# ECONOMIC BENEFITS OF WETLAND CREATION FOR WATER QUALITY

WWT
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**Final report**
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## Disclaimer

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# Executive summary

*This report presents a scoping analysis of the natural capital benefits of creating 25,000 hectares (ha) of water quality wetlands in England and Scotland by 2050. Although all wetlands improve water quality, water treatment wetlands are specifically designed to improve water quality by dealing with pollutants in water using the natural functions of vegetation, soil, and organisms to treat different wastewater streams (WWT, 2020a). The costs and benefits associated with creating water treatment wetlands are estimated. Delivering these wetlands would have multiple ecosystem services benefits, as well as financial costs and other costs (e.g. opportunity costs).*

**WWT are calling for the creation of 100,000 hectares of new and restored wetlands in the UK by 2050,** to make a real difference to nature recovery and to restore the critical ecosystem services and functions provided by wetlands.

The natural capital account (NCA) presented in this report is part of WWT's Roadmap to 100,000 hectares work, which aims to assess both the spatial and economic potential for large-scale wetland restoration targeted at tackling some of the key issues faced by UK society. The work has a particular focus on four themes where wetlands can provide solutions, namely (1) wetlands for carbon storage (specifically saltmarsh for blue carbon), (2) wetlands for urban wellbeing (3) wetlands for flood resilience and (4) wetlands for water quality (detailed in this report).

The NCA and accompanying reports have been developed separately for each of the four themes (focussing on 25,000 ha of wetland creation targeted at each theme). The accounts can also be aggregated to value the benefits provided by all 100,000 ha of wetlands in the WWT ambition. These aggregated benefits, together with a summary of all four accounts, are presented and discussed in the main project technical report, while detailed reports are provided separately for the individual accounts (such as this).

The analysis supporting the accounts ensures they can be aggregated with a low risk of double counting because (1) there is little overlap in the target wetland areas, (2) a wider potential wetland area providing similar benefits has been identified for each account, and (3) the approach taken in estimating costs and benefits are consistent across accounts. The account results do not show exactly where to create wetlands. They show the feasible returns to society from a realistic wetland creation strategy.

Only a selection of the potential benefits has been quantified and valued in this analysis, and further research is needed to increase the certainty of results and understand a wider range of benefits. Nevertheless, the results show substantial potential benefits from water quality wetland habitat creation.

The analysis of these benefits has followed Defra's ENCA guidance, where relevant, and aligns to HM Treasury Green Book appraisal principles. The total gross benefits are estimated at £1.3 billion over 60 years. The impacts on benefits assessed in this account include loss of food provision, water quality, water supply and recreation. These benefits could incentivise a range of stakeholders to contribute to water quality wetland creation and maintenance costs, and some benefits, such as water quality, have market value. Development of these funding approaches requires further research, which can build on the quantification and valuation of water quality wetland benefits in this report.

Any funding will also depend on the costs of wetlands for water quality, which include the wetland creation costs, and the costs of maintaining them over time. Total costs are referred to as liabilities in the natural capital account.

Table ES 1 describes the distribution of benefits and liabilities to businesses and wider society of water quality wetland creation. In this account, the benefits to society amount to £1.7 billion (assessed over 60 years in present value terms), but loss of benefits to businesses (e.g. farms) amounts to £400 million, and therefore the gross asset value over 60 years amounts to approximately £1.3 billion. The main benefits arise from water supply (i.e. avoided wastewater treatment costs) and water quality – which justify the investment.

The liabilities in this account amount £365 million over 60 years: to £287 million for the creation of wetlands (assumed to be within the first 27 years of the analytical period) and £78 million over 60 years for the maintenance of water quality wetlands.

The total net asset value of water quality wetlands in England and Scotland amounts to £955 million over 60 years which highlights that although there are significant costs, there are significant net benefits of creating these wetlands.

Table ES 1: Natural capital asset valuation and liabilities associated with 25,000 ha of wetlands for water quality wetland creation in England and Scotland, assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

| 2024 prices | Valuation metric | Value to businesses | Value to the rest of society | Total |
|---|---|---|---|---|
| **Asset values (monetised)** | | | | |
| Food provision | Opportunity cost of agricultural land changed to water quality wetlands | (400) | | **(400)** |
| Water quality | Value of improvement in WFD status of rivers | | 546 | **546** |
| | Avoided wastewater treatment costs | | 1,115 | **1,115** |
| Recreation | Welfare value for created wetland | | 59 | **59** |
| **Total gross asset value** | **Mix of values** | **(176)** | **1,720** | **1,320** |
| **Liabilities** | | | | |
| Creation costs[1] | | (287) | | **(287)** |
| Maintenance costs[1] | | (78) | | **(78)** |
| **Total gross liabilities** | | (365) | | **(365)** |
| **Total net asset values (monetised)** | | **(541)** | | **955** |

*Other material unquantified benefits: Avoided carbon emissions from traditional wastewater treatment plants, habitat benefits*

**Table notes:**

[1] Costs that are necessary to produce benefits (e.g. Water quality wetland habitat creation and maintenance costs).

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# 1 Introduction

## 1.1 Project objectives

This project aims to support WWT's ambition to create 100,000 hectares of new and restored wetland habitat in the UK by 2050 to make a real difference to nature recovery and to restore the critical ecosystem services and functions provided by wetlands in the UK.

**Error! Bookmark not defined.**To achieve this 'Blue Recovery', WWT have published proposals for wetland solutions focussed on four key themes:

1. Wetlands for water quality
2. Wetlands for carbon storage
3. Wetlands for urban wellbeing
4. Wetlands for flood resilience

Each proposal details the partnerships and policy frameworks required to reach the 100,000 ha target, laying out the steps needed to move from small-scale, ad-hoc wetland creation to a strategic network of larger, connected wetlands that maximise benefits to society.

WWT's Roadmap to 100,000 hectares work aims to assess both the spatial and economic potential for large-scale targeted wetland restoration. Specifically, it involves:

- Mapping both the spatial demand for wetlands and suitable areas for wetlands designed to address these themes, for example, via natural flood management wetlands, constructed treatment wetlands, community urban wetlands, sustainable drainage systems or saltmarsh creation;
- Quantifying, through natural capital accounting, the scale of the potential benefits provided by large-scale, targeted wetland creation - benefits that are often underappreciated in considerations of wetland policy options; and
- Developing resources and engagement materials to demonstrate this potential.

Natural capital accounts (NCA) have been developed to estimate the multiple benefits of creating wetlands for each theme:

- **Wetlands for carbon storage (saltmarsh blue carbon).** The NCA for saltmarsh creation for carbon storage focuses on the carbon sequestration benefit from the creation of saltmarshes in the UK.
- **Wetlands for urban wellbeing**. The NCA for urban wellbeing wetlands focuses on benefits, such as recreation, physical and mental health, and urban cooling, from the creation of freshwater wetlands near urban areas.

