetation. It occurs on brown earth soils of neutral pH, where soils are moist but freely draining. It is characteristic of ungrazed roadside ditches and choked streams throughout lowland Britain.

### Woodlands, scrub and hedges

Hedges on the site were all relatively species-poor, comprising the **W21 hawthorn - ivy scrub community**, with a ground flora usually dominated by nettles due to the rich alluvial soils and possibly fertiliser drift.

This scrub type is characterised by constant hawthorn, ivy and bramble. It is a diverse community, the variation being related to soils and the origin of the scrub. The community occurs on moderately acid to strongly alkali soils. It may be deliberately planted or colonise naturally. It is the commonest scrub type in lowland Britain, occurring on neglected land and, very commonly, as hedges.

Four sub-communities are recognised in Britain, of which the W21a ivy - Common Nettle sub-community occurred at Coleshill. This is characterised by Common Nettles and Cleavers, often with grassland species. The stands are generally species-poor, and are often of recent origin. The soils are often nutrient-rich. It is the commonest sub-community, and is very common in Britain.

Where the margins of the Cole were wooded, this was principally the W6 Alder - Common Nettle woodland community. This woodland type is characterised by a canopy of Alder (*Alnus glutinosa*) or Crack Willow (*Salix fragilis*), sometimes with a little Downy Birch (*Betula pubescens*), and a fairly species-poor ground flora of Common Nettle (*Urtica dioica*), Cleavers (*Galium aparine*) and other nutrient-loving herbs. The shrub layer is usually patchy and open, with Grey Willow (*Salix cinerea*) and Elder (*Sambucus nigra*). It occurs widely on moist, nutrient-rich alluvial soils in lowland Britain, on riverbanks, by ponds and in valley bottoms.

Five sub-communities, which form an ill-defined sequence running from wetter to drier ground, are recognised in Britain. At Coleshill, the W6b Crack Willow sub-community was present. In this sub-community, Alder is replaced by Crack Willow (or, exceptionally, White Willow, *Salix alba*), often where it has been deliberately planted and managed on riverbanks etc. The other species are very similar to the typical sub-community. It occurs not infrequently in suitable locations throughout lowland Britain.

One patch of Blackthorn scrub (W22 Blackthorn - bramble scrub) occurred north-west of Coleshill Bridge. This scrub type is characterised by Blackthorn (*Prunus spinosa*), which usually forms dense stands by spreading suckers. It is often the only woody species present. The field layer is usually species-poor due to dense shade. The soils are often deep, moist and nutrient-rich. It occurs as hedges, invading neglected land on sea cliffs, banks and woodland margins. It is widespread through the British lowlands.

#### Swamps

In addition to the swamp vegetation associated with some margins of the River Cole, some of the floodplain locally supported swamp vegetation communities S26 and S7.

One stand of S26 Common Reed - Common Nettle fen was found at Coleshill in a ditch on the north side of Tellhard's Copse. This community is associated with nutrient-rich, neutral to slightly basic water margins with seasonal water inundation. It is a variable community, characterised by Common Reed, Common Nettle, Cleavers, Marsh Bedstraw, Hemlock Water-dropwort (*Oenanthe crocata*), Hedge Bindweed (*Calystegia sepium*) and Great Willowherb (*Epilobium hirsutum*). It is common in lowland ditches, riverbanks and fens, and also occurs in coastal reedbeds and floodplains which have been disturbed. It occurs on moist organic or mineral substrates, on groundwater gleys and on sites sometimes flooded in winter. The Coleshill community was not typical of the community type as a whole.

Scattered patches of S28 Reed Canary-grass swamp vegetation occurred in ditches around the area, often with prominent *Epilobium hirsutum*.

This is a tall swamp community, dominated by stands of Reed Canary-grass which spread to form patches 1 - 2 m tall. It is a variable community, and is often quite species-poor. It is frequent in ungrazed situations on river banks and pond margins in lowland Britain. There are three sub-communities which show a transition related to water table.

#### Other vegetation types

Nettle beds occurred on some ditch and river-bank sides.

One stand of *Reynoutria sachalinensis* was found opposite Tellhard's Copse.

Arable headlands with many weed species were present in the two fields north west of Coleshill Bridge.

### 7.2.4 Summary of the value of the floodplain communities

With the exception of the fritillary field, there were few floodplain areas of particular value.

Species of particular note included:

*Fritillaria meleagris* (Snake's-head Fritillary) is of particular interest in Site 44, but was not seen during this survey despite careful searching. It flowers in April/May and is very inconspicuous afterwards (unless fruiting). An account of the Fritillary in Wiltshire is given in Gillham (1993).

*Filipendula vulgaris* (Dropwort) is usually thought of as a plant of chalk and limestone, but does occur on water meadows. It was seen in the fritillary meadows (Site 44) and also, surprisingly, in an improved pasture (Site 29), indicating that the interest of the pastures may not have been completely destroyed.

*Bromus commutatus* (Meadow Brome) and *B. racemosus* (Smooth Brome), old meadow grasses, were both found scattered widely in the area, sometimes as arable weeds.

### 7.2.5 Restoration

It was not an aim of this work to provide detailed restoration proposals, but a few ideas are given below. Much practical advice on restoration of wet grasslands is available from the RSPB (e.g. Andrews & Rebane 1994).

The main grazing field (upstream of Coleshill Mill) would make an ideal site for restoration to an irrigated water meadow (cf. Rackham 1986), where water is fed off from the river in an elaborate series of channels to fertilise and irrigate the meadow during the winter, and left to dry out in the spring. This results in a network of microhabitats with regular inputs of seed and silt, potentially enriching the sward.

To enrich existing meadows, hay crops could be taken off the richer meadows and spread over the poorer ones to give a source of seeds. Species could be transplanted into the swards to enrich small areas.

Native black poplars could be planted beside the rivers. Many more have been found in Wiltshire since the recent flora (Gillham 1993).

The ditches south of Coleshill Park (e.g. Site 32 and 35), and most of the river banks south of the weir, are quite rich in wetland species and could act as a source of colonisation for suitable habitats created elsewhere on the site.

The backwater (Site 31) has potential for improvement if it is re-flooded and some of the willows pollarded again.

## 8. Invertebrate ecology: Cole

The broad aim of the invertebrate monitoring programme has been to describe and assess changes in the conservation value of the communities following the restoration of river and floodplain habitat.

The invertebrate monitoring programme on the Cole is one of the special studies of the demonstration project. The work has been undertaken by Mericia Whitfield, with assistance from Dave Walker, Antony Corfield and Penny Williams.

### 8.1 Aquatic macroinvertebrates

#### 8.1.1 Aims

The aims of the monitoring programme are:

- (i) To assess the present ecological value of the existing river, together with associated ditches and floodplain pools within the restoration area, in order to provide guidance information for the restoration design.
- (ii) To estimate any changes in the species-richness and conservation value of the aquatic macroinvertebrate fauna of the restoration area in the years following restoration work. (Conservation value will be assessed in terms of average species rarity.)
- (iii) To monitor the aquatic macroinvertebrate fauna of the downstream reach to assess impacts resulting from the construction work (and, as a control, the upstream reach).
- (iv) To monitor the conservation value of the aquatic macroinvertebrate fauna of the old channel (if retained after new channel construction).

#### 8.1.2 Methods

##### The main monitoring survey programme

##### Field survey methods

The first (summer) set of three-minute macroinvertebrate samples were carried out on 25th May, 20th June and 30th June 1994. Sample stations were established in the upstream control reach, the restoration reach and the downstream impact reach (see Figure 8.1).

Nine 100-m river sections were surveyed in total: two in the upstream (control) reach, four in the restoration reach, and three downstream. In each 100-m survey section, the equivalent of one three-minute hand-netted sample was collected. This was made up of 12 15-second samples, which were kept separate and processed separately in the laboratory (see below). Where possible, three samples were taken from each of four habitats: 'run', 'riffle', 'pool' and 'bank'. The sampling strategy is compatible with RIVPACS work undertaken by NRA.

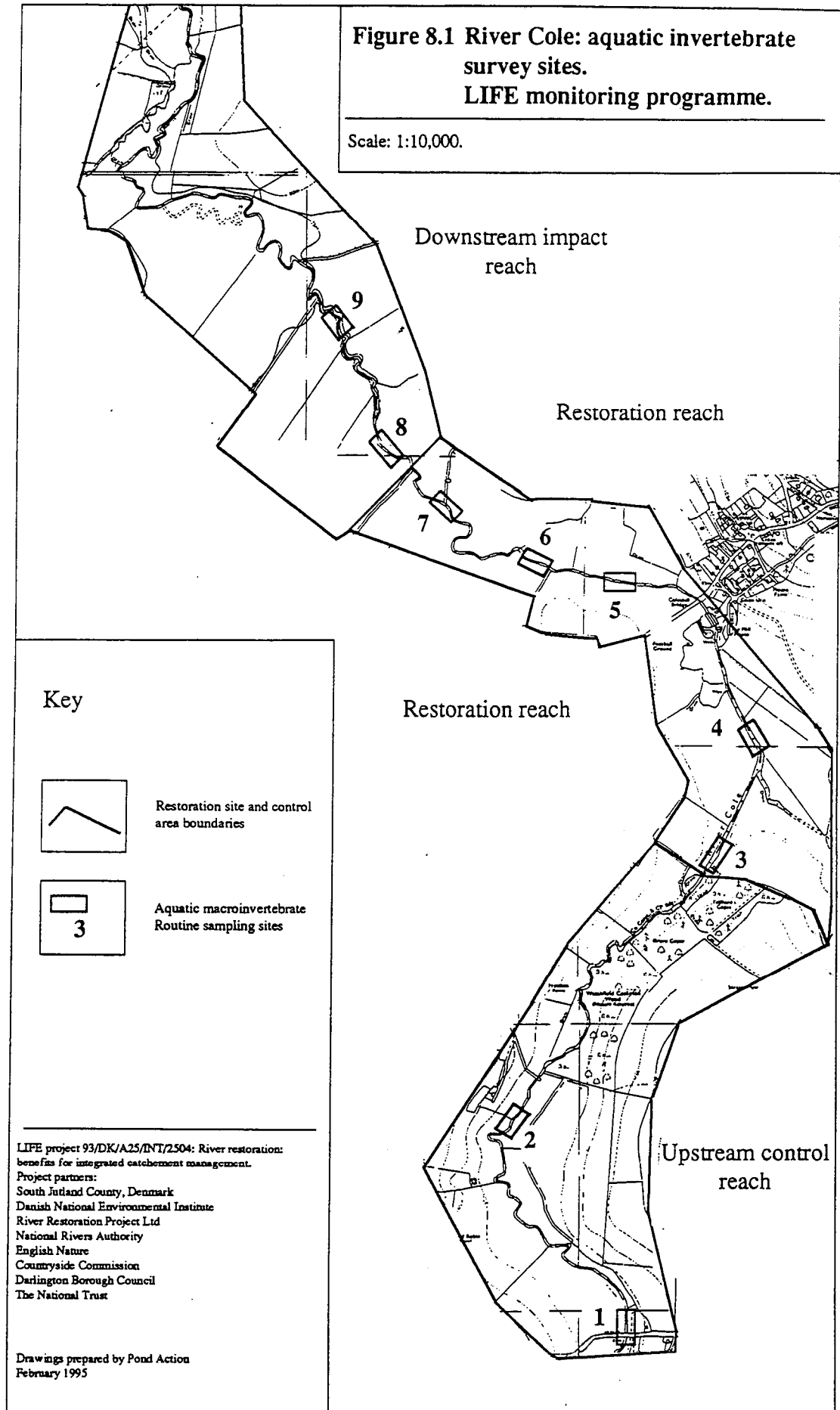
The sampling strategy was designed in order to allow:

- (i) assessment of conservation value using species-level data.
- (ii) the calculation of BMWP and ASPT scores.
- (iii) replicated sampling to describe changes in species-richness and community structure in a statistically meaningful way

All the three-minute samples were taken by the same surveyor, Mericia Whitfield, in order to minimise bias or variation of skill and/or effort. Each sub-sample was placed separately in a plastic bag, labelled, and returned to the laboratory for sorting and species-level identification.

**Figure 8.1 River Cole: aquatic invertebrate  
survey sites.  
LIFE monitoring programme.**

Scale: 1:10,000.



### Laboratory processing of samples

Samples were sorted 'live' as soon as possible after return from the field, and sorting was exhaustive: i.e. all specimens found were removed and preserved in 70% industrial methylated spirits. (In a very few cases, where numbers were unmanageable - e.g. elmids beetles or very small mayflies in some samples - a representative proportion of specimens was removed for identification.) Exhaustive sorting is preferred for conservation-related work because of the need to be certain that all species (as opposed to, for example, families) have been extracted from samples.

Macroinvertebrates were, with a few exceptions, identified to species-level<sup>1</sup>. Specimens were identified by Mericia Whitfield.

Further macroinvertebrate surveys of the nine lengths using this methodology were carried out in the autumn (November 1994): identification and cataloguing of these autumn samples is not yet complete.

### The 'bug-hunt' surveys

Further macroinvertebrate surveys, using an alternative methodology ('bug-hunting'), were carried out on 31st May 1994. These surveys, unlike the three-minute samples, were all carried out within the projected river restoration area, but also included sites which were not part of the Cole itself. The 11 sites 'bug-hunted' were:

- six sections of the river (see Figure 8.2);
- two ditches and a 'bypass' flowing into it;
- the Mill House weir and mill-pond;
- small temporary grazing meadow ponds.

### 'Bug-hunting' methodology

Each of the 11 'bug-hunt' sites was searched, with a net and by hand, paying attention to all microhabitats present, for one hour. As far as possible, macroinvertebrates found were identified by eye, recorded and returned to the water. Specimens requiring microscopic examination for accurate species-level identification, however, were preserved in 70% IMS and returned to the laboratory. As before, most specimens were identified to species-level. The 'bug-hunts' were carried out by Mericia Whitfield and Dave Walker.

A composite list, showing all species recorded in each reach during both the 'bug-hunts' and the three-minute samples is given in Table 8.1. See Box 1 for a more detailed description of both sampling methodologies used.

### Survey programme in subsequent years

In Year One, nine reaches were sampled (four within the restoration section, two above it, and three below). In Year Two, whilst the new channel is colonising, samples will be taken from the two upstream and three downstream reaches. In the final year, samples will be taken from the four original reaches in the old channel, from the two upstream and three downstream reaches, and from four reaches within the new channel. Sampling will take place twice in each year.

<sup>1</sup>The following taxa were not identified to species-level: nymphs of Heteroptera, e.g. Corixidae, Gerridae (identified to family-level); Diptera (identified to family-level); larvae of some Coleoptera, e.g. Dryopidae, some Dytiscidae, Gyrinidae (identified to family-level); females of certain Coleoptera, e.g. *Oulimnius*, *Halipus (ruficollis* gp.) (identified to genus); Oligochaeta; Nematoda; Nematomorpha; Hydracarina.

## Box 1. Sampling strategy

### Three-minute samples: selection of sampling areas

A representative 100-metre stretch of each of the nine lengths of the Cole was chosen for sampling. In theory, each stretch was to have been further sub-divided into 'Riffles', 'Banks', 'Runs' and 'Pools'. In practice, at the time of the summer samples this proved to be largely impracticable, since few viable riffles, runs or pools were present (only Reach 7 provided enough of these to form adequate proportions of the sample). The other stretches, therefore, were divided instead into 'A', 'B', 'C', and 'D' ('B' being 'Banks' in each case). Samples from each of these four divisions were further sub-divided into three triplicate sub-samples. The samples from stretches 1 - 6, 8 and 9, therefore, were each divided into sub-samples as follows:

A(i), A(ii) and A(iii);    B(i), B(ii) and B(iii);    C(i), C(ii) and C(iii);    D(i), D(ii) and D(iii).

Reach 7, however, was sub-divided into:

Riffles (i), (ii) and (iii);    Banks (i), (ii) and (iii);    Runs (i), (ii) and (iii);    Pools (i), (ii) and (iii).

### Sampling method

In each 100-metre stretch, 12 15-second sub-samples were taken using a pond-net (three from each 'habitat' as described above), care being taken to keep each entirely separate. Samples were not examined on site, but were placed immediately into a container for laboratory sorting and species-level identification.

### Strengths/advantages of three-minute sampling method using replicate sub-samples

- (i) This strategy is compatible with NRA RIVPACS work, allowing BMWP/ASPT scores to be calculated.
- (ii) The replicate sub-samples allow statistical analysis of species-richness and community structure, and thus enable changes in these to be noted, or comparisons with other sites to be carried out.
- (iii) Species-level identification allows assessments of sites' conservation value to be made.

### Bankside sorting ('bug-hunts')

The 11 'bug-hunt' sites included:

- six river sections within the restoration area of the Cole;
- two ditches and a bypass flowing into it;
- the Mill House weir and millpond;
- small temporary ponds in adjacent grazing meadow.

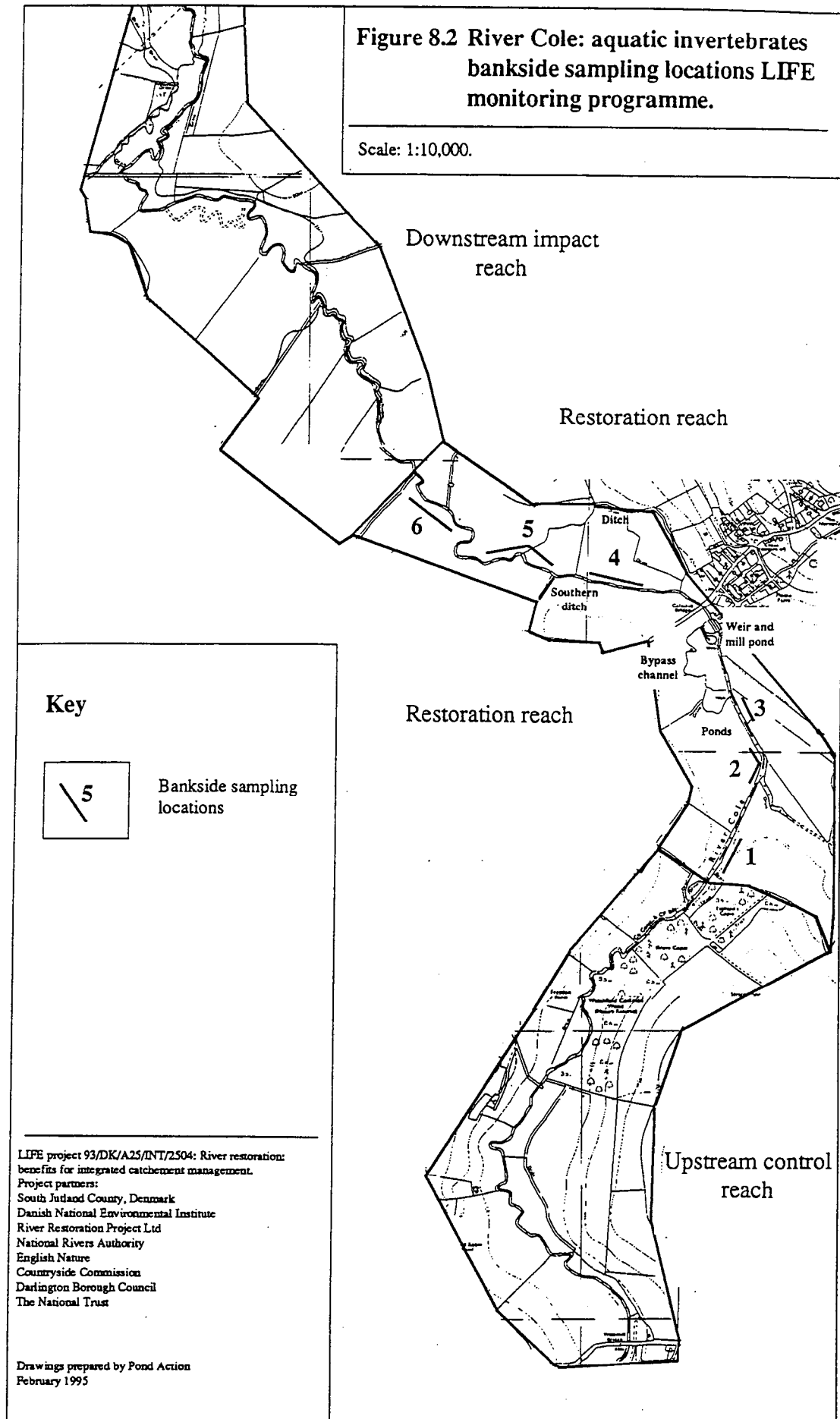
Each of the 'bug-hunt' sites was searched, with a net and by hand, paying attention to all microhabitats present, for one hour, with the object of finding as many of the species present at each site as possible. Macroinvertebrates found were identified by eye where practicable, recorded and returned to the water; specimens requiring microscopic examination for accurate species-level identification were preserved in 70% IMS and returned to the laboratory.

### Strengths/advantages of 'bug-hunting' method

- (i) 'Bug-hunts' allow the surveyor to actively search for specimens, exercising his/her own discretion as to the microhabitats examined and how long is spent on each. It is often, therefore, a superior method for finding species which are extremely active or cryptic, or which may be firmly attached to large submerged objects such as wood or large rocks. (For example, the Nationally Notable B whirligig beetle *Gyrinus urinator* - a very active, fast-moving species which is largely a surface-dweller - was recorded in four out of six river stretches which were 'bug-hunted', but in only two out of nine stretches sampled using the three-minute method. Similarly, the freshwater sponge *Spongilla lacustris* was only recorded at all in one of the 'bug-hunt' stretches, where it was found growing on a large submerged log, although it is undoubtedly present in other stretches since caddis larvae known to be associated with sponges (*Ceraclea albimacula*) were recorded). It is therefore a useful way of adding to species lists obtained by the three-minute sampling method.
- (ii) As with the three-minute method, 'bug-hunting' also provides species-level information which can allow an assessment of a site's conservation value (but not statistical analyses) to be made.

**Figure 8.2 River Cole: aquatic invertebrates  
bankside sampling locations LIFE  
monitoring programme.**

Scale: 1:10,000.



### Assessment of nature conservation value of communities

A National Conservation Index (NCI) was used in order to achieve a relatively objective comparison of the river sampling sites. The NCI (described below), however, is a provisional system which should be regarded as an aid to assessing conservation value, and not as an absolute measure of conservation value without further consideration of all available information.

(i) *All species present are given a numerical value depending on their rarity.*

Common species are given the value 1; local species the value 2; Nationally Notable B species 4; Nationally Notable A species 8; and so on, up to the most endangered species (Red Data Book 1 or RDB1), which are given a value of 64.

(ii) *The values of all the species present are totalled to give a Species Rarity Score or SRS.*

If the communities being assessed were of exactly the same type, then it would be valid to use this score to assess the relative merits of the sites. However, different types of site would be expected to have different species-richness. For example, new sites of high quality would be expected to support less species than more mature sites of a similar quality, and acidic sites of high quality would be expected to support less species than alkaline sites of a similar quality, and so on. However, the average rarity of the species in these sites would usually be expected to be similar, irrespective of species numbers and site type.

(iii) *The SRS is then divided by the number of species present: this gives the Species Rarity Index or SRI.*

The SRI should (in theory) give a good comparison between sites of any type. It should also be relatively independent of sampling effort. However, during this survey SRIs were only calculated from surveys of the main river when using standard sampling methods.

### 8.1.3 Results

Full species lists from all samples - both standard ('three-minute') and bankside ('bug-hunt') - are given in Table 8.3. Notes on the distribution, ecology etc. of notable and local species are given in Table 8.4.

#### Overview of the conservation value of the aquatic macroinvertebrates of the river and floodplain

During the surveys of the Cole undertaken for the RRP, 126 aquatic macroinvertebrate species were recorded (representing approximately 17% of the British list in those groups which were identified to species). Of these, three were Nationally Notable B and 11 are considered to have a localised distribution (see Table 8.4 for definitions of these terms).

Of the nationally notable species, only one, *Gyrinus urinator* (a whirligig beetle), was recorded from the main channel. This species was recorded from main sites 8 and 9 and from 'bug-hunt' sites 2, 3, 4 and 5. (Gyrinid larvae were also recorded from many of the sites surveyed: these were not identifiable to species, but are also likely to have been *urinator*.) This species is therefore likely to be widespread throughout the control, restoration and impact reaches. The other two nationally notable species, *Hydroglyphus pusillus* (a diving beetle) and *Helochaetes lividus* (a water scavenger beetle), were found only in the small temporary pools in the grazing meadow, in the upstream section of the restoration reach. This emphasises the care which will need to be taken in the area adjacent to the river during construction work, and the probable value of any extra diversity in flood regimes on the meadow.

Of the local species recorded during the studies, an alderfly, *Sialis nigripes* is noteworthy: the exact distribution of this species is still not clear, since it has only relatively recently been recognised in Britain (see notes in Table 8.4). A single record of this species was made from main survey site 7, in the downstream section of the restoration reach. (It has since also been recorded in several of the autumn samples, which are still only partially identified, and may well be found in more as the identification work is completed). Also of local interest is the White-legged Damselfly (*Platycnemis pennipes*), which is present, often in abundance, throughout much of the length of the main river.

Overall, the river and its flood plain have a good diversity of species, but none of exceptional rarity. Only one nationally notable species has so far been recorded in the river itself (out of a total of 115 species). The value of off-river sites should also not be overlooked. Though the drain and the southern ditch were both species-poor, they nevertheless supported some species which were not found in the river itself.

### Structure of the macroinvertebrate communities

All the river sites had communities which were rich in snail, mayfly, beetle and caddisfly species. Numbers of snail species in the main survey sites varied between 12 and 19 (between 21% and 38% of the species recorded at those sites). Numbers of mayfly species were less, though still good for the area and the time of year (spring surveys are more valuable for this group), with up to eight species being recorded from sites.

Numbers of beetle species, though variable, tended to be good with up to 16 species (24%) being recorded from any one site: since relatively fast-flowing rivers are not noted, however, for the richness of their water beetle communities it was not surprising that some sites had as few as five beetle species. Caddis flies were also present in good numbers and richness in most sites. Like mayflies, many caddis species are not best recorded during the summer. Nevertheless, numbers in individual main survey sites ranged between five and 17, with all but two sites (the slack reaches 3 and 4) having over ten species. Caddis species contributed up to 33% of the species-richness in some sites.

The technique of 'bug-hunting' tends to be rather selective, and so does not lend itself easily to comparisons of community structure. It was evident, however, that the one true still-water community on the site (the small temporary pools) had a fauna which was markedly different from those in the other sites examined, consisting primarily of beetle species (14 of the 16 species). Eight (half) of the species recorded from the pools (seven beetles and one bug), including two nationally notable species, were found nowhere else on the site.

### Differences between the main survey sites

Table 8.1 shows the cumulative number of species for each site, together with species rarity indices (SRIs), BMWP scores and ASPTs.

In terms of species-richness, the poorest communities tended to occur in the middle of the surveyed area, i.e., around the restoration reach. The poorest communities were found in the slack section in the upstream part of the restoration reach. (sites 3 and 4). The poor species-richness here is almost entirely due to the presence of a lower number of caddis fly species. The two most species-rich sections of the river lie at either end of the surveyed area (sites 1 and 9). The latter is of particular note, as it falls within the downstream impact reach.

**Table 8.1 Macroinvertebrate numbers and indices for main survey sites on the Cole, May to June 1994**

Site	No. of species	SRI	BMWP	ASPT
1	66	1.076	205	5.26
2	52	1.038	195	5.13
3	45	1.111	154	4.97
4	51	1.078	175	5.15
5	56	1.071	202	5.46
6	52	1.096	216	5.54
7	61	1.207	210	5.53
8	63	1.143	228	5.56
9	68	1.147	218	5.32

There are some apparent trends in SRI, with those of the downstream sites 7, 8 and 9 being higher. It is noticeable that site 3, despite low species-richness, has a relatively high SRI. An SRI of 1.00 to 1.20 is provisionally considered to be of moderate nature conservation value, and most of the sites fall into this category. Site 7 has an SRI of 1.207 (partly due to the record of *Sialis nigripes*), and would be considered to be of high value. (Whilst *S. nigripes* has no official status as yet, it has been treated as a Nationally Notable A species for the purpose of the SRI calculation, owing to the uncertainty over its distribution (see Table 8.4).)

BMWP scores show much the same pattern as species numbers, reflecting as they do the richness of clean-water species. The slow-flowing sites 3 and 4 have the lowest BMWP scores and the downstream sites, in general, the highest. ASPTs, too, are lowest in the species-poor slow-flowing sections, with the highest values being found in the downstream sections.

#### Variation within and between the main survey sites

The use of replicate samples allows variation within sites to be compared, and statistical comparisons between sites to be made. Replication also allows comparisons of different habitats (run, riffle, pool and bank) within sites to be made. At the time of survey, however (before restoration), only banks and runs were consistently present, so only this comparison can be made. Average numbers of species and averages for SRI, BMWP and ASPT, together with their standard deviations, are shown in table 8.2.

**Table 8.2 Average species numbers and indices for replicate samples from main survey sites on the Cole, May-June 94**

Site	No. of species	SRI	BMWP	ASPT
1	21.5 ± 4.8	1.026 ± 0.050	104.3 ± 16.0	4.94 ± 0.25
2	22.6 ± 6.3	1.020 ± 0.026	108.4 ± 22.4	5.07 ± 0.29
3	11.3 ± 6.8	1.024 ± 0.047	56.6 ± 23.4	4.58 ± 0.44
4	16.8 ± 6.4	1.022 ± 0.046	68.8 ± 19.1	4.43 ± 0.30
5	18.0 ± 4.9	1.019 ± 0.054	101.3 ± 23.7	5.51 ± 0.49
6	21.8 ± 3.2	1.035 ± 0.055	109.1 ± 16.0	5.52 ± 0.45
7	21.9 ± 7.4	1.132 ± 0.125	112.1 ± 26.0	5.57 ± 0.37
8	24.3 ± 4.8	1.109 ± 0.070	129.9 ± 20.5	5.63 ± 0.27
9	23.2 ± 6.9	1.081 ± 0.063	116.4 ± 23.7	5.25 ± 0.32

In one-way analysis of variances, all macroinvertebrate indices (species numbers, SRI etc.) test positively for there being differences between the sites ( $p < 0.0001$ ). Differences between sites in terms of average species numbers and BMWP are more pronounced than when using cumulative data. This suggests that in some of the more species-poor sites one or two areas of rich habitat are having a large effect on the final number of species seen there. In general, the averages from the replicates reflect the cumulative totals, but it is notable that this is not always the case. Site 2, for example, which had low total species-richness, has the third highest average species-richness. In general, however, the middle sites were, once again, the lowest in species-richness and BMWP score. Results for SRI and ASPT are also similar to those seen with cumulative data, with the downstream four sites and site 3 having higher SRIs, and sites 2 to 4 the lowest ASPTs.

In one-way analyses of variance to test the difference between habitats (i.e. bank/'not bank') there are significant differences only for species-richness ( $p < 0.002$ ), with more species on average (23.6) being recorded from the bank compared to other habitats (19.0). The difference for SRI is almost significant ( $p < 0.1$ ), with an average SRI for bank habitats of 1.075 compared to an average of 1.044 for other habitats. BMWP is higher in bank habitats, though this is not at all significant. ASPT is lower in bank habitats (5.02 compared to 5.21), reflecting the more strictly lentic nature of many of the higher scoring BMWP families.

In two-way analyses of variance (site/habitat), there are highly significant differences between sites ( $p < 0.001$ ). The relationships between bank and no. of species, SRI and ASPT noted above are all significant ( $p < 0.0001$  for no. of species;  $p < 0.05$  for SRI;  $p < 0.02$  for ASPT).

#### **Future surveys**

The level of variation seen in the replicates so far allows a calculation of the power of future analyses and an estimation of the magnitude of change which would be necessary before a difference (before and after restoration) was statistically observable.

Assuming that the replicates are treated randomly (i.e. site and habitat ignored), then if the real average species increase (or decrease) across all replicate samples were 2.5 there would be an 80% chance of proving this statistically at the 95% level. If the true change were 3 species, there would be a 95% chance of proving this statistically at the 95% confidence level. So we can be almost certain of detecting a 15% change in invertebrate species-richness. This analysis ignores the fact that some of the variation in the samples can be explained by habitat. The real power of any future analysis should, therefore, be higher than this.

**Table 8.3**                      **Macroinvertebrate species recorded from Coleshill:  
summer 1994**

**KEY**    S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
          B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
          BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>GASTROPODA</b>																				
<b>Neritidae</b>																				
<i>Theodoxus fluviatilis</i>	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-	-	-	-	-	-
<b>Valvatidae</b>																				
<i>Valvata cristata</i>	-	+	+	+	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-
<i>Valvata piscinalis</i>	+	+	+	+	+	+	+	+	+	-	-	+	-	-	+	+	-	-	-	-
<b>Hydrobiidae</b>																				
<i>Potamopyrgus jenkinsi</i>	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-
<b>Bithyniidae</b>																				
<i>Bithynia leachi</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	-	+	-	-	-	-	-
<i>Bithynia tentaculata</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	-	-	-
<b>Physidae</b>																				
<i>Physa acuta</i>	+	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Physa fontinalis</i>	+	-	+	+	-	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-
<b>Lymnaeidae</b>																				
<i>Lymnaea auricularia</i>	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Lymnaea palustris</i>	+	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
<i>Lymnaea peregra</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	-	+	-	-
<i>Lymnaea stagnalis</i>	+	+	-	+	+	-	+	+	+	-	+	+	-	-	+	-	-	-	-	-
<i>Lymnaea truncatula</i>	-	+	+	-	-	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-
<b>Planorbidae</b>																				
<i>Planorbis carinatus</i>	-	+	+	+	+	-	+	-	-	-	-	+	+	-	-	+	-	-	-	-
<i>Anisus vortex</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	-	-	-
<i>Bathymphalus contortus</i>	+	+	+	+	+	+	+	+	-	-	+	+	-	-	-	-	-	-	-	-
<i>Gyraulus albus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-
<i>Armiger crista</i>	+	+	+	+	+	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-
<b>Ancylidae</b>																				
<i>Ancylus fluviatilis</i>	+	+	+	+	+	+	+	+	+	+	-	-	-	+	+	-	-	-	-	-
<b>Acroloxidae</b>																				
<i>Acroloxus lacustris</i>	+	+	+	+	+	+	+	+	+	-	+	+	-	-	+	+	-	-	-	-
<b>BIVALVIA</b>																				
<b>Unionidae</b>																				
<i>Unio tumidus</i>	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Anodonta anatina</i>	+	+	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>Sphaeriidae</b>																				
<i>Sphaerium corneum</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	-	-	-
<i>Sphaerium rivicola</i>	-	-	+	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-

Table 8.3  
(continued)Macroinvertebrate species recorded from Coleshill:  
summer 1994

KEY S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>OLIGOCHAETA</b>	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>HIRUDINEA</b>																				
<b>Piscicolidae</b>																				
<i>Piscicola geometra</i>	+	+	-	-	+	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-
<b>Glossiphoniidae</b>																				
<i>Theromyzon tessulatum</i>	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-
<i>Hemiclepsis marginata</i>	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Glossiphonia complanata</i>	+	+	+	+	+	+	+	+	+	-	-	+	+	+	-	-	+	-	-	-
<i>Glossiphonia heteroclita</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Helobdella stagnalis</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<b>Erpobdellidae</b>																				
<i>Erpobdella octoculata</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-
<i>Erpobdella octoculata cocoon</i>	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Erpobdella testacea</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Trocheta subviridis</i>	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	-	-
<b>MALACOSTRACA</b>																				
<b>Asellidae</b>																				
<i>Asellus aquaticus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-
<i>Asellus meridianus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<b>Crangonyctidae</b>																				
<i>Crangonyx pseudogracilis</i>	+	-	+	+	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
<b>Gammaridae</b>																				
<i>Gammarus pulex</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+
<b>EPHEMEROPTERA</b>																				
<b>Baetidae</b>																				
<i>Baetis fuscatus</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Baetis rhodani</i>	+	+	+	-	+	+	+	+	+	+	-	-	+	+	+	+	-	-	-	+
<i>Baetis scambus</i>	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Baetis vernus</i>	+	-	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+
<i>Centroptilum luteolum</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cloeon dipterum</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Leptophlebiidae</b>																				
<i>Habrophlebia fusca</i>	+	+	-	+	+	+	+	+	+	-	-	-	+	+	+	-	-	-	-	-
<b>Ephemeridae</b>																				
<i>Ephemera vulgata</i>	+	-	-	-	+	+	+	+	+	-	-	-	+	+	+	-	-	-	-	-
<b>Ephemerellidae</b>																				
<i>Ephemerella ignita</i>	+	+	+	+	+	+	+	+	+	+	-	-	-	-	+	+	-	-	-	+

**Table 8.3**  
(continued)

**Macroinvertebrate species recorded from Coleshill:**  
**summer 1994**

**KEY** S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>EPHEMEROPTERA (continued)</b>																				
<b>Caenidae</b>																				
<i>Caenis horaria</i>	-	+	-	+	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Caenis luctuosa</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
<b>PLECOPTERA</b>																				
<b>Nemouridae</b>																				
<i>Nemoura cinerea</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<b>ODONATA</b>																				
<b>Platycnemididae</b>																				
<i>Platycnemis pennipes</i>	+	-	+	+	-	+	+	+	+	-	+	-	+	+	+	-	-	-	-	-
<b>Coenagrionidae</b>																				
<i>Coenagrionidae (indet.)</i>	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Ischnura elegans</i>	+	+	+	+	+	-	+	+	+	-	+	+	-	+	+	+	-	-	-	-
<b>Calopterygidae</b>																				
<i>Calopteryx splendens</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+
<b>HETEROPTERA</b>																				
<b>Hydrometridae</b>																				
<i>Hydrometra stagnorum</i>	-	-	-	-	-	-	-	-	-	+	-	+	-	-	+	-	-	-	-	-
<b>Veliidae</b>																				
<i>Velia caprai</i>	+	+	-	-	-	-	-	-	+	+	+	+	+	-	-	+	+	+	-	-
<i>Velia sp. nymph</i>	+	+	+	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>Gerridae</b>																				
<i>Gerris lacustris</i>	+	-	-	+	-	-	-	-	-	+	-	-	+	+	+	+	-	-	+	-
<i>Gerris nymph</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Nepidae</b>																				
<i>Nepa cinerea</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Notonectidae</b>																				
<i>Notonecta glauca</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Corixidae</b>																				
<i>Micronecta sp. nymph</i>	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Corixa punctata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Corixid nymph</i>	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Hesperocorixa linnei</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hesperocorixa sahlbergi</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Sigara dorsalis</i>	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	-	-	-	-	-
<i>Sigara falleni</i>	-	-	-	+	+	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-
<i>Sigara fossarum</i>	-	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-

**Table 8.3**  
(continued)

**Macroinvertebrate species recorded from Coleshill:  
summer 1994**

**KEY** S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>COLEOPTERA</b>																				
<b>Halipilidae</b>																				
<i>Haliplus flavicollis</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Haliplus fluviatilis</i>	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
<i>Haliplus lineatocollis</i>	-	+	+	+	+	-	+	-	+	-	-	+	-	-	-	+	-	-	-	-
<i>Haliplus ruficollis</i> gp female	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Haliplus wehnckei</i>	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
<b>Dytiscidae</b>																				
<i>Laccophilus minutus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Hyphodrus ovatus</i>	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Hydroglyphus pusillus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Hydroporus planus</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Hydroporus tessellatus</i>	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Nebrioporus depressus</i> (elegans)	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	-	+	-	+
<i>Stictotarsus duodecimpustulatus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Platambus maculatus</i>	+	+	+	-	+	+	+	+	+	-	-	+	+	+	+	+	-	-	-	-
<i>Agabus bipustulatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Agabus nebulosus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Ilybius fuliginosus</i>	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-	-	+	-
<i>Ilybius quadriguttatus</i>	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-
<i>Dytiscid larva</i>	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>Gyrinidae</b>																				
<i>Gyrinus urinator</i>	-	-	-	-	-	-	-	+	+	-	+	-	+	+	+	-	-	-	-	-
<i>Gyrinid larva</i>	-	+	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>Hydrophilidae</b>																				
<i>Hydrophilid larva</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Anacaena globulus</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Anacaena limbata</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Laccobius minutus</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Laccobius bipunctatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Helochaes lividus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Helophorus aequalis</i>	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-
<i>Helophorus grandis</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
<i>Helophorus brevipalpis</i>	+	+	-	-	-	-	+	+	+	-	-	+	+	-	-	-	-	-	+	-
<i>Helophorus granularis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Helophorus minutus</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-
<i>Helophorus obscurus</i>	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<b>Hydraenidae</b>																				
<i>Ochthebius dilatatus</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Hydraena riparia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<b>Dryopidae</b>																				
<i>Dryopid larva</i>	-	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-

Table 8.3  
(continued)Macroinvertebrate species recorded from Coleshill:  
summer 1994

KEY S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>COLEOPTERA (continued)</b>																				
<b>Elmidae</b>																				
<i>Elmis aenea</i>	+	+	+	-	+	+	+	+	+	+	-	-	-	+	+	-	-	-	-	+
<i>Elmis aenea larva</i>	+	+	-	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Limnius volckmari</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Oulimnius tuberculatus</i>	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	-	-	-	-	-
<i>Oulimnius sp. (adult female)</i>	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>MEGALOPTERA</b>																				
<b>Sialidae</b>																				
<i>Sialis fuliginosa</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sialis lutaria</i>	+	+	-	+	-	+	+	+	+	-	-	+	+	+	-	-	-	-	-	-
<i>Sialis nigripes</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>TRICHOPTERA</b>																				
<b>Rhyacophilidae</b>																				
<i>Rhyacophila dorsalis</i>	+	+	-	-	+	+	+	+	+	-	-	-	-	+	-	-	+	-	-	-
<i>Rhyacophilidae pupae</i>	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Hydroptilidae</b>																				
<i>Hydroptilidae (indet)</i>	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>Psychomyiidae</b>																				
<i>Lype reducta</i>	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Tinodes waeneri</i>	-	+	-	-	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-
<b>Polycentropodidae</b>																				
<i>Cyrnus trimaculatus</i>	-	-	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Plectrocnemia conspersa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-
<i>Polycentropus flavomaculatus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Hydropsychidae</b>																				
<i>Hydropsyche angustipennis</i>	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Hydropsyche contubernalis</i>	+	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Hydropsyche instabilis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hydropsyche pellucidula</i>	-	-	-	-	+	+	+	+	+	-	-	-	+	+	-	-	+	-	-	-
<i>Hydropsyche siltalai</i>	+	+	-	-	+	+	+	-	+	+	-	+	-	+	-	-	+	-	-	-
<i>Hydropsychidae indet.</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hydropsychidae pupae</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Limnephilidae</b>																				
<i>Limnephilidae (indet)</i>	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Halesus digitatus</i>	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Halesus radiatus</i>	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-	-	-
<i>Potamophylax rotundipennis</i>	-	+	-	-	+	+	+	-	+	-	-	-	+	-	-	-	-	-	-	-
<i>Anabolia nervosa</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-	-	-	-	+
<i>Limnephilus lunatus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+

Table 8.3  
(continued)Macroinvertebrate species recorded from Coleshill:  
summer 1994

KEY S1 to S9 =main channel standard survey sites (1-9) - see Figure 8.1;  
B1 to B6 =main channel bug hunt sites (1-6); BW = weir and mill pond;  
BS = southern ditch; BD = drain; BP = temporary pools; BB = bypass cahnnel

	S1	S2	S3	S4	S5	S6	S7	S8	S9	BI	B2	B3	B4	B5	B6	BW	BS	BD	BP	BB
<b>TRICHOPTERA (continued)</b>																				
<b>Goeridae</b>																				
<i>Goeridae pupae</i>	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Goera pilosa</i>	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<b>Sericostomatidae</b>																				
<i>Sericostoma personatum</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Molannidae</b>																				
<i>Molanna angustata</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<b>Leptoceridae</b>																				
<i>Athripsodes aterrimus</i>	+	-	-	-	+	+	-	-	+	-	-	+	-	+	-	+	-	-	-	-
<i>Athripsodes cinereus</i>	+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	-	-	-	-
<i>Ceraclea albimacula</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ceraclea annulicornis</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ceraclea dissimilis</i>	+	+	+	+	+	-	+	+	+	+	+	-	-	-	+	-	-	-	-	-
<i>Mystacides azurea</i>	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Mystacides longicornis</i>	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Mystacides nigra</i>	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>DIPTERA</b>																				
<b>Chironomidae</b>																				
<i>Tipulidae</i>	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Simuliidae</i>	+	+	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<b>SPECIES TOTALS</b>																				
<b>GASTROPODA</b>	17	17	16	19	12	15	15	15	14	4	11	16	9	6	8	9	1	3	0	0
<b>BIVALVIA</b>	2	2	2	2	2	1	2	3	3	0	2	2	1	1	1	1	0	0	0	0
<b>HIRUDINEA</b>	5	3	3	2	4	3	4	6	4	1	2	4	3	2	0	1	3	1	0	0
<b>MALACOSTRCA</b>	3	2	3	3	3	2	2	3	2	1	3	2	2	2	2	2	1	3	0	1
<b>EPHEMEROPTERA</b>	7	6	3	4	7	5	8	8	7	3	2	1	4	4	5	3	0	0	0	3
<b>PLECOPTERA</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<b>ODONATA</b>	3	2	3	3	2	2	3	3	3	1	3	2	2	3	3	2	0	0	0	1
<b>HETEROPTERA</b>	4	2	2	5	2	1	0	3	4	3	3	4	3	2	4	3	1	1	2	0
<b>COLEOPTERA</b>	11	6	8	6	6	5	12	7	16	2	4	7	7	6	7	3	0	2	14	2
<b>MEGALOPTERA</b>	1	1	0	1	1	1	2	1	1	0	0	1	1	1	0	0	0	0	0	0
<b>TRICHOPTERA</b>	13	11	5	6	17	17	13	14	14	7	5	3	5	6	6	4	2	5	0	2
<b>TOTAL</b>	66	52	45	51	56	52	61	63	68	22	35	42	37	33	36	28	8	16	16	9

**Table 8.4 Notes on nationally notable, local and other aquatic macroinvertebrate species recorded from the River Cole, May - June 1994**

**Category definitions**

**Nationally Notable A:** Scarce - recorded in Britain from only 15 - 30 10-km squares of the National Grid.

**Nationally Notable B:** Scarce - recorded in Britain from only 31 - 100 10-km squares of the National Grid.

**Local:** Species not falling into any of the 'RDB' or 'Notable' categories, but usually either (a) confined to certain limited geographical areas within which they may, however, be present in large numbers; (b) of widespread distribution, but present only in small numbers where they occur; or (c) restricted to a very specialised (or perhaps threatened) habitat of which, however, they may be a common component.

