Waterways Management Strategy and Action Plan 2022/23-2026/27

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Contents

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1 Executive Summary

The purpose of this strategy and five year action plan is to provide a framework for sustainable and cost effective management of the Broads navigable waterways from 2022/23 to 2026/27. The character and usage of the different parts of these publicly accessible waterways varies considerably. This means that a fixed management approach would not give the best outcome for recreational users, environmental considerations or allow efficient deployment of Broads Authority resources. Developments in legislation and varied stakeholder interests also means that the Authority's approach needs to be flexible, based on sound evidence and be transparent in decision-making and communication.

In developing a holistic approach to managing the Broads waterways, the key drivers are:

- safety of those using the waterways;
- accessibility where public navigation rights exist;
- environmental protection and enhancement;
- and sensitivity to the special landscape character of the Broads.

The underwater conditions are an important feature for the safety and access of recreational boating. Therefore, sediment and water plant management are key areas for waterways management in the slow flowing, lowland rivers and broads. Important landscape and biodiversity factors at the edges of the waterways are the type and condition of bankside vegetation, such as reeds or trees. Management of the bankside vegetation for navigational purposes needs to be considerate of all current factors where presence of these habitats is an important feature. In the lower river reaches and through some larger broads, channel markers help define the managed channel. Differentiation of navigation conditions inside and outside of these marked channels allows for some different management, or even no interventions at all, outside these marked areas.

To help focus the Authority's work to meet waterway management objectives, a set of guiding principles have been developed when considering if, where and how operational activities are carried out. Through following these principles, this strategy and action plan sets out the evidence used, management actions required, natural processes to consider and multiple objectives to be gained, through all of the waterways management activities.

The finite level of Authority staff resource and cash budgets available for managing the waterways means that having a clear prioritisation process is critical. For each management activity the data gathering methods and prioritisation process are presented. Forward work plans can then be developed to meet objectives and priorities. The reporting and review process are also described.

2 Introduction

2.1 Geographic scope

The publicly accessible rivers, broads and channels within the Broads Authority Executive Area form the geographic extent of this strategic guidance and action plan for waterways management activities carried out by the Broads Authority. The character and usage of the different parts of these publicly accessible waterways varies considerably. This means that a fixed management approach would not give the best outcome for recreational users, environmental considerations or allow efficient deployment of Broads Authority resources.

The Norfolk and Suffolk Broads Act 1988, defines the navigation area as all navigable stretches of the rivers Bure, Yare and Waveney and their tributaries (rivers Ant, Thurne and Chet), including Oulton Broad, Haddiscoe New Cut, and the navigable part of the river Wensum in Norwich upstream of its confluence with the Yare. In addition to the main rivers, there are a range of broads, channels and dykes which have an established public right of navigation. However, given the complexity of private landownership and historical variation to access rights, simply using tidal variation within the Broads as a means of identifying where a public right of navigation exists is not wholly sufficient.

The navigational responsibilities for Breydon Water and the lower reaches of the Yare, Bure and Waveney were transferred to the Broads Authority from the Great Yarmouth Port Authority in June 2012. As a result, the boundary of the Authority's navigation area was extended to a limit just upstream of Haven Bridge on the river Yare. This point is also the current downstream limit of navigation for hire craft.

Mutford Lock, at the eastern end of Oulton Broad, marks the Broads Authority's boundary with the Port of Lowestoft managed by Associated British Ports (ABP). Mutford lock is now fully owned, managed and maintained by the Broads Authority following a transfer from ABP in 2021. The lock is currently operated under contract by East Suffolk District Council. The lock is almost exclusively used by private craft, with a small amount of commercial traffic. Hire craft are not permitted to pass through the lock.

The extent of the Broads Authority's navigation management responsibility does not include "adjacent waters" (Broads Authority Act 2009, Part 1 Sect. 2.2) nor areas excluded from the definition of the navigation area provided in the Norfolk and Suffolk Broads Act 1988 (Part 2, Sect. 8).

The Authority maintains the navigation area for the purposes of navigation to "such standard as appears to it to be reasonably required; and (b) take such steps to improve and develop it as it thinks fit". This strategy and action plan define the waterways management objectives and operational practices carried out.

2.2 Vision

The vision in the Broads Plan (2017-22) relating to navigation within the Broads waterways is that: -

“The past and present importance of the waterways for navigation, biodiversity and recreation is recognised and cherished, and the asset is protected, maintained and enhanced. Wildlife flourishes and habitats are maintained, restored, expanded and linked effectively to other ecological networks. Land and water are managed in an integrated way, with local and landscape scale management creating resilience and enabling flexible approaches to meet changing environmental, economic and social needs.”

To help break down this vision, three overarching aims are adopted for this strategy:

- User experience - The Broads Authority shall manage the navigation area so that users feel informed and safe, have an enjoyable experience and are able to appreciate the special qualities of the Broads environment.

- Sustainable management - The actions carried out by the Broads Authority shall be targeted so that resource use is efficient; have biodiversity protection and carbon reduction embedded throughout; and by working with landowners and other statutory bodies, ensure works are carried out according to current legislation and best practice. For the purposes of this strategy, the definition of sustainable management is to safeguard the special qualities of the Broads and that they are sustained for future generations to use and enjoy; using active engagement to ensure fairness and balance across user groups; and where interventions are carried out, seek to maximise environmental benefits.

- Transparency - The Authority shall monitor the condition of the waterways, have a clear, evidence-based prioritisation process for arranging work programmes and have open communication with stakeholders to incorporate user feedback. A five year plan shall be produced, with progress reported annually.

2.4 Drivers for waterways management

2.4.1 Norfolk and Suffolk Broads Act 1988

The Norfolk and Suffolk Broads Act 1988 sets out the general functions of the Broads Authority https://www.legislation.gov.uk/ukpga/1988/4/contents in Section 2(i):

It should be the general duty of the Authority to manage the Broads for the purpose of-

- Conserving and enhancing the natural beauty, wildlife and cultural heritage of the Broads;
- Promoting opportunities for the understanding and enjoyment of the special qualities of the Broads by the public; and
- Protecting the interest of navigation.

In discharging its statutory duty to maintain a safe navigation, a fundamental part of this provision is securing reasonable water depth. Section 10 of the Act states that the Authority shall

- Maintain the navigation area for the purposes of navigation to such standard as appears to it to be reasonable required;
- Take such steps to improve and develop it as it thinks fit.

Under Section 2, Schedule 5 (1) The Authority may –

- "Deepen, dredge, scour or excavate any part of the navigation area; and
- Sell, or otherwise dispose of as it thinks fit, any material removed from any part of the navigation area in exercise of its powers under this paragraph."

The Broads Authority has certain byelaws enforceable within the Broads navigation area and some affect adjacent waters. Speed limits have been in force throughout the Broads since 1992. The benefits of the Authority enforcing these byelaws are managing waterways safety, prevent bank erosion and reduce disturbance to wildlife. See https://www.broads-authority.gov.uk/__data/assets/pdf_file/0020/180632/Speed_Limit_Byelaws1992-1.pdf

2.4.2 User requirements

As previously set out in the 2007 Sediment Management Strategy (see https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/conservation-publications-and-reports/water-conservation-reports), the main requirement for waterways users was defined as sufficient water depth and width of river for most vessel types at most states of the tide. The dimensions for navigable areas were defined as the "waterways

specifications", with typical cross section diagrams showing the depth, width and non-managed margins for the separate management units.

2.4.3 Broads Plan

The Broads Plan (2017-22) sets out specific actions for maintaining and enhancing the navigation where the Authority has a significant role. These are:

- Implement dredging regimes in accordance with defined waterways specifications, and seek resources/legislation to accelerate the removal of sediment in the Broads system
- Implement plans and good practice guidance to reduce soil erosion into the waterways, manage areas lost or vulnerable to erosion, and dispose of dredged material in sustainable and beneficial ways
- Maintain existing navigation water space and develop appropriate opportunities to expand or extend access for various types of craft
- Carry out appropriate water plant cutting and tree and scrub management programmes and seek resources to increase operational targets
-

2.4.4 Protected species (national)

The main provision for the protection of species in the United Kingdom is the Wildlife and Countryside Act 1981 as amended. Amongst other things, the Act makes it a criminal offence to:

- intentionally kill, injure or take a wild bird or animal;
- intentionally or recklessly damage or destroy a nest, or place of shelter or rest for wild animals
- intentionally pick, uproot or destroy wild plants.

The measures apply to the birds & animals listed in Schedule 5 to the Act (for example in the Broads all bat species, otter and water vole), and to the plants in Schedule 8 (such as holly-leaved naiad).

2.4.5 Conservation of Habitats and Species

The European Union Habitats Directive ensures the conservation of a wide range of rare, threatened or endemic animal and plant species. Some 200 rare and characteristic habitat types are also targeted for conservation in their own right. In the Broads 28 sites covering a

total of more than 7,500 hectares are nationally designated as Sites of Special Scientific Interest (SSSIs). Most of these sites are of international importance for their habitats and wildlife as the Broads Special Area of Conservation (SAC) and the Broadland Special Protection Area (SPA). The SAC and SPA designations under the EU directives are protected in the United Kingdom via the Conservation of Habitats and Species Regulations 2010 (as amended). A sizable area of the Broads is also designated for its biodiversity as a "Wetland of International Importance" under the Ramsar Convention.

As a public body, the Authority has a duty to take reasonable steps to conserve and enhance the special features of SSSIs when carrying out its statutory duties. Impacts of planned works need to be assessed and assent sought from Natural England, if the works are likely to cause damage to or affect the condition of a designated site. Where an SSSI is also a Protected or Ramsar site, a Habitats Regulations Assessment will also need to be carried out to determine whether a likely significant effect will occur from the activity, on the protected site; this also applies to works close to protected sites.

2.4.6 Port Marine Safety Code

The Broads Authority is defined as a Competent Harbour Authority under the Pilotage Act 1987. As such, the Authority is required to comply with the duties and responsibilities set out in the Port Marine Safety Code (PMSC). See the webpages for more information on the PMSC https://www.broads-authority.gov.uk/boating/navigating-the-broads/safety/port-marine-safety-code

The Authority developed a Safety Management System which identifies all hazards related to marine activity and is required to carry out a risk assessment and put in place measures to reduce these risks as far as is reasonably practicable. The requirement for the Authority to control the hazards identified in the Safety Management System risk assessment contributes to the management principles and actions outlined in this strategy and action plan. See the website for more information on the Safety Management System https://www.broads-authority.gov.uk/__data/assets/pdf_file/0021/252453/SMS-version-7.0.pdf

Specifically focussed on waterways management, the PMSC requires the Authority to undertake hydrographical surveys and maintenance dredging to ensure that the hydrographic regime is protected. Navigation authorities have a statutory duty to respond to pollution incidents in their waters. The Broads Authority's Oil Spill Contingency Plan https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/water-quality/?a=183795 is intended to guide staff and other responsible organisations through managing an oil spill in navigable parts of the Broads network. Other pollution incidents on the Broads waterways are reported to the Environment Agency.