- **Wetlands for flood resilience**. The NCA for flood resilience wetlands focuses on benefits such as flood risk management, food provision, air quality regulation, carbon sequestration, recreation, and physical health.
- **Wetlands for water quality**. The NCA for water quality wetlands detailed in this report focuses on the water quality benefits provided by freshwater wetlands located in areas with particularly poor water quality. The benefits included are food provision, water quality, and recreation.

Assessing the benefits provided highlights the beneficiaries from the creation of these wetlands, which helps to inform who could fund the creation (capital) and maintenance (operational) costs involved. For example, wastewater treatment companies, and developers required to deliver Nutrient Neutrality, may be interested in providing capital investment in the creation of water quality wetlands that remove pollutants like phosphorus from the water. Local authorities may be interested in funding the operational investment required due to the water quality benefits and recreational benefits from water quality wetlands.

The remainder of this report provides evidence to demonstrate the value associated with creating wetlands for water quality. To do this, the NCA has been developed for a target area of potential water quality wetland creation in England and Scotland. The account organises data on wetlands that would be created, the services they support, the value of the benefits they provide to people, and the distribution of those benefits across businesses and society into the future. The benefits are compared to the costs of water quality wetland creation and maintenance in a balance sheet.

## 1.2 Project scope and consistency across accounts

In line with WWT's ambition to create 100,000 ha of wetland in the UK by 2050, the scope of this project is to estimate the multiple benefits of creating 25,000 ha of wetlands for each of the four themes. Although the natural capital accounts (NCA) and accompanying reports have been developed separately for each theme, these accounts can be aggregated to value the benefits provided by all 100,000 ha of wetland.

The analysis supporting the accounts ensures they can be aggregated with a very low risk of double counting, because:

- **Little overlap in target wetland areas**. The areas of wetland creation targeted in each account have been mapped according to criteria that identifies the areas most suitable to fulfilling the primary purpose of that wetland (i.e. flood resilience, urban wellbeing, water quality improvement, and saltmarshes). Although it is feasible that an area may be well suited to wetlands that provide both for example, flood resilience and an improvement in water quality, it has been found, by overlaying the target wetland areas in each account, that the areas targeted for these specific purposes do not overlap. This therefore reduces concerns of double counting the benefits of wetland creation across the accounts.

- **Wider potential wetland area providing similar benefits**. Each account has identified a larger potential wetland area than the 25,000 ha priority area actually covered by the account. Although benefits have been estimated for defined target wetlands, the benefit values applied are generally averaged at a regional or national scale rather than being spatially explicit at the site level. This means that the calculated benefits are not tied to specific locations within the target area, but rather represent a typical value that could be achieved at other wetland sites if the sites we have mapped to demonstrate the vision were not available. This includes if they were not available because they were used for a different wetland type. As a result, even if two accounts identify overlapping target wetlands, there are alternative locations that could be used, so there is no double counting of the benefits. This is because the values used are not dependent on the exact site but reflect the typical benefits that could be realised in various potential locations. Therefore, if a wetland were moved from one location to another within the wider potential area, the values they generate would not be compromised. The account results do not prescribe specific locations for wetland creation; instead, they illustrate the potential societal returns from implementing a realistic wetland creation strategy across a broader landscape.
- **Consistency in approach**. The approach taken in estimating the costs and benefits are consistent across accounts, allowing for aggregation across accounts. The accounts have monetised costs and benefits based on a 2024 price year and have projected costs and benefits over 60 years. All accounts have assumed that an equal area of wetlands is created each year between 2024 and 2050 (i.e. the year in which the target area of wetland creation is achieved).

## 1.3 Report structure

This report documents the approach taken and the key results, including key data gaps and uncertainties, for the wetlands for water quality natural capital account. The structure of the report is as follows:

- **Section 1: Introduction** – introduces the project objectives and outputs.
- **Section 2: Approach** – provides an overview of the natural capital analysis and its application to the creation of wetlands for water quality.
- **Section 3**: **Scope of the natural capital account** – describes the spatial boundaries of the natural capital account and the method used to define these spatial boundaries.
- **Section 4**: **Summary of the analysis** – describes the analysis used to build the NCA.
- **Section 5: Account results** – presents the water quality creation benefits results.
- **Section 6: Conclusions and recommendations** – summarises the results of the NCA and provides recommendations on the interpretations of, and future updates to, the accounts.
- **Appendix 1: Benefit methodologies –** details the quantification and economic valuation methods used to produce the results reported.

# 2 Approach

*This section provides a description of the natural capital accounting method used and the approach taken to develop an account for water quality wetlands in GB.*

## 2.1 Natural capital accounting

Natural Capital is "the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people"[1]. A natural capital approach can be defined as distinguishing between the natural capital stocks and the flows of benefits they provide; projecting benefits into the future and linking the provision of benefits to the extent and condition of assets. The intention is to ensure that business decisions prioritise maintaining the assets to maintain benefits, and not to maximise one of the benefits at the expense of others or the natural capital asset itself.

Systematic and consistently generated evidence and repeated updates are what distinguish accounting from one-off assessments. Accounting offers comparability across space and time, bringing rigour to the presentation of data on natural capital assets, the services they provide, the benefits and hence value of those services, and the distribution of those benefits across society and into the future.

The approach to developing the water quality wetlands account is based on the Corporate Natural Capital Account (CNCA) framework for the Natural Capital Committee in 2015 (eftec, RSPB and PWC, 2015). This framework is also the basis of BSI:8632 on Natural Capital Accounting for Organizations[2]. Natural capital accounting involves producing a natural capital balance sheet and a natural capital income statement mirroring traditional financial accounting. The intention is to present information to the decision makers in a format they are familiar with so that the impacts and dependencies on the natural capital is considered more explicitly and in conjunction with other forms of capital.

The **natural capital balance sheet** has two parts: asset values (of the benefits natural capital produce for businesses and wider society) and liabilities (on what needs to be spent to create and maintain natural capital). The natural capital balance sheet and its supporting schedules answer five key questions:

I. What assets do we own and/or manage?

II. What benefits do they provide and to whom?

III. What are these benefits worth?

IV. What does it cost to maintain the assets?

[1] Source: Natural Capital Protocol https://naturalcapitalcoalition.org/natural-capital-protocol/

[2] Available at: https://shop.bsigroup.com/products/natural-capital-accounting-for-organizations-specification?pid=000000000030401243

V. How do costs compare to benefits over time?

The following supporting schedules hold the information gathered to answer the above questions:

- **Natural Capital Asset Register –** which records the stock of natural capital assets in terms of their extent, condition, and spatial configuration (e.g. size and status of designated sites). These indicators help determine the health of natural capital assets and their capacity to provide benefits[3].
- **Physical Flow Accounts –** which quantifies the benefits that the assets deliver in physical terms. The changes in the quantity / quality of the assets and their benefit provision over time are also shown.
- **Monetary Flow Accounts –** which estimates the economic value of the benefits in monetary terms and discounts the projected future flow of these benefits to provide the present value for the assets. This uses data from actual markets and other (non-market) values. The value of the benefit should be net of the cost of producing the benefit.
- **Natural Capital Liabilities Account –** which details the costs of activities required to sustain the capacity of the natural capital assets to provide benefits over the long term, including management actions for the habitats identified in the asset register.