Note that some of the species listed below as 'local' are placed in this section because, while they are known to be uncommon, very little information is presently available and they have no 'official' status. Judgement has, where necessary, erred on the side of caution: at least one of these species, *Sialis nigripes*, is almost certainly in reality considerably rarer than the term 'local' would imply.

**Note:** A short section containing notes on species which are not sufficiently scarce to be categorised as 'local', but which are nevertheless of some interest in the context of this report is appended to this table. References throughout to 'Britain' denote mainland Britain, and do not include Ireland.

**Nationally Notable B species**

*Gyrinus urinator* (COLEOPTERA: Gyrinidae). A whirligig beetle.

Scarce: almost completely limited to the extreme south coast of England, but there are a few scattered isolated records in N. Wales, Cheshire and Yorkshire. (The nearest record on the distribution map appears to be in Hampshire; however, Pond Action did record this species at Pinkhill Meadow in Oxfordshire, where it may have arrived from the river alongside.) A species of lowland running water. (Foster, 1985; Friday, 1988; Pond Action, 1995.)

It was recorded, in the Cole, in lengths 8 and 9 (three-minute samples) and in the 'bug-hunt' lengths 2, 4, 5 and 6. This was by far the most widespread Notable species recorded, but it is interesting that it was recorded in four out of six 'bug-hunt' sites, but in only two out of nine of the three-minute-sampled stretches. It is probable that this is due to the extremely swift swimming-in-circles behaviour characteristic of this beetle (hence its English name), coupled with its ability to vanish very effectively when disturbed, making it a species which is far more likely to be found when actively looked for, rather than by means of a formal general sampling technique. (See notes on sampling in Table 8.4.)

*Helochaeres lividus* (COLEOPTERA: Hydrophilidae). A water scavenger beetle.

Typically found in ponds with some aquatic plant cover. More likely to occur in the south-east than in other parts of Britain (appearing fairly common in Oxfordshire), and apparently absent altogether from Scotland. (The species may well, however, have been under-recorded in the past, since it is by no means always easy to distinguish from the equally scarce *H. punctatus*, and both species do on occasion occur together.) (Friday, 1988; Pond Action, 1994 and unpublished observations.)

During this survey, this species was recorded only during the 'bug-hunt', in the temporary ponds in the grazing meadow near the river, and it is indeed a species one would expect to find in a grassy, shallow and stagnant pond rather than in running water.

(continued)

**Nationally Notable B species (continued)*****Hydroglyphus pusillus* (COLEOPTERA: Dytiscidae). A diving beetle.**

Locally distributed in the south of England and the Midlands. The preferred habitat of this species is said to be heath pools, mossy ditches, and new, man-made ponds, where it is often one of the earliest colonisers (as it in fact was at Pinkhill Meadow in Oxfordshire). At the present time, though, this species appears to be fairly common - and perhaps even on the increase, at least in Oxfordshire, where in recent years it has been recorded from a wide variety of different types of water body, from rivers, streams and ditches to lakes and ponds. (Foster, 1981; Friday, 1988; Pond Action, 1994, 1995 and unpublished data.)

During the Cole survey work, this species, like the above, was again recorded only during the 'bug-hunt', in the temporary ponds in grazing meadow. Notwithstanding its current apparent lack of fussiness regarding habitat, its presence in such a shallow, grassy, stagnant water-body is particularly characteristic of the species.

**Local species*****Erpobdella testacea* (HIRUDINEA: Heteroptera.) A leech.**

This leech is restricted to England and Wales, where it is widespread but rather uncommon. Typically found in small, poorly-oxygenated and overgrown ponds, though it may occasionally be found in stagnant, overgrown sections of rivers. It appears to be tolerant of organically polluted habitats. A carnivore which devours whole oligochaetes, Cladocera, insect larvae and rotifers. (Elliott and Mann, 1979; Elliott and Tullett, 1982.)

It is interesting that this leech, so typical of relatively anaerobic, stagnant environments, was recorded from stretch 9 of the Cole. It presumably came from a part of the sample which was netted in a slow-flowing, perhaps silted-up area. *Erpobdella octoculata* and *Trocheta subviridis*, as would be expected in a river, were far more widespread erpobdellids in this survey.

***Glossiphonia heteroclita* (HIRUDINEA: Glossiphoniidae). A leech.**

A predator of molluscs, oligochaetes and insect larvae which is found chiefly in lakes, ditches and ponds, but also among the marginal vegetation of slow-flowing streams and rivers (but apparently never occurring in fast-flowing waters). Widespread, but local and uncommon in most of Britain, but apparently completely absent from the northern part of Scotland. Known hosts for this species include Ancyliidae, *Bithynia tentaculata*, *Lymnaea* spp. and *Physa fontinalis*. (Elliott and Mann, 1979; Elliott and Tullett, 1982.)

This leech was recorded in only one sample: the 'bug-hunt' stretch 2. Again, it may be a species which (since like other glossiphoniids it attaches itself very firmly to the substratum or to vegetation, and since it is very small, and due to its yellow colouring tends to be very effectively camouflaged) is more likely to be found in a 'bug-hunt' than a more formal three-minute sample. However, this stretch was particularly slow-flowing and contained many species more characteristic of ponds than rivers. Note, also, that the known hosts for the species (listed above) were all available in this stretch of river.

***Hemiclepsis marginata* (HIRUDINEA: Glossiphoniidae). A leech.**

A sanguivorous ectoparasite of amphibian larvae and fish, occurring in almost all types of freshwater, and often thriving in stagnant, weedy ponds where the more common fish leech, *Piscicola geometra*, is absent. Little is known as yet, however, about its life-cycle. Widespread distribution throughout Britain, but it is rather uncommon. (Elliott and Mann, 1979; Elliott and Tullett, 1982.)

In this survey, this species was recorded in two of the main survey stretches (stretches 3 and 8), and these were, in general, more slow-flowing than the more central stretches.

(continued)

**Local species (continued)**

*Sphaerium rivicola* (BIVALVIA: Sphaeriidae). A freshwater cockle or orb mussel.

This is the largest *Sphaerium* species in Britain, and very recognisable because of its characteristic pronounced concentric ridges. Usually found in slowly-flowing rivers and canals, being fairly generally distributed in central and southern England as far north as Yorkshire, but in no other part of Britain with the exception of a small number of records from north-east Wales, near the English border. (Ellis, 1978; Kerney, 1976.)

In the River Cole, *S. rivicola* was recorded in two stretches of the three-minute survey (3 and 4), and two of the 'bug-hunt' stretches (2 and 3). These stretches, in fact, largely coincide, either overlapping or lying adjacent to each other. Moreover, they are indeed the more slow-flowing areas of the river.

*Platynemis pennipes* (ODONATA: Zygoptera: Libellulidae). The White-legged Damselfly.

Locally common where it occurs in southern England and the Midlands, though it is said to be apparently 'susceptible to even slight pollution' (Hammond). It breeds in weedy streams, rivers, and seepages bordering streams, where adults have a noticeable preference for sites where there is abundant vegetation, frequently flying in company with *Calopteryx splendens*. They do not sustain flight for long, but rest frequently on plants - both sexes are distinctive for their fluttering style of flight, and also for the very noticeable expanded, white-coloured hind tibia. Adults' flight is between May and September. (Hammond and Gardner, 1983; d'Aguilar, Dommanget and Préchac, 1986.)

This damselfly was by far the most widespread of all the Notable and local species in any of the summer samples: indeed, it was among the most widely-distributed of any species in the River Cole, including the common ones, occurring in seven of the nine three-minute-sampled stretches, and also in four of the six river stretches that were 'bug-hunted', so that it is clearly breeding very successfully in the Cole. During the summer sampling visits (May - June), large numbers of adults were also observed emerging, mating, and on the wing up and down the river banks and among the marginal vegetation, behaving very much as described above.

*Sialis fuliginosa* (MEGALOPTERA: Sialidae). An alder fly.

It is of great interest that all three species of *Sialis* known from Britain (including the following, *Sialis nigripes*, which until recently was not known to be present in Britain at all) were recorded in the Cole, albeit never all together in any one stretch. It is sufficiently remarkable, however, that all three were present in one relatively short stretch of river. *Sialis* spp. adults apparently all lay their eggs on silt, sometimes at considerable depth, before climbing out to pupate among leaves on land. However (although information on the two less common species is lacking), it appears that each of the three have more-or-less precise requirements in the type of vegetation they require upon which to lay their egg-masses: hence, perhaps, their differing distribution within the Cole (since the larvae, naturally, will tend to be found near the place where they dropped into the water).

*Sialis lutaria*, the commonest of the three species, lays its eggs on stems and leaves of emergent vegetation (but also, occasionally, on stones, tree-trunks and bridges). However, *S. fuliginosa* apparently always lays its eggs on the leaves of deciduous trees, always 3 - 5m above the water surface. Unlike *lutaria* again, which is found in almost all types of fresh water, *fuliginosa* appears to be limited to moderately fast streams and the upper reaches of rivers. Unfortunately, very little beyond this is known about the species: the larvae are, however, known to be very active predators, hunting and devouring mainly chironomids and stonefly nymphs. The species' distribution is not fully known, but there have been records in south-west England (Dartmoor) and in the Lake District. It is likely to be perhaps slightly less uncommon than is generally thought. (Elliott, 1977.)

In the Cole, *S. fuliginosa* was recorded in one stretch only in the summer samples: stretch 5 (three-minute samples) - this was indeed a stretch which was lined with trees, and very shaded. A clearer picture of the distribution of all three *Sialis* species in the Cole will be gained when identification of the autumn samples is completed (see remarks in following paragraphs).

**Local species (continued)*****Sialis nigripes* (MEGALOPTERA: Sialidae). An alder fly.**

This *Sialis* is almost certainly far less common than the previous species, possibly meriting a more 'exclusive' ranking than Local; however, its abundance and distribution are still so poorly-known that it has not, as yet, been

allocated any status at all. The situation regarding this species, however, is extremely interesting, since it was only recognised as part of the British fauna at the end of the 1970's when, by chance, a specimen mistakenly identified as *fuliginosa* was sent to Barnard for confirmation, and recognised as *nigripes* - a far more interesting record since it had been hitherto unknown in this country. (Unfortunately, the same year a new key to *Sialis*, only covering the first two species, had just been published - naturally, this was instantaneously discarded as useless!) Subsequently, specimens at the British Museum (Natural History) were carefully examined and a number were found to be misidentified *S. nigripes*, the earliest of these being dated 1867, showing that the species, if an immigrant at all, was certainly not a recent one.

At any rate, distribution is still not known, but specimens so far recorded suggest a southern England distribution pattern. The species may prefer large open rivers, but this is not known for certain either. It appears from foreign studies that egg-laying in this species takes place exclusively on dead emergent plant stems extending above the water surface (e.g. *Scirpus*), and such plant stands would also therefore constitute the larval habitat. (Barnard, 1977; Elliott, O'Connor and O'Connor, 1979.)

In the Cole, this *Sialis* species, like the above, was recorded during the summer in one stretch only: stretch 7. (*Sialis lutaria* was also recorded in this stretch, although not in stretch 5.) (Since beginning identification of the autumn samples, however, specimens of this species have been found in other stretches: it is clear that *S. nigripes* is by no means limited to stretch 7. A clearer picture of its distribution in the study section of the Cole will be available when identification of this second batch of samples is completed.)

***Ceraclea albimacula* (TRICHOPTERA: Leptoceridae) A caddis fly.**

Locally distributed throughout Britain, but with only a few records from Scotland. Larvae of this species are never abundant where they occur. Found in rivers, streams and canals, where the larva feeds upon freshwater sponges. (Wallace, 1990 and 1991.)

This caddis species was recorded in the Cole in length 8 of the three-minute samples. Although no sponges were recorded from this length, *Spongilla lacustris* was recorded in stretch 6 of the 'bug-hunt' - just upstream from this stretch, and sponges are almost certainly present here as well - they are notoriously difficult to take in a timed netted sample, but much easier to find in a 'bug-hunt'.

***Mystacides nigra* (TRICHOPTERA: Leptoceridae). A caddis fly.**

Found throughout England and Wales, but there is always a very small number of records from each area, and there are hardly any in Scotland. (It is just possible, according to Wallace, that the species might be somewhat under-recorded due to its short flight period compared to the other *Mystacides* species, but he believes it to be genuinely uncommon.) In streams, rivers, lakes and canals, on a variety of substrates including stony areas, tree-roots, etc. (but not usually on mud). Often occurs together with one or both of the other *Mystacides* species, but usually in much smaller numbers. (Wallace, 1990 and 1991.)

*Mystacides nigra* was recorded only in stretches 1 and 7 of the three-minute samples: as suggested by Wallace, the three *Mystacides* species were indeed all present in the surveyed portion of the Cole, but the common *M. longicornis* was far more abundant - *nigra* appeared to be limited in distribution to these two pockets.

***Potamophylax rotundipennis* (TRICHOPTERA: Limnephilidae). A caddis fly.**

Very local and probably only in England (there is one single record from Scotland, but it is very old). In streams and small rivers with a sandy bottom, or a sandy substratum with stones. Usually found as one or two specimens only. (Wallace 1990 and 1991.)

(continued)

**Local species : *Potamophylax rotundipennis* (continued)**

This species was (along with *Gyrinus urinator*) the second most widespread in this survey of all Notable or local species, being recorded in six stretches sampled (stretches 1, 5, 6, 7, and 9 of the three-minute samples, and stretch 4 of the 'bug-hunt'). It was, however, as described by Wallace, almost invariably found in very small numbers, mainly in ones and twos, among larger numbers of more common limnephilids such as *Halesus* spp. or *Anabolia nervosa*.

***Helophorus granularis* (COLEOPTERA: Hydrophilidae). A water scavenger beetle.**

A very tiny *Helophorus* species, typically preferring shallow, grassy ponds. Widespread, but very local in distribution. Although not frequently found, when it does occur it may do so in considerable abundance, often sharing its habitat with large numbers of *Helophorus* of one or more different species. (Friday, 1988; Pond Action, unpublished observations.)

Found here during the 'bug-hunt' in the temporary ponds in the grazing meadow - exactly the type of habitat where one would expect to find it- the species was indeed sharing its habitat with other *Helophorus* species, since, in all, six were recorded in this very small area, ranging from the biggest (*H. grandis*) to this, the smallest of Helophorinae.

**Other species of interest*****Trocheta subviridis* (HIRUDINEA: Erpobdellidae). A leech.**

This species, which is certainly not scarce enough to be local (although it is described as 'widespread but not common'), is nevertheless mentioned here because it has appeared somewhat more common in rivers in recent years than used to be the case. Like *Erpobdella octoculata*, it is a carnivore rather than a sanguivore, feeding on aquatic and terrestrial invertebrates and occasionally also on carrion. It is found in ditches, drains, sewers, streams and rivers, tolerating very high levels of organic pollution. (It is often abundant in sewage effluent channels, and is said to occasionally turn up in toilet bowls!) The young leeches stay in the water for their first year, but adults are amphibious and they usually leave the water, burrowing into the soil. However, they return to the water to breed between June and September. The species is widespread throughout England and Wales, and in Scotland there are a few records arranged in a line between Edinburgh and Glasgow. (Elliott and Mann, 1979; Elliott and Tullett, 1982.)

In the River Cole, *Trocheta subviridis* was recorded in three lengths of the three-minute samples: 1, 5, and 7. If this species is indeed becoming more common in rivers in recent years, it may indicate a rather widespread reduction in water quality. However, it is possible that mis-identifications occurred in the past, since the species (to the naked eye) bears a very strong resemblance to *Erpobdella*, especially *testacea*, looking particularly like the specimen of the latter species illustrated in the colour plate in the FBA leech key (where, moreover, *Trocheta subviridis* itself is not illustrated). In addition, of course, it is worth pointing out that the time when the summer surveys took place coincides with the season when adult *Trocheta* are returning to the water to breed, so that there would probably be a steep rise in the population numbers in the water around this time.

## 8.2 Semi-terrestrial invertebrates (special study in the River Cole)

### 8.2.1 Aims

Where possible, within time and budget, the aim of the monitoring programme is:

To estimate the change in the species-richness and conservation value of the terrestrial macroinvertebrate fauna in the years following restoration. Conservation value will be assessed in terms of average species rarity.

### 8.2.2 Methods

#### Pitfall trapping

Pitfall trapping began in autumn 1994, when 100 pitfall traps (0.375litre storage jars, 'Clear 1126', from The Stewart Company, Croydon) were set: 60 in the restoration reach, and 40 in the downstream impact reach. Placement of the traps was in nests of five, in areas chosen to represent different distinct habitats. In practice, sites were chosen so that two habitat types could be represented in the same location, e.g. bank top and bank bottom. Within habitats, the traps were placed with five metres separating any two traps.

**Table 8.5 Location of pitfall traps on floodplain of the Cole**

Habitats represented	Section	NGR
Shallow bank near bank bottom & Shallow bank near bank top	Restoration, upstream	SU2353193156
		SU2356892815
Steep bank near bank bottom & Steep bank near top	Restoration, downstream	SU2332193543
		SU2260593637
	Impact	SU2232093988 SU2223294086
Wet hollows in meadows & Higher ground in meadows	Restoration, upstream	SU2353892980
		SU2345793072
	Impact	SU2222293989 SU2211693938

Traps were filled with a 33% solution of commercially-available antifreeze as a preservative, and were left for four weeks, being checked regularly. At the end of this time, the traps were removed, sealed and returned to the laboratory where the contents were washed (to remove mud), before preservation in 70% industrial methylated spirits.

#### Water traps

In those sites with limited cattle access (the steep bank sites) water traps will be placed at ground level during the summer months. Up to five water traps in nests will be used, in locations similar to those used for the pitfall traps. Collection will be at weekly intervals, to avoid problems with dessication.

**Malaise traps**

Six malaise traps will be placed on obvious flight lines during the summer. Placement will avoid areas used by cattle. Collection will be fortnightly for 12 weeks.

**Identification**

Ideally, the following groups will be identified to species-level:

Coleoptera: Carabidae

Diptera: Sciomyzidae, Stratiomyidae, Dolichopodidae, Tipulidae, (Syrphidae).

Heteroptera: Auchenorrhyncha

Araneae

**8.2.3 Results**

No invertebrates have yet been identified from the first season's trapping. Several observations, however, are of note:

- (i) It is likely that several of the sites chosen for the autumn survey will need to be dropped or changed in the future, because of problems with cattle interference.
- (ii) Collection frequency from pitfalls and water traps near water-level will need to be increased to two or three times a week, in order to prevent or ameliorate problems with flooding. For this reason, traps will need to be set in outer shields to facilitate removal and subsequent replacement. Though this would take longer initially, such a system would be re-usable in future years.

## 9. Birds: Cole

### 9.1 Introduction

The restoration works on the River Cole are expected to have a significant effect on bird populations, particularly those of wading birds and waterfowl (see Table 9.1). The aim of the bird monitoring programme, therefore, is to determine whether populations of breeding and overwintering birds do indeed change following restoration of the river.

Although wetland species will be of particular interest, the monitoring programme has been designed to obtain information both about these 'target' species and other common species, particularly passerines.

The work reported here was undertaken by Jon King (Oxford University) and Jeremy Biggs. Statistical analysis and method testing (which is not presented in detail here) has been undertaken by Dave Walker.

**Table 9.1 Wetland associated birds which may benefit from river restoration: monitoring programme 'target' species**

Species	Reason for interest
Mute Swan	Recovering from decline in central Southern England and Midlands
Lapwing	National decline
Snipe	Decline on lowland grassland (candidate Red Data Book Species)
Redshank	Decline on lowland grassland (candidate Red Data Book Species)
Curlew	Uncommon breeding wader in Oxfordshire/Wiltshire
Shoveler	Rare breeder in Oxfordshire/Wiltshire (on edge of UK range in the region)
Teal	Rare breeder in Oxfordshire/Wiltshire
Garganey	Nationally rare breeding species
Moorhen	Population decline where river engineering occurs
Coot	Common, but abundance probably reduced by severe river engineering
Water Rail	Uncommon wetland breeding species in Oxfordshire/Wiltshire
Barn Owl	National decline; often forages in river valleys
Kingfisher	Possible population declines due to river pollution and engineering
Yellow Wagtail	Wetland species perhaps affected by land drainage
Grey Wagtail	National decline (climate- and possibly habitat degradation-related).
Grasshopper Warbler	National decline; associated with wetland habitats
Sedge Warbler	Wetland species; climate related declines.
Reed Warbler	Wetland species
Reed Bunting	National decline

### 9.3 Survey methods

Birds were surveyed by making counts along transects which follow particular features, and in 'compartments' (mainly fields). Transect counts are primarily intended to monitor changes in populations of riverside species and passerines. Compartment counts are mainly intended for breeding waders (and potentially waterfowl using flooded grasslands).

Figure 9.1 shows the transect routes; Figure 9.2 shows the compartments. The transects were subdivided into up to three subsections to ensure that there is continuous coverage of the current river course. Figures 9.1 and 9.2 also show the area downstream of the main restoration site which is being used as a 'control'.

#### 9.3.1 Transect surveys

A system of transects for the study site and the adjacent control site (immediately downstream from the study site) was developed in spring 1994. Five transects were established, four within the restoration area and one on the control site. The paths of the transects were designed to meet the following criteria:

- (i) to adequately cover all principal habitats within both the study and control areas;
- (ii) to maximise the lengths of existing river channel surveyed.

The following methodology has been established for the transects:

- (1) To assess breeding bird presence and abundance, transects should be undertaken in the months of April, May and June. For overwintering birds, surveys should take place in December, January and February.
- (2) Each survey season should consist of six field visits (one in each half-month period during the three month period) with all five transects to be surveyed during each field visit. Ideally, field visits should be evenly spaced (i.e. at 15-day intervals) throughout the survey period.
- (3) Transects should be undertaken in relatively consistent weather conditions, both within and between field visits. Conditions clearly likely to detrimentally affect bird activity (heavy rain, high winds, extreme cold) are best avoided, within the restrictions of the fieldwork timetable.
- (4) The first transect is to be started within 30 minutes of dawn, the five transects to be surveyed in the same order (for statistical purposes). This order is determined by the numbering of the transects (1 to 5). Surveying the five transects in the same order should minimise time-of-day effects operating between field visits, as each transect will start at approximately the same time relative to dawn (there are insufficient field visits in each season to permit randomisation).
- (5) Transects are to be walked at a slow but consistent pace, with the minimum amount of stopping required for field identification.
- (6) Within each transect, the sections alongside the current or former river channels are recorded separately from non-riverside sections, thus dividing the transects into two or three subsections.
- (7) Contacts with each bird should be identified as being either within 25m of the observer (i.e. within a 50-m band centred on the transect line) or as over 25m from the observer. Furthermore, summer transects should distinguish between contacts with singing individuals and contacts with calling or seen birds. (This data may be used for assessment of territory densities.) This distinction does not apply to winter surveys.

In April-June 1994, the methodology described above was applied to five field visits between 30 April and 26 June. Logistical and practical reasons prevented the full number of visits (six) being made, and

coverage was not as even throughout the period as would have been ideal. However, the data gathered was adequate to meet the objectives of the project. Observations in the field were recorded on a hand-held dictaphone and subsequently transcribed for analysis.

### 9.3.2 Compartment counts

Compartment counts were mainly intended for waders. Four species (Lapwing, Redshank, Snipe and Curlew) might be expected to occur on the site. (Three of these were in fact seen). Compartments were counted whilst walking the transects, with occasional stops-and-scans overfield to count any waders present. In 1994, this method was adequate to record the limited number of waders present.

In 1995, it is intended that the more rigorous standard BTO/RSPB wader survey method be adopted: this involves walking every field to within 100m (or less) of every point, and recording all wader observations using a mapping technique similar to the BTO Common Birds Census mapping methodology. Three visits per summer should be made: the first and last at dawn, and the second at dusk (one each in the periods 15-30 April, 1-21 May and 22 May-15 June). This method allows reasonably accurate quantification of breeding wader numbers following analysis of the resulting maps.

The BTO/RSPB method takes account of the following requirements for individual species.

#### Lapwing

Counts should be made when birds are sitting (late March-late April). Incubating birds should be located with several counts between 0900 and 1200 over the recommended period.

#### Redshank

Flying birds showing alarm should be counted between 0900 and 1700 hours in late May to early June.

#### Snipe

Counts of drumming males should be made within 3 hours of dawn or dusk, on at least three occasions during April and May.

#### Curlew

General methods outlined above are adequate for this species.

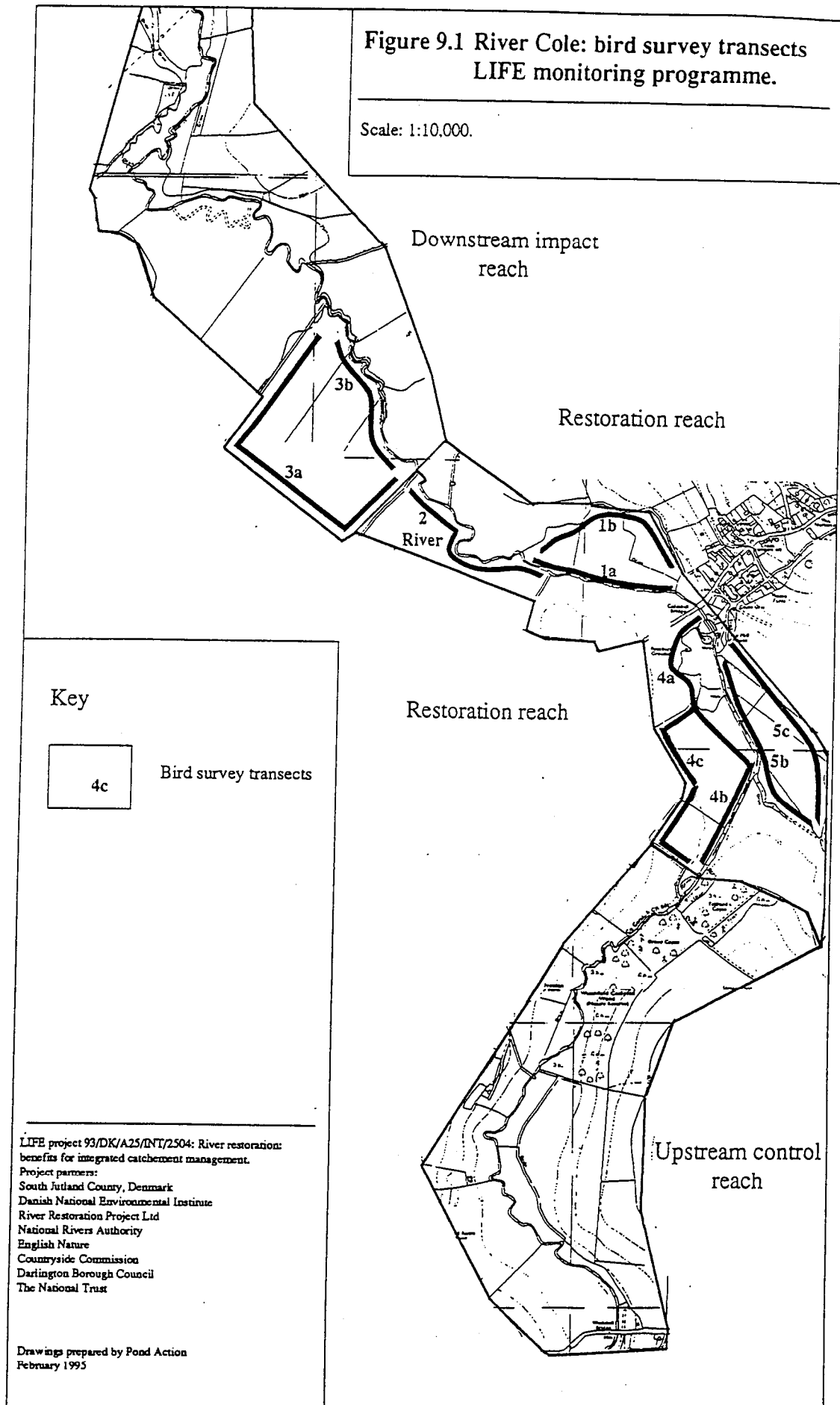
### 9.3.4 Statistical design of the survey methods

Statistical analysis of the first year data-set has been undertaken to assess the levels of change which will be detectable using the survey techniques described. The 1994 data-set has been looked at in considerable detail in this analysis, and only two simple examples of the outputs from this analysis are mentioned here.

Analysis of the data indicates that to be statistically detectable using current methods the numbers of Lapwing recorded per transect would need to increase from the current (1994) 0.34 birds/transect to about 1.17 birds/transect (an approximately four-fold increase). In contrast to this, much smaller changes in Moorhen numbers could be detected. If numbers increased from the 1994 average of 0.53 birds/transect to 0.76 birds/transect, this would be statistically significant.

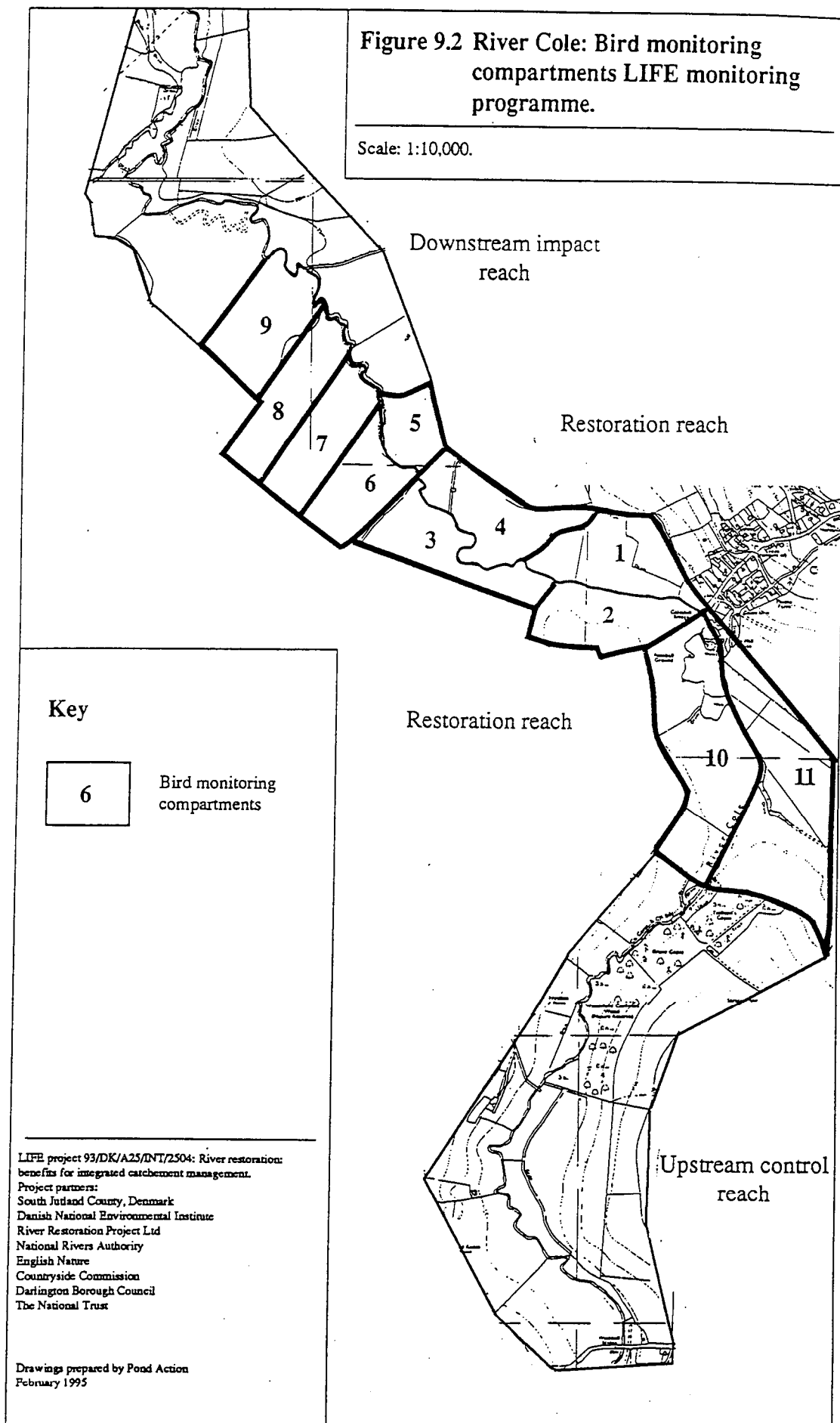
**Figure 9.1 River Cole: bird survey transects  
LIFE monitoring programme.**

Scale: 1:10,000.

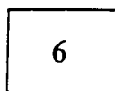


**Figure 9.2 River Cole: Bird monitoring compartments LIFE monitoring programme.**

Scale: 1:10,000.



**Key**



Bird monitoring compartments

LIFE project 93/DK/A25/INT/2504: River restoration: benefits for integrated catchment management.

**Project partners:**

South Jutland County, Denmark  
Danish National Environmental Institute  
River Restoration Project Ltd  
National Rivers Authority  
English Nature  
Countryside Commission  
Darlington Borough Council  
The National Trust

Drawings prepared by Pond Action  
February 1995

## **9.4. Results**

### **9.4.1 Birds on the restoration site**

#### **Breeding season: 1994**

The following is a very brief summary of some of the results obtained during the summer 1994 survey work.

A total of 58 species were recorded during the survey. Of the 19 target species identified as being of importance, only six were present in the restoration area. These were Mute Swan, Lapwing, Moorhen, Kingfisher, Yellow Wagtail and Reed Bunting, all of which probably bred (except Kingfisher, which probably bred in the Control reach). Lapwing were most numerous on the site in the right bank arable field, downstream of Coleshill Bridge (Compartment 10).

The three 'target' species seen in the Control area, but not on the restoration site, were Curlew, Redshank and Sedge Warbler. Curlew probably bred in this area and the two other species may have bred. Details of these observations, and the requirements of unrecorded 'target' species, are outlined in Table 9.2.

Currently, the restoration area had a greater diversity of woodland and scrub species (e.g. Song Thrush, Treecreeper and Little Owl were recorded only in the restoration area), with the control area holding some species more typical of open farmland (e.g. Grey Partridge and Quail).

#### **Winter survey: 1994/1995**

The winter 1994/95 survey was in progress at the time of completion of this report. Despite periods of heavy rain and extensive (although short-lived) flooding at Coleshill, few wetland birds were recorded. Notable for their absence on the site were Snipe and other waders, with only one overwintering Green Sandpiper seen. In addition, no waterfowl of note were recorded.

More detailed description of passerine and non-wetland species will be included in the next monitoring report.

**Table 9.2** Target species recorded during the 1994 breeding season

Species	Abundance category*		Comments
	Restoration site	Control	
Mute Swan	I	-	One pair may have bred on the restoration site.
Lapwing	I	II	Probably bred downstream from Coleshill Bridge in right bank arable field; possibly bred upstream from Coleshill Bridge in left bank pasture.
Snipe	-	-	Requires extensive rank, wet grassland.
Redshank	-	I	Possibly bred downstream of control area.
Curlew	-	I	One pair attempted breeding in control area.
Shoveler	-	-	Requires undisturbed shallow static water.
Teal	-	-	Requires undisturbed shallow static water.
Garganey	-	-	Requires undisturbed shallow static water.
Moorhen	I	I	
Coot	-	-	Requires rather deep water, with slow flow-rate.
Water Rail	-	-	Requires thick sedge/reed areas with pools.
Barn Owl	-	-	Provision of nest-boxes suggested.
Kingfisher	-	I	One pair probably bred in the control area.
Yellow Wagtail	I	II	
Grey Wagtail	-	-	Seen in the area in winter.
Grasshopper Warbler	-	-	Requires sedge and/or reed beds with scrub.
Sedge Warbler	-	I	May breed in control area.
Reed Warbler	-	-	Requires reedbed for breeding.
Reed Bunting	I	I	

\*Abundance estimates give numbers of individuals recorded on each field visit for each of the control and study areas:  
I = 1-9; II = 10-99; III = 100+.

