Britain's inland waterways:
Balancing the needs of navigation and aquatic wildlife

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What is the Inland Waterways Advisory Council (IWAC)?

IWAC is a public body which provides independent advice to Government, navigation authorities and other interested parties on matters it considers appropriate and relevant to Britain's inland waterways.

Created in April 2007 by the Natural Environment and Rural Communities Act 2006, IWAC is supported by Defra and the Scottish Government. It succeeded the former Inland Waterways Amenity Advisory Council, created in 1968 to give advice on the amenity and recreational use of canals and rivers managed by British Waterways.

In England and Wales, IWAC's remit covers all of the inland waterways such as:

- canals (including those managed by British Waterways, canal companies, local authorities and smaller independent bodies);
- rivers (including those the responsibility of the Environment Agency, British Waterways and port authorities);
- the Norfolk & Suffolk Broads, and
- the navigable drains of the Fens.

In Scotland, IWAC's remit covers inland waterways that are owned or managed by, or which receive technical advice or assistance from, British Waterways.

What is IWAC's role?

IWAC's role is to ensure that the inland waterways are sustainably developed to meet the needs of all who use and enjoy them. Once used mainly for freight transport, the waterways now have a strong recreational and amenity use.

They act as an effective catalyst for the regeneration of local economies, acting as a focus to bring economic, social and environmental benefits to cities, towns and rural communities.

IWAC has published reports which include: reducing carbon dioxide emissions by moving more freight onto inland waterways, the restoration priorities of disused waterways, good practice guidance on promoting the potential of the inland waterways through the planning process, using the waterways to encourage social inclusion and showing the contribution that waterways can make to rural regeneration.

More about IWAC
For further information on IWAC and to see copies of its reports, visit our website at **www.iwac.org.uk**

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Summary

UK Government policy is to promote the sustainable use and development of all the inland waterways of England and Wales and to maximise the contribution they make to the needs of the nation and local communities. The Scottish Government has a similar policy for canals in Scotland.

The aim of this report is to help those involved with non-tidal inland waterways to facilitate the use of the waterways for sustainable navigation whilst protecting and, where practicable, enhancing their biodiversity.

The Key Conclusions

As a whole, the inland waterways system in Britain makes an important contribution to biodiversity and to aquatic wildlife in particular. In the interests both of nature conservation and of the continuing attractiveness of the system to its users, this contribution needs to be protected and, where practicable, enhanced.

The contribution of the system to wildlife conservation is far from uniform: at one extreme there are internationally and nationally important designated sites with legal protection, notably the Broads and some peripheral waterways (such as the Montgomery and Pocklington Canals) undergoing, or with plans for, restoration of navigation; at the other there are some stretches devoid of much nature conservation interest.

The extremes constitute a small proportion of the whole system. The vast majority of it is of modest conservation interest and here the wildlife value and the attractiveness for users can, and should, be affected directly by how the waterways are managed and by other controls. With appropriate management almost all waterways can deliver some wildlife benefits compatible with other requirements on them, including navigation, often without incurring any significant additional costs. Clearly effort and any additional expenditure must be balanced against the wildlife benefits obtained and sustainability considerations but, in many cases, improvements in wildlife conservation value can be achieved at little or no additional cost by ensuring that this aspect is considered at the planning stage of waterway maintenance or restoration work.

The value of each part of the system for aquatic wildlife conservation evolves over time and all nationally protected sites (Sites of Special Scientific Interest or SSSIs) are subject to continuing re-assessment by the statutory agencies. Whilst both UK and Scottish Government policy is to maintain or restore SSSIs to favourable conservation status, a few SSSIs on very busy waterways have never reached and are unlikely ever to reach favourable conservation status even with large expenditure and resource input and the best efforts of the waterway managers. In such cases, it may be best to focus limited available resources on SSSIs where achievement of favourable status is a realistic proposition. Conversely, other sites may grow in importance and may justify legal protection in future.

Changes in wildlife value arise because a whole cocktail of pressures, as well as navigation, affects waterway wildlife. Physical alterations, such as the installation of weirs on rivers and bank protection, affect habitat availability. Water quality is important, especially nutrient pollution from both point and diffuse sources. The Water Framework Directive aims to address such issues by establishing programmes of measures directed towards the achievement of ecological quality targets in all surface water bodies and should be a major stimulus to improving wildlife value of the waterways system. Other factors affecting aquatic wildlife value include hydrological impacts (e.g. water diversion, abstraction and impoundment), fishery management and invasive species.

Many non-tidal navigable inland waterways are already managed to serve navigation demands, as required by statute in many cases, in an appropriate balance with other requirements including those of aquatic wildlife. Such a management approach, both sustainable and by consensus, is supported by the Inland Waterways Advisory Council (IWAC); it should continue and be extended to all waterways.

There are a small number of waterways, both in use for navigation and with plans for restoration, where their importance for aquatic wildlife should be given extra consideration in their design and management, even as far as limitations on boat movements, boat speed or the type of vessels allowed.

Achieving a sustainable balance between navigation and aquatic wildlife conservation does not necessarily cost more, but where it involves significant additional costs these should be shared between those who benefit.

Across the system, navigation and wildlife bodies need to be actively engaged at all levels of management and consultation, to decide on shared objectives, to agree on approaches to impact assessment, to ascertain the optimum balance for future management, to develop good practice methods and to monitor outcomes, if the country is to get the best value out of its inland waterways.

The Key Recommendations

Navigation authorities/bodies should:

- develop consistent and appropriate procedures to assess ecological impact in advance of works that may affect aquatic wildlife, at a level of detail commensurate with the risks to or benefits for wildlife in each case; for works requiring consent from the environment agencies or other bodies, these should be consistent with existing procedures and guidance used by the consenting authorities;
- in consultation with wildlife bodies, develop waterway based local biodiversity action plans tailored specifically to contribute to decisions on waterway maintenance and management; these may be very brief or more complex, depending on the activities being undertaken;
- bring together engineers (civil or marine), the waterway industry, environmental professionals (including ecologists) and navigation experts, including those within statutory agencies, to develop and implement appropriate mitigation and enhancement measures for waterway wildlife, while ensuring that essential works to the waterway are not prevented by excessive mitigation costs;
- produce Waterway Conservation Management Plans (CMPs) for the limited number of waterways (active navigations and those under restoration or proposed for restoration) with significant nature conservation interest and review existing waterway CMPs;
- seek to engage local stakeholders and statutory environment and nature conservation agencies, to foster mutual understanding on matters relating to navigation and wildlife and to work in partnership to develop and implement good practice;
- be active partners (directly or through the Association of Inland Navigation Authorities AINA) in contributing to the development and implementation on their waterways of the River Basin Management Plans required by the Water Framework Directive, to ensure that navigational waterway interests are taken fully into account.

AINA should provide a forum for, and actively encourage, dissemination of the considerable experience of larger navigation authorities on management of waterways for navigation and wildlife to the smaller navigation authorities.

Development agencies, English regional bodies and all local authorities throughout Britain should:

- take an interest in developing the full potential of inland waterways in their areas for navigation users, wildlife and for the community as a whole;
- engage with navigation authorities, statutory conservation and environment agencies, landowners and the voluntary sector to agree future development and conservation plans for these waterways;
- ensure that appropriate protection and development provisions are included in regional spatial strategies and local development plans.

Voluntary sector organisations should:

- develop a more effective dialogue on navigation and nature conservation issues to share experience, develop best practice and to address issues such as coordinating the use of volunteers.

There is a particular need for wildlife non-governmental organisations (NGOs) to participate in the local and national consultation and liaison arrangements of navigation authorities, as well as responding positively to requests for involvement in waterway restoration projects.

Government and regulatory bodies should:

- recognise fully the value of navigable inland waterways in River Basin Management Plans established under the Water Framework Directive, making full use of provisions for the designation of artificial and heavily modified water bodies and setting alternative objectives as appropriate, thus ensuring that navigation authorities are not subjected to disproportionate costs.

Waterway related businesses should:

- contribute to the protection of the waterway environment by adopting good practices which avoid damage to wildlife and minimise water pollution, and by encouraging their customers to do the same.

IWAC will:

- keep this matter under regular review to identify changes and, where possible, anticipate problems.

Introduction

The non-tidal navigable inland waterways of Britain are a valued resource receiving well over 350 million visits by users of different kinds every year. The navigable channels of these waterways are used by pleasure craft and, to a limited extent, for carriage of freight and can, with appropriate management, also contribute to aquatic wildlife conservation.

This report identifies the wildlife potential of different types of navigable waterway and how this can be affected by a range of factors including the waterway's management and use for navigation.

The background to the study

The nature conservation value of our canals and navigable rivers is increasingly important to the many waterway users who enjoy the natural world and are interested in wildlife. International and national law, regulatory frameworks and planning policies recognise the importance of biodiversity in sustainable development. Regeneration of waterways relies on their environmental quality and attractiveness, as well as on social and economic factors.

Over the last five years our understanding of the relationship between navigation and aquatic wildlife conservation on non-tidal waterways has changed significantly as a result of hydrodynamic and ecological research. A broad portfolio of mitigation and enhancement techniques has been developed, ranging from management of navigation activity to soft bank protection, as well as experimental methods such as creation of off-channel reserves in an attempt to protect rare plant species in formerly derelict canals restored for navigation.

Recent years have also seen a rise in the use of consensus-building techniques which, by involving stakeholders at all stages of waterway restoration, have encouraged more open and positive dialogue between parties involved in waterway management and the definition and achievement of shared objectives.

Aims of the study

This study, funded by the Department for Environment, Food and Rural Affairs (Defra), aims to promote understanding of the relationship between navigation and aquatic wildlife and to recommend best practice methods that will help encourage the sustainable use of the waterways.

The report brings together engineering, social and ecological expertise. It aims to be concise and readable, give practical guidance and provide signposting to sources of further information.

Our hope is that this report will encourage the consideration of the needs of navigation and aquatic wildlife in waterway planning and management and the application of good practice so that:

- overall, the aquatic wildlife conservation value of waterways is protected and, where practicable, enhanced;
- navigation on currently navigable waterways is not unreasonably limited by nature conservation constraints;
- restoration to navigation of currently un-navigable waterways is facilitated while taking full account of nature conservation and sustainability;
- bodies responsible for, or interested in, either navigation or nature conservation are informed and empowered to reach agreements rather than allowing conflict to develop.

Maryhill Locks, Forth & Clyde Canal

Resolfen, Neath Canal

Scope of the report

The study:

1. summarises the biodiversity value of the waterway channel and its current use by boat traffic;
2. examines the relationships between boat use and aquatic wildlife;
3. examines case studies of, and other evidence on, ways of balancing the requirements of navigation and aquatic wildlife;
4. recommends best practice that can provide an improved, more consensual, way ahead. However, the study does not set out to provide a detailed technical manual of good practice.

The study considers only the relationship between navigation and aquatic wildlife in the main waterway channel and waterbodies directly connected with it, such as backwaters, weir streams and by-washes. The main focus is on the impact of motorised vessels and on ways in which they can best be accommodated.

In terms of geographical coverage, the study covers England, Wales and Scotland. It includes solely the canals of Scotland, all non-tidal waterways of England and Wales plus the Norfolk and Suffolk Broads, which are partially tidal. Other navigable tidal rivers and estuaries are also an important component of the inland waterways network, many with significant wildlife interest, but are outside the scope of this report which considers only freshwater or slightly brackish systems.

Although important for nature conservation and sometimes directly affected by waterway use, the following are also not covered by the study:

- areas adjacent to waterways, such as river floodplains, non-navigable canal feeders and reservoirs, towpaths and hedgerows;
- lakes, except where they are an integral part of the waterway (e.g. Scottish lochs forming part of the Caledonian canal), because they have a very different ecology;
- disturbance of wildlife by activities on board moored boats - these effects are similar to those arising from recreational use of the waterway banks generally.

Inland Waterways Advisory Council (IWAC)

IWAC's predecessor organisation, the Inland Waterways Amenity Advisory Council, was a statutory body set up by the 1968 Transport Act to advise UK Government and British Waterways (BW) on strategic policy for the use and development of the 2000 miles of inland waterways managed by BW.

Under the Natural Environment and Rural Communities Act 2006, the Council became the Inland Waterways Advisory Council on 1 April 2007. Its remit in England and Wales was widened to cover the strategic use of all inland waterways; in Scotland it continues to cover those waterways which BW manage or in which BW has an interest.

Key web resources

Association of Inland Navigation Authorities (AINA): **www.aina.org.uk**

British Waterways (BW): **www.britishwaterways.co.uk**

British Waterways Scotland (BWS): **www.britishwaterways.co.uk/scotland/scot_home/index.html**

Broads Authority (BA): **www.broads-authority.gov.uk**

Countryside Council for Wales (CCW): **www.ccw.gov.uk**

Department for Environment, Food and Rural Affairs (Defra): **www.defra.gov.uk**

Environment Agency (EA): **www.environment-agency.gov.uk**

Inland Waterways Advisory Council (IWAC): **www.iwac.org.uk**

Inland Waterways Association (IWA): **www.waterways.org.uk**

Joint Nature Conservation Committee (JNCC): **www.jncc.gov.uk**

Natural England (NE): **www.naturalengland.org.uk**

Scottish Environment Protection Agency (SEPA): **www.sepa.org**

Scottish Government: **www.scotland.gov.uk**

Scottish Natural Heritage (SNH): **www.snh.gov.uk**

Sea and Water: **www.seaandwater.org**

The Waterways Trust: **www.thewaterwaystrust.co.uk**

The Wildlife Trusts: **www.wildlifetrusts.org**

Welsh Assembly Government: **www.wales.gov.uk**

The Target audience

The report will be of relevance to a wide range of bodies, particularly:

- individual navigation authorities, the Association of Inland Navigation Authorities (AINA) and The Waterways Trust;
- other waterway interest bodies, including the voluntary sector (e.g. the Inland Waterways Association, other national groups and individual waterway societies);
- UK Government departments such as the Department for Environment, Food and Rural Affairs (Defra), Department for Transport (DfT), Department for Communities and Local Government (DCLG), Department for Culture, Media and Sport (DCMS);
- the Scottish Government (SG) and Welsh Assembly Government (WAG);
- local authority planning and countryside officers;
- statutory bodies such as Natural England (NE), Scottish Natural Heritage (SNH), Countryside Council for Wales (CCW), Joint Nature Conservation Committee (JNCC), Environment Agency (EA), Scottish Environment Protection Agency (SEPA);
- voluntary nature conservation organisations (e.g. The Wildlife Trusts);
- landowners and others with rights over waterways and related land.

We hope that the report will also prove of interest to individual waterway users, particularly boaters, anglers, walkers and naturalists, and to other stakeholders, including waterway related businesses.


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Understanding the waterways

The non-tidal inland waterway system of Britain is extraordinarily diverse. It includes navigable rivers, some with locks, and artificial waterways ranging from the narrow canals of the English Midlands to ship canals, as well as many navigable fenland drains and broads.

Some have been important for navigation for many centuries, while man-made waterways expanded rapidly from the 17th century onwards, initially for agricultural drainage purposes and then to satisfy the transport needs of the industrial revolution. Each type of waterway has its own special characteristics and historical background. On most waterways, navigation authorities have a statutory duty to maintain navigation.

UK Government policy promotes the sustainable development of the navigable inland waterway system and recognises its role in a number of fields, including recreation, transport, regeneration, water management and conservation of the built and natural heritage. The Scottish Government has a similar policy for canals in Scotland.

The inland waterways resource

There are over 6000km of currently navigable inland waterways in England and Wales, about 1500km of which are tidal. In addition, there are about 900km of managed, un-navigable waterways and a further 2000km of abandoned un-navigable waterways. There are some 225km of canals in Scotland, as well as navigable sea lochs and tidal rivers. (**Map 3.1**).

The development of inland waterway navigation in Britain began with the use by vessels of naturally navigable estuaries and rivers. Navigation was gradually improved by installation of weirs and locks on rivers, by artificial 'cuts' by-passing difficult river sections and later by completely man-made canals, often crossing river basin boundaries. Some channelised rivers and new water bodies built primarily for land drainage purposes were also used for navigation.

The legacy of this development is a wide variety of waterway types (**Map 3.1**) including:

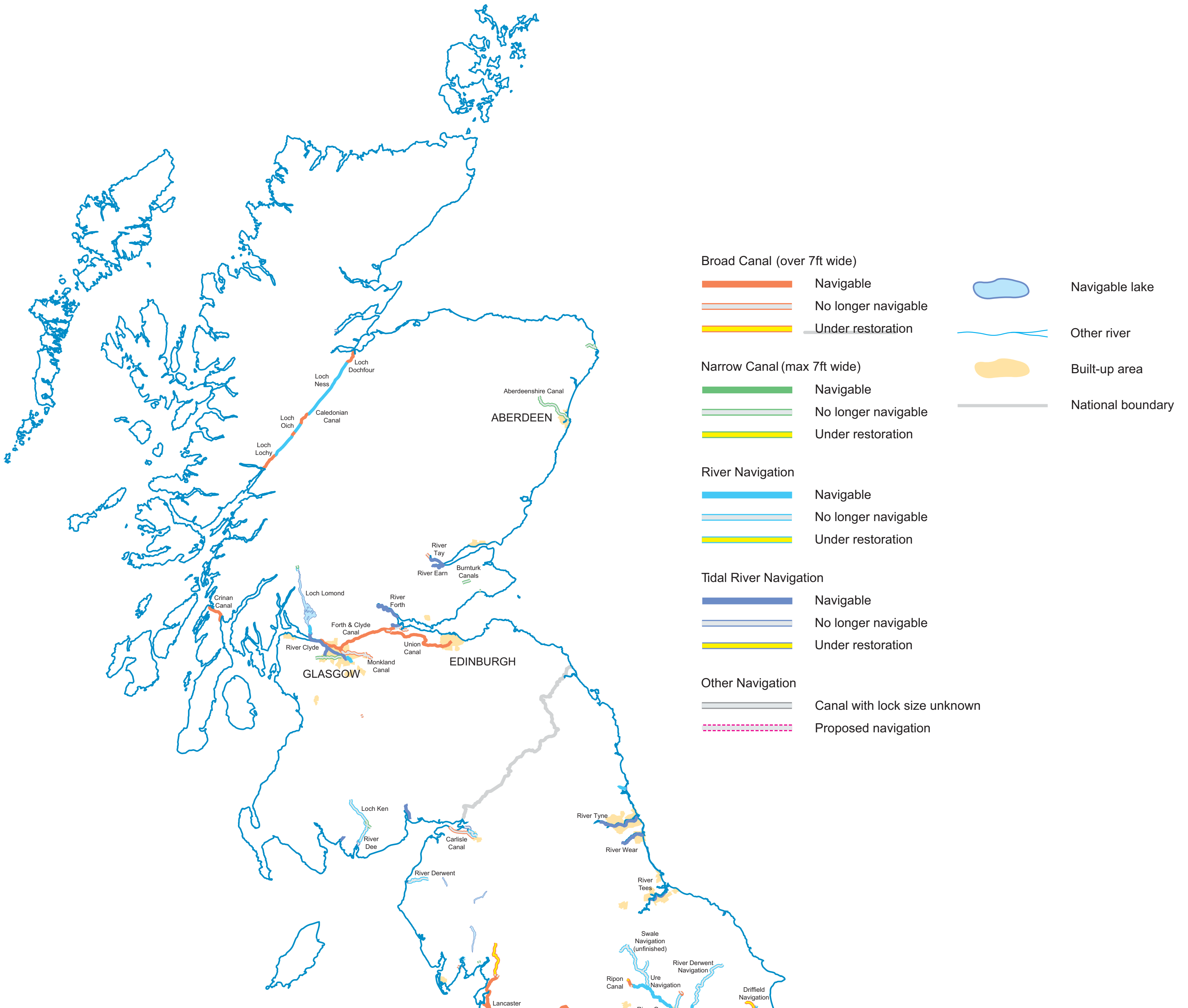
- narrow, broad and ship canals;
- navigable rivers (ranging from fairly natural to heavily modified);
- the rivers and shallow lakes of the Norfolk and Suffolk Broads ('Broadland'), which are partially tidal;
- navigable drains, mainly in the Fens of eastern England;
- navigable lakes and lochs (e.g. Loch Lomond, Loch Ness, Llyn Tegid and Windermere);
- tidal rivers and estuaries (not considered in this report except for the Broads).

These waterway types each have their distinctive environmental characteristics and often support different types of wildlife (Chapter 4).

Vessels have used the River Ouse wharves such as **King's Staith** in York from Roman times

Some sections of river navigations were later by-passed by canals, as on the **Aire & Calder**

Figure 3.1 Map of waterway types



Extent of each type of waterway as a proportion of the total length of currently navigable* inland waterway in Great Britain

Waterbody size and type	**%**
Narrow canals	18
Broad and ship canals	26
Non-tidal natural or modified rivers (including lochs on linear waterways)	23
Land drainage channels	5
Broadland rivers and Broads	3
Tidal waterways	25

* - navigable by motorised craft

Weirs and locks were built on rivers such as the **Thames** to improve navigation

Some Fenland drains have been made navigable; this is Cowbridge Lock near Boston

Figure 3.1
Shows typical river characteristics.

Some rivers are naturally navigable but the majority of non-tidal navigable rivers have been regulated by the construction of locks and weirs. In some cases substantial sections have been by-passed by artificial cuts (canal sections). Although some rivers have been heavily canalised (e.g. the River Lee), most have few navigation related engineering works between locks and retain predominantly natural banks. Water supply is usually based on the natural river flow. Water flow velocities are usually higher than in canals and flooding may occur frequently. Dredging may be required to remove shallow spots in the navigation but the need is usually quite localised.

Lakes and broads (shallow lakes of The Broads) are natural or man-made waterbodies that vary greatly in depth and rarely have any engineering works carried out on their banks.

Some rivers in fenland areas were built for land drainage but are also used for navigation. These have some similarities to canals. Water flows in summer may be very low but much higher in winter. Managed water levels often vary greatly, typically with high levels in summer to maintain supplies to agriculture and low levels in winter to assist land drainage.

Some canals, such as the **Forth & Clyde**, were built to allow seagoing vessels to cross the country

Many canals in England were built to take 'narrow boats' only **2.13m** (7 feet) wide

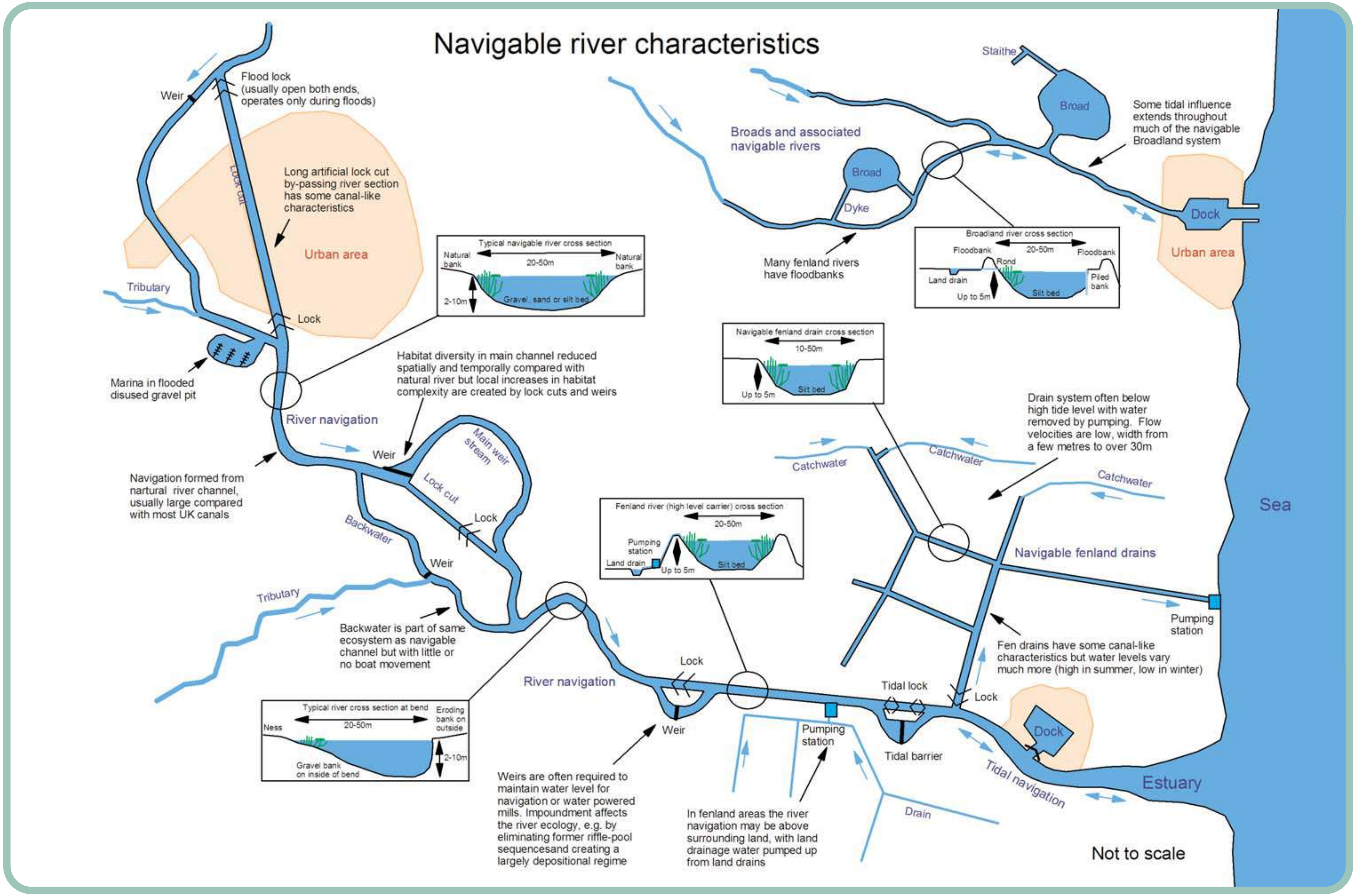
Figure 3.2
Shows typical canal characteristics.

Canals are man-made watercourses typically with reservoirs and feeders to supply them with water. They usually have a generally saucer-shaped cross-section but often with deeper water on the towpath side. Banks may be protected from erosion, for example by the use of piling. Where the water must be retained above the natural water table, the canal is normally lined with puddled clay. Water flow velocities are typically low, water levels closely controlled and flooding is rare.