The monetary flow and cost accounts distinguish values to businesses from values to the rest of society. These supporting schedules provide all the data required for the balance sheet which compares the asset values to the costs of maintaining those values.

Where understanding and evidence allow, calculation of assets and liabilities can take account of expected changes to future costs and benefits of management, and external factors such as population growth or climate change. Otherwise, caution is needed when interpreting the bottom line of natural capital balance sheet – as BSI 8632 states, a positive net asset value is not necessarily an indication of sustainable asset management.

## 2.2 Preparing a natural capital balance sheet for water quality wetlands

This analysis includes both a natural capital benefits account, which relates to Steps I – III above, and a natural capital liabilities account, which relates to Steps IV – V. The benefits and liabilities have been estimated for the water quality wetlands within the accounting boundary. The method used to define the accounting boundary is explained in Section 3.1.

The structure of the account allows calculations to link data on the extent of the assets identified in the asset register, to value data on flows of ecosystem services, through the process shown in Figure 2.1. The product of quantity and unit value gives an estimate of

[3] The natural capital asset register is also the basis for scoping the natural capital risk register, and for a materiality assessment (see Section **Error! Reference source not found.**) to determine the content of the flow and liabilities accounts.

annual value. Asset values are calculated by summing the expected future annual values of benefits over 60 years, discounted according to HM Treasury (2020) Green Book Guidance.

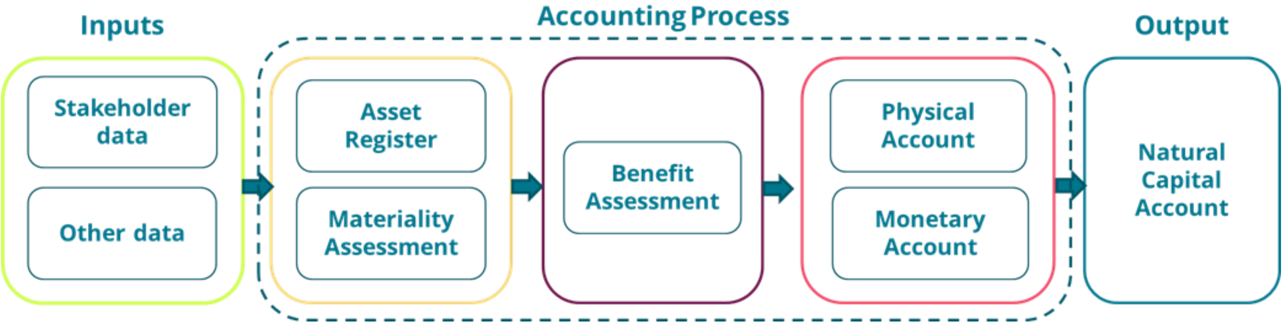


Figure 2.1: Outline of accounting process

The balance sheets for the creation of water quality wetlands are presented in Section 5. The assumptions and evidence used are provided in Appendix 1.

# 3 Scope of the natural capital account

*Scoping of the account defines the spatial boundary of the account, the natural capital assets and the benefits covered and presentation of results.*

## 3.1 Spatial boundaries and asset register

The spatial boundary for the creation of water quality wetlands lies within England and Scotland. The intended spatial boundary of the account was the UK, but due to limited open-source data for Wales and Northern Ireland, the spatial boundary was reduced to only include England and Scotland.

### *3.1.1 Identifying suitable locations for wetlands for water quality*

The natural capital assets are defined by the extent of areas suitable for water quality wetlands. Detailed mapping methods are available in the accompanying technical guidance document (Section 2; Appendix III). In summary, this involved the following steps:

- **Step 1. Selecting areas with high 'demand' for wetlands for water quality**, by identifying the Water Framework Directive (WFD) waterbody catchments that are in most need of positive water quality interventions by selecting (a) coastal and river waterbodies with a failing WFD status (i.e. 'bad' and 'poor' status; (Environment Agency, 2019a,b; SEPA, 2023a,b,c); and (b) catchments with high rates of housing development which could negatively impact water quality (number of newbuilds built per local authority, household projection data by local authorities); and
- **Step 2**. **Mapping potential wetland locations within 'demand' areas** by identifying locations that are capable of being a wetland based on (a) topographic wetness index (TWI); (b) removal of site constraints/obstacles to wetland creation (e.g. railway lines, buildings, etc.); (c) zones of influence based on pollution sources (i.e. the travel of pollution from the source, namely agriculture, forestry, and industrial and urban areas).

### *3.1.2 Identifying suitable 'demand' catchments for target wetlands*

In this analysis, the creation of water quality wetlands has been distributed across England and Scotland in line with population levels shown in Table 3.1. A pro rata distribution of wetlands means that the benefits will be distributed to people across the UK (in this case across England and Scotland, due to data limitations), rather than concentrated in a specific region.

Table 3.1: WQ wetland creation area per country, based on population.

| Country | Population | % of population | Target WQ wetland area allocation (ha) |
|---|---|---|---|
| Total | 62,016,138 | 100% | 25,000 |
| England | 56,550,138 | 91% | 22,797 |

| | | | |
|---|---|---|---|
| Scotland | 5,466,000 | 9% | 2,009 |

Table note: Due to a lack of data on Wales and Northern Ireland, water quality wetlands in Wales and Northern Ireland are not included in the asset register for this iteration of the natural capital account for water quality wetlands.

Based on a target area of 22,797 ha of water quality wetlands in England and a target area of 2,009 ha of water quality wetlands in Scotland, the target areas were identified based primarily on the ability of wetlands to improve WFD status via phosphorus (P) removal, using available data on target P load reduction and P removal efficiency of Constructed Treatment Wetlands. While data availability limits the ability to include other pollutants in this analysis, we assume that wetland creation for P removal will have a positive impact on a range of other pollutants, particularly from diffuse sources.