## 10. Fisheries: Cole

### 10.1 Introduction

The River Cole appears to provide a classic case of the impacts of flood defence engineering works on fish populations. Surveys immediately before and shortly after the land-drainage works undertaken on the Cole in 1975/76 indicated a 90% reduction in the biomass of Chub and a 95% reduction of Dace biomass (TWA, 1980).

Subsequent monitoring of fish populations on the Cole has been undertaken as part of the NRA's five year rolling programme. The most recent survey work was in 1992<sup>1</sup> and this study has been used as the main source of information for this chapter. The 1992 survey provides a partial baseline for the restoration study, but further pre-restoration survey work on the Cole is planned for spring 1995. Survey information is also available from 1975-1980

The River Cole is a designated EU Coarse Fishery for 20.3 km of its length, from Acorn Bridge to the confluence with the Thames. Between 1988 and 1992 two fish mortalities were reported: on the Dorcan Brook and on the Cole at Sevenhampton. The latter incident killed at least 150 fish and was due to the combined effects of low flow and slurry pollution. In response to fish kills, and to specific request from anglers, over 5,500 coarse fish were stocked into the river in the period from 18 October 1989 to 30 January 1990. Most of these fish were put into the river at Coleshill, in the mill channel. Species added were Common Carp, Crucian Carp, Dace, Chub, Roach and Bream.

### 10.2 Aims

The aim of the fish monitoring programme on the Cole is to assess the changes in fish species-richness (number of species) and biomass following restoration. As well as contributing to the ecological description of the site, the data will be interpreted in terms of the amenity and economic benefits of any changes in the fishery.

### 10.3 Methods

The pre-restoration survey will be undertaken by NRA Fisheries staff as a specially commissioned survey. It is intended to complement the results of the 1992 survey, and will be repeated in 1996. The next rolling programme survey will be due in 1997.

Survey work will use standard electro-fishing techniques. In the 1992 survey, each selected reach was electro-fished with stop nets, with at least two runs through the section. An upstream run was also undertaken at most sites to confirm the results of the main survey section. Further details of the methods of the study are given in NRA (1992).

Nine sites were surveyed by the NRA in the 1992 survey. Three sites are relevant to the restoration study (see Figure 10.1): these were Fresden Farm (site located in the upstream control reach), Coleshill Park (restoration reach) and Roundhill Farm (site located in the downstream impact reach). 'Angling species' were measured and weighed, and 'minor species' were noted and their relative abundance assessed.

<sup>1</sup> NRA (1992). *River Cole fisheries survey*. National Rivers Authority Thames Region, Thames West Area.

**Table 10.1 Fisheries survey sites on the River Cole restoration site**

	NRA site number	Sites surveyed in 1994
Downstream impact reach	CLF 6	Roundhill Farm (13 August 1992)
Restoration site	CLF 5	Coleshill Park (7 May 1992)
Upstream control reach	CLF 4	Fresden Farm (6 February 1992)

## 10.3 Results

### 10.3.1 Fish fauna of the Cole

The following species were recorded in the Cole in 1992: Bleak, Bream, Bullhead, Chub, Common Carp, Dace, Eel, Gudgeon, Minnow, Perch, Pike, Roach, Three-spined Stickleback, Stoneloach, Tench.

Of the nine sites surveyed in 1992, four had biomasses in excess of the EU 20g m<sup>-2</sup> limit. These were Friar's Farm, Snowswick Farm, Inglesham Road Bridge and upstream of St. John's Bridge.

The three sites within the Coleshill restoration study (Fresden Farm, Coleshill Park and Roundhill Farm) all had low biomasses (12.3, 5.8 and 10.4 g m<sup>-2</sup>). The lowest biomass was in the mill leat at Coleshill.

#### Fresden Farm (Site CLF 6)

Bream, Chub, Common Carp, Dace, Gudgeon, Perch and Roach were recorded in the reach. Bullhead were abundant and Minnow, Stoneloach and Three-spined Stickleback were present.

Total biomass of angling species was 12.3 g m<sup>-2</sup>, with Gudgeon the most numerous fish. The channel was described as overwide and lacking significant features throughout most of its length, although bankside vegetation was 'good'.

#### Coleshill Park (upstream of Coleshill Mill) (Site CLF 5)

Bream, Chub, Dace, Gudgeon, Perch and Roach were recorded in the reach. Stoneloach and Three-spined Stickleback were present. The reach had a lower biomass than any of the other eight reaches surveyed.

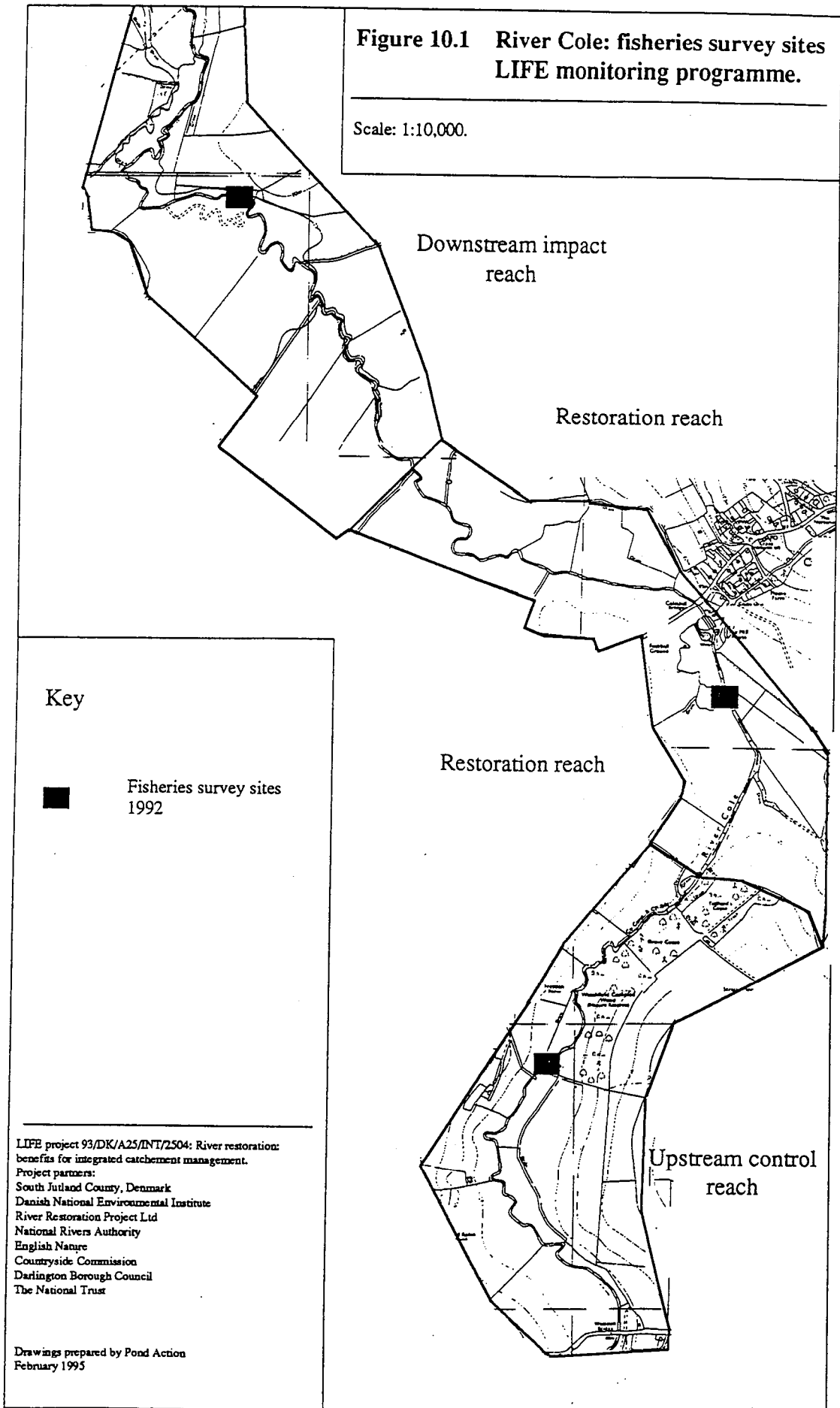
#### Roundhill Farm (Site CLF 4)

Bleak, Chub, Dace, Gudgeon, Perch, Pike and Roach were recorded in the reach. Minnows were abundant, and Bullhead and Stoneloach were present.

The section surveyed had two pools but no riffles. There were dense stands of Common Clubrush (*Schoenoplectus lacustris*). No comment was made by fisheries staff about the quality of this reach as fish habitat.

**Figure 10.1 River Cole: fisheries survey sites  
LIFE monitoring programme.**

Scale: 1:10,000.



**Key**



Fisheries survey sites  
1992

LIFE project 93/DK/A25/INT/2504: River restoration:  
benefits for integrated catchment management.

Project partners:

South Jutland County, Denmark  
Danish National Environmental Institute  
River Restoration Project Ltd  
National Rivers Authority  
English Nature  
Countryside Commission  
Darlington Borough Council  
The National Trust

Drawings prepared by Pond Action  
February 1995

## 11. Public perception: Cole

### 11.1 Introduction

Monitoring of the public perception of river restoration is one of the six areas of the LIFE monitoring project which are being undertaken in special detail. The perception study has focused on the Skerne (see Chapter 21), as it is acknowledged that in the urban environment one of the major benefits of river restoration is likely to be public amenity. In contrast, the number of individual people likely to benefit immediately from the Cole restoration is likely to be small, notwithstanding the potentially large benefits to society. For this reason, the monitoring of public perception on the Cole has been informal, and this section of the report is intended only to briefly review some impressions of the views of local residents. It has been prepared by Jeremy Biggs.

### 11.2 Public perception of the Coleshill restoration site

#### 11.2.1 Approach to consultation

Public perceptions of the Coleshill restoration project have been canvassed informally in the course of a variety of contacts with members of the local community. These have included:

- (i) Two public meetings with local residents to describe the project
- (ii) Meetings with tenants of the National Trust, who farm the restoration site
- (iii) Meetings with members of the local football club, whose pitch is on the floodplain within the restoration site.

#### 11.2.2 Concerns of the local community

The principal concerns that have been expressed by the community revolve around the issues of access, and changes in land use brought about by an increase in flooding.

##### Visitor pressure

That the restoration work on the Cole will increase the profile of the site is of concern to some residents, who feel that this is likely to encourage more visitors to the area. An increase in use of the site has already been noted by some residents (although, presumably, most of the visitors are people involved in monitoring the site!).

##### The effect of increased flooding

Flooding is of greatest significance for two groups in Coleshill: tenant farmers and members of the football club. Detailed negotiations have been undertaken with both groups in the course of developing the restoration scheme.

Negotiations with farmers have revolved around changes in land-use and payments to compensate for loss of earnings. A wide variety of incentives are available to farmers (including reduction of rents by the National Trust) to balance any losses of income, and these will be applied on the restoration site wherever possible. Negotiations with the local football club have focused on a 'planning gain' for the club, in the form of a one-off payment to accept an increased risk of flooding on the pitch.

#### 11.2.3 Future work

Informal analysis of local attitudes will continue throughout the scheme. At present, it is not planned to undertake a more formal analysis of the perceptions of residents of Coleshill.

## 12. Appraisal of the benefits of restoration for integrated catchment management: Cole and Skerne

### 12.1 Introduction

The main objective of the LIFE demonstration project is to assess the value of river restoration in integrated catchment management. This aspect of the project is a special study on both sites, reflecting its overall importance to the project.

Work on this section of the project has been undertaken by Jeremy Biggs, with additional material from Penny Williams. Meg Postle is currently providing guidance on data held by the NRA which will be of relevance to the assessment of benefits.

### 12.2 The potential benefits of restoration

This section of the project will investigate the potential benefits of restoration for:

- (i) flood defence
- (ii) water quality and pollution control
- (iii) fisheries
- (iv) nature conservation
- (v) public amenity and recreation

Wherever possible, benefits will be assessed in economic terms, although for some aspects of the study this is currently very difficult (for example, the economic benefits of increased invertebrate diversity are difficult to assess realistically at the moment).

There is a very wide range of potential impacts of restoration, and a representative selection of these has been listed in Table 12.1. It will not be possible to deal with all of these in the course of the project, but the monitoring programme will have data relevant to many. During the next six months, the main areas of analysis will be determined.

As Table 12.1 shows, the approach will be:

- (i) to identify the way in which the demonstration sites may illustrate a potential benefit (for example, by reducing flood peaks)
- (ii) to describe, and if possible measure in economic terms, the change at the demonstration site scale
- (iv) to attempt to scale the benefit up, realistically, from the site level to the catchment level, to assess its significance at the catchment scale.

Table 12.1 Analysis of the benefits of river restoration

Area of river management	Potential benefit of river restoration	Demonstration site objective	Measurement	Source of information	Approach to assessing effect at site scale	Approach to assessing effect at catchment scale
Flood defence	Reduce cost of flood defence works	Wider, lower hydrograph peaks	Change in hydrograph shape	Monitoring programme	Not applicable	Cost of flood defence capital schemes
		Flood water stored on floodplain	Volumes on floodplain	Monitoring programme	Hydraulic modelling	Hydraulic modelling
		Install 'soft' bank protection measures or keep channel natural	Geomorphology; river corridor survey; technical data on cost of bank protection	Monitoring programme; NRA data	Compare costs/performance with 'traditional' engineering	Scale up using NRA data
	Reduce cost of river 'maintenance'	Reduce costs of dredging	Estimate from NRA data	Local NRA data	Costs of labour, machinery, admin. etc.	Calculate cost of maintenance programmes at catchment scale
		Reduce costs of weed cutting	Estimate from NRA data	Local NRA data	Costs of labour, machinery, admin. etc.	As above
		Reduce costs of clearing trash, wood etc.	Estimate from NRA data	Local NRA data	Costs of labour, machinery, admin. etc.	As above
	Reduce need for River Corridor Surveys	NOT APPLICABLE	Cost of River Corridor Survey	NRA/Monitoring Programme	Calculate amount of RCS undertaken in relation to amount of river maintenance	Assess effect of reducing maintenance and therefore RCS at catchment scale.
	Reduce need for river valley land drainage	Reduce costs of land drainage for farmers/landowners	Costs of land drainage	Estate records	Cost of labour, machinery etc.	As above
		Reduce need for public subsidy of arable crops	Cost of subsidising crops (production and storage)	Estate records, technical literature	Compare crop subsidies to cost of Countryside Stewardship scheme	Extrapolate to catchment

Table 12.1 Analysis of the benefits of river restoration

Area of river management	Potential benefit of river restoration	Demonstration site objective	Measurement	Source of information	Approach to assessing effect at site scale	Approach to assessing effect at catchment scale
Water quality	Reduce diffuse pollutant concentrations (N, P, sediments, organics)	Reduce nitrate concentrations in river	Nitrogen budgets	Monitoring programme data	Compare restoration reach with upstream and downstream controls.	Model catchment scale effects using site data to validate.
		Reduce phosphate concentrations in river	Phosphate budgets	Monitoring programme data	Compare restoration reach with upstream and downstream controls.	Model catchment scale effects using site data to validate. Main financial implication is river water treatment costs.
		Reduce sediment concentrations in river	Sediment budgets	Monitoring programme data	Compare restoration reach with upstream and downstream controls.	Model catchment scale effects using site data to validate. Main financial implication is river water treatment costs.
		Reduce need for fertiliser application	Cost of fertiliser, cost of fertiliser subsidies, environmental impact of fertiliser production	Estate records, literature data	Use detailed records from landowners/farmers on sites.	Extrapolate effects to valley/catchment scale. Calculate cost implications.
		Reduce diffuse pollutants associated with urban runoff	Various pollutants occur in urban runoff	Monitoring programme data (?); published literature	Compare to costs of treatment	Relate to length of urban watercourses
	Reduce need for monitoring of diffuse nutrients (reduction of inputs may reduce need for monitoring or change monitoring priorities).	NOT APPLICABLE	Cost of monitoring routinely undertaken by NRA.	NRA data	Calculate cost per monitoring station. Assess effect of changing no or frequency or type of measurements.	Combine sampling cost data with catchment scale nutrient budget data to assess cost savings/efficiencies of redesigning sampling programme.

Table 12.1 Analysis of the benefits of river restoration

Area of river management	Potential benefit of river restoration	Demonstration site objective	Measurement	Source of information	Approach to assessing effect at site scale	Approach to assessing effect at catchment scale
Fisheries	Increase value of fishery	Increase fish biomass and diversity	Fish biomass and species richness	Monitoring programme; local club charges/rents	Rents to landowners, charges made by angling clubs, rod license fees	Scale up using NRA data
		Reduce need for restocking	Cost of labour, stock and transport	NRA data	Economic analysis	Assess against national costs/effort of restocking
		Reduce permissive monitoring programme	Frequency/cost of monitoring programme	NRA data	Calculate costs per reach or sample	Calculate catchment scale impact of cost savings/efficiencies of sampling programme redesign.

**Table 12.1 Analysis of the benefits of river restoration**

Area of river management	Potential benefit of river restoration	Demonstration site objective	Measurement	Source of information	Approach to assessing effect at site scale	Approach to assessing effect at catchment scale
Conservation	Increase habitat diversity	Increase river channel habitat diversity	River corridor survey	Monitoring programme	Compare habitat diversity before and after restoration	Scale up to catchment level
			Floodplain NVC plant communities	Monitoring programme	Compare habitat diversity before and after restoration	Scale up to UK level
	Increase biodiversity on site	Increase invertebrate species richness	Aquatic invertebrate species richness; Terrestrial invertebrate species richness;	Monitoring programme	Compare species richness, conservation value before and after restoration	Scale up to catchment level
		Increase plant species richness/abundance Extend high value communities	Species richness in river channel; Species richness on floodplain; Channel vegetation abundance	Monitoring programme	Compare species richness, conservation value and vegetation abundance before and after restoration.	Assess effect on extent of high value riverine habitats in UK
		Increase bird species richness	Species richness of common wetland birds	Monitoring programme	Compare population sizes before and after restoration.	Extrapolate to regional national level for individual species.
		Establish populations of Snipe and Redshank	Number of pairs breeding	Monitoring programme	Compare population sizes before and after restoration.	Extrapolate to regional national level for individual species.
	Reduce frequency of monitoring	NOT APPLICABLE	Compare costs of different river conservation assessment methods	Monitoring programme	Compare costs of different programmes and assess (i) level of data redundancy (ii) need for such survey in restored rivers.	Extrapolate reach scale observation to catchment scale.

Table 12.1 Analysis of the benefits of river restoration

Area of river management	Potential benefit of river restoration	Demonstration site objective	Measurement	Source of information	Approach to assessing effect at site scale	Approach to assessing effect at catchment scale
Recreation and amenity	Improve landscape	Protect and improve landscape	NRA landscape assessment	Monitoring programme	Compare landscape before and after	Assess in relation to extent of river landscape in Britain
		Create river valley grasslands	NVC survey; GIS techniques	Monitoring programme (vegetation survey)	Compare vegetation before and after	Scale up to catchment or UK level
		Increase public appreciation of landscape	Public perception surveys; economic valuation of improvements	Monitoring programme	Compare values before and after restoration	Extrapolate to catchment scale (e.g. compare to value of other large areas of semi-natural habitat).
	Provide informal recreation	Improve access to riverside (horse, pedestrian)	Increase public appreciation of amenity	Monitoring programme	Use contingent valuation; literature data	Extrapolate to catchment scale
	Provide educational opportunities					
Encourage new rural enterprises	Encourage farm diversification	Improve game shooting on site	Abundance of game birds	Monitoring programme (bird survey data), estate information	Estimate estate rents from shooting	Extrapolate to catchment scale.
	Create new river valley woodlands	Floodplain woodland established	Income from forestry	Forest Authority records; estate data	Compare value of timber products with agricultural products	Extrapolate to catchment scale

# RIVER SKERNE

RIVER SKERNE

## 13. River Skerne: background information

### 13.1 Introduction

Background information about the River Skerne and its catchment was gathered to provide:

- (i) baseline information needed for the design of the restoration works.
- (ii) background for the monitoring programme.

### 13.2 Methods

Background data collected includes:

- (i) historical, documentary and map information relating to the restoration site itself. The sources of information used for this work are listed in Table 13.1.
- (ii) data on the wider catchment of the Skerne.

The main sources of information for this section of the report are the Skerne catchment audit undertaken by Malcolm Newson and Amanda White, the landscape study by SGS Environment, the NRA Skerne Action Group report and the preliminary public perception study by Maureen Fordham. All except the Skerne Action Group report were undertaken specifically for this project.

### 13.3 Catchment information

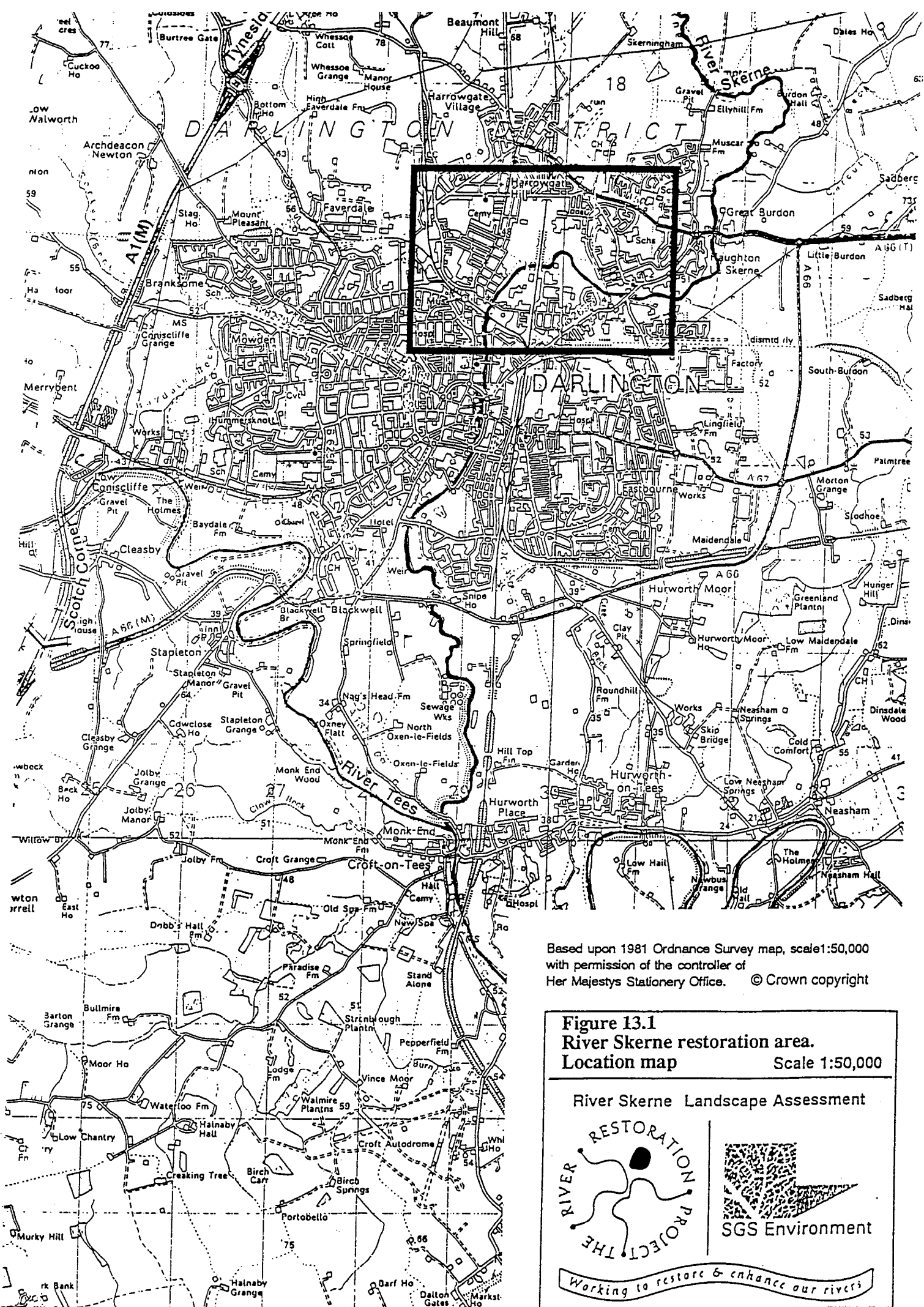
The catchment of the River Skerne covers an area of approximately 250 sq km, having a low stream frequency which reflects the general sparsity of the drainage network in Lowland Britain (Ward, 1981). Drainage density is low at only 0.134, reflecting the relatively low precipitation received by the catchment annually, the relatively high permeability of the basin geology and the relative flatness of its relief.

Archer (1992) thus describes the Skerne as having a lowland catchment, its highest point being 222m above sea level occurring west of Shildon. The resulting topography is fairly even, and large areas of land have been subject to annual inundation (notably the large alluvial plain of Bradbury, Preston and Mordon Carrs). The area is characterised by poor drainage throughout the year and most settlements in the catchment have developed on naturally elevated and thus drier sites.

The River Skerne is a minor tributary of the River Tees, with a total length of approximately 50 km, starting near Trimdon to the north and joining the Tees 5 km to the south of Darlington. The river traverses relatively flat rural land to the north, skirting the towns of Sedgfield and Newton Aycliffe, until it reaches the edge of the study area at Haughton-le-Skerne. From here through the centre of Darlington, the river has been canalised and its course straightened through time. To the south of the town, the river regains its natural appearance and meanders through open country to meet the Tees to the north of Croft-on-Tees.

The restoration demonstration site occupies a 2km stretch of the River Skerne between Haughton Bridge and Skerne Bridge<sup>1</sup> (see Figure 13.1).

<sup>1</sup> This bridge is also known as the 'Five-Pound-Note Bridge' because it is the bridge that appears on the back of the current five pound note. It was the railway bridge for the Stockton and Darlington Railway.



Based upon 1981 Ordnance Survey map, scale 1:50,000  
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**Figure 13.1**  
**River Skerne restoration area.**  
**Location map**

Scale 1:50,000

River Skerne Landscape Assessment



Working to restore & enhance our rivers

### 13.4 Geology and soils

The basin geology consists of basal Magnesian Limestone, capped by boulder clay. River floodplain areas consist mainly of glacio-fluvial sands and gravels, whilst the channel itself is frequently bounded by its own alluvium.

The soils are generally reddish coarse loams which are slowly permeable and liable to seasonal waterlogging. The channel itself is bounded by its own alluvium which appears to be cohesive, providing a stable edge. After flooding, it is reputed that up to 25 cm of silt can be deposited on the banksides (D. Race, *Durham County Conservation Trust Bulletin*, May 1987).

The restoration reach contains the Rockwell which is a glacial conglomerate, a rocky outcrop below which a spring, now piped, used to surface.

**Table 13.1 Sources of information used to compile background information about the River Skerne restoration site.**

Author	Date	Title
Archer, D.	1992	"Land of Singing Waters". Rivers and Great Floods of Northumbria. pp 41-49. Spredden Press.
Darlington Borough Council	1994	The Borough of Darlington Local Plan, Consultation Draft. Darlington Borough Council.
Durham County Conservation Trust Ltd	1987	Bulletin. pp 25-33. Durham County Council.
Durham County Council	1994	County Durham Structure Plan Review, Consultation Draft. Durham County Council.
Durham County Council	1993	County Durham Nature Conservation Strategy. Durham County Council.
Fordham, M	1994	The River Skerne Public Perception Report: Stage 1. Draft report for the River Restoration Project. Flood Hazard Research Centre, Middlesex University
NRA (Northumbria Region)	1992	River Skerne Action Group Progress Report.
NRA (Northumbria and Yorkshire Region)	1994	River Corridor Survey River Skerne.
NRA (Northumbria and Yorkshire Region)	1994	River Skerne survey 1994. Report on fish population monitoring.
NRA (Northumbria Region)	1992	Fisheries stock assessment report 1991. River Skerne. Hurworth Burn Reservoir (NZ 408 334) to River Tees Confluence (NZ289 102).
NRA (Northumbria and Yorkshire Region)	Undated	River Tees Catchment Management Plan. Consultation Report.
Newson, M., White, A. and Padmore, C.	1994	River Restoration Project, River Skerne: Geomorphological Evaluation, Pre-Project.

### 13.5 Land use

The River Skerne rises near Trimdon, Co. Durham (NZ 362348) approximately four kilometres upstream of Hurworth Burn Reservoir (NZ 407337). It then traverses mainly agricultural land under arable and sheep grazing until it skirts Sedgfield where there are relatively large inputs from the industrial estate. Between Sedgfield and Newton Aycliffe to the south west the land use is predominantly sheep grazing on the valley floor and arable where there is a slight rise in land and therefore an increase in drainage. Newton Aycliffe also inputs industrial and domestic effluent, and at this point three major tributaries enter the watercourse: Howden Beck, Demons Beck and Woodham Burn, which also carry industrial effluent. Between Newton Aycliffe and Darlington, the area is again rural with cattle grazing becoming an important landuse. Through Darlington the river is a typical urban watercourse, with limited industrial drainage. The river Skerne eventually enters the River Tees approximately 2.5 km south of Darlington.

The restoration area, on the outskirts of Darlington, is a public open space consisting of two main areas:

- (i) a relatively wide flat floodplain area to the east of the railway main line
- (ii) a narrow corridor to the west of the railway line.

The northern edge of the area is defined by housing built in the 1970s and 1980s. The southern side of the river is edged by industrial and trading estates and, towards Haughton Road, a 1960s housing estate. A car-dealer operates adjacent to Haughton Road and backs onto the public open space. The east coast main-line railway bisects the area, and the Bishop Auckland branch-line marks the downstream limit.

The site and immediate surroundings include old industrial areas that have been tipped, existing industrial areas, residential areas of various ages, from nineteenth century terraces, through 1950s social housing, to 1990s mixed housing developments. These are set within formally landscaped areas and areas of rough grassland, scrub and ponds, allotments and railway embankments. The area is a much altered one of tipped land, past riverworks, and amenity and nature conservation plantings.

### 13.6 Water quality and source of pollution

Of some importance to the restoration proposals is the existing legacy of pollutants within the river corridor. There are no records of the tipping works of the mid-19th century which produced the steep embankments. This material, which is believed to be inert slag, was moved around to form the extended escarpment to the north of the Henry Williams industrial site towards Dropwell. Material which came from the Phoenix Tubeman factory in the mid 1980s was tipped to the north of Rockwell and is believed to contain some contaminants. There is some concern that new excavations may reveal contaminated material, and for this reason a number of trial pits are planned.

Heavy metal analysis of bed sample sediments analysed during the catchment audit indicated contamination of the river bed with zinc, copper, lead and cadmium. Zinc and copper are of particular concern, because they were recorded as exceeding the highest levels of standard guidelines (Interdepartment Committee on the Redevelopment of Contaminated Land - ICRCL - and the Dutch guidelines). Zinc and copper are phytotoxins which could seriously inhibit plant growth, and therefore measures would need to be included to deal with this material safely, in accordance with current legislation, either on- or off-site.

Of further concern is the possible mobility of contaminants and the NRA recommends that the standard leach test be conducted, as well as pH tests, to check that this does not become a problem. Cut off drains or trenches may be required during restoration works to prevent contaminated water from areas such as the reclaimed Tubeman site entering more sensitive parts of the site (such as the Rockwell Conservation Area).

## 13.7 Archaeology

There is likely to be some archaeological interest in the area. During the landscape study (SGS Environment, 1995), a local historian reported the excavation some years ago of an old (c. 13th century), moated cruck house in the area which is now the Red Hall estate. This is no longer exposed.

Skerne Bridge, which carried the Stockton and Darlington railway, is a scheduled Ancient Monument. It was recognised as the first railway bridge on a steam-hauled public passenger service; the event which is commemorated on the five pound note is the opening of the service in 1825.

There are no other listed structures in the area, although Haughton Church to the north of Haughton Bridge, has Saxon origins with Norman additions.

## 13.8 History

The River Skerne within the study area has been dramatically altered over the last century by man's activities. The channel planform has been examined using four historical map series (1850 - 1860, 1923, 1940 - 1945, and the 1960s Metric) at a scale of 1:10560 for imperial and 1:10,000 metric. The gradual modification of the channel is shown in Figure 13.2.

The first edition Ordnance Survey map of 1857 shows the river running in a natural channel on a meandering course, traversing flat agricultural land. The 1923 map shows a dramatic change in the area to the west of the main-line railway with the expansion of Darlington Forge Ironworks and development of the housing area at Rise Carr.

Over the years, the river has been canalised and its corridor dramatically narrowed by the creation of the industrial plateau and formation of steep embankments. The effect of the housing appears to be less significant. The railway appliance works and Stephenson Locomotive Works to the north-east of the main line also required flat land, and a considerable amount of tipped material was necessary to achieve this. However, the course of the river in this section was only canalised into its present line when the corridor became very much the heart of the town's industrial base between 1923 and 1940.

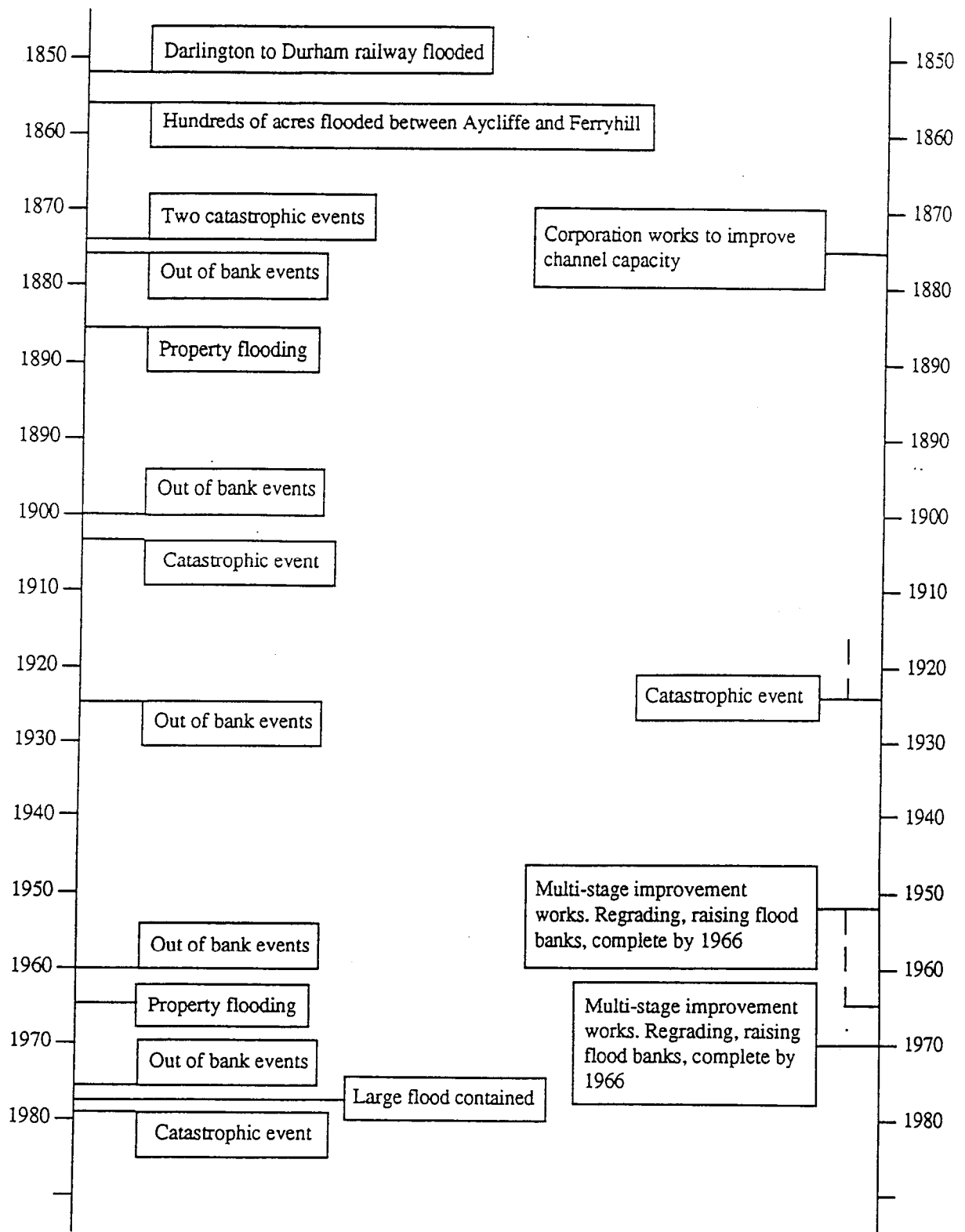
In 1850 - 1860, the River Skerne was sufficiently untouched to justify its being considered a naturally sinuous and meandering channel. However, with such low gradient, low discharge and thus low stream power, situated in cohesive drift materials, it is unlikely that the Skerne would have had a particularly actively eroding channel (Ferguson, 1981) other than points at which the river comes across beds of sand and gravel.

The current cross-section of the River Skerne is fairly uniformly wide and deep, but this is unlikely to have been the dominant morphology of the natural channel (this is demonstrated by the "natural" reach upstream of the motorway culvert near Aycliffe). Many artificial modifications have taken place over the last 150 years, both up- and downstream, which have drastically altered not only the cross-section, but also the planform and long-profile of the River Skerne (shortened by approximately 1.1 km since 1850), through re-alignments, re-grading and improvements in channel capacity.

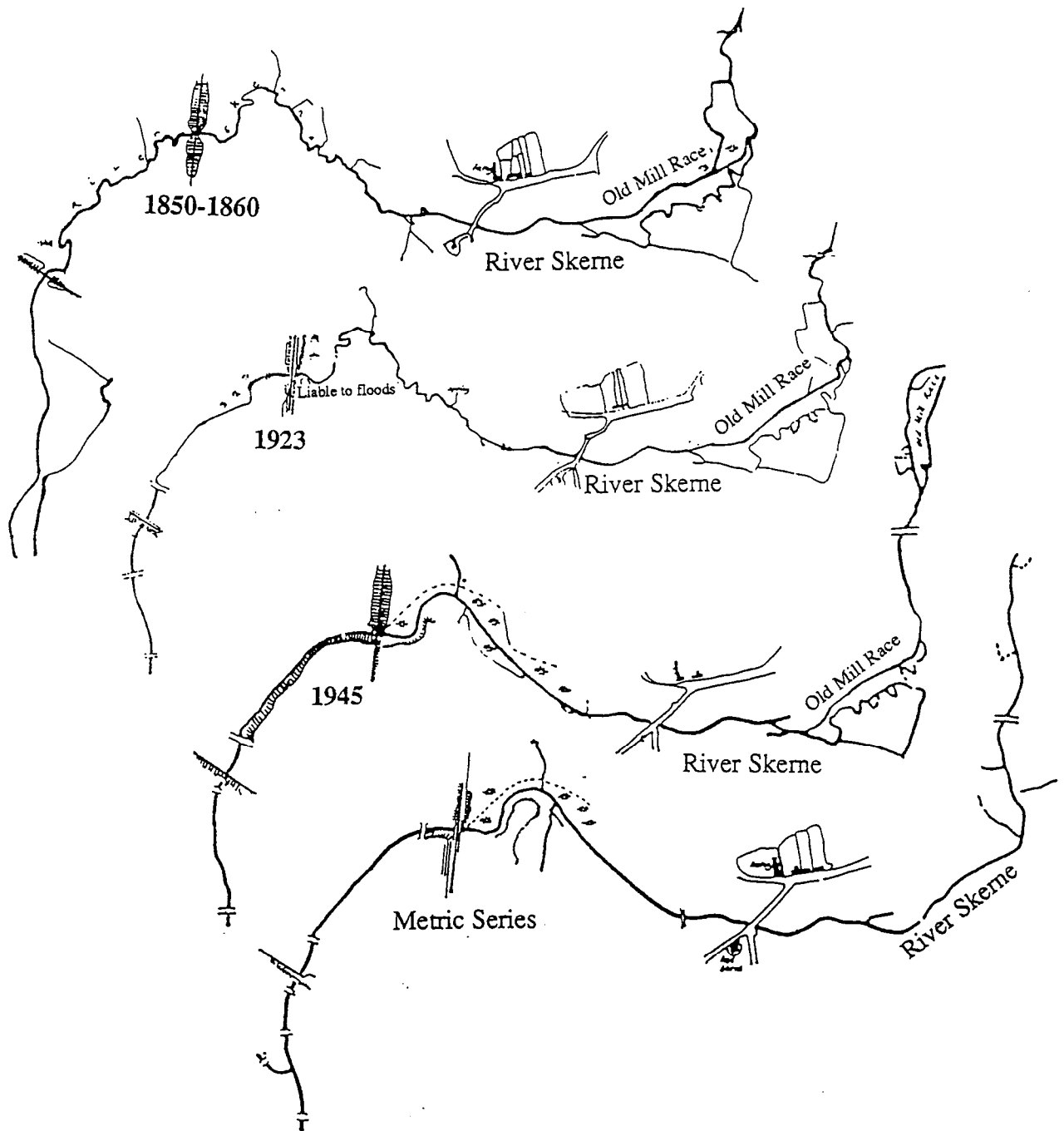
David Archer (1992) catalogues the history of reported flood events and channel maintenance works on the River Skerne. Fig. 13.2 summarises his work. It should be stated, however, judging from the map evidence, that channel modifications were a factor prior to the first reports of flooding in Darlington discussed by Archer, and may even have contributed to their occurrence. The 1850 map suggests realignment and channelisation accompanied by intensive agricultural drainage of land in the upper catchment.

