

NRA-Misc 14

Sources

Issue one
River catchments



NRA

National Rivers Authority

NRA-ELWA



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The NRA and the Environment Agency

The National Rivers Authority is soon to become part of a larger organisation which will have responsibilities not just for the environmental protection of water, but also of land and air.

This change will not affect the concepts set out in this issue of 'Sources'.

The idea of treating the river and its catchment as an integrated system is fundamental to the protection of the water environment.

Catchment management and catchment management plans will continue to be a key tools for the Environment Agency for the foreseeable future.

introduction

Sources



ENVIRONMENT AGENCY

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This is the first issue of *Sources*, a series of educational resources about the water environment for secondary school teachers. *Sources* is produced by the National Rivers Authority.

The National Rivers Authority manages rivers. This means that we plan how they are used, and what must be done to protect and improve them. It also means that we must take account of the views and needs of many different people – from anglers and canoeists to managers in industry and the companies that supply our homes with water.

The subject of this first resource book is River Catchments: it focuses on four contrasting river catchment areas to demonstrate the varied and often conflicting issues which affect the water environment and concern river users.

In *Sources* we take an enquiring approach, encouraging you and your students to ask the right questions and explore all the possible answers. We provide the starting points for you to find out for yourselves about the decision-making process, and to come to informed conclusions about the sustainable use of our rivers, lakes and coastal waters.

ENVIRONMENT AGENCY



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introduction

how to use Sources

This issue of Sources is designed primarily for teachers of Geography at Key Stages 3 and 4 of the National Curriculum. 'A' Level students may also find it relevant to their studies. There are five main components to the book:

- **The first part of the book introduces the National Rivers Authority, the concept of the river catchment and the idea of planning improvements and setting targets for their achievement within a catchment.**
- **This is followed by guidance on how to research the factors that influence the river catchment.**
- **Using case studies of four contrasting river catchments, we highlight some of the real issues which have to be managed in order to protect the water environment.**
- **At the end of the book you will find simple outline maps, designed to be copied for overhead projection or classroom use, which relate to each of the four case studies. Use these in conjunction with Ordnance Survey maps and other local information.**
- **At intervals throughout this issue of Sources, 'viewpoint' pages set out different perspectives on the water environment. Use these as starting points for discussion or role play, or to supplement work on the case studies or your local river catchment.**

The four case studies included in *Sources* have been chosen to illustrate issues which are common to many rivers.

The case studies are presented simply as examples: they are designed to offer a guide to the study of river catchments, not to limit the scope of project work to the rivers described here.

Study of the local water environment will engage students' interest at a very different, and more personal, level than the study of more remote or abstract concepts could ever hope to achieve.

We encourage you to use these examples as models for the study of your own local water environment. Many of the issues and conflicts described here are widespread, and the terms of the discussion outlined will be useful for the discussion of many rivers other than the ones which we have named.

introduction

what is the National Rivers Authority?

The National Rivers Authority (NRA) is responsible for protecting and improving the water environment in England and Wales.

The 'water environment' includes not just rivers, streams and lakes, but underground water resources, wetlands, estuaries and the waters around the coast.

The NRA is involved in:

• **Safeguarding water resources:**

We measure and monitor how much water is available, and licence how much can be used for water supply, industry etc.

• **Pollution control:**

We work with industry, sewage treatment companies, farmers and the public to prevent pollution and improve water quality

• **Fisheries:**

We carry out work to maintain and improve fish populations and their river habitats

• **Conservation:**

We protect the water environment as a wildlife habitat and conserve its natural features

• **Recreation:**

We promote recreational activities on, in and around water

• **Navigation:**

We balance the needs of boat users and the environment on many rivers

• **Flood defence:**

We aim to protect people and property from flooding from rivers and the sea

The NRA has to combine all its responsibilities efficiently, for the benefit of the water environment and the people who use it. To do this, the NRA works with local people to plan and manage changes and improvements to the water environment where they are needed.

introduction

where are the boundaries of a river catchment?

When we talk about the 'catchment' of a river, we mean the total land area from which water drains into that river: all the land around, above and below the river, the tributaries that flow into the river, and the water which is held in the soil and in underground rocks.

The catchment does not end at the river's edge: its boundaries might extend for miles beyond the riverbank.

Thinking of a river in terms of its catchment is a helpful way to plan for the future, because the activities that take place within the catchment – whether they are industrial or recreational – can all affect the river and its associated water environment.

Viewing the catchment as a whole helps us to see that the successful protection and improvement of the water environment involves a wide range of people whose different interests can sometimes conflict with each other; farmers and fishermen, landowners and local government, environmental organisations and industry, business people and the general public – all make different demands upon the river and its catchment. The NRA draws up all its plans for improving the water environment on the basis of river catchments. The *Catchment Management Plan* is one of the NRA's most fundamental tools.

introduction

planning for the future

Drawing up a plan for the management of any river starts with a consideration of both the natural characteristics and man's uses of the river catchment.

▮ **The physical environment:**

Geography and geology are key factors in determining the physical nature of the river and its catchment

▮ **Climate:**

Rainfall and weather patterns dictate the amount of water in the river and within the catchment

▮ **Farming and forestry:**

Their impact can directly affect the way water drains from the land, and the quality of rivers and groundwater

▮ **Urban development:**

Towns, villages, buildings, roads, railways and other developments can affect the way water moves around the catchment, and the quality of the water

▮ **Water supply:**

Rivers and aquifers (underground rock strata that hold water) are important sources of water for domestic supplies, industrial needs and for irrigation for farming

▮ **Disposal of sewage and industrial effluent:**

For centuries, rivers and coastal waters have been used as places to dispose of sewage and other waste

▮ **Fish:**

Rivers are home to a wide range of freshwater fish and other aquatic species

▮ **Wildlife and landscape:**

River catchments provide habitats for a wide range of insects, birds and mammals: and many also include areas of outstanding natural beauty or sites of special ecological or historical interest that must be conserved

▮ **Sport and recreation:**

Rivers and their surroundings provide opportunities for sports and leisure pursuits such as boating, walking and fishing

▮ **Flood defence:**

Flooding is a natural occurrence. Where people and property are at risk, there may be a need to construct flood defence measures such as flood walls or overflow channels. New development on the floodplain can increase the risk of flooding

introduction

conflicts and compromises

Conflicts and compromises

In some cases different aspects of the water environment will overlap with each other: improvements in river water quality might lead to an increase in the fish population, for example. Sometimes, different activities might conflict with each other: the fertiliser used by a farmer might improve his crops, but then, if it seeps through the soil into the river or groundwater, it might cause pollution.

Drawing up targets

When the different uses of a river are clear, then we can begin to decide what improvements are needed and draw up targets to aim for. By comparing future targets with the current situation, we can see how much has to be done. The smaller the gap, the more realistic it will be to solve the problem quickly and easily. The bigger the gap, the more likely it is that the problem might take some time to solve. It is important to remember that there might be a number of different options to resolve any particular problem, and that big problems are sometimes best tackled in stages.

Limitations

Any action plan will have to take into account the cost of making improvements and who should pay for them. The NRA might recommend, for example, that a factory owner should reduce the amount of effluent being discharged into a river in order to improve its quality. The owner might see little or no financial benefit in carrying out the necessary work, or perhaps would agree but might not have the money to pay for it.

Limitations like this could prevent some parts of the plan from changing from ideas into reality. But that does not mean that the plan is pointless. While some targets might not result in immediate improvement, it is important that they exist for the longer term. If a target is difficult or expensive to reach, then it might prompt people to find another way of doing the same job.

Money is not the only limitation. There are all kinds of impediments to change. Reducing the use of fertilisers to prevent water pollution, for example, could mean smaller crops and less income for farmers. Building a new flood wall could prevent access to the river for anglers and walkers. In the final plan, some compromises will have to be made.

introduction

how to find things out: identifying research sources

The NRA uses 'Catchment Management Plans' to set priorities and take action to protect and improve the water environment. Different people will have different opinions about what the priorities should be.

Where is the best place to find out what their opinions are?

The list on this page indicates the kinds of organisations and groups that might be useful to contact. Add other groups or individuals, particularly those who might have local information or opinions.

- **British Waterways Board** (canals)
- **Conservation organisations**
(eg English Nature, Council for the Preservation of Rural England)
- **Country Landowners Association**
- **Countryside Commission**
- **Environmental pressure groups**
(eg Friends of the Earth, Greenpeace)
- **Farming organisations** (eg National Farmers' Union)
- **Government departments** (eg Departments of Environment, Transport, Trade and Industry and the Ministry of Agriculture, Fisheries and Food)
- **Her Majesty's Inspectorate of Pollution** (industrial air pollution)
- **Landowners**
 - **Local Authorities** (eg Borough, District and Metropolitan Authorities for planning, recreational amenities, waste disposal etc)
 - **Local action groups** (eg conservation or community groups)
 - **Local industries**
 - **National Parks Authority**
 - **National Rivers Authority**
 - **National Trust**
 - **Salmon and Trout Association**
 - **Sports Council**
 - **Sports and leisure organisations**
(eg Ramblers' Association, angling clubs)
 - **Water companies**
 - **Wildlife organisations**
(eg Royal Society for the Protection of Birds)

When you contact an organisation or an individual for information, always make sure your request is clear and simple: above all, be specific.

Whether you telephone or write, make sure that you state exactly what information you need.

A vague request for 'anything about pollution' is unlikely to produce much useful information, but a precise query about a particular stretch of river or an individual factory would result in a much more valuable response. Plan your request in advance, so that you can be clear about what you want to know.

Always allow plenty of time to receive answers: most people are willing to be helpful, but few will be able to drop everything to deal with your request immediately. Plan your research to allow time for replies. Don't expect to receive all your information by return of post.

introduction

overlapping interests: planning your research

The list of organisations gives a clear sense of the diversity of interests in the water environment. It shows how much research could be done, but it does not show us where to start. How might the research be organised effectively?

First, does each name on the list represent a distinct interest in the water environment or a different use of the river?

Do some organisations have interests which overlap or conflict with those of others?

Can different organisations and individuals be grouped together in any helpful way?

Break your own list of organisations into groups with similar interests. A useful way to do this would be according to uses of the river catchment.

You will probably find that some names appear more than once (eg the National Trust might provide information on conservation and on recreation). Some organisations might have interests that overlap in one area (eg the local council and Friends of the Earth might agree on the need to prevent river pollution) but conflict in another (eg Friends of the Earth might oppose the same local council's plans to build shops and restaurants to attract people to a picturesque but delicate environment that needs special protection).

If you are working with a group of people, make sure that everyone involved is aware of what everyone else is doing: this way, you can avoid leaving any gaps – 'but I thought you were doing that' – and can ensure that people do not waste time by doing the same things.

- Ecology and conservation
- Farming
- Fisheries
- Forestry
- Flood protection
- Industry
- Navigation
 - Sewage and waste disposal
 - Sports and recreation
 - Tourism
 - Urban development
 - Water supply

introduction

setting priorities: making sense of what you have found out

Having identified possible sources of information, and organised your research by dividing river users into groups with different interests, the final stage involves making decisions based on the information you have gathered and drawing up a plan for the river catchment. Faced with differing and sometimes conflicting points of view, how is it possible to set priorities and decide what steps should be taken to improve the water environment? Is it possible to satisfy everyone? This is how the NRA evaluates the evidence it gathers about river catchments:

- **First, from our own knowledge of the catchment and the evidence of different water users, we identify the key issues that concern the NRA and river users. These will be varied, and could include:**
 - poor water quality near a factory or sewage treatment works
 - homes at risk from flooding
 - the need for more water to supply a growing town
 - illegal fishing
 - concern about the impact of tourism on wildlife
 - risk of groundwater pollution from an old landfill site
- **Secondly, the possible options for addressing the issues are considered**
- **Finally, the various advantages and disadvantages of each option are assessed and decisions are made about what to do**

It is important to remember that the purpose of this planning process is to make improvements for the overall benefit of the water environment and everyone who uses it.

Many issues raised during research will highlight conflicts between competing uses, between different activities, or between the conservation of natural resources and activities or uses that are harmful to them.

This means that it is not reasonable to expect that the priorities and actions described in the plan will necessarily resolve all conflicts: they attempt instead to achieve a balance for the overall betterment of the water environment.

One positive side-effect of this attempt to achieve balance is that the process of research and consultation can improve communications between different groups and create greater understanding of different people's views and needs.

Viewpoints: Farming



FARMING IS AN IMPORTANT ECONOMIC ACTIVITY

MODERN FARMING PRACTICES HAVE GREATLY IMPROVED CROP YIELDS

THE RIVER PROVIDES AN IMPORTANT DRAINAGE SYSTEM FOR MY FIELDS

ANIMAL SLURRY FROM THE FARM IS A CHEAP AND EFFECTIVE FERTILISER

A STRIP OF NATURAL VEGETATION BETWEEN MY CROPS AND THE

RIVERBANK WILL PROVIDE HABITATS FOR RIVERSIDE WILDLIFE

IT IS NOT JUST CHEMICALS THAT CAUSE POLLUTION. ORGANIC

WASTES LIKE SLURRY, MILK AND RUN-OFF FROM SILAGE USE

UP THE OXYGEN IN WATER: THEY CAN KILL FISH.