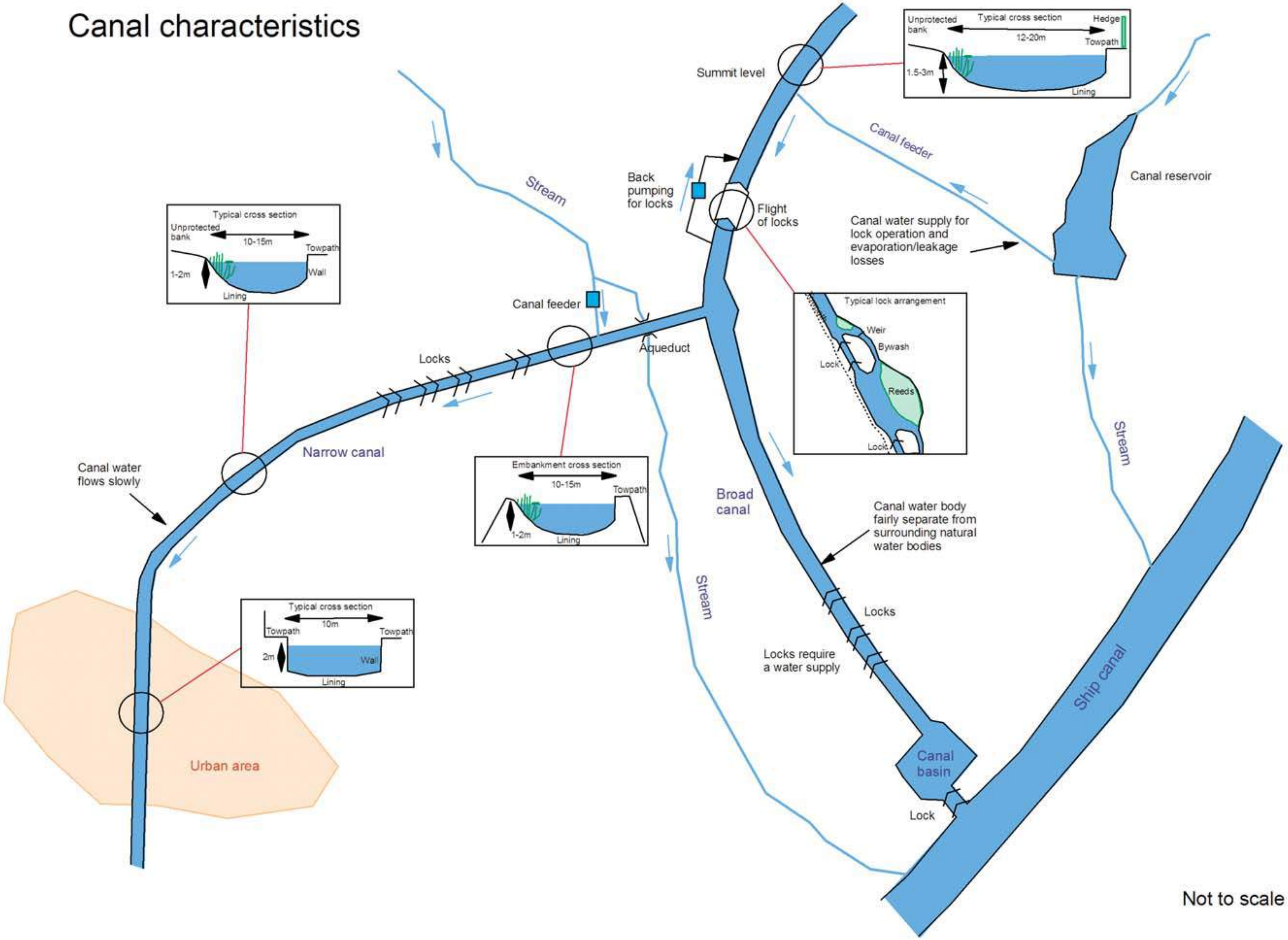
Changes in level are accomplished by locks, which are often grouped in 'flights' for ease of operation and management.

Sizes vary from the narrow canals of the English Midlands, with channels typically 8-15m wide and less than 2m deep and lock sizes limiting boat widths to just over 2m, to ship canals over 50m wide and up to 10m deep (e.g. Manchester Ship Canal). Periodic dredging is usually required to maintain navigable depth. The aquatic habitat of canals often differs from that of surrounding natural water bodies and their uniform cross-sections offer lower habitat diversity than most lowland rivers (see Chapter 4).

Figure 3.1



Navigable river characteristics
Weir
Flood lock
(usually open both ends, operates only during floods)
Lock cut
Long artificial lock cut by-passing river section has some canal-like characteristics
Urban area
Tributary
Lock
Marina in flooded disused gravel pit
Typical navigable river cross section
Natural bank
20-50m
Natural bank
2-10m
Gravel, sand or silt bed
Habitat diversity in main channel reduced spatially and temporally compared with natural river but local increases in habitat complexity are created by lock cuts and weirs
River navigation
Navigation formed from nartural river channel, usually large compared with most UK canals
Weir
Main weir stream
Lock cut
Lock
Backwater
Weir
Tributary
Backwater is part of same ecosystem as navigable channel but with little or no boat movement
Typical river cross section at bend
Eroding bank on outside
Ness
20-50m
2-10m
Gravel bank on inside of bend
River navigation
Weirs are often required to maintain water level for navigation or water powered mills. Impoundment affects the river ecology, e.g. by eliminating former riffle-pool sequencesand creating a largely depositional regime
Lock
Weir
Fenland river (high level carrier) cross section
20-50m
Pumping station
Land drain
Up to 5m
Silt bed
Pumping station
In fenland areas the river navigation may be above surrounding land, with land drainage water pumped up from land drains
Drain
Tidal lock
Tidal barrier
Lock
Dock
Tidal navigation
Estuary
Not to scale
Staithe
Broad
Broads and associated navigable rivers
Broad
Dyke
Many fenland rivers have floodbanks
Broadland river cross section
Floodbank
20-50m
Floodbank
Rond
Land drain
Piled bank
Up to 5m
Silt bed
Some tidal influence extends throughout much of the navigable Broadland system
Dock
Urban area
Navigable fenland drain cross section
10-50m
Up to 5m
Silt bed
Drain system often below high tide level with water removed by pumping. Flow velocities are low, width from a few metres to over 30m
Catchwater
Catchwater
Catchwater
Navigable fenland drains
Sea
Pumping station
Fen drains have some canal-like characteristics but water levels vary much more (high in summer, low in winter)



Canal characteristics
Summit level
Unprotected bank
Typical cross section
Hedge
12-20m
Towpath
1.5-3m
Lining
Canal feeder
Canal reservoir
Back pumping for locks
Flight of locks
Canal water supply for lock operation and evaporation/leakage losses
Stream
Typical cross section
Unprotected bank
10-15m
Towpath
1-2m
Wall
Lining
Canal feeder
Typical lock arrangement
Weir
Bywash
Lock
Reeds
Lock
Locks
Aqueduct
Narrow canal
Canal water flows slowly
Embankment cross section
10-15m
Towpath
1-2m
Lining
Broad canal
Stream
Canal water body fairly separate from surrounding natural water bodies
Typical cross section
10m
Towpath
Towpath
2m
Wall
Lining
Stream
Locks
Locks require a water supply
Ship canal
Canal basin
Lock
Urban area
Not to scale

Figure 3.2

Canal sites such as **Stoke Bruerne** are major visitor attractions, as well as popular stops for boaters

Inland waterway marinas support a wide range of small businesses

The origins, uses and value of the waterways

Rivers in Britain were used for navigation from the earliest times. From the medieval period onwards, many were substantially modified to make them better suited to navigation. Between the 14th century and the start of the main canal building era of the mid/late 18th century, river engineering more than doubled the 1000km of non-tidal British rivers which were navigable in their natural state. The waterways system expanded rapidly from the late 18th century with the construction of numerous artificial canals reaching its zenith in the mid-19th century, when over 6400 km of non-tidal canals and river navigations, many interconnecting, were in use (**Map 3.1**).

The driving force for the construction and improvement of most waterways, both rivers and canals, was the desire of entrepreneurs and investors to create a more efficient method of transport to facilitate trade and commerce. In doing so they created a transport system which made a vital contribution to the Industrial Revolution.

As rail and road transport came to dominate, the original transport and communication function of the inland waterways largely disappeared from all but a few large waterways. Now, many of the non-tidal waterways see relatively little freight traffic. Instead, they have become a multi-functional resource of value both to the country as a whole and to local communities.

The principal components of this value are:

- a leisure and tourism resource - the system is used by over 60,000 licensed privately owned craft, together with some 2,500 boats available for holidays through hire, timeshare and hotel boat arrangements and a further 200 boats offering day trips to the public.

The banks and towpaths of BW-managed waterways receive over 300 million visits each year by walkers, cyclists, anglers and sightseers. BW estimates that visitor spend is at least £1.5 billion per year for its own waterways.

The EA estimates that the non-tidal River Thames alone generates 14 million day visits annually and 28 million casual visits, contributing around £200 million to local communities. Tens of millions more use the remaining waterways in some way;

- support, in whole or in part, for a significant number of businesses; including boat hire yards, marinas, boat builders, equipment manufacturers, chandleries, angling equipment suppliers; together with local shops, pubs, restaurants, visitor centres and so on;
- freight use - around 50 million tonnes of freight are carried on UK waterways annually of which about 7% are entirely internal traffics, mainly on the larger inland waterways based on the Thames, Humber, Mersey and Severn river systems (the rest being seagoing traffic that penetrates the larger, mainly tidal, waterways). It is both UK and Scottish Government policy to increase the use of the waterways for freight and appropriate traffics in England and Wales have been identified by UK Government sponsored working groups and AINA reports;

Carriage of aggregates by barge can reduce road traffic

Many waterway structures are listed, including this cottage and split lock bridge on the **Stratford Canal**

The former **Clarence Dock in Leeds** is the focus for major waterside redevelopment

Community boats encourage access to waterways and their wildlife by a wide range of social groups

- a focus for urban and rural regeneration schemes. There are striking examples in cities, such as Birmingham (Brindley Place), Glasgow (Port Dundas), Manchester (Castlefield), Leeds (Clarence Dock) and London Docklands, as well as in a range of smaller towns (such as Market Harborough and Devizes) and at rural sites. Much of the rural potential is still largely unexploited;
- a route for telecommunications - by use of canal towpaths as routes for fibre-optic cables;
- a significant role in water management (and locally in water transfer for public supply, as with the Llangollen and the Gloucester & Sharpness Canals), as well as in flood defence;
- a heritage resource - much of the canal system, in particular, has outstanding heritage value with entire canals or specific lengths and structures recognised as being of national and international importance. BW is the third largest owner of listed buildings and structures in the country;
- a community resource which helps to support national policies for improving the quality of life, for example through education and training, volunteering, health and well-being, sustainable transport routes for walking and cycling, and outdoor access for those with disabilities;
- an ecological resource - the waterways have long been known for their nature conservation value. Nearly all waterways have some value for wildlife and this component is an important part of the attraction of waterways to the public. As with the built heritage, some lengths have been recognised as being of national or international importance for wildlife. This is described in more detail in the next chapter.

Thames sailing barges were very efficient, with over 300 square metres of sail often operated by a crew of only two

Propeller driven vessels under power create turbulent water flows at the stern

Vessels on the inland waterways

In the early days of the waterways, vessels were towed from the bank by men or horses, propelled by use of a barge pole (shaft or quant), or relied on natural elements such as the wind or current. Steering was facilitated by use of a large rudder and devices such as leeboards.

From late in the 19th Century, vessels driven by steam engines via a propeller (or very occasionally paddles) became widespread on larger waterways. These were followed early in the 20th century by boats fitted with internal combustion engines, which rapidly became almost universal. Steering is achieved by a rudder onto which the propeller jet is directed or by use of drive units such as outboard motors or other omni-directional drives, where the propeller shaft itself can be rotated in a horizontal plane.

Devices such as bow-thrusters are sometimes used on modern freight barges, allowing larger vessels to navigate safely in confined waters. These have also become more popular on smaller pleasure craft, particularly canal narrow boats.

The change from early methods of propulsion to propeller driven craft has greatly increased the interaction between the vessel and the waterway channel environment (Chapter 6).

Navigation authorities

Just over half of the navigable largely non-tidal system (by length) is owned or managed by British Waterways (BW), nearly a fifth by the Environment Agency (EA), with the rest being the responsibility of over 20 other navigation authorities and bodies. The largest of these is the Broads Authority (BA); others include local authorities, trusts and private sector companies (**Map 3.2**).

Waterway legislation

While some inland waterways are largely natural, most non-tidal navigable waterways were constructed or improved under powers granted by Acts of Parliament. These allowed the promoters, usually private companies, to construct and operate their waterways and to charge tolls.

Many of these Acts still apply, making matters very complex for navigation authorities; for example, there are over 370 Acts relating to waterways managed by British Waterways, the earliest being the Lee Improvement Act passed in 1424 (and written in the court language of the time - Norman French). These Acts often provide navigation authorities with many of their operational powers and determine their relationships with landowners and their powers to make charges for uses of the waterway. On many waterways, they place a duty upon the navigation authority to maintain provision for navigation. In some cases, the complexity and antiquity of the legislation creates barriers to efficient management of waterways and there is a need for modernisation and rationalisation.

The construction of canals and artificial sections of river navigations, such as locks and lock cuts, usually involved purchase of the land by the navigation company. Thus these sections of waterway are generally still owned by the navigation authority, giving them significant powers to carry out works for the benefit of both navigation and other requirements such as nature conservation.

Waterway restoration provides opportunities for volunteers to learn practical skills and to provide benefits for the wider community

Marginal wetland plants such as the yellow flag can add to the attractiveness of a waterway and provide habitat for dragonflies and juvenile fish

However, many sections of riverbed and most banks and some weirs on navigable rivers remain the property of the riparian landowners, although the navigation authority may have powers to carry out certain management activities, such as dredging. Thus, a partnership approach may be essential to implement management measures for the benefit of wildlife.

Many of Britain's waterways were nationalised in 1948, becoming the responsibility of the British Transport Commission. These waterways were eventually passed in 1962 to British Waterways (see **Map 3.2**), whose principal duties are set out in the 1962 and 1968 Transport Acts. These include duties to maintain navigation for certain types of vessel on different waterways.

Similarly, a number of important river navigations in England and Wales which had come under the control of navigation conservancy bodies or drainage commissioners were taken over by water authorities in 1974. On privatisation of the water industry in 1989, these became the responsibility of the National Rivers Authority and later (in 1996) the Environment Agency (see **Map 3.2**). The Agency is currently attempting to rationalise the varied waterway legislation under which they must operate.

There are still a significant number of waterways, both large and small, which are the responsibility of private companies, local authorities, drainage boards or charitable trusts, operating under a very wide variety of legislation, much of it anachronistic.

The public navigation authorities have had statutory duties to further wildlife conservation for some time. The Natural Environment and Rural Communities Act 2006 extended to all public bodies a duty to conserve biodiversity in the exercise of their functions, including restoring and enhancing species populations and habitats.

A summary of legislation relevant to inland navigation and wildlife is given in **Appendix 1**.

UK and Scottish Government policies for the waterways

The UK and Scottish Governments have recognised the inland waterways of England and Wales, and the canals of Scotland, as a national asset that contributes to social and economic success at a local, regional and national level.

Both Governments have set out their proposals to encourage a modern, integrated and sustainable approach to their use and to enable them to fulfil their economic, social and environmental potential. These policies are set out in Waterways for Tomorrow (2000), which applies to the waterways in England and Wales, and in Scotland's Canals: An asset For the Future (2002) which applies to BW's canals in Scotland.

The Governments' policies seek to protect, conserve and enhance all of the inland waterways of England and Wales, and the canals of Scotland, as an important part of the national heritage (built and natural) while, at the same time, to maximise the opportunities that they offer for:

- leisure, recreation, tourism and sport;
- urban and rural regeneration;
- education and social inclusion;
- freight transport;
- water transfer;
- innovative uses such as telecommunications routes.

These aims are to be achieved by:

- improving the quality of the infrastructure;
- encouraging partnership with the public, private and voluntary sectors, which can offer new skills and sources of funding;
- encouraging cooperation between navigation authorities;
- encouraging viable waterway restoration and development projects to extend the navigable system;
- integrating policy for the waterways more effectively into other Government policies.

Key information sources

AINA (2004) Demonstrating the value of waterways: A good practice guide to the appraisal of restoration and regeneration projects

AINA (2005) New Channels, New Challenges: Action Plan 2005/6 – 2007/8

British Waterways (2005) Our Plan for the Future 2005-2009

Broads Authority (2004) The Broads Plan 2004: A strategic plan to manage the Norfolk and Suffolk Broads

Defra (2000) Waterways for Tomorrow

Environment Agency (2005) Your Rivers for Life: a Strategy for the Development of Navigable Rivers 2004-2007

IWAAC (2001) Planning a Future for the Inland Waterways

IWAC (2007) The Inland Waterways of England and Wales in 2007

Scottish Executive (now Scottish Government) (2002) Scotland's Canals: An asset for the Future

IWAC's publication The Inland Waterways of England and Wales in 2007 has also advised the UK Government that an update to its policy for the inland waterways is needed, giving due attention to climate change, environmental improvement, public health and community cohesion.

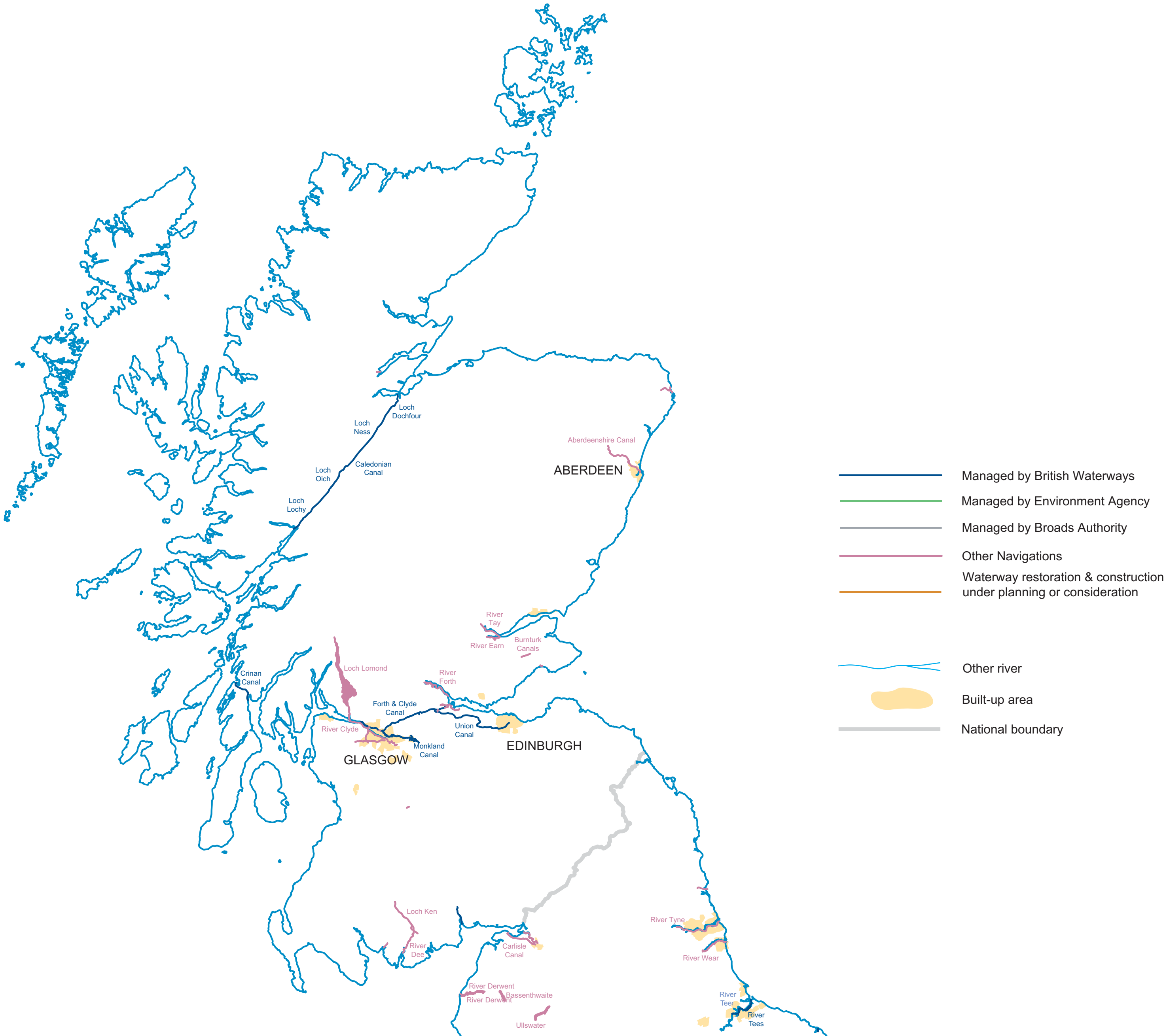
Navigation remains central to national policies for the waterways and both BW, via the UK and Scottish Governments, and EA, via the UK Government, have received substantial direct public investment over the years to help them tackle their safety and asset maintenance backlogs. However, many smaller navigation authorities struggle to make ends meet financially.

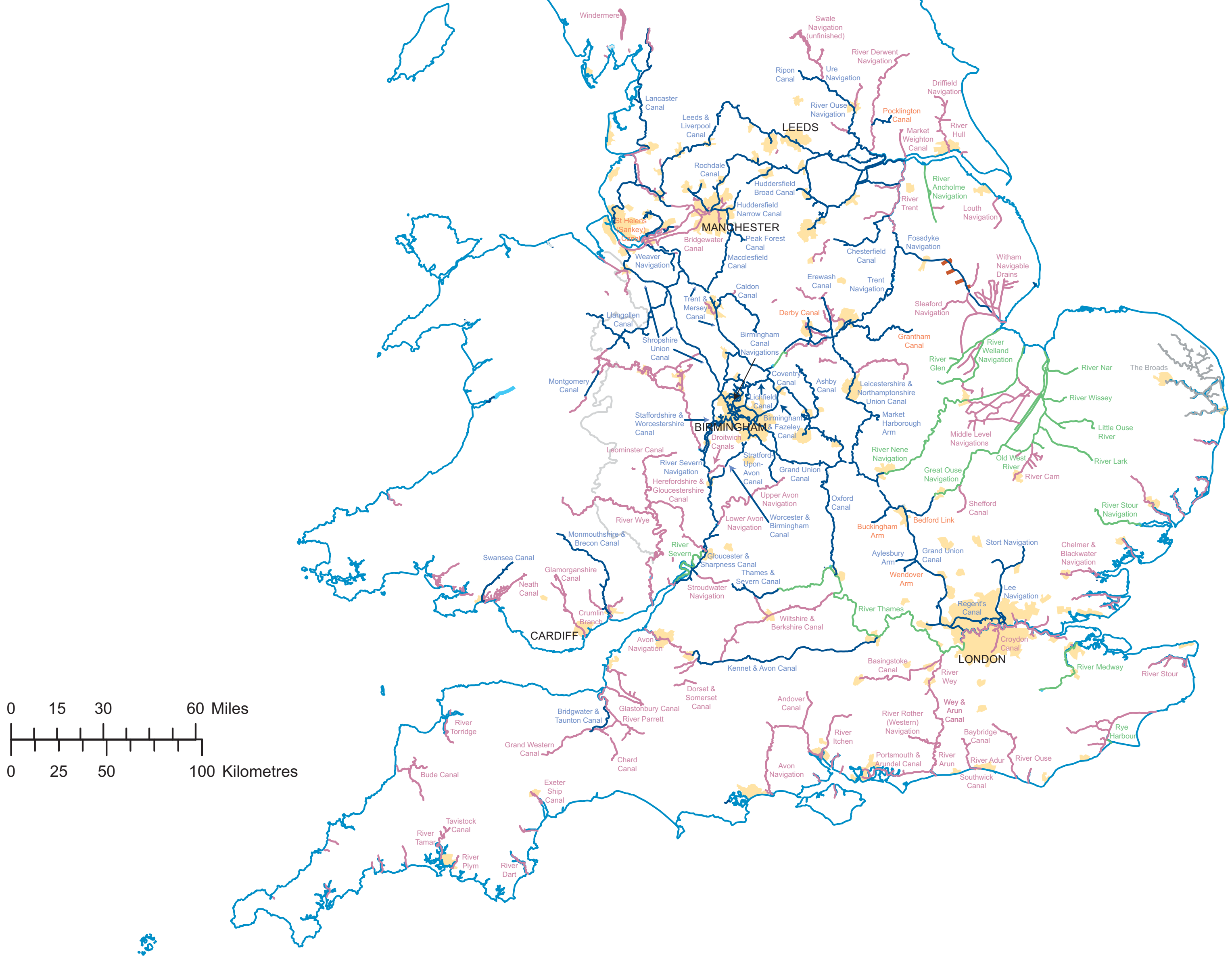
This financial assistance underpins a buoyant recreation and tourism market for leisure boating, which generates substantial income for some navigation authorities and for associated businesses. An actively used waterway is often the focus for public and private sector interest in both the channel and the towpath, as well as in developing waterside land. BW in particular, but also privately owned waterways, has benefited significantly from partnership development deals with local authorities and the private sector. All of these projects are focussed on a vibrant waterway channel used by boats.

The challenge, as the UK and Scottish Governments have recognised, is to maximise the range of benefits which the canals of Scotland and all the inland waterways of England and Wales can offer without damaging their inherent value. The protection of their nature conservation interest contributes to this value. Protecting and enhancing wildlife is therefore an integral part of the national policy framework for the waterways and wildlife needs to be considered as part of the whole range of benefits which waterways can deliver.

Identifying this contribution and balancing the demands of navigation and nature conservation are the central themes of this report.

Figure 3.2 Map of waterway authorities





0 15 30 60 Miles
0 25 50 100 Kilometres
Windermere
Swale Navigation (unfinished)
River Derwent Navigation
Ripon Canal
Ure Navigation
Driffield Navigation
Lancaster Canal
River Ouse Navigation
Pocklington Canal
Leeds & Liverpool Canal
LEEDS
Market Weighton Canal
River Hull
Rochdale Canal
Huddersfield Broad Canal
River Ancholme Navigation
Huddersfield Narrow Canal
River Trent
Louth Navigation
St Helens (Sankey) Canal
MANCHESTER
Bridgewater Canal
Peak Forest Canal
Fossdyke Navigation
Chesterfield Canal
Weaver Navigation
Macclesfield Canal
Witham Navigable Drains
Erewash Canal
Trent Navigation
Caldon Canal
Trent & Mersey Canal
Sleaford Navigation
Derby Canal
Llangollen Canal
Grantham Canal
Birmingham Canal Navigations
Shropshire Union Canal
River Welland Navigation
River Glen
River Nar
The Broads
Montgomery Canal
Coventry Canal
Ashby Canal
Leicestershire & Northamptonshire Union Canal
Lichfield Canal
River Wissey
Staffordshire & Worcestershire Canal
Birmingham & Fazeley Canal
Market Harborough Arm
BIRMINGHAM
Little Ouse River
Droitwich Canals
Middle Level Navigations
Leominster Canal
Stratford-Upon-Avon Canal
River Nene Navigation
Old West River
River Lark
River Severn Navigation
Grand Union Canal
Great Ouse Navigation
River Cam
Herefordshire & Gloucestershire Canal
Upper Avon Navigation
Oxford Canal
Shefford Canal
River Stour Navigation
River Wye
Lower Avon Navigation
Worcester & Birmingham Canal
Buckingham Arm
Bedford Link
Monmouthshire & Brecon Canal
Stort Navigation
River Severn
Grand Union Canal
Chelmer & Blackwater Navigation
Swansea Canal
Gloucester & Sharpness Canal
Aylesbury Arm
Glamorganshire Canal
Thames & Severn Canal
Wendover Arm
Neath Canal
Stroudwater Navigation
Lee Navigation
Regent's Canal
River Thames
Crumlin Branch
Wiltshire & Berkshire Canal
CARDIFF
Avon Navigation
Croydon Canal
LONDON
Kennet & Avon Canal
Basingstoke Canal
River Medway
River Stour
River Wey
Dorset & Somerset Canal
Andover Canal
Wey & Arun Canal
Bridgwater & Taunton Canal
Glastonbury Canal
River Parrett
River Torridge
River Rother (Western) Navigation
Rye Harbour
River Itchen
Baybridge Canal
Grand Western Canal
Chard Canal
River Arun
River Adur
River Ouse
Avon Navigation
Portsmouth & Arundel Canal
Southwick Canal
Bude Canal
Exeter Ship Canal
Tavistock Canal
River Tamar
River Plym
River Dart


FALCON
HOTEL
FALCON INN
WINDTHIEF

Importance of waterways for nature conservation

As agricultural, industrial and urban development has proceeded apace over the last century or so, the natural environment and its wildlife have come under increasing pressure.