The long-profile of the River Skerne is exceedingly low, with an even gradient throughout its length. The only steepening occurs at Aycliffe village as the river traverses a limestone outcrop and returns to boulder clay with beds of sand and gravel.

**Figure 13.3 Comparative chronology of flooding and maintenance on the River Skerne**



**Figure 13.2** Change in the planform of the Skerne in the restoration reach 1850-1960



### 13.8.1 Changes between 1850 and 1923

The channel past Haughton Bridge was probably straightened prior to 1850, as it stands out when compared with sections up- and downstream at this time. The channel abandoned its natural course in favour of Haughton Mill Race, and artificial cut-offs and straightening occurred just downstream of Haughton Bridge.

Widening and deepening of cross-section, and re-alignment of planform, were carried out on the reach from the York-Berwick railway bridge to Darlington gas works.

### 13.8.2 Changes between 1923 and 1945

Between 1923 and 1945, the river planform was altered between Haughton Bridge and the York-Berwick railway by extensive straightening and, apparently, by widening and deepening. From the railway to the gas works floodbanks were also raised to improve channel capacity.

### 13.8.3 Changes post-1945

After 1945, map evidence suggests that there was no further change in planform. However, there was probably further widening and deepening, as Archer (1992) chronicles a multi-stage improvement works beginning in 1952, which included the following:

- (i) The weir at the outlet to South Park Lake was remodelled as a gauging weir and the sluice gates were removed.
- (ii) Russell Street Weir was lowered by 18 inches.
- (iii) The channel at Five Arches Bridge was lined with sheet piles and deepened by 6 feet.
- (iv) From Five Arches Bridge to Haughton Road Bridge the channel was enlarged, and flood banks were raised at Haughton School.
- (v) The Cocker Beck (which had contributed heavily to flooding in the town) was diverted into the Tees via the Baydale Beck upstream of Cockerton, and the Baydale's channel was enlarged.
- (vi) Re-grading, raising and strengthening of flood banks took place from Bradbury to Holdsworth Bridge.

Though the largest programme, these were not the final set of alterations the Skerne was to experience. From 1970 - 1972, riverside buildings were purchased and demolished by the Council to allow for further cross-sectional widening (from 25 to 35 feet) through Darlington town, and a reinforced concrete wall was added to the west bank (Archer, 1992).

The last 25 years has seen great changes in the corridor, but with relatively little change to the river itself. The new housing developments along the entire north side of the river are the most significant change. The area to the north-east of the main line, formerly liable to flood, was drained in the mid-1970s, and the Phoenix Tubeman Works (formerly Stephenson Locomotive Works) was reclaimed in 1984 by Darlington Borough Council. The terraced housing and allotments adjacent to the north bank of the river between the main line and Albert Bridge were cleared in the early 1970s and new housing built. The southern side of the river has also been transformed over recent years. The massive Darlington Forge Works has been replaced by a trading estate, and the council have gradually bought up sections of the embankment and reclaimed it in phases. The industrial land on the plateau to the south-east of the main line was bought in the 1970s by the council, who then reclaimed the embankment. Coupled with further deepening of the channel to the west of Haughton Bridge, a gas main and a main sewer were laid adjacent to the river in the early 1970s. The existing tamed parkland appearance from Haughton Bridge to Rockwell was a response to the new housing, and is a result of further clearance and drainage of the mid 1980s.

Durham County Council have recently carried out environmental improvements adjacent to Albert Bridge, and Darlington Borough Council have plans for a major project adjacent to Skerne Bridge in order to improve its setting and make it into a tourist attraction, linking it into the Railway Heritage Trail.

The result of these schemes has been a change in attitude towards the river over recent years. The influence of heavy industry has been reduced, and the various landscape schemes, in conjunction with the creation of a cleaner environment, have combined to make the corridor into a viable and potentially very attractive public open space.

**Table 13.2**      **Change in channel length and sinuosity on the River Skerne, 1850 - 1960.**

Reach	Year			
	1850-60	1923	1940-45	1960
A Ricknall Farm to Ketton railway viaduct	5.9km	5.8km	5.8km	5.8k
B Ketton railway viaduct to Great Burdon road bridge	6.1km	5.9km	5.6km	5.6k
C Great Burdon road bridge to Darlington gas works (includes restoration reach)	4.0km	3.7km	3.5km	3.5k
Total channel length	16.0km	15.4km	14.9km	14.9k
Total sinuosity	1.203	1.13	1.096	1.09

### 13.9 Designations

Skerne Bridge is a scheduled Ancient Monument. There are no listed buildings within the restoration area, although Haughton Church, located adjacent to Haughton Bridge, is Grade I listed, and Red Hall immediately to the east is a Grade II listed building. Haughton Village Conservation Area includes a small area immediately to the west of Haughton Bridge, but it is unlikely that the river restoration proposals will conflict with policies governing this status.

There are no statutory Nature Reserves within the area, but there are three sites with nature conservation interest: Skerne Ponds, Rockwell Pastures and St William's Pond. All three include water bodies and semi-natural vegetation.

There are three public footpaths within the area. The path from Henry Street, which runs adjacent to the allotments, past Skerne Ponds, under the Five Arches Bridge and through to Rockwell linking into the housing area at Littlebeck Drive, is the longest route. A bridleway joins this path at Skerne Ponds linking north into the housing area. The two short lengths of paths at the extreme east end of the site include a link between Haughton Road, over Hutton Avenue footbridge, through to housing to the north and a link along the river bank through to Haughton Bridge.

A number of main service pipes and connections exist within the reach, such as a gas main, an electricity main and a sewer.

### 13.10 Structure Plan

The Draft County Structure Plan Review was issued for Public Consultation in April 1994, and the Deposit Plan is due for completion in the winter of 1994. Within this document, Policy Nos 57, 64 and 92 are particularly relevant to the Skerne restoration site:

Policy 57 states:

"The improvement and enhancement of the county's environment should include....

- c) Tree planting, particularly in areas deficient in planting and where it assists in the creation of wildlife habitat or community woodlands."

Policy 64 states:

"Nature conservation in the county should be achieved by....

- b) Seeking to safeguard sites of nature conservation importance....
- e) Encouraging the creation of new areas of nature conservation interest, particularly in association with appropriate development schemes or on reclaimed sites or redundant land."

Durham County Council's Nature Conservation Strategy 1993, in addition sets out a number of policies and design guidelines, including "Wetlands and Watercourse" (Ref. 5.1.4, page 24). This will be revised to take account of the Draft County Structure Plan and the recently published Department of the Environment's Planning Policy Guidance No. 9 on Nature Conservation, published in October 1994.

### 13.11 Local Plan

The Borough of Darlington Local Plan Consultation Draft was produced in March 1994, and the Deposit Plan is now in preparation.

Map 2, included in the document Urban Area Inset, highlights the River Skerne corridor and indicates a proposed recreation route along its entire length throughout the area of study, with a number of cycle routes linking into it. The plan also identifies the three areas of nature conservation interest, Haughton Village Conservation Area, and a highway safeguarding area between Skerne Bridge and Albert Bridge, a zone identified for the proposed Cross Town Route.

Within the document there are a number of policies relevant to the River Skerne Restoration Project, but Policy E40 highlights the area specifically. The following proposals are outlined:

- (i) The extension of the riverside footpath and cycleway.
- (ii) The introduction of more varied vegetation.
- (iii) Improvements to the setting of Skerne Bridge.
- (iv) Collaboration with the National Rivers Authority to develop a proposed 'riverside revival' to bring about 'landscape, habitat and access improvements'.

The council is shortly to publish a Strategy for the Green Environment, which 'will promote the concept of green corridors and their management for recreation and nature conservation and landscape'. The River Skerne corridor and the two railway lines within the area are identified as existing principal wildlife corridors.

One of the proposals within the Strategy is the preparation of management plans for all areas of nature conservation interest.

## 14. Geomorphology: Skerne

The River Skerne on the Darlington restoration site is a highly modified river, with most channel features eliminated in order to control flooding in the town.

### 14.1 Aims

The aims of the river morphology monitoring programme on the Skerne are similar to those of the Cole. However, work on the Skerne complements the Cole study as restoration on the Skerne is taking place under much more constrained conditions. In particular, levels of flood defence service should not be compromised by the restoration scheme (and in fact a small improvement in protection is expected).

The main aims of the monitoring programme are:

- (i) To compare the morphometry of the old and restored channels.
- (ii) To assess the stability of restored channel sections.
- (iii) To assess channel sediment mobilisation and deposition, including evaluation of sediment release downstream.
- (iv) To provide information relevant to the restoration design.

This section of the monitoring programme is based on the catchment audit, and related work, undertaken by Malcolm Newson, Amanda White and Catherine Padmore (all Newcastle University). It also makes use of data collected during the land survey by Site Survey Services Ltd.

### 14.2 Methods

#### 14.2.1 River geomorphology

The main components of the geomorphological monitoring programme are:

- (i) catchment audit: describes the geomorphological context of the catchment, reviewing the existing geomorphology and factors which influence geomorphology (such as sediment sources and land drainage engineering).
- (ii) site-specific monitoring, including:
  - Sediment sampling to characterise the bed and banks of the old and new channels.
  - Transect surveys of the original and restored river channel at 100-m intervals and at closer intervals (10-15m) in selected sections.
  - Construction and post-construction monitoring at defined intervals of time. It is anticipated that survey techniques used will be similar to those used on the Cole.

#### Catchment audit methods

The catchment audit followed standard techniques used by the NRA., and reviewed a variety of catchment data. The channel planform was examined using four historical map series (1850 - 1860, 1923, 1940 - 1945, and the 1960s) at a scale of 1:10,560 and 1:10,000. The study reach of the Skerne was divided into 3 reaches for convenience:

- a) Ricknall Farm to the York to Berwick railway viaduct at Ketton

- b) York to Berwick railway viaduct at Ketton to road bridge at Great Burdon
- c) Road bridge at Great Burdon to Darlington gas works (includes the project reach)

Field survey was undertaken at 28 sites along the river where cross-sections were measured and sediment samples collected from the river bed and bank. Thirty sediment samples were taken during the fluvial audit of the Skerne; in many sections which were measured for channel dimensions it was not possible to reach bed and bank materials, though these were chosen on riffles or riffle equivalents (vegetated sections) for comparability. The bank sediments sampled were exposed (i.e. eroding) and at summer flow levels. Bed sediments were sampled in bulk from riffles.

Samples were analysed for particle size and heavy metal content. Field evidence and site-specific information was then used to assess current channel stability and the operation of the sediment system.

#### **Site specific survey work**

A land survey of the restoration site was undertaken during 1994. This provided cross-sections at approximately 100-m intervals on the existing channel.

More detailed instream physical habitat descriptions were made in a 150-m representative reach on the restoration site. This work was undertaken as part of a study of the PHABSIM physical habitat modelling technique undertaken by Catherine Padmore of Newcastle University. This project seeks to classify channels by habitat features and also provide field data for the application of the PHABSIM model in north-east England.

### **14.2.2 Floodplain geomorphology**

#### **Topographic survey**

The topographic survey of the floodplain of the restoration area was undertaken during August 1994. Contour intervals were in the order of 10-20cm, to give an accurate interpretation of surface topography.

#### **Aerial photographs**

Recent and historical aerial photographs have been inspected to review floodplain morphology. A new aerial survey of the site was undertaken in October 1994.

## **14.3 Catchment audit**

### **14.3.1 Catchment characteristics**

The Skerne catchment is about 250 sq km in area, and is largely boulder clay capped and low-lying with relatively good infiltration. Further basic information about the catchment is given in Chapter 13 (Background: Skerne).

### **14.3.2 Historical change in the Skerne catchment: map analysis**

The main course of the river was divided into three reaches for map analysis.

#### **Reach A Ricknall Farm to the York-Berwick railway viaduct at Ketton**

This section of the river is primarily agricultural in nature. Parts of the upper catchment upstream of Ricknall Mill appeared to have been canalised prior to the compilation of the 1850 map series.

1850 - 1923

The planform underwent various changes during this period. The channel was straightened from Ricknall Farm downstream to Demon's Beck, and the Beck's length extended to meet its new confluence with the Skerne. An old mill race at Aycliffe was abandoned in favour of the river's natural course. Downstream of Aycliffe straightening did not occur, but meander cut-offs from this period are in evidence: two occur where the river swung east at Brafferton Mill. There was also evidence of one meander which occurred 350m downstream prior to 1850, as the railway embankment had been constructed over the abandonment. These cut-offs would appear to have resulted from natural river processes.

It is possible that the cross-section was widened and deepened throughout the reach, but this is certain at Aycliffe village, possibly in response to higher volumes of flow.

Re-grading of the profile in this reach may have contributed to planform change during this period and straightening shortened the length of the river (see Table 13.2).

1923 - 1945

Very little further modification was in evidence between the 1923 and 1945 map editions other than the canalisation of the Demon's Beck.

1945 - 1960s

Channelisation of the formerly straightened reach from Ricknall farm to Demon's Beck was apparent. The river abandoned mill races, including that at Holme Mill, in favour of its natural course. There appears to have been a slight loss of sinuosity downstream of the motorway culvert, which might coincide with Archer's (1992) record of extensive re-grading and improvement works running until 1966. The cross-section may have been deepened as a result, and channel sides appear less irregularly shaped. The section upstream of the motorway culvert includes a reach which may be considered almost natural. It bears no resemblance to the rest of the river, having low, actively eroding banks in sand and gravel and being shallow with riffles and pools.

This may reflect a combination of factors. An increase in gradient, due either to downstream re-grading or geology or both, the river, having recently crossed the limestone outcrop at Aycliffe, drops more sharply and swings into the sands and gravels of its floodplain. There may even be an increase in supply of bed material to this section from the Aycliffe quarries (limestone and gravel).

**Reach B    York-Berwick railway viaduct at Ketton to road bridge at Great Burdon**1850 - 1923

Cut-offs were an important feature of planform change in the reach at this time, one occurring prior to 1850 at Horse Banks. The second consists of a major by-pass of a highly sinuous and meandering section at Sandy Holm, which left Ketton Bridge stranded. The abandoned section was even straightened to become a ditch. A small cut-off, - apparently a natural response, perhaps to alterations upstream - occurred 100m downstream of this.

This activity again shortened the long-profile of the Skerne, and the cross-section of the reach was increased as embankments raised along the Barmpton stretch increased the flood capacity of the channel.

1923 - 1945

Large meander cut-offs which occurred on the east side of Elly Hill seem artificial in their scale and straightness. Re-alignment was also carried out on a meandering section previously by-passed by Great Burdon Mill Race. This also implies a degree of cross-sectional alteration and shortening of river length.

1945 - 1960s

Further re-alignment work was carried out between Ketton and Barmpton, and the River abandoned its straightened but natural course in favour of Great Burdon Mill Race. This coincides with re-grading work noted by Archer (1992).

**Reach C     Road bridge at Great Burdon to Darlington gas works (includes the project reach)**

Historical changes in the reach which includes the restoration site are described in Chapter 13 (Background).

**14.4     The contemporary channel: planform and section**

The contemporary Skerne channel is almost entirely man-made, with a sinuosity of 1.09 - i.e. virtually without conventional or natural planform features. Exceptions include a couple of short reaches above and below Barmpton village, a longer reach below Hall Garth, and the only truly 'natural' reach, between the A1M culvert and the Fujitsu site at Aycliffe. Interestingly, these short sections also include contemporary sediment sources, as the bends migrate slowly by lateral erosion (because the bank materials are dominantly cohesive clays) and riffle-pool sequences which act as hydraulic (and hence habitat) controls. Elsewhere, in summer the main longitudinal hydraulic controls are either artificial obstacles such as weirs or bridge piers or, more commonly, large patches or islands of weed growth. The main sediment sources include gravels from the bed and banks where glacial materials form the channel boundaries and silts/clays from urban sources or from the sub-aerial weathering (wetting/drying or freezing/thawing) of the near-vertical banks.

Channel bed width and depth to bankfull levels were measured at 28 cross-sections between the lower end of the project reach and Ricknall Farm. Figure 14.2 shows that there is very little pattern to the channel width in relation to distance downstream from the source of the Skerne. It is often possible to use a regression approach based on 'natural' cross-sections to design (or restore) channel dimensions, but in this case there is no prospect of obtaining such information. The influence of engineering for flood protection is shown in Figure 14.3, where the channel capacity is shown to have a huge scatter and no significant trend against downstream distance.

The severe modification of the channel meant that there were no sites where the modern planform and sectional geometry of the Skerne could be used to aid the design of the restored reach; consequently, the results of the catchment audit suggest that it is necessary either:

- (i) To use the historical information derived from map studies of the catchment to prepare restoration designs.
- or
- (ii) To extend the study to an un-altered channel at a similar distance from its source and under similar climate and parent materials in the Darlington area.

Since the latter course was, effectively, impossible, the design was necessarily guided by old maps of the Skerne catchment.

## 14.5 Channel sediments: sources and sinks

### 14.5.1 Bed and bank sediments

There was a distinct fining of bed materials downstream, though this did not become pronounced until Barmpton village (see Figure 14.4). Gravel continued to feature in bed materials below here, but it was increasingly joined by sand and by fines (silts/clays).

By contrast, bank materials change very little, the most obviously exceptional sample being that from the boulder clay section above Aycliffe (Figure 14.5).

### 14.5.2 Bank structure on the Skerne

Because of the fine, cohesive nature of the bank materials, they are much less erodible by flow shear than would be the case of coarser alluvium; engineered channels in these coarser materials frequently suffer problems of bank stability but there are no indications of severe bank erosion on the Skerne. In summer most bare faces are covered by tall vegetation. Stable tree-lined reaches are rare, but around Aycliffe the riparian vegetation corridor is much more dense - elsewhere, grazing or arable agriculture extends to the bank tops. Only rarely do the farm fences show signs of being destroyed by channel migration. Bank protection appears to have been minimal, although south of Hall Garth the owners of a golf course on the west bank have attempted to gain ground from eroding outer bends by dumping stone prior to creating in-channel benches to add to the interest of their greens. This is associated by the landowner on the opposite bank with an increase in bank instability on that side.

Because of the paucity of contemporary sediment sources, there is, therefore, little pattern to the resultant transport/morphological system. As mentioned above, riffle-pool sequences are virtually restricted to a higher gradient reach in mid-catchment where the channel entrenches boulder clays. Guidance to restoration design is again hard to divine, except that the fine-grained alluvium of the Skerne floodplain appears to make moderately stable banks even where near-vertical, and that gravels are a feature of riffles throughout the catchment; however, there is no contemporary source for them in the lower reaches where restoration will occur. The dilemma must be, therefore, whether to introduce gravel riffles as part of restoration; they may well be transported out or infilled with fines.

## 14.6 Design considerations and maintenance of a restored Skerne reach

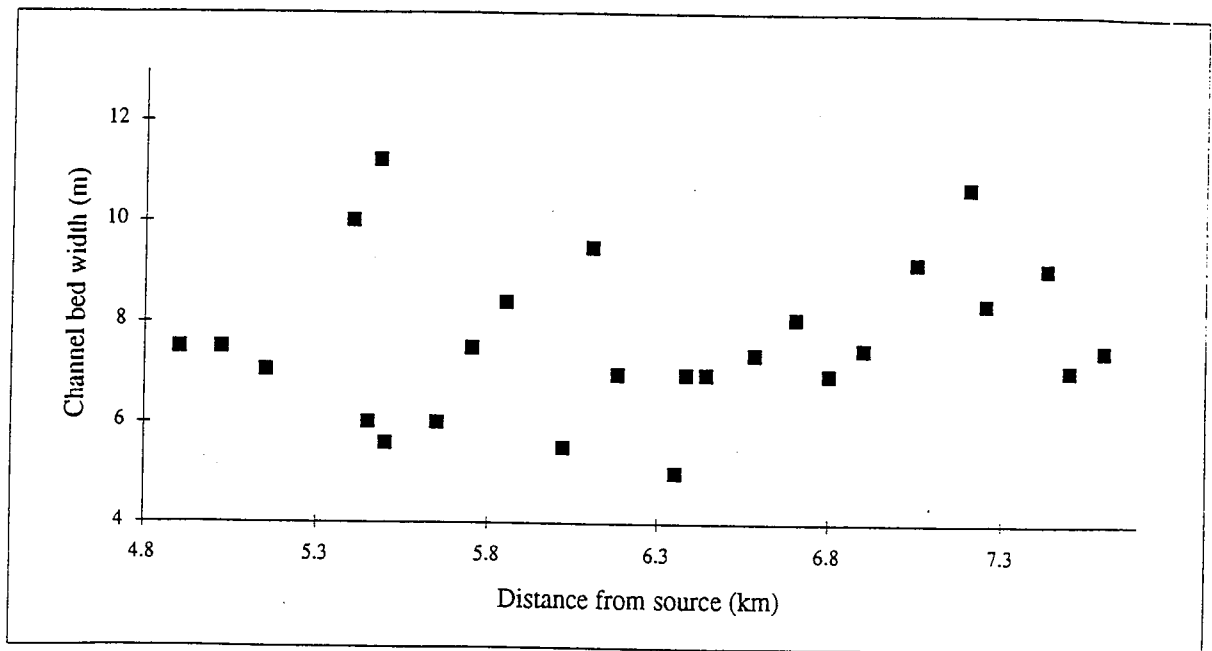
The audit enabled the following conclusions to be drawn about the design of the restoration scheme:

- (i) In terms of in-channel habitat features, the restoration reach and those immediately upstream lack diversity as a result of successive flood defence schemes. They lack sinuosity but also the natural hydraulic controls provided by stores of actively-transported coarse sediment; control has passed in summer to the high concentration of macrophyte vegetation and it is essential to make further inspections as soon as this dies back.
- (ii) There may be two reasons for the lack of physical features in the river (other than the natural low gradient of the whole catchment) - both relate to the reduced sinuosity of the contemporary Skerne. One is that meandering was formerly an active process, supplying sediments for transport by the river (and hence deposition at periodic intervals). The other is that hydraulic resistance patterns produced by a meandering channel located the riffle-pool sequence in a regular pattern. The re-introduction of sinuosity in the restoration reach alone may not, alone, create better habitat (except by increasing length).
- (iii) It is difficult to provide guidance to those designing the restoration on channel dimensions because there are no contemporary analogues where the gradient is similar to that of the restoration reach. For an 'artists impression' of the potential of the restoration reach, it is worth considering the reach between the AIM culvert and the Fujitsu factory but it is unlikely that the restoration reach can be accorded sufficient gradient to create active bed features. Rather,

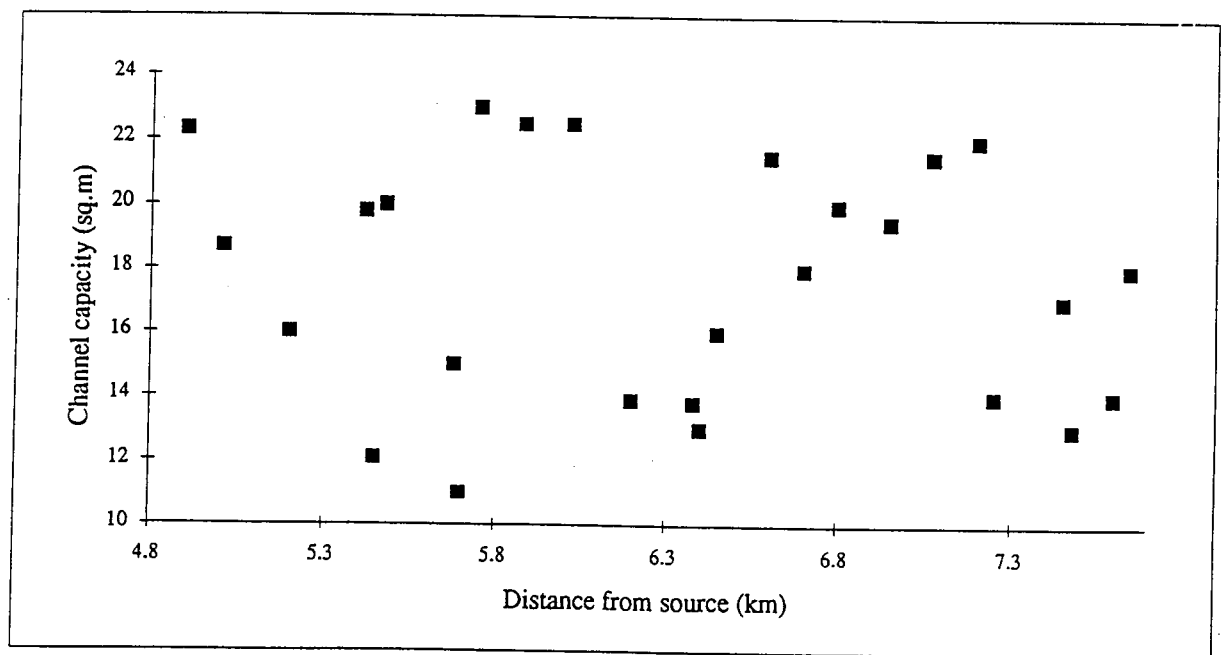
a purely hydraulic design based upon desirable landscaping features and static fish habitat features may be the best approach. As part of this, the historical planform of the lower Skerne can be used as guidance, but extreme care is necessary in new excavations to avoid unstable materials in the made-ground of the modern floodplain.

- (iv) Sediments in the restoration reach, which contain lead, zinc, cadmium, copper, manganese and iron in significant concentrations, are likely to be disturbed or redistributed during the restoration works. As it is difficult to judge how available these metals will be biologically, a precautionary approach is required to the physical disturbance of the sediments and to chemical water quality which might result from the full restoration programme.

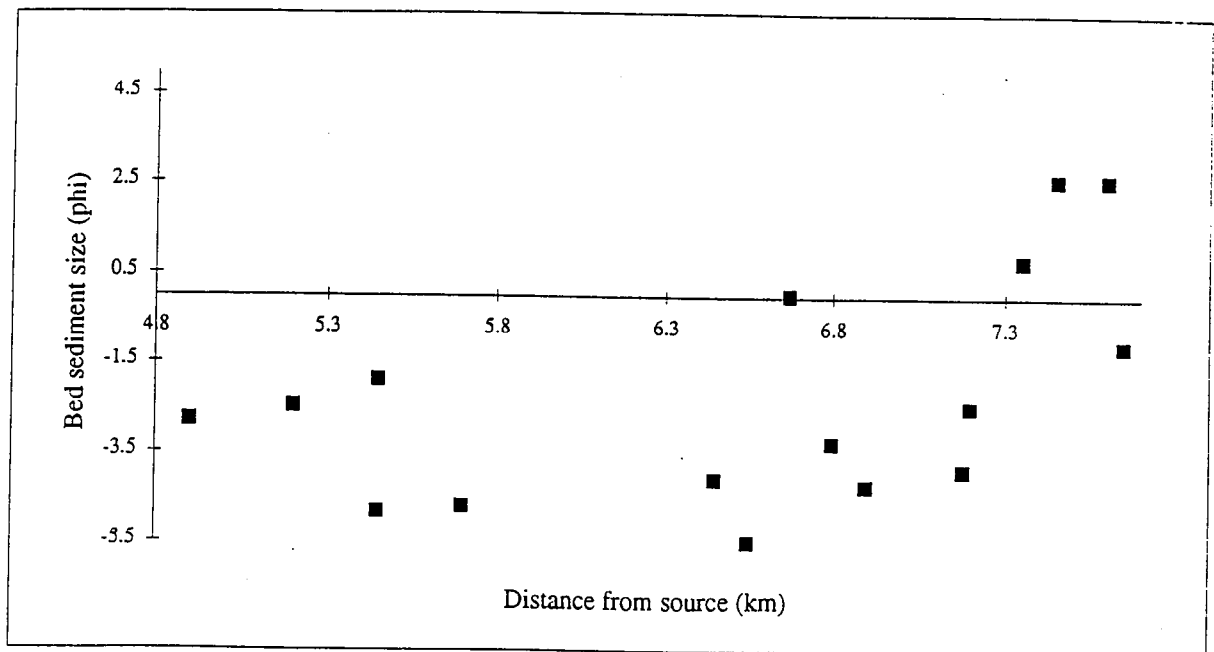
**Figure 14.2** River Skerne: Channel width (m) v distance downstream (km)



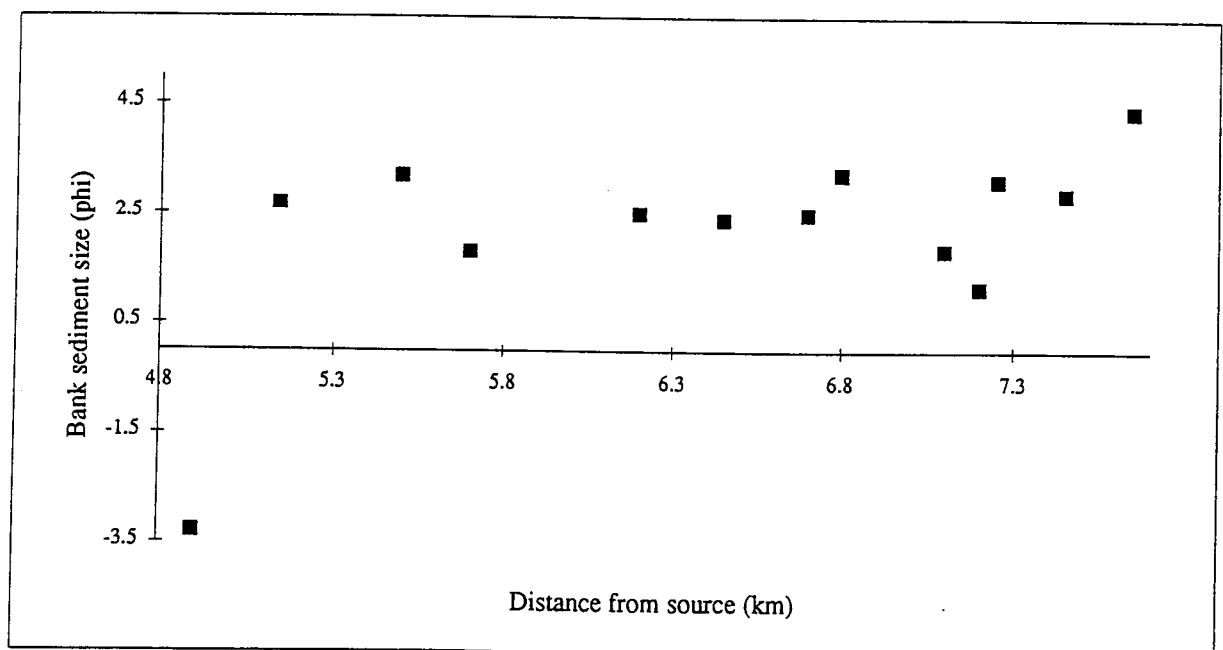
**Figure 14.3** River Skerne: Channel bankfull capacity (sq.m.) v. Distance downstream (km)



**Figure 14.4** River Skerne: Bed sediment size (phi scale) v distance downstream



**Figure 14.5** River Skerne: Bank sediment size (phi scale) v distance downstream



## 14.7 The morphology of the restoration reach

### 14.7.1 Introduction

Detailed measurements of the current channel morphology were made in a representative section of the Skerne, in the upper section of the restoration reach.

### 14.7.2 Survey methods

Physical habitats were recorded over a 150-m reach on 15 transects 10m apart (except transects 1 and 2, which were 5m apart).

The location of the reach investigated is shown on Figure 14.1

Transects were marked with wooden pegs at bankfull level. Water depth, mean velocity (assumed to be at 0.6 x recorded depth) and substrate were recorded at 1-m intervals across the channel. Width:depth ratios were calculated.

The presence of any major obstructions to flow were also recorded. Over much of the reach, the main flow obstruction was dense stands of Fennel Pondweed (*Potamogeton pectinatus*).

Water levels were also surveyed at the left bank for each cross-section. This allowed water surface slope and bed gradient to be calculated at each cross-section.

### 14.7.3 Results

There was very little variation in the physical structure of the survey section. The mean width of the channel in the survey section was 9.38m, with a mean water depth of 0.63m. Although there were some slight variations in bed level, these were mainly due to the presence of dumped rubbish, such as bricks and concrete, rather than to natural variations due to riffle units.

At the time of survey velocities within the reach were, as would be expected, low.

Vegetation reduced water depth and increased the width:depth ratio. The two shallowest transects had the greatest proportion of gravel in their substrates, with about 35%. Most transects of intermediate depth had a smaller proportion of gravel (10 - 15%). Four of the 15 transects had no gravel.

Vegetation appeared to increase the range of water velocities occurring. In other words, in the absence of inert morphological features, the dense stands of vegetation did create some physical habitat diversity.

## 15 Landscape assessment: Skerne

The landscape assessment for the River Skerne was undertaken by SGS Environment. The following information, figures, drawings and photographs draw directly from their report.

### 15.1 Aims

The main aim of the landscape assessment was to provide baseline data for the monitoring programme. This consisted of:

- (i) describing and classifying the landscape of the restoration sections into elements or character areas
- (ii) undertaking an evaluation which identified individual management needs of each area, noting whether landscape areas/features in the river restoration section should be conserved in their current form or modified.

### 15.2 Methodology

#### 15.2.1 Landscape Assessment

The process of describing, classifying and evaluating landscapes was achieved using three methods:

- (i) inventory/description: a factual documentation of the landscape, including a description of character, the elements which contribute to this, and their interactions. In order to convey the essential character of landscape or its sense of place, aesthetic and perceptual factors are included in the description, and this involves subjective judgements;
- (ii) classification: a division of the study sites into landscape areas which have distinct and recognisable character, and grouping together areas of the same type. This involves a considerable degree of professional judgement;
- (iii) evaluation: a judgement of the relative value of different areas of landscape, or of different features within them and assessment of appropriate management strategies.

The assessment followed standard NRA landscape assessment methods (NRA, 1993). These methods were modified slightly to fulfil some of the specific requirements of the demonstration project:

- (i) The broad visual envelope of the river corridor and the various Local Authority initiatives in respect of landscape, recreation and conservation objectives were considered in some depth in order to provide a logical integration with the detailed proposals for modification to the river channel, as formulated by the River Restoration Project
- (ii) The study area boundary generally follows the visual envelope of the river corridor as defined by landform and development edge. However, two additions to this were recognised: the open space immediately to the east of the main-line Railway running northwards adjacent to the Rockwell housing area, and the open space running south between the Keepsafe site and the Devonshire Road housing area.
- (iii) The 'macro-landscape' assessment was reduced in scope to provide a strategic landscape context for the immediate study area rather than the wider catchment area of the River Skerne. Macro, micro and detailed landscape assessments were undertaken. This involved the completion of detailed survey forms and the taking of panoramic photographs.
- (iv) Because of the relatively short section of river valley under consideration and the specific purpose of the landscape assessment, it was decided to carry out a more focused survey, using

1:5000 plans for the macro and micro assessments and 1:2500 for the detailed assessment instead of the 1:25000, 1:10000 and 1:5000 suggested by the NRA.

The 2-km stretch of river was divided into sections. These were either defined by important landmarks, or by a change in character of the river corridor. In all cases the reaches did not exceed the 500-m length suggested in the NRA methodology.

### **15.2.2 Macro-landscape assessment field survey**

Viewpoints were selected and a structured survey was undertaken of the key landscape elements:

- dominant landscape elements forming the main influences on landscape character;
- historical, cultural and other special associations which also influence landscape character;
- a brief description encapsulating the essential character of the landscape;
- first impressions of the aesthetic and perceptual characteristics of the landscape.

A field evaluation was then carried out noting the condition of landscape elements, pressures affecting the landscape and priorities for action for:

- land use and settlement;
- tree cover and open space;
- recreation and amenity features, pathway and desire lines;
- other features.

The area was ascribed to the appropriate value class and management strategy.

### **15.2.3 Micro landscape assessment field survey**

This assessment was carried out in parallel with the Macro Survey.

The following items were recorded in each of the zones identified:

- a general description of the landscape character within the sample stretch;
- overall impressions of the river banks and margins;
- particular features in the river corridor;
- a visual assessment of water quality;
- an evaluation of quality and the appropriate management strategy.

### **15.2.4 Detailed Assessment**

This assessment involved making judgements in the form of target notes following the completion of the survey sheets, and covered the following aspects:

- features which are essential to conserve, both man-made and natural;
- the presence or absence of features which are characteristic of the macro and micro river landscape areas, as defined in the strategic assessment;
- opportunities for enhancement, relating separately to the river itself, the river banks, and peripheral areas including points covered by the macro assessment.
- actions were assigned to the categories of 'Restoration', 'Conservation', 'Enhancement' and 'Management'.

### **15.2.5 Analysis and Reporting**

Material gathered in the field was collated, reviewed and analysed. Each of the six areas has been described in terms of its landscape character highlighting key features.

### **Evaluation**

A professional judgement about the value of each area was made. There are no comparable NRA landscape assessments to which to refer; nor do any County landscape assessments covering areas within major settlements exist.

Management strategies for each zone were developed within the 'conservation', 'restoration' and 'enhancement' framework. Design ideas were developed bearing in mind the constraints identified and the detailed input on the immediate river corridor provided by the River Restoration Project Skerne Working Group.

The broad financial implication of these measures was assessed, and an indication of the order of cost assigned to each proposal.

### **15.2.6 Illustrations (Figs. 15.1 - 15.27)**

Survey and Visual Analysis plans indicate existing conditions and their impacts, although they do not include detailed items such as services because of the restrictions of scale. The Macro Landscape Assessment plan covers the area of study, and character sketches are provided for each section of the reach (Figs. 15.8 - 15.15).

A Micro Landscape Assessment plan indicates the landscape character within the immediate river corridor (Figure 15.16). Detailed Sheets summarise specific targets for each section in terms of notes which are keyed to plans.

The Landscape Strategy Plan identifies the major opportunities for restoration of the river and its landscape context (Figure 15.17). Photographs (Figures 15.18 - 15.27) provide an overview of existing conditions and character within each section in November 1994.

### 15.3 Micro landscape assessment (Figs. 15.9 - 15.27)

Figure 15.16 describes the landscape character within the immediate river corridor. This indicates that the majority of the reach has a suburban open character, although there are significant stretches of semi-natural enclosed and some suburban enclosed areas. The plan also summarises the evaluation of character within each section. Over a significant part of the reach, the corresponding left and right banks have dissimilar character.

Figure 15.9 provides a key to the character sketches (Figs. 15.10 - 15.15) and the photographs (Figs. 15.17 - 15.27) which cover the major features and provide an overview of existing conditions in each section in November 1994. No aquatic vegetation and little herbaceous material was visible at the time of the survey in November. The figures referred to in each Section refer to the relevant character sketch and sheet(s) of photographs.

#### 15.3.1 Section 1 - Skerne Bridge to Albert Bridge (Figs. 15.10 and 15.18)

##### River channel/banks

The channel has a largely silty bed, with a few boulders. The river flows smoothly along a canalised straight channel which has a large retaining wall on the left side and a steep solid embankment on the right bank.

##### River margins

The setting is predominantly urban and includes unattractive industrial premises, as well as an historic railway bridge. There are some significant trees at the water level at the foot of the retaining wall, and a few on the embankment.

##### Appearance of water

The water is discoloured with some debris.

##### Notable/characteristic features

The major features are man made: the historic railway bridge, the road, the retaining wall with the unsightly black pipes, the engineered embankment and the predominantly non-native trees.

##### Landscape character

The area has a degraded industrial, urban enclosed character on the left bank with semi-natural vegetation enclosing the reclaimed right bank.

##### Evaluation - Grade 3/4 Restoration/Enhancement

The existing vegetation is the only positive element within the degraded area. Opportunities for channel restoration are restricted by the existing retaining wall and topography to the creation of riffles and pools. Selective macrophyte control, planting and the creation of nesting platforms were suggested in the River Corridor Survey Report.

### **15.3.2 Section 2 - Albert Road to the Western Edge of the Allotments (Figs. 15.11 and 15.19)**

#### **River channel /banks**

The channel is smooth with generally slow-flowing water containing a riffle. The fairly straight course is canalised with sections retained by gabions on both sides.

#### **Margins**

Medium-quality new housing, a recently landscaped gap site, and unsightly industrial buildings provide a medium to poor quality urban setting. The section includes amenity tree and shrub planting on the sloping grass area on the right bank, and on the left bank a steep embankment covered with semi-natural woodland.