CHEMICALS IN FERTILISERS AND PESTICIDES SEEP

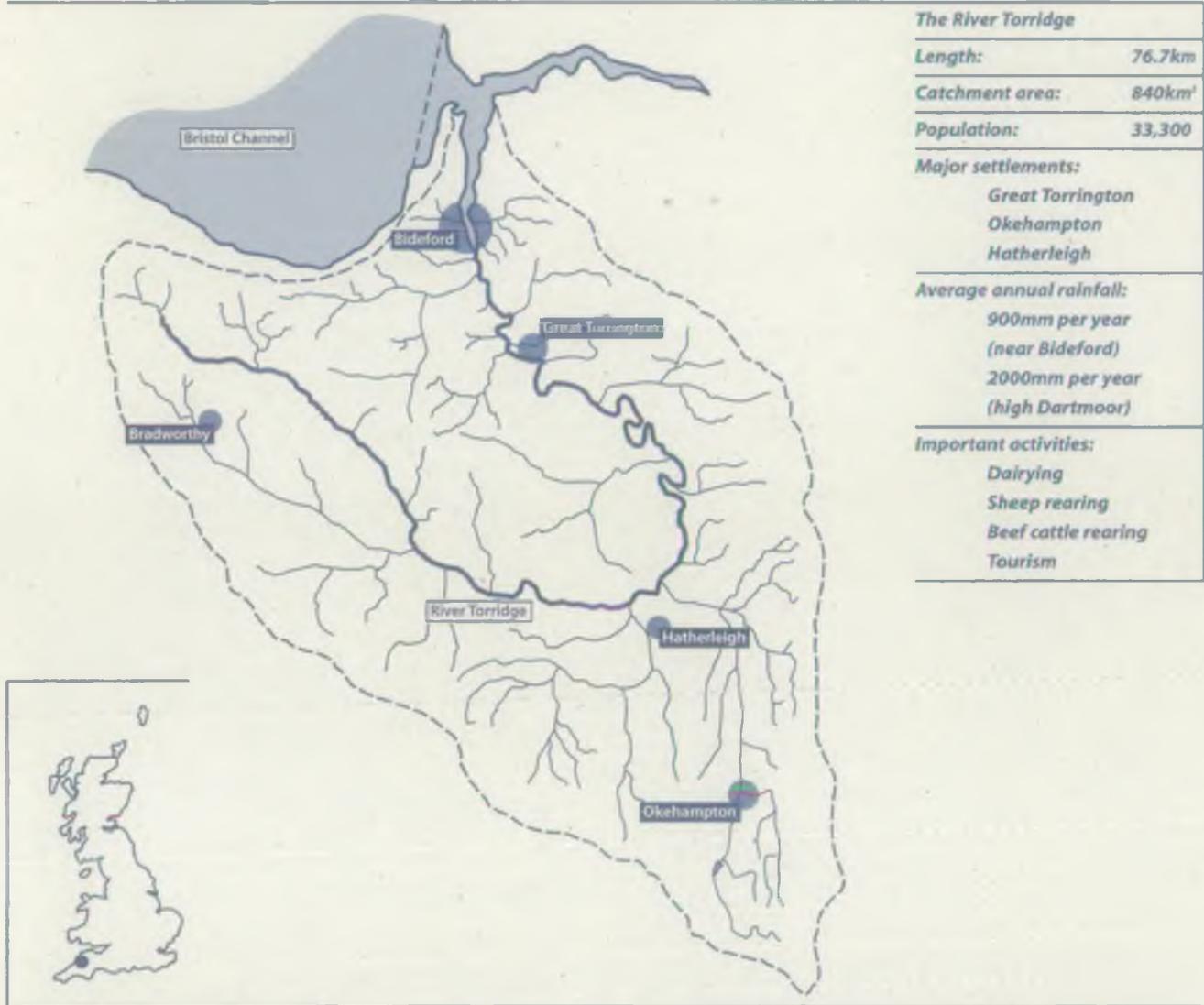
THROUGH THE SOIL INTO RIVERS AND GROUNDWATER

FARMERS CAN BE PROSECUTED AND

FINED FOR POLLUTING RIVERS

The River

Torridge



The River Torridge drains a large part of north-west Devon. The main river flows for 76.7km from Seckington Water, widening out into its estuary at Bideford. The river catchment is mainly rural, and with the exception of the major towns of Great Torrington, Okehampton and Hatherleigh, the area is sparsely populated.

Agriculture is the most important land-use in the catchment. As dairy farming, sheep and beef rearing are the chief activities, most farmland is used for grazing. About 7% of the area is wooded, and 64% of these trees are coniferous.

The River Torridge was made famous as the location for both Henry Williamson's novel *Tarka the Otter*, and the film adapted from it, *Ring of Bright Water*. In both book and film, the river and its surroundings are presented as 'unspoiled' habitats not just for Tarka and the rest of the otter population, but also for a wide and flourishing variety of other animals, plants and fish. However, signs of decline in the quantity and quality of water in the river have led to more recent concern for the local environment.

The River Torridge catchment includes a rich diversity of water environments, from fast flowing upland streams to the river's tidal estuary. The river and its surroundings are home to many fish, birds, mammals, insects and plants.

The river rises, in part, within the Dartmoor National Park. Its scenic valleys attract tourists, but are also valuable wildlife habitats.

Parts of the Torridge estuary are specially protected because of the importance of the water environment and the species it supports.

Canoeing, walking and angling are all popular recreational activities along the banks of the River Torridge.

Example: conflicting demands in the Torridge catchment

Tourism is a major industry in this area, and many local businesses depend on the busy summer trade for their year round livelihood. Visitors are attracted by the scenery, and the popularity of features such as the Tarka Trail could lead to more development of shops, hotels etc.

More visitors would bring more money and boost the local economy. Too many visitors, however, could damage the very environment they have come to see. A balance could be struck by carefully controlling the expansion of tourist facilities to bring long-term benefits rather than short-term gain.

How can recreation and conservation be balanced in a river catchment?

Consider

- The recreational demands of the public
- The environmental value of the catchment area
- The fact that the NRA has a duty to promote both recreation and conservation

factfile

exercise one

- **The Tarka Trail includes a footpath between Annery Kiln and Petrockstowe**
- **One of the NRA's responsibilities is to conserve wildlife and plantlife, and to enhance the natural beauty of the water environment**
- **Activities like walking, bird-watching and angling attract people to the river and its surroundings**
- **Traffic noise, car fumes and other disturbances can frighten or harm wildlife**
- **Tourism is one of the chief industries in the Torridge area**
- **The NRA has a duty to promote recreation in the water environment**
- **The development of the Tarka Trail, and the re-opening of an old railway route to walkers and cyclists, have increased public access to the countryside in the Torridge area**
- **Visitors and tourists need services such as shops, restaurants and hotels**

Although farming takes place on land, and not in water, it can still cause water pollution. Water draining off the surface of the land, or through the soil, can carry traces of pesticides and fertilisers into rivers and groundwater.

Dairy farming is very important to the economy of the rural Torridge catchment. Many farmers make use of some animal waste in the form of 'slurry' (mainly manure mixed with dirty water) as a fertiliser. They also use *silage* – grass that is cut in summer and kept for winter feed.

Both slurry and the concentrated liquid which comes from fermenting silage can cause serious pollution if they get into a river.

As they break down they quickly use up all the oxygen in the water.

Fish and other aquatic species may die.

Slurry and silage are usually stored somewhere on the farm until they are needed.

Example: pollution prevention

A local farmer with a small dairy herd was recently fined by the NRA for polluting the River Torridge with slurry. Heavy rain had topped up his slurry tank so that it could hold no more. The farmer had spread extra slurry on a field sloping down to the riverbank: the rain washed it straight downhill into the river.

The farmer could do a number of things to prevent the same thing happening again and avoid another costly fine. Keeping rain water out of the tank would leave more room for slurry. Only spreading slurry on a field that is well away from the river, and avoiding spreading during wet weather, would reduce the risk of pollution. He might consider reducing the size of his herd, so that he does not have a problem with too much slurry.

How can farmers prevent water pollution?

Consider

- Different types of farming activity
- Potential sources of pollution on the farm
- Ways in which farmers could improve the environment

factfile

exercise two

- **There has been a 160% increase in the number of dairy cattle in the Torridge catchment over the past 30 years**
- **Arable farming has decreased in the Torridge catchment since the 1950s**
- **It is predicted that dairy farming will continue to be the main agricultural activity in the catchment in the future**
- **The climate in the area is generally warm in summer, with mild but wet winters. However, in the past 15 years, there have been six significant periods of drought**
- **The river plays an important role in providing free drainage of the surrounding agricultural land**
- **Young salmon are particularly at risk from water pollution**
- **Legal regulations control the use of slurry, silage and fuel oils used on farms**
- **Because of over-production right across Europe, farmers are increasingly being encouraged to leave some land uncultivated in return for compensation payments. This practice should create more opportunities for conservation in the countryside**

In the late 1980s, concern had grown about a decline in salmon and trout stocks in the River Torridge catchment. Salmon and sea trout are migratory fish. The young are hatched in the clean, fast flowing upper reaches of rivers where the riverbed gravels provide the right habitat for female salmon to lay their eggs. The growing fish swim downstream and migrate to the sea, travelling hundreds of miles to feeding grounds in the North Atlantic. The mature fish return by instinct to the very river in which they were born. They swim upstream against the flow of the river to reach their spawning gravels, and the cycle begins again. Pollution, silting up of river gravels as a result of farming and forestry practices, illegal fishing, and building of dams and weirs to control river levels and prevent flooding have all been identified as contributing to the decline in fish stocks.

Example: fisheries and flood protection

The salmon is a strong and determined species, capable of swimming against the flow of the river and of leaping over many obstacles in its path. An impassable barrier, such as a dam or a weir, however, will block the salmon's run upstream, preventing the fish from reaching their breeding grounds. Unable to spawn, the salmon population will be at risk of depletion. Weirs and dams are important for regulating river levels, often in order to prevent flooding. On the River Torridge, nearly all these barriers now incorporate special 'fish passes' which allow the salmon to continue upstream, without affecting river flow or flood protection.

How can fish stocks be protected?

Consider

- The importance of healthy fish stocks to the environment
- The importance of other activities taking place in the catchment
 - The needs of local fishermen
- The importance of preventing flooding in the catchment

- **The Atlantic salmon is a native wild species which is conserved under European regulations**
- **The number of salmon and sea trout in the Torridge has declined since the 1950s**
- **The successful survival of young fish depends on the quality of the water in the river**
- **A byelaw was set on the Torridge in 1992 to limit the amount of fish a fisherman is allowed to catch**
- **There are 21 weirs and obstacles on the River Torridge and its tributaries, but only four are complete barriers to the passage of fish**
- **Flood defence work can change the physical form of the river (by making the channel wider or deeper, for example). This can conflict with conservation.**
- **Pollution incidents have killed fish in the Torridge on a number of occasions**
- **Illegal fishing (using illegal methods of catching fish, or taking fish which are carrying eggs, for example) has contributed to the decline in numbers of fish**

Viewpoints: Environment

HOW CAN WE PRESERVE THE NATURAL ENVIRONMENT FOR FUTURE GENERATIONS

SIMPLY BY BETTER CARE AND ATTENTION
MOST POLLUTION INCIDENTS COULD BE PREVENTED

WE SHOULD BE ABLE TO GET AWAY FROM THE BAD OLD DAYS OF DIRTY INDUSTRIES WITH MODERN TECHNOLOGY.

THE STATE OF OUR ENVIRONMENT INDICATES THE HEALTH OF THE WILDLIFE INDICATES

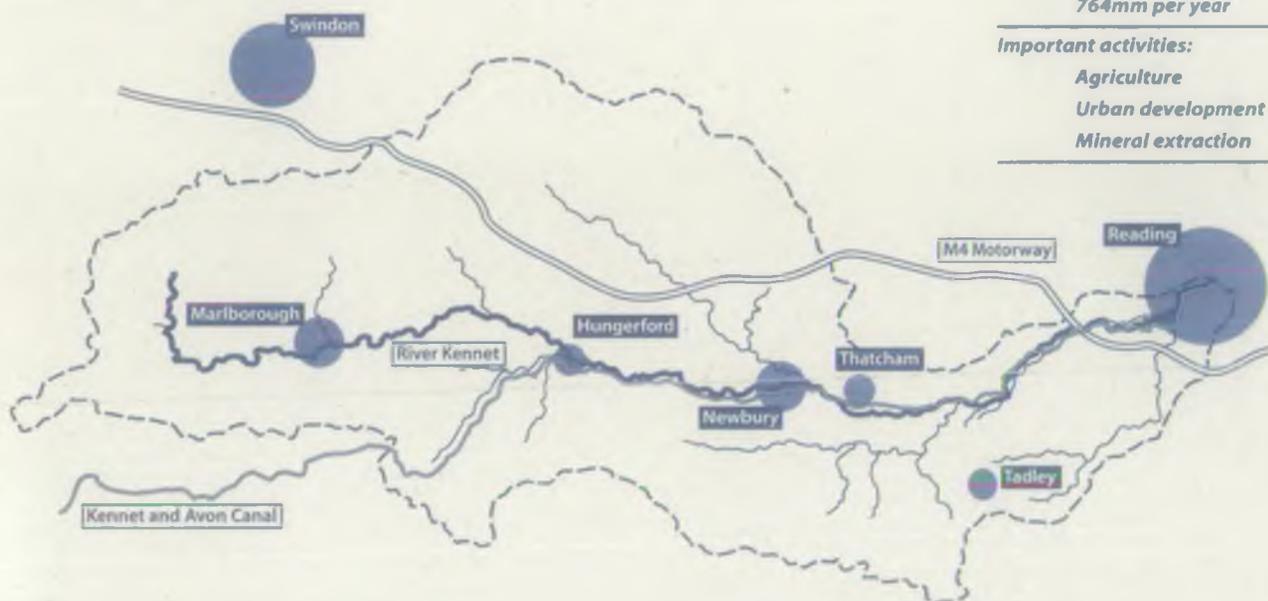
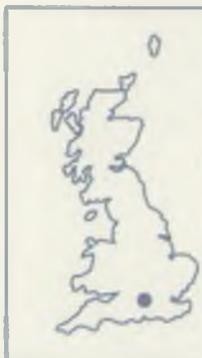
FISH TO REPLACE THOSE THAT HAVE BEEN KILLED BY POLLUTION CAN BE EXPENSIVE

URBAN DEVELOPMENT CAN BRING PROBLEMS OF POLLUTION AND INCREASING DEMAND FOR WATER

A CLEAN AND HEALTHY RIVER IS A GREAT ASSET, WHETHER IT IS IN A TOWN, CITY OR IN THE COUNTRYSIDE



The River Kennet



The River Kennet

Length:	98km
Catchment area:	1164km²
Population:	211,000
within 20km of catchment	1,000,000

Major settlements:

Marlborough
Newbury
Reading

Average annual rainfall:

764mm per year

Important activities:

Agriculture
Urban development
Mineral extraction

The River Kennet is the largest tributary of the Thames. Rising to the north west of the town of Marlborough, the Kennet flows southward and eastward to join the Thames at Reading, and, in summer, contributes half of the water flowing in the Thames downstream of Reading. The catchment is bounded to the north, west and the south by chalk Downs, and the Kennet – like many of the smaller watercourses of the catchment – is fed from a spring in the underlying chalk.

Much of the catchment falls within the North Wessex Downs *Area of Outstanding Natural Beauty*, and the archaeological importance of sites such as Avebury ensures that the western part of the catchment is strongly protected from largescale development.

The quality of the River Kennet is generally very good. However, the condition of the river between Newbury and Reading, where there has been significant urban development over the past 40 years, is a cause of much local concern.