The following criteria were used to identify 'demand' catchments where:

- The **potential wetland area is sufficient for water quality to improve to 'good' WFD status** The WQ wetland area needed to achieve 'good' status in each catchment was estimated according to the P load reduction required to achieve a 'good' WFD status (i.e. according to the current P load in a waterbody catchment vs the target load required to achieve 'good' status[4]) and a P removal efficiency water quality wetland removal efficiency[5] of 0.67g $m^{-2}$ $year^{-1}$ (Lyu, et al., 2024);
- The **Reason for Not Achieving 'Good' Status (RNAGS)** (Environment Agency, 2015) **is phosphate**. This increases the correlation between the creation of water quality wetlands which have been mapped based on the potential to remove P (see above point), and the ability of these wetlands to impact the WFD status of catchments surrounding and downstream of the wetlands;
- **Current WFD status is 'bad'** (from modelled concentrations) i.e. creating water quality wetlands where the need is greatest (where the WFD status needs to improve the most); and
- **Current WFD status is 'poor'** (from modelled concentrations). These catchments were ranked according to the catchments with the **smallest proportion of wetland area created on higher grade agricultural land[6]** (i.e. grades 1 and 2). This prioritises the creation of water quality wetlands where the need is higher but minimises the opportunity

[4] Target P load reduction was calculated for each catchment using national datasets (PR19 data for England and equivalent data for Scotland) produced using the SIMCAT SAGIS models (Environment Agency, 2019c; SEPA, 2012a), which show forecasted phosphate concentrations, loads and source apportionment for sampling points in waterbodies. Data was first summarised by waterbody. Mean flow was then back calculated from the mean P load and concentration. Mean flows and the target concentrations required to achieve 'Good' WFD status were used to calculate the target phosphorus load reduction required to achieve 'Good' status. The quantity of P removal required to achieve the target load was derived. The area of wetland required to achieve this reduction was derived using the specified removal efficiency, to assess whether mapped wetland potential was sufficient to achieve this reduction.

[5] A P removal efficiency of 0.67g m-2 year-1 is reported as the median mass removal rate for tertiary surface flow treatment wetlands with targeted upstream P removal, applied to domestic wastewater treatment (Lyu, et al., 2024). While higher removal efficiencies are reported for different wetland types and settings this conservative estimate was chosen because (a) treatment wetlands for wastewater treatment are only a subset of the instances where treatment wetlands could provide solutions. For wetlands used in wider catchments, background P levels, and hence removal rates, are likely to be lower as compared to wastewater scenarios; and (b) the Lyu study used a global dataset: lower efficiencies are likely in temperate regions, as compared with warmer climes.

[6] Agricultural Land Classification (ALC) for Wales and England (Welsh Government, 2017; Defra, 1988) and Land Capability for Agriculture classification (LCA) for Scotland (James Hutton Institute, 1981) classify land from grades 1 – 5 and grades 1-7 respectively, where ALC/LCA grades 1 and 2 are the highest quality agricultural land (i.e. few limitations for agricultural land; higher yields) and ALC/LCA grades 3 and above represent lower quality agricultural land.

costs of using agricultural land for creating wetlands.

The creation of water quality wetlands impacts the water quality in the catchments surrounding and downstream of the wetlands. The asset register therefore also includes the length of rivers in the catchments in which wetlands are being created (i.e. the catchments for target wetlands identified using the process detailed above).

## 3.2 Benefits

The potential benefits of WQ wetland creation to assess are based on the list of individual benefits included in (Defra, 2020) 'Enabling a Natural Capital Approach' (ENCA). This includes:

- Food provision
- Fishing (commercial)
- Timber
- Water supply
- Renewable energy
- Carbon sequestration
- Air quality regulation
- Flood risk management
- Noise reduction
- Temperature regulation
- Recreation
- Physical health
- Education
- Volunteering
- Amenity
- Biodiversity
- Soil
- Water quality
- Landscape
- Non-use values

Further to this list, minerals, other fibres and materials as well as mental health benefits were also considered.

A subset of these benefits have been included in this account, based on expert judgement on the material benefits provided by water quality wetlands and on the availability of data. Benefits thought to be material to the account, but that are excluded (e.g. because they lack data), are noted as part of the results of the analysis. The benefits included in this account are also complementary to the benefits being assessed in the other natural capital accounts described in the introduction. For example, although water quality wetlands could provide some flood risk management benefits this is not the primary benefit of water quality wetlands, and the flood resilience wetlands account has been developed for this primary benefit. Therefore this benefit has not been included in this analysis.

The methods used to assess these benefits for WQ wetland creation in England and Scotland are described in Section 4.2.1 and Appendix 1. The calculations are linked to the location and size of the wetlands, as identified in the asset register, described in Section 4.1. Monetary valuations are prioritised in the accounts, and cover food provision, water quality, and recreation benefits.

The baseline year for the analysis is 2024 and the reporting year for the analysis is 2050. The annual results in the account report the 2050 results as this is the year in which the total target WQ wetland area is reached and therefore provides a snapshot of the benefits and costs of water quality wetlands once they have all been created. Monetary values published in earlier price years are inflated to 2024 values using the latest HM Treasury (2023) GDP deflators. Asset values are estimated using HM Treasury (2022) Greenbook guidance following a declining discount rate and a 60-year assessment period.

# 4 Summary of analysis

*This section presents the data for the water quality wetland creation account. The account uses data from the latest available year.*

## 4.1 Asset Register

The asset register is a registry of all natural capital assets within the boundary of the account. It forms the foundation of the account and records the extent and condition of the assets. In this account, the extent of the assets has been quantified, and the condition of the water quality wetlands that will be created is assumed to be good, given that they are being created with the purpose of providing benefits.

The account is divided into the potential water quality wetland creation area and the target water quality wetland creation area. The distinction between these is that the potential area is the total area in England and Scotland where wetlands for water quality could be created. The target area represents a quarter of the overall area of wetland creation that meets WWT's 100,000 ha ambition, targeted from within the potential creation area (i.e. mapped locations of wetland potential within areas with the greatest 'demand' for wetland solutions (see https://www.wwt.org.uk/wetland-potential). Target water quality wetlands have been mapped based on characteristics that will help maximise the benefits they can provide relative to their costs.

The potential creation area is used to provide context for the target creation area. As shown in Table 4.1, the total potential creation area for wetlands for water quality in England and Scotland amount to 68,531 ha. This suggests that there are substantial areas of land in England and Scotland that are suitable for wetlands creation aimed at water quality improvement. In practice, the decision to create water quality wetlands will also be based on local information and judgement.

The target creation area for water quality wetlands in GB is 25,835 ha. This slightly exceeds the 25,000 ha figure (i.e. one quarter of the 100,000 ha ambition) to ensure the inclusion of all of the mapped wetland locations identified within the refined priority 'demand' catchments (see Section 3.1 for more information on the method used for defining the spatial boundaries of this account).