#### **Appearance of water**

The water is discoloured, with no vegetation in evidence.

#### **Notable/characteristic features**

The most notable features are the trees on the industrial embankment and the large willows on the riverside.

#### **Brief description and landscape character**

The area has a semi-natural character on the left bank, changing to an urban open parkland appearance on the right bank.

#### **Evaluation - Grade 2/3 Conservation/Restoration**

Opportunities for radical restoration works are limited by landform, but in-channel improvement could include the creation of riffles and pools and on the bank, and small wetland areas could be created on flatter areas. Tree management should be implemented by way of selective felling and pruning to increase light levels, and new planting should be carried out to increase diversity.

### **15.3.3 Section 3 - East Edge of Allotment to Five Arches Bridge (Figs. 15.12, 15.20 and 15.21)**

#### **River channel/banks**

The channel has a silty, smooth bed with a few boulders. The river flows slowly along a canalised channel which has gabion walls along some of its length, and steep banks elsewhere.

#### **River margins**

The setting is low-quality urban, including allotments, poorly-contained housing located on an elevated plateau, and industrial premises. The industrial units are distanced from the corridor by a densely tree covered embankment containing deciduous species. The river is generally lined with trees of a mix of indigenous and exotic species.

#### **Appearance of water**

The water is discoloured and lifeless, with some debris.

#### **Notable/characteristic features**

The notable man-made features include an ugly culvert which has highway-type guard-railing edging the river, the attractive Five Arches Bridge, a large concrete retaining wall adjacent to a steep embankment,

remnants of fencing, and manholes which stand in excess of 1m above ground level. In addition, the tree cover adjacent to the river is particularly strong in this confined corridor, and within this there are some exceptional poplars and willows.

#### **Landscape character**

The area has a complex, visually confusing character, changing from urban enclosed to semi-natural enclosed and back to urban enclosed on the right bank. The left bank is a contrast to this, consisting of an attractive green corridor of semi-natural vegetation.

#### **Evaluation - Grade 3 Restoration**

The existing trees and the Five Arches Bridge are positive elements within this degraded section. Opportunities for enhancement of the river channel are restricted by the existing topography and retaining walls but, as in Sections 2 and 3, riffles, pools and the creation of adjacent wetland areas could be incorporated. Selective felling and pruning of trees and new planting should be implemented.

### **15.3.4 Section 4 - Five Arches Bridge to Rockwell (Figs. 15.13, 15.22 and 15.23)**

#### **River channel/banks**

The river continues to have a canalised appearance, but now follows a sinuous line. The bed is silty with a few pebbles, the banks have a uniform profile with steep sides, and the flow is slow.

#### **River Margins**

Development is situated some distance from the water course, and this consists of large unsightly industrial units on an elevated plateau on the left bank and housing on rising ground on the right bank. The area on either side of the channel is complex, containing a range of vegetation including recent tree planting, largely deciduous, on the industrial embankment and adjacent housing, the wetland and the railway embankment of the Rockwell Conservation Area.

#### **Appearance of Water**

The water is discoloured, with little or no debris.

#### **Notable/Characteristic Features**

The major man-made features include the Five Arches Bridge, the railway embankment and the ugly electrification gantries. The ecologically rich Rockwell Conservation Area, a clump of willows on the right bank, and the developing tree belts are positive features.

#### **Landscape Character**

The character has a predominantly urban open feel which is relieved by the semi-natural vegetation of the Conservation Area.

#### **Evaluation - Grade 3/Restoration**

The existing area of nature conservation interest is the most important and sensitive area. Opportunities for restoration to the channel are constrained by the conservation area itself and an area believed to be contaminated on the left bank. However, reducing the angle of the banksides and the creation of conditions for marginal plants should be explored in conjunction with the formation of a more varied longitudinal section. Priority should be to achieve a relationship between the Conservation Area and river. A boardwalk may be necessary to maintain the riverside path. In addition, the control of Himalayan Balsam in this area is a priority.

### **15.3.5 Section 5 - Rockwell to Old Hedgerow on the Southern Bank (Figs. 15.14, 15.24 and 15.25)**

#### **River channel/banks**

The river follows an almost straight course along a canalised smooth channel. The bed is silty, the flow slow and the river banks have a uniform profile with steep sides.

#### **River margins**

The wide straight floodplain has few trees, set in a sterile landscape of mown amenity grass. Large industrial units are located on a distant, elevated plateau and housing on rising ground on the right bank.

#### **Appearance of water**

The lifeless water is discoloured with little evidence of debris.

#### **Notable/characteristic features**

The most notable features are the engineered channel and its setting. There are also some ugly outfalls. The two large willows represent the only notable positive attributes.

#### **Landscape character**

The reach has an overwhelmingly unnatural, engineered character, lacking in diversity and richness.

#### **Evaluation - Grade 3 Restoration**

There are very few positive features, and great opportunities for a wide range of state-of-the-art restoration techniques. These could include creating meanders, and variations in width and depth of the channel and type of substrate to create a diverse range of vegetation and habitats. In addition, tree planting and better improved access along the riverside should be incorporated into a radical redesign of the river and its landscape setting which would include a fundamental change of management of the public open space.

### **15.3.6 Section 6 - Old Hedgerow/Hutton Avenue Footbridge to Haughton Road (Figs. 15.15, 15.26 and 15.27)**

#### **River channel/banks**

The river is reasonably straight, running in a canalised channel. The bed is silty, the flow slow and the river banks are uniform and steep. There is also a pronounced terrace on the left bank as a result of flood defence works.

#### **River Margins**

Mediocre quality housing provides an unattractive suburban setting. The riverside is largely treeless, set in a context of closely-mown grass with the occasional young tree. A smallholding edges a significant length of the right bank.

#### **Appearance of water**

The lifeless water is discoloured and largely free of debris.

#### **Notable/characteristic features**

The unsightly concrete Hutton Avenue footbridge which supports a black gas-pipe stands out in this featureless reach. The river terracing, some culverts, and a corrugated iron fence add to the poor visual quality. Haughton Road is also a major visual detractor and source of noise. A clump of trees on the right

bank near Haughton Bridge represents the only positive feature.

### **Landscape character**

The character is one of degraded suburban parkland.

### **Evaluation - Grade 3 Restoration**

There is a lack of positive features, and existing services and the smallholding provide significant constraints to any restoration proposals. Opportunity should be taken, where possible, to create a more natural river profile within these constraints. In addition, planting and a change in management would increase diversity. The Himalayan Balsam, as in all sections, requires control.

## **15.3.7 Summary**

Figures 15.1 - 15.5 (below) summarise the quantitative analysis of the assessment which forms part of the baseline information. Each section of the reach has been broadly evaluated in terms of landscape character and of the overall management strategy required. As the corresponding left and right banks have dissimilar characters, the assessment is based on evaluating both sides separately and dividing the figures in half in order to relate it back to the length of the section.

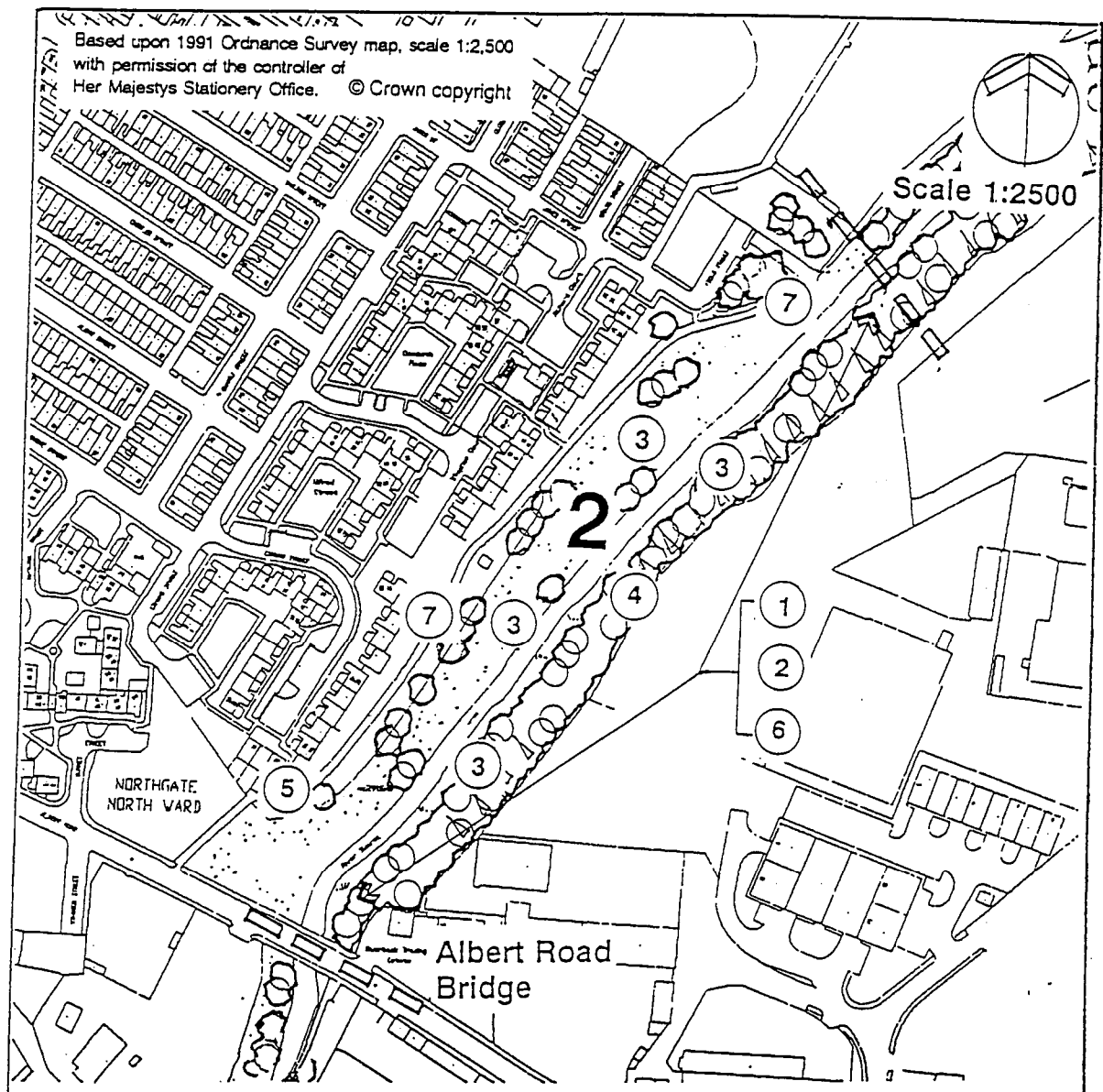
The evaluation for each section indicated in the text and Figure 15.16 shows the value class and management strategy, which can cover more than one category. The tables indicate a breakdown within each category. When a relatively small percentage is recorded in the tables, then this is ignored in terms of the evaluation shown in the text.

The majority of the river corridor falls within Value Class 3 (72%) and into Management Strategy "Restoration" (77%).

## **15.4 Detailed landscape assessment**

In order to satisfy the particular requirements of the brief, items within the entire area of study are included within the target notes in the following figures. The notes summarise the main points from both macro and micro survey work.

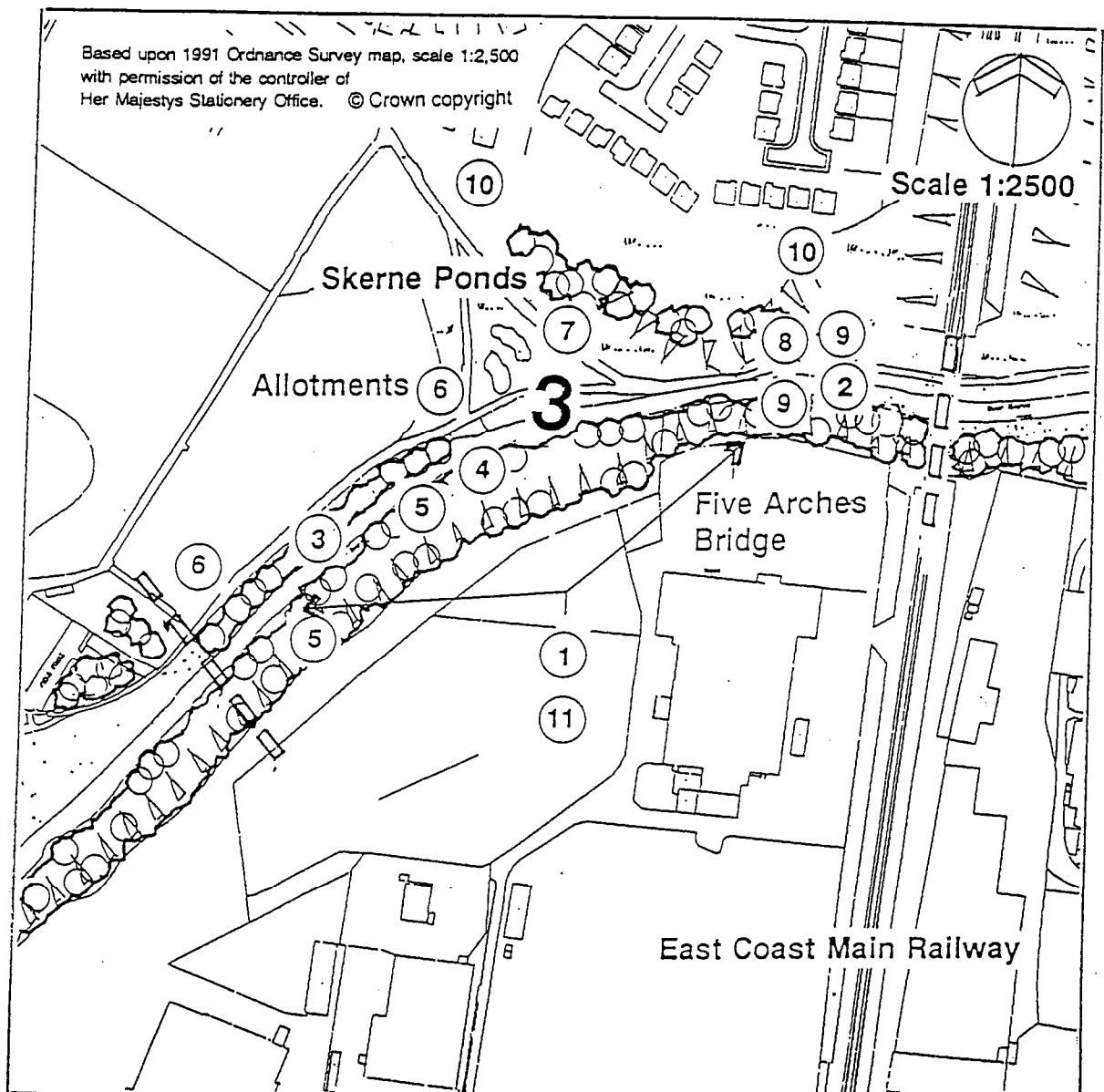
**Figure 15.1. Extract from Detailed Landscape Assessment. Section No.2. Albert Road Bridge to the Western Edge of the Allotments**



#### Detailed Survey

The right bank has a gentle slope with housing defining the visual envelope. This fronts onto a public open space which is largely mown grass with groups of mainly exotic trees and shrubs. Significant groups of trees, largely willow, are located on the bankside. The left bank has a steeply sloping embankment leading to an industrial plateau which consists of semi-natural planting. There is no formal river edge path although opportunity exists to provide a route from the top of the right bank along the river and under Albert Road Bridge, avoiding the crossing of a busy road and informal path on the left bank. The river has a smooth canalised channel and the water is discoloured.

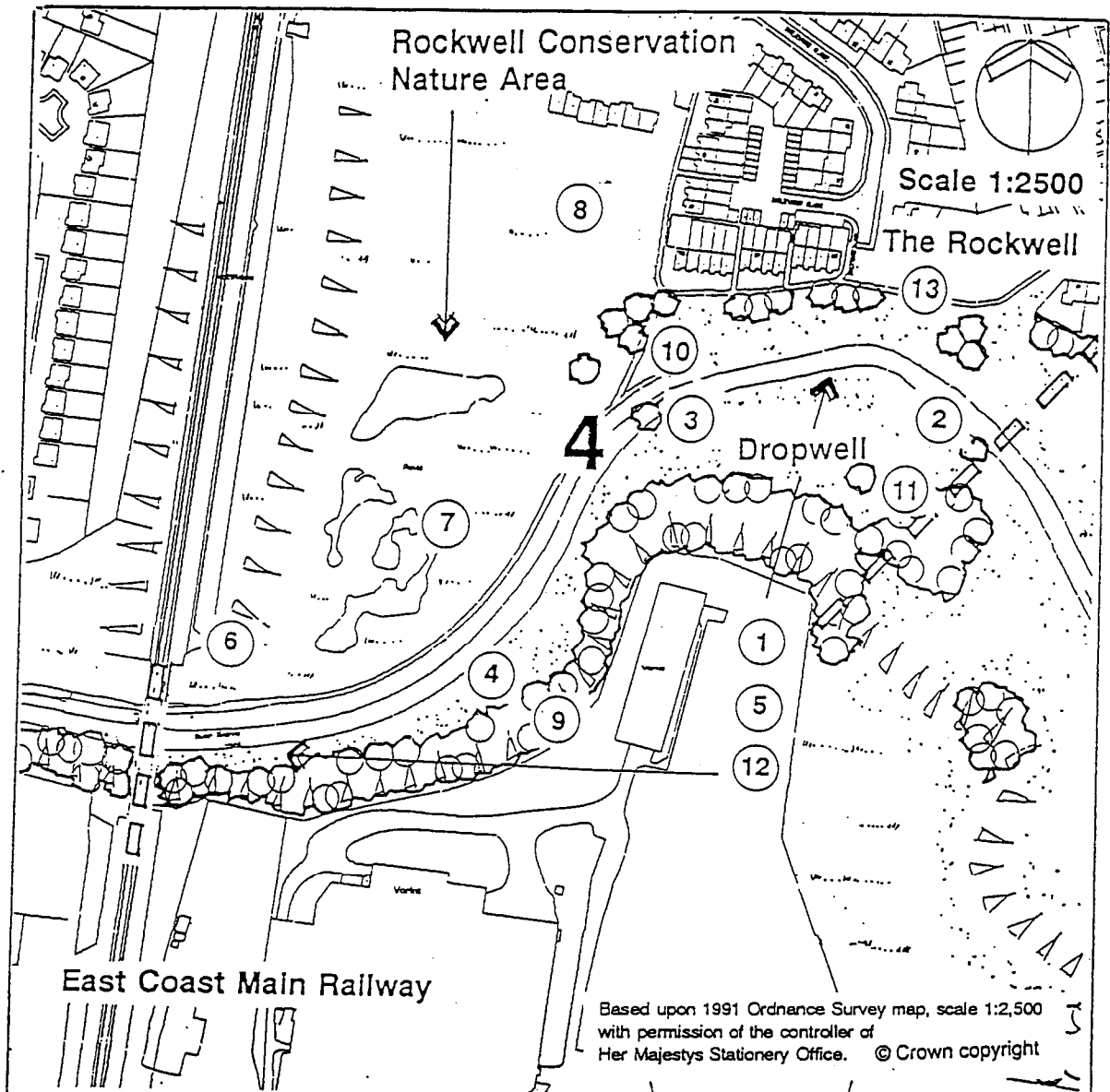
**Figure 15.2. Extract from Detailed Landscape Assessment.  
Section No.3. East Edge of Allotments to Five Arches Bridge**



#### Detailed Survey

This section contains a series of different spaces on the right bank with a fairly uniform appearance on the left bank. On the right bank, the path runs on an elevated route adjacent to allotments in a tight corridor dropping down to the culvert where the space opens to an informal area before tightening as the path approaches Five Arches Bridge owing to a major embankment and retaining wall. The left bank has semi-naturalised planting on a steep embankment leading to an industrial plateau. The river has a uniform profile with a canalised edge.

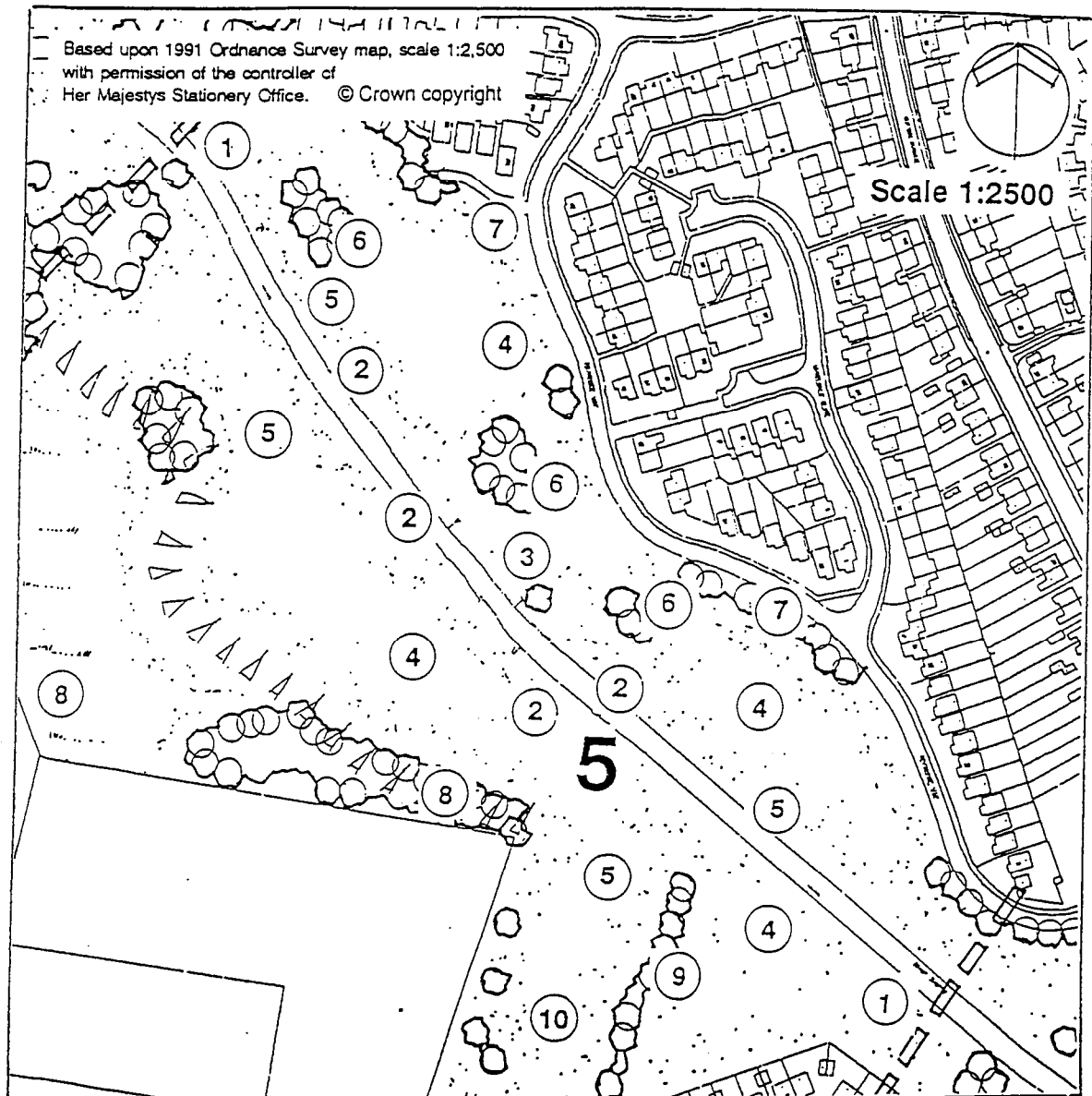
**Figure 15.3. Extract from Detailed Landscape Assessment.  
Section No.4. Five Arches Bridge to Rockwell**



#### Detailed Survey

The right bank has three major areas. Adjacent to housing there is a belt of trees and mown grass down to the river. Downstream is the Nature Conservation Area which contains a series of pools and rising from this is the railway embankment which provides spectacular views of the river corridor. The left bank consists of a steeply sloping embankment leading to an industrial plateau and contains a flat mown grass edge adjacent to the river. Although the river curves it is canalised with little evidence of marginal vegetation. There may be scope for restoration of the left bank to reunite it visually and ecologically with the right bank.

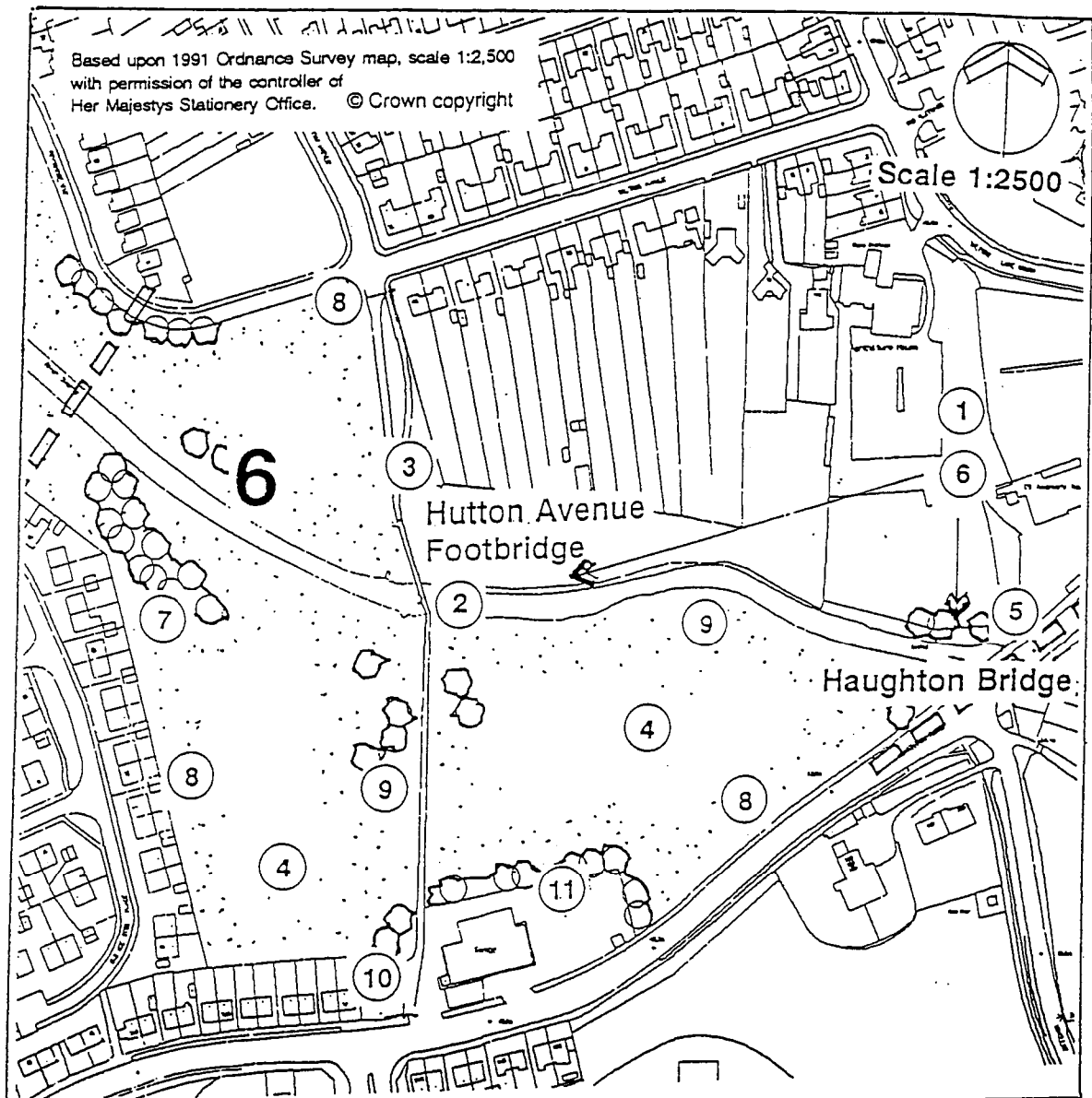
**Figure 15.4. Extract from Detailed Landscape Assessment. Section No.5. Rockwell to Old Hedgerow on the Southern Bank**



#### Detailed Survey

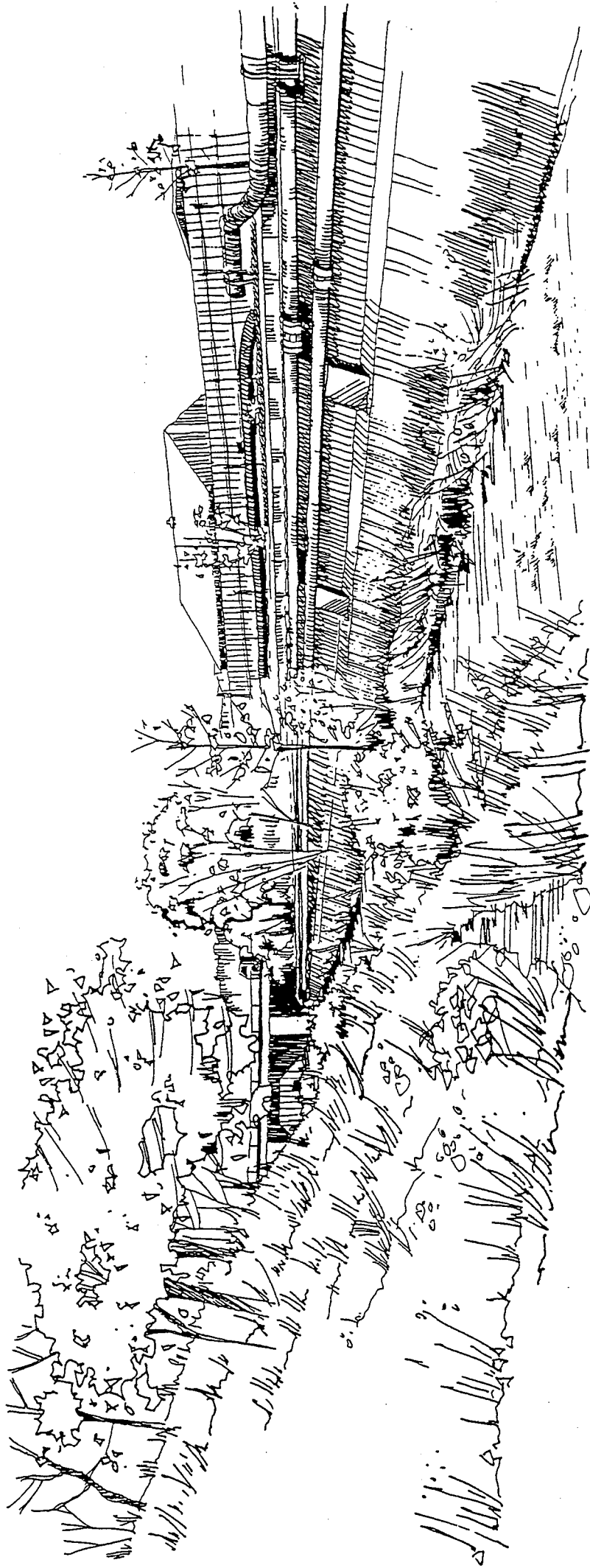
The river within this section has been dramatically straightened and canalised and has little evidence of marginal plant life. Both banks have large flat expanses of featureless mown grass. There are no formalised paths despite both sides being well used by walkers and cyclists. The visual envelope of the right bank is defined by housing which as a well established tree belt in places and the left bank is defined by the industrial plateau where large buildings dominate the skyline. This section offers considerable opportunity for river restoration and these proposals should be linked with a radical redesign of the corridor in terms of access and planting.

**Figure 15.5. Extract from Detailed Landscape Assessment. Section No.6.  
Old Hedgerow on the Southern Bank to Houghton Road**



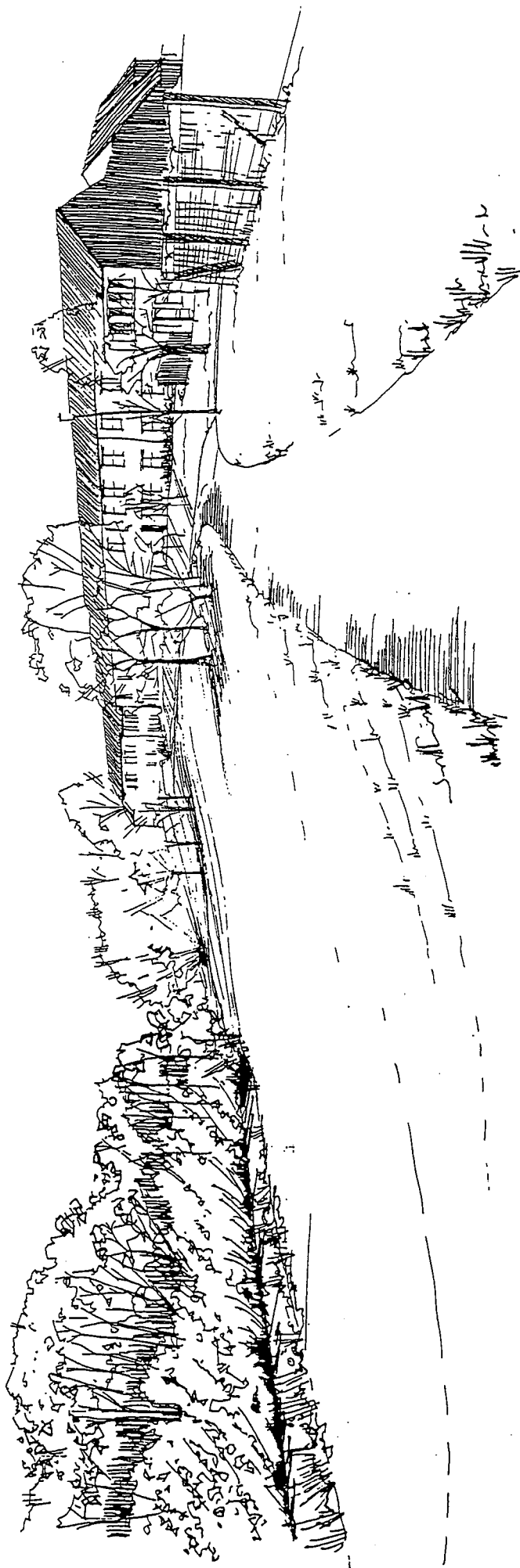
#### Detailed Survey

The section has been subject to flood defence work and has a pronounced terrace on one side of the left bank. There is little evidence of marginal vegetation and no riverside trees. The left bank consists of a large area of gang mowed grass with occasional small trees. The housing and road edges are weak and impart a poor visual quality to this section. The right bank is largely in private ownership. Opportunities for river corridor restoration are severely limited by existing gas pipe and private ownership.



## River Skerne Landscape Assessment

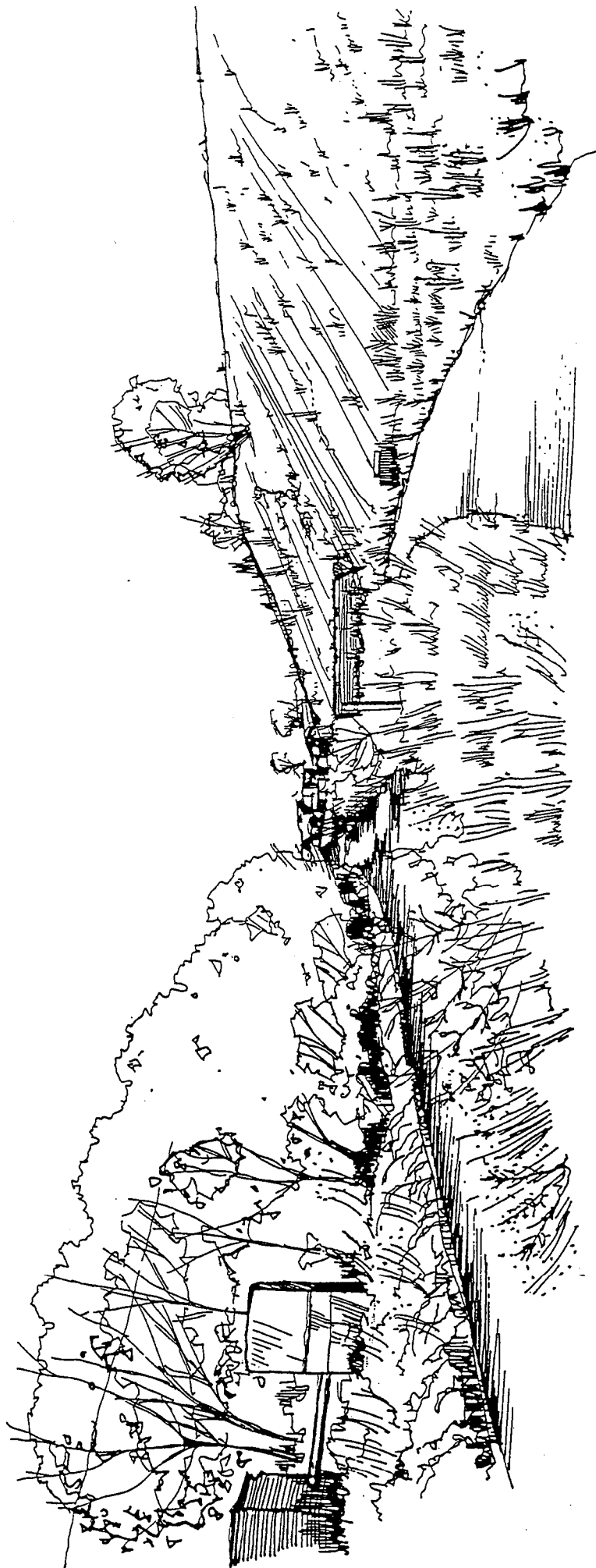
Figure 15.10 Character Sketch - Section 1  
Skerne Bridge to Albert Road Bridge



## River Skerne Landscape Assessment

Figure 15.11 Character Sketch - Section 2

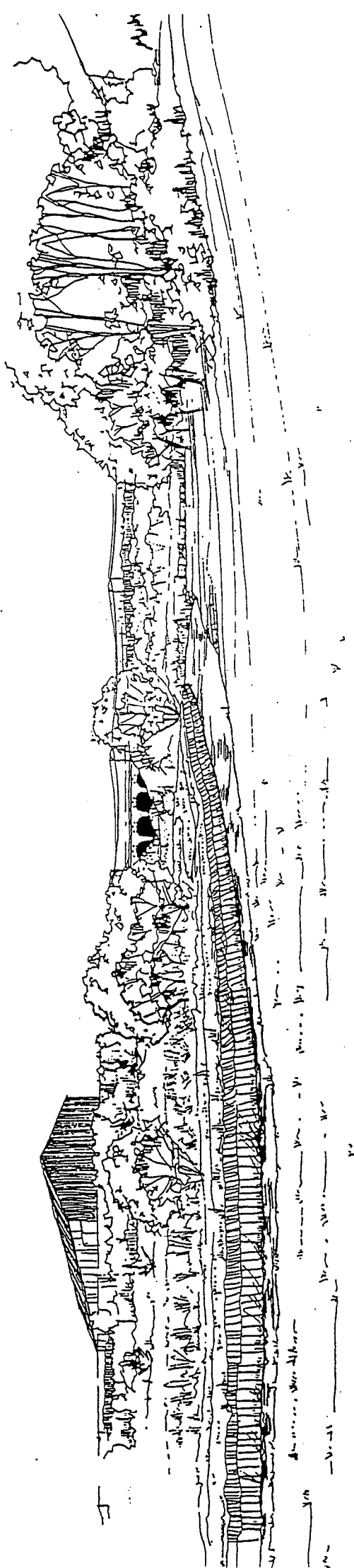
Albert Road Bridge to the Western Edge of the Allotments



## River Skerne Landscape Assessment

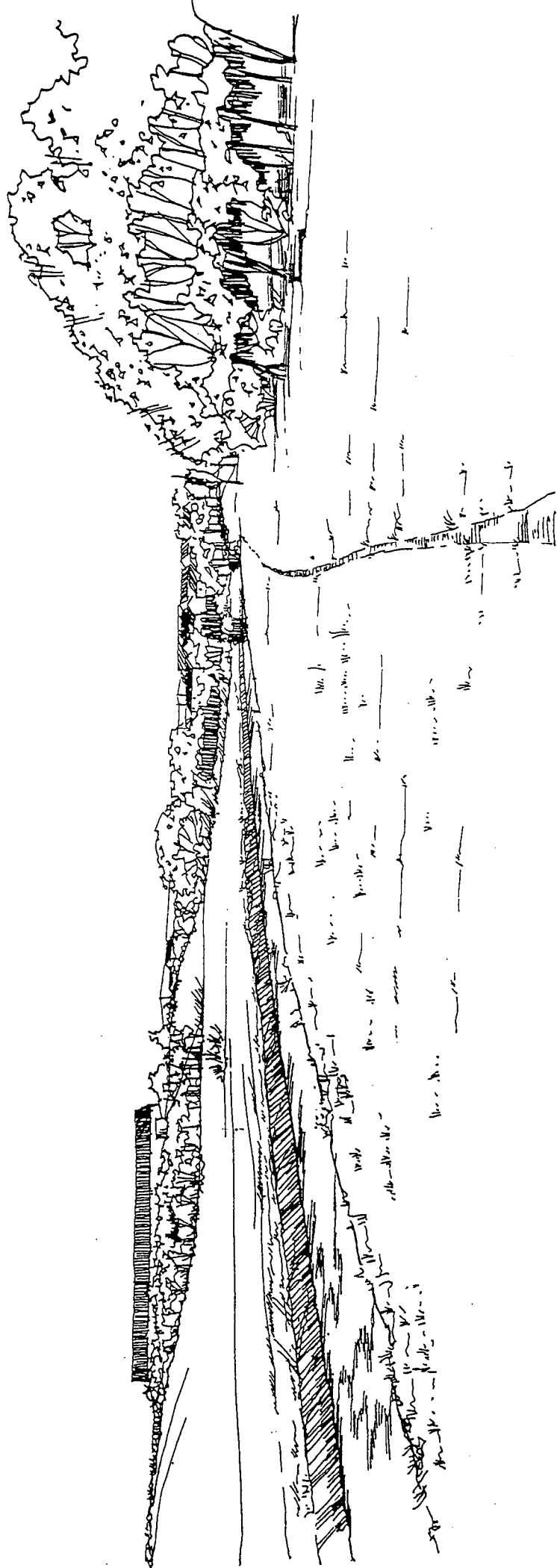
### Figure 15.12 Character Sketch - Section 3

Section No.3. East Edge of Allotments to Five Arches Bridge



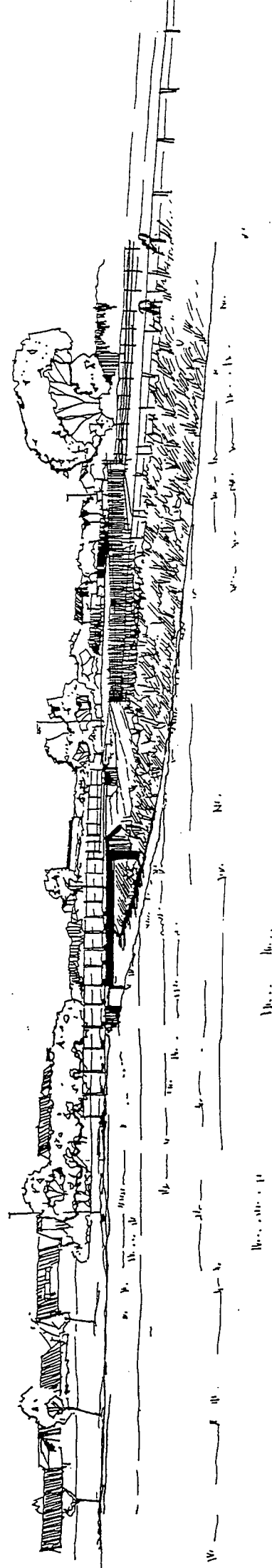
**River Skerne Landscape Assessment**

**Figure 15.13 Character Sketch - Section 4  
Rockwell to Old Hedgerow on the Southern Bank**



River Skerne Landscape Assessment

Figure 15.14 Character Sketch - Section 5  
Rockwell to Old Hedgerow on the Southern Bank



River Skerne Landscape Assessment

Figure 15.15 Character Sketch - Section 6  
Old Hedgerow on the Southern Bank to Houghton Road

## 16. Hydrology and channel hydraulics: Skerne

Hydrological monitoring on the Skerne is intended to assess the effects of restoration on flood attenuation in the urban environment.