The catchment includes a 58km stretch of the Kennet and Avon Canal, which was reopened to traffic in 1990.

exercise One

urban development within the catchment

The Kennet valley has seen significant change over the last 40 years with urban development at Newbury, Thatcham, Tadley, Theale and Reading. Pressure for urban expansion is expected to continue in the future, particularly because of Swindon which, although located outside the Kennet catchment, is a major growth point with an impact on surrounding areas.

Urban expansion increases the demand for water supplies and for services such as sewage treatment and waste disposal. It is vital to plan for these services in advance to avoid environmental problems. For example, increasing the amount of water taken from rivers or groundwater by too much could lead to streams drying up or groundwater levels dropping. This would have an impact on fish and wildlife. An increase in the amount of sewage effluent could lead to a deterioration in water quality.

Example: preventing problems before they arise

Urban development increases the demand for water supply and sewage disposal.

Building new homes, factories or shopping developments near the river could mean they are at risk from flooding.

It is vital to identify potential problems and risks before development decisions are made. To do this, the NRA works with local authorities when they are drawing up their long-term plans.

This way new developments can be built, but to a scale and in locations where they can be properly serviced without damaging the environment.

Early planning like this could help avoid costly mistakes such as homes that cannot be occupied because they cannot be supplied with water, or because they might be flooded.

How can urban development take place without damaging the environment?

Consider

- The reasons for urban expansion
- The services needed by urban developments
- The impact of urban growth on the environment
- The recreational needs of a growing population

factfile

exercise one

- **Within the Kennet catchment, there is considerable pressure for urban growth**
- **New building plans, together with roads and other infrastructure, could have a significant impact on the water environment**
- **Urban growth and increased mineral extraction will be concentrated in the Kennet valley downstream of Newbury**
- **An increase in the population of the catchment will lead to an increase in the volume of sewage effluent**
- **There are 55 *Sites of Special Scientific Interest* in the Kennet catchment. These are areas that contain rare or unusual species and wildlife habitats**
- **Urban growth will increase the demand for water supply**
- **Major urban flooding occurred in the Kennet catchment in 1947, 1971 and 1979**
- **One local authority, Newbury District Council, has organised a special study of the landscape within its boundaries. Information from the study will help the Council decide which changes in land use would be desirable and which would not**
- **The NRA would not support any development or change in land use that it considers would cause damage to the water environment**
- **Any development that would be likely to impede the drainage of flood water, or increase the number of people or properties at risk from flooding, would be contrary to NRA policy**

the River Kennet

exercise two

recreation, conservation and commerce on the Kennet and Avon canal

Completed in 1810, the Kennet and Avon Canal created an important commercial waterway link between the River Thames and the port of Bristol. Competition from the railways, however, quickly made canal transport unprofitable and it fell into decline. The Kennet and Avon Canal Association was formed in 1951 with the aim of restoring the waterway as a viable navigation. This aim was achieved in 1990, and the canal now forms not just an important recreational resource for boat traffic and water-based recreation, but also an important environmental *corridor*.

The Kennet and Avon Canal is owned and operated by British Waterways Board (BWB). The NRA and BWB work closely together to achieve a sensible balance between commercial and environmental considerations.

Example:

recreation and conservation

Boating is a popular leisure pursuit on the canal, but the canal bank footpaths also attract walkers and anglers.

Boat traffic increases the turbidity of the water and can damage fish and wildlife habitats, and visitors bring litter.

Regular consultation with BWB and boat users is helping to promote more responsible use of the canal. It also provides the opportunity to hear what boat owners and users think, and leads to the sensible provision of facilities.

Publicising the litter problem could result in local schools or community groups getting involved in a litter clean-up.

How can the use of a navigable waterway be sustained without damaging the local environment?

Consider

- The needs of boats and boat owners
- The advantages and disadvantages of boat traffic
 - Other types of recreation
 - Ecological considerations

factfile

exercise two

- **The British Waterways Board owns and operates the Kennet and Avon Canal. Local Authorities also contribute to the running costs**
- **Within the Kennet catchment, the canal supports over 200 private boats, eight hire boats and five day-trip boats. Many more boats pass along this stretch on the way to and from other waterways**
- **The amount of boat traffic on the canal is forecast to increase in the future**
- **The NRA is committed to promoting recreation within the catchment, where it is appropriate**
- **Keeping the canal open costs money – for maintenance, operation of locks etc. Leisure developments are one way of attracting investment to pay for the upkeep of the canal**
- **The footpaths along the canal banks link with long distance footpaths and attract over 10 million visitors each year**
- **The canal supports canoe clubs at Newbury and Reading, and is used each year for important canoe and raft races**
- **The Kennet and Avon Canal attracts 170,000 anglers each year**
- **Boat traffic increases water turbidity and can have a detrimental influence on fish and other wildlife, and on the condition of the river banks**

exercise three

water supply and the environment

The largest water abstractor in the Kennet catchment is Thames Water, which takes water direct from the River Kennet near Reading.

A number of smaller companies, supply water in specific areas, and some industries and farmers also abstract water for their needs from the environment.

Groundwater is a considerable asset within the catchment.

The geology of the area is mainly chalk, a porous rock which soaks up rainfall and acts as a natural water store called an *aquifer*. Boreholes can be drilled into aquifers to abstract water.

The needs of water users must be carefully balanced with the needs of the environment. Taking too much water from rivers can reduce river flow and damage wildlife and the environment.

Taking too much water from aquifers can reduce the level of the water table, and this too can affect the flow of rivers.

Example: Sharing resources

The West Berkshire Groundwater Scheme is a group of 33 boreholes with a complex network of pumps and pipelines. The scheme is owned by the NRA, but operated in conjunction with Thames Water.

It was originally designed to pump groundwater into local streams which eventually flow into the Lower Thames to increase the flow in the Thames during periods of drought. The extra water enabled Thames Water to continue taking the amount of water needed to supply homes and other properties, despite the drought.

In fact, such situations probably only arise once in every 7–10 years. Now the NRA has made an operating agreement with Thames Water so that the scheme can be used when required to replenish local river flow levels to the benefit of the local environment and local water supply.

How can demand for water supply be met without damaging the water environment?

Consider

- Who uses water in the catchment
 - How much water is available
- The impact of abstraction on the environment
 - Whether water use can be reduced

factfile

exercise three

- A recent NRA study concluded that public water supply demands in the catchment can be met from existing sources until 2011
- Future increases in demand for water are predicted for Reading and Newbury
- Currently, one third of the water abstracted from rivers and aquifers within the Kennet catchment is used to supply areas that are outside the Kennet catchment
 - Most of the water that is taken from rivers and aquifers is eventually returned to rivers after use (eg most domestic water goes back into rivers when it has passed through the sewage treatment works). Water from the River Kennet that is used outside the catchment, however, is not returned to the River Kennet but to the River Thames
- Annual rainfall in the Kennet catchment is very unevenly distributed, from 900mm on the Hampshire Downs down to 650mm in the Reading area
- The West Berkshire Groundwater Scheme currently provides water to supplement low river levels in times of drought
 - It would be possible to use the West Berkshire Groundwater Scheme as a source of water supply
- The NRA must ensure that the amount of water flowing in a river is enough to support fish and other aquatic plant and wildlife
- A lot of water is wasted through inefficient use, or because it leaks out of the supply pipelines
- Recycling saves water. Installing meters to measure water consumption, and making people pay for the amount of water they use, could help to reduce waste

Viewpoints: Recreation



Bird watchers need peace and quiet

I would like to be able to go fishing whenever I choose

Picnic litter and discarded fishing tackle are a danger to wildlife

Joggers and walkers love to use the riverbank footpaths

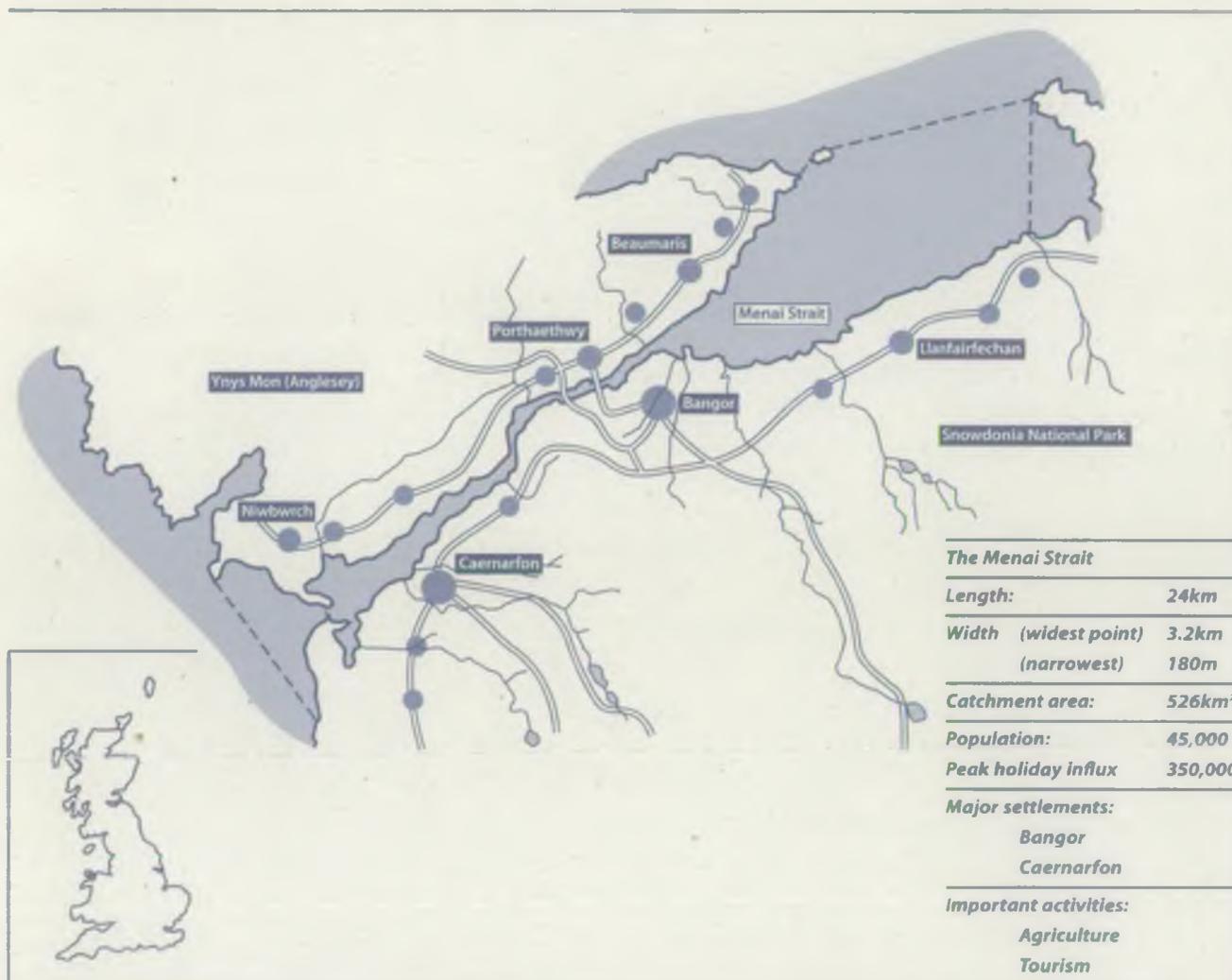
A watersports development would boost the local leisure industry

Heavy boat traffic causes erosion of the riverbanks

Windsurfing and jet-skiing are exciting sports

Canoeing is an increasingly popular activity

The Menai Strait



The Menai Strait is a narrow sea-channel which separates the island of Anglesey – Ynys Mon in Welsh – from the mainland of North Wales.

The catchment of the Strait includes all the area below high water, and the coastal strip that influences the Strait. The catchment is bounded to the north east by an imaginary line between Ynys Seiriol and Pen y Gogarth (Great Orme's Head) and in the south west by an imaginary line from Ynys Llanddwyn to Dinas Dinlle.

Two famous nineteenth century bridges span the Strait:

Thomas Telford's Menai suspension road bridge (1827) and Robert Stephenson's Britannia railway bridge (1849) which now also carries the A5 Holyhead road.

In its narrow middle section, swift tidal flow gives the Strait river-like characteristics. Towards either end, however, the waters take on the character of an estuary as they widen out to the more open seas of Conwy and Caernarfon Bays.

The Menai Strait is famed for its scenic beauty, ecological importance and wide-ranging recreational opportunities. The Strait is popular for a wide variety of water sports and is the location of the Sports Council for Wales' water sports centre at Plas Menai. It also supports an important shellfishery.

the Menai Strait

exercise one

boat traffic and wildlife

The Strait is no longer a merchant seaway. One or two large passenger ships use the Strait annually, but by far the greatest use is made by fishing vessels and other small craft. The sheltered areas of the Strait are very popular for sailing, and boating is a popular local tourist attraction. Navigation aids such as buoys, perches, marks and the Penmon lighthouse facilitate safe passage through the Strait.

Discharges from boats within the Strait, particularly of bilges and toilet waste, cause localised problems, while boating and other activities along the shores of the Strait can disturb wildlife. The NRA supports plans to designate the Strait as a marine nature reserve in order to conserve its wildlife, but also recognises that this designation may affect the level of boating that can take place in the future.

Example: striking a balance

Tourism is a major industry in the Menai Strait. Local councils are keen to promote sailing as an attractive recreational activity for visitors. Local councils are also responsible for maintaining harbours and moorings along the Strait.

The NRA also wants people to be able to enjoy the Strait not just for boating but for its wildlife and scenery.

The NRA seeks byelaws to control potentially damaging activities such as discharging bilges and toilets into the water. These byelaws are enforced by the NRA and local councils. They are an example of organisations working together to ensure that sailing and boating opportunities can be maintained, while the environment is protected.

How can boating activities be pursued without damaging the environment?

Consider

- Who sails, and why
- The problems caused by boat traffic
- Ways of controlling those problems without discouraging people from going sailing and boating

factfile

exercise one

- About 20 commercial angling boats, and a large number of privately owned small boats are used within the Strait
- Each summer weekend, approximately 200 anglers fish from boats on the Straits
- There are ten local sailing clubs on the Strait, with over 2000 members between them
- The University College of North Wales at Bangor uses the area to the east of the Menai Bridge for rowing.
- A two-week long regatta is held every summer, when over 150 boats compete. This event is a very popular tourist attraction
- The Welsh Yachting Association forbids dumping of waste from boats
- Dredging to keep the channel and docks clear for navigation can stir up silt and pollutants from the bed, affecting the quality and appearance of the water
- Dog walking, horse-riding and boating can disturb wildlife such as roosting waterfowl
- Mooring chains that scrape the channel bed can cause environmental damage
- The Strait has over 600 moorings for yachts and powered boats

The population of the Menai Strait catchment area can increase almost tenfold during the summer tourist season. Many of the visitors are attracted by the wide-ranging recreational opportunities offered by the Strait and its surrounding areas.