The asset register contains two datasets: the areal extent of the wetlands potentially being created (including the identified target area within this), and the length of waterbodies (i.e. rivers) in the catchments where these wetlands are located. The asset register shows a breakdown by baseline status (Bad and Poor status). It is expected that a greater proportion of wetland area could be created in waterbodies with a Poor status than in waterbodies with a Bad status; a lower reduction in P is required for these waterbodies, which in turn requires less space and a smaller area of wetland to achieve this reduction. Fewer waterbodies have sufficient area to provide a high load reduction of P, as would be required if starting from a

Bad status.

Table 4.1: Overview of Asset Register: Areal extent of potential wetlands for water quality.

| Country | Baseline status | Potential creation area (ha) | Target creation area (ha) |
|---|---|---|---|
| England | | | |
| | Bad | 3,144 | 1,260 |
| | Poor | 60,763 | 22,340 |
| | Moderate | - | - |
| Scotland | | | |
| | Bad | 577 | 156 |
| | Poor | 4,047 | 2,079 |
| | Moderate | - | - |
| **Total** | | **68,531.1** | **25,835.0** |

Table 4.2: Overview of Asset Register: Length of waterbodies in 'demand' catchments containing the potential locations for water quality wetland creation.

| Country | Baseline status | Waterbody length (km) |
|---|---|---|
| England | | |
| | Bad | 66.8 |
| | Poor | 1,315.1 |
| Scotland | | |
| | Bad | 14.1 |
| | Poor | 110.3 |
| **Total** | | **1,506.2** |

The asset register also shows a breakdown of potential and target areas of water quality wetland creation by Agricultural Land Classification (ALC) for England and Land Capability for Agriculture classification (LCA) for Scotland (henceforth referred to as Agricultural Class (AC) for both England and Scotland). Land can be classified from grades 1 – 5, where AC grades 1 and 2 are the highest quality agricultural land (i.e. few limitations and higher yields) and AC grades 3 – 5 represent lower quality agricultural land. Breaking down the extent by AC reflects the aim to create most water quality wetlands on lower grade agricultural land to reduce the opportunity cost of foregone agricultural production. Assuming the effectiveness of the wetlands is the same, the ratio between benefits and costs will be higher if low grade agricultural land could be used for water quality wetlands. Table 4.3 shows the asset register split into AC grades 1 – 2 and AC grades 3 – 5.

Table 4.3: Overview of Asset Register: Breakdown by AC high and low

| Country | Baseline status | Area of wetlands by AC | | | | Total | |
|---|---|---|---|---|---|---|---|
| | | High grades 1-2 | | Low grades 3-5 | | | |
| | | Potential creation area (ha) | Target creation area (ha) | Potential creation area (ha) | Target creation area (ha) | Potential creation area (ha) | Target creation area (ha) |
| **Total area of wetlands** | | **16,955** | **6,625** | **51,576** | **19,210** | **68,531** | **25,835** |
| England | | | | | | | |
| | Bad | 312 | 140 | 2,832 | 1,120 | 3,144 | 1,260 |
| | Poor | 16,439 | 6,399 | 44,324 | 15,941 | 60,763 | 22,340 |
| | Moderate | - | - | - | - | - | - |
| Scotland | | | | | | | |
| | Bad | 138 | 38 | 438 | 119 | 577 | 156 |
| | Poor | 65 | 48 | 3,982 | 2,031 | 4,047 | 2,079 |
| | Moderate | - | - | - | - | - | - |

Water quality wetlands are designed to improve water quality in surrounding and downstream waterbodies. This natural capital account estimates improvements in water quality based on the amount of P removed by water quality wetlands, relative to the water quality targets for achieving Good waterbody status. This data is shown in Table 4.4.

Table 4.4: Amount phosphorus (P) removal by target wetlands for water quality

| Indicator | | Quantity P (kg/year) |
|---|---|---|
| Total amount of P removed by water quality wetlands | | **173,094** |
| | England | 158,119 |
| | Scotland | 14,975 |

Table note: The total amount of phosphorus (P) removed each year by the total target area of 25,000 ha of wetlands created.

## 4.2 Natural Capital Asset Values

This section provides a summary of the methods used to estimate natural capital asset values for the creation of water quality wetlands in England and Scotland, with further details in Appendix 1. The account results represent a sum of England and Scotland. Where possible, the methods described have been used consistently for both countries.

### *4.2.1 Methodology*

Table 4.5 provides an overview of the benefits included in the accounts and the methods used to evaluate them (see Appendix 1 for a detailed methodology). A longer list of benefits was considered for inclusion in this account, based on Defra's natural capital guidance. Of these, the benefits shown in Table 4.5 were identified as being material for this analysis. Some material benefits are not quantified and are noted accordingly in the results.

The distribution of benefits between private benefits (e.g. to farmers) and benefits to wider society are also noted.

As explained in Section 3.1, the spatial boundaries and asset register included in this account are twofold; (1) the water quality wetlands themselves, and (2) the waterbodies (i.e. rivers) adjacent to the water quality wetlands. The two spatial boundaries are used to estimate different benefits from the creation of water quality wetlands:

- **WQ wetland boundaries** are used to estimate food provision disbenefits from forgone production, water quality benefit from avoided water treatment costs, and recreation benefit from visits to newly created wetlands.
- **Catchment boundaries** are used to estimate water quality benefit based on the length of river in which status is improved.

Table 4.5: Overview of benefits included in the account.

| Benefit | Description | Annual Physical Flow Measure | Monetary Valuation Metric & Method | Beneficiary |
|---|---|---|---|---|
| Food provision | Opportunity cost estimated according to the area of agricultural land converted to water quality wetland, the area of water quality wetlands created on AC Grades 1-2 and AC Grades 3-5, and the associated foregone income from agricultural production (i.e. opportunity cost). | Agricultural land converted to water quality wetland (ha/yr) | Opportunity cost of agricultural production (£/ha) | Farmers |
| Water quality | Estimated according to the length of rivers in target catchments that experience an improvement to 'good' status as defined by the Water Framework Directive (WFD) and the amenity and recreational benefit provided by an improvement in status. It is assumed that half (i.e. 50%) of the WFD status improvement is attributable to the creation of water quality wetlands (see Section 4.2.2 for more details on the assumption made). | Length of rivers with improvement in WFD status (km) | Value of improvement in WFD status of rivers (£/km) | Society |
| | Estimated according to the amount of phosphorus that is removed by water quality wetlands, which therefore does not need to be treated by traditional wastewater treatment plants. The avoided cost of treating phosphorus in wastewater treatment plants are used to estimate water quality benefit. It is assumed that half of the avoided costs are attributable to the creation of water quality wetlands (see Section 4.2.2 for more details on the assumption made). | Phosphorus removed by water quality wetlands (kg P) | Avoided wastewater treatment operational costs (£/kg P) | Society |
| Recreation | Estimated according to (1) the number of additional visits to areas adjacent to a created water quality wetland (based on the area of that wetland) and an estimate | Recreation visits to created wetland (visits/yr) | Benefit to visitors evaluated as total welfare value from | Visitors |

| | | | | |
|---|---|---|---|---|
| | of the welfare value associated with each visit to fen marshes (as modelled by ORVal and applied to wetlands) and (2) the number of existing visits to agricultural land and the additional welfare benefit gained from visiting areas adjacent to wetlands, which have a greater landscape diversity, as opposed to agricultural areas. | | (ORVal) tool[7] | |

Table note: Additional visits to wetlands have been estimated using the ORVal model which estimates the number of visits per ha to different habitat types and has been adjusted to account for the visits that would have occurred on agricultural land prior to the creation of a water quality wetland.