2.5 Developments in legislation and policy

2.5.1 Broads Authority Act 2009

Since the production of the Sediment Management Strategy in 2007, the drivers which shape how the Authority works and the way in which priorities are set has changed.

Notably over this time the Broads Authority Act 2009 was passed through parliament. The 2009 Act supplements the 1988 Norfolk and Suffolk Broads Act and gave the Authority various new powers, including the following of relevance to waterways management:

- giving the Haddiscoe Cut a public right of navigation
- made possible the transfer responsibility for the navigation on Breydon Water and sections of the lower Yare, Bure and Waveney from the Great Yarmouth Port Authority, with navigational responsibilities transferred to the Broads Authority in June 2012.
- gave powers to manage vegetation on private land where overhanging trees or shrubs either endanger or cause significant obstruction to the passage of vessels

2.5.2 Conservation of Habitats and Species Regulations 2010

The Conservation of Habitats and Species Regulations 2010 make it an offence (subject to exceptions) to deliberately capture, kill, disturb the animals listed in Schedule 2 (includes all bats and otter as examples in the Broads). However, any actions which may disturb these species can be made lawful through the granting of licenses by Natural England. Licenses may be granted for a number of purposes (such as science and education, conservation, preserving public health and safety), but only after Natural England is satisfied that there are no satisfactory alternatives and that such actions will have no detrimental effect on wild population of the species concerned.

2.5.3 Broadland Rivers Catchment Plan 2014

Following the formation of the Broadland Catchment Partnership, hosted by the Broads Authority, the Broadland Rivers Catchment Plan was produced in 2014. This plan has as its first aim to improve in land management to reduce run-off and soil loss to water, which was a major objective of the 2007 Sediment Management Strategy. The network of partners and activities funded from a variety of sources within the wider Broadland Rivers catchment has generated benefits for sediment management of greater value than could be achieved by the Broads Authority in isolation.

2.5.4 Broads Biodiversity and Water Strategy (2019-2024)

In July 2019 the Authority adopted the refreshed Broads Biodiversity and Water Strategy and Action Plan. See https://www.broads-authority.gov.uk/__data/assets/pdf_file/0029/180965/broads-biodiversity-strategy-2019.pdf. The Action Plan focuses on priorities for the Broads Authority as a lead or joint delivery partner, as well as on key conservation projects led by other organisations working within the Broads. Future benefits intended to arise from identified actions in the plan, of direct relevance to waterways management activities includes: -

- Larger areas of reed swamp to provide better habitat for wildlife such as bittern and protecting shallow areas so water plants can grow in sheltered conditions
- Restoration work to increase the diversity of water plants, improving the aquatic environment for species and enhancing wildlife viewing opportunities for visitors
- The many environmental benefits of clear water for people, habitats and wildlife are continued
- Resilient river habitat is supporting a sustainable, balanced and healthy fishery
- Wildlife (particularly fish) breeding, wintering and feeding areas are improving
- Priority invasive non-native species are being eradicated or controlled to manageable background level to protect biodiversity, water flow and navigation

Where there are opportunities to achieve multiple objectives through the planning and implementation of waterways management activities, then these biodiversity benefits will be incorporated.

2.5.5 Environmental Permitting (England and Wales) Regulations 2016

The Environmental Permitting (England and Wales) Regulations came into effect in 2016 to streamline the legislative system for industrial and waste activities into a single permitting structure for those activities which have the potential to cause harm to human health or the environment. As dredged sediment from rivers is classed as a waste, meeting the requirement of the regulations has necessarily meant some project planning and application requirements have changed. More information on placing dredged sediment on riverbanks can be found on the Environment Agency website https://www.gov.uk/guidance/d1-waste-exemption-depositing-waste-from-dredging-inland-waters.

2.5.6 Water Environment (Water Framework Directive) Regulations (2017)

River Basin Management Plans have been produced by the Environment Agency, in consultation with partners, to meet the aims of the Water Framework Directive. The plans

are a single system of water management divided by natural geographical and hydrological unit, instead of according to administrative or political boundaries.

The regulations require that all inland and coastal waters, such as within the Broadland catchment, must reach at least good status. The catchment plans include a definition of how good status should be achieved, through the establishment of environmental objectives and ecological targets for surface waters.

The 2017 update to the original 2003 regulations imposes duties on the Environment Agency to carry out certain functions so as to ensure compliance, in particular when deciding whether to grant, vary or revoke certain permits and licences which affect water quality. When carrying out waterways management actions, the Broads Authority frequently needs to seek permits from the Environment Agency. Activities include application of herbicides near water, operating on flood defence assets and the treatment of dredged sediment.

2.5.7 Climate Emergency Declaration 2019

In 2019 the United Kingdom government declared a climate emergency, with the Broads Authority and Norfolk and Suffolk county councils following suit with their own policy announcements aimed at reaching net-zero carbon emissions by 2030. A carbon budget produced for the Broads Authority's own internal carbon emissions showed that over 50% of the total carbon emissions were generated by the vehicles, plant and vessels involved with waterways management. This has provided a focus for action to reduce these emissions whilst keeping up with waterways maintenance priorities.

3 Principles of waterways management

3.1 Overview

To help focus the work required to meet waterway management objectives in the Protected Landscape of the Broads, a set of guiding principles have been developed when considering if, where and how operational activities are carried out. Achieving the safety requirements needed by waterways users and maintaining standards of river channel management across the whole of the navigable system is an on-going process. The Broads environment is highly dynamic and often the navigation management interventions simply alter environmental conditions to meet particular objectives. Hydrological and ecological processes then typically work to return conditions to a more natural state. As this strategy is largely concerned with routine maintenance of river channel conditions to meet the various objectives of users, biodiversity and water quality, the rotational aspect of management interventions will mean that a range of habitat and vegetation conditions will always exist at the wider spatial scale. Achieving Best Value for the Authority and creating gains for the natural capital of the Broads are driving forces for all management activities. Natural capital refers to the elements of the natural environment which provide valuable goods and services to people. For example, a reedbed can be regarded as a natural capital asset, from which flows valuable benefits, or ecosystem services, such as water quality improvements and carbon capture. The principles in Table 1 help to meet the complex challenges of managing the Broads waterways. Additional detail is given on the background to each principle and intended direction of travel in the following sub-sections.

Table 1. Waterways Management guiding principles

Guiding principles	Implementation challenges
Aims and objectives for managing the waterway are clearly communicated	• Waterways have multiple functional objectives and sometimes conflicting requirements • Understanding when managing the cause or a symptom
Evidence is used to guide management actions	• Need to assess the gap between conditions in the waterways and the desired state • Are there additional sources of evidence or changes in policy which need to be considered • Options appraisals to include considerations of Best Value and impacts on natural capital

Guiding principles	Implementation challenges
Management actions are defined and targeted to meet the aims	• Waterway management specifications need to be clearly defined • Relative priority of particular locations and the scope of works needs to be planned
Management actions take into consideration natural processes	• Aim to work with natural process, rather than against them • Use best practice to reduce environmental impacts • Adopt proactive biosecurity measures to reduce risk of spreading invasive non-native species
When management action is taken, aim to deliver multiple objectives	• A broad consensus can be gained through delivering multiple objectives • Consider trade-offs and sometimes deciding not to deliver everything everywhere • Waterways are part of the mosaic of wetland habitats and are not considered in isolation • Understand the impacts that recreational demands can have upon the Broads environment, its natural capital and public enjoyment • taking a wider catchment approach where this allows long-term again and sustains investment in the Broads protected landscape
Learn and adapt	• Regularly report progress and review the effectiveness of the work carried out • Utilise evidence to guide future decisions

3.2 Aims and objectives for managing the waterways

As set out in Section 2.2, the overarching aims of this strategy are to: -

- provide a positive and safe experience for waterways users
- to carry out sustainable management of the waterways
- and ensure transparency in decision-making and reporting

A series of specific delivery objectives related to these aims are embedded in the tables within Section 4. Section 4 introduces the different waterways management techniques regularly carried out within the Broads.

3.2.1 Using evidence to guide management actions

Whether above or below the waterline, the condition, quality and special features of the rivers and broads needs to be understood, if the maximum benefit is to be gained from management actions carried out. Some examples are given here.

Measurement and mapping of water depth is obtained through hydrographic surveys. The current minimum standard for these surveys is to provide a set of points with a maximum density of a 1 m spatial grid, corrected to Ordnance Survey (OS) vertical datum at Newlyn (ODN).

See the Authority web pages for the published maps showing water depth across the Broads https://www.broads-authority.gov.uk/boating/navigating-the-broads/water-depths. Water depths are published relative to mean low water level, see section 4.1.2 for more details. The information has been published by the Broads Authority in order to meet its duties as a harbour authority with particular attention to the requirements of the Port Marine Safety Code.

Above the water line, the vertical air draft available for vessels passing under bridges is also key information communicated to waterways users. Gauge boards either side of each bridge indicate the clearance height at the current state of tide/water level. Typical clearance heights for each bridge relative to mean summer high water are published on the Authority web page here https://www.broads-authority.gov.uk/boating/navigating-the-broads/bridge-heights-and-opening-times.

For riverside tree management an approach to categorising and prioritising riverside tree and scrub management has been produced and is shared on the Broads Authority website https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/riverside-tree-and-scrub-management. Each river valley is surveyed to determine the types of habitat present and the work required to make improvements for navigation safety. Each stretch of river is prioritised to reflect how soon the work should be undertaken. Survey notes are also taken regarding ecological features to retain, such as trees with bat potential, scrub

overhanging the water where there is low impact on navigation, fish spawning features and other points of conservation interest.

Where water plant management is required to maintain navigational access, cutting locations are identified through working with the waterways users, statutory partners including Natural England, and draws heavily on a range of environmental monitoring carried out by the Broads Authority. Water plant management is very much a responsive activity, with the work programme varying each season, depending on where the plants occur. Given the sensitivity of fish and other aquatic life to the operational impacts on water quality, such as changes to suspended sediment and dissolved oxygen levels, working within best practice environmental guidelines is important. More information is on the webpages https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/water-plant-cutting.

3.2.2 Management actions are defined and targeted to meet the aims

The 2007 Sediment Management Strategy generated the concept of waterways specifications, which describe the target water depths to be maintained in particular sections of the rivers and broads.