Virtually the entire Strait is accessible for bathing, although the rocky shore limits significant use to a few locations.

As well as swimming, the Strait is popular for canoeing and water skiing. The standards of water quality needed to ensure that all these activities can be pursued safely and enjoyably are high. To ensure that suitable water quality is maintained, the NRA imposes strict conditions for the discharge of any effluent into the Strait.

Example: costs and benefits

The NRA has a duty to encourage recreational use of the Menai Strait.

There are a number of sewage outlets in the Strait which affect water quality and discourage some people from participating in sports which take place in the water.

Local people, the NRA and the water company which is responsible for disposing of sewage recognise the economic importance of watersports in attracting vital tourist trade to the area. The local population will have to meet some of the cost of improving sewage treatment through their water bills. This cost, however, would not be as great as the loss that could be felt if pollution were to drive tourists away from the Menai Strait. Plans to improve the quality of discharges from the sewage treatment works have now been agreed.

How can people's enjoyment of water sports in the natural environment be ensured?

Consider

- The benefits to an area of attractions such as water sports
- Water quality problems that could discourage water sports
 - Ways of improving water quality
- Who pays for improvements in water quality and who benefits

factfile

exercise two

- **Water sports are generally increasing in popularity**
- **Popular sports in the Menai Strait are canoeing, windsurfing, water and jet skiing and scuba diving. All these sports involve contact with the water**
- **Sewage is discharged into the Strait at 28 outlets**
- **European regulations set legal standards for water quality at beaches where significant numbers of people go swimming. The bathing beach at Morfa Dinlle near Dinas Dinlle is one such beach**
- **The Strait is the site of the Sports Council for Wales' national watersports centre at Plas Menai, where 160,000 days of tuition are provided every year**
- **The NRA has duties to develop the recreational potential of the water environment, but also to conserve and enhance its wildlife and landscape**
- **Apart from tourism, agriculture is the other main activity in the catchment**
- **Plans to make the Strait a marine nature reserve may result in the need for increased control over some recreational activities**
- **The Strait is intensively used for water sports and has several outdoor pursuits centres**
- **Bathing waters at Penmaenmawr are not subject to the European regulations as they are less frequently used for swimming. Nevertheless, people do swim here, but water quality at this location would not have met the European standards in three out of the four past years**

**marine and shellfisheries:
conservation and exploitation**

The Menai Strait provides habitats for an enormous range of marine species. These are important from the point of view of conservation – the area includes a number of protected 'Sites of Special Scientific Interest' – and for commercial exploitation. The resident fish communities of the shore, channel and sand/mud flats are complemented by summer and winter immigration of species from the Irish Sea. Less common visitors, including rarities such as red mullet, serve to increase the overall diversity of marine life. This natural resource is exploited both commercially and for recreation. The Strait is a popular sea angling venue, and sea fish, shell fish and crustaceans, as well as licensed net fishing for salmon and sea trout, provide the basis for commercial trade in fish. Strict European regulations governing the quality of shellfish waters exist in order to protect public health

Example: identifying the problem

Healthy water quality is vital for the success of the commercial shellfish trade. Currently, the shellfishery in the Menai Strait fails to meet the standards for shellfish waters, because the level of copper in the water exceeds the level set by the European Commission.

The NRA is investigating where the copper comes from – it might occur naturally in the geology of the Strait, or it could be coming from a discharge from industry or a sewage treatment works.

If copper is naturally present, and not the result of pollution, then the EC may pass the shellfishery. If the copper comes from human activity, then the NRA will have to take steps to control this pollution if the shellfishery is to get a clean bill of health.

How can the success of the commercial shellfish trade be ensured?

Consider

- The importance of healthy shellfish beds
 - Other uses of the water environment
- The need to protect the ecology and the physical landscape

- The Countryside Council for Wales has recorded 96 different species of marine fish in the Menai Strait
- The sheltered waters of the Strait support important commercial shellfisheries where mussels, winkles, whelks and scallops are cultivated and harvested
- The impact of sewage discharged into the Strait has resulted in special conditions being imposed on some shellfisheries which must clean the shellfish by a defined process before they can be sold for human consumption
- The Strait is an important route for migrating salmon and sea trout. (Exercise 3 in the River Torridge case study, called 'Protecting fisheries', tells you more about migratory salmon and sea trout)
- Flat fish which breed in the waters at each end of the Menai Strait make an important contribution to the fish population of the Irish Sea
- In 1989, 765 tonnes of cockles were landed by hydraulic dredging, but this dredging process may be adversely affecting the ecology of the Strait
- There are three classes of shellfish beds (A, B and C). Shellfish from class B and C beds require more treatment before they can be sold for human consumption. Sampling of Menai Strait mussels shows the beds to be class B and C
- There is considerable illegal netting of salmon and sea trout in the Strait, often disguised as fishing for marine species
- The European Commission has set standards for the quality of water for shellfish beds. The NRA aims to ensure that discharges into the Strait do not prevent the shellfish waters from meeting these standards
- The NRA aims to ensure that marine fishing does not over-exploit salmon or sea trout, or pose any obstruction to the migrating fish

Viewpoints: Industry



Cleaning up polluted rivers can be difficult and very expensive

Waste from factories is polluting our rivers

Local industries provide jobs for thousands of people

Reducing waste can save money

Industry makes the products we want and need

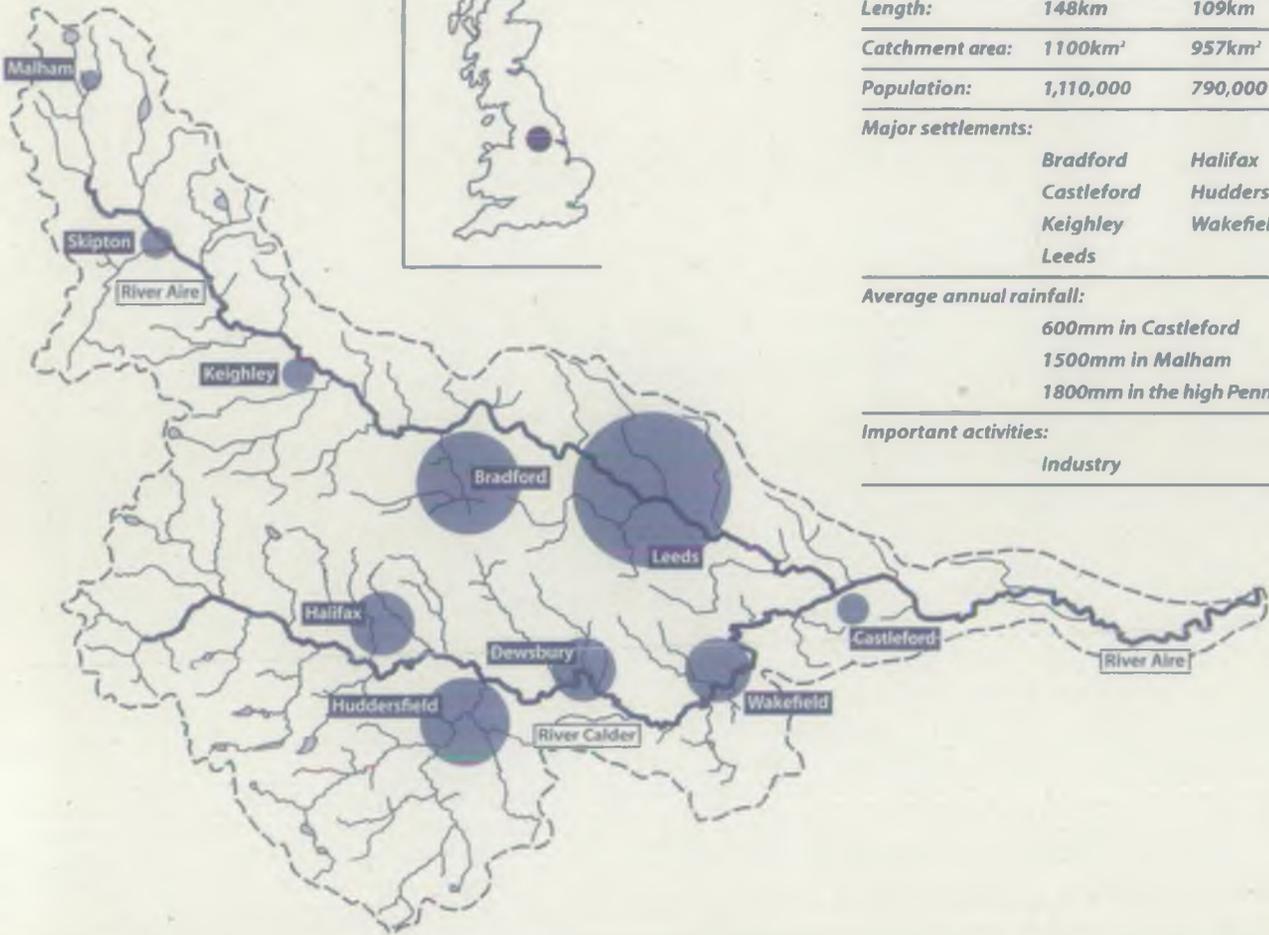
Improving the environment will cost my company money. I will have to put up prices

A thriving business needs to expand

Some factories produce waste that contains dangerous chemicals

The Rivers

Aire & Calder



The Rivers Aire and Calder

	River Aire	River Calder
Length:	148km	109km
Catchment area:	1100km ²	957km ²
Population:	1,110,000	790,000
Major settlements:	Bradford Castleford Keighley Leeds	Halifax Huddersfield Wakefield
Average annual rainfall:	600mm in Castleford 1500mm in Malham 1800mm in the high Pennines	
Important activities:	Industry	

The headwaters of the River Aire rise on the limestone moorlands around Malham in Yorkshire. The River Calder rises on the Pennine Moors, west of Todmorden. The Aire flows through the cities of Leeds and Bradford, while the Calder passes through the West Yorkshire conurbation towns before joining the River Aire at Castleford. From here, the Aire continues on to join with the Yorkshire Ouse near Goole. The last 26km of the River Aire are tidal.

The adjoining catchments of the Rivers Aire and Calder owe much to the development of the industrial revolution, in particular the textile industry, which along with the chemical industry,

is still important today. Both rivers have suffered from decades of pollution from the disposal of industrial and sewage effluent.

The Aire and the Calder join at a point 13km below Knostrop Sewage Treatment Works which serves Leeds. This means that the lower reaches of the River Aire carry sewage effluent from a population of nearly two million, and 80% of Yorkshire's industrial effluent.

Both rivers and their tributaries flow through steep and relatively narrow valleys which react quickly to rainfall. Rapid rises in river levels present flood risks in a number of areas, particularly on the Calder.

exercise one

water quality and industry

The industrial revolution and subsequent industrial activity have left the rivers Aire and Calder with a legacy of serious pollution.

The combined catchment areas contain a wide range of industries which discharge effluent either directly into rivers, or indirectly via sewage treatment works.

The discharge of any effluent into a river must have the permission of the NRA. The NRA sets conditions relating to the amount and content of the effluent, in order to control the quality of the river.

The River Calder is badly affected by chemical residues from big chemical manufacturing plants and textile works.

There are few direct discharges into the river. The majority of industrial effluents are discharged into the sewer system.

Despite treatment at the sewage treatment works, traces of chemical substances can still get into the river.

Example: preventing pollution

The NRA had received many public complaints about discoloration of the River Calder as it flowed through the town of Hebden Bridge. The source of the discoloration was found to be a discharge of effluent from a sewage treatment works which had agreed to treat waste containing dyes from a textile manufacturing plant. Although the quality of the water was not badly affected by the waste, the appearance of the river was unacceptable, particularly as Hebden Bridge is a popular tourist attraction.

The textile industry has to use dyes. The solution in this case was for the NRA to make it a condition for the sewage treatment works to control colour before discharging its waste into the Calder, thus preventing any further discoloration of the river.

How can pollution be controlled without adversely affecting industry?

Consider

- Sources of industrial pollution
- The environmental impact of pollution
 - Ways of controlling pollution
- The costs and benefits of controlling pollution

factfile

exercise one

- **There are many textile and chemical industries in the catchment areas of the Rivers Aire and Calder**
- **Residues from detergents and moth-proofing insecticides which are used in textile manufacturing are discharged into rivers**
- **It is against the law to discharge effluent into the water environment without the consent of the NRA**
- **One way of reducing pollution is to reduce the amount of waste being produced, or to eliminate waste altogether**
- **The NRA aims to build good working relationships with industry, in order to prevent pollution and improve the quality of rivers**
- **The *Aire and Calder Waste Minimisation Project* is a joint initiative involving local industries, the NRA, local authorities and other organisations. The aim of the project is to reduce the amount of water used by industry and the amount of effluent it produces**
- **Companies participating in the Aire and Calder project have found that reducing water use and waste can save money**
- **Some substances are considered to be very dangerous to the water environment: mothproofing agents, which are used in the textile industry to protect the cloth, are amongst them**
- **Industrial waste can pose a serious pollution risk to the water environment**
- **Some stretches of the rivers Aire and Calder, and some of their tributaries, have very poor water quality**

Most old sewer systems were designed to collect water and waste from homes and industry as well as surface water run-off from roads, fields etc. Water and waste flow through 'combined sewers' to a sewage treatment works before the treated waste is discharged into the river.

These systems incorporate 'combined sewer overflows' (CSOs) which discharge some effluent directly into rivers without treatment. Combined sewer overflows were designed only to come into operation during very wet weather when the volume of water in the system, and the flow in the river are great enough to dilute the waste and reduce its potential for pollution.

With a growing population, many sewer systems and sewage treatment works in the Aire and Calder catchments are no longer big enough to deal effectively with the amount of waste.

Many existing systems are ageing, inefficient and simply too small.

Consequently, combined sewer overflows operate far too frequently when there is not enough water in the system or the rivers to dilute the waste.

The result is pollution.

Example:

making up for the past

Many pollution problems in the Aire catchment are directly related to combined sewer overflows. In some cases, it only takes light rainfall to cause sewage to overflow into rivers which are not swollen by heavy rain. It is not practical to reduce the volume of sewage produced by a significant amount. The only feasible way of dealing with the problem is to improve the inadequate sewer system. This costs money. The NRA has worked out a plan of work with Yorkshire Water Services which will prevent the unsatisfactory operation of 90 combined sewer overflow points. The plan may take up to ten years to complete, but this way the costs will be spread out so that the environment can be improved in an affordable way.