As on the River Cole, water-level and discharge data is being collected prior to analysis as part of a project being undertaken by Hydraulics Research (funded by the Ministry of Agriculture, Fisheries and Food) on the hydraulics of environmentally designed channels.

In addition to the data collection for this project, most of the hydrological monitoring work during 1994 focused on preparatory work for the design of the restoration works.

This section is based on the work of Hydraulics Research, and uses data collected routinely by the NRA at South Park weir, data collected from water level monitors on the restoration reach and the results of a land survey commissioned for the project.

### 16.1 Aims

The aims of hydrological monitoring on the Skerne are:

- (i) to provide detailed river channel water-level data to validate hydraulic modelling of the site before and after restoration.
- (ii) to assess the impact of restoration on floodplain groundwater/surfacewater levels.
- (iii) to provide data for interpretation of floodplain vegetation change.
- (iv) to provide information which will help project design.

This report deals with the current features of the site, and does not contain further information about the proposed design of the restoration scheme.

### 16.2 Methods

#### 16.2.1 River channel hydraulics

##### **Land survey**

Channel dimensions and floodplain levels were surveyed in summer 1994. River cross-sections were measured every 100m. The floodplain of the restoration site was also surveyed.

##### **Discharge data**

The volume of water discharged by the River Skerne is measured continuously by the NRA at South Park weir (4km downstream of the restoration site). This provides a continuous record back to 1956.

##### **Water level monitoring**

Two continuous monitoring stations were established in the River Skerne (see Figure 16.1). Water level recorders were placed at Houghton Bridge and on the Five Arches Bridge.

## 16.2.2 Groundwater and surfacewater levels on the floodplain

### Groundwater levels

Darlington Borough Council holds an extensive set of soils survey data (which includes floodplain water tables levels) for the restoration site. Interpretation of this data-set is currently in progress. Groundwater monitoring stations will be installed during site investigations in spring 1995. It is intended to install piezometers to provide data on water levels.

### Observations of floods

Flood events will be observed directly when they occur and the extent of flooding mapped. Photographs of the previous major flood of the site (in 1979) have been used in hydraulic model calibration.

## 16.2.3 Modelling methods

Hydraulic modelling is being undertaken for the project by Hydraulics Research Ltd. as part of the MAFF research project on the hydraulics of environmentally designed channels.

Data from the catchment and the South Park gauging station were used to create hydrographs for various flood events (1 in 2 year through to 1 in 100 year). These hydrographs were developed using a computerised version of the Flood Studies Report (micro-FSR).

The most extreme event was on 29 March 1979, when some properties adjacent to the restoration site were flooded. The discharge was the highest recorded in 34 years of continuous monitoring. Flood outlines for the site, based on the hydrographs of 1 in 2 year to 1 in 100 year floods, were prepared.

## 16.3 Results

### 16.3.1 General characteristics of the Skerne catchment

The catchment of the River Skerne is 250 sq km, which is about twice the size of the River Cole's catchment (129 sq km). The maximum altitude of the Skerne catchment is 222m. The mean annual flow of the river is similar to that of the Cole ( $1.61 \text{ m}^3 \text{ s}^{-1}$ , compared to  $1.18 \text{ m}^3 \text{ s}^{-1}$  on the Cole).

The Skerne restoration site has a number of spring-line water sources. These include the Rockwell to the north of the Rockwell nature reserve, and springs and seepages on the south side of the river.

### 16.3.2 Flood events

The most recent extreme flood event on the River Skerne was in 1979, when the flood that occurred was slightly greater than the 1 in 100 year event. This flood event was used to calibrate the hydraulic model of the restoration reach. A variety of flood events were modelled and the flooded outlines of the 1 in 2 year and 1 in 100 year flood events illustrated (see Figures 16.2 and 16.3).

There is relatively little difference in the area of land flooded by the two events. This is mainly because the area that can be flooded under any circumstances is small as a result of the reduction in size of the flood plain because of industrial tipping.

However, the predicted 1 in 100 year event is high enough to cause limited flooding of properties to the north of the restoration site (showing agreement with the flooding observed in 1979).

### **16.3.3 Floodplain water tables**

Preliminary analysis of data held by Darlington Borough Council suggests that floodplain water levels may be quite high, especially in areas of peat (which occur throughout the restoration reach).

More detailed analysis of this data has yet to be undertaken. Site investigations (in the spring of 1995) will provide additional data on floodplain water levels.

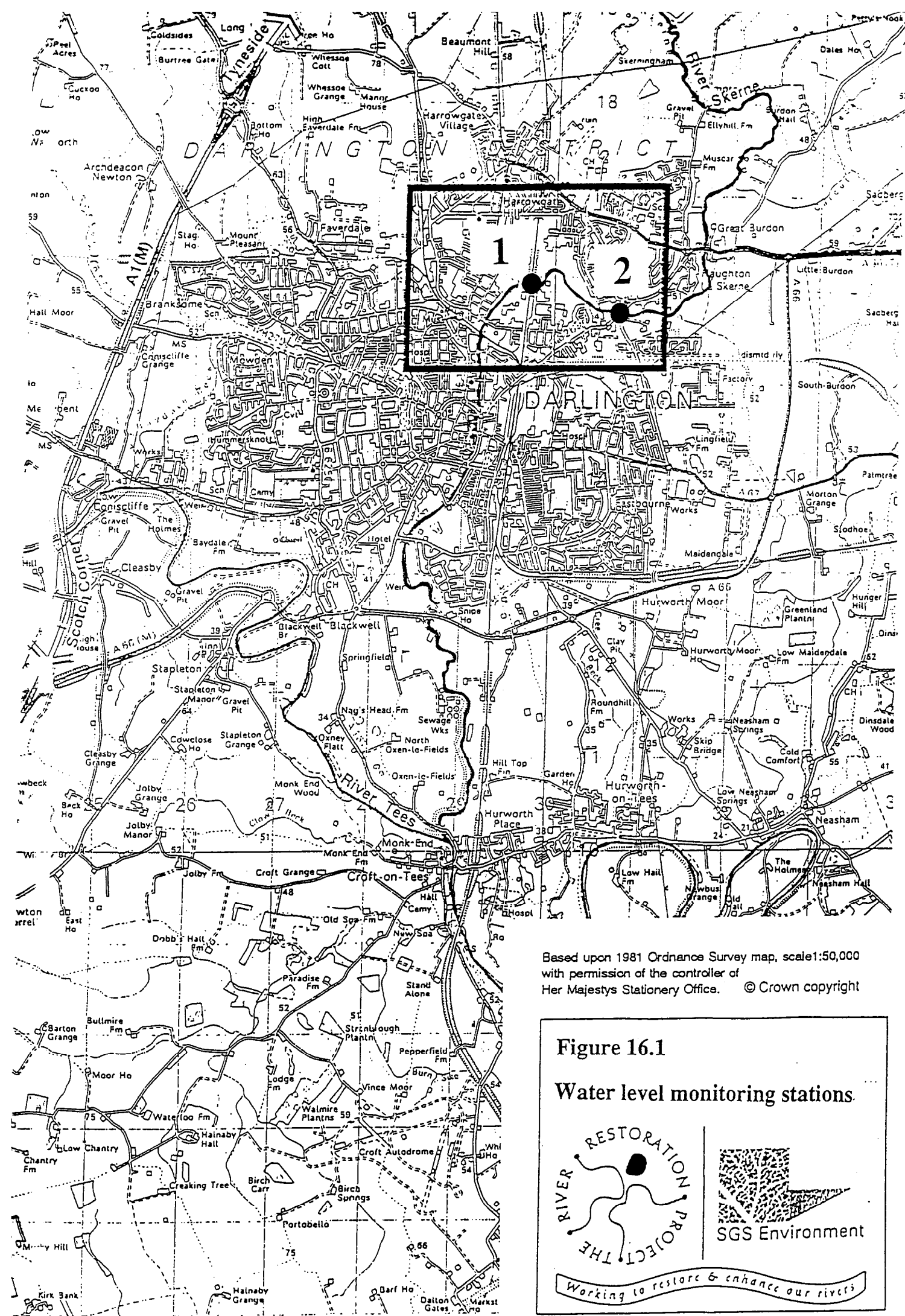


Figure 16.1

## Water level monitoring stations.



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class A. ASPT.EQIs (a biological measure of the absence of organic pollution) for the same survey were 0.77 for the 'downstream of Haughton' site and 0.86 for the Cleveland street site. Once again, both values are low, suggesting poor water quality, though the Cleveland Street site cannot be said to fall outside EQI class A.

### 17.3.2 Seasonal trends within the restored section

Monitoring at John Street between 1973 and 1994 has shown marked seasonal trends in some of four determinands of interest, ammoniacal nitrogen, total oxidised nitrogen, soluble reactive phosphorus and total suspended solids. These trends can be seen in Figures 17.1. to 17.4.

Ammoniacal nitrogen and soluble reactive phosphorus appear to peak in September, when flows in the river will be relatively low and dilution less. Total oxidised nitrogen has a less evident tendency to be higher in the summer months than the winter. The increased dilution in the winter months is obviously being offset by an increased rate of run-off from farmland at this time.

Total suspended solids show an obvious increase during the winter months when run-off is high, and when discharge is high and able to carry high sediment loads. The more consistent results for the Skerne compared to the Cole are likely to be due to the much longer period of recording (20 years compared to three years) which help to average out fluctuations in suspended solids levels.

### 17.3.3 Annual trends in water quality in the River Skerne

Annual trends at John Street, Great Burdon (1.5km above the restoration reach) and Ketton Bridge (7.5km above the restoration reach) are shown in Figures 17.5 to 17.8 for ammoniacal nitrogen, total oxidised nitrogen, soluble reactive phosphorus and total suspended solids.

Prior to 1985, levels of ammoniacal nitrogen were very high in the Skerne, with levels at Ketton Bridge normally exceeding those at John Street (there was no monitoring at Great Burdon at this time). In 1985 and 1986, ammoniacal nitrogen averaged over 20mg/l at both Ketton Bridge and John Street. These extremely high levels were perhaps the result of the decommissioning of the coking works at Coatham. After these two years the amounts of ammoniacal nitrogen in the river fell to levels below those seen before 1985, and since then there has been a trend for levels in the river to decrease with time.

Total oxidised nitrogen shows no obvious trend with time, being consistently high. There is a suggestion that recent years (1990 to 1994) have been particularly high at Ketton Bridge, though this trend is not so evident in Darlington (John Street). Soluble reactive phosphorus has not been monitored as consistently as some other determinands, but there is the suggestion that 1990 and 1991 were particularly high years.

Suspended solid levels in the river have been rather variable, with an indication that 1979 to 1984 were particularly high. Levels at Ketton Bridge appear to exceed those at John Street on most occasions.

Average BMWP.EQI and ASPT.EQI for the closest sites on the Skerne with pre-1994 data (Ketton Bridge and Hurworth Place) are shown in Figure 17.9, together with data from the Cocker Beck, which flows into the Skerne just below the restoration section. For the Ketton Place site (above the restoration section) the figures suggest consistently poor water quality. For Hurworth Place the figures suggest poor water quality in 1991 followed by a gradual improvement in 1992 and 1993. The Cocker Beck which enters the Skerne just below the restoration section has generally low water quality, with the suggestion of a slight improvement over the past two years.

### 17.3.4 Water quality trends in the River Skerne catchment

Figure 17.10 shows the trends in BMWP.EQI and ASPT.EQI within the catchment. Sites furthest upstream are shown on the left of the histogram and the Cocker Beck which flows in between Ketton Bridge and Hurworth Place, is separated on the right. Figures are averaged over 1991 to 1994.

There appear to be no obvious trends in the catchment, in either BMWP.EQI or ASPT.EQI. This suggests that there is no single dominant polluting discharge in the catchment. The main factor affecting water quality in the Skerne catchment as a whole is believed to be the discharge from sewage treatment works.

In addition to those sites with some historical data, sampling at four new stations (see Table 17.2) has also been started by the NRA in connection with the Skerne restoration programme. These sites add to two others, giving six of particular relevance to the monitoring programme. All six sites lie between Ketton Bridge and Hurworth place, with two within the restoration section itself. First results from these sites are shown in Table 17.4, with upstream sites at the top of the table.

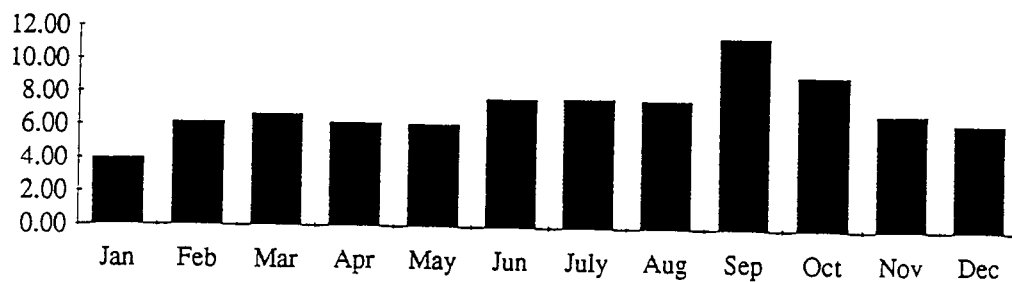
**Table 17.4 Biological sampling of the six new sites on the River Skerne**

SITE	SEASON	BMWP	ASPT	BMWP. EQI	ASPT. EQI
Barmpton	Spring	41	3.73		
Mill Lane	Autumn	80	4.21	0.81*	0.92*
Downstream of Haughton	Autumn	46	3.54	0.48	0.77
Cleveland Street	Spring	61	4.36		
Cleveland Street	Autumn	69	4.06	0.68*	0.86*
Town Hall	Autumn	68	4.00	0.69*	0.85*
Snipe House	Spring	60	4.29		

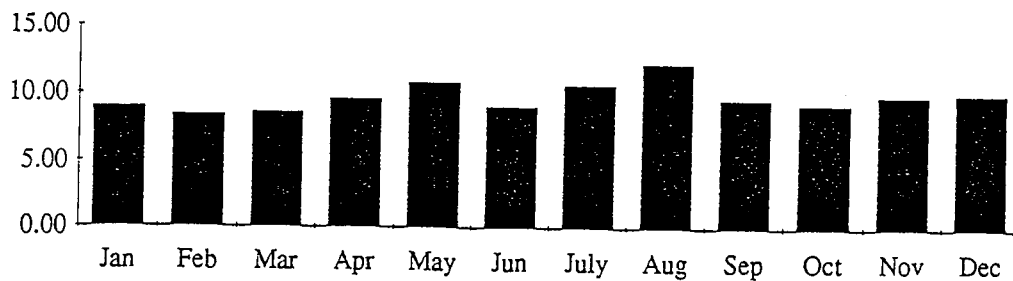
\* EQIs derived from RIVPACS predictions where certainty of prediction validity is less than 1%.

There appears to be no trend in water quality, as assessed by biotic indicators, in the proximity of the restoration section. The Cleveland Street site appears to have water quality similar to sites above and below Darlington, and the 'downstream of Haughton' site appears to have relatively low water quality. However, there is an inherent variability of sampling during the estimation of biotic indices, and biotic indices are also affected by several considerations (habitat etc.) which do not relate to water quality. Analysis of small scale differences in the water quality of the river should, therefore, await further seasons work.

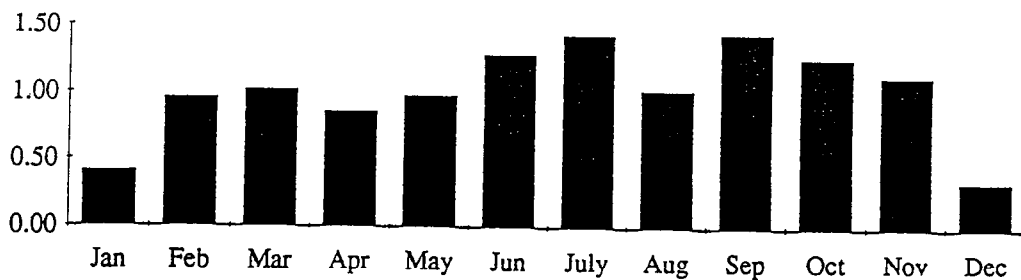
**Figure 17.1 Seasonal variation in ammoniacal nitrogen (mg/l): John Street**



**Figure 17.2 Seasonal variation in total oxidised nitrogen (mg/l): John Street**



**Figure 17.3 Seasonal variation in soluble reactive phosphorus (mg/l): John Street**



**Figure 17.4 Seasonal variation in suspended solids (mg/l): John Street**

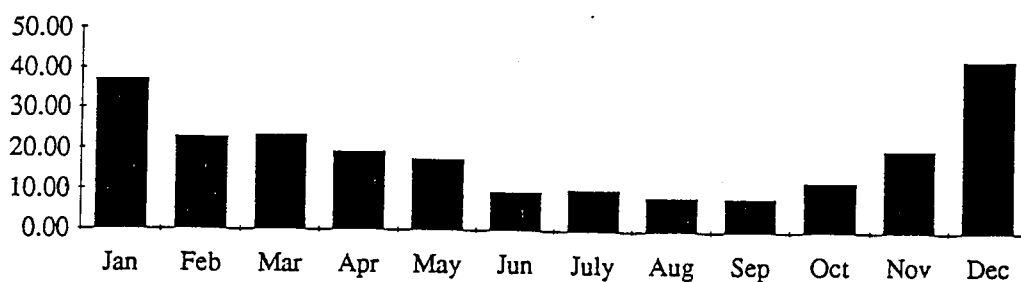


Figure 17.5 Variation in ammoniacal nitrogen (mg/l) in the River Skerne

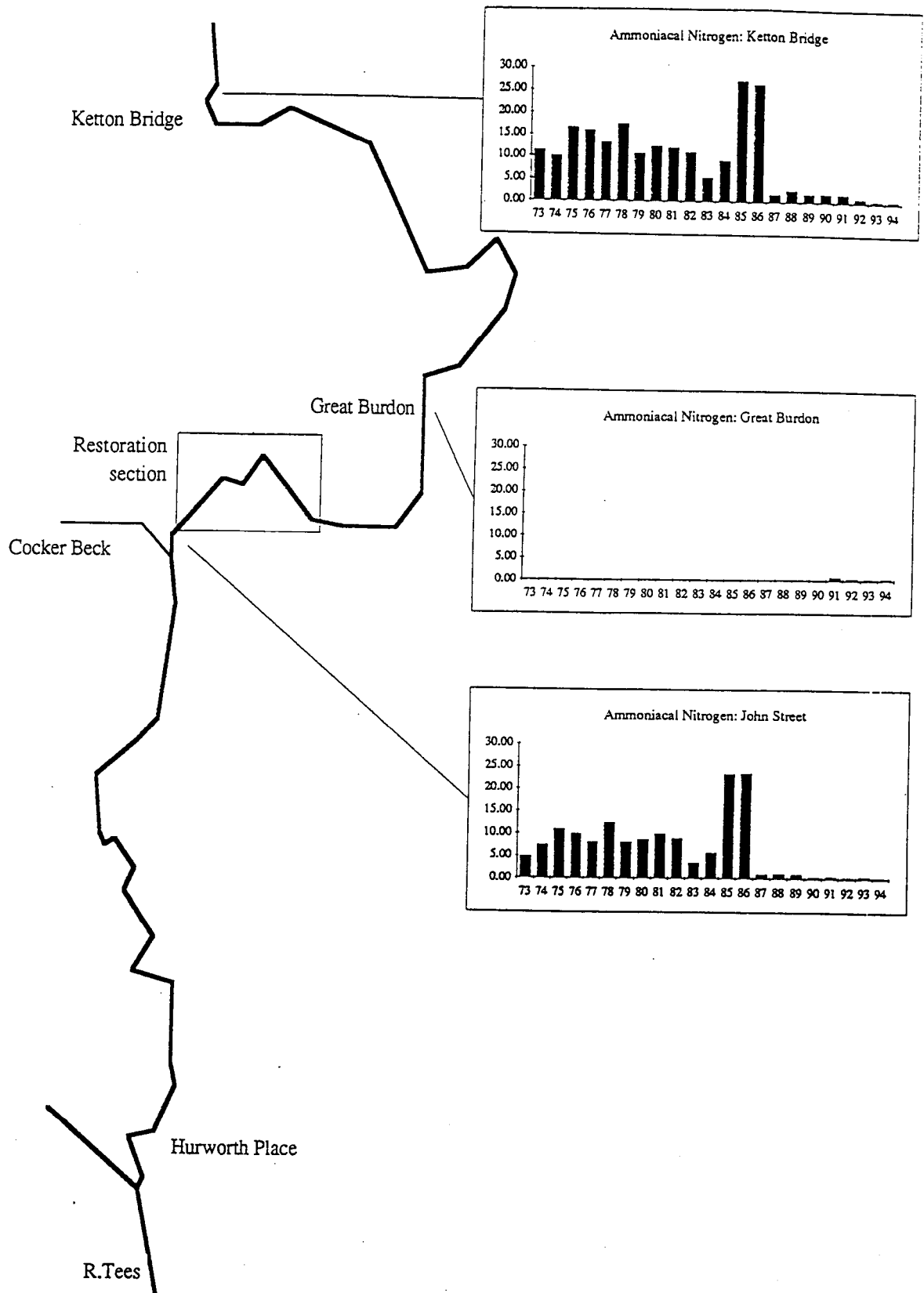


Figure 17.6 Variation in total oxidised nitrogen (mg/l) in the River Skerne

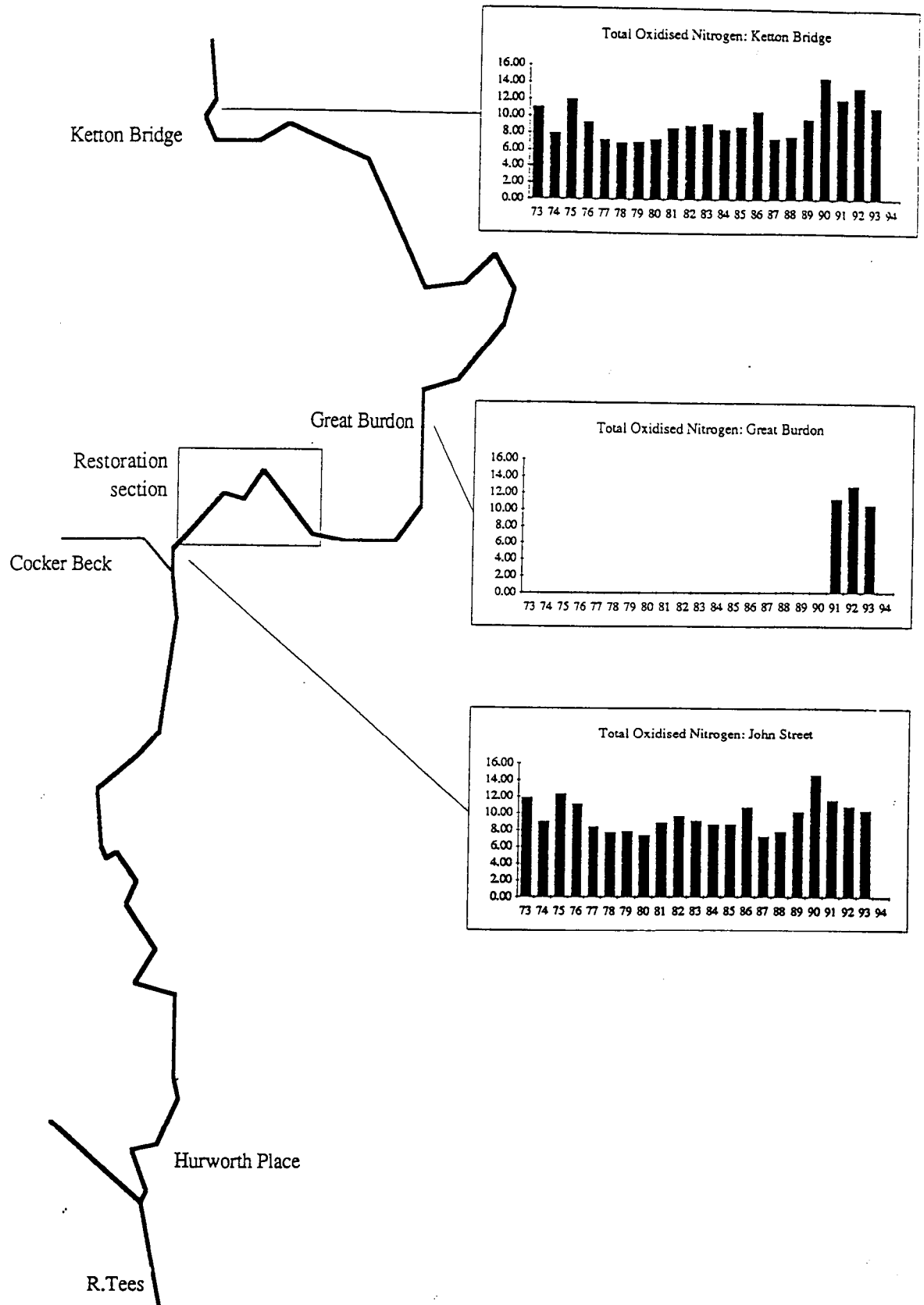


Figure 17.7 Variation in soluble reactive phosphorus (mg/l) in the River Skerne

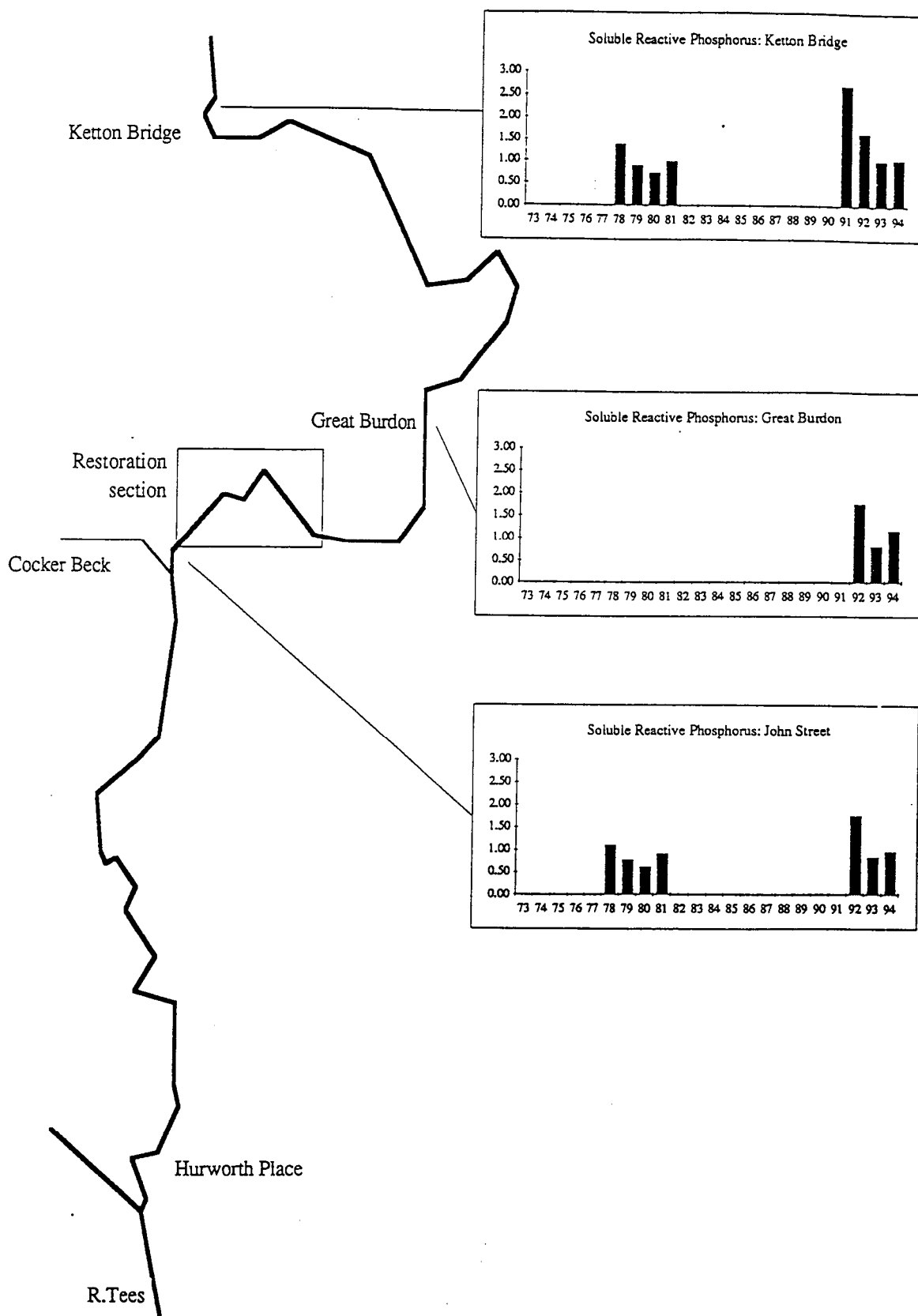


Figure 17.8 Variation in suspended solids (mg/l) in the River Skerne

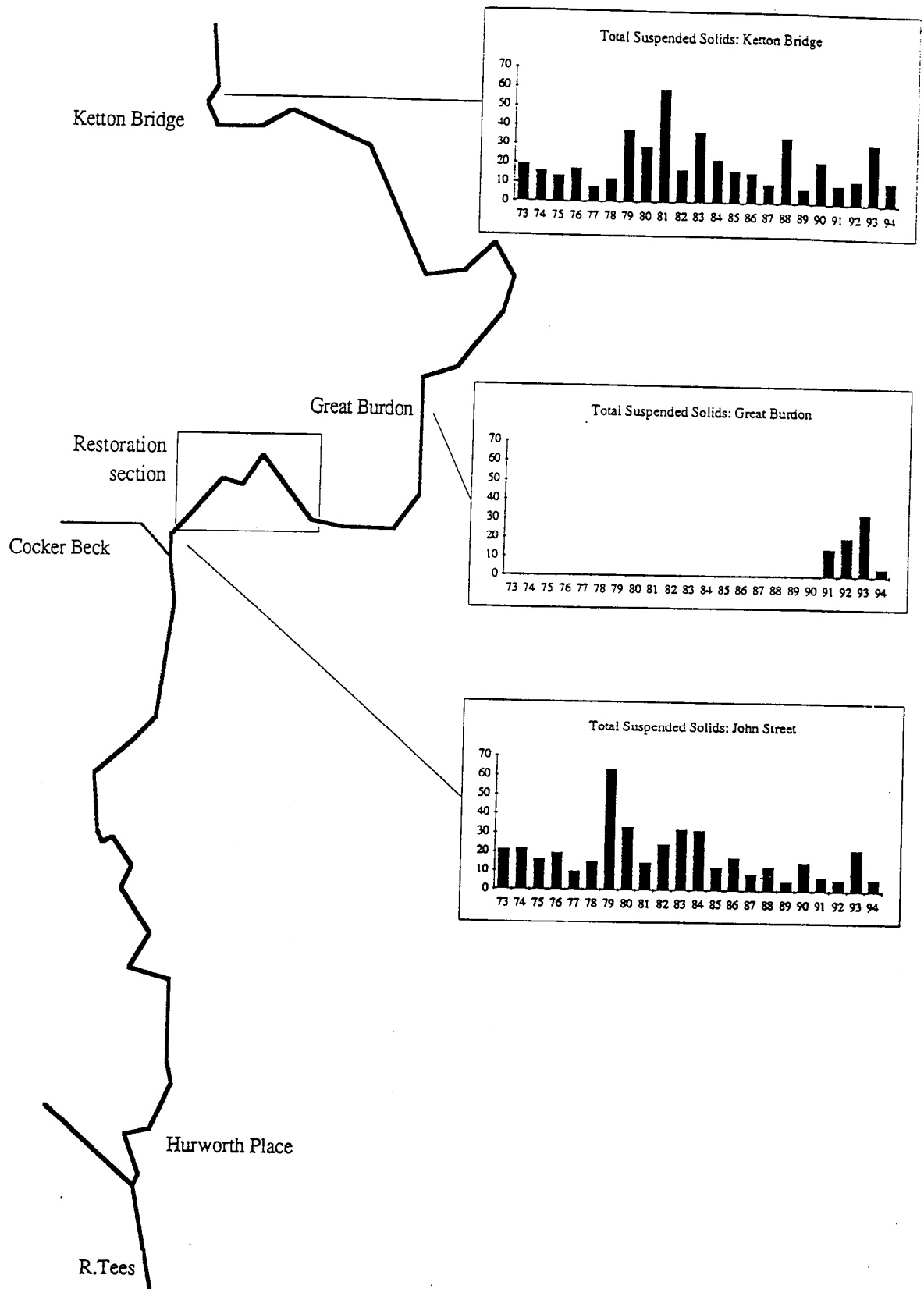


Figure 17.9 Variation in BMWP.EQI AND ASPT.EQI in the River Skerne

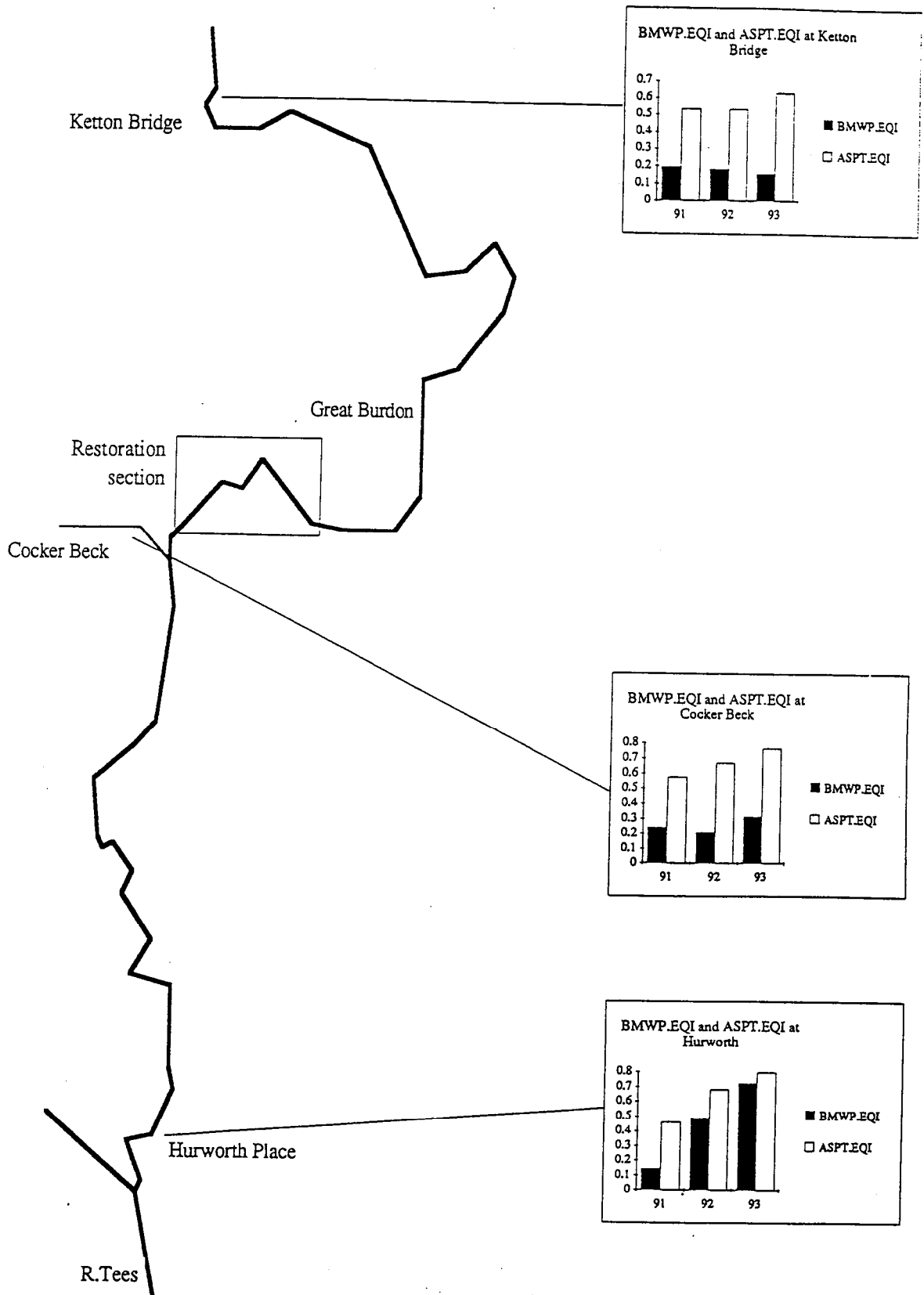
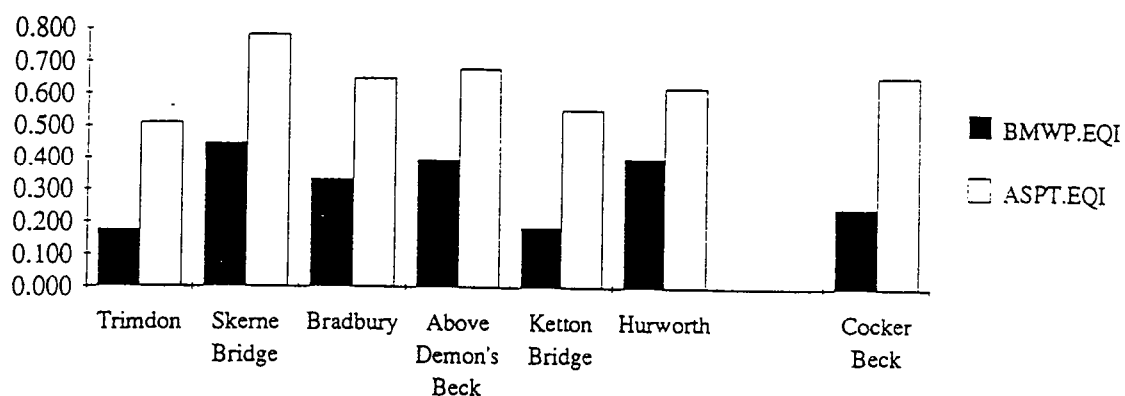


Figure 17.10 BMWP.EQI and ASPT.EQI in samples from the Skerne catchment



## 18. Vegetation: Skerne

Vegetation assessment of the River Skerne involved surveys within (a) the river channel and corridor and (b) on the floodplain.