The user-defined waterway specifications were developed in partnership with user representatives to:

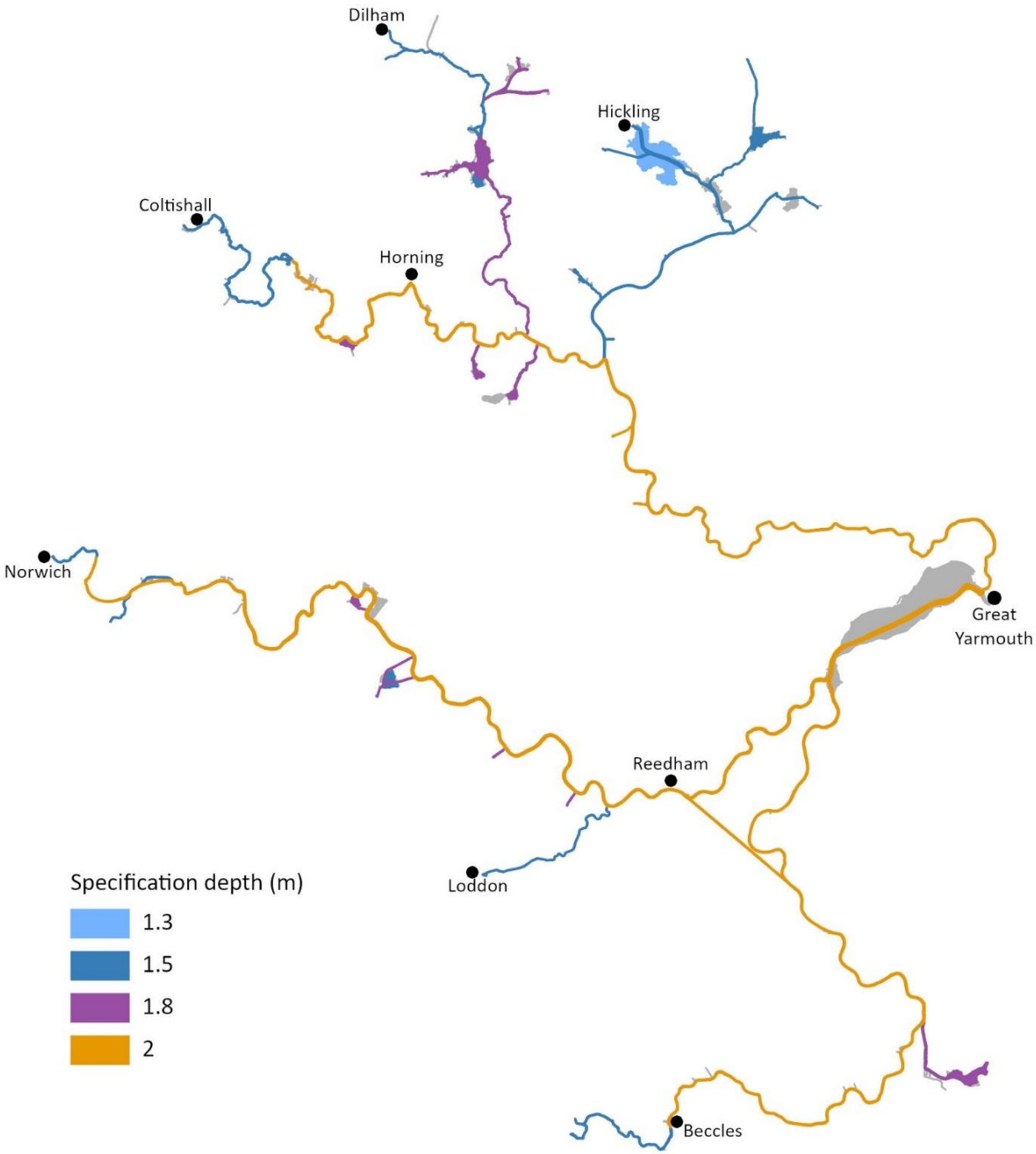
- Provide a straightforward and transparent rationale for works
- Facilitate provision of information to the public
- Allow agreement of partners at a strategic level to simplify site specific discussions
- Help to quantify programmes of works and longer-term financial budget plans.

The target depths for different river stretches has been reviewed since 2007, typically as new evidence or user requirements have become clearer. The most up to date map is given in Figure 1.

As well as the depth of water, other dimensions of the physical space in which vessels operate need to be understood and defined. Together these features form the “navigable envelope” and includes: -

- width of river (bank to bank)
- height of water plants growing from the bed
- width of emergent and water plants growing at the river edges
- distance of tree growth over the river edge and overhanging the water

Figure 1. Map of the waterways specification depths for rivers and broads



As the above features are all driven, wholly or in part, by natural processes, a considerable variation in any one or all of these features may be observed within a river stretch at any one time. As such the management required to maintain minimum standards will be rotational over different timescales. For example, water plant cutting is focussed at high priority locations within the growing season each year (May-September), whilst for riverside tree management priority management action is spread across a five year work programme.

Breaking down the whole of the Broads navigation into smaller Management Units helps in the prioritisation and reporting processes. Sections of river with consistent channel type, recreational usage and landscape character have been identified and are shown in the table at Appendix 4.

3.2.3 Management actions take into consideration natural processes

The requirement to manage a river channel arises when some aspect of the river type, character or the vegetation it supports, does not meet a particular management objective. The types of natural process which have the potential to interact with waterways specifications includes: -

- water plant growth within the waterbody – comprising both wholly submerged plants and those emerging from shallow water
- erosion protection - having a buffer area of submerged and emergent plants at the river edge helps to reduce the impacts of waves and water flow
- succession of plant communities on riverbanks - for example wet woodland would be the ultimate plant community in most parts of the Broads if left to entirely natural processes
- channel hydro-morphology – the erosion/sedimentation processes working to shape the river according to water flow rates, local soil types and existing channel features
- sediment deposition and accumulation in very low energy areas, particularly the open water of the broads themselves
- Breydon Water is a unique estuarine/saltmarsh feature in the Broads, with its own hydrological regime and sediment dynamics, supporting one of the largest winter wetland bird populations in the UK
- Biosecurity risks from non-native invasive species needs to be considered for all operational work. The Biosecurity Environmental Standard Operating Procedure is available here https://www.broads-authority.gov.uk/__data/assets/pdf_file/0020/196211/Biosecurity-Guidance-Draft.pdf

Working with natural processes can reduce on-going maintenance effort and achieve other benefits such as for biodiversity. However, the objectives to achieve adequate and safe navigation space for users often run counter to natural processes, so seeking opportunities and adopting best environmental practice is critical during the planning phase of maintenance works.

3.2.4 When management action is taken, aim to deliver multiple objectives

All Broads Authority strategies and action plans contribute to achieving the aims and objectives of the Broads Plan https://www.broads-authority.gov.uk/about-us/how-we-work/strategy. The areas where waterways management activities can make the most positive contributions to Broads Plan objectives are: -

Reducing our carbon footprint

In 2019 the Authority resolved to work towards making the organisation 'carbon neutral' by 2030, with a further objective of reducing all carbon emissions to zero by 2040. Of the internal carbon budget calculated for 2018/19, over 50 % of the emissions came from fuel used for transport and operational work. Waterways management activities utilise the greatest volume of diesel fuel across all Authority's operation work areas, so carbon reduction actions in this area are critical to meeting the "zero emission" objective.

To facilitate the financial and technological changes required to meet these challenging targets, "carbon pricing" is a financial tool that aids this process by allowing:

- The environmental and social costs of carbon emissions to be quantified
- The responsibility of emissions to be shifted back to the emitter instead of society at large, known as the "the polluter pays principle".

Independently from governmental regulation, businesses or organisations may voluntarily impose a carbon price on their own operations – this is internal carbon pricing. An internal carbon pricing system can be used to inform strategy and cost-benefit analyses, providing a clear financial incentive to invest in cleaner, more efficient operations. It can also allow organisations to "get ahead of the curve" by preparing for additional governmental regulation of emissions in the future.

The most common internal carbon pricing model globally is shadow pricing, where a hypothetical monetary value reflecting the negative environmental impact of emitting one tonne of carbon is factored into strategic decisions. A 2019 policy report published by the London School of Economics concluded that "a shadow price consistent with a net-zero target would start at £50 per tonne of carbon dioxide (tCO2) (with a range of £40–100) in 2020" (How to price carbon to reach zero-emissions in the UK - 2019 policy report, LSE).

For the financial year 2020/21, the cost of diesel for Authority vessels and equipment was £29,621, producing 179.8 tonnes of CO_2eq emissions. With a shadow carbon price of £50/tonne, the carbon cost of these emissions is £8,990. Adding this hypothetical cost to the cost of fuel leads to a 30% increase in overall cost of diesel for Authority vessels and equipment. This data is summarised in Table 2. Therefore, if this internal carbon price is adopted, a sustainable measure to significantly reduce the carbon footprint, such as use of biofuels, would be financially justified if the biofuels cost was less than 30% more than the standard diesel.

Table 2. Diesel used for operational vessels and equipment, financial year 2020/21

Cost of fuel (£)	Volume of fuel (L)	CO2e emissions (tonnes)	Carbon cost (£)	Cost of fuel + carbon cost (£)
29,621	65,198	179.8	8,990	38,611

The Broads Authority already understands its own greenhouse gas emissions profile, and has established science-based target initiatives for emissions reduction. Total Broads Authority operational emissions are estimated at 619 tCO_2eq per year (Climate Change action plan July 2020 report https://www.broads-authority.gov.uk/__data/assets/pdf_file/0022/330088/Climate_Change_action_plan-ba240720.pdf). Setting a carbon shadow price at £50/tCO_2eq, the carbon cost of Authority emissions is £30,950 per year.

Utilisation of internal carbon pricing in the strategic planning and cost-benefit analyses for investments, such as fuel, heavy plant and vessels, would allow the Authority to financially incentivise selection of low-carbon technologies that may be more expensive than traditional (fossil-fuelled) options. This shadow price should be set to at least £50/tCO_2eq to align with net-zero targets and reported recommendations.

Habitat restoration/creation

Beneficial re-use of dredged sediments has been a project design concept well utilised in the Broads, with two European Union funded projects participated in during the past decade. Creating a reed margin at Salhouse Broad through the PRISMA project https://www.broads-authority.gov.uk/looking-after/projects/prisma, then led to a larger-scale lake restoration project with recreation of a one hectare reed swamp at Hickling Broad, as part of the CANAPE project https://www.broads-authority.gov.uk/looking-after/projects/canape. Both projects revolved around "building with nature" and delivered multiple benefits for users and biodiversity.

Eroding riverbanks can be rebuild or protected with "soft" erosion protection construction techniques utilising dredge sediments. See the guidance leaflet https://www.broads-

authority.gov.uk/__data/assets/pdf_file/0025/218581/Riverbank-stabilization-guide_Final_21_01_2016.pdf. Opportunity also exists to restore historical river dredging disposal sites, where wetland habitat restoration and sediment re-use benefits can be gained.

Environmental Protection

Operational best practice and guidance has been produced by the Broads Authority to ensure that its waterways management activities do not detrimentally impact on the characteristic landscape, wetland environment and biodiversity features of Broads. The Environmental Standard Operating Procedures https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/conservation-publications-and-reports/environment-standard-operating-procedures cover all the major operational areas which have potential to cause environmental or ecological harm. The guidance is reviewed annually and forms a contributory part to how the Broads Authority implements the tasks and projects generated through this Waterways Management Strategy and Action Plan. The guidance is generic across all operators in the Broads, so can be used by individuals or organisations to help guide their practical works. Please note that for third parties using this guidance, where consents or permits are required to carry out works, all responsibility rests with the applicant.