How can the waste disposal needs of a growing population be addressed?

Consider

- What happens to domestic waste
- The impact of domestic waste on the water environment
 - How pollution can be controlled
- The importance of investing in sewage treatment

factfile

exercise two

- **Nearly two million people live in the Aire and Calder catchments**
- **The disposal of domestic and industrial waste has a major influence on the quality of the water in rivers**
- **There are 63 sewage treatment works within the two catchments**
- **About 45km of the River Aire is classed as poor in quality**
 - **Most water quality problems in the Aire and Calder catchments occur downstream of sewage treatment works**
 - **The majority of sewage treatment works in the catchment treat a mixture of domestic and industrial effluent**
 - **The quality of the water in the River Aire makes it unfit for many water sports**
 - **The quality of the River Calder has a major impact on the quality of the lower reaches of the River Aire**
- **The NRA will only give its consent for a discharge of effluent where it is satisfied that the effluent will not make the quality of the river worse**
- **Many water quality problems in the catchments are due to old and inadequate sewage infrastructure**

exercise three

flood protection in the Calder catchment

The catchment of the River Calder is predominantly urban, with the river flowing through the towns of Halifax, Brighouse, Huddersfield, Dewsbury and Wakefield before joining the River Aire at Castleford. The Calder and its tributaries flow through steep and relatively narrow valleys, and reacts very quickly to rainfall.

River levels can rise rapidly creating a sudden risk of flooding.

Buildings on the river floodplain – the flat, wide area either side of the river channel – are not only at risk from flooding themselves, but can cause problems elsewhere.

The floodplain is the river's natural overflow storage area.

The impermeable surfaces of buildings and roads prevent the floodplain from soaking up water, sometimes diverting the run-off to areas which would not otherwise be at risk from flooding.

Over the years, several disastrous floods have occurred in the Calder valley. Homes, roads and shops have all been damaged. As a result, the NRA has an on-going programme to build flood defences to protect the community.

Example: flood protection for the Calder valley

It is not possible to prevent rainfall, nor is it possible to change the physical nature of the Calder valley.

It would be totally impractical to suggest that towns and people that have established themselves in the area should move. Given these constraints, the NRA must still aim to protect people and property from flooding.

Where the risk of flooding is significant, the NRA provides flood defence schemes such as flood walls to keep the floodwaters out of homes and other buildings. The NRA also monitors rainfall and river levels 24 hours a day to ensure that advance warning is given of when and where flooding might occur.

Most importantly perhaps, the NRA is working with local authorities to make sure that new development in the Calder valley will not increase the risk of flooding further.

How can the risk of flooding be reduced?

Consider

- Who and what is at risk from flooding
- How does man contribute to flood risk
- Which aspects of flooding cannot be controlled by man
 - Which aspects of flooding can be controlled by man

- Due to the narrow, steep-sided valleys of the Calder catchment, development has been concentrated on the flat valley floor close to the river
- Serious flooding problems in the Calder valley are mainly a legacy of development resulting from the industrial revolution
- Inner city regeneration is providing some opportunities for reconstructing river channels with a higher degree of flood protection
- Some flood defence measures can detract from the natural beauty of the river and its surroundings
- The NRA aims to protect people and property from flooding by flood defence measures and by providing flood warnings
- The standard of flood protection on the River Aire has been improved by making changes to the river channel as well as by building flood defences
- The lower reaches of the River Aire are tidal. The NRA has recently completed a major scheme to improve defences along this stretch of river to prevent tidal flooding
- The nature of the Calder valley causes the river level to rise rapidly in response to heavy rain. As a result, several disastrous floods have occurred in the past
- The NRA aims to ensure that new development is not at risk from flooding itself, nor will it contribute to flooding elsewhere
- When carrying out flood defence work, all reasonable opportunities are taken by the NRA to conserve the natural surroundings, to enhance wildlife habitats and to promote recreation

Glossary

Abstraction

Removal of water from surface waters (rivers, streams) or groundwater (underground) water for use. Water is usually removed by pumping.

Aquifer

A layer of underground rock which holds water. Porous rocks (eg chalk) allow water to pass through them. Where a layer of porous rock overlies a layer of non-porous rock, then the water cannot pass any further. It is stored in the porous rock, which becomes an aquifer. Water can be pumped out of an aquifer through a borehole.

Confluence

The point at which two rivers meet.

Floodplain

The naturally flat expanse of land alongside the river. When the river level is high following heavy rain, the floodplain provides a natural overflow area for the river to flood.

Run (fish)

The journey upstream from the sea to their breeding grounds of migratory fish such as salmon and sea trout.

Silage

Winter feed for cattle. Silage is grass that is cut in summer, and fermented in a storage silo. Silage can pollute water.

Slurry

A mixture of animal waste, water etc that can be used as fertiliser, but which can also pollute water.

Spawn (fish)

To produce eggs.

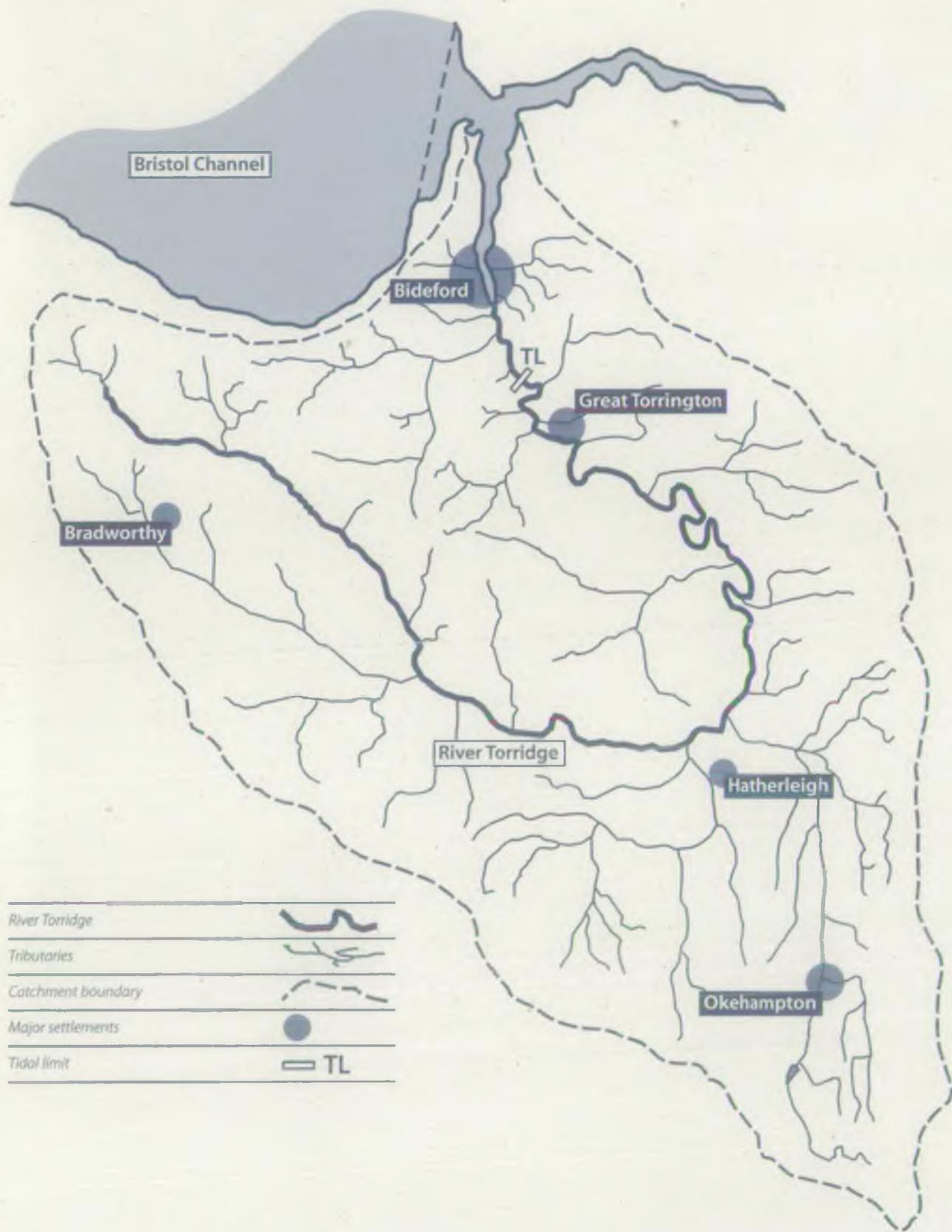
Turbidity

A measure of how cloudy the water looks. Cloudiness is caused by light reflecting on particles suspended in the water.

Maps

The maps on the following pages relate to the four catchment areas described in the case studies. The maps can be photocopied for distribution to students or for overhead projection. Using the basic features of the catchment, and information from other sources (eg Census data, Ordnance Survey maps etc) it would be possible to make overlays or additional maps showing other aspects of the geography and/or use of these catchments.