For both areas, the broad aim of ecological survey work has been to enable an assessment to be made of the vegetation changes which result from the restoration of the river and floodplain. This has involved the establishment of monitoring stations within:

- (i) The restoration habitat (river and floodplain).
- (ii) An upstream length of channel/floodplain to act as a control.
- (iii) A downstream area to assess any downstream impacts of the restoration (e.g. excess sediment deposition).

In addition to providing a baseline from which future change can be measured, the first year of survey work has provided data which describes the current conservation status of the riparian and floodplain community. This information has been essential in order to ensure that the restoration design does as little damage as possible to species and areas of existing conservation interest.

### 18.1 River corridor surveys

#### 18.1.1 Methods

##### River Corridor Survey rationale and methods

The River Corridor Survey was undertaken over: (a) the existing 2km of channel within the restoration area (b) 1km lengths up and downstream.

The detailed methodology for the River Corridor Survey has broadly followed the standard NRA methodology given in *River Corridor Surveys, Conservation Technical Handbook No. 1* (NRA 1992). The main modification to the recommended technique was that wetland plant species lists were provided for every 0.5km length surveyed.

The River Corridor Survey was undertaken by Debbie Cowen (NRA) in August 1994. Species lists will be checked on a second site visit in early summer 1995.

##### **Assessing the conservation value of the plant community**

The conservation value of the River Skerne's vegetation community was also assessed, by Penny Williams, on the basis of the presence of the number of wetland species and the number of nationally uncommon (i.e. local, nationally scarce or Red Data Book) wetland plants in the river corridor.

A Species Rarity Index (SRI) was used in order to achieve a relatively objective comparison of the sites with sites in other areas (see Chapter 7).



### 18.1.2 Results of the River Corridor Survey

A full report describing the results of the River Corridor survey is given in Cowen (1994). This report provides a description and species lists for each 500- m reach of the River Skerne within the survey area, together with photographs and annotated maps for each reach.

A summary of the results of this study, together with further analysis of the conservation value of the river communities, is given below.

#### Description of the vegetation types in the Restoration reach

The river channel through most of the survey reach (from Haughton Road bridge to Five Arches Bridge) is trapezoidal in shape and ecologically impoverished (Figure 18.3), but retains a number of natural features, including riffles. Downstream of Five Arches Bridge, the river has artificial banks which reduce the diversity of marginal areas, although some artificial features, such as weirs, have created areas where flow is more varied.

Wetland plant species lists for the survey reaches within the restoration area (reaches 3 - 6) are given in Table 18.1.

Throughout its length, characteristic plant species of the river channel were Fennel Pondweed (*Potamogeton pectinatus*) and filamentous algae, with large stands of Branched Bur-reed (*Sparganium erectum*), Reed Sweet-grass (*Glyceria maxima*) and Common Club-rush (*Schoenoplectus lacustris*). Other emergents such as Reed Canary-grass (*Phalaris arundinacea*) were less common and tended to be restricted to the upper bank side.

The river banks supported mainly tall herb and ruderal and grass communities dominated by Common Nettle (*Urtica dioica*), Creeping Thistle (*Cirsium arvense*), Himalayan Balsam (*Impatiens glandulifera*), Great Willow-herb (*Epilobium hirsutum*) and tall umbellifers such as Hemlock (*Conium maculatum*).

Tree and shrub cover varied considerably between each section, but was generally sparse.

The most interesting and botanically diverse areas of the river corridor were associated with wetlands, particularly the Rockwell Conservation Area, adjacent to the river in Reaches 5 and 6 (e.g. see Figure 18.4). These included a series of permanent ponds, temporary pools, flushes, willow scrub and wet ground with species such as Great Pond-sedge (*Carex riparia*), Jointed Rush (*Juncus articulatus*), Water Plantain (*Alisma plantago-aquatica*) and Water Solider (*Stratioides aloides*), the latter almost certainly introduced.

It is worth noting that the railway embankment is botanically rich and supports a large number of Common Orchids (*Dactylorhiza fuchsii*) and other species such as Toadflax (*Linaria vulgaris*).

#### Description of the vegetation types in the upstream Control reach

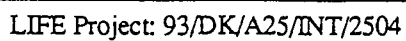
The reaches up to 1km above the restoration area were similar to the adjacent restoration reach, with a trapezoidal channel, dominated by Fennel Pondweed (*Potamogeton pectinatus*), filamentous algae, Branched Bur-reed (*Sparganium erectum*) and Common Club-rush (*Schoenoplectus lacustris*). Steep banks supported rank grassland and ruderal species.

#### Description of the vegetation types in the downstream Impact section prior to the physical works.

This section was characterised by a greater proportion of tree shade and urban development than other reaches. The channel flora was similar to upstream areas, and included stands of Branched Bur-reed (*Sparganium erectum*) and Reed Sweet-grass (*Glyceria maxima*). However, bank vegetation was often restricted by shade or the presence of urban structures immediately abutting the channel.

**Table 18.1 Wetland plant species recorded from the River Skerne (1994)**

National Rarity Score			u/s Control		Restoration reach				d/s control	
Aquatics			1	2	3	4	5	6	7	8
1	<i>Callitriche stagnalis</i>	Common Starwort	-	-	-	+	-	-	-	-
2/2	<i>Ceratophyllum demersum</i>	Hornwort	-	-	-	-	+	+	-	-
1	<i>Elodea canadensis</i>	Canadian Waterweed	-	-	-	-	-	+	-	-
1	<i>Lemna minor</i>	Common Duckweed	-	-	-	-	+	+	-	-
1	<i>Myriophyllum spicatum</i>	Spiked Water-milfoil	-	-	-	-	+	+	-	-
2	<i>Potamogeton pectinatus</i>	Fennel Pondweed	+	+	+	+	+	+	+	+
1	<i>Potamogeton natans</i>	Broad-leaved Pondweed	-	-	-	-	+	-	-	-
1	<i>Polygonum amphibium</i>	Amphibious Bistort	-	-	-	-	+	-	-	-
1	<i>Sparganium emersum</i>	Unbranched Bur-weed	-	+	-	-	-	-	-	-
1	<i>Stratioides aloides</i>	Water Soldier	-	-	-	-	+	-	-	-
Emergents										
1	<i>Agrostis stolonifera</i>	Creeping Bent	-	+	+	+	+	+	+	+
1	<i>Alisma plantago-aquatica</i>	Water- plantain	-	-	-	-	+	+	-	-
1	<i>Angelica sylvestris</i>	Wild Angelica	+	-	-	-	-	-	-	-
1	<i>Barbarea vulgaris</i>	Winter-cress	-	+	+	+	+	-	+	-
2	<i>Carex riparia</i>	Greater Pond-sedge	-	-	-	-	+	+	-	-
1	<i>Cirsium palustre</i>	Marsh Thistle	+	+	+	+	-	+	-	-
1	<i>Epilobium hirsutum</i>	Great Willow-herb	+	+	+	+	+	+	+	+
1	<i>Filipendula ulmaria</i>	Meadowsweet	-	-	-	-	+	-	-	-
1	<i>Glyceria maxima</i>	Reed Sweet-grass	+	+	+	+	+	+	+	+
1	<i>Impatiens glandulifera</i>	Himalayan Balsam	+	+	+	+	+	+	+	+
1	<i>Juncus articulatus</i>	Jointed Rush	-	-	-	-	+	-	-	-
1	<i>Juncus inflexus</i>	Hard Rush	-	-	-	-	+	+	-	-
1	<i>Lythrum salicaria</i>	Purple Loosestrife	-	-	-	-	+	-	-	-
1	<i>Lysmachia vulgaris</i>	Yellow Loosestrife	-	-	-	-	+	+	-	-
1	<i>Phalaris arundinacea</i>	Reed Canary-grass	-	+	+	+	-	-	+	-
1	<i>Polygonum amphibium</i>	Amphibious Bistort	-	+	-	-	-	-	-	-
1	<i>Polygonum persicaria</i>	Redshank	+	+	+	-	-	-	+	-
1	<i>Schoenoplectus lacustris</i>	Common Club-rush	+	+	+	+	+	+	+	-
1	<i>Sparganium erectum</i>	Branched Bur-reed	+	+	+	+	+	+	+	+
1	<i>Symphytum officinale</i>	Common Comfrey	-	-	-	-	-	+	-	-
1	<i>Typha latifolia</i>	Bulrush	-	-	-	-	+	-	-	-
Trees and shrubs										
1	<i>Salix</i> sp.	Willow	+	+	+	-	+	+	+	+
1	<i>Salix caprea</i>	Goat Willow	-	-	-	+	+	+	+	+
1	<i>Salix fragilis</i>	Crack Willow	-	-	-	+	+	-	-	-
1	<i>Salix x argentea</i>	Silver Willow	-	-	-	+	-	-	-	-
1	<i>Salix x chrysocoma</i>	Weeping willow	-	-	-	-	-	-	-	+



**Figure 18.3 River Skerne (Reach 3), highly channelised.**



**Figure 18.4 Rockwell Conservation Area with the R. Skerne beyond (Reach 5).**



### 18.1.3 Conclusions

#### Species-richness

As a whole, the reaches of the River Skerne were:

- (i) moderately poor in wetland plant species.
- (ii) of similar species-richness in the control reaches and in the restoration reach.

The channel supported very few aquatic species: only three aquatic macrophytes were recorded from the channel along the whole survey length. In addition, the species present (e.g. Fennel Pondweed, *Potamogeton pectinatus*) were plants often characteristic of enriched or otherwise polluted water.

The diversity of marginal wetland plants was also poor, with an average of only around 12 species per reach associated with the channel alone (i.e. not including the wetland enhancement areas). The middle and upper river banks were dominated by a relatively impoverished rank ruderal community, including extensive stands of nettle (*Urtica dioica*).

The presence of a series of permanent ponds and wet ground adjacent to the river in Reaches 5 and 6 significantly increased the botanical diversity of the river corridor in these reaches.

#### Uncommon species

No rare or nationally notable wetland plant species were recorded from any of the survey reaches, and the occurrence of local species (i.e. species present in less than 600 10-km grid squares in Britain) was very low (only three species, see Tables 18.2 and 18.3). In addition, two of these local species were associated only with the off-river ponds and pools in Reaches 5 and 6.

#### Overall conservation value

Using the Species Rarity Index (SRI) to assess the overall conservation value of the reaches (see Table 7.3 in Chapter 7), all are considered to be of only moderate conservation value (on a four-point scale: low, moderate, high, very high).

**Table 18.2 Summary data for wetland plant species recorded from the River Skerne in 1994**

	u/s control		Restoration reach				d/s control	
	1	2	3	4	5	6	7	8
Number of plant species	10	14	12	14	25	19	12	9
Number of uncommon species	1	1	1	1	3	3	1	1
Species Rarity Score	11	15	13	15	28	22	13	10
Species Rarity Index	1.10	1.07	1.08	1.07	1.12	1.15	1.08	1.10
Conservation category	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod

Note: The presence of a series of permanent ponds and wet ground adjacent to the river in Reaches 5 and 6 significantly increased the botanical diversity of the river corridor in these reaches.

**Table 18.3 Descriptions of uncommon species recorded from the River Skerne in 1994**

***Ceratophyllum demersum* (RANUNCULALES: Ceratophyllaceae). Rigid Hornwort.**

Local in eutrophic or brackish, still, shallow waters. Often present in dense masses, almost completely filling small ponds and ditches. Nationally, the species is found scattered throughout England, but is rare in Wales and Scotland. (Clapham *et al.*, 1989.) On the Skerne, this species was limited to the pond and pool areas on the floodplain associated with Reaches 5 and 6.

***Carex riparia* (CYPERALES). Greater Pond-sedge.**

Nationally, the species is typically found by slow-flowing rivers and in ditches and ponds, and also (though more rarely) on drier ground. From its national distribution this species only just deserves the definition of 'uncommon' (i.e. recorded from less than 600 10-km grid squares in the UK). Overall, Greater Pond-sedge is very generally distributed in the south of England and the Midlands, but more local in the west and north as far as Fife. (Clapham *et al.* 1989, Stace 1991.) On the Skerne, this species was limited to the pond and pool areas on the floodplain associated with Reaches 5 and 6.

***Potamogeton pectinatus* (POTAMOGETONACEAE). Fennel Pondweed.**

Widespread throughout Britain in base-rich water of the lowlands, but absent from mountainous districts of Wales, N.England and Scotland. Found in eutrophic or brackish water in a wide range of lowland habitats: one of the most pollution-tolerant *Potamogeton* species. (Clapham *et al.* 1989; Croft *et al.* 1991.) On the River Skerne, this species was found commonly within the channel in the restoration and control areas.

## 18.2 Floodplain survey

### 18.2.1 General aims

The aim of the floodplain survey has been to describe the change in the character and conservation value of floodplain habitats before and after restoration. Conservation value is here measured in terms of:

- (i) Changes in the number/rarity of plant species in different habitat compartments.
- (ii) Changes in landscape/community complexity.

### 18.2.2 Description of floodplain survey methods

The basis for floodplain monitoring will be:

- (i) A background literature study
- (ii) A Phase 1 habitat survey of the area to be restored, with vegetation assigned to National Vegetation Classification (NVC) community types
- (iii) Species lists for all major habitat or compartment types.

The survey area includes (i) the area of floodplain to be restored, together with (ii) a 1-km upstream control section and (iii) a 1-km downstream section, which could possibly be impacted by the restoration scheme. Most of the pre-construction survey work will take place in early summer 1995.

### 18.2.3 Floodplain plant communities: initial assessment

The following information summarises the results of an initial assessment of the floodplain communities undertaken by Debbie Cowen as part of the River Corridor survey and by SGS Environment during landscape assessment.

A more detailed Phase 1 vegetation survey will be undertaken by Tim Rich in early summer 1995, and will include:

- (i) A habitat map of the study area with NVC types
- (ii) Species lists with estimated frequencies for compartments in the restoration area

#### Existing data

Most of the restoration area adjacent to the river from Haughton Bridge down to the Rockwell Conservation Area is a closely-mown parkland landscape devoid of features, with the exception of a few groups of native and non-native trees. In addition to the canalisation of the river, the land has been drained and subjected to major disturbance when gas pipelines and sewers were laid in the 1970s. In 1984 the area was cleared of remaining vegetation, graded and made into the sterile corridor which exists today.

The embankment behind the south bank of the river between the Five Arches Bridge and Albert Bridge is a continuous belt of largely indigenous mature trees and shrubs. As well as being a valuable ecological resource, this corridor provides effective screening of unsightly industrial buildings on the plateau.

A developing belt of trees planted in the 1980s on the industrial embankment to the east of Five Arches Bridge will further extend the importance of this wildlife corridor. There are also a number of areas with semi-natural scrub and grassland vegetation, such as the railway embankments, the Rockwell

Conservation area, and the Square Mile Project Area (this last is managed as an education resource by Haughton School).

The most significant area of conservation value on the restoration site is the Rockwell Conservation Area. Prior to the housebuilding and reclamation works of the late 1970s, this area was subject to waterlogging by the springs which surface in the area and to regular flooding by the river. An article in the Durham County Conservation Trust's Bulletin of May 1987 describes the recent history of Rockwell.

Rockwell was saved from development following a campaign by the Durham and Teesdale Naturalists Field Club in the mid 1970s. In the 1980s, a local naturalist, Dave Race, in conjunction with the Durham County Conservation Trust and other local conservation bodies, persuaded Darlington Borough Council to retain this area of approximately 1.5 hectares as an ecological and educational resource, a vestige of how the floodplain once looked. With funding from the Railside Revival Project, existing ponds were enlarged, new ponds made, indigenous trees planted and wildflowers sown. In conjunction with the adjacent railway embankment, the area provides a range of habitats which support a rich flora and fauna, including Great Crested Newts, 16 species of butterfly, and a wide variety of terrestrial and aquatic plants (including Common Spotted Orchids on the railway embankment). 60 species of birds have also been recorded at Rockwell.

Skerne Ponds, located to the west of Five Arches Bridge, is similar to Rockwell but smaller in area. Like Rockwell, it was formerly subject to waterlogging due to springs and flooding, and it is proposed as a future extension to the Rockwell Conservation Area.

St William's Pond is the third site of nature conservation interest within the area: it is also believed to provide breeding habitat for Great Crested Newts. The pond is surrounded by housing, and located approximately 0.5 km from the river. Although a narrow open space connects it with the Skerne, this area is currently a sterile green space, which restricts its value as a potential wildlife link.

Dropwell is the only remaining semi-natural area on the south bank of the river to the west of Five Arches Bridge. This too was the site of a spring. This formerly ecologically rich area has been gradually reduced in size to a clump of blackthorn and some large willows.

There are also two significant remnants of ancient hedgerows adjacent to Devonshire Road. These contain a wide range of native species of trees and shrubs: ash, hawthorn, elder, etc.

## 19. Invertebrate ecology: Skerne

Broadly, the aim of the invertebrate monitoring programme has been to describe and assess changes in the conservation value of aquatic macroinvertebrate communities following the restoration of the river.

The invertebrate monitoring programme on the Skerne is being carried out by the NRA (Northumbria and Yorkshire region).

### 19.1 Aims

The aims of the monitoring programme are: (i) to estimate the change (if any) in species-richness and conservation value of the aquatic macroinvertebrate fauna in the years following restoration; and (ii) to monitor the reach downstream of the restoration area in order to assess impacts from the restoration work.

### 19.2 Methods

Macroinvertebrates have been surveyed and processed using the BMWP/RIVPACS methodology currently in routine operation in the NRA. Samples for analysis have been taken from the Skerne at Barmpton, Mill Lane, Haughton, Cleveland Street/John Street, Town Hall and Snipe House. (See Tables 17.2 and 17.4 for locations and dates.)

In addition to the standard family-level identification required for BMWP survey work, invertebrates have also been identified to a mixed-taxa level (including several groups which were identified to species-level), and counts of abundance have been made.

### 19.3 Results

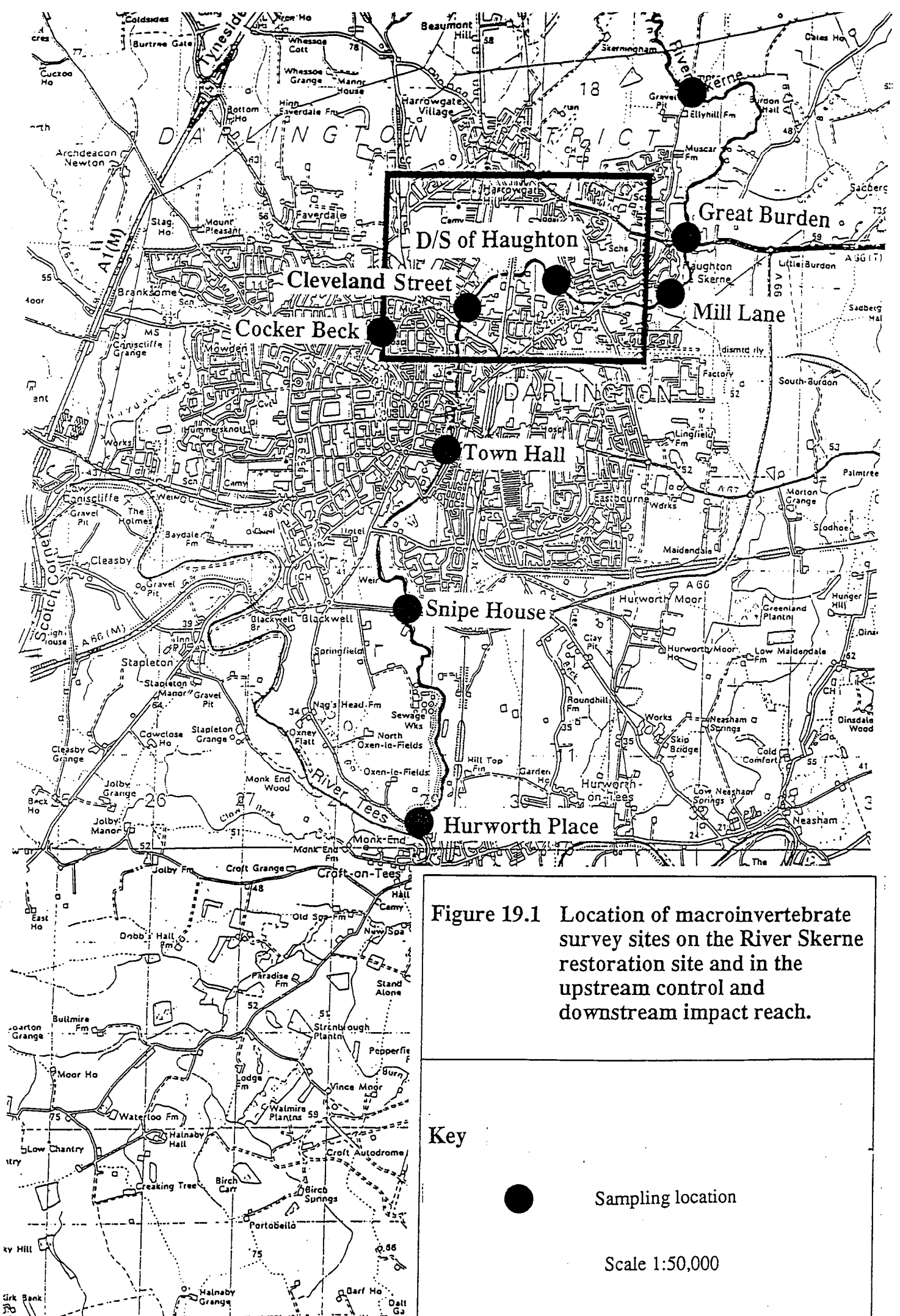
Table 19.1 summarises the results of species-level recording so far.

Table 19.1 Numbers of macroinvertebrate species recorded from the Skerne in 1994		
Site	Date	Number of species
Barmpton	23/5/94	5
Mill Lane	30/9/94	13
Downstream of Haughton	30/9/94	12
Cleveland Street/John Street	30/9/94	9
Cleveland Street/John Street	23/5/94	11
Town Hall	30/9/94	13
Snipe House	23/5/94	10

It is clear that all sites at present have very low aquatic invertebrate species-richness, and the value for Barmpton is particularly low. The Species Rarity Index (see section 8.1.2, above) of all the sites is 1 (low value).

#### Survey programme in subsequent years

Assuming that the same level of variation is seen in a subsequent set of samples from the restoration reach and downstream of it, it is likely (90% chance) that a real difference of 33% in species numbers would be provable at the 95% confidence level.



## 20. Fisheries: Skerne

### 20.1 Introduction

A wide variety of studies indicates that river habitat improvements promote fish diversity and abundance, and improve the value of fisheries. Indeed, the effect of river improvements on fish populations is one of the few well-documented areas of river enhancement and rehabilitation works.

However, the larger fish that are of interest to anglers were, until recently, almost entirely absent from the Skerne. Surveys by the NRA in 1991 found only two individual fish (an Eel and a Brown Trout) above South Park weir, and it was as a result of this that the NRA began a re-stocking programme in 1992.

### 20.2 Aims

The aim of the fish monitoring programme on the Skerne is to assess the changes in fish species-richness (number of species) following restoration. In view of the very limited 'sport' fish population, it is possible that particular attention will need to be given to 'minor species'. Information about minor species is reviewed below.

As well as contributing to the ecological description of the site, the data will be interpreted in terms of the amenity and economic benefits of any changes in the fishery.

### 20.3 Methods

The monitoring of fish populations on the restoration site will be undertaken by NRA fisheries staff as part of the rolling programme of fisheries survey work in the region.

NRA surveys of the Skerne were undertaken in 1991 and 1994. In 1991, nineteen sites on the Skerne were surveyed, and in 1994 seven sites were surveyed. Table 20.1 lists the sites relevant to this study.

Two additional stations will be surveyed in spring 1995 as part of the restoration site monitoring programme. The location of sampling sites is shown in Figure 20.1.

Previous surveys were conducted using standard electro-fishing techniques with stop-nets. Each stop-netted section was fished twice. Further details of the methods of each survey are given in the reports prepared by NRA Fisheries staff<sup>1</sup>

<sup>1</sup> NRA (1991). Fisheries stock assessment programme. River Skerne 1992. NRA Northumbria Region.

NRA (1994). River Skerne survey 1994. Report on fish population monitoring. National Rivers Authority, Northumbria and Yorkshire Region.

**Table 20.1 Fisheries survey sites on the River Skerne restoration site and in the upstream control reach and downstream impact reach**

	NRA site number	Site surveyed in 1991	Site surveyed in 1994 (or to be surveyed in 1995)
Downstream impact reach	7	Pitch and Putt 1	
	8	Pitch and Putt 2	
	9	Victoria Embankment	Victoria Embankment (1995)
Restoration site	10	Henley Street	
	.		Albert Road (1995)
	.		Riverside Way (1995)
	11	Salters Avenue	
Upstream control reach	4		Haughton Bridge (1994)
	12	Mill Lane	
	13/5	Burdon Hall	Burdon Hall (1994)
	14	Barmpton 1	
	15	Barmpton 2	
	6		Ketton Bridge (1994)

## 20.3 Results

### 20.3.1 Sport fish in the Skerne

Prior to the restocking with Dace and Brown Trout in 1992 and 1993, the Skerne above Darlington South Park weir had virtually no fish of interest to anglers. In 1991, only two sport fish (a Brown Trout and an Eel) were caught in the thirteen sites above South Park weir. Both fish were caught at the Victoria Embankment sample station in the centre of Darlington. No sport fish were recorded above South Park weir in any of the pre-1991 surveys.

### 20.3.2 Three-spined Stickleback, Stone Loach and Minnow

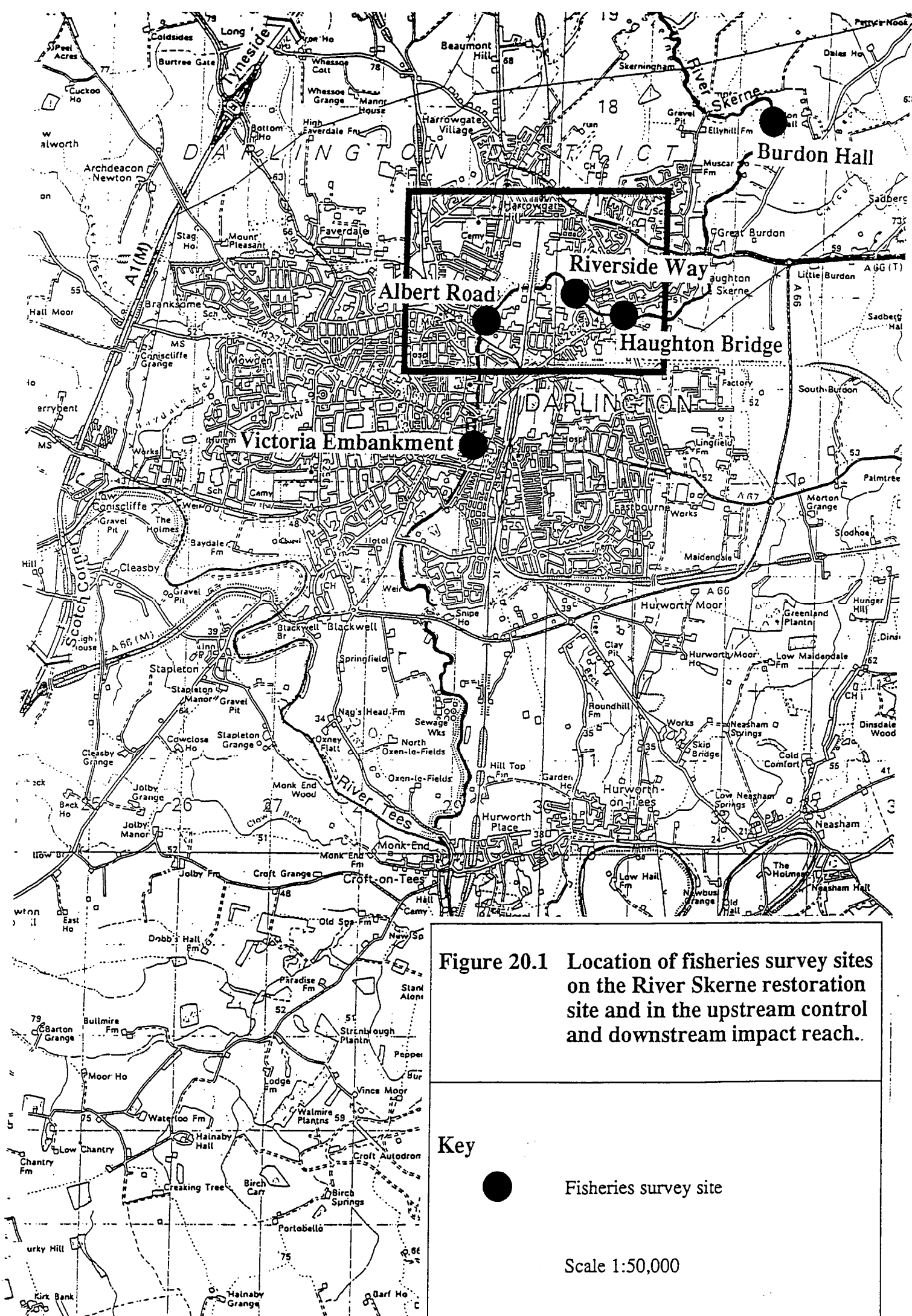
Although sport fish were extremely rare above South Park, so-called minor species were still present. In pre-1991 surveys, Three-spined Sticklebacks were present in four out of five sites above South Park and Stone Loach were present at one site.

In the 1991 survey, Three-spined Sticklebacks were recorded at 12 of the 13 sites above South Park weir. However, Stone Loach and Minnows were not found above the weir.

In 1994 there appeared to be evidence of Stone Loach and Minnow spreading in the Skerne. Stone Loach were either common or abundant at all four sites surveyed above South Park (Haughton Road Bridge, Burdon Hall, Ketton Bridge, Bradbury). Minnows, which had not previously been recorded above South Park weir in any survey, were present at Ketton Bridge. Three-spined Sticklebacks were common or abundant at three of these sites.

### 20.3.3 Stocking of the Skerne with Dace and Brown Trout

In 1992 and 1993 23,002 Brown Trout were stocked into the Skerne upstream of Darlington. 1090 Dace were also put into the river during the same period.



**Figure 20.1** Location of fisheries survey sites on the River Skerne restoration site and in the upstream control and downstream impact reach.

**Key**



Fisheries survey site

Scale 1:50,000

## 21. Public perception: Skerne

Monitoring of the public perception of river restoration is one of the six areas of the LIFE monitoring project which are being undertaken in special detail. The perception study has focused on the Skerne, as it is acknowledged that in the urban environment one of the major benefits of river restoration is likely to be public amenity. Immediate public appreciation is less likely to be important on the River Cole, which is more isolated and less accessible.

### 21.1 Aims

The aim of the public perception study is to assess the public appreciation of the objectives and effects of river restoration. The study will investigate people's views about the river, and the value of the river to them in economic terms. This data will form part of the overall assessment of the benefits of restoration.

The public perception study has had two main stages: (i) a pilot study to make a preliminary assessment of attitudes to the project; and (ii) a detailed questionnaire survey to investigate the views of Darlington residents about the current status of the river. The questionnaire survey will be repeated once the works are completed to investigate the way in which the completed scheme is perceived.

The work reported here was specially commissioned for the restoration project, and has been undertaken by the Flood Hazard Research Centre of Middlesex University. The principal workers have been Maureen Fordham and Sue Tapsell. The perception study has also benefited from information obtained in the course of the work of the Skerne Community Liaison Officer, Deidre Murphy.

### 21.2 Methods

#### 21.2.1 Preliminary survey

Public perception work started with a preliminary study which investigated public attitudes, made contact with relevant local organisations, and obtained a variety of background information about the site.

An archive of photographic material and a variety of materials held in the Reference Section and Centre for Local Studies of Darlington Library was initiated.

A list of key informants was compiled using a 'snowball' (Burgess, 1982) approach, where one informant suggests another and so on. This began with individuals and organisations already involved with the restoration scheme and followed with names from the Darlington Library Community Information File. Because the River Restoration Project on the River Skerne made its initial public contacts at a very early stage of project design (and largely through this preliminary study), few interest groups formed around the subject area, and so contact with these (often vociferous) groups and individuals did not occur at an early stage.

A number of people and organisations were contacted by telephone and, where appropriate, appointments made for meetings and interviews.

#### Limitations of the preliminary survey

The preliminary study was constrained by a limited budget and the speed with which the work had to be undertaken. Despite this, there was no serious damage to the project, although it did make the initial stages very pressurised.

### 21.2.2 Questionnaire surveys

A questionnaire survey of approximately 200 people will be undertaken before and after the works. The questionnaire is included in Appendix 2 in the format in which it will be presented to the public.

The questionnaire was designed to cover the following main areas:

- (i) the activities for which people use the river.
- (ii) people's views of the river as it is now.
- (iii) the enjoyment that people obtain from visiting the river.
- (iv) people's views about the proposed restoration design.
- (v) people's willingness to pay for the improvements proposed.
- (vi) people's expectations for the river once restoration works have been completed.

The questionnaire is also being used to address a local issue, the construction of a new bridge across the Skerne, which has become associated with the restoration scheme at the request of Darlington Borough Council.

The questionnaire was developed by staff of the Flood Hazard Research Centre of Middlesex University, and was tested on a small sample of local residents prior to the finalisation of all questions. The trial confirmed that the pilot questionnaire was, as expected, too long and a number of questions were simplified or removed. The questionnaire survey is currently in progress, and preliminary results are expected towards the end of February 1995.

### 21.2.3 Acknowledgements

This report was made possible by the many people who freely gave their time and much information. In particular, officers and members of the following organisations generously gave their time, and in the case of Darlington Borough Council, the use of their facilities:

Darlington Borough Council  
 National Rivers Authority  
 Darlington Library, Reference Section and Centre for Local Studies  
 Durham Wildlife Trust, Darlington Group  
 Darlington Historical Society

The opinions expressed do not necessarily reflect those of the key informants.

## 21.3 Pilot study results

### 21.3.1 Attitudes to, and use of, the local river environment

Site visits (31 August 1994 and 2 September 1994) showed that both sides of the river (where accessible) were well used by people of all ages. The site visits were undertaken during the school holidays, so one would expect there to be, perhaps, an increased use by children and guardians. Observations revealed children playing (running about and cycling), collecting blackberries with adults, and just walking around the site. Some children/young people had constructed rope swings from the riverside trees. Cyclists (both children and adults) were seen on the pathways, and one motor-cyclist was seen on the north bank near Riverside Way. Two horse-riders were observed at the Five Arches Bridge end: there is a riding school on the south side of the river near the Red Hall estate and horses graze in enclosed fields on the northern bank between the footbridge and the Haughton Bridge. People also appeared to be walking purposefully, presumably using the site as an access route to somewhere else.

The main uses of the study site at present appeared to be informal walking, particularly with dogs and also with children, and for access to other parts of Darlington. The footbridge near Haughton Bridge appears to be very well used (a local resident said the bridge was "amazingly well used"). A number of people visit the river and cross the bridge every day. Some do so two or three times a day because they use the footbridge for

access to work, to public transport or into the town and for regular pursuits such as walking the dog. Feeding the ducks and watching the birds and other wildlife were given as popular pursuits while walking along the riverbank.

The preliminary survey showed that there was already some local school/educational use of the site and suggested that this could easily be extended during and following the River Restoration Project work. Schoolchildren of both primary and secondary age have used the site for project work. One local school (Haughton Comprehensive) involved in the "Square Mile Project", had seeded an area with wild flowers, and another (Longfield Primary School) was involved in early (1985) tree-planting initiatives with Durham Wildlife Trust.

Those people spoken to all expressed concern for the river environment, and were very interested in any project that was going to improve the river in any way:

"I just think it's a beautiful spot."

"It is a very pleasant area."

"Well, it's the local patch isn't it?"

"I feel very strongly about the river."

One informant felt that building another bridge and/or footpath would encourage further use of the river environment and that this would be beneficial; greater familiarity with the area and its wildlife would promote greater interest and concern and limit vandalism.

The Skerne Bridge is a focus of interest for the local people and it would clearly be an important feature of any tourism initiatives, e.g. a circular walk. One informant was pleased to see that

"...the Council are going to do something about the Skerne Bridge...at last they are going to clean it up."

The Rockwell (Rock Well) is a valued site of historical, cultural and geological interest, but concern was expressed about its present state:

"Rockwell is in a mess...It is not properly looked after since the initial interest and clean-up. It is collecting rubbish, the spring is dry."

Generally, the attitude to the study area appeared during the preliminary survey to be very positive and concerned. Many people had moved to the area because of the open space and the river. When asked what would make the site better, a local resident responded:

"A bridge at the other end."

An informant remarked upon recent river management by the NRA which she believed had been:

"...far too severe". [It] left no protection for birds or fish - no weed in the water for fish to shelter in - destroyed part of the bank - it crumbled away. A lot of people were making comments about it."

Whether or not this was a justifiable criticism of the river management, it showed how local people were concerned when they saw something happening to 'their' river. Concerns such as these were identified at an early stage with the preliminary study, making it easier to address them later in the public consultation process.

### 21.3.2 Issues of concern

A number of issues of concern were highlighted by the pilot study and provided a valuable starting point for further negotiation and planning. These arose during (a) interviews with DBC officers (i.e. these are issues that were perceived by them, on the basis of past experience, to be of concern to local people); (b) through interviews with other informants; (c) through documentary research; and (d) through personal observation.

**Pollution** of the river was mentioned by a number of informants, and is particularly evident in documentary sources going back over a hundred years:

"The Skerne is easily the most polluted watercourse in the whole area."

The present state of the river was felt by some informants, however, to be reasonable; they had seen the river in poorer condition on other occasions and some had reported pollution incidents to the NRA. They were, of course, responding to visible signs of pollution and would be unaware of less easily perceived chemical changes. It was understood by one informant that there was a recurring pollution problem:

"Something flushes into rivers in times of heavy rain which knocks out fish but doesn't harm vegetation - water weeds."

It was felt that the river had water quality problems but

"Since Trimden Cokeworks closed down you can see the bottom of the river. I had heard that the river supported some fish - not many species but large numbers of them."

The issue of **flooding** was raised initially by officers of Darlington Borough Council as a possible cause for concern. There was little opportunity for this issue to arise during interviews, but it was mentioned by one informant when the possibility of changing the course of the river was raised. She remarked that the river had been straightened for flood control reasons and that any change to its course might increase the present flood risk. She felt it might be an issue of concern to others, although she did not express any great personal concern.

Concern was expressed over the possibility of disturbance and damage to **nature conservation** interests along the river area. This concern was expressed by ordinary residents and not just environmental group representatives. The improved access offered by a new bridge and/or footpath was perceived to be the cause of this, bringing greater numbers of people into an area that was generally secluded.

**Vandalism** in general was mentioned by some informants as an issue, and more particularly such things as the use of **airguns** (and other guns) which had been noted on the site; the making of **rope swings on the riverside trees** which damaged the trees; and **motorbike riding**, which is also a problem elsewhere in Darlington<sup>1</sup>. One informant remarked that:

"Bikers used to be a problem...but since the housing was built and since the presence of a local policeman it has not been so bad."

**Kids hanging out** by the bridge was an issue raised by one informant, who felt that they were sometimes held to be a nuisance when in fact they just congregated there, talking and not actually doing anything wrong. However, it is how the local people perceive them that is inevitably the deciding factor and if they view such 'hanging out' negatively then they might be concerned at its spread downstream to another bridge. More positively, a second bridge was thought to present the possibility of "spreading the load" and thus relieving the existing site.

Should a new footpath be constructed then the **safety, security and privacy** of certain residential areas, presently located at some distance from footpaths, was believed by two informants to be at risk. This

<sup>1</sup> An initiative has been underway at Firth Moor, in the southern part of Darlington, during the 1994 summer, school holiday period to redirect this interest onto managed sites in the Borough; the contact person for this is Liz Robinson, Safer Community Co-ordinator, Darlington Borough Council.

highlights the distributional problems of environmental management where there are invariably spatially differentiated costs as well as benefits.

**Dog fouling** was not mentioned as a problem by local residents but this was probably because many were themselves dog-walkers! It is likely that the problem of dog fouling will crop up in the detailed questionnaire. The look of the riverside area, in particular **weeds by the river** (nettles, thistles, docks, etc) were mentioned by one informant as needing attention if the area were to be improved. These plants are also present along made footpaths, i.e. alongside areas which people expect to be managed.