3.2.5 Learn and adapt

The Waterways Management Strategy builds upon the 2007 Sediment Management Strategy and pulls together all of the management requirements to best manage the navigable envelope. This more holistic management approach is the result of learning and adaptation in how waterways management work is planned and implemented.

Being able to adapt how the Broads waterways are managed will enable a range of objectives to be met and gain value for money. For example, the development of the Broadland Catchment Partnership and Plan has been a major step towards the strategic aim of balancing the inputs of sediment into the Broads with that removed from the waterways through dredging.

4 Management techniques

4.1 Sediment management

4.1.1 Objectives

Sediment transport and accumulation in the rivers and broads is a highly dynamic process. Numerous environmental parameters, such as tides, rainfall, water quality, land use and physical disturbance of the riverbanks all contribute to the rate and location of sediment erosion and deposition. To ensure adequate water depth for navigation, the Authority intervenes in these processes to remove sediment accumulations which impact on waterways users.

Whilst the Broadland Catchment Plan has a focus to reduce soil loss in the wider Broadland rivers catchment, there are still sources of erosion and sediment generation within the rivers and broads themselves. These internal sources and recirculation of previously deposited sediments will mean that some sediment shall always accumulate at certain locations.

Table 3 lists the objectives to meet the sediment management challenges over the next five years.

Table 3. Sediment management objectives

	Objective	Action	When
1A	Obtain high quality hydrographic data to ensure up to date bathymetry of the navigable rivers and broads	Conduct hydrographic survey of rivers and broads as per the rolling programme. Targeted re- survey of areas dredged in past 12 months	Annually. Dec-Feb
1B	Identify areas of the navigation not meeting waterway specifications	Use hydrographic data to complete the mapping and quantification of sediment not meeting the waterway specifications	Annually. May
1C	Update hydrographic charts for public information and safety	Refresh charts and make available here https://www.broads-authority.gov.uk/boating/navigating-the-broads/water-depths	Annually. June

	Objective	Action	When
1D	Generate a forward dredging programme to maximise compliance with the waterways specifications	Refresh prioritisation matrix with updated sediment volumes and locations to guide the dredging work plan for the next financial year	Annually. July
1E	Obtain the best available data to calculate mean low water level	Follow programme of water level data collection at heads of navigation; or obtain third party data	Annually. October
1F	Report to Navigation Committee on progress against the planned dredging programme and updated prioritisation list	Quarterly reporting on work programme progress to Navigation Committee Annual reporting of previous years completed work programme Annual review of waterways specification compliance and revised dredging prioritisation list	Each meeting June September

4.1.2 Evidence

Measurement and mapping of water depth is obtained through hydrographic surveys. See the Authority web pages for the published maps showing water depth across the Broads https://www.broads-authority.gov.uk/boating/navigating-the-broads/water-depths. The information has been published by the Broads Authority in order to meet its duties as a harbour authority under the Port Marine Safety Code and the requirements of the UK Hydrographic Office.

The current minimum standard for these surveys is for a dataset processed to provide a set of points with a maximum density of a 1 m spatial grid corrected to Ordnance Survey (OS) vertical datum at Newlyn (ODN).

To aid the reporting of compliance against Waterways Specification targets, the navigation area has been broken down into Management Units. These are definable stretches of river, individual broads, or marked channels within broads, where there is some level of uniformity of usage or general character.

As water levels vary daily and seasonally, a modelled water level that can be used as a standard reference is required when setting a target depth in each management unit. To ensure that the specification depth is present at most states of tide, the reference water level is taken as the average level at low water (or mean low water). Data from river level gauges operated by the Environment Agency has been used to calculate "mean low water level" at 18 stations across the navigable system. The Authority also gathers data at other key locations to fill in the gaps in coverage.

There are two important metrics for determining how well a management unit is meeting its water depth specification. Both are calculated through GIS computer modelling of the hydrographic survey data and the set dimensions of the waterways specification (see Appendix 1). The first is the percentage area compliance to the specification depth within the area of each management unit. The second is the proportion of the non-compliant area having a sediment height of greater than 30 cm above target, indicating a substantial accumulation and therefore significant deviation from the waterways specification.

These waterways specification compliance metrics are used to prioritise the dredge requirement across all of the management units. Two additional factors are brought into this prioritisation matrix. First is a simple numeric score (1 = low, 2= medium, 3 = high) indicating the level of waterway use, as determined through the four yearly Broads boat census. Second is a numeric score (1 = low, 2= medium, 3 = high) for the number of reported groundings or depth related issues within the managed channel.

These four values are multiplied, with each management units result ranked high to low, to give the priority order of sites. This method prioritises sites that have the greatest need to achieve waterways specification where users will gain most benefit from dredging. See Appendix 4 for the full table of management units prioritised in rank order according to this methodology.

This process provides a coarse filter when considering site-specific issues but will nevertheless assist in determining the priority of schemes. Each site-specific project will then need to be put through a design and feasibility process. Formulating a final programme is likely to be iterative, with identification of appropriate working practices, environmental mitigation measures and permitting requirements. All of which will then influence budgets, allocation of equipment across other projects and timing of works.

4.1.3 Management actions

Four main options are considered for sediment management. These are;

- Do nothing
- Source control (bank erosion protection, sediment and run-off reduction in the catchment)

- Dredging (physically remove sediment from where it has accumulated)
- Channel management options (strategic use of channel markers, clarity on waterways specification and where these are applied)

Each option was considered with the following conclusions drawn.

Do Nothing

The navigable rivers and broads are classified under the Water Framework Directive as heavily modified waterbodies, which require continued management to protect people and their livelihoods and the wildlife that has adapted to these managed conditions. The "do nothing" option is therefore inappropriate and unacceptable; however, it might be the correct action for some isolated waterbodies or areas of high biodiversity value or potential.

Source Control

Whilst source control measures undoubtedly represent the most sustainable way to manage sediment, achievement of wider benefits make this approach a long term option. For more details on specific action and priorities, see the Broadland Catchment Partnership webpages https://broadlandcatchmentpartnership.org.uk/. Furthermore, source controls will neither resolve internal redistribution of sediment or bankside erosion so must be used in combination with other options.

Dredging Techniques

Whilst dredging is an effective technique for managing sediment, the logistical, sustainability, regulatory and cost efficiency challenges associated with individual projects and the longer term programme are significant. Project planning tasks such as locating appropriate sites for sediment re-use; adapting to changes in legislation; procuring, operating and maintaining suitable dredging equipment; and gaining landowner agreements, all require a range of professional skills and experience to create a sustainable dredging programme.

The current in-house operational capability of the Broads Authority for delivering dredging projects is based around pontoon mounted, long-reach excavators which dredge and re-handle sediment. For transport of dredged material from the waterway to the re-use location, a combination of wherries and a concrete pump are used. Wherries can feasibly transport material several kilometres from one location to another; whilst the concrete pump is used to off-load sediment to areas further away from the river than excavators can reach on their own. This approach gives operational flexibility to meet the demands of a range of different locations and sediment re-use scenarios.

Hydrodynamic dredging, or using the river current to disperse sediments which have been physically agitated into the flow, is an option in the faster flowing rivers near Great Yarmouth. Sediment managed in this way is carried downstream, emulating the natural

transportation of sediment in a river. A proportion of the sediment will ultimately be transported out sea via Great Yarmouth, with heavier particles redepositing closer to the dredge site. Use of water injection dredging contractors has been successfully utilised on the rivers Bure and Waveney near to Great Yarmouth. As a rule of thumb, this technique can only be used effectively up to ten kilometres by river from Great Yarmouth (Haven Bridge) and strictly on an ebb tide. As such, only shoals and isolated areas can be effectively managed using this technique, as redeposition the sediment can be high if working outside these constraints.

Channel management options

Different ways of thinking about channel management, other than dredging, may be considered where there is scope to do so, such as where river width is sufficient to accommodate a different definition of the width or position of the managed or marked channel. This is a sustainable option which potentially allows for the natural river channel processes or erosion and sediment deposition to operate, whilst ensuring a clearly defined, safe channel and river space is sufficient for waterways users. This approach is already utilised, particularly in the lower reaches of the Broadland rivers. In such locations channel markers indicate the line of the managed channel and areas outside the markers are not subject to management or reporting against waterways specification targets. For more information of this technique, see section 4.5.

The waterways specifications and definition of management units outlined in this strategy is one way in which the Authority has learnt and adapted its processes. Balancing the waterways usage and need for maintenance is aided by greater use of detailed GIS modelling of actual waterways depths, location of aids to navigation and target profiles for channel maintenance.

4.1.4 Taking into consideration natural processes

Siltation within the Broads does not occur uniformly across the riverbed. River channels scour sediment in areas of high flow and deposit it in areas of low flow, such as the insides of bends. Shoals, or areas of sediment deposition, are natural phenomena and are often home to the greatest range of aquatic life, such as emergent water plants, waterfowl nesting spaces, vulnerable mollusc populations and fish spawning habitat. To preserve such features in the river profile, the definition of non-intervention margins, and the 1:2 slope between margins and managed channel, are used throughout the navigable system.

4.1.5 Aim to deliver multiple objectives

The most sustainable projects involving dredged sediment are those that deliver multiple benefits. Examples of such projects are: working with Norfolk Wildlife Trust at Hickling Broad to recreate a one hectare reed swamp at Chara Bay; rond level reedbed creation at

Peto's Marsh at Suffolk Wildlife Trust's reserve at Carlton Marshes; and supplying sediment at strategic locations for the Environment Agency's flood bank strengthening or crest raising programme. Working with partners to ensure added value is achieved in all stages of these projects and promoting all of the Broads Authority's statutory duties is an important objective of this strategy.

4.1.6 Five-year work plan

Current outline dredging plans extend to 2025/26, as shown in Table 4. With the refreshed dredging prioritisation process and recalculated sediment volumes presented in this strategy, as summarised in Appendix 4, refinement of this forward plan will be completed by July 2022 and updated annually.

Table 4. Dredge work programme to 2025/26

Date range	Site	Dredge Volume (m^3)
Apr – Aug 2022	Oulton Broad	10,000
May 2022 – Aug 2023	River Ant (Stalham Dyke/Sutton Broad)	24,500
Sep 2022 – Feb 2023	Bure (Wroxham – Coltishall)	15,000
Apr – Aug 2023	Oulton Broad	10,000
Sep 2023 – Jan 2024	Bure (Wroxham – Coltishall)	15,000
Dec 2023 – Feb 2024	River Yare	2,500
Mar – Jul 2024	Oulton Broad	5,000
Apr – Jul 2024	River Waveney	5,500
Aug – Sep 2024	Bure (Wroxham – Coltishall)	2,000
Sep 2024 – Jan 2025	River Ant (Wayford – Barton)	8,500
Mar – Sep 2025	Waveney (Geldeston – Beccles)	7,000
Nov 2025 – Apr 2026	South Walsham Broad	9,500

4.2 Water plant management

4.2.1 Objectives

The Broads Authority manages the Broads waterways, providing clear access along the main rivers and within the marked channels through open broads. Submerged or floating leaved water plants form an integral part of this open water environment, providing food for birds and refuge for fish and a multitude of invertebrates.