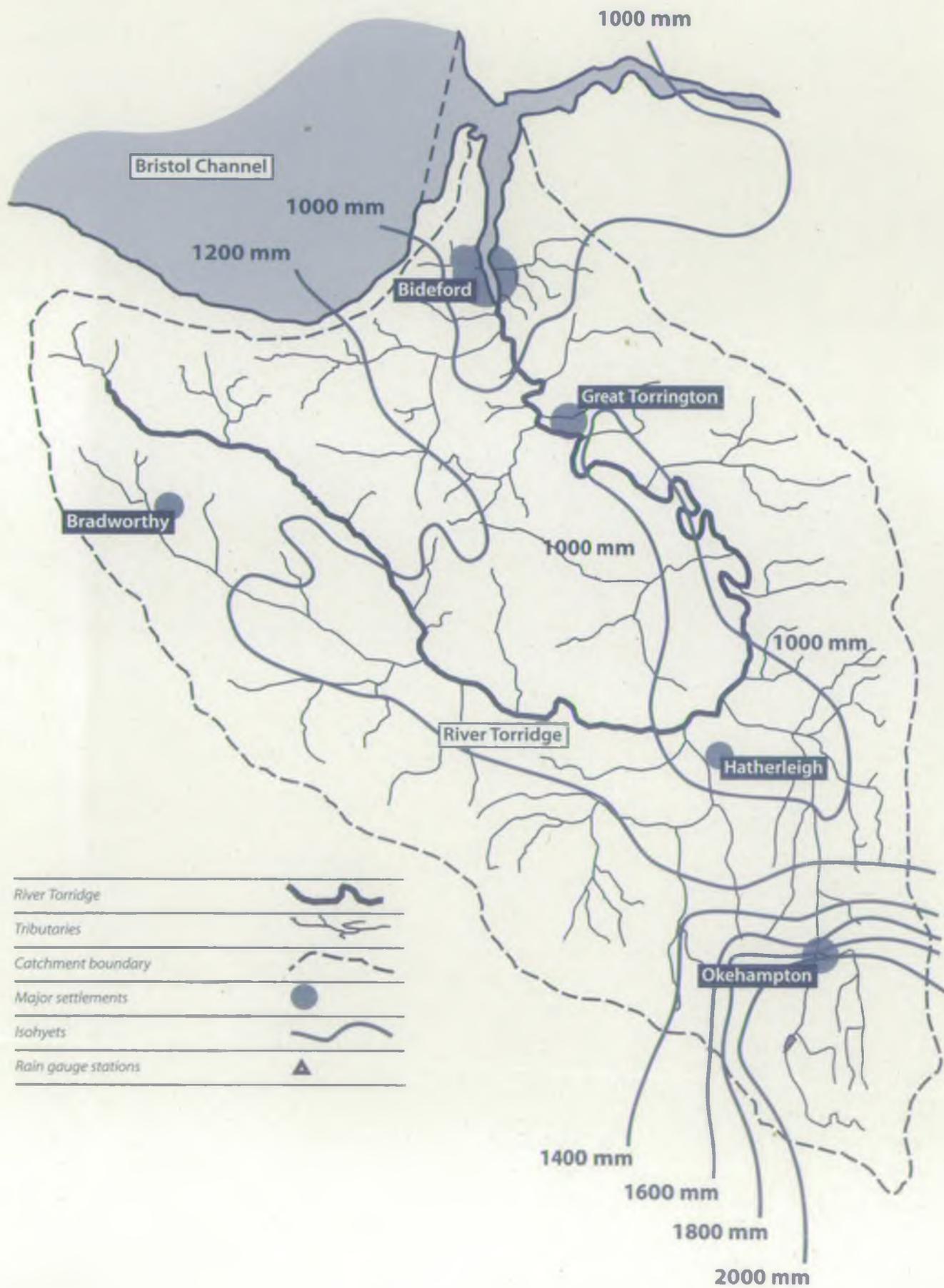
River Torridge
Map A
Torridge catchment



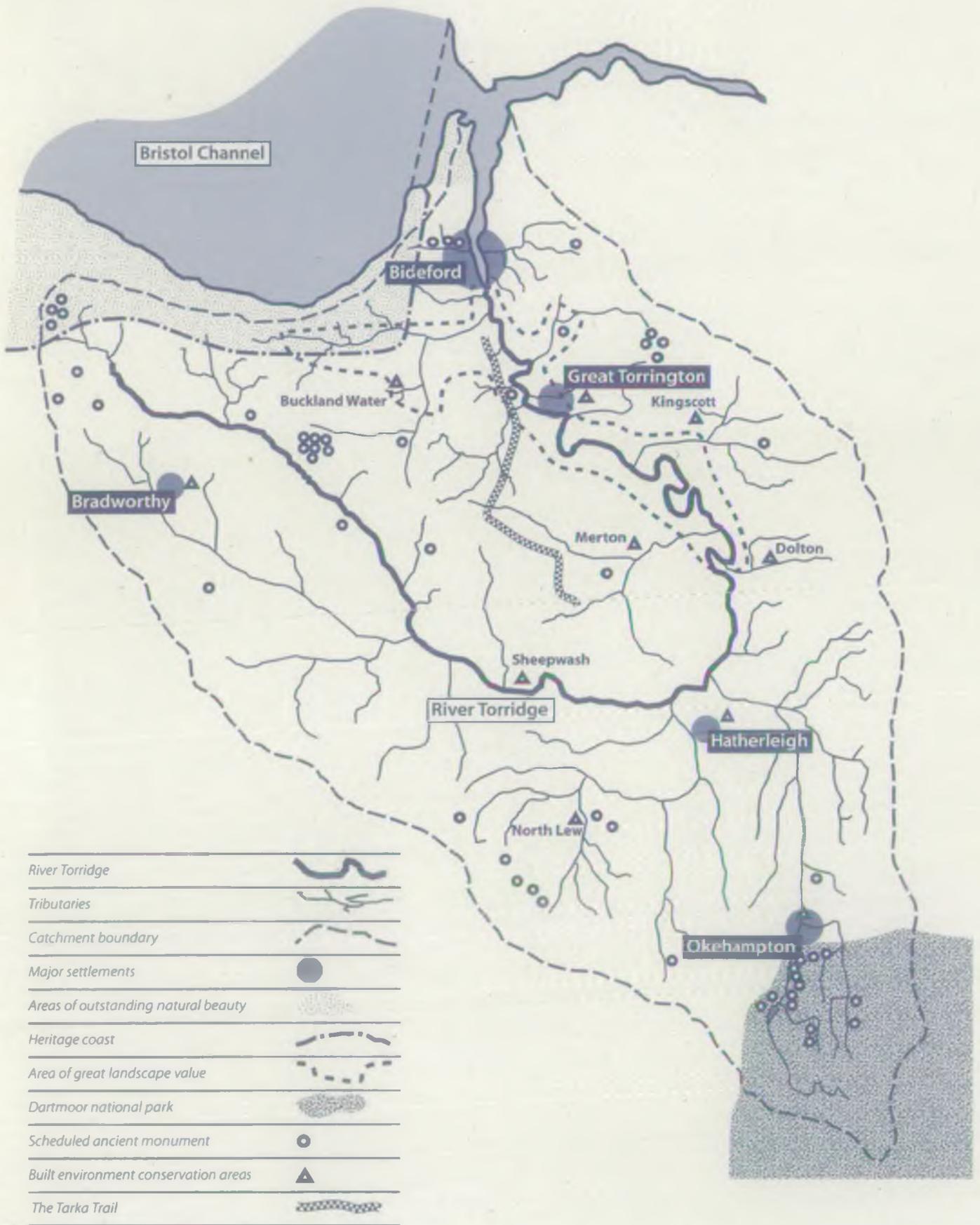
River Torridge

Map B

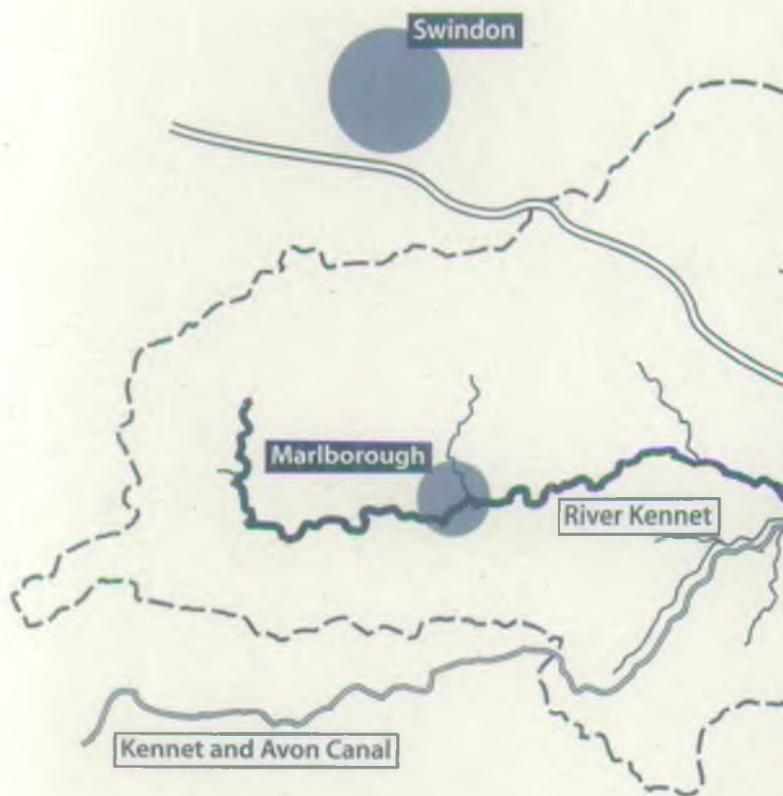
Rainfall distribution

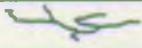


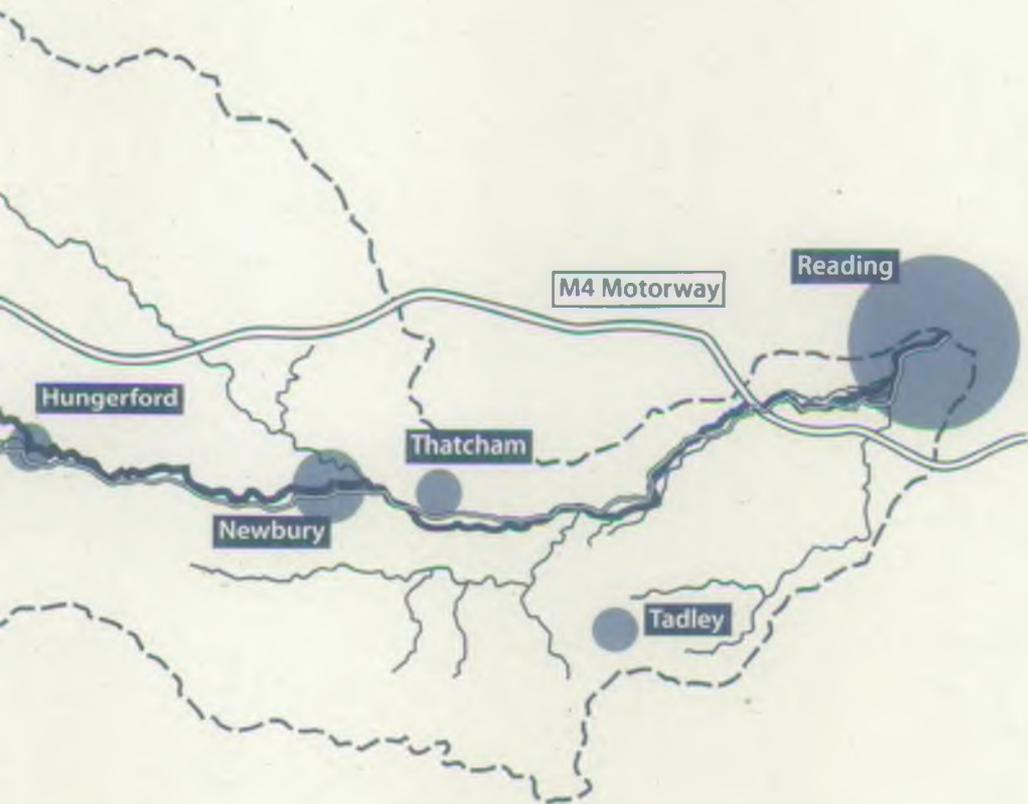
River Torridge Map C Landscape and Heritage



**River Kennet
Map A
Kennet Catchment**

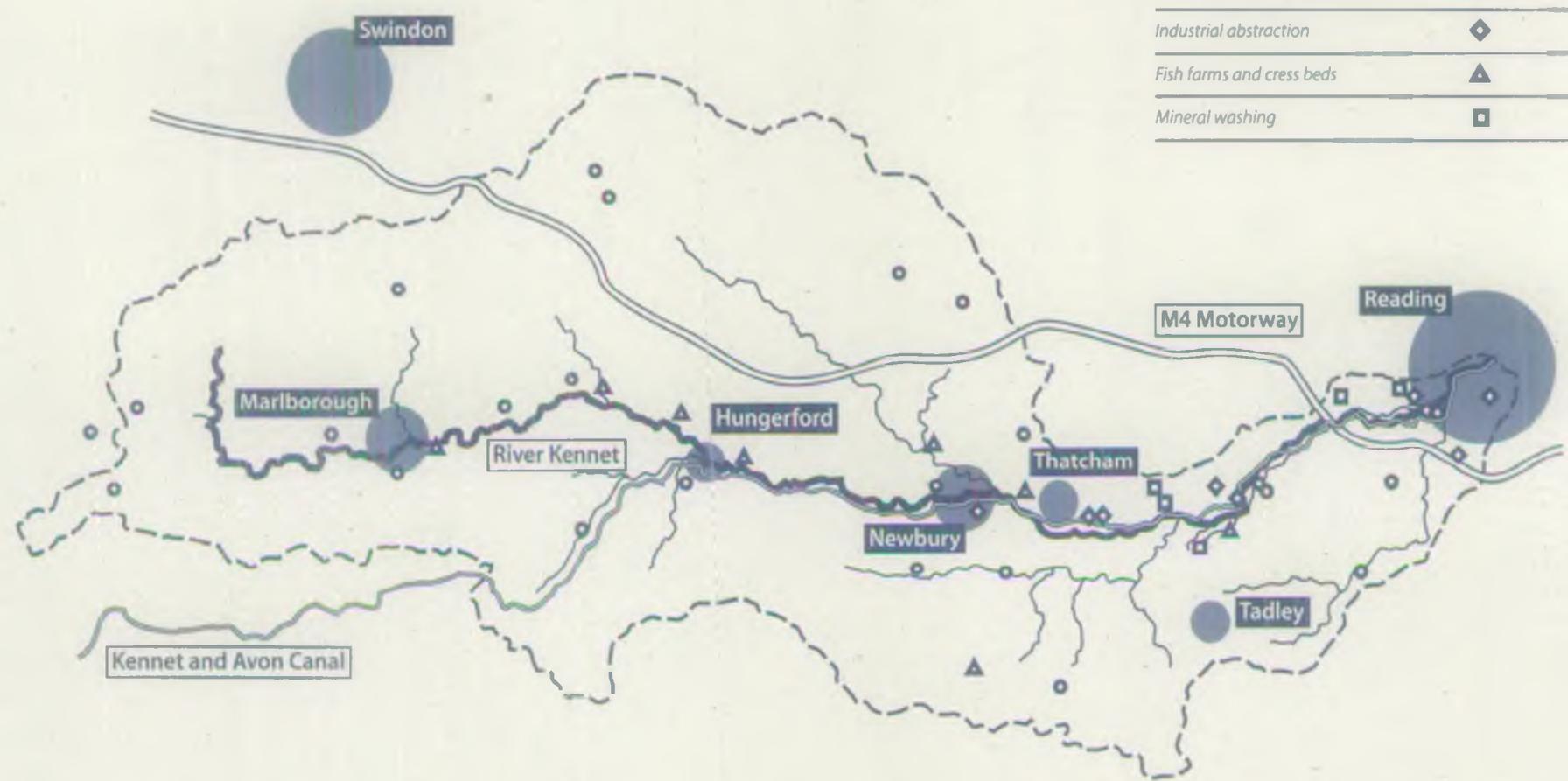


River Kennet	
Tributaries	
Kennet and Avon canal	
M4 motorway	
Catchment boundary	
Major settlements	



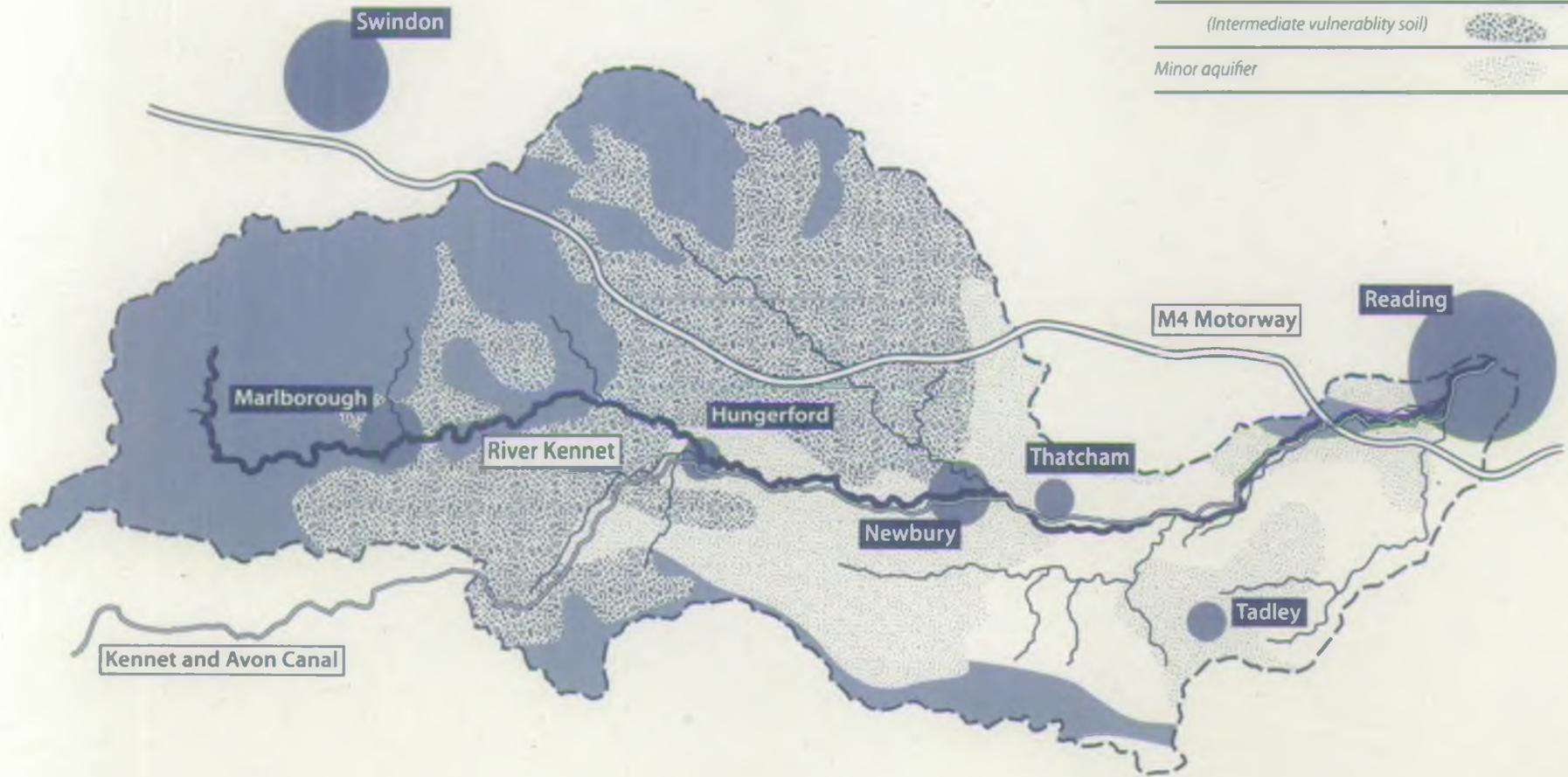
River Kennet
Map B
Water resources and abstraction