The state of the existing footbridge, both aesthetically ("not a pretty sight") and structurally was of concern. In view of the level of use of the bridge, this would seem to be both a priority and an opportunity for (largely amenity) enhancement.

The preliminary study found nobody who went **fishing** in the study area and it was not mentioned during interviews (although local fishing clubs were not contactable during the study period) except once when an environmental group representative expressed concern for the encouragement of fishing if it were to include or impact upon the ponds on the site which support Great Crested Newts.

Some members of the local community and their political representatives were concerned that money proposed to be spent by DBC for the RRP project (i.e. on the footbridge and the surveys of local attitudes) would be an **inappropriate use of funds**. There are areas and groups in the Borough where there is a considerable social need, and some might wish the funds available for river restoration to be re-directed there. This is a common response to 'environmental' works which can appear to some as merely cosmetic.

### 21.3.3 Issues of positive gain

The preliminary study showed that, as would have been hoped, not all the issues surrounding the restoration scheme were negative. A number of issues of positive gain were identified by informants.

A commonly reported advantage of the project (in its widest sense) was in terms of a **reduction/removal of river pollution**. The Skerne has a long history as a polluted river -

"Everyone in Darlington would like to see the Skerne cleaned up."

and the study suggested that any proposals that might lead to an improvement in this area would probably be welcomed.

Linked to this was the need perceived by some for a general **clean-up of the area** which the restoration project was perceived to include. This could have negative ecological effects, however, if the cleaning-up were to be visualised in terms of closely mown grass and the planting of exotic trees.

Greater **access to the river environment**, from both the general river corridor works but also primarily through the construction of the bridge, was seen to be a benefit for many. This was variously described as an amenity gain through cutting down the walking distance on the way through the town; as a benefit for elderly people who could then visit other parts of the site; as a benefit for environmentalists, making it easier for them to reach all areas of ecological interest, on both sides of the river ("I can't wait"); and as an aid to the use of the site as an **educational resource**, both generally - encouraging people to value wildlife through increased contact with it - and specifically for the schools that do or could use the area for study.

The project generally was seen to represent a positive gain for **nature conservation** values and perhaps to suggest some more permanent security for its ecological value.

It was suggested that the River Restoration Project could act as a positive **community focus**, especially for younger members of the community, by encouraging, or further encouraging, interest in the river area and through processes of self-policing.

### 21.3.4 The footbridge

Darlington Borough Council have been planning for some years to construct a new footbridge across the Skerne. Whilst the construction of footbridges might, at first sight, seem to have little to do with river restoration, it could be an issue in many urban schemes, where access to different parts of a river is likely to be important.

The proposal for a new footbridge met with a divided response. Preliminary contacts found that it was regarded more as a positive advantage than as a possible problem issue. Local residents felt that, on the whole, a new bridge (making two crossing points) would be beneficial, but local environmentalists were somewhat split over the issue of a bridge. While some welcomed it as it would make access to the other side of the river easier and quicker, others felt that it would open up sensitive areas and so make them liable to damage and disturbance.

"I am quite well in favour of it [a second bridge]. It will open up parts of the river not usually visited and this would be a good thing."

Two local residents felt that the existing bridge was in a poor state of repair and would benefit from some attention. One expressly stated that her priority was the condition of the existing bridge and that if there were to be a choice between repairing the existing bridge and building another, then she would favour repair and rehabilitation of the existing bridge. Concern about the look of the bridge as well as its structural state was expressed.

"A good idea to spend money on this [the existing bridge]."

"It is in poor repair and often vandalised and not a pretty site. It could be made more vandal-proof than it is."

One resident thought that a second bridge would be beneficial for elderly people who would like to visit the other side of the river but for whom the walk up to the existing bridge was "too much".

## 21.4 Public consultation and participation

Research (summarised in Tunstall et al, 1994) has demonstrated that early, wide and continuing consultation is preferred by the majority of the public. In this project, the preliminary study has also been used:

- (i) to make initial contacts, which were greeted very positively (people were grateful for being consulted at a very early stage).
- (ii) to give people an early opportunity to raise issues of concern, although there were few new issues that they could identify.

The preliminary study indicated that information should be passed on to the community in a number of ways. Recommended techniques were production of leaflets, encouraging local media coverage, organising public meetings/exhibitions, provision of a 'comments book', the initiation of a community forum, the inclusion of a community liaison officer role within the project management structure and the provision of information on site during construction. Most of these were subsequently undertaken. Following the preliminary study, most of these options were put into practice.

**Table 21.1**                      **Issues of concern and positive gain**

**Issues of concern**

- Pollution
- Flooding
- Nature conservation
- Access
- Kids 'hanging out'
- Safety, security and privacy
- Dog fouling
- Weeds by the river (nettles, thistles, docks etc)
- State of the existing footbridge
- Fishing
- Inappropriate use of funds

**Issues of positive gain**

- Reduction/removal of river pollution
- Clean-up of the area
- Access
- Educational resource
- Nature conservation
- Community focus

## **21.5 Overall conclusions and recommendations from the preliminary study**

The study suggested that the people of Darlington would welcome - albeit cautiously - the proposals for river restoration. Their caution was, primarily, a symptom of a lack of information at the time of the survey.

There was already a concern for, and enjoyment in, the wildlife found on the site and any proposals would have to demonstrate protection for the existing nature conservation value and preferably an enhancement of it.

The anticipated disruption of the construction period had to be acknowledged and proposals for minimising it made clear. The study indicated that alienation of public opinion was a danger should access across the river be disrupted (through work on the existing footbridge for example) or should access to the river area itself be limited.

It was clear that safety concerns could be an issue, connected both to construction and post-construction phases, and that they were better acknowledged (although not exaggerated) and dealt with at an early stage.

Local environmental groups had already carried out a considerable amount of work on the site and had strong feelings about it. They were generally positive about the proposals, making it important that the project did not 'take over' and exclude them from the decision making.

**Table 21.2**      **List of documentary sources**

A	From a file held in Darlington Library entitled: <i>Local Project 4: River Skerne, U418a</i> . (x = not photocopied)	
	1	"The Skerne"      From W.H.D. Longstaffe's History of Darlington. 1854
	2	"The Carrs Around Darlington"      From C.P. Nicholson's "Those Boys O' Bondgate". 1949. 2pp
	3	"The Skerne Walk"      From C.P. Nicholson's "Those Boys O' Bondgate". 1949. 2pp
	4	"When Skerne Set Darlington Industries in Motion"      Article by R. Scarr, Darlington and Stockton Times, 22nd September 1956. 2pp
	5	"The Skerne Hides a Long History - once a Mill Centre"      Article by W.J. Lee, Northern Dispatch, 6th November 1959
	6	"Mills and Bridges on the Skerne"      Article by W.J. Lee, Northern Dispatch, 20th November 1959. 2pp
	x7	"Skerne made an Industry Thrive"      Article by Peter King, Evening Dispatch, 4th September 1973 [suggestions for schoolchildren's project work]
	8	Durham County Council      Report of the County Health Inspector on the Condition of the River Skerne and Tributaries. 11th September 1900. 10pp
	9	Darlington, Borough of. Borough Surveyor's Office      Report on the best means to be adopted to prevent flooding of the low-lying streets adjoining River Skerne. 20th February 1904
	10	Darlington, County Borough of. Town Clerk's Department      The Course of the River Skerne: within the County Borough of Darlington: Memorandum by the Town Clerk. 22nd March 1938. 2pp
	11	Darlington, County Borough of. Town Clerk's Department      Pollution of River Skerne, 11th November 1938
	12	Darlington, Council of. Social Services      River Pollution. 1970. 2pp
	13	Darlington      Skerne Bridge Improvement. List of Subscriptions. c1840
	x14	Articles from the Northern Dispatch      18th January 1962; 20th May 1968 [Skerne Park area]
	15	Articles from the Evening Dispatch      23rd April 1970
	16	Articles from the Evening Dispatch      30th April 1970; 16th July 1970
	17	Articles from the Darlington and Stockton Times      11th July 1970; 18th July 1970
	18	Articles from the Evening Dispatch      22nd February 1971; 25th February 1971; 1st March 1971
		Articles from the Darlington and Stockton Times      6th March 1971
	19	Articles from the Evening Dispatch      23rd September 1971. 2pp
	20	Articles from the Evening Dispatch      24th September 1971. 2pp
	21	Articles from the Evening Dispatch      6th November 1971
	22	Articles from the Evening Dispatch      6th July 1972
		Articles from the Northern Echo      4th October 1972
	x23	Map showing course of the river Skerne through Darlington
	x24	Map showing course of the River Skerne from Darlington to River Tees from 1856 OS Map Scale 6" - 1 mile [too far south]
	x25	Map showing course of the River Skerne through Darlington. c1970 [hand drawn/copied]
	26	Map showing course of the River Skerne from source, near Trimdon, to River Tees. c1970. 2pp
	x27	Photocopy of Darlington Council Minutes [report of the Town Clerk already copied]
	x28	Map of Darlington [too far south]
	29	Newspaper cuttings: Darlington and Stockton Times, 9th March 1991 Northern Echo, 27th February 1991

**Table 21.2**                      **List of documentary sources**

<b>B Newspaper Cuttings Index:</b>			
Darlington Rock Well			
1	Picture of well, description and legend: Cuttings Book 1959 p.27		
x2	Description of Rockwell: Darlington and Stockton Times 3 May 1884 p4		
3	Architect at Town Hall fights plans to extend a housing estate which would obliterate Rock Well. Photo. Cuttings Book 1976 pp 105, 114		
x4	History of preserving for a nature reserve. Cuttings Book 1992 p148		
Darlington Rockwell Pastures			
5	Wildlife haven to be set up in Rockwell Pastures area. Cuttings Book 1984 p157, 158		
6	Durham Conservation Volunteers begin work on wildlife sanctuary. Cuttings Book 1985 p10		
7	Wins major award in Northumbria in Bloom competition. Cuttings Book 1986 p110		
8	Land to be transferred to North Housing Association to build 150 houses and flats. Cuttings Book p154		
9	Rockwell receives top environment award. Cuttings Book 1987 p222		
10	ditto p237		
11	North Housing Association agrees to build 50 houses. Cuttings Book 1989 p121		
12	Residents plan to fight proposals for more houses and flats. Cuttings Book 1989 p151		
13	Plans to build a bridge across the Skerne. Cuttings Book 1990 p221		
14	Home partnership. Cuttings Book (Northern Echo 27.9.86)		
<b>C Catalogue</b>			
1	Race, Dave. Rockwell Urban Conservation Project. In Durham County Conservation Trust Ltd. Bulletin May 1987. U415g475 L.C.		
2	Durham County Conservation Trust Darlington Group. Rockwell Pastures. Local Group Act. 9th March 1985. U418m L.C.		
<b>D Photograph Index</b>			
Rockwell			
1	Glebe House, Haughton, Rockwell area, from 1st ed OS map 1856 S.I.18 (print from a slide)		
2	"Ye Rock Well on ye coy's estate". 2415B		
3	Tree planting at Rockwell Pastures 4203B. March 1985 b/w photo		
4	Rockwell Pastures and surrounds. Includes series of photographs taken of same views at different times of the year and in different years. 1987-1991 colour. Accession numbers 14235-14479		
5	The course of the River Skerne within the County Borough of Darlington. Acc No. 7177. Class No. U418a (print from a slide)		
<b>E Miscellaneous</b>			
1	Manson, R. Taylor. 1884. "Pebbles from the Rock Well" in <b>Zig-Zag Ramblings</b> . Darlington: Printed at the "Times" Office. pp 3-6		
2	Map and list of old field names 1840. From the Estate Book of John Allan		
3	Particulars of Sale of Mill, machinery and dwelling houses, within 1 mile of Stockton & Darlington Railway. 1844		
<b>F Maps</b>			
1	County Durham Sheet	LV6	1856
2	County Durham Sheet		1884
3	County Durham Sheet	LV2	c1856
4	County Durham Sheet		1896

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# Appendices

# Appendix 1. Plant quadrat monitoring data for the River Cole (Oct 1994)

## Section 1a

% cover

### Section 1 (upper bank)

	i	ii	iii	iv
<i>Anthriscus sylvestris</i>	0	0	0	2
<i>Calystegia sepium</i>	5	10	5	5
<i>Galium aparine</i>	3	20	15	8
<i>Trisetum flavescens</i>	4	0	8	7
<i>Urtica dioica</i>	85	75	30	25

### Section 2 (low bank)

	i	ii	iii	iv
<i>Agrostis stolonifera</i>	0	0.5	3	0.5
<i>Cardamine flexuosa</i>	0	0	1	5
<i>Galium aparine</i>	0	5	2	4
<i>Lolium perrene</i>	0	0	0	1
<i>Scropularia auriculata</i>	0	0	0	1
<i>Urtica dioica</i>	2	5	0	0
<i>Veronica beccabunga</i>	0	0	0	0.25

### Section 3 (in river)

	i	ii	iii	iv
<i>Scropularia auriculata</i>	0	2	30	0
<i>Myriophyllum spicatum</i>	7	5	5	0

### Section 4 (middle of river)

	i	ii	iii	iv
<i>Nuphar lutea</i>	2	2	0	0
<i>Schenoplectus lacustris</i>	30	80	10	30

## Appendix 1. (cont)

### Section 1b

% cover

#### Section 1 (mid bank)

	i	ii	iii	iv
<i>Anthriscus sylvestris</i>	0	7	4	8
<i>Agrostis stolonifera</i>	25	12	35	20
<i>Cardamine flexuosa</i>	1	0	0	1
<i>Dactylis glomerata</i>	1	10	6	8
<i>Heracleum sphondylium</i>	0	3	0	0
<i>Festuca rubra</i>	0	0	0	2
<i>Lolium perenne</i>	30	25	15	12
<i>Lamium album</i>	0	4	0	0
<i>Ranunculus repens</i>	0	4	0	2
<i>Rumex obtusifolius</i>	0	0	2	1
<i>Soncus oleraceus</i>	0	1	0	2
<i>Stellaria media</i>	0	1	0	0.5
<i>Taraxacum</i> sp.	2	0	1	4
<i>Urtica dioica</i>	0	30	17	5

#### Section 2 (base of bank)

	i	ii	iii	iv
<i>Agrostis stolonifera</i>	8	8	15	1
<i>Apium nodiflorum</i>	0	0	10	0
<i>Lycopus europeus</i>	12	0	0	0
<i>Polygonum lapathifolium</i>	0	0	10	0
<i>Myosoton aquaticum</i>	0	1	0	0
<i>Rumex obtusifolius</i>	6	3	0	0
<i>Urtica dioica</i>	35	40	15	10

#### Section 3 (in river)

	i	ii	iii	iv
<i>Myriophyllum spicatum</i>	22	55	0	5
<i>Nuphar lutea</i>	0	0	12	12
<i>Fontinalis antipyretica</i>	3	0	11	7

#### Section 4 (middle of river)

	i	ii	iii	iv
<i>Myriophyllum spicatum</i>	20	30	0	0
<i>Nuphar lutea</i>	0	8	0	0

## Appendix 1. (cont)

### Section 2a

#### % cover

#### Section 1 (outer bank)

<i>Glyceria maxima</i>	0	38	38	28
<i>Holcus lanatus</i>	1	0	0	0
<i>Juncus effusus</i>	0.5	0	0	0
<i>Juncus inflexus</i>	3	0	0	0
<i>Lolium perenne</i>	2.5	3.5	0.5	3
<i>Lycopus europeus</i>	1.5	0	0	0
<i>Mentha aquatica</i>	4	4	0.5	1
<i>Myosotis scorpioides</i>	7	5	1.5	1.5
<i>Ranunculus sceleratus</i>	0.3	0	0.3	0.25
<i>Rumex crispus</i>	1.3	1	0.3	1.5
<i>Sonchus oleraceus</i>	0.3	0.3	0.3	0.25
<i>Taraxacum</i> sp.	1	0	0	0
<i>Urtica dioica</i>	0	1	0	0.25
<i>Veronica beccabunga</i>	2	1	0	0

#### Section 2 (low bank/water)

	i	ii	iii	iv
<i>Glyceria maxima</i>	5	70	75	90
<i>Lemna minor</i>	0	0.3	0	0.01
<i>Mentha aquatica</i>	48	27	0	0
<i>Myosotis scorpioides</i>	6	2.5	2.5	0.75
<i>Veronica beccabunga</i>	0.5	0	0	1

#### Section 3 (shallow water)

	i	ii	iii	iv
<i>Glyceria maxima</i>	0	0	0	19
<i>Lemna minor</i>	0	0	0	0.01
<i>Nuphar lutea</i>	0	0	0	0
<i>Sagittaria sagittifolia</i>	0	0	0	0
<i>Sparganium emersum</i>	0	0	0	0
<i>Veronica beccabunga</i>	0	0	0	0

#### Section 4 (middle of river)

	i	ii	iii	iv
<i>Nuphar lutea</i>	2	40	2	0

## Appendix 1. (cont)

### Section 2b

	% cover			
	Section 1 (outer bank)			
	i	ii	iii	iv
<i>Achillea millefolium</i>	0	0.3	0	0
<i>Agrostis stolonifera</i>	11	27	20	10
<i>Dactylis glomerata</i>	0	0	0	0.5
<i>Geranium molle</i>	0	0.3	0.3	0
<i>Glyceria maxima</i>	2	4	0	0
<i>Holcus lanatus</i>	0	0	0	0.5
<i>Lolium perenne</i>	1	8	13	7
<i>Lycopus europaeus</i>	0.3	0	0	0.25
<i>Myosotis scorpioides</i>	0.3	8	15	16
<i>Polygonum amphibium</i>	0	0	0	0.5
<i>Ranunculus repens</i>	0.5	0.5	3.5	3
<i>Rorripa palustris</i>	0	0	0	0.25
<i>Ranunculus sceleratus</i>	0.3	0.3	0.3	0.25
<i>Rumex crispus</i>	0	3	0	0.5
<i>Sonchus oleraceus</i>	0	0	1	0.5
<i>Taraxacum</i> sp.	0	1	0	0
<i>Urtica dioica</i>	0	0.5	0.3	1
<i>Veronica beccabunga</i>	0	1	1	23

### Section 2 (low bank/water)

	i	ii	iii	iv
<i>Glyceria maxima</i>	70	6	0	0
<i>Juncus effusus</i>	0	0	8	0
<i>Myosotis scorpioides</i>	16	60	21	5
<i>Nuphar lutea</i>	2	0	0	0
<i>Polygonum amphibium</i>	0	0.5	0	0
<i>Sparganium emersum</i>	0	8	25	50
<i>Veronica beccabunga</i>	9	12	6	50

### Section 3 (shallow water)

	i	ii	iii	iv
<i>Glyceria maxima</i>	8	0	0	0
<i>Lemna minor</i>	0	0.1	0	0
<i>Nuphar lutea</i>	25	19	0	0
<i>Sagittaria sagittifolia</i>	0	1.5	0	0
<i>Sparganium emersum</i>	0	27	90	90
<i>Veronica beccabunga</i>	2.5	0	0	0

### Section 4 (middle of river)

	i	ii	iii	iv
<i>Nuphar lutea</i>	25	20	14	0
<i>Scheuchzeria palustris</i>	0	0	55	60
<i>Sparganium emersum</i>	0	1	10	40

## Appendix 1. (cont)

### Section 2c

% cover

#### Section 1 (outer bank)

	i	ii	iii	iv
<i>Agrostis stolonifera</i>	0	2	0.3	0.25
<i>Anthriscus sylvestris</i>	0	0	8	0
<i>Arrhenatherum elatius</i>	2	3	0.5	0
<i>Calystegia sepium</i>	0	4	10	0
<i>Epilobium hirsutum</i>	1	0	0	1
<i>Galium aparine</i>	1	0	0	3
<i>Heracleum sphondylium</i>	3	0	0	0
<i>Lamium album</i>	1	0	0	0
<i>Lolium perenne</i>	8	0	0	0
<i>Urtica dioica</i>	50	65	65	85

#### Section 2 (low bank/water)

	i	ii	iii	iv
<i>Anthriscus sylvestris</i>	1.5	1	0	0
<i>Barbarea vulgaris</i>	2	0	0	0
<i>Cardamine flexuosa</i>	1	5	0	0
<i>Epilobium hirsutum</i>	2	0.5	0	0
<i>Lolium perenne</i>	1	1	0	0
<i>Myosoton aquaticum</i>	1.5	0	0	0
<i>Rumex obtusifolius</i>	0	3	0	0
<i>Urtica dioica</i>	6	0	0	0
<i>Veronica beccabunga</i>	1	0	0	0

#### Section 3 (shallow water)

	i	ii	iii	iv
<i>Elodea nuttallii</i>	0	0	0	0.5
<i>Fontinalis antipyreticum</i>	0	1	0	0.5
<i>Potamogeton pectinatus</i>	4	11	12	5
<i>Myriophyllum spicatum</i>	36	15	14	6

#### Section 4 (middle of river)

	i	ii	iii	iv
<i>Fontinalis antipyreticum</i>				
<i>Potamogeton pectinatus</i>				
<i>Myriophyllum spicatum</i>	0	1	0	4

## Appendix 1. (cont)

### Section 3a

	% cover			
	Section 1 (outer bank)			
	i	ii	iii	iv
<i>Agrostis stolonifera</i>	0	0	1	1
<i>Arrhenatherum elatius</i>	0	0	0	4
<i>Anthriscus sylvestris</i>	2	5	4	9
<i>Agropyron repens</i>	0	10	0	80
<i>Angelica sylvestris</i>	0	0	0	15
<i>Calystegia sepium</i>	0	0	2	4
<i>Cirsium arvense</i>	0	1	1	0
<i>Epilobium hirsutum</i>	0	0	0	2
<i>Galium aparine</i>	2	1	1	2
<i>Phleum bertolonii</i>	0	0	1	1
<i>Lolium perenne</i>	0	0	4	0
<i>Lycopus europeus</i>	0	0	1	0
<i>Myosoton aquaticum</i>	0	0	0	1
<i>Phalaris arundinacea</i>				
<i>Ranunculus repens</i>	2	0	0	0
<i>Rumex obtusifolius</i>	0	0	2	0
<i>Scutellata galericulata</i>	0	0.3	0	0
<i>Scrophularia auriculata</i>	0	0	0.3	0
<i>Urtica dioica</i>	12	25	15	7

### Section 2 (low bank/water)

	i	ii	iii	iv
<i>Arrhenatherum elatius</i>	0	0	4	0
<i>Agrostis stolonifera</i>	0	0	0	1
<i>Agropyron repens</i>	5	0	0	0
<i>Barbarea vulgaris</i>	0	5	0	0
<i>Cardamine flexuosa</i>	0	0	1	1
<i>Dactylis glomerata</i>	0	0	0	5
<i>Eupatorium cannabinum</i>	0	0	5	20
<i>Epilobium hirsutum</i>	0	4	1	8
<i>Equisetum arvense</i>	0	0	0	1
<i>Galium aparine</i>	0	0	1	2
<i>Lycopus europeus</i>	0	0	3	0
<i>Lolium perenne</i>	0	0	2	0
<i>Myosoton aquaticum</i>	1	1	0	4
<i>Phalaris arundinacea</i>	20	0	30	0
<i>Ranunculus repens</i>	1	0	0	0
<i>Scutellaria galericulata</i>	0	0	0	0.25
<i>Scrophularia auriculata</i>	0	2	3	0
<i>Urtica dioica</i>	50	60	25	15

### Section 3 (shallow water)

<i>Phalaris arundinacea</i>	60	0	13	0
-----------------------------	----	---	----	---

### Section 4 (middle of river)

	i	ii	iii	iv
<i>Potamogeton pectinatus</i>				
<i>Myriophyllum spicatum</i>	0	5	0	10
<i>Phalaris arundinacea</i>	7	0	0	0

## Appendix 1. (cont)

### Section 2d

% cover

#### Section 1 (outer bank)

	i	ii	iii	iv
<i>Agrostis stolonifera</i>	1	0	0	0
<i>Anthriscus sylvestris</i>	1	0	1	1
<i>Arrhenatherum elatius</i>	0	0	1	0
<i>Calystegia sepium</i>	0	7	6	3
<i>Epilobium hirsutum</i>	0	0	2	1
<i>Equisetum arvense</i>	5	4	3	1
<i>Galium aparine</i>	1	2	0	1
<i>Phalaris arundinacea</i>	0	0	1	1
<i>Urtica dioica</i>	75	60	50	60

#### Section 2 (low bank/water)

	i	ii	iii	iv
<i>Cardamine flexuosa</i>	0	0	0	1
<i>Calystegia sepium</i>	5	25	30	40
<i>Phalaris arundinacea</i>	55	60	60	40
<i>Urtica dioica</i>	35	45	12	15

#### Section 3 (shallow water)

	i	ii	iii	iv
<i>Calystegia sepium</i>	0	3	19	4
<i>Phalaris arundinacea</i>	75	90	70	80
<i>Urtica dioica</i>	0	0	0	3

#### Section 4 (middle of river)

	i	ii	iii	iv
<i>Phalaris arundinacea</i>	0	5	0	0

## Appendix 1. (cont)

### Section 3b

% cover

	Section 1 (mid/upper bank)			
	i	ii	iii	iv
<i>Anthriscus sylvestris</i>	1	2	1	5
<i>Arrhenatherum elatius</i>	50	20	35	45
<i>Dactylis glomerata</i>	5	3	2	4
<i>Galium aparine</i>	0	1	7	1
<i>Holcus lanatus</i>	0	0	15	10
<i>Lolium perenne</i>	1	0	0	1
<i>Lamium album</i>	1	3	7	0
<i>Taraxacum</i> sp.	0	0	0	0
<i>Urtica dioica</i>	30	70	25	40

	Section 2 (low bank to water)			
	i	ii	iii	iv
<i>Urtica dioica</i>	50	10	10	10
<i>Phalaris arundinacea</i>	40	25	15	25

	Section 3 (in water)			
	i	ii	iii	iv
<i>Phalaris arundinacea</i>	25	85	15	0

	Section 4 (middle of river)			
	i	ii	iii	iv
Open water	100	100	100	100

## Appendix 1. (cont)

### Section 3c

	% cover			
	Section 1 (mid/upper bank)			
	i	ii	iii	iv
<i>Achillea millefolium</i>	3	0	5	3
<i>Arrhenatherum elatius</i>	0	0	30	35
<i>Calystegia sepium</i>	10	10	8	0
<i>Cirsium arvense</i>	8	5	12	3
<i>Galium aparine</i>	0	1	1	0
<i>Lamium album</i>	8	10	15	9
<i>Lolium perenne</i>	0	3	0	0
<i>Lycopus europeus</i>	0	0	0	12
<i>Polygonum amphibium</i>	8	0	1	5
<i>Phalaris arundinacea</i>	0	5	0	0
<i>Potentilla reptans</i>	3	1	0	0
<i>Rumex obtusifolius</i>	2	2	1	0
<i>Rubus</i> sp.	0	0	3	8
<i>Urtica dioica</i>	1	30	3	11

#### Section 2 (low bank)

	i	ii	iii	iv
<i>Calystegia sepium</i>	3	2	0	4
<i>Cirsium arvense</i>	2	0	0	0
<i>Potentilla reptans</i>	1	0	0	0
<i>Myosotis scorpioides</i>	0.5	0	0	0
<i>Myosoton aquaticum</i>	0.5	0	0	0
<i>Phalaris arundinacea</i>	10	30	50	75
<i>Polygonum amphibium</i>	0	0	10	0
<i>Urtica dioica</i>	40	50	20	20

#### Section 3 (in water)

	i	ii	iii	iv
<i>Phalaris arundinacea</i>	0	0	50	50

#### Section 4 (middle of river)

	i	ii	iii	iv
<i>Schoenoplectus lacustris</i>	0	30	0	2
<i>Sparganium erectum</i>	0	0	3	0

**MIDDLESEX UNIVERSITY  
CONFIDENTIAL**

**THE RIVER SKERNE PUBLIC PERCEPTION SURVEY  
STAGE II**

---

**FOR OFFICE USE ONLY**

---

Questionnaire number .....

Location                      **DARLINGTON**

---

Interviewer .....

Interview number .....

Date                          ....../....../1995

Day                            .....

Street                        .....

Time interview started (24 hour clock) .....

Time interview finished (24 hour clock) .....

Length of interview (minutes) .....

Approximate distance of house from river:

- |    |  |   |
|----|--|---|
| a) | Riverside property .....               | 1 |
| b) | Within 250 metres/yards .....          | 2 |
| c) | Between 250 and 500 metres/yards ..... | 3 |
| d) | Over 500 metres/yards .....            | 4 |

House classification

Dwelling type:-

Age of dwelling:-

Detached house	1	Pre 1918	1
Semi-detached house	2	1919 - 1938	2
Terraced house	3	1939 - 1965	3
Bungalow	4	1966 - 1977	4
Flat	5	Post 1977	5

[Q.3] How often do you visit the river in summer, that is between April and September, and in the winter between October and March?  
[SHOW CARD 1] CIRCLE ONE ANSWER

<b>SUMMER:</b>	Daily	1
	Several times a week	2
	Weekly	3
	Fortnightly	4
	Monthly	5
	2/3 times a year	6
	Once a year	7

<b>WINTER:</b>	Daily	1
	Several times a week	2
	Weekly	3
	Fortnightly	4
	Monthly	5
	2/3 times a year	6
	Once a year	7

[Q.4] Which section(s) of the river do you visit?  
[SHOW MAP A]

	YES	NO	DON'T KNOW
Section 1	1	2	-9
Section 2	1	2	-9
Section 3	1	2	-9
Section 4	1	2	-9
Section 5	1	2	-9
Section 6	1	2	-9

[Q.8] What do you dislike about the river?  
 [PROBE AND RECORD VERBATIM - INCLUDE NON-USERS TOO]

.....  
 .....  
 .....

[FOR RESPONDENTS WHO DO NOT VISIT THE RIVER ONLY  
 - PROBE AND RECORD VERBATIM]

[Q.9] If you do not visit the river, can you give me the reasons why?

.....  
 .....

## SECTION 2 QUESTIONS ON ASPECTS OF THE RIVER AND SURROUNDING OPEN SPACE

[Q.10] I would like to ask your views on certain aspects of the river and surrounding open space as it is at present between Skerne Bridge and Haughton Bridge.

RATE ON A SCALE OF -5 TO +5

[SHOW CARD 4 - NOTE ANY COMMENTS AND PROBE]

For each of the following please rate on a scale of: -5 = very bad, +5 = very good.

Very bad					No opinion						Very good	Don't know
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5		-9

a) The mown and unmown grass in the area

.....  
 .....

i) The shape of the river channel between Skerne Bridge and Five Arches Bridge eg: uniformity, width, depth etc.

.....

.....

j) The shape of the river channel between Five Arches Bridge and Hutton Avenue Bridge eg: uniformity, width, depth etc.

.....

.....

k) Access to the river

.....

.....

l) Maintenance of the riverbed and banks

.....

.....

m) Cleanliness of open space and river banks ie litter, dog fouling etc.

.....

.....

n) The nature and surface of the footpaths

.....

.....

[Q.11] How attractive do you think the **different sections** of the river are between Skerne Bridge and Haughton Bridge?

**[SHOW SECTIONS ON MAP - RATE ON A SCALE OF -5 TO +5  
SHOW CARD 5]**

Very unattractive										Very attractive		Don't know
-5	-4	-3	-2	-1	0	1	2	3	4	5	-9	
						Section 1		.....				
						Section 2		.....				
						Section 3		.....				
						Section 4		.....				
						Section 5		.....				
						Section 6		.....				

[Q.12] How attractive **overall** is the section of river between Skerne Bridge and Hutton Avenue Bridge in its current state?

**[SHOW CARD 6 - PLEASE TICK ONE BOX]**

**PLEASE RATE ON A SCALE OF:**

**-5 = Very unattractive, to +5 = Very attractive**

Very unattractive										Very attractive	
-5	-4	-3	-2	-1	0	1	2	3	4	5	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

## SHOW RESTORATION MAP

I'm now going to show you a plan proposed to change the river here in Darlington.

This is the proposed scheme. It would involve creating bends in the rivercourse in Sections 5 and 6 (see map) which may involve the loss of some of the open space available for recreational activities such as football etc. Some of the concrete retaining walls will be given a softer appearance with extra planting including trailing plants. The new bends in the river channel in section 5 would make the river less uniform, with variations in width and depth and river bed materials. The scheme would create wetland areas and pond areas joined to the river to attract new wildlife and would involve new landscaping with trees, plants and flowers. It is planned that the scheme will lead to an improvement in the quality of the water in the river. Moreover, Darlington Borough Council are considering the possibility of an additional new footbridge and footpaths, which I will come on to later. Although the scheme would provide the same or an improved level of flood protection to nearby properties as at present, some of the open land by the river (the original floodplains) would be liable to natural flooding as it is at present.

[Q.14] Can I ask you what you like about this scheme?

[RECORD VERBATIM AND PROBE]

.....  
.....  
.....

[Q.15] Can I ask you what you dislike about this scheme?

[RECORD VERBATIM AND PROBE]

.....  
.....  
.....

[Q.16] Would you visit the river more often or less often than you do now if the above changes were to be carried out or would it make no difference?

More often	1
Less often	2
Make no difference	3
Don't know	-9

## SECTION 4 FOR RESPONDENTS WHO HAVE NOT VISITED RIVER IN LAST 12 MONTHS

### SHOW RESTORATION MAP

I'm now going to show you a plan proposed to change the river here in Darlington.

This is the proposed scheme. It would involve creating bends in the rivercourse in Sections 5 and 6 (see map) which may involve the loss of some of the open space available for recreational activities such as football etc. Some of the concrete retaining walls will be given a softer appearance with extra planting including trailing plants. The new bends in the river channel in section 5 would make the river less uniform, with variations in width and depth and river bed materials. The scheme would create wetland areas and pond areas joined to the river to attract new wildlife and would involve new landscaping with trees, plants and flowers. It is planned that the scheme will lead to an improvement in the quality of the water in the river. Moreover, Darlington Borough Council are considering the possibility of an additional new footbridge and footpaths, which I will come on to later. Although the scheme would provide the same or an improved level of flood protection to nearby properties as at present, some of the open land by the river (the original floodplains) would be liable to natural flooding as it is at present.

[Q.20] Can I ask you what you like about this scheme?

[RECORD VERBATIM AND PROBE]

.....  
.....  
.....

[Q.21] Can I ask you what you dislike about this scheme?

[RECORD VERBATIM AND PROBE]

.....  
.....  
.....

[Q.22] Do you think you would visit the river if the above changes were to be carried out?

YES	1
NO	2
DON'T KNOW	-9

[Q.24] From what you have been told about the proposed scheme for the river, are you in favour of it being carried out? How strongly are you in favour or against its being carried out?

**PLEASE EVALUATE AND RATE ON A SCALE OF:**  
**[SHOW CARD 9]**

Strongly against				No opinion			Strongly in favour
-3	-2	-1	0	+1	+2	+3	

Restoration .....

## SECTION 5 WILLINGNESS TO PAY QUESTIONS - ALL RESPONDENTS

### READ OUT

There are many miles of river in England and Wales which like the River Skerne in Darlington have been changed, through being straightened or put in concrete channels as part of flood defence schemes, or which have been altered in other ways. Although money is being spent to tackle particular problems on rivers, such as pollution and low flows, currently very little money is spent by national and local authorities on schemes generally to return rivers to a more natural condition.

We want you to think about whether you would be prepared to pay additional national and local taxes to fund schemes to return rivers to a more natural condition. This may be a difficult question if you haven't thought about it in this way before. We hope these comments may help you decide.

In current circumstances, you may not be able to afford to pay any more in national and local taxes to fund river restoration. Also there may be other environmental problems such as air pollution or other areas of public expenditure (such as education, law and order, or health care) upon which you would prefer any extra money to be spent. Or you may prefer all public expenditure to be reduced so that national and local taxes can be reduced.

[Q.25] We would like to find out if you would be prepared to pay, on behalf of your household, a small increase in national and local taxes each year to return rivers to a more natural condition?

Would you be prepared to pay for:

	YES	MAYBE	NO	DON'T KNOW
a) a national programme which would include the River Skerne	1	2	3	-9
b) the scheme for the River Skerne only, funded locally, which I showed you in the drawing earlier	1	2	3	-9

IF YES/MAYBE TO A) national programme, AND B) Skerne scheme GO TO Q.26

IF NO/DON'T KNOW TO A) AND B) GO TO Q.28

IF YES/MAYBE TO A) AND NO/DON'T KNOW TO B) GO TO Q.28

IF NO/DON'T KNOW TO A) AND YES/MAYBE TO B) GO TO Q.26

- a) What my household could afford to pay .....
- b) The amount I already have to pay in local and national taxes .....
- c) The enjoyment I will get from visiting the river .....
- d) What it is fair for my household to pay .....
- e) The other things I would like to spend money on .....
- f) The environmental benefit of the change .....
- g) My fair share of the cost .....

We wanted to find out how worthwhile you think the proposed scheme will be and how much you would be willing to contribute to such a scheme. However, a major part of the funding for the project has been raised by grants from the European Commission LIFE fund, with some additional funding from the partners: the National Rivers Authority, English Nature, the Government's Advisors on Nature Conservation, the Countryside Commission and Darlington Borough Council. **So the people of Darlington will not be required to pay anything extra for the scheme over and above what they are currently paying in Council Tax.**

## SECTION 6 BRIDGES AND FOOTPATHS

The River Project and Darlington Borough Council are also considering providing an additional footbridge and footpaths along the river here.

[Q.29] Can I ask you, do you use the current Hutton Avenue footbridge over the river?  
[SHOW MAP OF LOCATION]

YES	1
NO	2
DON'T KNOW	-9

**IF YES GO TO Q.30**  
**IF NO GO TO Q.31**

c)	In favour of a new bridge at location C	1	2	-9
d)	In favour of a new bridge at location D	1	2	-9
e)	In favour of a new bridge at any of the locations	1	2	-9
f)	In favour of a new bridge at a different location	1	2	-9
g)	Not in favour of a new bridge at any location	1	2	-9
h)	Would prefer to have existing bridge refurbished instead of an additional bridge	1	2	-9
i)	Would like to have a new bridge as well as having the existing bridge refurbished	1	2	-9

[Q.34] Can you tell me why you are in favour or against a new footbridge?  
**[PROBE AND QUOTE VERBATIM]**

.....  
 .....

[Q.35] If you are in favour of a new footbridge but in a different location to the ones proposed can you show me on the map where you would prefer the footbridge to be and why.  
**[SHOW MAP AND MARK LOCATION - PROBE AND QUOTE VERBATIM]**

.....  
 .....  
 .....

## SECTION 7 AFTER CHANGING THE RIVER

[Q.40] Do you think that a scheme to change the river would lead to it being more or less safe for children and other users than at present or would the changes make no difference to safety?

[PLEASE CIRCLE - SHOW CARD 17]

More safe	1 GO TO Q.60
Less safe	2 GO TO Q.60
Make no difference	3 GO TO Q.61
Don't know	-9 GO TO Q.61

[Q.41] Do you think that changing the river would result in increased or reduced recreation opportunities?

[SHOW CARD 18]

Increased opportunities	1
Reduced opportunities	2
Would remain the same	3
Don't know	-9

[Q.42] Do you think that changing the river will result in:

[SHOW CARD 19]

Loss of wildlife and wildlife habitat	1
Increase of wildlife and wildlife habitat	2
No change in wildlife and wildlife habitat	3
Don't know	-9

[Q.43] What gains or losses do you then think could result from changing the river?

.....

.....

.....

Not at all  
important

Very  
important

0 1 2 3 4 5 6 7 8 9 10

--	--	--	--	--	--	--	--	--	--	--

[Q.46] What form do you think that consultation should take?

[SHOW CARD 22]

[PLEASE CIRCLE FOR EACH ONE]

YES NO DON'T  
KNOW

- |    |                        |   |   |    |
|----|------------------------|---|---|----|
| a) | public meetings        | 1 | 2 | -9 |
| b) | letters or leaflets    | 1 | 2 | -9 |
| c) | newsletter             | 1 | 2 | -9 |
| d) | personal visits        | 1 | 2 | -9 |
| e) | notice in newspapers   | 1 | 2 | -9 |
| f) | local radio/TV         | 1 | 2 | -9 |
| g) | an exhibition          | 1 | 2 | -9 |
| h) | posters                | 1 | 2 | -9 |
| i) | local referendum       | 1 | 2 | -9 |
| j) | other (please specify) | 1 | 2 |    |

.....

[Q.47] Out of these which ONE form of consultation would you prefer?

[SHOW CARD 22]

[PLEASE CIRCLE ONE ANSWER ONLY]

- |       |                        |    |
|-------|------------------------|----|
| a)    | public meetings        | 1  |
| b)    | letters or leaflets    | 2  |
| c)    | newsletter             | 3  |
| d)    | personal visits        | 4  |
| e)    | noice in newspapers    | 5  |
| f)    | local radio/TV         | 6  |
| g)    | an exhibition          | 7  |
| h)    | posters                | 8  |
| i)    | local referendum       | 9  |
| j)    | other (please specify) | 10 |
| ..... |                        |    |
| k)    | don't know             | -9 |