### *4.2.2 Water quality wetlands natural capital asset values*

The accounts identify a range of benefits from water quality wetlands in England and Scotland, including regulating services provided by water quality wetlands (i.e. water quality), provisioning services (i.e. food provision) and cultural services (i.e. recreation).

Table 4.6 shows annual physical flow and monetary values once the target area for wetland creation is reached (in 2050), as well as the monetary 60-year present value (PV60) for each benefit. The PV60 represents the asset value, calculated by summing the expected future annual flow of benefits over 60 years, discounted according to HM Treasury (2020) Green Book Guidance to express in present value terms. The monetary values reported in 2050 have also been discounted according to HM Treasury (2020) Green Book Guidance. Based on the discount factor applied, values in 2050 are approximately 59% lower than the values would be in the baseline year (2024).

The highest values in the wetlands for water quality account (Table 4.6) are generated from the water quality benefit, where the avoided water treatment costs make up 84% of gross asset value and the recreational, amenity, and non-use value from improvements in water quality (i.e. a change in WFD status) make up 41% of gross asset value. The disbenefit to food provision reduces the gross asset value by 30% and the recreational benefit provided by wetlands makes up 4% of gross asset value.

Part of the water quality benefit is estimated using the replacement cost method, namely the cost difference associated with reaching a nutrient reduction target by relying on the capacity of natural systems as opposed to utilising engineered (i.e. grey) alternatives (Watson et al., 2020). The water quality benefit is therefore estimated as the avoided cost of upgrades to existing wastewater treatment plants and associated drainage infrastructure including reducing flow to Sewage Treatment Works (STWs) through water efficiency measures and/or improvements to sewage discharge quality (e.g. N or P stripping) (Watson et al., 2020) based on the amount of P removed by water quality wetlands. Water quality wetlands are also likely to remove a number of other pollutants, such as nitrate and pesticides, which would reduce the volume of pollutants processed by wastewater treatment plants and thereby reduce

[7] Day, B. H., and G. Smith (2018) Outdoor Recreation Valuation (ORVal) User Guide: Version 2.0, Land, Environment, Economics and Policy (LEEP) Institute, Business School, University of Exeter. https://www.leep.exeter.ac.uk/orval/

wastewater treatment costs further. Wastewater treatment costs associated with the removal of pesticides, using methods such as activated charcoal, are particularly expensive. The removal of pesticides by water quality wetlands could therefore avoid large costs by wastewater treatment plants.

In this account the water quality benefit has been estimated as avoided wastewater treatment costs based on a reduction in P. Alternatively, the value of this benefit could have been estimated based on the mitigation costs of purchasing nutrient credits under nutrient neutrality requirements which have a market value ranging from ~£2,500/kg of P to ~£50,000/kg of P depending on the extent of nutrient neutrality affected catchments, housing pressure, and availability of mitigation solutions at present. However, these prices are defined as mitigation costs for additional nutrient pressures from new developments, as opposed to costs associated with reducing the existing nutrient load in waterbodies.

The other part of the water quality benefit estimates recreation, amenity, and non-use benefits from improving the water environment (i.e. measured as a change in WFD status) based on values estimated by the National Water Environment Benefit Survey (NWEBS) (Environment Agency, 2013). These values are estimated according to a change in WFD status in rivers in each region (e.g. a change from 'bad' to 'poor' WFD status). The high value associated with the water quality benefit can be attributed to (1) the substantial improvement in status in targeted waterbodies (i.e. improving from a bad or poor status to good status) and (2) the multiple benefits that are valued and bundled to estimate an overall water quality benefit. The recreation benefit valued here estimates an increase in recreation to waterbodies (i.e. rivers) where the status has improved. The recreation benefit measured separately in this account estimates the improvement in recreation from visits to areas adjacent to the water quality wetlands themselves. The recreational benefit in these benefit estimates occur on different natural capital assets, and so can be added.

Estimating the benefits provided by Water quality wetlands involves comparing a scenario in which water quality wetlands are created to a baseline scenario. The baseline scenario (i.e. the scenario in which water quality wetlands are not created) can be defined as either: (1) water quality improvement is delivered through traditional wastewater treatment plants, or (2) water quality is not improved. Therefore, the creation of water quality wetlands either: (1) reduces the costs of improving water quality from traditional wastewater treatment by delivering the same benefit at a lower cost, or (2) water quality wetlands deliver an improvement in water quality which otherwise would not have occurred. In reality, the baseline scenario is likely to involve a combination of the situations described above whereby the water quality in some waterbodies is improved by traditional wastewater treatment plants whilst the water quality in other waterbodies does not improve. It is not possible to know which of the baselines will happen in future without very detailed modelling of catchments, so it has been assumed that for half of the waterbodies affected, the creation of water quality wetlands reduce wastewater treatment costs to deliver an improvement in water quality, and in the other half of waterbodies, the creation of water quality wetlands provides an improvement in WQ which would not have otherwise occurred.

The account also includes the opportunity cost associated with changing agricultural land into water quality wetlands (Table 4.6), estimated according to the loss of income from agricultural production. The opportunity cost has been reduced by prioritising the creation of water quality wetlands on lower grade agricultural land (i.e. AC grades 3-5) which generally produce lower value outputs (see Appendix 1 for further details on the methodology). Nonetheless, the opportunity cost of converting this land to water quality wetlands reduces the total asset value by 30%.

The total gross value of creating wetlands for water quality is approximately £33 million in 2050 and £1.3 billion in present value terms over 60 years. Most of these benefits accrue to wider society.

The total gross value of creating wetlands for water quality does not include the benefits that could not be quantified or monetised, but that nonetheless contribute to the overall value of water quality wetlands. One of the material non-monetised benefits are the avoided carbon dioxide emissions from traditional wastewater treatment plants. Wetlands for water quality are designed to remove pollutants, such as phosphorus, thereby reducing the volume of pollutants that would need to be treated in traditional wastewater treatment plants, which consequently reduces the inputs they use, such as energy, leading to a reduction in carbon dioxide emissions.