Agricultural drainage, urban flood defence measures and sewage, agricultural and industrial pollution have contributed greatly to a steep decline in the extent and quality of natural wetland habitats in Britain since the early 20th Century.

Meanwhile, man-made developments have also created new habitats; the canal system is a prime example. With sensitive management, most navigable inland waterways can deliver some wildlife value while fulfilling their function as a recreational boating or transport resource; a small proportion have become sufficiently important for wildlife to warrant formal protection.

Box 4.1

What is nature conservation value?

This is the value society places on wildlife and the natural environment. Rare species and habitats are especially highly regarded. Sites that are unusually species-rich are also valued, because human influences such as pollution and habitat destruction typically result in species loss – making highly biodiverse sites a rare occurrence. The naturalness of a site is also a criterion used in evaluating its wildlife value. The exceptional value placed on critically threatened species and on the best wildlife sites is recognised by giving them special protection under national and international policy or legislation.

Nature conservation value at a local level is also recognised in local biodiversity action plans (LBAPs), county wildlife sites and local nature reserves.

Nature conservation value includes more than just formally protected sites and species however. Even on waterways of low or moderate value, common species such as mute swan and heron, or widespread groups such as dragonflies and kingfishers, can be a significant attraction for leisure users and give them much pleasure.

The River Wye navigation retains many natural features and is of international wildlife value

The waterways and nature conservation

The non-tidal navigable inland waterway system is home to a wide range of valued wildlife, from native crayfish and water voles to kingfishers and rare water plants. Individual waterways differ widely in their conservation value (**Box 4.1**).

While some waterways are of low wildlife conservation value, dominated by a few common pollution-tolerant species and with little opportunity for this to be changed, most are of moderate value and present opportunities for wildlife conservation and enhancement.

A small proportion (less than 10% by channel length) of the national non-tidal inland waterway system comprises waterways where the channel is so rich in plants and animals, or supports species that may be so uncommon or rare, that it is included in a site designated as being of national or international importance for nature conservation (**Map 4.1**).

The Basingstoke Canal showing a diverse marginal plant community

Hickling Broad is an internationally important wildlife site and is also a navigation resource (Photo: Shorebase)

There are four key factors that both influence the value of any waterway for wildlife and determine why some sections are of particular importance. These are:

1. the natural habitat type;
2. water chemistry and quantity;
3. bank and channel structure;
4. boat pressure.

The first of these factors is reviewed briefly below. A more detailed analysis of the others is given in Chapter 5 and Chapter 6.

Waterway habitats

Many large navigable rivers of Britain retain their importance for wildlife, despite construction of headwater reservoirs and flood defences, as well as alterations in their catchment run-off characteristics due to agricultural and urban development.

But, in reality, whether a waterbody is valuable as a wildlife habitat is little affected by its origin.

Canals, for example, are man-made channels, most no more than a few hundred years old. For wildlife, however, their value is that they help recreate an ancient habitat now largely lost from lowland Britain. In the past, 2000 years and more ago, Britain's lowland rivers were often multi-threaded, sprawling across their floodplains to provide a maze of slowly flowing channels with partly connected backwaters and cut-off pools. Despite being artificially constructed clay-lined channels, modern canals, especially those that are abandoned or little used by boats, happen to recreate this now uncommon slow-flowing river habitat type very closely, even to the extent that canal dredging mimics the natural, periodic channel scouring of river floods.

Otters benefit from waterway connectivity

This explains why canals with good water quality can be so important for freshwater plants and animals. Drainage, modern agricultural practices and flood prevention measures have changed flood plains in much of Britain beyond recognition. Most lowland rivers are now deeper, faster-flowing and confined to a single channel; their wide range of floodplain channels, backwaters and pools have been irrevocably lost. As these habitats have disappeared, the plants and animals that evolved to use them have become rare. This is exacerbated by the pervasive spread of water pollution, particularly inputs of plant nutrients.

The narrow canal system, built mainly in the 18th and 19th Centuries, was probably at its richest ecologically in the early 20th Century, after the decline of heavy freight traffic and before the more recent increase in use by pleasure craft.

There is a paradox then, that when man created canals he created a refuge for species orphaned from the range of wild river habitats that we have all but destroyed in many parts of Britain.

Sometimes even habitats that have long been thought of as quintessentially natural have turned out to be far from it. Until the 1950s it was assumed that the Norfolk Broads were natural lakes but it is now known that they too are man-made, created by medieval peat digging in the 12th-14th centuries and flooded at the end of that time. Today, despite their artificial origin and modern day problems with nutrient enrichment, these sometimes navigable shallow lakes are unique with some supporting a range of uncommon water plants of international importance seen nowhere else in Britain.

The wildlife of waterway channels is reviewed in **Box 4.2**.

Without management, open water and eventually all aquatic habitat may progressively be lost in disused canals

The waterways as wildlife corridors

The waterways are wet corridors along which many species move, sometimes aided inadvertently by boats and anglers or even deliberately introduced.

Some effects of this connectivity are positive: dredged sections of river and canal re-colonise quickly with plants and animals; species affected by pollution or loss of habitat can spread easily into new areas as water and habitat quality improves.

It does, however, have a negative side, as it provides a rapid dispersal route for less desirable non-native invasive species, such as signal crayfish and floating pennywort, which can pose real threats to native wildlife. Invasive plant species, such as floating pennywort, can also interfere with boat traffic by fouling propellers or even physically blocking the waterway.

Succession

A shallow body of standing water left to its own devices will become colonised by submerged and emergent vegetation. With time, emergent species such as reeds and rushes will extend across the whole water body; in the absence of a continuing supply of water, over a longer period, silt and decaying vegetation may replace the open water, sometimes leading to the creation of valued habitats of fen and wet woodland, often dominated by alder. Other trees can eventually take over and the wet habitat may ultimately be lost. This process is known as succession.

In most river navigations, even those no longer used by boats, the process of colonisation by reeds is limited by flow velocities and no specific management is needed to maintain open water habitat.

However, canals, drainage channels and shallow lakes often have low flow velocities and boat movement. This means that weed cutting or dredging may be needed to prevent loss of open water habitat through encroachment of emergent plants, such as reeds, across the whole channel width. Such management may be necessary to maintain navigation but may also be important for maintenance of biodiversity.

Canals are generally artificially lined, with artificially constructed water feeders, so they are isolated to a large degree from the surrounding hydrology. Therefore, on derelict canals where water supply is not maintained, succession often does result in loss of all aquatic and wetland habitat, with the canal bed ending up full of trees.

Active management of canals is therefore often necessary to maintain the aquatic and associated wetland wildlife interest, even on disused waterways.

Box 4.2 - Waterways are important for a wide range of plants, invertebrate animals and fish, as well as water dependant mammals

Wetland plants
For convenience, plants that grow in wet places are usually divided into three groups that describe their preferred position in the water: submerged, floating-leaved and emergent.

Emergent plants often dominate waterbody edges. They include rushes, reeds, sedges, reed grasses and the many flowering plants that thrive in wet ground.

Submerged plants grow mainly under water. They include pondweeds, stoneworts, water-buttercups and water-milfoil species.

Floating plants like duckweeds and water-lilies have leaves that float on the surface.

The last two of these categories are often combined to create a fourth: aquatic plants.

Aquatic plants
There are about 70 aquatic plant species found on the inland waterways. Because these plants mostly grow submerged, many need clear water conditions to give them enough light to survive, although floating leaved plants are more tolerant.

On navigable waterways, one of the most important groups is the true pondweeds (Potamogeton species). A few high quality canal sections are particularly important for these plants and some pondweeds would be very rare indeed were it not for canals such as the Rochdale, Montgomery and Pocklington.

Another important group is the stoneworts, or charophytes. These are very ancient plants, part way between algae and higher plants. They are particularly sensitive to nutrient pollution, so many species are rare. Norfolk Broads such as Hickling and Martham are critical for these plants, which can also be found in canals. Stoneworts often occur in the early stages of succession after waterbody creation or in undisturbed waters.

One plant, floating water plantain, is protected by European legislation on three canals – the Montgomery, Rochdale and Cannock Extension.

Protection of rare submerged plants can conflict with pressures for greater boat traffic but areas of friction are uncommon. Many waterways, especially smaller canals, support few submerged plant species, as the water is too polluted or disturbed by boats. Here only a few tolerant species may survive, including floating leaved plants such as water lily and aliens such as Nuttall's pondweed.

On waterways which are wide and deep compared with the size of boats using them, as on many river navigations, or where boat traffic is light, waterway sections sometimes occur with clear water. Here, if pollution levels are low and the water is not too overgrown by emergent plants, submerged species often thrive, giving communities that are sometimes of exceptional value. Such waterways include some of the navigable Norfolk Broads, some river navigations (e.g. the Wye, Ure, Derwent) and a number of little- or non-navigated canals, often located around the periphery of the canal system, such as the Basingstoke Canal, which, in the early 1990s supported almost half the UK's native aquatic plant species.

However, while the effects of organic pollution have been reduced over recent years in many of our navigable rivers, most are still affected by excessively high levels of plant nutrients derived from treated sewage discharges and agricultural run-off. This tends to lead to dominance by a few tolerant plant species, including algae, which limits the development of diverse aquatic plant communities.

Emergent plants
Fortunately, most marginal wetland plants such as reeds, rushes and sedges are more tolerant of water pollution than their submerged cousins. Some tall mat-forming species like reed sweet-grass are also robust enough to withstand considerable boat wash.

But even for marginal plants, the bank type is important. Waterway edges with vertical steel piling obviously have reduced potential for marginal plant development.

But the natural earth banks of rivers, lakes and many canals, and even decaying stone-reinforced banks, can provide a foothold for these edge-loving species. In higher quality sections of canals more uncommon marginal plants are sometimes found, such as tubular water-dropwort, tasteless water-pepper and narrow small-reed.

There are few protected marginal plants particularly associated with navigable waterways. The main exception is cut grass, a Biodiversity Action Plan (BAP) priority species1 that grows locally along canals such as the Bridgwater and Taunton Canal.

Aquatic invertebrates
Aquatic invertebrates include water beetles, water bugs, larvae and nymphs of dragonflies, mayflies, caddis flies, stoneflies, alderflies, true flies, leeches, flatworms, snails, mussels, shrimps, crayfish, and many more.

Aquatic invertebrates of waterways
Canals and navigable rivers contrast in the habitats they provide for invertebrates. In still or very slowly flowing canals the greatest variety of invertebrates is usually found at the channel margin and amongst submerged or marginal plants.

Few animals live in the fine, easily disturbed sediments of the channel centre of a typical clay lined canal. In contrast, areas of pebbles, sand and gravel in the bottom sediments of navigable rivers are an important invertebrate habitat, although even here more species live near the channel margin than in the centre.

In both types of waterway, plants are important for many different kinds of invertebrates, providing shelter or food; so waterways with abundant and diverse vegetation are also likely to be rich in invertebrates.

Protected species and habitats - The principal protected species and habitats associated with navigable waterways are listed in **Appendix 2**.

and birds.

Invertebrates of river navigations
The large navigable rivers, such as the Thames, Severn and Nene, support rich invertebrate communities, often including species found only in the biggest rivers. Special animals like the club-tail dragonfly and rare species of mayfly, snail and caddis fly live in the silts and fine sands and among tree roots on the channel margin.

Of the navigable rivers, the Wye is rather unusual: faster flowing with shingle bars. Its special invertebrate community is associated with exposed pebbles and shingle along its margins, especially craneflies and water beetles.

Canal invertebrates
The central areas of canals are usually poor for invertebrates and, unless there are aquatic plants there to provide shelter, most have few animals except fly larvae and worms. The margins are usually richer, and their value increases for aquatic species (particularly dragonflies, waterbugs, beetles, snails and caddis-flies) as banks become more natural and more vegetated. The damp edges are also important for terrestrial and semi-terrestrial animals. Along the Basingstoke Canal alone about eighty-five species of hoverfly have been recorded and here and elsewhere a wide range of uncommon beetles, bugs and flying insects live in or use the damp ground and plants on the waterway edge. Some canals also support populations of protected species, such as the native freshwater crayfish (Austropotamobius pallipes) and the depressed river mussel (Pseudanadonta complanata).

Invertebrates of navigable lakes and broads
The navigable lakes and broads resemble canals in having rich invertebrate assemblages on the lake margins and where water plants are abundant, with generally fewer species amongst the fine bottom sediments. In the open water, microscopic water fleas and other Crustacea (zooplankton) often play an important role in keeping the water clear by filtering algae from the water.

Protected invertebrates
Most sections of protected waterways are notified for a range of components of the habitat, often focussing on aquatic plants, rather than their invertebrate communities specifically. However, in some canal SSSIs, invertebrates make a significant contribution to their interest. For example, the SSSI notifications of the Ashby and Pocklington canals refer specifically to invertebrate assemblages.

Navigable rivers, lakes, broads and canals also support a number of invertebrate species that are sufficiently endangered to be protected under legislation or policy.

Fish
Most of the navigable waterway system supports fish populations. Some river navigations, such as the River Wye, River Severn and River Dee, are good salmon and trout fisheries and support rare species such as lampreys and, in the Wye and Severn, twaite shad.

In many river navigations, including fen drains, non-migratory coarse fish dominate. Species commonly found include barbel, bream, carp, chub, gudgeon, perch, roach tench and stickleback, with some rivers also supporting eels, pike, grayling and brown trout. Less common fish such as bleak, bullhead and ruffe also occur, while the protected spined loach is present in a few fenland navigations.

Most canals also support coarse fish populations, including the same coarse fish species as the river navigations, with the general exception of barbel. A few canals also support populations of spined loach. The Caledonian Canal and some other upland canals support thriving salmonid fish populations.

Overall, coarse fish populations have been increasing in the rivers of England and Wales as water quality has improved; it is not known whether there has been a similar general trend in the canals.

In urban areas, fish populations in the rivers and canals are often poor, limited by a lack of physical habitats, and sometimes by pollution incidents.

In the waterway system, most protected fish species are found only in a few navigable rivers. However, eels, which are probably quite widespread across all the navigable waterways, were designated a Biodiversity Action Plan species in 2007, reflecting the large decline that has occurred in eel populations over recent years.

Mammals
The navigable waterways are an important part of the habitat of two protected aquatic mammals, otters and water voles. In addition, many bats (all of which are protected) feed over water, including the navigable waterways.

Other widespread mammals using the navigable waterways include the water shrew and, less welcome, the American mink, an escapee from fur farms, which has helped to decimate water vole populations in many areas of Britain.

Birds
Birds are some of the most visible animals on the waterway system. The most commonly seen are waterbirds such as herons, mute swans, mallards, coots and moorhens, while sedge warblers and the elusive kingfisher are also widespread on the navigable waterways in England. However, a variety of other species breed in some locations including little and great-crested grebes and grey wagtails.

The Broads are particularly important for over-wintering waterfowl, several of its shallow lakes being designated under national or European legislation.

With the exception of game birds and some waterfowl outside the closed season, and species covered by open general licences issued for control of nuisance species, British birds are protected under national legislation. In addition, the kingfisher is specially protected under Schedule 1 of the Wildlife and Countryside Act, making it an offence to disturb this species during the breeding season.

More information on their status, ecology and management requirements is given in **Appendix 3**.

Table 4.1 **Wildlife site designations**

Designation	Acronym	Designation under/by	Relevance to waterway management
International			
Ramsar site		The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, Iran, 1971, as amended). Sites are listed by UK Government to protect valued wetlands.	These sites are protected under the Habitats Regulations (S.I. 1994:2716, as amended). This means that before permitting any plan or project which is likely to have a significant effect on the site and is not directly connected with or necessary to the management of the site, the competent authority must carry out an 'appropriate assessment' of the implications for the site. Plans or projects which will have an adverse effect on the conservation objectives may only be allowed where there is no alternative and there are 'imperative reasons of overriding public interest (IROPI). Note that these inland sites are all also sites of special scientific interest (SSSIs) and also receive the protection detailed below.
Special Area for Conservation	SAC	EU Habitats Directive (79/409/EEC). Sites are recommended by the UK Government and designated by the EC to protect habitats and (non-bird) species listed in Annex I and Annex II of the Directive.	
Special Protection Area	SPA	EU Birds Directive (92/43/EEC as amended). Sites are classified by UK Government on the basis of agreed criteria on their bird populations.	
National			
Site of Special Scientific Interest	SSSI	Wildlife and Countryside Act 1981 (as amended by the Countryside and Rights of Way (CROW) Act 2000 (in England and Wales) and the Nature Conservation (Scotland) Act 2004 (in Scotland)). Sites are notified by Natural England, Scottish Natural Heritage or the Countryside Council for Wales on the basis of published criteria (NCC, 1989), using county-level areas of search.	Sites (based on biological or geological interest) are notified by the statutory nature conservation agency (Natural England, CCW, and SNH). Protection is mainly through a requirement to obtain consent for any of the 'operations likely to damage' (OLD) listed in the citation. Certain statutory bodies do not require consent but must consult the conservation agency and request assent.
National Park	NP	National Parks and Access to the Countryside Act 1949, National Parks (Scotland) Act 2000. National Parks are designated by the UK and Scottish Governments.	National Parks are designated for the conservation and enhancement of the natural beauty and cultural heritage and promotion of public enjoyment of the area, while having regard for the social and economic wellbeing of the local population. This is reflected in the application of planning policies. Several waterways run through National Parks.
National Nature Reserve	NNR	National Parks and Access to the Countryside Act 1949 or Wildlife and Countryside Act 1981. Declared by the UK and Scottish Governments, where SSSI are regarded as being of national importance.	NNRs are managed primarily for nature conservation, usually by the statutory nature conservation agency (NE, CCW, and SNH). A few canals and a number or river navigations lie within NNRs.
Areas of Outstanding Natural Beauty/National Scenic Areas (Scotland)	AONB/NSA	National Parks and Access to the Countryside Act 1949 (in England and Wales) (as amended by the Environment Act 1995 and the CROW Act 2000). Scottish Development Department Circular 20/1980 (in Scotland).	AONB and NSA are designated on account of their outstanding natural beauty and this is protected through policy and the planning system. Where an AONB has a Conservation Board, the Board has an additional purpose to increase public understanding and enjoyment of the special qualities of the area. Several waterways run through AONB but there is little interaction with NSA.
Local			
Local Nature Reserve	LNR	National Parks and Access to the Countryside Act 1949. Sites are designated by local authorities after consultation with the statutory nature conservation agency.	Local Nature Reserves (LNRs) are places with wildlife or geological features that are of special interest locally. A key feature is that they offer people special opportunities to study or learn about nature or simply to enjoy it.
County Wildlife Site	Various - CWS, SINC, SNCI	Local planning authority Local Plan policies. Sites are identified by local authorities, often on the advice of local wildlife trusts.	Many waterways are identified as County Wildlife Sites; the protection of the wildlife interest of these sites must be taken into account by planning authorities in their decisions.

Nature conservation: policies and legislation

Sections of waterways which support critically important habitats, communities or species can be protected by statutory and non-statutory designations as described in **Table 4.1**. Waterways may receive this protection for the nature conservation value of the channel itself, or for associated features including the floodplain of navigable rivers and, for the canal system, feeder reservoirs and bat roosts.

Overall, only a very small proportion (about 8.5%, of which 1.5% relates to the River Wye alone) of the navigable channels of the currently navigable non-tidal or partially tidal waterway system is included in sites designated as being of national or international importance for wildlife.

However, this is not a constant picture. Occasionally, waterway SSSIs lose their special interest, for example reed warblers on the River Avon (Warwickshire), and are recommended for denotification.

UK and Scottish Government policy is to maintain or, where necessary, restore SSSIs to favourable conservation status. However, a few SSSIs on very busy waterways have never reached and are unlikely ever to reach favourable conservation status for all their cited features, having been notified before this concept was formalised. IWAC supports the continuing review of such sites by the conservation agencies and exploration of all options for achieving the intended nature conservation benefits, with denotification if there is no realistic prospect of realising such benefits.

In Britain, the navigable (or partially navigable) waterway system currently has (**Map 4.1**):

- 26 sites of international importance (SAC, SPA and Ramsar), which include the navigable channel; and
- about 48 biological sites of special scientific interest (SSSIs) which are notified at least partly because of the value of the navigable channel or its wet margins.

There are many additional sites notified as SSSIs alongside waterways, some managed by navigation authorities, which are not considered here because they do not include the waterway channel or are notified solely for their geological interest.

Sites may also have quasi-legal protection if they are identified by local planning authorities as being of local nature conservation importance (e.g. County Wildlife Sites), and this may be material to decisions on individual planning applications. A range of non-statutory nature reserves is also established and managed by non-governmental organisations such as The Wildlife Trusts.

Further detail on legislation is given in **Appendix 1**.

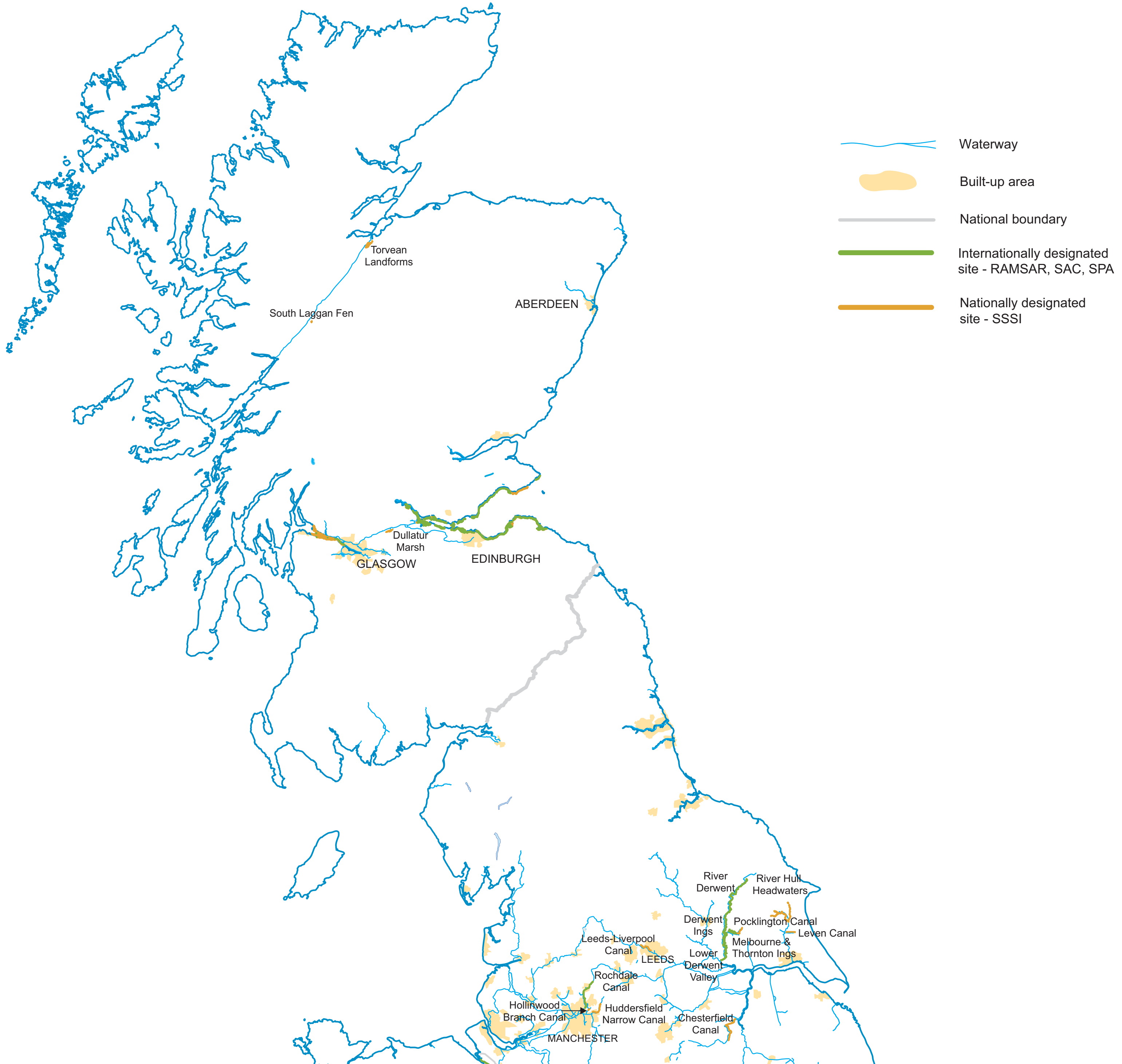
Statutory obligations and policy

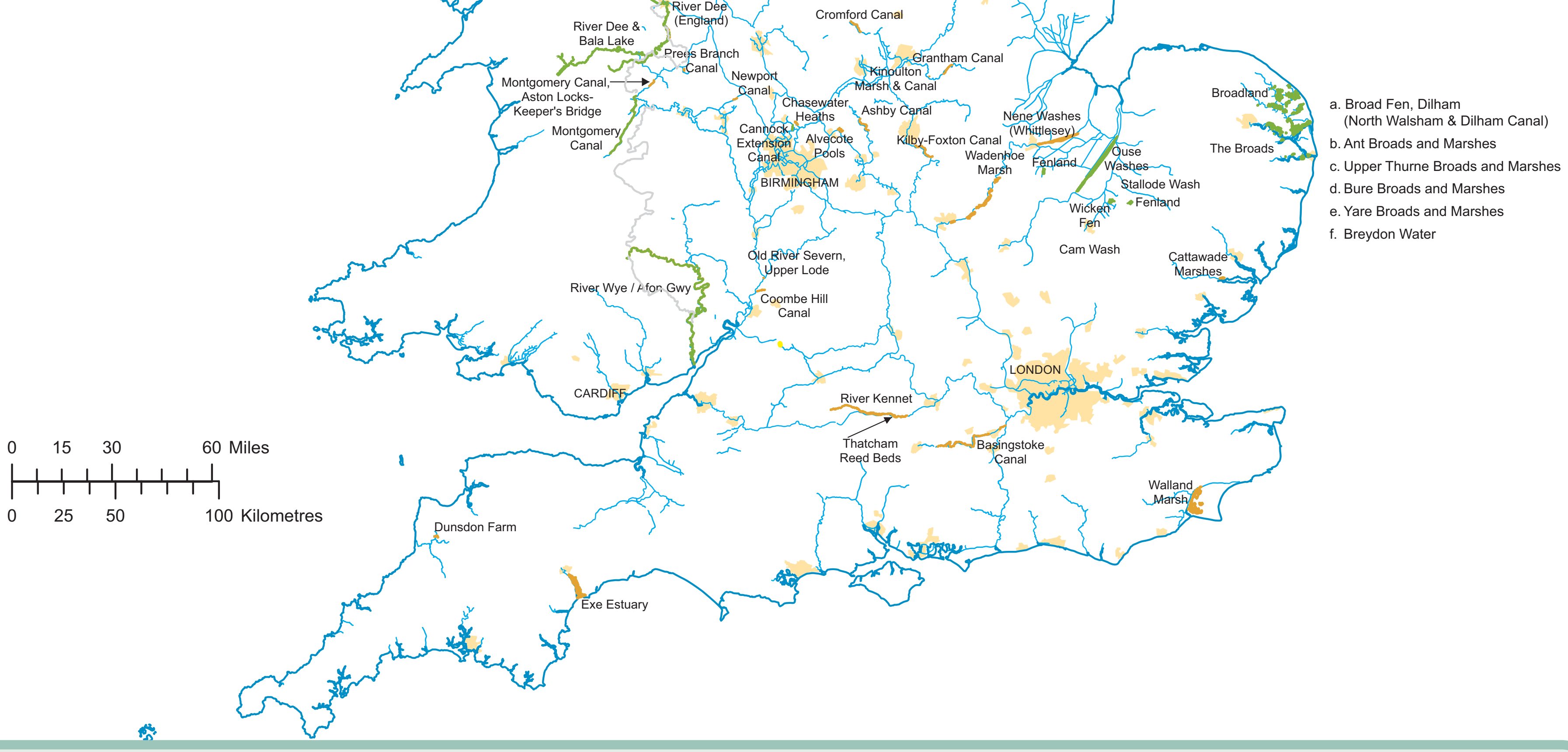
As part of their statutory obligations all public bodies, including the EA, Broads Authority and BW, have a responsibility to further nature conservation in carrying out their own functions. For waterway-associated bodies, these duties need, however, to be balanced with duties relating to navigation.