River Kennet	
Tributaries	
Kennet and Avon canal	
M4 motorway	
Catchment boundary	
Major settlements	
Public water supply abstractions	
Industrial abstraction	
Fish farms and cress beds	
Mineral washing	



**River Kennet
Map C
Groundwater**

River Kennet	
Tributaries	
Kennet and Avon canal	
M4 motorway	
Catchment boundary	
Major settlements	
Major aquifer (High vulnerability soil)	
(Intermediate vulnerability soil)	
Minor aquifer	



Tributaries



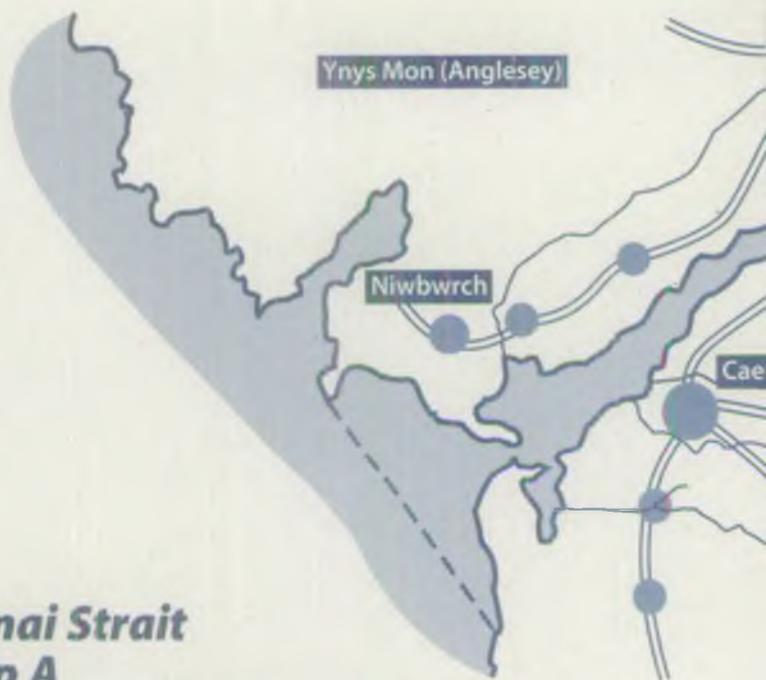
Major roads



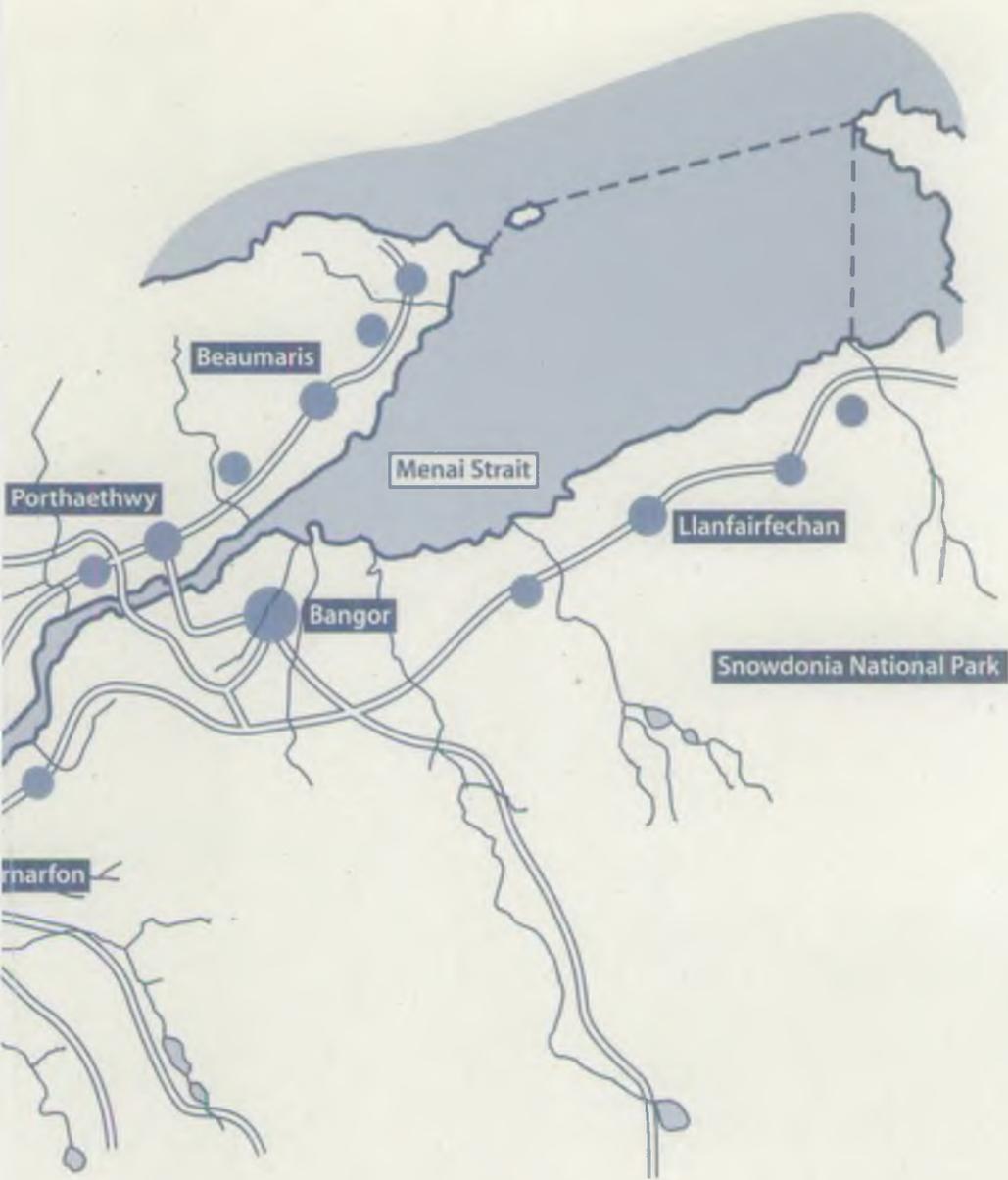
Catchment boundary



Major settlements



**Menai Strait
Map A
Menai Strait catchment**



Beaumaris

Menai Strait

Porthaethwy

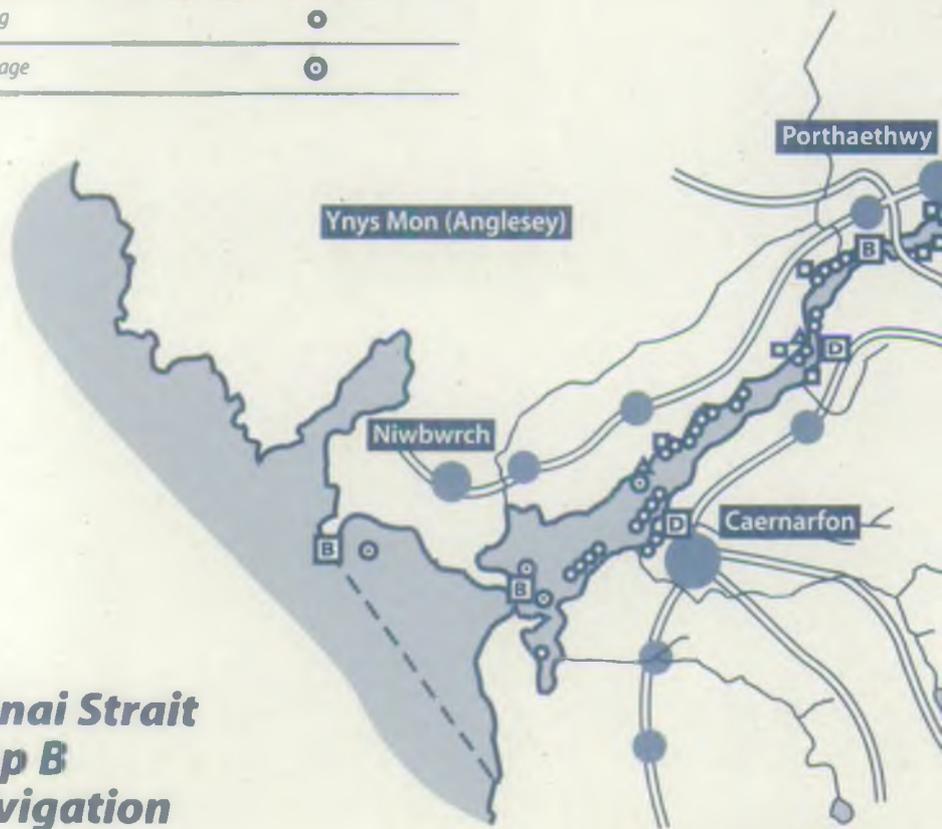
Llanfairfechan

Bangor

Snowdonia National Park

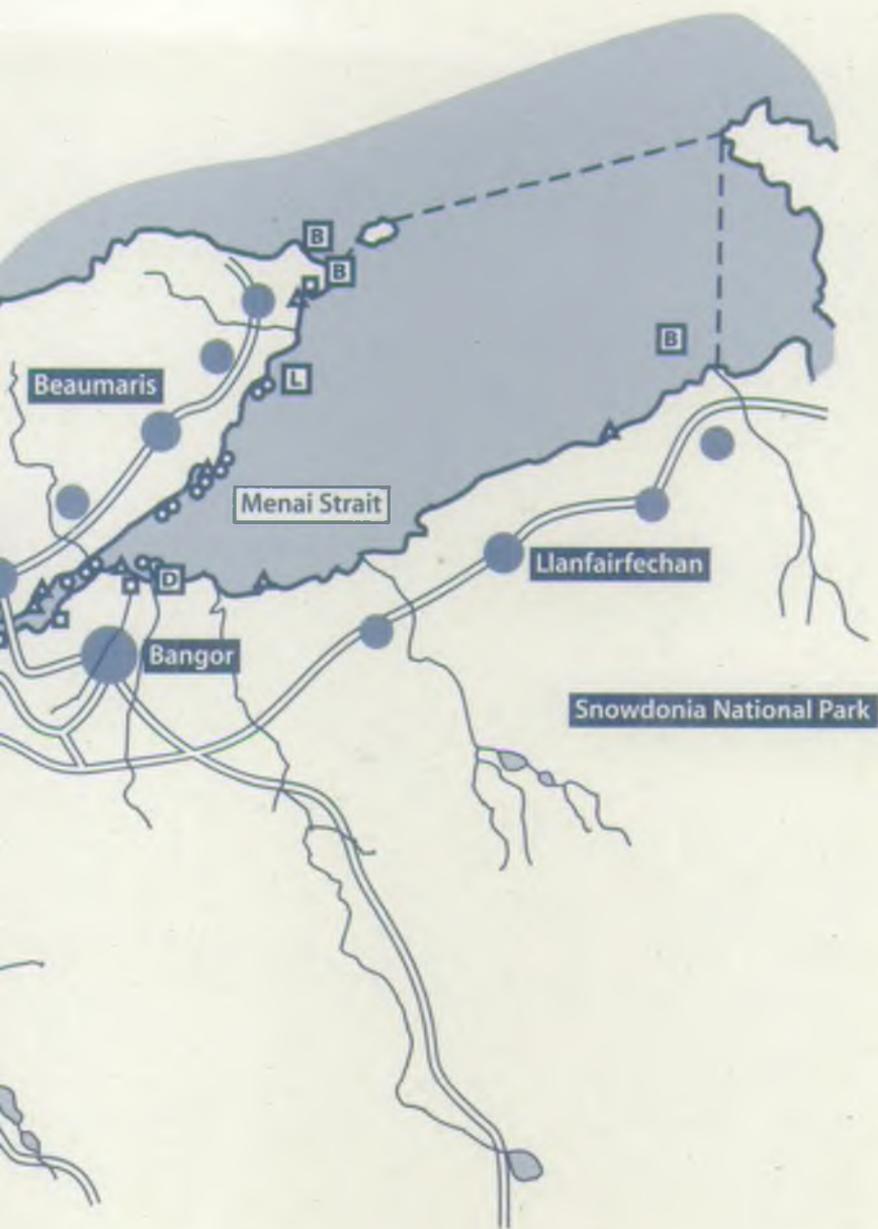
Ynarlun

Tributaries	
Major roads	
Catchment boundary	
Major settlements	
Beumaris lifeboat	
Lighthouses and beacons	
Docks	
Piers	
Slipways and jetties	
Mooring	
Anchorage	