Another material non-monetised benefit are the habitat and biodiversity benefits associated with the creation of wetlands. Poor water quality, leading to, for example, eutrophication, can alter biodiversity. Both the creation of habitat in water quality wetlands, and downstream improvement to habitat in adjacent waterbodies, is expected to benefit biodiversity.

## Table 4.6: Summary of benefits values in the wetlands for water quality creation account

| **Annual overview** | **Physical flow** | | | | | **Monetary value** | | | | | **PV 60 years (£m)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Produced at: January 2024** | **Physical indicator (unit/yr)** | Businesses | Rest of society | **Reporting (2050)** | **Confidence** | **Monetary indicator (£m/yr)** | Businesses | Rest of society | **Reporting (2050)** | **Confidence** | **Constant baseline** |
| | **Key monetised benefits** | | | | | | | | | | |
| Food provision | Agricultural land changed to water quality wetlands, ha | 25,835 | - | 25,835 | ● | Opportunity cost of agricultural land changed to water quality wetlands | (10) | - | (10) | ● | (400) |
| Water quality | Length of rivers with improvement in WFD status, km | - | 1,382 | 1,382 | ● | Value of improvement in WFD status of rivers | - | 14 | 14 | ● | 546 |
| | P removed by water quality wetlands, kg P | - | 86,547 | 86,547 | ● | Avoided wastewater treatment operational costs | - | 28 | 28 | ● | 1,115 |
| Recreation | Recreation visits to created wetland | - | 6,537,080 | 6,537,080 | ● | Welfare value for created wetland | - | 1.5 | 1.5 | ● | 59 |
| **Material non-monetised benefits: avoided carbon emissions from traditional wastewater treatment plants, avoided investment in traditional wastewater treatment capacity, habitat benefits** | | | | | | **Total gross value** | | | **33** | | **1,320** |

The quality of the data used for physical and monetary estimates for each benefit is assessed using the rating described in Table 4.7.

Table 4.7: Assessment of confidence in physical and monetary benefit estimates

| Level of confidence | Symbol | Description of confidence |
|---|---|---|
| Low | ● (red) | Evidence is partial and significant assumptions are made so that the data provides only order of magnitude estimates of value to inform decisions and spending choices. |
| Medium | ● (yellow) | Science-based assumptions and published data are used but there is some uncertainty in combining them, resulting in reasonable confidence in using the data to guide decisions and spending choices. |
| High | ● (green) | Evidence is peer reviewed or based on published guidance so there is good confidence in using the data to support specific decisions and spending choices. |
| No colour | ● (grey) | Not assessed |

## 4.3 Natural Capital Liabilities

The liabilities in the natural capital account reflect the expected costs of water quality wetland creation (i.e. CAPEX) and maintenance (i.e. OPEX). The costs of creating wetlands for water quality have been estimated based on costs from a study by eftec which looked at costs of freshwater wetlands in England (eftec, 2015). The costs provide a range of high and low-cost estimates. It has been assumed that these costs can also be applied to Scotland.

The undiscounted annual capital cost of creating 957 ha of water quality wetlands per year is approximately £16 million until 2050, after which no more wetland is created (as the wetland creation target is reached) and no further CAPEX costs are incurred. The discounted cost of creating water quality wetlands in 2050 is approximately £6.6 million and the present value cost of all wetland creation over 60 years is £287 million.

The costs associated with maintaining water quality wetlands (i.e. OPEX costs) increase annually in line with the cumulative area of wetland each year up to 2050. The maintenance costs of these wetlands are approximately £185 per hectare per year (central value) in 2024 prices. After 2050, the undiscounted annual maintenance costs for 25,835 ha of water quality wetlands amount to approximately £4.8 million per year. The discounted cost of maintaining water quality wetlands in 2050 is approximately £2 million and the present value of maintenance costs over the study period almost amount to £78 million.

The present value costs of wetland creation and maintenance over a 60-year period total approximately £365 million.

# 5 Account results

*The asset values are reported in the natural capital balance sheet. The asset values are separated into private benefits and benefits to wider society. Asset values are calculated by summing the expected future annual flow of benefits over 60 years. Where possible, future values take into account expected trends in the quantity and/or value of the benefit. Where this information is not available, benefits are assumed to be constant over time. This assumption increases the uncertainty of the results, which is further discussed in Chapter 6.*

## 5.1 Water quality wetland NCA balance sheet

Table 5.1 reflects the distribution of benefits and liabilities to businesses and wider society. In this account, the benefits to society amount to £1.7 billion (assessed over 60 years in present value terms) and the costs to businesses (e.g. farms) amount to £400 million.

In general, there is moderate confidence in both the physical and monetary flow estimates, with present value estimates having greater uncertainty due to assumptions on future trends. Key gaps and uncertainties for the account include:

- The unquantified benefits listed in Table 4.6 which are expected to be material.
- The avoided wastewater treatment costs are solely based on a reduction in P, however water quality wetlands are likely to also remove other pollutants which would further reduce wastewater treatment costs.
- The water quality benefits in this account have been estimated based on the assumption that half of the water quality wetlands created would displace the costs typically incurred by wastewater treatment plants to achieve the same water quality improvement, whilst the other half of water quality wetlands created provide an additional benefit by improving the water quality in waterbodies where water quality otherwise would not have been improved. The division in the approach used to estimate the benefit provided by water quality wetlands in improving water quality is based on uncertainty in the baseline scenario (i.e. the likely trajectory of events in the absence of the creation of water quality wetlands). The division in these benefit estimates could vary.
- The use of sustainable drainage systems (SuDS) in both urban and rural environments to prevent the mobilisation of pollutants and the subsequent costs of environmental damage have not been considered separately but are likely to perform a critical role in water quality improvement.
- The location of water quality wetlands in a waterbody catchment will affect the wetlands' ability to improve the water quality of surrounding waterbodies and therefore the benefit associated with an improvement in water quality.

The liabilities associated with the cost of creating and maintaining water quality wetlands in England and Scotland are estimated at £365 million over the next 60 years, which is approximately 24% of the gross asset value of the benefits. These costs might be met by business or wider society, depending on how they are delivered, but have been allocated to businesses in the account. Accounting for these costs, the total net asset value of water quality wetland creation in England and Scotland is approximately £955 million.