The ratification by the UK of the Convention on Biological Diversity in 1994 placed a duty on the UK Government to promote sustainable development and encouraged the development of national biodiversity action plans. This led to the development of national species and habitat action plans under the UK Biodiversity Action Plan, as well as local Biodiversity Action Plans. In line with this aim, BW is currently aiming to develop Biodiversity and Heritage Action Plans for all their waterways, to help evaluate and manage the natural and cultural resources of their inland waterways in a consistent manner. For the navigable rivers, the relevant national and local habitat and species action plans (HAPs and SAPs) are applied.

The recently published Planning Policy Statement 9: Biodiversity and Geological Conservation (PPS9) in England takes this one step further by recognising the importance of biodiversity in sustainable development and in the context of rural renewal and urban renaissance. PPS9 is particularly relevant to waterway restoration.

Map 4.1 Internationally and nationally protected sites of the inland waterways





Biological SSSIs which include the navigation channel (or a section of it) of a non-tidal or partially tidal inland waterway

Dullatur Marsh SSSI
(Forth & Clyde Canal)

Pocklington Canal SSSI

Melbourne & Thornton Ings SSSI (Pocklington Canal)

Derwent Ings SSSI
(Pocklington Canal and River Derwent)

River Derwent SSSI
(River Derwent and Pocklington Canal)

River Hull Headwaters SSSI
(Driffield Navigation)

Leven Canal SSSI

Leeds& Liverpool Canal SSSI

Rochdale Canal SSSI

Huddersfield Narrow Canal SSSI (Huddersfield Narrow and Ashton Canals)

Hollinwood Branch Canal SSSI
(Ashton Canal)

Chesterfield Canal SSSI

River Dee SSSI

Cromford Canal SSSI

Prees Branch Canal SSSI
(Ellesmere (Llangollen) Canal)

Fenn's, Whixall, Bettisfield, Wem and Cadney Mosses
(Ellesmere (Llangollen) Canal)

Montgomery Canal Aston Locks to Keeper's Bridge SSSI

Montgomery Canal SSSI

Newport Canal SSSI (Shropshire Union Newport Branch Canal)

Grantham Canal SSSI

Kinoulton Marsh & Canal SSSI (Grantham Canal)

Cannock Extension Canal SSSI

Chasewater Heaths SSSI
(Wyrley & Essington Canal)

Alvecote Pools SSSI
(Coventry Canal)

Ashby Canal SSSI

Kilby to Foxton Canal SSSI
(Grand Union Canal)

Broad Fen, Dilham SSSI
(North Walsham & Dilham Canal)

Ant Broads and Marshes SSSI

Upper Thurne Broads and Marshes SSSI

Bure Broads and Marshes SSSI

Yare Broads and Marshes SSSI

Breydon Water SSSI

Wadenhoe Marsh & Achurch Meadow SSSI
(River Nene)

Nene Washes Whittlesey SSSI
(River Nene)

Ouse Washes SSSI
(Old Bedford River)

Stallode Wash, Lakenheath SSSI
(River Little Ouse0

Cam Washes SSSI

Wicken Fen SSSI (Wicken Lode)

Cattawade Marshes SSSI
(River Stour)

River Wye SSSI

Old River Severn Upper Lode SSSI

Coombe Hill Canal SSSI

River Kennet SSSI

Thatcham Reed Beds SSSI
(Kennet & Avon Canal)

Basingstoke Canal SSSI

Walland Marsh SSSI
(Royal Military Canal)

Dunsdon Farm SSSI
(Bude Canal)

Exe Estuary SSSI
(Exeter Ship Canal)

Non-tidal or partially tidal inland waterways where the navigation channel (or a section of it) is part of one or more European Wildlife Sites

Pocklington Canal (SAC, SPA/Ramsar)
River Derwent (Yorkshire) (SAC, SPA/Ramsar)
Rochdale Canal (SAC)
River Dee (Cheshire) (SAC)
SUC Welsh Branch (Llangollen Canal) (SAC, Ramsar)
Montgomery Canal (Wales) (SAC)
Cannock Extension Canal (SAC)
Rivers Wye and Lugg (SAC)
River Ant and Broads
(The Broads SAC, Broadland SPA/Ramsar)
Broads associated with Rivers Yare, Bure, Thurne
(The Broads SAC, Broadland SPA/Ramsar)
Breydon Water (River Yare) (SPA/Ramsar)
River Nene (SPA/Ramsar)
Old Bedford River (SAC, SPA/Ramsar)
Wicken Lode (SAC, Ramsar)
River Stour (Essex) (SPA/Ramsar)
Bude Canal (SAC)

Nature conservation in the context of waterway restoration and development

Reviews of major waterway restoration projects in England, Scotland and Wales were carried out by IWAAC in 1998 and 2001 and a further update was published in 2007. In total, more than 100 waterways restoration and development projects were identified as in progress or recently completed in Britain, ranging from the repair of specific heritage structures such as the Anderton Boat Lift (Cheshire) to the restoration of major lengths of derelict canals and the development of wholly new waterways.

Conflicts with nature conservation are often most acute in restoration schemes, both as a result of the restoration works and the subsequent use of the waterway, as many derelict waterways have developed valued aquatic biological communities. Mitigation measures aimed at reducing adverse impacts on wildlife can sometimes limit the use of the waterway for recreation and amenity purposes. In other cases, restoration projects may benefit both navigation and wildlife, as in the restoration and agreed management of Barton Broad.

As with most types of development, the recent strengthening of nature conservation and water environment legislation has had major implications for waterway restoration and development. This is particularly so for those waterways designated under national and EU legislation and for undesignated lengths which support protected species, where the need to comply with wildlife legislation may impose additional requirements on restoration or management proposals.

Examples of waterways where nature conservation has been or is a key consideration for restoration or waterway management include:

- Basingstoke Canal (SSSI);
- Montgomery Canal (SAC and SSSI);
- Rochdale Canal (SAC and SSSI);
- The Broads (Ramsar, SAC, SPA and SSSIs);

(see **Appendix 5**, Case Studies, for more details).

The development of local Biodiversity Action Plans, Biodiversity and Heritage Action Plans and of web based information on species and habitats (e.g. NBN Gateway and FreshwaterLife websites), together with the availability of more general information on how to develop restoration projects in partnership with local wildlife organisations, now provides a good framework for future waterway project promoters.

The increased level of protection for wildlife and the recognition of the wider benefits of creating a waterway that supports a diverse ecology mean that it is more important now that waterway restoration scheme promoters should:

- include environmental and biodiversity issues from the start of project planning;
- consult widely at an early stage with statutory and non-statutory nature conservation organisations and stakeholders.

Non-navigation factors that affect waterway nature conservation value

The influence of navigation on the nature conservation value of waterways is considered in the next chapter. However, boat use and waterway management for navigation are not the only factors that can affect this value.

Hydrology, channel characteristics, water quality, fish stocking, tree shade and the presence of alien species are all important, and may be dominant in shaping aquatic wildlife communities. These factors must be taken into account in determining how best to balance the needs of navigation and wildlife on a particular waterway.

The wider context

It can be difficult to determine any causal relationships between navigation and wildlife on a waterway without first understanding the wider context of the waterway's geography, its hydrological catchment and other uses for which it is managed. Many other factors, natural and anthropogenic (man-made), can affect the aquatic biological communities that are supported and their nature conservation value, including the physical and hydrological characteristics of the waterway, the quality of the water, fisheries management and presence of invasive plants.

In many cases, the influence on wildlife of these factors may be similar to the effects of boat use and this must be recognised when determining the main factors influencing the waterway's ecological status.

Hydrology

The natural hydrology of rivers and lakes determines the type of plant and animal communities they support. Faster flowing water supports species with higher demands for oxygen, a need for substrates with a high proportion of sand, gravel and boulders, and a natural tolerance of physical disturbance from floods.

Flood flows can be an important part of the natural annual cycle in river navigations, sweeping away much of the aquatic vegetation each winter. Floods scour soft sediment from the river bed, tending to restore a more natural channel. This is a process which may be beneficial to navigation and wildlife, although heavy rain also washes soil into rivers. However, flood flows also erode banks, which may not be so welcome to navigation users or riparian landowners; floods can also leave sand and silt bars across the exits from lock cuts, which may hinder navigation.

Flooding on some rivers is important for maintenance of nature conservation interest in floodplain water meadows and some riverside pits, a number of which are SSSIs. However, these areas are not usually affected by navigation, so are not considered further in this report.

Canals are hydrologically similar to natural slow flowing floodplain river channels. A major difference is that such river channels are part of the same hydrological system as the main river, being linked through surface connections or through shallow groundwaters in gravels or chalk.

In contrast, canals are usually lined with clay and supplied with water from specific (sometimes remote) sources, although most do receive local drainage inputs as well.

In canals, plants and animals present depend less on high oxygen concentrations but need still or slowly moving water through their main growing seasons.

Lakes lie somewhere between these two hydrological extremes for rivers and canals. Wind and wave action create well-oxygenated water and wave effects on shorelines which may produce clean sands and gravels at the lake margin, whilst silty substrates dominate in deeper areas.

Changes to hydrology which alter natural patterns, such as over-abstraction or impoundment of rivers, may change the nature conservation value of rivers.

Flood flows in rivers can result in transport of large quantities of silt, as evidenced by the high levels of turbidity seen here in the **River Avon at Warwick**

Successful waterway management which maximises benefits to wildlife depends on a good hydrological understanding of the waterway and, in the case of a canal, its water feeders.

Maintaining a sufficient supply of water for navigation and wildlife is a problem on some waterways, particularly canals. Under the Water Act 2003 and the Water Environment and Water Services (Scotland) Act 2003, some water abstractions for waterways are now covered by the licensing regimes operated by EA and SEPA; stricter regulation may ensue in areas where natural rivers are deemed to be over-abstracted.

Physical habitat modifications

A range of activities not related to navigation affects the physical habitat quality of rivers, canals and lakes. Some of these activities reduce their nature conservation value.

On rivers, the most significant early influence was typically impoundment by weirs to power mills. On navigable waterways, most such impoundments became part of the waterway infrastructure and this aspect is dealt with in the next chapter.

Many rivers have also been physically modified by drainage works and flood defence engineering, undertaken to drain agricultural land and protect property from flooding. The effect has been to turn some rivers into drains: straightened, over-deepened channels, in which natural blockages such as debris dams (which help diversify the shape and hydrodynamics of natural channels) are rigorously removed. In urban areas, river-banks are often almost entirely artificial, with little natural vegetation.

Canals are, of course, man-made waterways, with their physical characteristics largely determined during their construction. The typical canal pattern with a towpath bordering one margin often leaves a more natural off-side bank which may be reed-fringed, cattle poached or occasionally graded into wet woodland. In urban areas, canal edges are often reinforced by less sympathetic vertical stone or brick walls and the offside is often bordered directly by buildings.

Navigable lakes, because of their size, generally suffer fewer physical manipulations than other waterways. However, where they border urban areas, these too often have bank areas that are highly modified and sometimes artificially reinforced.

Water and sediment quality

Natural waters exhibit a variety of water chemistry ranging from the 'hard' waters of chalk and limestone catchments to the softer waters of igneous, sandstone and organic catchments. The water quality of rivers is largely a function of the geology of the natural catchment, on which is superimposed the influence of pollutants, mainly of human origin.

In contrast, the basic water chemistry of canals is determined by the sources and the amount of feed water taken, which may be from outside the surrounding natural catchment or via pumped groundwater. Thus canal water quality can be influenced by the way its water resources are managed, so the water quality in a canal may be markedly different from the water quality in surrounding natural watercourses, although it can also be affected significantly by land drainage inputs. Again the effects of pollution entering the canal are superimposed on other factors which determine the basic water quality.

Sediments, particularly fine organic silts typical of canals and slow flowing waterways, can act as a sink for pollutants. These can have direct effects on animals living in the sediment and, if conditions change, may be re-released into the water column.

Along with hydrological, physical and climatic factors, the basic water chemistry is highly important in determining the type of ecological communities expected to be present in a waterway in the absence of pollution or disturbance by boats.

Table 5.1 **Major pollutant types impacting navigable waterways**

Pollutant	Source	Biological Impact
Nutrients (especially nitrogen and phosphorus)	Agriculture (livestock, inorganic fertilisers), treated sewage effluent, septic tanks, detergents, industrial discharges.	High levels of nutrients in water can lead to eutrophication, a condition where a few tolerant species of plant produce excessive growth and reach nuisance proportions but where species diversity is greatly reduced. Ultimately higher (flowering) aquatic plants are lost completely with knock-on effects for the many animal species that depend on them for food and habitat. As these plants are lost, algae begin to dominate waterways (typically filamentous species in flowing water and planktonic species in still water). This can create water quality problems for fish and other animals if algal blooms deoxygenate the water and cause fluctuations in its pH. In general, annual mean phosphorus levels in the waterways should not exceed 100 µgl-1 total phosphorus (TP) for naturally eutrophic systems and 35 µgl-1 TP for mesotrophic systems. Above these levels, biological damage becomes progressively more likely.
Heavy metals and other toxic chemical compounds	Urban: industrial effluent, urban run-off, sewage effluent. Rural: mining and farming including agricultural run-off, pesticides and veterinary medicines.	Such toxins produce a wide range of lethal and chronic effects on fish, invertebrates and, in some cases, plants. These include death of sensitive species, adverse behavioural changes, deformity, loss of reproductive ability and reduced viability of young.
Organic matter	Sewage works, septic tanks, livestock waste, sediments from agriculture and urban areas, algal blooms from eutrophicated waters.	Reduction in oxygen levels and an increase in ammonia concentrations can cause fish deaths and reduce the diversity and abundance of fish and invertebrate communities, particularly in running waters, where biological communities have a requirement for higher natural oxygen levels.
Silt	Agriculture (e.g. ploughing, over grazing), channel bank erosion.	Increased water turbidity can cause declines in aquatic plants. Sedimentation can swamp fish spawning grounds and habitats for juveniles along lake edges and in river gravels. Sediments can also carry nutrients, especially phosphorus.
Oils, petroleum	Urban, road and industrial run-off, boat fuel spills and bilge water discharge.	Oils can be harmful to fish and some invertebrates. This is most likely to be an issue in enclosed marinas and on urban canals.

The ecological quality of much of the waterway system is degraded by pollutants. Boat movements can add to these water quality problems (see below), but if boat traffic were to cease, all but a small minority of waterways would still show some evidence of ecological damage as a result of poor water quality. Waterway pollutants derive from many sources and have a wide range of biological effects which are summarised, in very general terms, in **Table 5.1**.

The adverse effects of nutrient pollution (eutrophication) are particularly pervasive across the waterway system contributing, for example, to widespread loss of submerged plant communities in navigable lakes such as the Norfolk Broads. Eutrophication is rarely mentioned as an issue in large navigable rivers but historic records for nutrient-intolerant plant species in rivers, such as the Thames, and results of routine nutrient monitoring by the Environment Agency suggest that most large navigable rivers in England are widely degraded as a result of nutrient enrichment. It is estimated that over two thirds of lowland streams and rivers have phosphate levels above the thresholds likely to cause ecological damage (Defra 2003, **Table 5.1**).

While there are currently no comprehensive data that describe the extent of eutrophication effects in British canals, reference to phosphate monitoring by the environment agencies (EA and SEPA) shows that canals exhibit a wide range of nutrient levels. While a few canals which receive treated sewage effluent are categorised as having excessively high phosphorus levels, many are categorised as having low concentrations. In lowland and urban areas, canals are often less polluted by nutrients than the surrounding natural watercourses.

The sources of nutrient pollution are relatively well known with approximately 50% of phosphorus and 70% of nitrogen derived from farming and the remainder from industry and human and household wastes, mainly the treated effluents from sewage works. Overall, both phosphorus and nitrogen levels in water have continued to increase over the last 30 years (Eaton 1989 et al, Defra 2003). In some locations, such as the Broads, the introduction of phosphate stripping at sewage works and other measures has helped to reduce input levels.

A second major contaminant of navigable rivers, canals and lakes is organic matter derived mainly from treated domestic sewage and some industrial effluents. As it decomposes in the water, organic matter uses up oxygen and produces ammonia. In extreme situations this can result in fish and invertebrate kills. At lower levels it reduces invertebrate diversity, particularly in rivers where the invertebrate and fish fauna are adapted to naturally higher levels of oxygen.

Urban waterways often have highly reinforced banks and some are impacted by a cocktail of pollutants. Both reduce their ability to support rich wildlife communities

The alien floating pennywort can out-compete other species and almost block waterways, as here on the Chelmer and Blackwater Navigation

Roughly 25% of the river system as a whole has levels of organic matter (sanitary) pollution likely to cause harm to aquatic life (Defra 2003). Navigable rivers in England and Wales range in organic water quality from very good (for example, in the Rivers Wye, Ure and Derwent) to poor in several fenland waterways, according to the Environment Agency's general quality assessment. Canals show a slightly worse range of quality from good to poor, although the Caledonian Canal and its lakes show excellent quality throughout.

Urban waterways have long been subject to particular pollution pressures. Before the 20th century this was principally from untreated sewage and industrial sources, followed over the last 200 years by a vast range of chemicals associated with modern living. Today, with better pollution control, these waterways are slowly improving in quality. But many still receive inputs that range from the controlled discharges of industrial waste products to the everyday water that runs off the streets. These carry a cocktail of materials from our urban and transport infrastructure: metals, nutrients, pesticides, oils, organic matter and pathogens, a mixture that together can be as polluting as untreated sewage (**Table 5.1**).

Water quality is therefore a major factor influencing the wildlife value of waterways. Nutrient pollution is probably the most important issue. On canals, there are sometimes opportunities to improve water quality by better management of the water sources used, although availability of alternative sources is often very limited.

It is therefore essential to ensure that adequate data are available on water quality and that this information is taken into account in developing management prescriptions to achieve the best balance between navigation and wildlife interests.

The Water Framework Directive, currently being implemented, will for the first time set ecological quality targets for all surface water bodies and will define programmes of measures to achieve these. A partnership approach will be essential for successful delivery. Implementation will require greater consideration of ecological quality and collection of better data than hitherto. While there are still issues to be resolved regarding setting objectives on navigable waterways and concerns about implications for waterway restoration, the Directive should contribute towards reduction of adverse effects of nutrient pollution and other factors on the wildlife conservation value of our waterways, and will deliver benefits for all.

Fishery management

As well as effects from water pollution and physical changes to habitat, such as weirs blocking the movement of migratory fish, natural fish populations are sometimes heavily modified by artificial stocking for angling purposes. Increased populations of fish, particularly non-indigenous species, can have a significant impact on other elements of the ecosystem by increases in the predation on other fish and invertebrates, the grazing of aquatic plants and bed disturbance. The introduction of bottom-feeding fish such as carp can result in increases in suspended silt and uprooting of vegetation.

The practice of angling can also result in direct effects on flora and fauna as a result of pike removal, ground baiting and clearing of swims and bankside vegetation for ease of access.

Invasive species

A number of invasive alien plant and animal species can cause problems for native wildlife on navigated waterways. Amongst the most easily visible are floating plants such as least duckweed, floating pennywort, parrot's feather and water fern. These surface-covering plants can spread over the water, shading out the submerged plants beneath and reducing the waterway value for invertebrates, fish and birds and sometimes almost blocking the waterway to navigation. Other alien plants such as New Zealand pygmyweed (Crassula helmsii) cause problems by squeezing-out native plants both along damp edges and in the water.

Trees can be a mixed blessing: they can create cool areas for fish and habitats for white-clawed crayfish but they can also shade out water plants

Once established, all these nuisance plants can be difficult to eradicate and British Waterways and others have spent much time and effort seeking to reduce their abundance.

With other alien species the negative impact may be less visible to the naked eye but can be just as pervasive. On all but a few waterways our native white-clawed crayfish has now been eliminated by the spread of non-native crayfish - particularly signal crayfish which carry a highly virulent fungal disease, crayfish plague. Mink have helped to sharply reduce native water vole populations, whilst on turbid, heavily trafficked canals the highly predaceous zander (pike-perch) can have a significant negative impact on the populations of small fish, such as roach and gudgeon.

The interconnectivity of the waterway system provides routes by which alien species can spread, either naturally or assisted by operational use such as water transfer and boat movement. For example, the spread of the zebra mussel, which is a major nuisance in water supply systems, has been linked to boat movements. Other invasive and harmful animal species on our waterways include red-eared terrapins, which take waterfowl eggs and are a nuisance locally, and the Chinese mitten crab, which migrates into freshwater areas and damages banks.

Trees and shade

Current attitudes to trees and shade from both trees and buildings) often differ between canal and river managers.

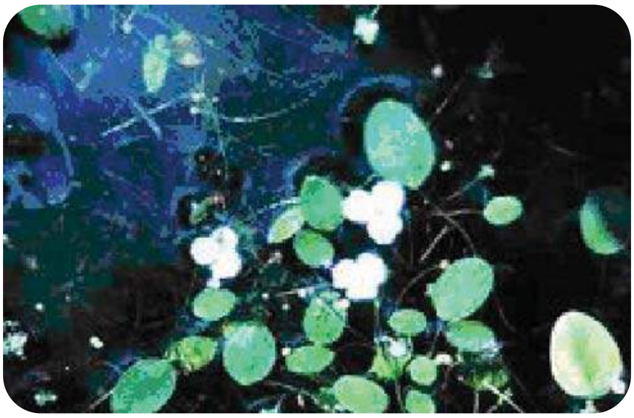
On canals and some lowland rivers, tree shade is often viewed as a problem. In high quality canals like the Basingstoke Canal, trees have shaded-out the margins and central water areas, leading to the decline of important aquatic and marginal plant communities and their associated invertebrate fauna. The loss of marginal reeds by over-shading can also reduce the potential for these plant fringes to give natural bank protection from boat traffic, thus adding to overall levels of stress on the aquatic biota. Although it is recognised that trees are a valued part of the landscape and offer refuge and shade for fish in hot weather, the accumulation of dead leaves may also partly deoxygenate the water column and add to siltation rates (Eaton 1996).

In rivers, and some navigable lakes, trees are generally viewed more positively. Their shade usually only extends across a small proportion of the channel width and again creates shelter for fish and a source of leaf detritus food for many invertebrate species and their fish predators; however, it can cause the decline of marginal plants.

Trees also provide a means of increasing bank stability in floods through the binding power of tree roots and, in some cases, a source of wood for natural debris dams in the channel, providing an important habitat for invertebrates and a refuge and food resource for fish (Gregory et al. 2003). However, tree growth in engineered structures such as embankments and masonry may also cause damage and potentially failure of the structure.

Overhanging trees can represent a serious hazard for boat users and can reduce the value of waterways used for sailing by blocking the wind.

Responsibility for management of trees overhanging waterways usually lies with the riparian owner, which may not be the navigation authority. This sometimes imposes a limitation on the deliverability of wildlife or navigation benefits.



Floating water plantain spread eastwards through the canal system in the 19th Century from its 'core' natural habitat in the lakes of Snowdonia and mid-Wales

Key information sources

EA website (What's in my backyard?):
http://www.environment-agency.gov.uk/maps/

SEPA website:
http://www.sepa.org.uk/

WFD website:
http://www.defra.gov.uk/environment/water/wfd/

Waterbody location and history
It is worth noting that the conservation value of artificial waterways in particular depends, in part, on accidents of location. The best-known example of this is the Basingstoke Canal, which partly owes its exceptional biological diversity to the occurrence of an unusual pH gradient along the canal, from alkaline to acid as it flows downstream, giving water conditions suitable for a wide range of species.

The potential for colonisation from other wetlands can also be fundamental to waterway value. The Basingstoke Canal, for example, has benefited from the proximity of both the acid pools and wetlands of the Surrey and Hampshire heaths and the lime rich springs emerging from below the chalk in the Greywell area. Similarly, genetic studies suggest that populations of the rare floating water plantain spread eastwards though the canal system in the nineteenth century from its 'core' natural habitat in the lakes of Snowdonia and mid-Wales. The Norfolk Broads, created by peat digging in the 12th to 14th centuries, owe much of their exceptional value to their location within the ancient coastal wetland expanses of Norfolk and Suffolk.

Floating water plantain spread eastwards though the canal system in the 19th Century from its 'core' natural habitat in the lakes of Snowdonia and mid-Wales

Climate change
There are clear indications that the climate is changing, with temperatures increasing, sea levels rising and a trend towards greater storminess and higher winter rainfall all leading to more frequent floods. Drier summers, combined with an increasing demand for water generally, may reduce summer flows in navigable rivers, especially in the south and east. This can affect aquatic ecology through lowering of water levels, where these are not retained by weirs, by reducing water velocities and by reducing dilution available for effluent discharges. Lower river flows may also result in less water being available to supply canals.

Sea level rise is a particular concern in relation to The Broads, as increased inland penetration of saline water may threaten sites of international nature conservation value and any breach of coastal defences could similarly damage the upper reaches of some river catchments and their associated broads.

Influence of navigation on aquatic wildlife

Broadly, the effects of navigation on aquatic waterway wildlife can be divided into adverse or beneficial impacts that result:

- directly from the movement of boats (e.g. physical damage to plants, the creation of high turbidity, the maintenance of open water habitat), or
- indirectly from the design and maintenance of navigation infrastructure (e.g. dredging, bank protection).