After four decades of water quality improvements, clearer water conditions are being experienced in many of the rivers and broads. This allows more light to penetrate through the water. Where conditions are suitable, this leads in turn to an increase in the growth of water plants. However, where water plants grow in dense beds, they can occupy a significant part of the river profile. If these plant beds occur within navigable areas, this can cause access issues for boats and other waterway users. Where growth occurs within the managed channel, the Broads Authority seeks to manage the impacts on navigation through cutting and removing this material.

The Authority aims to maintain navigation through a programme of annual water plant cutting, focused on the most significant areas of growth and guided by robust environmental operating procedures to ensure impacts to the habitat are managed and minimised. For more information see https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/water-plant-cutting.

Table 5 lists the objectives to meet the water plant management challenges over the next five year.

Table 5. Water plant management objectives

	Objective	Action	When
2A	Routine water plant cutting programme delivered each year for the historic areas of most significant growth	Completed method statements and mapping for the operational activity; all relevant permits and consents obtained; work to the latest Environmental Standard Operating Procedure https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/conservation-publications-and-reports/environment-standard-operating-procedures	April

	Objective	Action	When
2B	Maximise the beneficial re-use of the cut material	Where possible, seek composting or other sustainable outcomes for the cut material	On-going, site specific
2C	Communicate with stakeholders before initiating water plant cutting in new areas of the navigable waterways	Engagement with landowners, stakeholders and statutory bodies is required; environmental considerations to be considered alongside navigation requirements when developing new cutting activities	On-going, site specific
2D	Increase user's awareness of the navigational hazards and biodiversity value of water plant growth	Agree with stakeholders where signage may be most usefully installed Communication with boating interest groups to share locations of most impact and to consider management options available Awareness raising through publications, website and social media;	On-going, site specific
2E	Monitor water plant distribution and growth in Hickling Broad	Complete hydroacoustic survey of the broad Share mapping with stakeholders Share with stakeholders the survey information on the percentage cover of water plants, as exceeding threshold levels of plant cover triggers the cutting in the marked channel	June
2F	Monitor impacts of water plant cutting in terms of species present and changes in their abundance	Survey water plant species in the cut sections of the main rivers (rotational survey programme with sites visited at least every three years) Report on the species and abundance data for managed river stretches (river section within the Broads Annual Water Plant Survey report)	June December

	Objective	Action	When
2G	Respond to seasonal variation in water plant growth and manage flexibly in line with local priorities	Rangers to monitor water plant growth levels and report where impacts on navigation are experienced Maintenance team to deploy water plant harvesters as requirements demand	April - October
2H	Track resource usage to meet annual demands and help plan future requirements	Report to Navigation Committee on total staff days utilised on water plant cutting Track trends in water plant growth and area managed so resource allocation is sufficient to meet demands	October On-going

4.2.2 Evidence

Current locations where water plant growth meets the impact criteria are: -

- River Bure – Coltishall Lock (head of navigation) down to Wroxham
- River Ant – Tyler's Cut to downstream of Wayford Bridge
- Upper Thurne – Somerton Dyke down to Martham Ferry; Waxham Cut; Catfield Dyke; marked channel in Hickling Broad (June to August)
- Rivers Wensum and Yare – New Mills (head of navigation) downstream to Thorpe St Andrew (River Green stretch)
- River Waveney – Geldeston to downstream of Beccles

4.2.3 Management actions

Cutting water plants and removing the arisings works to maintain a water depth that is largely unrestricted for the passage of most boats. The water plant harvester vessels can cut at variable depths, up to a maximum depth of 1.5 m below the waterline, aiming to meet the waterway specifications for that management unit. Variation in water levels needs to be considered at the time of cutting so that any drop in water level doesn't then cause issues of growth not being cut to specification. Given the large area of the Broads navigable network suitable for water plant growth, and the rapidity with which they can grow, cutting is always reactive and water plants can soon reappear.

The environmental standard operating procedures that guide the work state that water plants will not be cut any lower than 30 cm from the bed of the channel (this is increased to 40 cm for Protected Sites), to ensure plant biomass and root networks are left in situ. See

https://www.broads-authority.gov.uk/__data/assets/pdf_file/0036/259938/1-Cutting-Water-Plants-ESOP.pdf.

Cutting within Protected Sites requires assent from Natural England and the Authority works closely with all stakeholders to balance access requirements for boats with the need to protect wildlife within the Broads.

Arisings from cutting are typically placed in low heaps (less than one metre high) on the bankside of the manged waterways. Given the structurally weak stems and leaves of water plants, they quickly dry out and shrink.

The Authority currently operates two water plant harvester vessels. Some flexibility in the internal resource use and potential to increase the time allocation to this management task is possible. However, the current annual programme is almost at capacity in terms of vessel resource, especially as most areas with water plants tend to peak in growth at the same time, between mid-June to early August.

4.2.4 Taking into consideration natural processes

Typical water plant growth is cut in the peak growing season but not eradicated entirely, ensuring the biodiversity and sediment stabilisation benefits remain. Viable habitat with physical structure, food availability and shelter for aquatic species is important, such as for invertebrates, fish and waterfowl. The root network and plant growth above the channel bed reduces sediment transport downstream, through binding the sediment together and reducing the flow velocity across the sediment surface. Water plants growing at the margins of rivers help to reduce bank erosion and decrease the input of sediment into the waterways.

During cutting, daily measurements are taken for water temperature and dissolved oxygen levels to ensure that conditions are not deleterious for fish and therefore are safe to carry out management activities. If background conditions are outside of best practice and regulatory guidance, the timing and or location of the works can be changed.

4.2.5 Aim to deliver multiple objectives

Within the Broads Biodiversity and Water Strategy, the biodiversity objectives listed in section 2.5 (page 11) all feature the benefits of a diverse and robust water plant community. Cutting is targeted so that only the portion of the plants actually having a direct impact on the channel are managed. Through defining the scope of activities to manage water plants in line with waterways specifications, the benefits of water plants for biodiversity and water quality are retained.

Where opportunities exist, composting the waste is carried out via third parties. Further work to develop this benefit is required, see objective 2B.

4.2.6 Five-year work plan

The routine annual work programme will include the existing priority stretches of river listed. If additional sites meet the impact criteria and cause a demonstrable, significant impact on navigational access or safety, then the procedures outlined above will be put into action.

4.3 Riverside tree management

4.3.1 Objectives

The management of riverside trees and scrub is the responsibility of the landowner or tenant. However, the Broads Authority has responsibility to maintain safe and navigable waterways. See https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/riverside-tree-and-scrub-management

The Broads Authority has to balance the needs of the navigation along with conserving and managing the natural habitat and species. This balance can be achieved through effective prioritisation, consultation and sensitive working practices. A typical river cross section with trees present is shown in Appendix 2.

Encroachment by trees and scrub over and into the water causes safety issues for navigation through the narrowing of the navigation channel and obstruction to sight lines, particularly on river bends. Dense growth of trees and scrub also has the effect of reducing the quality and strength of wind available for sailing vessels.

It is important to note that tree management in this context refers to a reduction in density of woody species and lowering average height over the medium term, and not the removal of all such growth.

Table 6 lists the objectives to meet the riverside tree management challenges over the next five year.

Table 6. Riverside tree management objectives

	Objective	Action	When
3A	Managed channels are free of obstructions	Remove fallen trees that have blocked a portion of the managed channel and/or which pose immediate hazards to waterways users	Year round
3B	Implement the 5-year rotational management plan for tree and scrub growing within 3 m of the river edge.	Complete plan for 2018/19 to 2021/22 Report to Navigation Committee on overall progress and lesson learnt following completion of the 2018/19 - 2021/22 plan	Mar 2022 April 2022
3C	Prepare and implement a 5-year	Complete riverside tree survey in 2021/22	Dec 2021

	Objective	Action	When
	rotational management plan (2022/23 to 2026/27) for tree and scrub	Prepare plan for 2022/23 to 2026/27, gaining consents and permissions from relevant statutory bodies (including Natural England, Environment Agency, Forestry Commission) Prepare detailed annual winter work programme, in line with the 5 year plan, and share with stakeholders Complete annual work programme using staff, volunteers and contractors	Mar 2022 June each year Sept – Feb each winter
3D	Identify high risk hazards to navigation arising from trees growing on private land	Rangers to identify and visually assess trees posing hazards to navigation Issue formal letters from the Authority notifying landowners of the presence of trees posing a hazard to navigation on their land, the need to rectify issues and the liabilities they face	Year round
3E	Staff competent in project planning and stakeholder engagement for all activities involving Protected Species	Ecology Team to become Associate members of the Chartered Institute of Ecology & Environmental Management	April 2022

4.3.2 Evidence

Broads Authority rangers monitor the condition of trees along the margins of rivers and broads for immediate risks to waterways users. Where urgent work is required, the landowner is advised by the Authority to undertake management to ensure liabilities are reduced and that a safe navigation space is maintained.

In 2015, an approach to categorising and prioritising riverside tree and scrub management was produced by the Broads Authority. Each river valley was surveyed by a Ranger and Ecologist to determine the types of habitat present and the work required to make improvements to navigation safety and wind availability. For each stretch of the river a priority class was assigned to reflect when the work should be undertaken. Notes were also

taken regarding ecological features such as trees with bat potential and other points of conservation interest.

This survey information was recorded electronically and prioritised maps produced for each river valley. Permissions from statutory bodies and landowners were then obtained for works to proceed during the winter months.

To improve efficiency and streamline the consenting process, assent was gained from Natural England for the Broads Authority to implement a five-year work plan, starting in winter 2017/18. This was the first time the whole of the Broads riverside tree management programme was planned and assessed over the medium term. This gained greater efficiency in stakeholder engagement and allowed opportunities for incorporating natural processes and multiple objectives to be built into the Authority's management activities.

The list of parameters utilised in the prioritisation process includes:

- sailing intensity
- general boat usage
- presence of moorings
- position of river-stretch (bends or straight)
- density of riverside growth
- width of channel lost to tree encroachment

4.3.3 Management actions

From the 5-year plan, detailed works specifications for all riverside tree management are to be prepared each year by the Ecology & Design Team. Annual input from Rangers and feedback from user groups is used to assist where variation to the priority order of areas identified for management activity is required.

Resources available to the Authority in carrying out riverside tree management activities include: -

- hydraulic tree shears attached to an excavator on a floating pontoon
- teams of staff and volunteers felling trees and processing the brash on riverbanks and from workboats
- contractors felling trees and processing the brash on riverbanks and from workboats

Use of hydraulic tree shears is the preferred option for the bulk of the workload, as it reduces staff time on site and manual handling requirements.

Formal consultation with the Environment Agency is required to test compliance with Water Framework Directive (WFD) objectives for each management unit where tree management activities are to be carried out. Formal application for licence to use herbicides near water is also required when stump treatment is specified.

Consultation will also be required with Broads Authority planning officers where trees fall within planning Conservation Areas and/or have Tree Preservation Orders (TPO).