**Menai Strait
Map B
Navigation**





Beaumaris

Menai Strait

Bangor

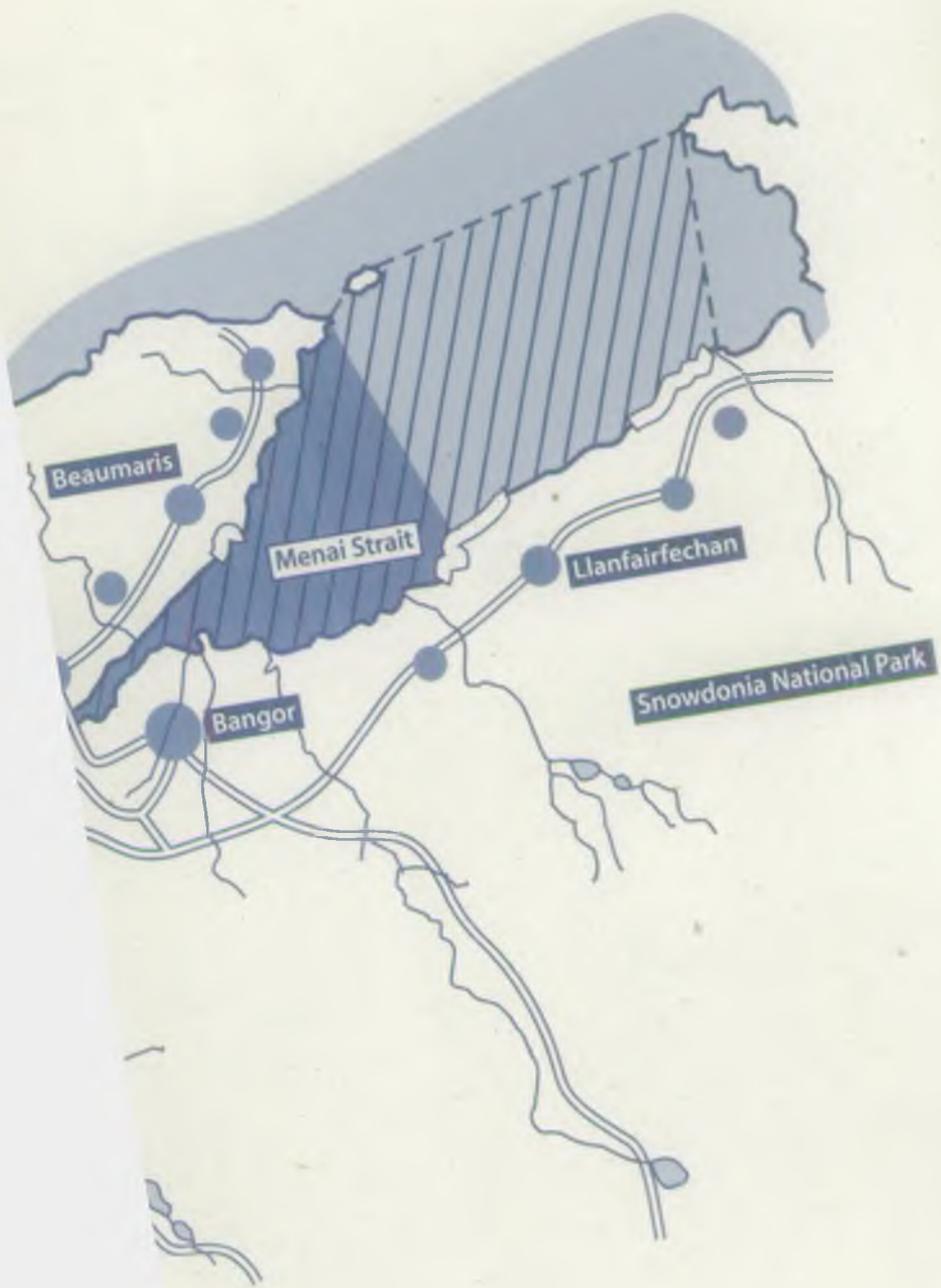
Llanfairfechan

Snowdonia National Park

Tributaries	
Major roads	
Catchment boundary	
Major settlements	
Salmonid fishery	
EC Designated shellfishery	
EC Designated bathing waters	
Other waters used by bathers	



**Menai Strait
Map C
Water quality targets**



Beaumaris

Menai Strait

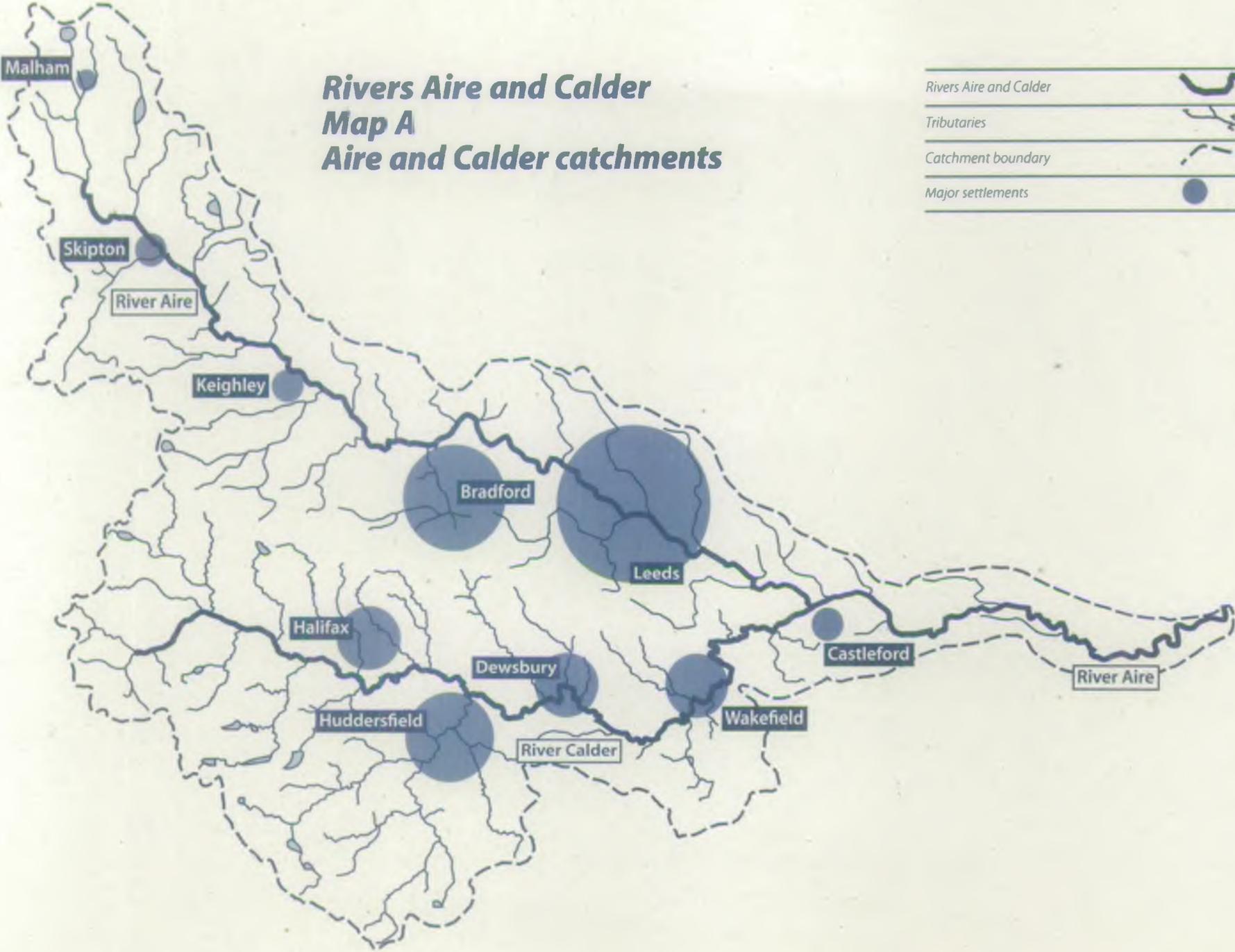
Llanfairfechan

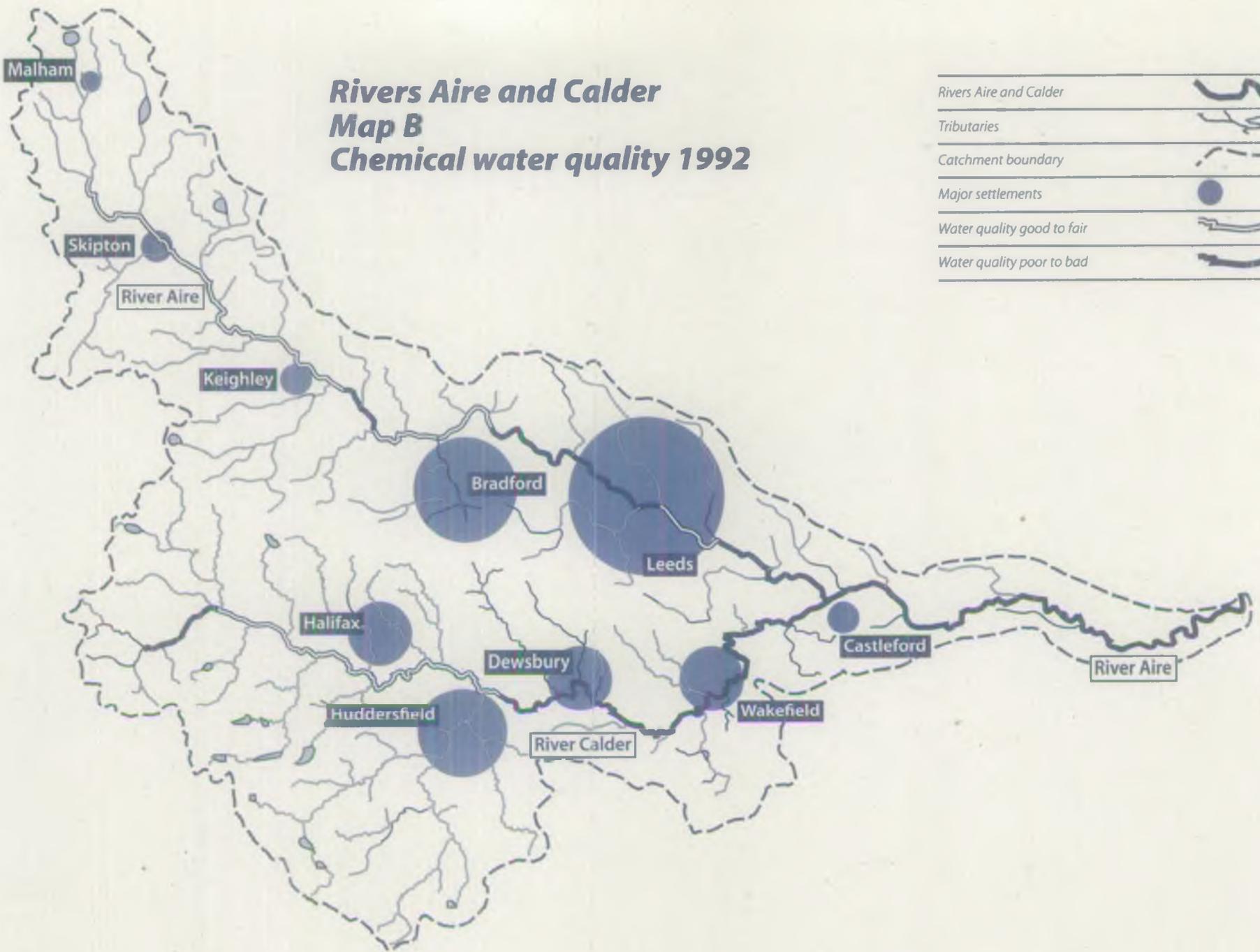
Bangor

Snowdonia National Park

Rivers Aire and Calder
Map A
Aire and Calder catchments

Rivers Aire and Calder	
Tributaries	
Catchment boundary	
Major settlements	





Rivers Aire and Calder
Map B
Chemical water quality 1992

Rivers Aire and Calder	
Tributaries	
Catchment boundary	
Major settlements	
Water quality good to fair	
Water quality poor to bad	

Malham

Skipton

River Aire

Keighley

Bradford

Leeds

Halifax

Dewsbury

Huddersfield

River Calder

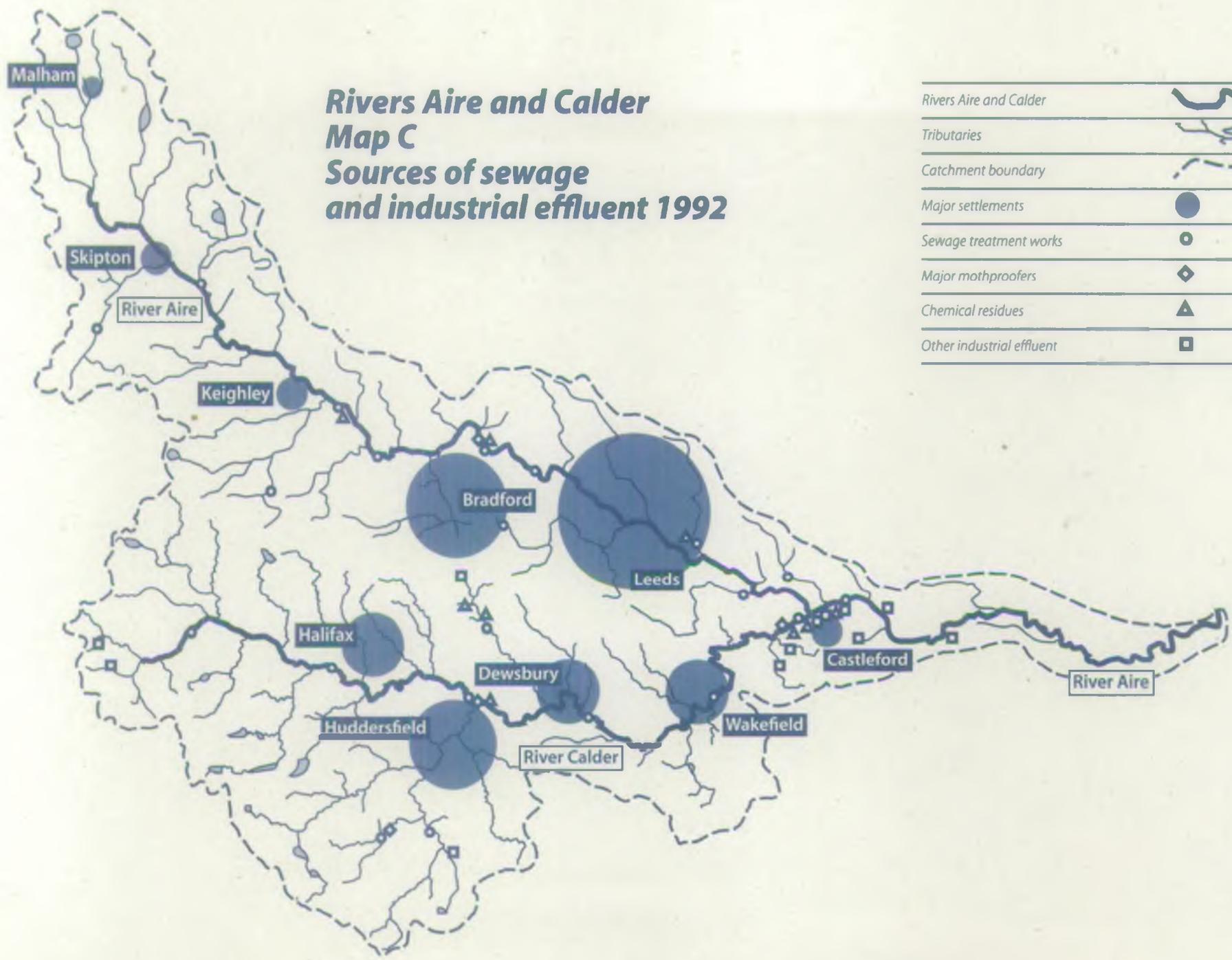
Wakefield

Castleford

River Aire

**Rivers Aire and Calder
Map C
Sources of sewage
and industrial effluent 1992**

Rivers Aire and Calder	
Tributaries	
Catchment boundary	
Major settlements	
Sewage treatment works	
Major mothproofers	
Chemical residues	
Other industrial effluent	





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The NRA is committed to the principles of stewardship and sustainability. In addition to pursuing its statutory responsibilities as Guardians of the Water Environment, the NRA will aim to establish and demonstrate wise environmental practice throughout all its functions.