This chapter aims to explain the ways in which the use of boats and waterway design and maintenance can influence aquatic nature conservation value.

Introduction

We have established above how wildlife value of navigable waterways can be affected by a range of factors other than navigation. However, this report is mainly concerned with balancing navigation activity and nature conservation. We need therefore to understand the mechanisms by which navigation use can affect nature conservation value, so we can select the most appropriate management regime to ensure navigation is sustainable.

Use of waterways by motorised boats, in particular, can lead to significant effects on aquatic wildlife. For a given boat and boat speed, the larger the channel cross-section the lower will be the physical interaction between boat movement and wildlife receptors on the bed and at the edge of the channel. Thus the effects of boat movement on aquatic wildlife vary in magnitude according to the type of waterway and the types of boat in use, with the greatest potential for effects on narrow canals of the English midlands and a much reduced potential on larger waterways, especially the navigable rivers (**Box 6.1**).

There is considerable evidence which shows that powered boats can have a wide range of undesirable impacts on the wildlife of some navigable waterways. Depending on other stress factors present, these effects may begin at low traffic densities particularly on small waterways where the channel is very restricted for the boats typically in use.

Some navigation related activities have a positive effect on waterway wildlife, provided they are carried out appropriately. Dredging, for example, is sometimes essential to arrest succession and help maintain high quality submerged plant communities in canals.

Box 6.1 Canals and rivers

Narrow canal (English midlands):
Typical channel cross-section is around 11.5m^2 (Willby & Eaton, 2004). Wetted cross-section of a typical narrow boat using the canal is about 1.6m^2. This gives a ratio of 7 to1 between channel and boat cross-sections. Also the depth below the propeller may be less than 0.5m.

Mid-reaches of the non-tidal Thames:
Typical channel cross-section is 350m^2. Many boats using the river are from the narrow canal system but even larger river cruisers are typically of no more than 5m2 wetted cross-section amidships. Thus the minimum ratio in this case is about 70 to 1 between channel and boat cross-sections. Depth below the propeller is typically greater than 3m.

Note that effects also depend on boat speeds, which are higher on the Thames than on a narrow canal (typically by a factor of 1.5 to 2 times), and on the fact that plant growth in deeper water is limited by attenuation of light through the water column.

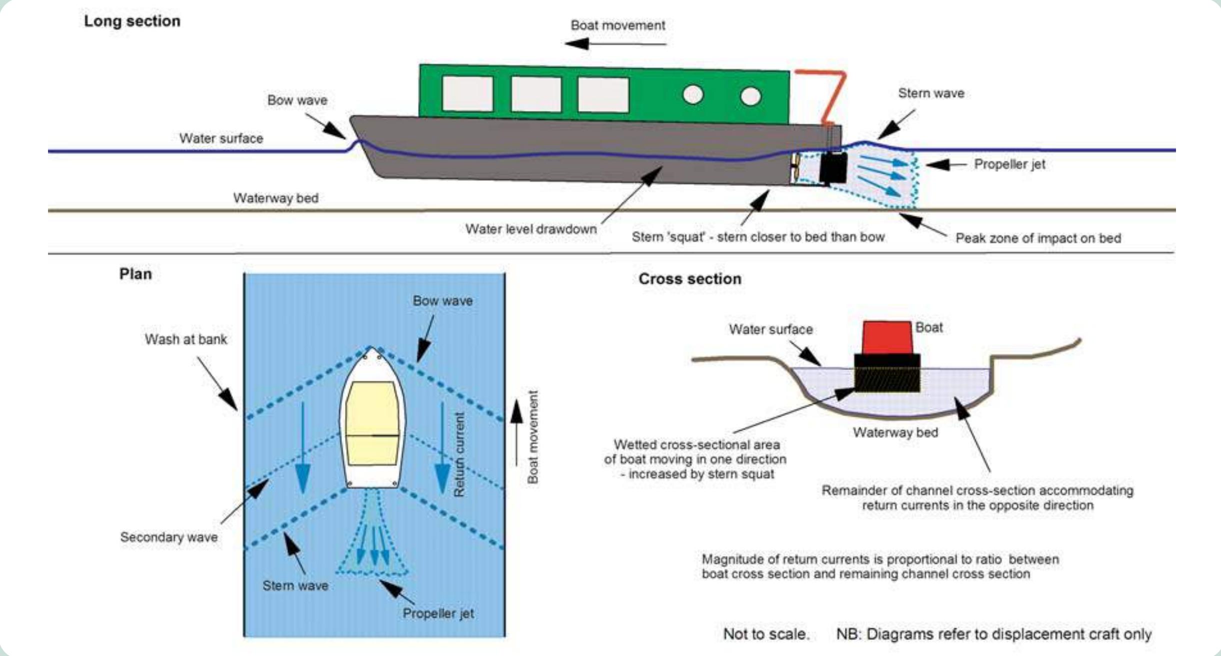
Effects of motorised boat movement

Boat movements influence the biota of navigable channels by:

- hydrodynamic impacts, including currents and waves;
- the re-suspension of bottom sediments;
- physical contact and entrainment (e.g. propellers cutting plants).

These forms of impact are well studied but hydrodynamic effects, in particular, are complex (**Box 6.2**) (Verheij, 2006) and effects depend on many variables including channel size and profile, boat dimensions, stability of bed materials, bank type, vessel speed and the design of the craft. This said, a number of generalisations can be made about the type and magnitude of impacts, which are summarised in **Tables 6.1** and **6.2**.

Box 6.2
Mechanisms by which boat movement can affect wildlife in waterways.



Boat movement on the **River Avon** does not result in high turbidity

The Worcester and Birmingham Canal (a narrow canal) is very turbid due to boat movements in a narrow, shallow channel

Waves

A boat moving in a channel causes a primary wave in the direction of travel, with the surface water level raised in front of the bow, pulled down somewhere in the middle of the boat and raised behind the stern, resulting in temporary drawdown of water level at the bank.

It also causes secondary waves, similar to wind waves, which start at the bow and stern and travel towards the bank. These too cause undulating water levels at the bank and can cause significant erosion and even bank failure if they are big enough to form a breaking wave at the bank. Fine eroded material is then distributed across the river bed. Wave generation is a function of the boat size, shape and speed and channel size (cross-section).

Waves put stress on underwater vegetation and breaking waves can uproot marginal plants.

The shape and amplitude of waves are very dependent on boat size and shape: for boats of the same beam moving at the same speed, shorter craft will often create greater breaking wave wash at the bank.

Return currents

The water displaced by a boat as it moves forwards has to move to fill in the 'hole' in the water left behind the boat, resulting in 'return' or 'reverse' currents running in the opposite direction to movement of the boat. The smaller the gap around the boat, the faster are these currents.

Thus the speed of return currents depends mainly on the ratio between the boat cross-section and the waterway cross-section and the boat speed. Average return currents for typical recreational craft on a narrow canal will be typically 5 to 7 times higher than on a larger river navigation (**Box 6.1**). For a particular navigation, and boat speed, larger and deeper draughted boats result in higher return currents.

Propeller jets

Propellers produce a conical jet of turbulent water behind the vessel when it is under power, which can be the major cause of re-suspension of bed sediments. The impact is largely a function of waterway depth, power applied, boat speed and stern gear design. Impacts are greatly reduced where there is a greater depth of water below the bottom of the boat hull. The effects are exacerbated by the drawdown of the stern of a boat under power (stern squat), bringing the propeller closer to the bed.

Direct effects

Physical contact between boat hulls and, particularly, propellers and submerged or emergent vegetation can clearly cause physical damage to vegetation. Again the magnitude of the effect depends in general on the size of the boat in relation to the size of the channel.

Sediments

Waves, return currents, contact with the bed and propeller jets can all cause suspension of bed sediments into the water column, loosening roots of plants and causing the water to become very turbid. This turbidity and deposition of sediment on plant leaves restricts light penetration, thus reducing or eliminating submerged plant growth. Nutrients and toxic contaminants may also be released to the water column.

As well as the characteristics of the boat, its speed and channel dimensions, the nature of the waterway bed is an important factor in determining the amount of sediment re-suspended. This is clearly greater, for example, in a shallow waterway with a silty or clay bed than in a deeper river with a sand and gravel bed.

Re-suspension of clay can form stable colloidal suspensions. Fine material eroded from waterway banks by wave wash can accumulate in the navigation channel, providing a source of readily suspended particles which can be mobilised by subsequent boat passage.

Table 6.1 **Factors that influence vessel impacts on waterway wildlife**

Factor	Effects
Waterbody type and size	Vessel impacts are greatest in narrow, shallow, still or slow-flowing waterways (i.e. canals). Here the propeller is very close to the bottom sediments and the channel base and sides receive the full force of all hull generated currents and bank reflected cross-currents, as well as the propeller jet. The magnitude of the environmental impact of the hydraulic forces decreases progressively with increasing distance from the bank, with increasing width of the waterway and with increasing depth relative to boat draught. In broader river navigations turbidity also decreases as background current speeds increase. Effects, per boat, are smallest in deep lakes and larger rivers where impacts are generally limited to wake wash on the shoreline.
Number of vessels	Vessel impacts increase with the number of boats moving along a waterway. Boat numbers affect the frequency with which boat induced currents and wash act to erode banks. As bottom sediments are stirred-up more frequently, larger particles are suspended in the water column for a longer period, increasing water turbidity.
Vessel speed and size	Boat speed and size act separately and together to influence boat impacts. In general, increased speed and larger boats (the increase in cross-section being the critical issue) have proportionally greater impacts on waterways. However there are critical thresholds when the two interact to cause greater, and sometimes lower, levels of damage.
Vessel design	Impacts on the channel sides and bed can be strongly influenced by the shape of the boat's hull and by the design of propellers and stern gear. There are numerous historic examples of boats designed for speed that created little wash, which provide examples of good hull design.

Clear water habitat protected from boat wash within emergent vegetation on the navigable Thames

In Britain, most research has been undertaken in smaller canals and Broadland rivers. There have also been many studies in continental Europe and North America, describing the effects of navigation by large vessels on larger channels and lakes.

Effects on plants

Aquatic plants are a vital and integral part of freshwater ecosystems. Submerged aquatic plants are the most susceptible to impacts from boats. Many uncommon species are found in waterways, with some protected by policy and legislation or by statutory designation of their sites. Effects can arise from all the mechanisms described in **Box 6.2**.

Emergent plants and, to a lesser extent, floating leaved plants growing at the edges of waterways are generally more tolerant of boat traffic than submerged aquatic plants. They can form areas of linear habitat, protected to some extent from boat wash, that are of particular value to juvenile stages of fish, some nesting birds (e.g. moorhen and coot) and invertebrates such as water beetles and dragonflies.

Larger emergent and submerged plants form an important part of the habitat structure on which invertebrates and many fish depend. Thus the presence or absence of such plants can affect the whole biological community.

Effects of boat movement on plants are dealt with in some detail in **Box 6.3**.

Box 6.3
Effects of boat movement on waterway plants

Canal vegetation fringe at 7000 bmy

Vegetation fringe on fenland river at 4000 bmy

Canal vegetation fringe at 500 bmy

Navigable river vegetation fringe at 8000 bmy

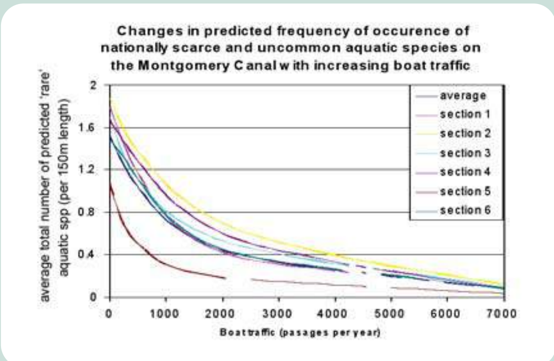
Effects on submerged plants

Smaller canals

In Britain, boat impacts on submerged plants have been most studied in smaller canals, where the ratio between boat cross-section and channel cross-section is at a maximum, so that effects are likely to be greatest. This has focussed particularly on traffic levels that cause damage to uncommon and protected species such as floating water plantain and rare pondweeds. Key work in this area has been undertaken by researchers at Liverpool and Stirling Universities (John Eaton, Nigel Willby and colleagues), who have used plant data from over 500 sites across the canal system to model boat impacts on plants in a 10m wide canal with a standard profile. This model shows that on these smaller waterways, some impact of boats on aquatic plants can be detected at very low levels of vessel activity, although results vary between species and on many canals diversity reaches a peak typically at around 1000 boat movements per year (bmy), with a decline and a move towards more tolerant species at higher traffic levels. Effects are reduced on canals with larger cross-sections.

A few waterways are of recognised importance for floating water-plantain and the rarer pondweeds. In some cases, these appear to thrive best in waterways that either have no boats and are maintained by periodic dredging or have very low levels of boat movement. In general up to about 500 boat movements per year (bmy) in a narrow canal will cause little or no damage to these plants. Recent findings suggest that the very few nutrient poor, high conservation value canals (i.e. the Welsh part of the Montgomery Canal and potentially the top of the Rochdale Canal and the Huddersfield Narrow Canal), are particularly sensitive to damage to rare plants (Wilby et al. 2001, Willby & Eaton, 2002). This appears to be because plant species grow, and therefore recover from boat damage, much more slowly in these low nutrient status canals. In other cases, however, rare species such as floating water-plantain maintain significant populations with much higher levels of boat traffic (greater than 1500 bmy), which appear to benefit rare species by limiting competition by more robust species.

Effects can result from direct contact with the boat and from effects of currents and waves (Box 6.2), resulting in plants becoming damaged and uprooted. In narrow canals, above traffic densities of 2000-3000 bmy, levels of suspended solids increase rapidly, largely stirred up by boat propeller jets. This makes the water increasingly turbid, giving insufficient light to allow significant submerged plant growth, although floating leaved species can survive.



From Wilby & Eaton, 2002

Rivers, drains and lakes

In rivers, lakes and broads the general trend of declines in aquatic plants with greater levels of boat traffic are similar in principle to those `seen in canals (e.g. Vermaat & Debruyne, 1993, Garrad and Hey, 1988, Schutten & Davey, 2000), although it has been difficult to quantify these trends in relation to UK waterways, as most research has focussed on larger freight waterways in continental Europe and the USA.

Drawing conclusions from direct observation of aquatic plant communities present on these larger navigations is also difficult, as many waterways are affected by nutrient enrichment, which can limit the diversity of aquatic plant communities. However, effects from boat movement are expected to be much lower than on a narrow canal, as return currents are reduced (Box 6.1) and propeller jet effects at the bed are usually lower due to greater water depths. This is borne out by the lower turbidity seen on most river navigations compared with that observed in smaller canals. However, wave wash can still have significant effects on rivers, causing erosion of banks and turbidity and restricting development of healthy marginal emergent and submerged plant communities. This is a particular issue on some Broadland rivers where erosion rates may reach 0.3m per year (Murphy et al, 1995).

Effects on marginal plants

In canals, it is possible to retain a marginal vegetation fringe up to quite high traffic levels, although its width will decline as traffic increases. The fringe width will depend on many factors, including the bed gradient near to the canal edge. For a narrow canal with a natural bank with a gradient of 30°, for example, sweet reed grass will root out to nearly 2m from the bank with no boat traffic, reducing to 0.5m at 2500 bmy and 0.17m at 5000 bmy. Little change occurs in the number of species present as boat traffic increases, although the most tolerant species become more dominant and stands of plants become fragmented (Willby & Eaton (2002).

Where hard bank protection has been installed on a narrow channel with high levels of traffic, emergent vegetation may be eliminated entirely (see photo below), although there are examples of busy canals with extensive stands of emergent vegetation, even in front of steel piled banks.

On larger waterways, especially river sections without engineered banks, extensive fringes of reeds, reedgrasses and rushes up to several metres wide are common, even on waterways with traffic levels of 10000 bmy.

In general, impacts of boat movement on marginal plants are of less concern than effects on submerged plants, as techniques are readily available for encouraging rooting of marginal aquatic vegetation even where boat traffic levels are high (see Chapter 7).

Narrow canal with hard bank protection and 10000 bmy showing absence of marginal emergent vegetation

Only a few types of animal live in open water. Like this dragonfly larva, most prefer the protection, food and resting places they find amongst plants

Gudgeon find suitable habitat in many turbid canals

Effects on invertebrates

Surprisingly few studies have looked directly at the effects of boat traffic on invertebrates, so understanding has been inferred from knowledge of invertebrate life-histories.

Generally, it is believed that the most significant boat traffic effects on invertebrates are likely to be through loss of their habitats. The underwater structure provided by aquatic and marginal plants is particularly important. Plants provide a refuge from predators, protection from water movement, egg-laying and emergence sites, and an indirect source of food (many invertebrates graze algal films on the surface of higher plants).

Thus the greatest effects will occur on smaller canals, where boat traffic is sufficient to thin-out or remove the submerged and marginal plant stands, since these create the richest invertebrate habitat in most waterways. However, there are indications that some species decline before traffic densities build up to these levels (Murphy & Eaton 1983).

The sediment stirred up by boats in narrow and shallow waterways can smother invertebrate communities, for example by clogging invertebrate breathing structures. This can cause starvation in freshwater mussels by reducing their feeding ability. It is possible that the physical stress of boat induced currents may also affect many still water bottom living species in canals and drains. Effects on rivers are less pronounced and need to be set in the context of the effects of natural currents and wind induced waves.

Effects on fish

There is an extensive literature documenting the direct and indirect impacts of navigation on fish. Key impacts are shown in **Table 6.2**.

The specific effects of these impacts vary considerably both between individual fish species, the size of the waterway and the propulsion types and speed of the craft. Canoes, for example, probably cause no more than minor localised impacts, whereas single large ships cause major current, turbidity and wave wash effects in large navigable canals (Hendry & Tree 2000, Arlinghaus et al. 2002).

Overall, the net result of increasing motorised boat traffic on smaller UK canals is to create a shift in fish community composition and structure (Pygott et al, 1990; Hodgson & Eaton, 2000). For example, lightly trafficked waters with an abundance of vegetation are dominated by roach and perch with bream, weed-associated tench and sight hunting pike. Heavily trafficked canals have a lower diversity and biomass of fish, with the community dominated by small roach and the bottom feeding gudgeon, as well as sometimes very large carp.

Use of typical recreational craft on larger UK waterways, such as rivers, appears to have less effect on fish. Based on Environment Agency data, many navigable waterways support the same coarse fish species as similar non-navigable rivers.

Table 6.2 **Effects of vessel movement on fish**

Vessel impact	Effect on fish
Direct effect of currents	Causes dislodgement of eggs and young from favourable habitats and creates higher energy costs for feeding.
Shoreline waves & drawdown	Strands or destroys eggs and vulnerable newly hatched fry.
Indirect effect from loss of aquatic plants	Reduces the abundance of invertebrate food, which sustains the growth of larger fish. In addition plants provide substrates for egg laying and cover from predation.
Increased suspended sediments in the water	Can clog the gills of very young fish and reduce breeding success by depositing silt over the egg masses or smothering gravel spawning areas.
Increased turbidity	Can make it difficult for fish to find food and disrupt courtship and egg laying behaviours.
Noise and disturbance	Can adversely affect fish behaviour and, therefore, survival.
Direct entrainment in propellers	May be rare in adult fish (that avoid the passage of large boats), but may be significant for eggs and larvae.

Effects on birds and mammals

As with invertebrates and fish, some of the main impacts of boat traffic on birds are associated with loss of vegetation. At moderate levels of boat traffic, progressive loss of submerged plants and consequential loss of invertebrates and fish reduces food availability for species such as coot, grebe, heron and kingfisher. At very high boat densities, progressive loss of the marginal fringe reduces availability of nesting sites and protective cover. Water voles are also impacted because marginal wetland plants form a significant part of their diet. Otters depend in part on the presence of varied vegetated lake and river shorelines, whilst bat species, which feed on invertebrates emerging from the water surface, may also find less food as invertebrate biomass declines.

Direct effects on burrowing animals such as water vole and kingfisher can arise from excessive wave wash at the bank.

Disturbance may also be a factor, although boat movement forms only a small part of human disturbance on many waterways and many species become habituated to the presence of human activity.

Table 6.3 gives a summary of aquatic wildlife in a typical UK narrow canal, assuming mesotrophic-eutrophic water with low levels of pollution. This represents the waterway type where wildlife is most sensitive to boat movement and should not be taken as representative of larger waterways.

Table 6.3 Summary of aquatic wildlife in a narrow canal at different levels of boat traffic

Boat Traffic (bmy)	Physical effect on ecosystem	Plants	Invertebrates	Fish	Birds & Mammals
0 (non-navigated)	Largely clear still-water system, with accumulating sediments and progressively shallower water.	Progressive domination by floating-leaved species such as duckweeds, tall emergent plants and fast growing willows. Moderately rich in species, but loss of many aquatic plants over time. Very shallow sites may sometimes support uncommon species.	Can support diverse invertebrate communities in emergent vegetation.	Declining fish population as channel becomes shallower.	Habitat for some waterbirds and mammals.
0 - 500	Only periodic mechanical and hydrodynamic damage to plants from propeller and hulls.	Plant species diversity high. Uncommon submerged plant species thrive.	Diverse invertebrate community in marginal and aquatic vegetation.	Mixed population with tench, pike, stickleback and eel.	Good range of habitats for water birds and mammals.
500 - 2000	Increasing channel disturbance from boat currents causes damage and uprooting of sensitive aquatic plants.	Some key uncommon aquatic plant species decline and are lost. Good marginal fringe still retained. Overall plant richness high, maximising at roughly 1000 bmy.	Diverse invertebrate community in marginal vegetation.	Mixed population with tench, pike, perch, roach, rudd and eel.	Good range of habitats for most water birds and mammals.
2000 - 5000	Regular channel disturbance. Rapidly increasing water turbidity through this boat movement range, from suspension of bottom sediments by water currents.	Progressive narrowing of marginal reed fringe. Few aquatic species, which are mainly those with submerged or floating leaves, though precise impact depends on channel profile and bank material. Best where banks are soft and not steep sided.	Variable species richness and abundance, depending largely on the availability of marginal plant habitats.	Roach, tench, pike bream, perch. Decreasing biomass.	Loss of habitat, nesting areas and food sources for waterside birds and mammals e.g. water vole.
5000+	High water turbidity from water disturbance. High wave wash, bank erosion, high sedimentation.	Vegetation fringe patchy or absent in many canals. Aquatic species absent or mainly limited to those with submerged or floating leaves.	Impoverished communities. Few invertebrate species and usually few individuals.	Small/stunted roach, gudgeon, few perch. Carp where stocked.	Limited range of permanent water birds and mammals.

Pollution effects from boats are potentially greater in mooring areas and marinas.

Pollution from boats and boatyards

Minimising pollution from boats and boatyards is essential for the protection of aquatic wildlife. Principal causes for concern are antifouling paints and spillages of fuel and lubricating oils, as well as black water in inland marinas used by seagoing vessels. Of minor concern are also polluting materials in 'grey' water and engine exhaust emissions (**Table 6.4**).

Table 6.4 **Water pollution from boats**

Source	**Detail**
Antifouling paints	Tributyl tin, banned for use on small boats in 1987 and completely banned in the UK since 2003, was previously a common antifouling used on seagoing boats. It has been partially implicated in the loss of exceptionally high value plant communities on the broads and high levels remain in sediments around Broadland and around boatyards used by marine vessels. Modern antifoulants use copper and a suite of 'booster biocides' instead, some of which are known to be extremely damaging to freshwater organisms, including emergent and aquatic plants. There are particular concerns in the Broads where rare and protected stoneworts occur in navigable broads (Chapter 3) (Lambert et al, in press). Inland steel vessels tend to use bitumen paints for hulls rather than anti-fouling preparations. Earlier coal derived formulations released pollutants such as PAH to the water but modern oil derived paints are less toxic. Such toxins accumulate in sediments and affect wildlife, particularly where craft are moored for long periods, or dry docked for scraping and re-painting, especially in enclosed marinas (Willby 1994).
Fuel and lubricating oils	Hydrocarbon pollution arises mainly from fuel and lubricating oil spillages, direct fuel leakage from engines and, particularly, from pumping out of oily bilge water. In general, however, effects are mainly limited to enclosed areas with a high density of boats and levels of activity, e.g. marinas and boat yards (G. Newman pers. comm.).
Black water	Black water (from sea toilets) is still a concern on some inland waterways frequented by seagoing vessels, particularly The Broads.
Grey water	Grey water (water from sinks, showers etc.) is of concern particularly in relation to local effects of use of bleach or other toxic cleaning products, especially in areas with a high density of boats and levels of activity.
Exhausts	There may be a risk to fish and potentially other organisms from the exhaust emissions of outboard engines and inboard engines with wet exhaust systems - these types being prevalent mainly on river navigations. (Most craft on the canals have dry exhausts discharging directly to the air.) Emissions from recreational craft wet exhausts which remain in the water are largely a mixture of unburned and partially oxidised hydrocarbons including benzene, xylene, toluene, phenols, carbonyls and polynuclear aromatic hydrocarbons (PAH), as well as carbon dioxide. It has been estimated that approximately 40% of the hydrocarbons emitted from a wet exhaust are initially captured in the water phase, while the remaining 60% escape immediately to the air in exhaust gas bubbles (TNO, 2004). About 35% of the carbon dioxide dissolves in the water and may contribute to plant growth. Many of the organic components are volatile and of low solubility and therefore rapidly evaporate. Some hydrocarbons can form surface films on the water, while PAH tend to become bound to sediments. Research reported by TNO (2004) indicates that effects are small and that water quality standards based on maximum admissible concentrations of these compounds are generally not exceeded, although the situation regarding sediment contaminants is less clear.

Development and maintenance of waterways

Some of the most significant influences of navigation on aquatic wildlife come from the activities that surround navigation and enable it to function effectively. This includes both the historic legacy of waterway creation, maintenance engineering and ongoing development and operational management practices such as dredging.

Waterway infrastructure

River navigations have, over many centuries, experienced a wide range of impacts through modification of the natural river environment to provide power for mills and to support navigation. Typically these have involved deepening, removing shallow gravel shoals, the steepening of banks, the creation of cuts through meandering channels, blocking or abandoning side channels and maintaining navigable depths by the impoundment by weirs provided with locks.

Bank protection has also been installed in some areas but the majority of banks on navigable rivers and drains are reasonably natural. The presence of weirs has fundamentally changed the character of many rivers, replacing biological communities typical of faster flowing water containing riffle stretches by communities more typical of slower flowing deeper waters. Superimposed on these effects are the effects of boat movement described above.

Canals are totally artificial channels but many have changed considerably from their early days, as the advent of motorised boating and increases in traffic have led to increased pressure for banks to be protected from erosion and to provide hard edges for boat mooring. In the past this has typically been done using piling, creating a hard edge; this severely restricts emergent vegetation, burrowing by animals such as water voles and access by otters. Such banks reflect rather than absorb boat generated currents, amplifying wash, scour, turbulence and turbidity with knock-on effects for aquatic wildlife. Softer, more ecologically-friendly bank protection methods are now available (see Chapter 8).