The rotational management of tree and scrub growing within 3 m of the river edge is a distance based on the Broads Authority's statutory duty to maintain navigational safety and is the extent of Forestry Commission licensing exemption for carrying out such work. Management of trees at a distance greater than 3 m back from the river edge on private land would require different licensing and safety assessments, so is not considered within this particular process.

Maps of the areas to be managed each year is available on the Authority website https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/riverside-tree-and-scrub-management

4.3.4 Taking into consideration natural processes

To acknowledge and mitigate for potential impacts that each five year management plan cycle could have on Protected Sites containing designated features including trees, the Broads Authority is required to produce a Habitat Risk Assessment (HRA) Screening document. This describes the tree habitat features for which the site is designated and considers whether the proposed works are likely to have a significant effect upon those features.

For example, an HRA was produced for the 2017-21 plan with the Authority concluding that the works proposed were not likely to have a significant effect on the designated features. This conclusion is based upon the scope and scale of the works selected, the rotational nature of the management activities, the detailed works specification set for each stretch and the operational practices used on site.

Presence of Protected Species, such as bats and otters, helps shape specifications and timing of specific tree management work. Features within individual trees that are likely to host bats are carefully surveyed and recorded. Known and likely otter breeding sites, or holts, are again surveyed and recorded by the Authority's ecologists. Measures to protect such features, as required by UK legislation, includes: -

- Avoidance of disturbance to known and likely features, through pre-works surveys, appropriate works timing and clear plans as to where work can be carried out safely;
- Competent staff planning works and seeking appropriate licenses where required;

- Active retention of standing deadwood where this poses minimal hazard to navigation
- Management to create a mixed age structure of trees with a range features present
- Creation of “habitat piles” of cut timber at strategic locations to provide cover and additional otter breeding sites.

The HRA screening for the 2022/23 to 2026/27 plan will be completed, utilising the accumulated evidence and experience gained through delivery of the 2018/19 - 2021/22 plan.

4.3.5 Aim to deliver multiple objectives

There are two main navigational benefits to managing the riverside trees: -

- to maintain and improve navigational safety and
- to maintain and improve wind quality for sailing

Whilst tree and scrub management seeks to reduce the density of riverside trees and lower the average height over the medium term: this action in turn allows maintenance and extension of reedbed and open fen habitat at the river edges. The balance of managing two characteristic Broadland habitat and landscapes types is very much dependent upon the recent history and landscape qualities of individual river stretches. The detailed surveying and planning of works helps to retain or promote these local priorities, throughout the whole navigable river system.

4.3.6 Five-year work plan

The current plan is published on the Broads Authority webpages https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/riverside-tree-and-scrub-management. Once complete, the 2022/23 to 2026/27 shall be published on the same webpage.

4.4 Bankside habitat and erosion management

4.4.1 Objectives

Moving water naturally wears away riverbanks where flow and exposed sediments interact. This natural process is potentially amplified in the Broads where boats not observing speed limits create excess wash that has a negative impact on the riverbanks. Narrow sections of river channel, hard engineering acting to reflect wave energy back to natural edges and overgrazing of the waterways margins by livestock, are all factors that increase the risk of bankside erosion. Reduction of the factors that generate erosion above the expected background levels is the primary objective in this strategy.

Table 7 lists the objectives to meet the bankside habitat and erosion management challenges over the next five year.

Table 7. Bankside habitat and erosion management objectives

	Objective	Action	When
4A	Ensure compliance with vessel speed limits	Rangers to monitor and enforce	Year round
4B	Provide advice and guidance to landowners on how best to manage river edges	Advice and guidance provided through Navigation Works licensing https://www.broads-authority.gov.uk/planning/planning-permission/works-licences and Planning application processes https://www.broads-authority.gov.uk/looking-after/managing-land-and-water/bank-protection	Year round
4C	Work with landowners of high risk erosion sites	Identify and implement projects that deliver riverbank habitat and sediment management benefits (external funding may be required). See https://broadlandcatchmentpartnership.org.uk/initiatives/water-sensitive-farming/	On-going

4.4.2 Evidence

No routine assessment is carried out of riverbank condition or erosion rates. Problem areas are usually identified on a case by case basis.

4.4.3 Management actions

The landowner is usually responsible for work to reduce bank erosion. Flood risk management authorities usually only get involved where natural erosion threatens a flood defence. The local risk management authority, usually the Environment Agency, will need to agree to any bank protection work. Schemes requiring planning permission are encouraged to use soft engineering techniques, where possible, using natural materials such as alder pole piling or natural planting to limit erosion, rather than using concrete or steel sheet piles. See guidance here https://www.broads-authority.gov.uk/planning/planning-permission/design-guides/river-bank-stabilisation.

Prevention is typically much easier and cheaper than remedial actions later. A few simple steps could provide potential savings such as a reduction in loss of land which outweighs the cost of remedial measures.

Some steps landowners can take;

- Reduce stocking densities to avoid overgrazing and bank-side erosion, particularly during winter and spring months and drought conditions.
- Provide an alternative livestock water supply away from the river to reduce poaching impacts on riverbanks.
- Use temporary or permanent fencing to exclude livestock from damaged or vulnerable areas, and allow vegetation to regenerate.
- Consider establishing riparian buffer strips to encourage natural regeneration of riparian vegetation.
- Manage bankside footpaths to avoid damage to riverbanks and protect footpaths from bank erosion. Consider temporarily re-routing footpaths where erosion is severe until a solution has been established.

Work to be carried out by landowners may require multiple permits, licenses or consents from statutory bodies depending on the location, scope and design of projects. There is currently no national "one-stop-shop" for advice or permissions for riverbank management activities. Bodies with a role in permitting riverbank work includes, but not restricted to: -

- Broads Authority – Planning permission and/or Navigation Works Licence
- Environment Agency – Flood risk activities, see https://www.broads-authority.gov.uk/planning/planning-permission/design-guides/river-bank-stabilisation
- Natural England – work in or near Protected Sites, see https://www.gov.uk/government/publications/request-permission-for-works-or-an-activity-on-an-sssi

- Crown Estate – for work below high water level on tidal waterbodies in the Broads with a Crown Estate interest, see https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/coastal/

4.4.4 Taking into consideration natural processes

An understanding of the multiple functions and uses of the channel is the first step towards understanding how best to manage it.

The impacts of channel management activities should be minimised through careful site characterisation, planning and the inclusion of reasonable avoidance, mitigation and compensation measures. These considerations can lessen the likelihood of an activity being in contravention of environmental legislation such as the Water Framework Directive, Habitats Directive, Wildlife and Countryside Act (as amended).

4.4.5 Aim to deliver multiple objectives

Good channel management works as much as possible with natural processes and supports a broad range of ecosystem functions and services, including fisheries, navigation, amenity, habitats, biodiversity, landscape and water quality, in addition to flood risk and land drainage. When carrying out riverbank management, all these functions should be considered even if navigation or bank erosion are the primary drivers.

There are many impacts as a result of riverbank erosion. Firstly, and possibly the most significant to many landowners is the loss of land. Where footpaths exist along these riverbanks, they can also become lost to the river. This can have a vast impact to local residents, businesses and to the Highways Authority that manages them.

4.4.6 Five-year work plan

No routine programme of remedial works is set, but projects are considered on a case by case basis and as external funding allows.

4.5 Channel Marking

4.5.1 Objectives

Markers, typically posts or buoys, show where it is safe to navigate within a channel. Areas outside the channel are usually too shallow for most vessels or they have underwater hazards which may not be visible.

The Broads Authority's role as Duty Holder under the Port Marine Safety Code places a requirement to undertake hydrographic surveys and to position and maintain navigational marks where they will be of best advantage to vessels.

One safety and access consideration when positioning marker posts is the potential impact on sailing vessels.

Table 8 lists the objectives to meet the channel marking management challenges over the next five years.

Table 8. Channel marking objectives

	Objective	**Action**	**When**
5A	All Aids to Navigation are accurately located and referenced in the Authority's GIS mapping system	All new markers to be logged and recorded	On-going
5B	Consider use of channel markers where they present a cost effective channel management option	Long term costs of management options, including internal carbon pricing, to be assessed for scenarios where channel marking is feasible. As a case study, carry out cost-benefit analysis of channel marker usage compared to alternative channel management options. Use of 3D modelling of the river channel and marker positions to be used to assist quantification of benefits	On-going 2023
5C	Maintain and replace markers, as required	Carry out routine checking, defect reporting and the annual Trinity House inspection	Annual

	Objective	Action	When
		Condition assessment and prioritised replacement programme for markers developed and costed over the medium term (up to 10 years) Implement the site specific channel management plan for Breydon Water	2022 On-going

4.5.2 Evidence

Rangers regularly inspect all Aids to Navigation, using a GIS based inspection system. This sets out the frequency and responsibility of inspections, and is used to produce annual maintenance reports.

Historically markers have been placed in locations largely as a response to known hazards or to manage navigational safety generally. Utilising evidence for location and installation of channel markers for safety purposes is now a routine process through the Authority's duties to comply with to the Port & Marine Safety Code. This is implemented through the Authority's Safety Management System https://www.broads-authority.gov.uk/__data/assets/pdf_file/0021/252453/SMS-version-7.0.pdf. Progress and performance against the actions identified through the Safety Management System is tracked via stakeholder meetings of the Broads Boat Safety Management Group. Installation of new markers is based on evidence provided from rangers, stakeholder feedback and records of groundings and other incidents. A Broads Hazard Assessment review is carried out every five years involving a range of stakeholders.

Use of markers as a method of defining the managed channel with sustainability of channel maintenance regimes as a key driver is a different approach. Little evidence is available for the potential sustainability benefits that may arise from channel marker use to reduce the dredging requirement within channel. Objective 5B aims to improve understanding in this area.

4.5.3 Management actions

Markers in the Broads navigable system are typically found on the lower reaches of the main rivers, and through some larger broads, such as Hickling, Barton and Rockland. Breydon Water is very well marked, as the mudflats either side of the channel are not navigable at most states of tide.

Marker posts are regularly checked as part of our condition monitoring procedure. From there it is determined when posts are most likely needed to be replaced and this is then planned for as part of a five-year work programme.

4.5.4 Taking into consideration natural processes

By marking a defined channel, it not only assists boat users in navigating, it helps people to understand the navigable envelope and where the margins exist. It also aids the definition of the waterways management activities, such as dredging and water plant management. See the channel profile diagram with marker posts in Appendix 2. The environmental benefits of this approach to channel management are that the river margins can be left to function in a more natural way.

4.5.5 Aim to deliver multiple objectives

Channel marking contributes towards the Authority's duties under the Port Marine Safety Code, which formalises the multiple responsibilities for safety and environmental protection within UK ports and harbours.

4.5.6 Five-year work plan

Implementation of the ten year Breydon Water channel management plan is the main asset replacement work to carry out in this period. All other routine actions will be as per the channel management objectives in Table 8.

4.6 Bridge clearances

Passing under bridges can be dangerous if not done properly. Tides and rainfall amounts can alter the level of the water and so the amount of clearance will also vary by several feet in some places. The Broads Authority does not own or manage any of the fixed, lifting or swing bridges that cross over the Broads waterways.