Dredging

In general, dredging is essential to maintain sufficient water depth for safe vessel movement in canals, which have no natural periodic scouring from floods to keep their channel open. In rivers the navigational need varies between waterways. On faster-flowing rivers, which maintain a naturally deep channel, dredging may only be needed on a very local basis, typically to remove accumulated silt in artificial lock cuts and to remove sand bars that develop below locks. In fenland drains, lightly used canals or other slow flowing waterways, weed cutting may be necessary to maintain land drainage or navigation. In the case of invasive species such as floating pennywort, removal of the plant material is essential to limit the rate of re-colonisation. Dredging and weed cutting are also undertaken for flood management on many rivers and drains.

Canals are usually dredged every 15-30 years, though they may be spot-dredged more regularly, sometimes annually, where, for example, there is an inflow from a river. Restoration of derelict waterways often involves significant dredging.

Further detail on dredging and its impacts on wildlife is given in **Box 6.3**.

Benefits of navigation for aquatic life

In contrast to the evidence of ecological damage caused by boat traffic, there are a more limited number of attributable benefits. Thus although the trend is for a loss of species diversity with increasing boat traffic, a small number of species benefit. Gudgeon, for example, usually a turbid river fish, find a suitable habitat in many turbid waterways.

In canals, some physical disturbance is necessary to sustain open water habitats and prevent complete encroachment of marginal plants or dominance by invasive aquatic species. This disturbance can be achieved either by dredging and/or by boat movement at an appropriate level, which will vary according to the waterway concerned.

Waterway development can restore or create new aquatic habitat. For example, while there is concern in some cases that restoration of disused canals to navigation may adversely affect aquatic habitat in sections still in water, this is balanced by the fact that many derelict canals no longer hold water and restoration provides opportunities for the creation of new aquatic habitat. The net value for wildlife will depend on channel design features, traffic levels and water quality in the restored canal and the value of the damp or dry habitat of the derelict waterway that is lost during restoration. Thus it is important to be realistic about such benefits for biodiversity.

However some works may be mutually beneficial. For example, clearance of native plants at nuisance levels or invasive aliens not only facilitates navigation and improves a waterway's visual appearance but helps to improve its biodiversity. Similarly, restoration of silted and nutrient enriched lakes in Broadland has benefited both navigation and wildlife.

Extension of water space on currently navigable waterways by providing new off-line marinas can, with good design, provide valuable additional still water and marginal habitats, especially for fish.

In a wider context, improving access to water habitats through navigation helps to educate the community to value wildlife, which in turn has positive implications for nature conservation. In this respect, applications for funds for works required to maintain and enhance wildlife value on derelict waterways are likely to be more successful if these form part of integrated proposals to provide wider socio-economic benefits, such as restoration of navigation, access for other recreation, encouragement of social inclusion and interpretation and education facilities.

How wildlife legislation affects navigation

There are no reliable data describing the extent to which recreational and commercial use of the inland waterways are currently restricted by environmental considerations. However some stakeholders are concerned that changes to the designation process arising from the Habitats Directive and changes in legislation regarding the notification of SSSIs, introduced in England and Wales by the Countryside and Right of Way Act (2000) and in Scotland by the Nature Conservation (Scotland) Act (2004), may mean that some resources will no longer be available for sport and recreation activities (University of Brighton 2002).

Box 6.3
Effects of waterway development and maintenance on aquatic wildlife


Vertical banks and deep water limit marginal wildlife communities


Making rivers navigable often involves impoundment by weirs


Dredging can be beneficial for wildlife if carefully managed


Marinas can provide an off-line refuge for fish

Waterway infrastructure
Waterway wildlife on rivers is affected by impoundment for navigation and often by fundamental permanent changes to the physical nature of the channel. On canals the nature of the artificial channel is largely defined by the initial construction profile and the channel lining. However, the value of a waterway for wildlife can be greatly affected by the way the infrastructure is managed locally, particularly in relation to bank protection (hard edging generally having a deleterious effect) and the near-bank bed profile. Alternative methods of bank protection are described in Chapter 7.

For major waterway engineering restoration projects and for maintenance, short-term dewatering of a section of waterway may be required. The impacts of such work have been little assessed but are likely to be localised and temporary. Their significance will depend on whether there are particularly sensitive species present (e.g. water vole, native crayfish, and long-lived species, such as swan mussels). If so, population loss may be significant unless appropriate mitigation measures are implemented and the species may find it difficult to re-colonise after re-flooding.

The creation of off-line marinas is known significantly to benefit fish populations (Pinder 1997) but their value for other wildlife has been little studied. However given the sometimes elevated levels of pollutants, and shading from boats, they may be of relatively little value for groups such as plants and invertebrates (Vermaat & DeBruyne 1993) unless suitable habitat is a design component. The opportunity to incorporate new wildlife habitat is however becoming a more common feature in the design of inland marinas.

Restoration of derelict canals, while often creating new aquatic habitat, may also disturb or remove valued biological communities that have developed over many years. Even when only a shallow water body remains, this can support uncommon plants, such as six-stamened waterwort, and many invertebrates associated with emergent plants and wet scrub. Restoration to navigation is a major engineering endeavour that brings impacts related to:

- the temporary and permanent engineering works;
- the effects of boat use after restoration.

In practice, the implications of such developments for wildlife depend on whether:

- existing habitats would, in any case, be rapidly lost by further canal decay;
- recreation of new canal habitats will compensate for loss of existing habitats;
- measures can be undertaken to ensure that key species and communities can be maintained, in the long term, either within the new channel or in compensatory wetlands (see Chapter 8), although re-creation of the many factors that determine the characteristics of an existing habitat may be difficult to achieve in practice.

Dredging
Dredging can have positive effects on wildlife value, particularly in canals, as it:

- enlarges the channel, reducing the intensity of boat disturbance;
- limits succession by restoring open water conditions on disused or little used canals, in the same way that flooding does on rivers, thus maintaining habitat for submerged plants;
- often benefits some of the rarest species which are typically early succession plants that decline and are lost, as canals fill with silt and floating-leaved and marginal plants fill-in the channel;
- removes fine sediments, which may leave a firmer base for plant and invertebrate colonisation, increasing their chance to withstand buffeting from boat traffic;
- removes polluted sediments, where these have accumulated;
- removes sediment-bound nutrients, particularly phosphorus.

Typically silt and plants from the centre of the channel are removed, usually in the winter months, and current good practice stipulates that bank angles are designed so that any vegetation fringe on either bank edge, or at least the off-side on a canal, is largely retained.

The impact of dredging on ecosystems is always disruptive in the short term. Submerged plants are lost, together with the invertebrates living amongst them and on the waterway bed. Loss may be particularly significant for long-lived invertebrate species, such as freshwater mussels, and for uncommon and protected species, such as spined loach, which live amongst the plant stands (Perrow pers. comm.). However, in the medium and long-term the positive effects are realised.

Weed control
Plant cutting, as opposed to dredging, has been found to reduce plant diversity and encourage unwanted plant species like the alien Nuttall's pondweed (Baattrup-Pendersen, Larsen & Riis 2002). For invertebrates there is rapid recovery after both cutting and herbicide treatment of aquatic vegetation, with apparently no significant impact on fish (Monahan and Caffrey 1996).

However it should be noted that use of herbicides in or near water is often limited by water quality considerations and the relevant environment agency (EA or SEPA) must be consulted in advance.

Key information sources

English Nature, 1995. Canal SSSIs
management and planning issues.
English Nature Freshwater Series No. 2.

PIANC WG 10, 2006.
Environmental risk assessment of dredging operations.

PIANC WG 12, 2002.
Recreational navigation and nature.

PIANC WG 27 (in press)
Guidelines on the environmental impact of vessels.

Verheij H. (2006)
Hydraulic aspects of the Montgomery Canal Restoration. Report by Delft Hydraulics for BW.

There are greater potential impacts for navigation interests in cases of:

- new waterway development (e.g. re-opening abandoned canals for navigation, extending river navigations, the creation of new canals);
- use of the very few navigable canals, such as the Basingstoke, which are both of exceptional ecological value and where powered boat use is regarded as a threat to conservation value by regulators and some other users.

Where waterways are re-opened or developed for navigation, solutions have generally been found which seek to protect conservation value whilst allowing navigation (see Chapter 7).

On the few existing waterways where statutory protection may favour the rights of conservation over those of navigation, there may be a need for restrictions in use such as more stringent speed limits or limits on the number of boats. Limiting boat numbers will inevitably be unpopular with recreational users and the service industry that supports them and should be minimised by appropriate design of other mitigation measures.

Amongst the most significant impacts of wildlife conservation on navigable waterways is the cost to navigation authorities of managing the natural environment. For example, environmental impact assessments, the use of wildlife friendly bank protection, conservation dredging, the use of ecological enhancement or mitigation techniques and the curtailment of income-generating developments can all have significant economic and social implications which must be balanced against the wildlife benefits.

Conclusions

It is largely modern engine-driven boating on canals and infrastructure modifications to support this that can cause significant damage to nature conservation if not properly managed.

It is evident from the wealth of plant records and herbarium specimens from Victorian times that the commercial decline of the canals in the latter half of the 19th Century allowed colonisation by aquatic biota on a scale which their previous heavy traffic did not permit, especially where that traffic had already switched from the original horse-drawn craft to propeller driven craft. As already noted, the richest period ecologically was probably the mid 20th Century, after which the rise of pleasure cruising started to reduce quantities and qualities of channel vegetation and their associated faunas (Murphy & Eaton 1982; Willby, 1994).

Most boats using British river navigations are small compared with the size of the waterway channel, so the effects of boat movement are less pronounced than on the smaller canals. However, there are still issues to be addressed regarding the effects of wave wash and the opportunities for improved bank management to protect and enhance wildlife.

Motorised boat traffic is increasing, with national targets set to encourage greater use, so the issues of modern navigation's effect on nature conservation, particularly on smaller canals, are likely to remain a challenge for navigation managers.

Many of the adverse effects of navigation can be mitigated with good practice and Chapter 8 describes some methods for achieving this. However, it must be recognised that navigation is only one pressure affecting the ecological status of waterways and management should aim to address all these relevant factors in a co-ordinated and cost-effective way.

Case studies

This chapter summarises the overall conclusions to the findings from the ten case studies described in Appendix 5; these have been collated in co-operation with navigation interests to show how the relationship between nature conservation and navigation has been managed on different waterways.

The examples cover situations where reconciling the interests of navigation and nature conservation has been particularly difficult, as well as those where nature conservation benefits have been achieved without significant conflict with navigation interests.

The case studies

The focus of the case studies was on:

- the navigational use of the waterway and its nature conservation value;
- the effectiveness of communication and consensus building methods;
- the effectiveness of technical measures which facilitate navigation and maintain or enhance the nature conservation interest.

Ten case study summaries are given in Appendix 5. It should be noted that case study authors were not prompted with a list of possible techniques and asked "which did you use?" Instead, the reports provide unprompted answers and thus give greater insight to what factors the authors felt were important.

The case studies deal with a range of waterway types including:

- river navigations (the Thames, the Great Ouse system);
- the Broads;
- narrow boat canals (Montgomery, Ashby and Grand Union [Warwick & Napton section]);
- larger canals (Bude (part), Forth & Clyde, Lancaster & Rochdale);
- tub boat canals (Bude (part)).

The studies include fully navigable waterways and waterways which are the subject of current restoration or extension proposals.

Conclusions

The conclusions distilled from the case studies, which have been taken into account in developing the guidance in the next chapter, are:

- most waterways serve both navigation and wildlife and the key issue is agreeing where the balance should be in each case;
- on some waterways, wildlife value could be improved while maintaining navigation, contributing to the attraction of the waterway for visitors and to the maintenance of biodiversity - there are plenty of technical measures to do this;
- even on very busy waterways some wildlife benefit can be readily achieved, principally in the emergent vegetation and associated fauna;
- some waterways need special consideration for wildlife - these are often on the periphery of system;
- ongoing research is needed on new measures and on the cost-effectiveness of all measures;
- best outcomes are achieved when navigation and wildlife interests establish a good rapport;
- in any restoration or major works project, it is very important that planning involves both navigation, wildlife and other interests from an early stage and that adequate time is allowed for building consensus on the way forward and developing a project plan which has wide support;
- where wildlife is of particular value, preparation of a Conservation Management Plan or Strategy may be the best way forward;
- there is a need to be realistic as to what can be achieved and discuss issues openly;
- funding is a key issue, especially for front end feasibility or Environmental Impact Assessment studies in projects being promoted by small navigation authorities or waterway interest groups;
- misinformation is a major issue with new schemes, many responsible for wildlife do not understand navigation issues and vice versa;
- where wildlife is legally protected, navigation interests need to be aware of the proper procedures for obtaining the necessary permissions for their activities - in the end this is the same message that communication must be established early.
- where there is a statutory duty to maintain navigation, conservation interests need to be aware of the requirements and take these into account - aquatic interest can usually be maintained but in some cases it is likely to rely on fauna and emergent species rather than submerged aquatic flora.

Improving the balance between navigation and nature conservation

While opportunities for protecting or developing wildlife value may be very limited on a few stretches of waterway, in the majority of cases good planning, design and management practice will provide tangible wildlife benefits, increasing their attractiveness for many users and contributing towards realising their full potential as a multifunctional resource.

For the few inland waterways that are designated as being of exceptional wildlife value, complying with legislation and achieving the right balance with navigation will require detailed investigation and consultation.

A key to the adoption of best practice on the ground in any particular waterway situation is to ensure that all interested parties believe in it. Achieving this will require time and effort but will pay dividends in the medium and long term. This chapter outlines good practice in terms of organisational issues and consensus building, as well as identifying practical management measures. Comprehensive manuals for environmentally-friendly waterway engineering design |and maintenance are being developed elsewhere and this aspect is covered only briefly here.

Approaches considered

For any activity associated with navigation on the inland waterways, there will be potential interactions with their aquatic wildlife. The wildlife of the waterway environment is itself a significant attraction for many boaters and other visitors, as well as contributing to wider objectives for the protection of biodiversity.

Some activities can contribute both to navigation and wildlife interests, but with others it will be necessary to strike an appropriate balance in the approach taken.

Ways of achieving such a balance are varied, as described in this chapter. They can range from the education and persuasion of users to follow best practice through to the regulation of use, and from the modification of engineering practices through to habitat creation. Measures have been organised for convenience under the following main headings:

- advance planning;
- stakeholder engagement and consensus building;
- management of navigation activity;
- waterway infrastructure design and management;
- compensation for habitat loss or degradation;
- difficulties with the adoption of preferred solutions;
- summary of good practice recommendations.

It is important that feedback of views and practical experience is built in to the process, to advise future decision making.

Approaches available are summarised in Table 8.1 and described in more detail in the following parts of this chapter.

Advance planning

Waterways fulfil many different functions. They are an important tourism, leisure and social resource and a pivotal focus for waterside regeneration, as well as providing an important contribution to the conservation of wildlife and the built heritage. These are not independent attributes. Abundant and varied wildlife adds to the attraction of waterways to users (bankside and afloat) and to their value as an educational resource; users in turn can affect the wildlife value that attracts them. Effective planning and management are essential to obtain the maximum benefits from the waterway across all its functions.

Planning for wildlife should form part of this process, alongside the protection of other waterway attributes and satisfying the needs of users. This is essential if wildlife and navigation benefits are to be maximised and any negative effects of navigation mitigated. The key message is that, whether considering the management of a navigation, the restoration of a derelict canal or a specific task such as dredging, then planning for wildlife should be considered right from the start and should continue throughout the project.

Planning works on different scales. Design and technical considerations will be important for local, site-specific works. In contrast, business planning for waterway networks will involve prioritisation of expenditure and trade-offs. For example it may be best to focus expenditure on SSSIs where wildlife benefit to cost ratios are high and the achievement of favourable status is a realistic proposition, at the expense of highly stressed sites where even a large expenditure would not result in the restoration of favourable status.

For the few inland waterways where the aquatic habitat forms part of a statutorily protected national or international wildlife site, consultation with the relevant conservation agency is obligatory and time needs to be set aside to undertake surveys and obtain any necessary consents. Similarly, licenses may be required for work that may affect protected species, wherever it takes place. For many navigation authorities, protection and enhancement of wildlife is also a legal duty.

For routine work, advance planning may simply involve specifying adherence to published guidance. In some cases, particularly if consent is required for specific work that needs to be undertaken regularly, it is often most convenient to include all likely operations into a management plan which can be agreed in advance with regulators and other interested parties, rather than adopting a piecemeal approach.

For a major project, such as a waterway restoration scheme, it will be helpful to produce a formal ecological impact assessment report. This should establish the ecological baseline, evaluate potential impacts (positive and negative) of the project and identify enhancement, mitigation or compensation measures to be incorporated into the project, as appropriate. Further guidance is provided by the Institute of Ecology and Environmental Management's Guidelines for Ecological Impact Assessment in the United Kingdom [http://www.ieem.org.uk/ecia/index.html].

In these cases, it may be necessary to take expert, independent multidisciplinary advice (e.g. from ecologists, engineers, economists and navigation experts) to obtain best solutions for balancing the interests of navigation and wildlife, particularly where methods are new or little tested. The agreed environmental measures should be set out as part of an overall conservation management plan, or as a separate project-based environmental management plan, which should include ecological objectives and targets along with procedures for monitoring and auditing success in achieving them.

Stakeholder engagement and consensus building

The best results for the sustainable management of waterways will be achieved by the early engagement of all environmental and user interests to agree shared objectives and appropriate actions. Such user interests include those interested in social issues, economic development, cultural heritage, navigation, recreation and the natural environment. This is essential if the maximum benefits that a waterway can offer to navigation, wildlife and other interests are to be realised.

Establishing a rapport between navigation and wildlife interests will also assist in avoiding or resolving conflicts, should these arise. Navigation interests should aim fully to involve the statutory nature conservation body (NE, SNH or CCW) in significant projects. The environment agencies (EA, SEPA) and perhaps local authorities should also be included where issues such as water quality or flood risk management are important. It is also important that the voluntary sector, particularly local waterway societies and wildlife trusts, is brought on board.

In this way, consensus on good practice can be reached and promoted, with adherence to it increased. Promoting responsible behaviour by all users will minimise adverse effects on wildlife.

While this approach will help to avoid conflicts developing, difficulties will arise from time to time and success will depend on the commitment to a genuine partnership approach. Thus consensus building is akin to negotiation, about which research is voluminous. Some pointers to key aspects are given in **Box 8.1** and **Appendix 4**.

Waterway developments

A priority in promoting any major new waterway proposal will be the establishment of shared objectives and agreed actions. This should typically include the following steps.

- Form strategic partnerships with representatives of all interested parties.
- Develop a network of contacts with other stakeholders.
- Make sure outline plans are made known early, before there is a chance for rumours or misinformation to gain credibility with stakeholders.
- Provide detailed plans packaged into an evidence-based project plan, in which environmental protection and enhancement are an integral part of the initial works and future maintenance - not just bolt-on extras.
- Use the project plan as a basis for wider consultation and to expose plans to public scrutiny such as in meetings or other public events - techniques need to vary with different audiences and different proposals; there is no single type of public scrutiny process.
- Be open, honest and inclusive throughout. If there are uncertainties or it is likely that the plans will result in some damage to wildlife, recognise this and show what has been done to mitigate it.
- Where uncertainties arise from a lack of objective data, consider setting out proposals for data gathering.

Although the focus here is on navigation and wildlife conservation, steps such as these are typically applicable across a wide range of types of partnership.

Involving local and regional nature conservation organisations from the beginning will enable them to provide an early warning of projects which may prove contentious, increasing the likelihood of finding agreed solutions and reducing the potential for costly, time consuming and destructive conflicts at a later stage.

Waterway restoration and development may take a long time to implement, so procedures should be set up for maintaining dialogue with key partners and stakeholders. This may mean formally constituted forums and/or occasional public meetings to report progress and raise issues.

Table 8.1 **Approaches for balancing the needs of navigation and wildlife**

Source of effect (see Chapter 6)	Category of measure	Potential measures
Motorised boat use AND Development and maintenance of waterway infrastructure	Advance planning 	**Impact assessment**: effects on wildlife should be considered right from the start of any waterway project; this can range from a very simple ecological assessment following a standard checklist to production of a formal environmental statement to support an application for necessary permissions. For European wildlife sites 'appropriate assessment' may be required under the Habitats Regulations.
		Management agreements: may be negotiated with the statutory nature conservation agency (NE, CCW, and SNH) to cover routine or other planned operations within waterway SSSI, avoiding the need for repeated consultation and applications for consent for such work.
		Waterway conservation management plans: development of such plans can provide a valuable stimulus for stakeholders to work in partnership towards an agreed vision for the waterway and to commit themselves to the actions required to implement this vision. Such plans should include all aspects of conservation of the waterway, including built heritage, landscape, hydromorphology, water quality and wildlife, as well as navigation and other socio-economic aspects such as angling, setting out a programme of agreed measures over several years. They should include an account of options considered and an assessment of each option in terms of how it will meet (or not) environmental and socio-economic needs/criteria.
Motorised boat use AND Development and maintenance of waterway infrastructure	Stakeholder engagement 	**Form partnerships**: early establishment of working partnerships with key stakeholders, including navigation, wildlife and fisheries interests, helps to avoid the development of conflicts and allows different interests to be taken into account from the beginning, thus avoiding a waste of time and money in reworking plans to mitigate problems at a later stage. Emphasis on common concerns, such as curbing invasives that impact on navigation and biodiversity, can increase the strength of partnerships.
		Education: many conflicts are generated through dissemination of misinformation and a lack of technical understanding of issues of interest to other stakeholders. A pro-active approach to mutual education of different interest groups, through discussion, workshops, presentations and information boards on-site, can help to avoid such problems. Raising awareness about the links between boat movement and bank erosion, sediment re-suspension and aquatic plants is particularly important.
		User groups: these are an established and, if there is commitment to problem solving on both sides, an effective and valuable means of communication between waterway managers and users.
Motorised boat use	Management of navigation 	**Engineering solutions to boat design**: environmentally friendly boat design may include propeller and sterngear modification, wider adoption of hulls designed to minimise wash, use of lighter material, use of different type of propulsion (e.g. water jets, towing from the bank), where commercially viable.
		Local speed limits: to protect sensitive areas; may require boat handling training, education and information, enforcement.
		Zoning boat movement in space: for example concentrating boat traffic in a defined channel and protecting areas near banks, appropriate mooring management and good practice, definition of areas available only for non-motorised access, education and information.
		Mooring management: appropriate location and good management of moorings and hire boat bases, advice on boat handling at moorings, education and information, enforcement.
		Zoning boat movements in time: will usually involve seasonal restrictions.
		Restriction of the number of boat movements: may include controls on access, boat numbers as trigger for other actions, restriction of licence numbers.
		Pollution reduction: good practice guidelines for boat cleaning, painting, bilge water management, disposal of black water and better management of grey water (e.g. Green Blue initiative), good practice for and regulation of boatyard activities, education and information.
Development and maintenance of waterway infrastructure	Design and management 	**Channel design modifications**: may include channel bed stabilisation, increasing water depth, channel cross-section profile designed to provide for both navigation and maximum diversity of wildlife habitats (see **Table 8.3**).
		Environmentally sensitive bank protection: use 'soft' as well as 'hard' materials (singly or in conjunction), design to provide habitat for otters, water voles, native crayfish and marginal vegetation, which will support other fauna, replace hard by soft banks as the opportunity arises in suitable locations.
		Vegetation control: remove invasive species, ensure appropriate timing and use of selective methods for aquatic weed control where required.
		Mooring design: design marinas and other mooring areas to maximise wildlife benefit, for example by including refuge areas for fish and water voles, soft bank protection and space for marginal vegetation between pontoons and bank.
		Dredging mitigations: dredging should be part of a clear sediment management strategy; aim to minimise disturbance, avoid the spread of turbidity and encourage re-colonisation; deep-dredging rather than surface skimming is generally recommended.
		Dewatering mitigations: phase in space and time to minimise loss of wildlife; rescue fish and crayfish; consider off-site maintenance of rare plants for later replanting.
		Weirs and fish passes: weirs should be designed or modified to allow passage by otters; fish passes may be appropriate to reduce the effects of navigation structures on fish migration in river navigations.
		Restoring derelict canals to water: maximise opportunities for a net gain for wildlife by creating new aquatic wildlife habitat in ways compatible with the restoration of navigation.
Motorised boat use AND Development and maintenance of waterway infrastructure	Provision of compensatory habitat/ restoration of habitat 	**On-line habitat**: for example, installation of barriers of various kinds within the navigable channel to provide habitat that is protected from the physical effects of boat movement, bank modification to create improved marginal habitat, biomanipulation as part of habitat restoration (as, for example, on Barton Broad).
		Off-line habitat: modification of existing off-line habitats (e.g. backwaters, adjacent gravel pits), reconnection of historic aquatic habitat or creation of completely new aquatic habitat (linked to the navigation channel or isolated).

Developing Codes of Good Practice for waterway users

It is generally helpful to demonstrate that participants in a potentially damaging recreational activity will adhere to an approved Code of Good Practice. It is now common for national governing bodies of recreational groups to produce such codes. A diagrammatic representation of an approach for developing such codes and a list of examples is given in **Appendix 4**.

Promoting Codes of Good Practice

Whilst it is very laudable to produce Codes of Good Practice, this is no guarantee that participants in the activity will adhere to them. The need to achieve 'buy-in' was a key feature of the British Marine Federation (BMF) and Royal Yachting Association (RYA) "Green Blue" Initiative. For a code to be effective it has to:

- be practical and do "what it says on the box";
- be credible and promote best practice;
- promote the idea of freedom;
- be aspirational and look to the future;
- be innovative and inspiring;
- engender excitement and appeal to the individual;
- empower the audience;
- promote serious messages in a light way.

In essence, the aim appears to be that anyone straying outside these Codes of Good Practice is regarded as a 'bad sailor'. Another key feature of the Green Blue initiative is the detailed analysis done to decide how best to raise awareness amongst BMF members, the plethora of RYA individual members and affiliated clubs, as well as other inland navigation users. The methods being employed include demonstration projects, the production of CDs, leaflets, promotion at regattas and so on.

Box 8.1
Consensus building

Key principles

Bishop (1996) and others suggest that the key principles underpinning successful consensus building are:

- commitment to abide by the outcomes of the process;
- openness, honesty, trust and inclusiveness;
- sharing of credit for successes, outcomes and implementation;
- common information base/sharing of information;
- mutual education and sharing of each other's ideas and principles;
- multiple options are identified;
- decisions arrived at through consent.

Methods available

A number of methods can be employed as a means of consulting stakeholders, including:

- face to face interviews;
- written consultations;
- group consultations;
- parish questionnaires and newsletters;
- direct public consultation;
- user questionnaires;
- using maps to show who wants what and where;
- organisations' questionnaires.

Strategic partnerships

There is merit in entering into strategic partnerships (see, for example, Crowe and Mulder 2005) and perhaps underlining these with Memoranda of Understanding (MoU). For example, English Nature's MoU with the British Canoe Union and Canoe England "seeks to establish and promote a framework for co-operation between English Nature and the British Canoe Union at all levels". British Waterways advocates a partnership approach (with respect to social inclusion) in its "Waterways for People" (BW 2002) and also has a MoU with English Nature.

On-the-ground measures

A range of measures is commonly used in situ to manage recreation in a way that serves to minimise adverse environmental effects. The most commonly used measures are:

- awareness-raising through information provision and interpretation;
- zoning of activity;
- 'steering' users towards particular behaviours;
- maintaining a presence;
- formal agreements.

These measures are described in more detail in **Appendix 4**. Zoning and steering are considered in further detail in the next section.

Management of navigation activity

There are a range of proposed mitigation measures that focus on boat design or use, with the aim of reducing the physical footprint arising from boat movement and achieving a satisfactory balance between navigation and wildlife. Note that not all are yet proven or commercially available.

In some cases, a successful outcome will depend on actions by boat users themselves. Therefore, a key requirement is that they are fully informed as to how they can contribute to wildlife protection and be educated as to the reasons why they should do so. In other words, it is essential to achieve 'buy-in' by the boating community for a Code of Good Practice, as discussed above.

Speed limitation

Vessel speed has long been recognised as a key determinant of navigation impacts; speed limits are already imposed on most waterways for safety and environmental reasons.

Non-tidal river navigations and larger canals in Britain typically operate speed limits in the range 8 to 13kph (5 to 8mph), except for specific areas designated for water-ski users. On narrow canals the speed limit is 6.4kph (4mph).

For larger river navigations the principal mechanism by which boats affect nature conservation interest tends to be breaking wave wash at the bank: speed limits aim to avoid this. Where a waterway reach is particularly sensitive, due for example to a restricted channel size or special wildlife receptor, locally reduced speed limits may be an appropriate mitigation measure.

Similar principles can be applied to canals, where return currents and propeller jet effects become more important. Again, speed limitation will reduce the effects. Boaters are urged by navigation authorities and user organisations not to create a breaking wash. On parts of the narrow canal system with particularly restricted channels, responsible boaters typically need to travel more slowly than the maximum permitted speed to achieve this. Even on these smaller waterways, boat speeds of less than 3kph (about 2mph) cause little damage to banks and vegetation; further reducing the speed limit to this level has the potential significantly to reduce the effects of boat use on wildlife in key areas without an unacceptable effect on journey times, if applied selectively (see Montgomery Canal case study in **Appendix 5**).

Mitigating boat impacts by reducing speed limits over long distances can, however, reduce boaters' enjoyment of the navigation experience. The propulsion systems of some boats are not well designed to cope with prolonged running at very low speeds. In some circumstances, such as strong crosswinds or fast water flows, proper control of the boat will be jeopardised if speed is reduced too much. This can compromise safety and increase the likelihood that the boat will be driven off-course into more sensitive wildlife habitat.

Another difficulty is that speed limits are generally difficult to police. Boats do not usually have accurate speedometers, although the use of GPS is increasing, and many navigation authorities do not monitor boat speed, with only blatant offences being dealt with. Speed monitoring is possible, however. In the Broads and on the River Thames, for example, boat speeds are tracked with hand-held radar guns; on the Broads, limits are enforced by Rangers.

Another approach available on isolated sections of a canal is to limit the power of engines. For example, on the Grand Western Canal, power is limited to 2.5 horsepower per metre length of boat.

Nevertheless, achieving protection of aquatic wildlife through speed limitation is perhaps the most practicable mitigation measure available. Successful application will always depend to a large extent on buy-in from the boating community. This will require effective communication and education, backed up by enforcement where necessary. Acceptance will be more likely if additional restrictions are applied only to particularly sensitive locations where the need can be clearly explained.

Zoning boat movement in space: access restrictions

The impact of boat movement on aquatic ecology can also be managed by restricting access to sensitive areas. For example by:

- limiting the area available to boats in wide waterways and lakes, either by the creation of navigation lanes or by marking protected areas with buoys or signs;
- the creation of linear bankside habitat that is physically protected by underwater walls or other barriers;
- prohibiting access to, or use of propellers in, sensitive areas.

The first approach has been applied in the Broads in consultation with a liaison group comprising a wide range of stakeholders; for example, the wintering waterfowl refuges at Hickling Broad and non-intervention areas at Barton Broad provide undisturbed areas for wildlife.

Examples of the second approach are the underwater protective walls and benching which have been used successfully on a number of canals, for example the Kennet and Avon and the Rochdale Canals.

The last approach is only likely to be applicable in a very limited number of locations. For example, towing boats from the bank, which was clearly associated with low environmental impacts at relatively high traffic densities in the 19th century, is sometimes proposed as a local solution to impacts related to propeller driven craft (see Montgomery Canal case study in Appendix 5). However, there are practical implementation limitations associated with towing motorised boats, including towpath safety issues associated with use of the towline and the fact that motorised boats are not usually provided with large enough rudders to give effective steerage when being towed.

Mooring management

As the habitat at the waterway margin is often the most valuable part of a linear waterway for wildlife, boat mooring can be a significant factor that may affect wildlife.

Protection can be achieved by allocating areas of the bank for marginal wildlife development and discouraging mooring in these locations. Encouraging boating practice that minimises adverse effects where moorings are situated in sensitive stretches of waterway may also provide help.

Mooring in sensitive areas can be discouraged by warning signs or by using features such as leaving uncut vegetation on the towpath to discourage mooring which could damage vulnerable bank areas. This approach is used by many navigation authorities to reduce mooring impacts, such as BW on the Oxford Canal. However, for this approach to be effective there must also be enough acceptable mooring places available to satisfy demand.

As water is often shallow at the waterway margin, the propeller jet effects of boats leaving moorings under power are accentuated. Disturbance of the waterway bed can be reduced by first pushing the stern of the boat out into deeper water before reversing out slowly from the mooring. Again the success of this approach will depend on persuading boaters to adopt the practice; this may be more likely if it is promoted specifically in relation to particularly sensitive waterways where the need can be clearly explained.

Zoning boat movement in time: seasonal restrictions

The most intense use of the waterways is between May and September when about 90% of leisure boat movements occur. This coincides with the main growth and activity periods of aquatic plants; it is probably less critical for aquatic animals, most of which are either present all year (e.g. fish, water snails) or are present from autumn to spring in the water, then emerging as adults in the summer (e.g. dragonflies, mayflies). In the case of breeding birds, the most sensitive time will be the nesting season in spring.

There may, therefore, be specific times of the year when restricting boat movement could reduce biological impacts during critical phases of the life cycle of plants or animals.

However, as seasonal navigation restrictions would usually need to be applied during the peak boating season, this approach is often not compatible with the aim of achieving a balance between navigation and nature conservation. Again it may have limited applicability for off-line areas, for example Hickling Broad, where navigation is limited to protect wintering wildfowl refuges.

Restriction of the number of boat movements

Restricting boat movements may be an effective method for mitigating navigation impacts where sensitive species and communities are present. Where legislation allows, it can be achieved directly by limiting traffic through control points, such as locks, or through a requirement for boaters to pre-book accompanied passages.

Boat traffic density can also be reduced indirectly by limiting the numbers and types of boats licensed, or by controlling the locations and sizes of mooring facilities, hire-boat bases and the siting of trip boat operations. This is preferable to the imposition of limits.

Limitations on boat numbers are currently used on the Basingstoke Canal and the Montgomery Canal.

Restricting the level of boat movements will, however, usually be unpopular amongst boaters and navigation support businesses and may amount to a breach of statutory duties to maintain navigation. It should be used only as a last resort, possibly as part of a balanced package of measures for protecting the most valuable wildlife sites after other approaches, including speed limits and infrastructure measures, have been examined and deemed to be insufficient.

To be effective, the need for restrictions should be assessed on the basis of good ecological and boat traffic data. Proposals should be developed in discussion with stakeholder groups.

Reduction of pollution from navigation use

There is a range of pollutants associated with navigation, including antifouling paints, grey and black water and oils (**Table 6.4 in Chapter 6**).

The Green Blue initiative, set up by the British Marine Federation and the Royal Yachting Association in association with the Environment Agency, published an Environmental Code of Practice in April 2006. This very comprehensive guide identifies environmental legislation relevant to the marine industry; it sets out the business case for developing environmental management systems that ensure compliance with legislative requirements and embody voluntary good practice to address pollution and sustainability issues.

This document is aimed principally at boatyard activities relating to sea-going vessels but much of its content is equally relevant to inland boating, particularly the Broads.

Boat users also have a major part to play in ensuring that pollution from their activities is minimised. On inland waters, the key issues are the:

- avoidance of oil pollution from bilge water discharge by use of separate bilge compartments under engines, where oil from leaks can be collected and disposed of ashore, and use of oil removal filters on bilge water outlets;
- good design of fuel filler pipes to avoid blowback of fuel while refuelling;
- containment and proper disposal of paint and sanding residues when boats are washed down, cleaned and repainted;
- avoidance of use of cleaning products containing high chlorine concentrations or other toxic chemicals, which may then be discharged to the waterway in 'grey' water;
- control of toilet waste (black water), which should not be discharged overboard from sea toilets when on inland waters.

Some of these are covered in the Boat Safety Scheme; the Green Blue initiative has produced a number of guidance leaflets and posters along these lines. The messages need to be reinforced by the boating industry, navigation authorities and voluntary organisations.

Engineering solutions to boat design

In recent years, much engineering design effort has been directed towards modifying or re-designing craft so that they re-suspend less bottom sediment and create less wash (Verheij, 2006). **Table 8.2** outlines some techniques that have been suggested for this purpose.

Some designs could be retro-fitted to certain types of existing boats. Deflector plates, for example, could be fitted below the propeller on a typical steel narrow boat to re-direct propeller jets away from the bed. Most new design ideas are, however, only practicable in the long-term as most boats have a long life, so renewal of the boat fleet is generally slow. Some new boat designs aim not only to reduce damage to wildlife but to cause lower environmental impacts in terms of energy use, carbon emissions and use of recyclable materials. Current research on boat design includes the Ecoboat in the Broads (**Box 8.2**).

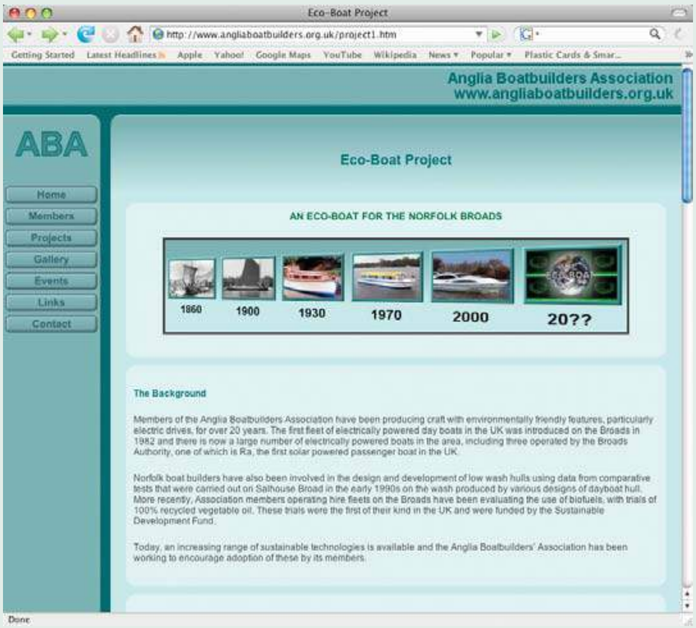
The use of low impact boats may be encouraged through licensing. For example, BW already has a 25% discount on its licence for electric motor boats.

Box 8.2
The Ecoboat: for a sustainable future on the Norfolk and Suffolk Broads

The Ecoboat project aims to develop a design brief for sustainable boats, incorporating features intended to reduce both global environmental impacts and local waterway nature conservation impacts (e.g. low wash hulls).

The Ecoboat project is an initiative of the Norfolk and Suffolk Boatbuilders Association, which acts as a forum for those involved in boatbuilding and allied trades and aims to increase awareness of the importance of sustainable and eco-friendly tourism.

The main aim of the Ecoboat project is to review sustainable technologies (e.g. reduced carbon emissions, alternative power sources, novel materials) and environmental best practices (e.g. waste handling, boat dismantling, recycling) that can be applied to navigation in the Norfolk and Suffolk Broads and use this to develop a brief for the construction of a boat that can be used for demonstration and evaluation.



The overall vision for the new design is that the boat should be constructed from sustainable materials, powered by renewable fuel sources, operated in a way that does not damage the environment, and that its components and structure should be capable of being recycled at the end of its life. (See Landamore et al, 2005 and 2006)

Table 8.2 **Modification of boat power systems, design and engineering**

Type of measure	Potential modifications
Modifications to propellers	Reduced propeller jet velocities, which can be achieved without loss of power by larger, lower speed propellers which have similar power output to small, high speed propellers. Redirecting propeller jets by, for example, retro-fitting a horizontal plate below the propeller.
Hull design and material	Refining hull designs by, for example, the use of tunnel sterns which give more control over the propeller. Hull shape can also be an important factor. Use of lighter hull materials creating boats with shallower drafts that displace less water when moving, reducing return currents (but not necessarily wash effects).
Use of different types of drive	Water jets, which are generally less disruptive to the channel, and new approaches, such as a whale-tail wheels, which produce power with far less disturbance. Electric boats produce less pollution locally, although overall benefit depends on the amount of pollution produced in generating the electricity. At present there is little information about the ecological effectiveness of these alternative drives.

In the longer term, environmental requirements could be incorporated into the boat safety certificate system used by BW, the EA and other navigations, subject to suitable provision for the continued operation of heritage vessels.

In the short-term, this approach is only really applicable to an extremely limited number of circumstances where boat access to a particular area of waterway is restricted to a few specified vessels.

Waterway infrastructure design and management

A number of measures involving manipulation of the waterway habitat are currently used, or are being investigated, which aim to assist navigation and wildlife to co-exist successfully. These are related to:

- channel design modification;
- environmentally sensitive bank protection;
- dredging;
- fish passes;
- mitigation of dewatering;
- restoring navigation to derelict canals.

Enhancement and mitigation measures need to be tailored to each site and to the specific species and habitats of interest. They should also be designed so that they harmonise with and promote national, regional and local biodiversity objectives (e.g. LBAPs, adjacent SSSIs).

Proposals should also consider the wider context, including the surrounding areas and not just the immediate length, seeking to enhance connectivity between habitats; for example, linking water vole habitats to prevent population isolation.

The long term sustainability of mitigation measures should be considered when assessing which to use: what works now might not work for very long and there may be long-term maintenance implications.

Where relationships between navigation use and wildlife tolerances are uncertain, design should incorporate flexibility for later modification or extension, should the need for this be indicated by experience following implementation. In this way the best protection should be achieved for key species and communities from any adverse effects of navigation use.

Channel design modification

Channel design modifications can increase the potential for the development of aquatic plant and animal communities by reducing boat-related impacts and increasing habitat heterogeneity. Examples are given in **Table 8.3**.

The effectiveness of these methods is currently difficult to assess due to lack of 'before and after' monitoring and the importance of local circumstances and design. A research project to test the efficiency of a range of techniques is being set up on the Montgomery Canal. The results will be available over the next few years and should help develop best practice.

Environmentally sensitive bank protection

Boat movements generally increase the rate of erosion of waterway banks. Significant bank erosion by boat wash can reduce the nature conservation value of marginal habitats and add sediment to the water, contributing to turbidity and bed siltation. However, it should be remembered that erosion by flood flows is a natural feature of some rivers and can be important for maintaining vertical banks, which are of value as nesting sites for bird species such as kingfisher and sand martin.

To improve bank stability, a wide range of techniques has been developed (**Table 8.4**). Although bank protection can reduce sediment re-suspension, such works are generally only of significant benefit to wildlife if they improve the bank habitats by providing protection from disturbance, increasing habitat heterogeneity and providing refuges. Specific provision can be made for water voles or crayfish, for example.

Traditionally, hard materials have been used to maintain the structural integrity of banks because their behaviour is well understood and they are relatively cost-effective. In some cases, such as on embankments, this may be the only realistic option. Such materials are not entirely negative for wildlife (**Table 8.4**).

Bioengineering options create a (usually) softer bank that absorbs waves and currents and allows marginal plants to develop. These plants then provide a natural barrier against erosion. Such ecologically friendly techniques tend to be a cheaper option in the short term, though some may not be as long-lasting as sheet piling, for example, and may require more maintenance.

Table 8.3 Design of the waterway channel to benefit wildlife

Type of measure	Potential modifications	Wildlife benefits
Increased depth	Increasing water cross-sectional area reduces return currents and wash, as well as lowering the risk of direct contact with plants by boat hulls and propellers. In most cases, the only practicable approach is to increase depth, which also reduces re-suspension of bed sediments by return currents and propeller jet effects. On canals, there may be limits to this approach due to the need to maintain the integrity of the lining and the stability of the side slopes (batters).	Maximizing channel cross-section and depth reduces direct physical effects of boat movement on both marginal and aquatic plants, while the reduction in turbidity benefits submerged plants. However, in natural rivers the potential adverse effects on valued shallow water habitats also need to be considered.
Bed stabilisation	Laying stones or other suitable material on the channel bed can reduce re-suspension of sediments and provide a firmer rooting medium for aquatic plants.	Work on the Middlewich Branch of the Shropshire Union Canal showed that stones provided a firmer growing medium for aquatic plants, increased the abundance of invertebrates by providing refuges and increased prey abundance, benefiting fish populations. Reduced turbidity increases the amount of light reaching the plants encouraging growth.
Channel profile modification	Modifications to the waterway channel profile to benefit wildlife may include provision of a variety of marginal characteristics, including both steep and shallow slopes, shelves at different depths and use of chippings to stabilise bed sediments.	A steep marginal profile will maximise the area for aquatic plant growth, and minimise areas available for emergent plant colonisation. Shelves or ledges at shallow depths can provide good habitat for emergent species, while deeper shelf areas will encourage aquatic plants. Use of chippings may assist plant rooting in mid-shelf areas.

Table 8.4 Bank protection and wildlife

Type of measure	Materials used	Wildlife value
Hard bank protection	Interlocking sheet steel piling is often used as a cost effective, long-lasting method of bank protection and can also provide a suitable bank for boat mooring.	Sheet steel piling, generally the material which mitigation often seeks to replace, can offer some benefit by reducing water column sediment loads and can create deep water which prevents marginal plants growing out into the habitats of uncommon aquatic plants. However, piling generally limits marginal vegetation development and reflects boat wash.
	Concrete walls and piling create a uniform, impenetrable surface but concrete walls can be readily shaped.	As for sheet steel piling but can be used to create underwater shelves to increase the potential for wetland plant establishment (e.g. Kennet and Avon Canal in the Bath valley).
	Sand/weak mortar/concrete bags can be used for bank protection or repairs and can be shaped to provide slopes.	Can promote plant establishment and provide habitat for invertebrates, including crayfish.
	Stones and stone products, including gabions and rip-rap.	Stone reinforced banks, depending on the size of the gaps between units, can absorb wave energy and provide a good habitat for plants and animals, although rip-rap comprising large stones is of little habitat value.
Soft bank protection	Coir rolls, made from coconut fibre.	Coir has good properties for rhizome and root establishment. Rolls can be pre-planted prior to being laid along the banks. However, coir can degrade rapidly (5 years in some cases), at which time it needs to be replaced; it can also be undermined by boat wash and can become snagged in boats' propellers.
	Willow walls or spiling (may be expensive if willows are not available locally).	For narrow channels (e.g. canals), shade management once the willow is growing may be an issue but the technique can be effective in larger waterways.
	Hazel faggots/bundles.	These can be set just below the water level and kept in place by geotextiles (see below) to trap silt to create a growing medium for marginal plants. However, they can become ineffective after about 5 years as the silt can be washed out.
	Geotextiles, in the form of open weave fabrics that can withstand wash and currents (e.g. nylon meshes) and which may be designed to allow plant growth.	Used successfully on a range of canals and rivers with high boat movements over the last 20 years. Cheaper and less disruptive to install than sheet-steel piling; the reed fringe it can help to create and/or maintain absorbs the energy from boat wash which reduces bank erosion. Can be effective in many situations up to c10.000 bmy in maintaining important marginal habitats for some invertebrate, fish and birds. Aesthetically more pleasing to many users.
	Reed fringes.	In some cases, particularly in wider sections of waterway, reed fringes can be established and maintained without any artificial bank protection to form a good defence against boat wash.

Table 8.5 **Mitigation measures to minimise adverse impacts of dredging activities**

Aims	Measures
Minimise disturbance to the existing plant and animal community.	Dredge outside the bird nesting and fish spawning seasons; thus consider avoiding late March to July. Leave reed beds and other emergent vegetation where practical, i.e. when the channel is wide enough to maintain navigation without having to dredge the whole width of the canal. After 1 year following dredging using this technique, reed warblers had re-colonised a stretch of the Grand Western Canal.
Avoid the spread of turbidity (and potentially other contaminants) during and after the operation.	Lower water level to prevent overflow to watercourses and other connected waterbodies. This can be particularly difficult after heavy rain. Set up a filter with coir or geotextiles to prevent overflow to particularly sensitive watercourses. Limit the movement of very turbid water beyond the immediate dredged area by using straw bales (e.g. Union Canal) and/or closed dredging buckets. Dredge deep in the main channel.
Encourage re-colonisation of dredged sections by plants and animals.	Dredge in short non-consecutive lengths. Dredge some marginal areas to shallow depths to maintain the seed bank. Create shelves if there is room and keep them shallow to improve vegetation development.

In some cases, a combination of hard and soft methods can be used effectively, for example stones coupled with geotextiles.

The effectiveness of geotextiles has been proven and they are widely used, for example in the Broads to reintroduce reedbeds along the eroded banks of rivers. Other bioengineering materials, for example coir rolls, have also been widely used on the waterways. These have often been locally successful, although, on balance, they have been found to degrade more quickly and to be less effective than geotextiles, particularly at high levels of boat traffic (John Eaton, pers. comm.).

Dredging

Dredging can have a range of effects on the wildlife of inland waterways, depending on the waterway type and characteristics. Deep dredging and suitable profiling can benefit wildlife (see **Table 8.3**).

However, dredging can cause temporary adverse effects, which should be minimised by the type of mitigation measure detailed in **Table 8.5**. These aim to:

- minimise disturbance to the existing plant and animal community;
- avoid the spread of turbidity and, potentially, other contaminants during the operation;
- encourage the re-colonisation by plants and animals of dredged sections.

Good knowledge of the location of the most important plant and animal species or communities is key to ensuring that impacts related to disturbance and the spread of turbidity are minimised. An environmental appraisal is now routinely undertaken by larger navigation authorities before dredging work is undertaken, which allows guidance to be given to dredging operators on the ground. Such an approach should be applied universally.

Where necessary, critical species may be removed prior to the dredging process and reintroduced following its completion.

Methods listed in **Table 8.5** are based mostly on practical experience and few published data are available on their ecological effectiveness. Further research is needed to determine the most effective dredging mitigation measures, particularly on waterways with high conservation value. The results of current work on the Grand Western Canal, where the effectiveness of dredging in short lengths is being investigated, should be available over the next two years.

Fish passes

In order to sustain migratory fish populations (e.g. salmon), unrestricted access to spawning grounds is required. Obstructions such as locks and weirs, which are commonly required for navigation purposes, can restrict these movements. Both legal and conservation considerations currently require a fish pass to be introduced into any new or significantly renovated river obstructions where there are populations of migratory fish.

There are many designs of fish passes including:

- pool and weir passes;
- baffled or steep passes;
- pre-barrages;
- artificial channels with low gradient.

The effectiveness of these designs has been shown to vary considerably, partly dependent on local conditions. Any new fish pass will need the approval of the relevant environment agency.

Dewatering mitigation
Dewatering is periodically required on canal sections as part of structural repair works or channel re-lining. In general it is undertaken in the winter months when the waterways are least used and, it is assumed, wildlife impacts will be least damaging.

Dewatering will inevitably be disruptive to the channel environment. Best practice methods to reduce its impact include minimising the period of dewatering and retaining at least some water in the channel bed. However, in practice, the effectiveness of these methods has been little assessed either in canals or other habitats.

Where species of conservation or other interest are present in a channel where dewatering is planned (e.g. fish, white clawed crayfish, rare plants), rescue and release can be undertaken. This has been successful in many cases, some long term. The Rochdale Canal, for example, was dewatered for many months during its restoration to navigation. Throughout this time, plants of floating water-plantain were removed from the canal, maintained in a botanic garden and successfully replanted after restoration was complete.

Restoring navigation to derelict canals
As mentioned above, there is an opportunity when reintroducing water to derelict canals during restoration to create new valued aquatic habitat. In assessing the potential effects on wildlife at the planning stage, it is important to consider both the newly created wet habitat and the existing damp or dry habitat that will be lost. The re-watered channel should be carefully designed to try to ensure that the new habitat will remain of significant value once boats are re-introduced.

Compensation for habitat loss or degradation
Compensation schemes aim to retain examples of the plants and animals of a waterway, such as scarcer aquatic plants, which may be impacted by the construction phase of a restoration project or by increased boat movements. For example, the planned use of offline reserves was instrumental in securing the agreement to restore navigation onto the Montgomery Canal SSSI. Reserves can be either in-channel or off-line (**Table 8.6**).

Creation of in-channel reserves has been most used on the continent. It has been trialled in Britain on the Rochdale Canal to protect floating water plantain. The results from this work have been broadly successful in the first few years after implementation, though boat traffic movements on this waterway are still modest (about 25% of the initial threshold of 800 bmy which would trigger further monitoring).

There remain issues about the long-term sustainability of such reserves, since they have shown a tendency for rapid siltation and invasion by emergent plants, and dredging them to retain their value for aquatic plants can require specialist equipment.

Biomanipulation, using 'exclosures' from which fish are excluded, has been trialled successfully on Barton Broad as part of a restoration scheme involving the removal of nutrient-rich sediment. This also benefits navigation. Excluding fish provides the right conditions for zooplankton such as water fleas to flourish. These feed on planktonic algae to produce clear water, which has resulted in the development of a diverse macrophyte flora.

In situations where navigation impacts cannot be mitigated in the main navigation channel, off-channel compensation schemes may be proposed. Ideally, off-channel reserves for aquatic plant communities should be relatively large, with a wide range of depths, a firm substrate for rooting and with good water quality. This implies that they would be relatively isolated from, but hydrologically connected to, the main channel, have few (if any) boat movements and low fish densities.

Monitoring of offline reserves has shown that, in the short term, they can support rich plant and invertebrate communities similar to those of the main channel (Willby & Eaton, 1996). However, in the longer term, they may lose the populations of the critical submerged plants for which they were usually created, although they may retain a high diversity of other species (Boedeltje et al., 2001).

Particular problems that have been identified with offline reserves, especially those directly connected to the main channel, include:

- water quality: if the water entering the reserve, either from the surrounding land or from navigation in the main channel, is silt-laden and turbid, then the reserve may silt up quickly;
- vegetation succession: silting-up can allow tall emergent vegetation extensively to colonise the compensation area, out-competing the submerged and floating-leaved plants which are typically the main reason for establishing the reserve;
- management: due to emergent plant and tree/shrub encroachment, sites need to be managed to maintain open water habitat equivalent to that originally present in the pre-restoration navigation channel. This has long-term cost implications.

Overall, the value of offline reserves will very much depend on local circumstances, together with their design and management. Continued research and monitoring is required to assess further the effectiveness of offline reserves in the longer term (see Montgomery Canal Case Study in Appendix 5).