4.6.1 Objectives

The Broads Authority has navigational safety duties to communicate the vertical air draft available for vessels wishing to pass under bridges. Together with all bridge locations, the typical air draft at summer mean high water for each bridge, and the opening procedures for lifting and swing bridges are communicated on the Authority website here https://www.broads-authority.gov.uk/boating/navigating-the-broads/bridge-heights-and-opening-times. Given that all the bridges are owned and operated by either local authority highways departments, Network Rail or Highways England, the Authority works closely with all parties to ensure accurate information and directions for navigators are available. Most bridges have a gauge board which provides the definite current clearance available. Where advance notice is required for vessels approaching bridges, additional gauge boards are installed on the approach to the bridge to allow time for navigators to make ready to pass under.

Table 9. Bridge clearance objectives

	Objective	Action	When
6A	Maintain clear gauge boards at bridges	Continue the routine inspection and maintenance programme for all gauge boards across the system	on-going
6B	Communicate typical vertical bridge clearances to mean summer high water	Review the available water level data to refresh the figures used for mean summer high water level using a standardised method	2022
6C	Explore ways to communicate live bridge clearance heights for bridges	Work with partners to make best use of new technology to communicate live bridge clearance information	on-going

	Objective	Action	When
6D	Long term trends in water levels are understood and the impacts on navigation communicated to stakeholders	Broads Authority members and officers to actively engage with the Broadland Futures Initiative in terms of navigation impacts	on-going

4.6.2 Evidence

The challenge of variation in water level at bridges means that waterways users need to consult the bridge gauge boards at the time of use. Pre-planning of passages and timing the passage under bridges can be assisted by reference to tide tables, available on the Authority website here https://www.broads-authority.gov.uk/boating/navigating-the-broads/tide-information. Vertical clearance under bridges is stated in terms of height relative to water at the average summer high water level. As for the mean low water level values used for communicating water depths in section 4.1, a periodic refresh of the summer mean high water level data used in the guidance is required to keep bridge information up to date.

From data collated and analysed by the Permanent Service for Mean Sea Level (PSMSL) the Great Yarmouth tide gauge station has shown a rise of between 3 and 4 mm per year since 1970. See the European Environment Agency website for more information https://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-7/assessment. Predictions under different climate change scenarios point towards a continuing rise in sea levels for the south-eastern UK. This will have an impact throughout the tidal Broads waterways and has implications for the available air draft and timing of when vessels that can pass under bridges. Analysis of Environment Agency river level data at Potter Heigham (2007-2020) showed that over the autumn and winter periods for 2019/20 and 2020/21, there was an increase of roughly 15% in the number of days when the clearance was too low for a small broads cruiser. The 15% increase was against the previous twelve years of data (2007 to 2018). The pattern of water level variation is not observable as a continuous long term trend in this particular dataset. High seasonal rainfall in the catchment area and associated high groundwater levels in the aquifer are also likely to play a major part in the recently observed winters with prolonged high water periods.

The Broadland Futures Initiative (BFI) is a partnership for future flood risk management in the Broadland area. It's main goal is to agree a framework for future flood risk management that better copes with a changing climate and rising sea level. Flooding can affect many aspects of community life in our area; tourism, recreation, the natural environment, agriculture and where we live and work can all suffer adverse impacts as a result of high

water levels. The Initiative will make sure that these interlinked interests are all considered, with the full involvement of local communities and other stakeholders.

4.6.3 Management actions

The maintenance and upkeep of the visibility and accuracy of the gauge boards is the most crucial action for the Broads Authority. The ranger team regularly check the gauge board condition and carry out periodic cleaning. Structural repairs are carried out as required, with a high priority given to these tasks.

4.6.4 Taking into consideration natural processes

Periodic refresh of the mean high water data is required, but not more than once every five years. The last set of calculations to generate the summer mean high water levels used in the clearance height table on the Broads Authority website was a one off activity from a limited dataset. A repeatable, standardised methodology is required going forward.

4.6.5 Aim to deliver multiple objectives

Waterways safety and user experience objectives are the critical ones when communicating bridge clearances.

4.6.6 Five-year work plan

All actions will be as per the bridge clearance objectives in Table 9.

5 Reporting and communicating progress

5.1 Quarterly operational updates

At each Navigation Committee meeting, progress on the major waterways management projects will be reported. Dredging projects will be tracked in detail, with dredge volumes and actual project costs reported. The planned and actual proportion of staff time spent on the different navigation management activities through this year will also reported.

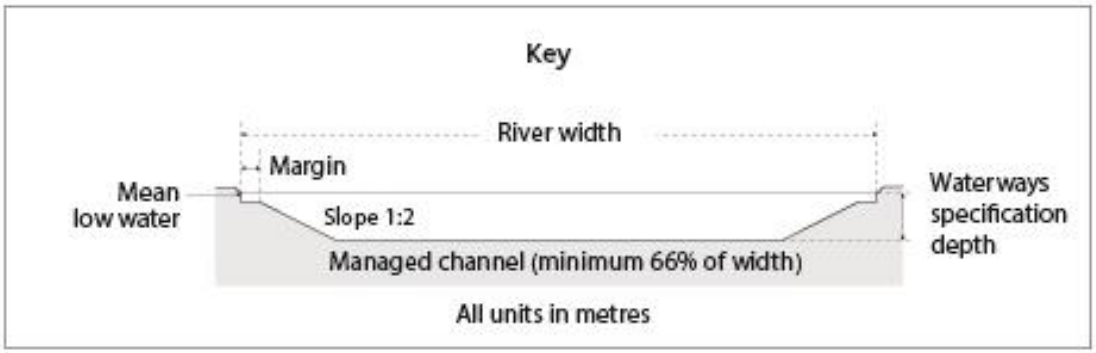
5.2 Annual review of waterways specification compliance and prioritisation

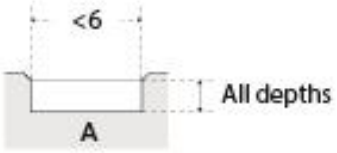
Each annual review will largely be focussed on the refresh of the routine hydrographic and post dredge surveys. With refreshed bathymetric data, compliance with waterways specifications and priority order of dredging requirements across all management units will be updated. This will help to keep project planning focussed on the highest priorities and facilitate discussions with stakeholders on future work programme options. The reporting on annual waterways specification compliance will be via Navigation Committee in September each year, to coincide with the forward work plan and budget setting timescales.

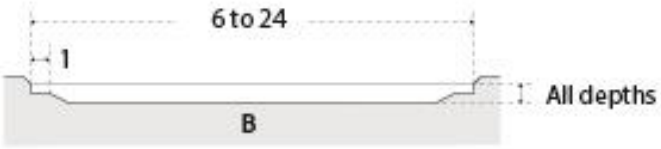
5.3 Review of five-year plan

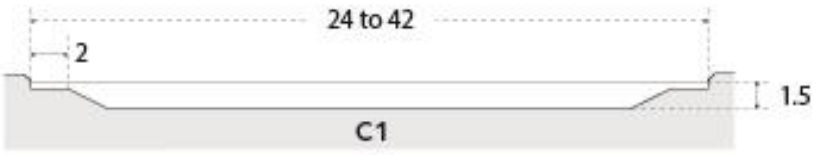
At the end of the five year plan a full review of progress against strategy aims and objectives will be carried out. Developments in methodologies and practices is an on-going process and the five year review enables these to be captured and evaluated.

Appendix 1 – Channel profiles and dimensions

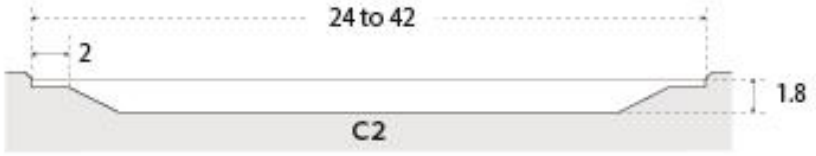








Diagrams A to E scaled relative to each other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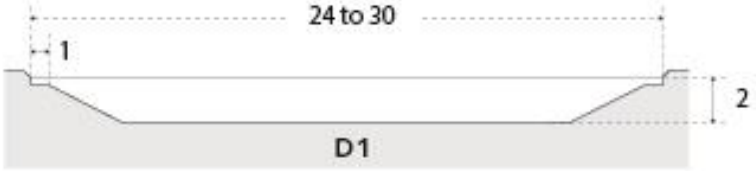
2
1.8
C2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2
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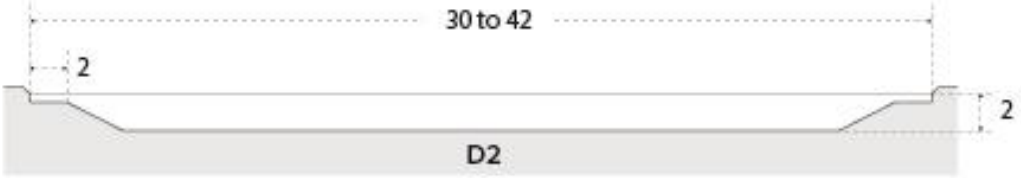
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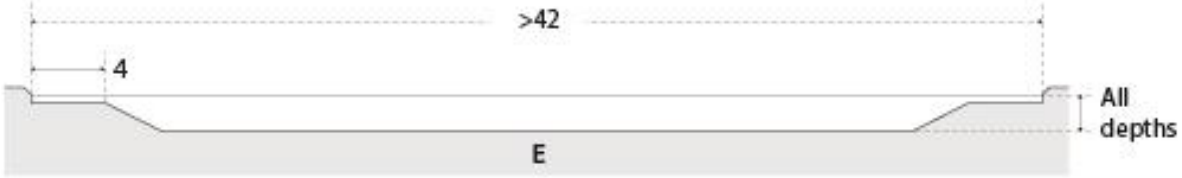
2
D2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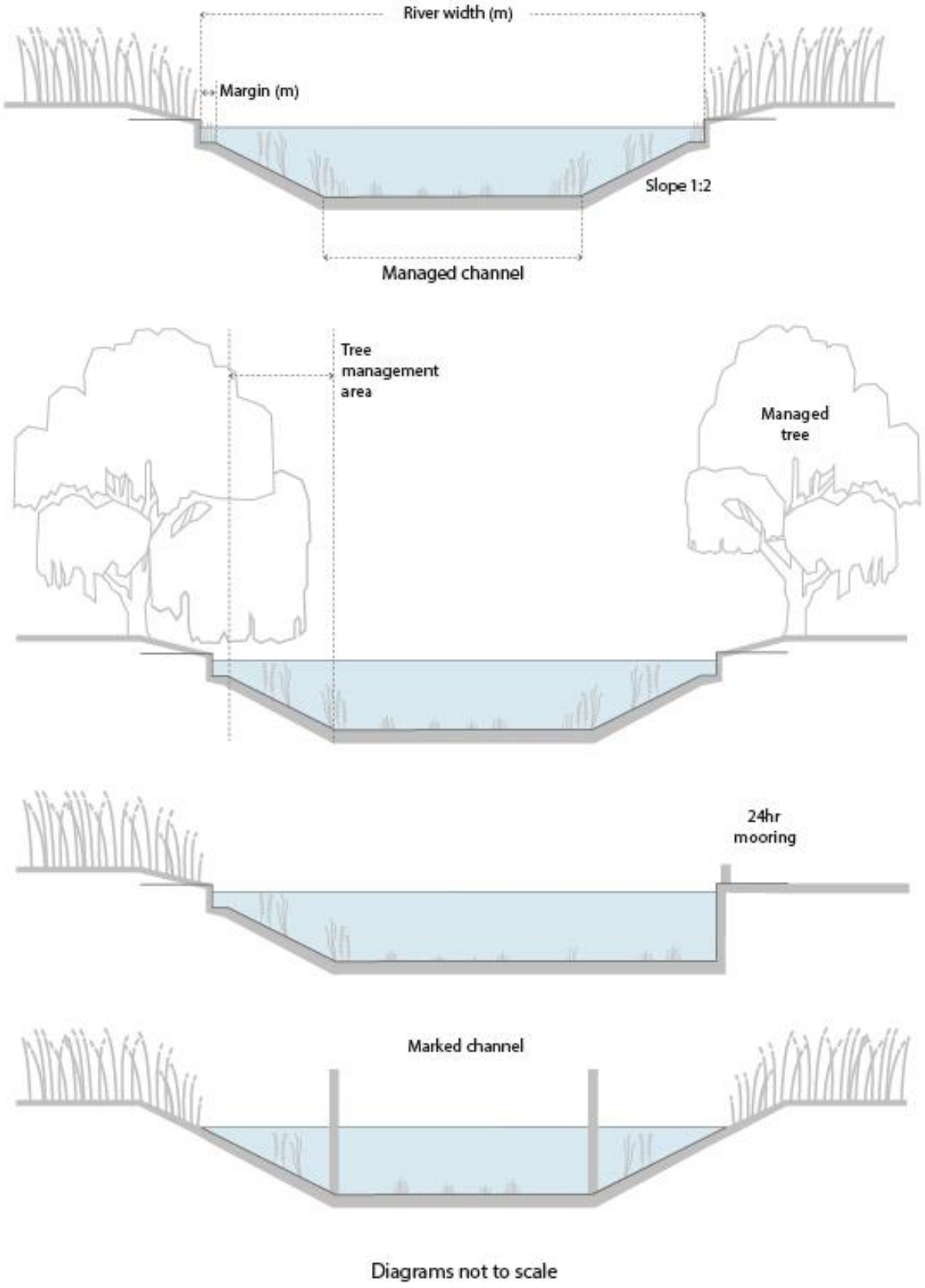
4
All
depths
E