Difficulties with the adoption of preferred solutions

A number of constraints may hinder the adoption of preferred solutions to mitigate the adverse effects of navigation on nature conservation. Clearly these constraints will differ widely depending on local circumstances, including differing views held by different local consultees. In general, however, the most significant are the following:

- **Profile raising.** Many involved in the waterway restoration movement have little experience in wildlife matters, while many in the wildlife movement have little understanding of how waterways function for navigation. Greater communication and sharing of information should be encouraged.
- **Limitations imposed by built heritage.** Many waterways in urban areas may be constrained by the nature of the built environment: in these places it may be impossible to install soft revetments. The walls of a waterway may have statutory protection under heritage legislation; some waterways are designated in full or part as Scheduled Monuments.
- **Engineering issues.** In some places, the need to ensure waterway structural integrity may make it impossible to adopt the best mitigation technique for nature conservation.
- **Uncertainty about success and costs.** Techniques are being constantly refined, but often their effectiveness can only be assessed over long periods of time.
- **Cost-effectiveness and sustainability of different solutions.** The ecological benefits of some new mitigation techniques have not yet been fully evaluated, making it difficult to assess their cost-effectiveness.
- **Information limitation.** Mitigation techniques (e.g. water vole-friendly banks) are developing very rapidly and staff on some smaller navigations have, as yet, little experience and training in their use. Wider dissemination of details of eco-friendly techniques would be beneficial.
- **Navigation legislation.** In some cases duties towards navigation placed on navigation authorities by their enabling legislation, or through public rights protected by statute, limit the adoption of some of the nature conservation management measures described above.

Table 8.6 Provision of nature reserve areas as compensatory habitat

Type of measure	Examples
In-channel reserves	These are separated-off areas of water within the main line of the navigation where the aim is to minimize boat traffic impacts so that vulnerable species, often uncommon submerged plants, can thrive. In-channel reserve areas are generally at least partly separated from the main channel by a physical barrier (e.g. earth bunds, metal piles, concrete walls) but are hydrologically connected with it. In lakes, such reserves may simply be roped-off or buoy-marked 'no-go' areas. In a more limited way, in-channel reserves can also include structures such as rafts that provide local cover for fish and roosting and nesting sites for birds. 'Exclosures' used to restore clear water conditions using biomanipulation (e.g. removal of fish to encourage zooplankton which remove algae and produce clearer water) can also be considered as a form of in-channel reserve.
Off-line reserves	These include non-navigated connected basins and lagoons or former canal channels, as well as dedicated areas set aside or created in marinas and mooring basins. Flooded, disused gravel pits adjacent to waterways can provide an opportunity for valuable habitat creation. Sidewaters (defined as a minimum 50% increase in channel width) can provide a habitat that is relatively sheltered from the effects of boat movement. This includes areas such as weir streams, lock bywashes, side ponds and large winding holes, as well as wide sections of waterway where there is space and a suitable bed profile to allow development of an extensive area of emergent and/or submerged vegetation. In some cases, the provision of off-line compensation may involve the construction of completely new pond areas. These will require a water supply, either from the waterway under restoration or from another source of similar water chemistry.

Many methods are currently being developed to try to minimise the impact of navigation on nature conservation. The next 5 to 10 years should bring considerable amounts of new information on the value of a range of mitigation techniques. For example, monitoring of mitigation schemes on the Rochdale and Montgomery Canals (see case studies in Appendix 5) should help assess their effectiveness in protecting rare plants in canals restored to navigation.

Summary of good practice recommendations

The key stages that should underpin any plan of action for balancing the needs of navigation and wildlife can be summarised as:

- establish a planning process;
- engage people and develop partnerships;
- find out what is there in terms of ecological value;
- decide on what needs doing to maintain navigation, while protecting and enhancing wildlife;
- do it;
- monitor outcomes and feed back and disseminate knowledge for use in future planning.

In conclusion, it is worth summarising who should take action, why it is necessary and how it should be done.

Who should take action?

The adoption of good practice in balancing the needs of navigation and wildlife is recommended to all promoters of waterway restoration and development, along with those involved in waterway operation and maintenance, for example navigation authorities, local authorities and the voluntary sector. This will usually best be achieved by a partnership approach involving navigation, wildlife and other interests.

Those in an advisory or wider enabling role, for example central Government, statutory nature conservation, countryside advisory bodies and local planning authorities, should contribute to developing and promoting good practice in this area.

Why is it necessary?

The UK has international and national commitments to protect and enhance wildlife, as well as national policies on sustainable development. All public bodies, including many navigation authorities, have legal duties towards nature conservation and it is recommended that all interested parties adopt the same approach. Sustainable management of the waterways will contribute towards the UK Sustainable Development Strategy targets for protecting natural resources and enhancing the environment and for creating sustainable communities (Defra, 2005).

By taking the initiative and adopting a partnership approach with wildlife interests, navigation bodies will be more likely to succeed in obtaining policy support and funding for the waterways.

How should it be done?

This chapter of the report signposts the way to good practice but is not a detailed manual of practical techniques. Detailed guidance can be found in the publications and on the websites detailed in the blue 'Key information sources' boxes in this report.

There are no magic bullets that enable single prescriptive recommendations to be given for a best method to use when developing, maintaining or operating inland waterways. The most suitable for a site will inevitably depend on many variables. These include natural factors (width, depth, underlying substrate, water quality), navigation related factors (boat traffic density, speed limit, required draught) and the legal status of waterway and the land it crosses (in terms of environmental designations).

The tables above set out guidance on and include a range of practical examples of good practice. Some further summary points are set out in **Table 8.7**.

Table 8.7 Good practice recommendations for waterway development and management

Issue	Discussion
Realism	In major developments it is important to be realistic, not over-optimistic, about the likely extent of impacts. It is always much easier to cost-in and implement mitigation at an early project stage; it is sometimes impossible, technically and financially, to retro-fit it.
Timing	Consider timing carefully to ensure that: • particularly vulnerable life stages are avoided (e.g. eggs or newly hatched fish, nesting birds); • works such as dewatering are carried out for the minimum time.
Management control	Effective management of waterway infrastructure and navigation can be effective in mitigating many of the negative impacts of navigation on wildlife and achieving additional benefits. Use of EIA and EcIA, control of mooring locations and early gathering of baseline data in critical locations all help to minimise ecological damage and enable protection and enhancement to be built in to waterway management plans at an early stage.
Where to enhance	If there are water quality issues because of pollution or high boat traffic, focus any enhancement on maximising the value of in-channel bank edge communities (such as having lower angled, well vegetated banks), but also create off-line water bodies to support the submerged plant communities and associated animals that are difficult to maintain in heavily trafficked waterways.
Banks	Management of bank habitats must clearly support the needs of navigation and towpath users, as well as striking a balance with conservation and engineering stability needs. However a wide range of soft engineering techniques are available which in many situations provide good, sometimes better, engineering alternatives to hard materials. Minimise the need for hard banks for linear moorings by focussing on marinas (such as BW's policy) and focus customer facilities such as moorings, marinas and wharves away from sensitive areas. Geotextiles appear be the most effective and long-lasting method for maintaining at least some marginal vegetation even on heavily trafficked canals (up to 10,000 bmy.). More widespread use appears justified.
Recognise opportunities	Industrial operations, particularly aggregates quarrying, may leave water filled pits alongside navigable watercourses which provide opportunities for the creation of nature reserves linked to the navigation or for off-line moorings. These relieve pressure on the wildlife of the main navigation channel. Similarly, the construction of new off-line marinas provides opportunities for the creation of valued habitat, provided this is properly designed.
Protecting rare aquatic plant communities	Mitigation methods for protecting uncommon submerged plants from traffic effects are all very new. Most are still in the development and trial stage. None have, as yet, been proven effective in the long term. Indeed an initial trial of creating off-line reserves (the method trialled for longest), although promising in the first few years, proved ineffective over longer periods under the management regime implemented. It is possible that (i) new techniques (e.g. modified boat designs) may give better results in future and (ii) it may be possible to modify existing approaches to increase their longevity (e.g. dredging offline reserves). However, based on current data, it is recommended that flexibility be built into management plans to allow experience gained from monitoring of success or otherwise to be acted upon.
Boat design	In the long term, using the best practice in boat design is likely to have very positive impacts on the canal environment for wildlife. In the short term alterations such as fixing deflector plates to boats can help reduce impacts, especially in ecologically sensitive areas where these issues are most critical.
Communicati on to ensure consensus	As the case studies in Appendix 5 of this report emphasise, the key to long term sustainable management of the navigable waterways is the continued use of extensive discussion and consultation. This helps to achieve consensus, form strategic partnerships with all interested parties and enable an open, transparent and inclusive process in all that is done.
Management plans:	Rather than starting fresh negotiations for every individual project on a waterway, the aim should be to obtain agreement on a comprehensive programme of work over a period of time.

Key information sources

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Defra (2005) Securing the Future. The UK's Sustainable Development Strategy

Defra (2006) Sustainable Development Indicators in your pocket (see www.sustainable-development.gov.uk).

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EA (2002) EIA Scoping Guidelines - guidance notes for 76 development types

Institute of Ecology and Environmental Management (IEEM) (2006) Guidelines for Ecological Impact Assessment in the UK

Institute of Environmental Management and Assessment (IEMA) EIA Guidance - see www.ieem.org.uk/ecia/

Inland Waterways Association (IWA) Practical Restoration Handbook

IWA Technical Restoration Handbook

Landamore et al, (2005 and 2006) Stage 1 and Stage 2 reports.

Moss B., Madgwick J. and G. Phillips 1996. A guide to the restoration of nutrient-enriched shallow lakes. Report for Environment Agency, Broads Authority, LIFE.

PIANC (1997) Conference report: geotextiles and geomembranes in river and maritime works

PIANC WG12 (1996). Reinforced vegetative bank protections using geotextiles.

PIANC WG7 (2003). Ecological and Engineering Guidelines for Wetlands Restoration in Relation to the Development, Operation and Maintenance of Navigation Infrastructures.

Royal Society for the Protection of Birds (RSPB), National Rivers Authority (NRA) and Royal Society for Nature Conservation (RSNC), 1994. The new rivers and wildlife handbook.

Strachan R. and Moorhouse T. (2006) Water vole conservation handbook, 2nd Edition.

The Green Blue - guidance for navigation users available at www.thegreenblue.org.uk

Conclusions and Recommendations

Conclusions

The conclusions of this report are given below. Supporting information is given in the chapters indicated.

- The navigable inland waterways system of England, Wales and Scotland comprises **a wide variety of waterways**, including river navigations, the Broads, navigable fenland drains and canals ranging from those designed for narrow boats to ship canals. These provide a wide range of aquatic habitats supporting **diverse biological communities** which respond to pressures in different ways (Chapter 3).
- While vessel movement has always had an interaction with the waterway environment, this has been greatly increased by the **introduction of propeller driven craft** compared with historic methods of propulsion, such as towage from the bank or use of sails (Chapter 3).
- The inland waterways system has become a **multi-functional resource** of value both to the country as a whole and to local communities. This resource contributes to leisure and tourism, commercial enterprises, freight transport, urban and rural regeneration, telecommunications, water management, the built heritage, community wellbeing, human health and nature conservation (Chapter 3).
- Navigation authorities often have **statutory duties to maintain their waterways** and enjoy various powers to enable them to do this. They all must, of course, comply with wildlife protection legislation and all public navigation authorities now have a statutory duty to promote nature conservation in the exercise of their functions (Chapter 3).
- As a whole, this inland waterways system makes **an important contribution to biodiversity** and to aquatic wildlife in particular. In the interests both of nature conservation and of the continuing attractiveness of the system to its users, this contribution needs to be protected and, where practicable, enhanced (Chapter 4).
- The **contribution of the system to wildlife conservation is far from uniform**: at one extreme there are internationally and nationally important designated sites with legal protection, notably the Broads and some peripheral waterways (such as the Montgomery and Pocklington Canals) which are undergoing, or with plans for, restoration of navigation; at the other there are some stretches devoid of much conservation interest (Chapter 4).
- The extremes constitute a small proportion of the whole system. **The vast majority of the waterway system is of modest conservation interest** and here the wildlife value and the attractiveness for users can, and should, be affected directly by how the waterways are managed and by other controls. With appropriate management almost all waterways can deliver some wildlife benefits compatible with other requirements on them, including navigation (Chapter 4).
- The **value** of each part of the system for aquatic wildlife conservation **evolves over time** and all nationally protected sites (SSSIs) are subject to continuing re-assessment by the statutory agencies. While UK and Scottish Government policy is to maintain or, where necessary, restore SSSIs to favourable conservation status, a few SSSIs on very busy waterways have never reached and are unlikely ever to reach favourable conservation status, even with large expenditure and resource input and the best efforts of the waterway managers. In such cases, it may be best to focus limited available resources on SSSIs where achievement of favourable status is a realistic proposition. Conversely, others sites may grow in importance and may justify legal protection in future (Chapter 4, Chapter 8).
- Changes in value arise because a **whole range of pressures, as well as navigation, affects waterway wildlife**. Physical alterations, such as the installation of weirs on rivers and bank protection, affect habitat availability. Water quality is particularly important, especially nutrient pollution from both point and diffuse sources. The Water Framework Directive aims to address such issues by establishing programmes of measures directed towards the achievement of ecological quality targets in all surface water bodies and should be a major stimulus to improving wildlife value of the waterways system. Other factors affecting aquatic wildlife value include hydrology (e.g. water diversion, abstraction and impoundment), fishery management and invasive species (Chapter 5).
- Navigation by **motorised vessels in particular can affect aquatic wildlife** via induced currents and waves, by re-suspending bottom sediments and by direct physical contact with aquatic plants. The extent of such effects depends on a number of factors, including the type of waterway, the relationship between vessel size and channel cross-section, the nature of the bed and the banks along with vessel speed (Chapter 6).
- The ways in which the **development and maintenance** of waterway infrastructure are carried out can also have a significant influence on the aquatic wildlife value of the waterway. This is particularly the case for dredging and bank protection (Chapter 6).

- In some cases, the well planned development and use of **waterways for navigation can also provide benefits for wildlife**, particularly where waterway restoration to navigation secures continued maintenance of aquatic habitat or where new habitat is created (Chapter 6).
- Many non-tidal navigable inland waterways are already managed to serve navigation demands, as required by statute in many cases, in an **appropriate balance** with other requirements including those of aquatic wildlife. Such a management approach, both sustainable and by consensus, is supported, should continue and should be extended to all waterways (Chapter 8).
- Early engagement of both navigation and wildlife interests in **constructive working partnerships**, particularly in the case of major projects such as waterway restoration, is likely to produce the best outcomes for waterway users and the environment (Chapter 8).
- **Tools** such as ecological impact assessment, management agreements and, particularly for waterways of high conservation value, **conservation management plans** can prove very valuable as aids to effective planning for waterway development and use (Chapter 8).
- Measures to **reduce stress on aquatic wildlife** will include the way navigation is managed. This may include specific local measures, as well as management approaches that can be applied across the whole inland waterway system (Chapter 8).
- **Channel cross-section profiles and banks** should be designed to minimise the effects of waves and currents, generated by boat movements, to encourage marginal vegetation and to provide habitat for species such as the otter, water vole and native crayfish. Creating new off-line habitats may be appropriate in special cases (Chapter 8).
- There are a **small number of waterways**, both in use for navigation and with plans for restoration, where their **importance for aquatic wildlife should be given extra consideration** in their design and management, even as far as limitations on boat movements, boat speed or the type of vessels allowed. Achieving a sustainable balance between navigation and aquatic wildlife conservation does not necessarily cost more but where it involves significant additional costs, these should be shared between those that benefit (Chapter 8).
- Across the system, **navigation bodies, local authorities, wildlife organisations and the waterways industry need to be actively engaged** at all levels of management and consultation to decide on shared objectives, to agree on approaches to impact assessment, to ascertain the optimum balance for future management, to develop good practice methods and to monitor outcomes, if the country is to get the best value out of its inland waterways (Chapter 8).

Recommendations

IWAC's recommendations which flow from this report and its conclusions are set out below.

For the inland waterways sector as a whole, in conjunction with the UK Biodiversity Partnership[1]
IWAC recommends that these bodies should:

- **encourage research** on the effects of navigation on biodiversity. Key areas might include (a) assessing the value of off-line and on-line nature reserves in a range of water quality and boat traffic environments, (b) evaluating dredging methods to enhance populations of key species, and (c) investigating the impact of boats on river navigations, considering all biota. Assessments of new mitigation methods should extend over the longer-term (5 to 10 years) in order to test the value of new techniques.
- where they are lead agencies for Biodiversity Action Plan (BAP) aquatic species or habitats occurring in and on the waterways, **encourage the collection of environmental and management information** on such species, especially those where knowledge is limited, and contribute to national target setting and reporting for these BAPs;
- recognise fully the **value of navigable inland waterways in River Basin Management Plans** established under the Water Framework Directive, making full use of provisions for the designation of artificial and heavily modified water bodies and setting alternative objectives as appropriate, thus ensuring that navigation authorities are not subjected to disproportionate costs.

[1] The inland waterways sector includes local authorities, local groups, central government, navigation authorities and waterways' user groups. The UK Biodiversity Partnership comprises a wide range of people from those who provide funds, amateur and professional experts to those who are interested in the rich wildlife and natural history of the UK. They include private individuals, business, Government and non-Government representatives. The Partnership is supported by a Standing Committee comprising representatives from Defra and the devolved Governments, as well as the statutory nature conservation agencies and Wildlife Link.

For development agencies, English regional bodies and all local authorities throughout Britain
IWAC recommends that development agencies (in England's regions, Scotland and Wales), UK Government Offices, English regional bodies and British local authority planning and countryside departments should:

- take active steps to **identify all active or derelict inland waterways** within their geographical areas;
- take an interest in **developing the full potential** of these waterways for navigation users, wildlife and for the community as a whole;
- engage with navigation authorities, statutory conservation and environment agencies, landowners and the voluntary sector to **agree future development and conservation plans** for these waterways;
- ensure that appropriate protection and development provisions are included in **regional spatial strategies and local development plans**.

For navigation authorities and navigation bodies
IWAC recommends that:

- where these are not already in place, navigation authorities should develop procedures that ensure an appropriate level of **ecological impact assessment** is undertaken in advance of carrying out works that may affect aquatic wildlife. Such assessments may range from simply following a standard checklist covering routine activities to a detailed ecological impact assessment in the case of more significant works;
- navigation authorities should take account of the results of these assessments in carrying out their functions and implement **appropriate mitigation and enhancement measures** for wildlife on their waterways;
- where waterways host BAP species or habitats, waterway based **local biodiversity action plans** should be developed, tailored specifically to contribute to decisions on waterway maintenance and management; these may be very brief or more complex, depending on the activities being undertaken;
- **Waterway Conservation Management Plans** (CMPs) should be in place for the limited number of waterways (active navigations and those under restoration or proposed for restoration) with significant nature conservation interest. Existing CMPs and other conservation plans should be regularly reviewed as new knowledge becomes available;
- navigation authorities should be **active partners**, either directly or through AINA, in contributing to the development and implementation on their waterways of the **River Basin Management Plans** required by the Water Framework Directive, to ensure that waterway interests are taken fully into account;
- in consultation with statutory nature conservation agencies, navigation authorities should encourage the **development of new mitigation and enhancement techniques** for waterway wildlife using a multidisciplinary approach involving engineers, navigation experts and ecologists, while ensuring that essential works to the waterway are not prevented by excessive mitigation costs. Environmental mitigation is a rapidly evolving field with a very wide range of solutions possible, many not yet well-developed (and possibly not even yet conceived) and ongoing research and development is urgently needed;
- national navigation authorities should **maintain and cultivate their links** with statutory environment and nature conservation agencies;
- all navigation authorities should seek to **engage local stakeholders**, to foster mutual understanding on matters relating to navigation and wildlife and to work in partnership to develop and implement good practice;
- AINA should provide a forum for, and actively **encourage dissemination** of, the considerable experience of larger navigation authorities on management of waterways for navigation and wildlife to the smaller navigation authorities;
- AINA should encourage its members and licensed boaters to take responsibility for **maintaining the conservation value of inland waterways**, for example by encouraging elements of self-policing;

- building on its 2005 report, **AINA should assist smaller navigation bodies** and restoration societies by developing
  - **a manual of conservation techniques** (i.e. an easily updateable document with lists of specialists for advice) to extend its current guidelines for aquatic wildlife;
  - **an easy-to-use pictorial guide** for use by operators, for example those involved in dredging;
- navigation authorities should undertake properly structured **monitoring of wildlife and boat use** on their waterways, to improve our understanding of the interactions and the success of different mitigation methods;
- **information should be shared** between authorities (through AINA) and with statutory wildlife bodies and the voluntary sector, to allow the real gaps in knowledge to be identified; effort can then be directed towards resolving these, rather than re-inventing the wheel in relation to each new waterway project. This applies both to technical and scientific experience and to consensus building.

For the voluntary sector

IWAC recommends that:

- a more effective dialogue **between voluntary bodies** in the navigation and nature conservation fields is established to share experience, develop best practice and to address issues such as coordinating the use of volunteers;
- local waterway societies should **take advice on wildlife protection matters** and should initiate dialogue with wildlife bodies at the earliest stages of restoration proposals;
- Non Governmental Organisations, such as County Wildlife Trusts, the Royal Society for the Protection of Birds (RSPB) and specialist nature conservation groups, should take an **active interest in inland waterways** and participate in the local and national consultation and liaison arrangements of navigation authorities, as well as responding positively to requests for involvement in waterway restoration projects;
- national waterway bodies, such as IWA and RYA, should continue to play a leading role in providing **education and guidance to local voluntary groups** and providing technical responses to information requests and consultations.

For waterway related businesses

IWAC recommends that:

- building on its 'Green Blue' initiative with the RYA and the publication of its Environmental Code of Practice, the British Marine Federation (BMF) should continue to **raise awareness among its members of environmental issues** and the role of boat designers, manufacturers, marina operators and boat chandlers in contributing to the protection of the waterway environment for wildlife;
- boatyards should follow the advice in the BMF Environmental Code of Practice to **minimise** entry to the water of any materials **that might be detrimental to wildlife**;
- developers and operators should aim to accommodate **wildlife-friendly areas within marinas** where practicable;
- waterway businesses who supply boat users should encourage **responsible navigation**, to minimise the adverse effects on wildlife, promote the use of environmentally friendly products and practices and minimise water pollution from boats.

IWAC will keep this matter under review to identify changes and, where possible, anticipate problems

Glossary and list of abbreviations

Aquatic plants - emergent and submerged plants

BA - Broads Authority

BAP - Biodiversity Action Plan

BMF - British Marine Federation

BMY - Boat Movements per Year

Bow-thruster - a propeller mounted in a transverse tunnel across the bow of a vessel, to provide sideways thrust for the bow when manoeuvring at low speed

Broads - a series of lakes in Norfolk and Suffolk created by medieval peat digging in the 12th-14th centuries and flooded at the end of that time

BW - British Waterways

By-wash - a bypass channel or culvert allowing water to flow round a lock from the higher to the lower canal level

CCW - Countryside Council for Wales, the Welsh Assembly Government's advisory body on nature conservation and countryside matters in Wales

CROW Act - Countryside and Rights of Way Act 2000

Cut - a canal or other artificial water channel

DCLG - Department for Communities and Local Government

DCMS - Department for Culture, Media and Sport

Defra - Department for Environment, Food and Rural Affairs

DfT - Department for Transport

Drain - an artificial waterway built primarily for land drainage purposes

EA - Environment Agency, the environmental regulator in England and Wales

EcIA - Ecological Impact Assessment

EIA - Environmental Impact Assessment

Emergent plants - plants with their roots submerged but with part of the plant growing above the water surface level

Eutrophication - the nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, among which increased production of algae and macrophytes and deterioration of water quality are found to be undesirable and interfere with water uses

Feeder - a pipe or channel supplying water to a canal

Invertebrate - an animal without a backbone, such as shrimps, insects, worms

IEEM - Institute of Ecology and Environmental Management

IEMA - Institute of Environmental Management and Assessment

IWAAC - Inland Waterways Amenity Advisory Council

IWAC - Inland Waterways Advisory Council

IWA - Inland Waterways Association

JNCC - Joint Nature Conservation Committee, a joint committee on the national nature conservation agencies in England, Wales and Scotland

Leeboards - large boards lowered into the water at the sides of a sailing vessel to reduce the amount of leeway (sideways movement), particularly when unladen

LBAP - Local Biodiversity Action Plan

Macrophyte - a member of the plant life of an area, especially in a body of water, visible by the naked eye

Narrow canal - a canal built to accommodate only narrow boats, which were generally about 21m (70 feet) long and 2.13m (7 feet) wide

NGO - Non Governmental Organisation

NE - Natural England (formerly English Nature), the UK Government's advisory body on nature conservation and countryside matters in England

Nutrients - in terms of aquatic plants, substances such as nitrogen and phosphorus compounds which are necessary for and stimulate plant growth

Omni-directional drive - a propeller drive on a vessel that is capable of rotation through 360° around a vertical axis, allowing the thrust from the propeller to be directed forwards, backwards or sideways

Organic - contains carbon or compounds of carbon

pH - a measure of the hydrogen ion concentration, which determines whether water is acid or alkaline - a pH of 7 is neutral, lower values represent acid water, higher values alkaline water

PIANC - the International Navigation Association

Quant - an East Anglian term for a barge pole used for propelling a boat by pushing off the waterway bed (quanting)

Ramsar site - a site listed under the Ramsar Convention on Wetlands of International Importance, Ramsar, Iran, 1971

Riparian - pertaining to the banks of a waterway

RSPB - Royal Society for the Protection of Birds

RYA - the Royal Yachting Association

SAC - Special Area of Conservation designated under the EC Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (92/43/EEC) (the Habitats Directive) (as amended)

SG - Scottish Government

SEPA - Scottish Environment Protection Agency, the environmental regulator in Scotland

Shaft - a canal term for a barge pole used for propelling a boat by pushing off the waterway bed (shafting or poling)

Ship canal - a canal designed to accommodate seagoing ships

SINC - Sites of Importance for Nature Conservation

SNCI - Sites of Natural Conservation Interest

SNH - Scottish Natural Heritage, the Scottish Government's advisory body on nature conservation and countryside matters in Scotland

SPA - Special Protection Area classified under EC Directive on the Conservation of Wild Birds (79/409/EEC), as amended

SSSI - Site of Special Scientific Interest notified under the Wildlife and Countryside Act 1981 (as amended)

Substrate - an underlying layer

Submerged plants - plants growing entirely within the water column

Swim - the tapered stern of a boat leading to the point where the propeller is mounted

Tub boat canal - a canal built to accommodate short rectangular container boats towed in trains, often provided with boat lifts instead of locks

WAG - Welsh Assembly Government

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Consensus building bibliography (Chapter 8) - See Appendix 4

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The report represents the views of IWAC, as advised by the members of the Steering Group and other consultees. It provides advice on the consideration of wildlife issues in relation to navigable inland waterways and illustrative examples of the way in which a balance can be achieved between navigation and wildlife interests. However, the success of specific approaches will vary according to the characteristics and use of the waterway concerned and IWAC urges readers to refer to more detailed information referenced in the report and to local circumstances before committing to any particular course of action. Neither IWAC nor its advisers can be held responsible for any planning or operational decisions made in relation to this study's findings.

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