Appendix 2 – Channel margin types



Diagrams not to scale

Appendix 3 – Mean low water levels (1993 and 2020)

Station Name	MLW 1993 (m ODN)	MLW 2020 (m ODN)	Difference (m)
Haven Bridge Great Yarmouth	-0.520	-0.558	-0.038
Reedham (River Yare)	-0.130	-0.090	0.040
Burgh Castle (River Waveney)	-0.240	-0.059	0.181
Haddiscoe (River Waveney)	-0.180	-0.049	0.131
Three Mile House (River Bure)	N/A	-0.038	
Oulton Broad (River Waveney)	-0.050	-0.001	0.049
Beccles Quay (River Waveney)	-0.040	0.001	0.041
Rockland St Mary (River Yare)	N/A	0.098	
Cantley (River Yare)	N/A	0.133	
Brundall (River Yare)	-0.040	0.139	0.179
Carrow Bridge (River Wensum)	-0.030	0.173	0.203
Acle Bridge (River Bure)	0.180	0.307	0.127
Repps (River Thurne)	0.230	0.347	0.117
Ranworth Broad (River Bure)	0.220	0.366	0.146
Hoveton Broad (River Bure)	0.240	0.371	0.131
Hickling Broad (River Thurne)	0.230	0.391	0.161
Barton Broad (River Ant)	0.260	0.398	0.138
Wayford Bridge (River Ant)	0.260	0.418	0.158

Appendix 4 – Management Units prioritised for dredging requirement

River	Location	Sediment Volume m3	Non Compliance area %	Proportion of Economic dredge	Level of use (1-3)	Priority Score	Notes
Waveney	Oulton Broad	52,420	81.1	0.72	3	175.5	Survey out of date; Priority for resurvey
Bure	Salhouse Broad	11,418	84.9	0.61	3	155.5	
Bure	South Walsham Broad	9,450	70.3	0.62	3	130.2	
Ant	Lime Kiln Dyke	3,308	76.9	0.82	2	126.7	Survey out of date; Priority for resurvey
Ant	Stalham Dyke	7,951	53.3	0.73	3	116.2	
Ant	Barton Broad (outside channel)	8,291	83.8	0.69	2	115.0	
Ant	Sutton Dyke	14,193	85.0	0.67	2	114.6	
Bure	Hoveton Viaduct Bridge to Salhouse	21,708	44.4	0.74	3	99.1	
Bure	Horstead to Coltishall Common	5,115	55.4	0.87	2	96.9	
Ant	Wayford Bridge to Barton Broad	12,701	46.7	0.68	3	95.8	
Bure	Malthouse Broad	6,646	52.3	0.59	3	93.1	
Yare	Rockland Broad (channel & dykes)	10,970	56.7	0.82	2	92.9	
Ant	Barton Broad to Ludham Bridge	14,055	54.1	0.55	3	89.6	
Thurne	Waxham Cut	9,078	89.2	0.94	1	84.2	Survey out of date; Priority for resurvey
Bure	Acle Dyke	3,684	86.4	0.97	1	84.1	
Waveney	Geldeston Dyke	2,278	89.2	0.94	1	84.1	
Bure	Cockshoot Dyke	418	84.4	0.90	1	76.0	
Waveney	Haddiscoe Cut	17,786	43.7	0.86	2	75.0	
Thurne	Catfield Dyke	3,817	74.1	0.96	1	70.9	
Bure	Slaughterhouse Yard to Bure Mouth	6,893	28.3	0.83	3	70.5	
Bure	Fleet Dyke	4,015	39.7	0.57	3	67.5	
Yare	Rockland Broad (outside channel)	103,259	65.0	0.99	1	64.7	Survey out of date;
Ant	Upstream of Wayford Bridge	2,266	55.3	0.56	2	62.3	

River	Location	Sediment Volume m3	Non Compliance area %	Proportion of Economic dredge	Level of use (1-3)	Priority Score	Notes
Ant	Tyler's Cut	1,419	65.1	0.47	2	61.6	
Bure	Mautby Mill to Slaughterhouse Yard	17,329	22.3	0.87	3	58.6	
Thurne	Heigham Sound	7,748	74.7	0.38	2	56.9	
Thurne	Hickling Broad (inside channel)	16,561	85.6	0.21	3	54.0	
Bure	Coltishall Common to Jubys Farm	8,165	47.9	0.52	2	49.6	
Bure	Salhouse Broad to Horning Church	16,420	22.3	0.73	3	48.8	
Thurne	Hickling Broad (outside channel)	191,548	73.5	0.62	1	45.5	
Yare	Thorpe Old River Yare	5,121	61.6	0.71	1	43.9	
Yare	Bishops Bridge to Postwick	21,815	24.6	0.88	2	43.2	
Yare	River Yare (Trowse Eye)	3,559	43.7	0.98	1	42.7	
Ant	Ludham Bridge to Ant Mouth	1,346	28.9	0.49	3	42.1	
Thurne	Womack Dyke	2,431	40.1	0.47	2	38.0	
Bure	Horning Church to Thurne Mouth	9,619	19.2	0.62	3	35.6	
Bure	Stokesby to Herringby Hall	6,087	12.8	0.86	3	33.0	
Ant	Barton Broad (inside channel)	13,222	22.6	0.45	3	30.9	
Bure	Upton Dyke	763	43.8	0.70	1	30.6	
Thurne	Deep/Deep Go Dyke	1,246	22.1	0.65	2	28.6	
Ant	Turkey Broad	7,739	43.8	0.65	1	28.4	
Yare	New Mills to Bishops Bridge	4,600	30.2	0.84	1	25.5	
Bure	Ranworth Dam	430	10.9	0.78	3	25.5	
Yare	Langley Dyke	786	13.0	0.95	2	24.6	
Waveney	Geldeston to Beccles	6,471	14.9	0.82	2	24.5	
Waveney	Beccles to Burgh St Peter	13,098	9.2	0.84	3	23.1	
Waveney	Oulton Dyke	3,011	12.4	0.86	2	21.2	

River	Location	Sediment Volume m3	Non Compliance area %	Proportion of Economic dredge	Level of use (1-3)	Priority Score	Notes
Yare	Postwick to Brundall	20,969	14.3	0.70	2	20.0	
Yare	Bargate (channel and dykes)	1,733	12.2	0.81	2	19.6	
Bure	Acle Bridge to Stokesby	4,903	11.7	0.78	2	18.3	
Thurne	Somerton Boat Dyke	370	61.9	0.28	1	17.6	
Thurne	Martham Ferry to Somerton Mill	2,985	38.9	0.44	1	17.2	
Bure	Herringby Hall to Mautby Mill	3,321	6.6	0.84	3	16.6	
Bure	Thurne Mouth to Acle Bridge	3,580	9.5	0.54	3	15.3	
Bure	Juby's Farm to Caen Meadow	1,612	17.4	0.39	2	13.7	
Thurne	Meadow Dyke	1,187	40.6	0.33	1	13.5	
Bure	Caen Meadow to Hoveton Viaduct	1,594	16.9	0.35	2	11.8	
Yare	Brundall to Cantley	15,263	7.1	0.81	2	11.5	
Thurne	Thurne Mouth to Martham Ferry	1,821	5.1	0.54	3	8.2	
Waveney	St Olaves to Breydon	4,781	3.6	0.87	2	6.3	
Thurne	Horsey Mere	9,153	37.0	0.16	1	6.0	
Chet	Loddon to Chet Mouth	1,989	18.1	0.32	1	5.8	
Thurne	Candle Dyke	165	5.2	0.51	2	5.4	
Yare	Cantley to Reedham	1,906	2.2	0.74	2	3.3	
Waveney	Burgh St Peter to St Olaves	2,097	2.1	0.77	2	3.2	
Thurne	Thurne Dyke	19	2.4	0.67	2	3.2	
Waveney	Breydon Water (inside channel)	2,713	1.1	0.86	2	1.9	
Yare	Seven Mile House to Breydon	716	1.2	0.75	2	1.7	
Yare	Reedham to Seven Mile House	305	0.6	0.85	2	1.0	
Bure	Bridge Broad	N/A	0.0	0.00	2	0.0	No survey data; Priority for survey
Thurne	Martham Dyke	N/A	0.0	0.00	1	0.0	No survey data;
Total sediment volume		**815,434**					