Table 5.1: Wetlands for water quality creation natural capital asset valuation, PV60 £m

| 2024 prices | Valuation metric | Value to businesses | Value to the rest of society | Total |
|---|---|---|---|---|
| **Asset values (monetised)** | | | | |
| Food provision | Opportunity cost of agricultural land changed to water quality wetlands | (400) | | **(400)** |
| Water quality | Value of improvement in WFD status of rivers | | 546 | **546** |
| | Avoided wastewater treatment operational costs | | 1,115 | **1,115** |
| Recreation | Welfare value for created wetland | | 59 | **59** |
| **Total gross asset value** | **Mix of values** | **(176)** | **1,720** | **1,320** |
| **Liabilities** | | | | |
| Creation costs[1] | | (287) | | **(287)** |
| Maintenance costs[1] | | (78) | | **(78)** |
| **Total gross liabilities** | | (365) | | **(365)** |
| **Total net asset values (monetised)** | | **(541)** | | **955** |
| *Other material unquantified benefits: Avoided carbon emissions from traditional wastewater treatment plants, habitat benefits* | | | | |

**Table notes:**
[1] Costs that are necessary to produce benefits (e.g. Water quality wetland habitat creation and maintenance costs).

### *5.1.1 Sensitivity analysis*

As has been noted above there is some uncertainty associated with the value of the benefits provided by water quality wetlands. Aspects of uncertainty include (1) the extent to which the creation of wetlands can improve the WFD status across a waterbody, and (2) the proportion of high- and low-grade agricultural land being converted to wetlands. To test the sensitivity of the results to these assumptions, the value of the relevant impacts (i.e. water quality and food provision) have been estimated based on different assumptions.

The area of wetland created in each waterbody catchment has been estimated based on the amount of P that needs to be removed in order for the waterbody to achieve Good status. It has been assumed that the improvement in water quality would occur within the same waterbody catchment that the wetland is being created. However, the capacity for wetlands to improve the water quality of a waterbody is dependent on the relative location of the wetland in the catchment (in the upstream or downstream part). If wetlands were located downstream of a waterbody, it has been assumed that the wetland would nonetheless improve the status of a similar sized waterbody downstream, and therefore deliver a similar benefit. To test the sensitivity of this assumption in the account, the length of the waterbodies benefitting from the water treatment provided by the wetlands has been halved. The result of this adjustment leads to:

- A total gross asset value of £1 billion over 60 years, as opposed to the £1.3 billion reported in Table 5.1, which is a decrease in value of the gross asset value of 21%.
- The total net natural capital asset values amount to £682 million over 60 years, which is a reduction of 29% in comparison to the net natural capital assets reported in Table 5.1, but nonetheless results in a positive benefit-cost ratio (i.e. the benefits of creating water quality wetlands still outweigh the costs).

The second aspect of the account on which the sensitivity has been tested is the disbenefit to food provision from the creation of wetlands. The opportunity cost of loss of farming income from agricultural land changed to water quality wetlands reported in Table 5.1 has been estimated based on the area of wetlands created on high grade (i.e. grades 1-2) and on low grade agricultural land (i.e. grades 3-5). The area of wetland created on these different land grades has been estimated using the process detailed in Section 3.1. To test the sensitivity of the results to these estimated areas, it has been assumed that 100% of water quality wetlands are created on high grade agricultural land. This adjustment leads to:

- The opportunity cost (i.e. a loss in farming income) increasing to £686 million in PV terms over 60 years, which is 1.7 times greater than the opportunity cost reported in Table 5.1.
- The total gross asset value changing to £1 billion over 60 years, which is a 22% reduction in the total gross asset value reported in in Table 5.1. The total net asset value amounts to £669 million over 60 years, which is a 30% reduction in the total net asset value reported in in Table 5.1. Nonetheless, the account maintains a positive benefit cost ratio, whereby the benefits of creating water quality wetlands outweigh the costs by £669 million over 60 years.

# 6 Conclusions and recommendations

The wetlands for water quality account can be used to (1) provide an evidence base for different groups and decision-makers to refer to on the size of the potential benefits provided by water quality wetland creation, and (2) to provide useful information to help manage natural capital assets, but more information on site-specific opportunity costs and benefits of water quality wetlands is needed.

As has been shown in the account results, wetlands for water quality have multiple benefits. The predominant purpose of these wetlands is to improve water quality. Although there are costs associated with creating water quality wetlands, including capital costs of wetland creation, operational costs of wetland maintenance, and opportunity costs of foregone farming income, the benefits to business and society outweigh the estimated costs. This result is robust to changes in assumptions around the extent of water quality impacts and the opportunity costs of the agricultural land used for the wetland creation.

### Improvements to the account:

The following suggestions are made to improve future analysis:

1. **Extend the accounting boundary to the entirety of the UK.** Due to a lack of data, Northern Ireland and Wales have not been included in this account. More work could be done to identify the areas in Northern Ireland and Wales that would benefit most from the creation of wetlands.

2. **Incorporate localised plans (Local Nature Recovery Strategies) as another geographical layer.** There is uncertainty around the accuracy of using national averages to understand benefits at a more specific local scale. As the national averages are figures from across England and Scotland, they iron out any site-specific discrepancies. However, there may be different opportunities for realising site-based or regional-based benefits of wetland creation. Where data is available at a specific scale, such data could be used in future accounts instead of wider-scale averages to make more reliable estimates of site-specific benefits.

3. **Refine benefit data.** More work could be undertaken to refine certain data, particularly:

    a. The **unquantified benefits** of WQ wetland creation such as:

        i. avoided carbon dioxide emissions from traditional wastewater treatment plants

        ii. habitat benefits;

        iii. avoided wastewater treatment costs from the treatment of other pollutants in addition to phosphorus;

   iv. avoidance of uncapped fines to water companies by introducing SuDS in urban catchments.

b. Consideration of **data beyond the scope** of this account, including the role of water quality wetlands as part of a **circular economy** in which the import and use of chemicals in wastewater treatment plants is avoided in cases where water quality wetlands replace traditional wastewater treatment. The nutrients removed by wetlands can also be applied to agricultural land, thereby offsetting the import and application of inorganic fertiliser. In particular, this reduces the need for imported mineral phosphate from finite, mined sources.

c. More detailed modelling of the all the benefits covered in this account would increase the certainty of the results.

4. **Develop a natural capital risk register.** An assessment of future risks and pressures is suggested to identify what actions can be taken to address them and how much these actions will cost. This will help address the points above, going forward, as well as help identify potential sources of finance for different actions.

WWT will continue to work to quantify the impacts of nature-based solutions, and aim to revisit the natural capital account in the future, addressing these limitations and gaps.

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# Appendix 1 – Benefit methodologies

## A1.1 Food provision

The creation of water quality wetlands on agricultural land is a disbenefit (i.e. cost) to food provision by ceasing agricultural production, and therefore agricultural income, on this land.

The cost to food provision from the creation of water quality wetlands is estimated based on hectarage of high grade (i.e. ALC/LCA[8] Grades 1-2) and low grade (i.e. ALC/LCA Grades 3-5) agricultural land changed to water quality wetlands. The breakdown is shown in Appendix Table 1.

Appendix Table 1: Total area of wetlands on ALC/LCA High and Low agricultural land

| ALC/LCA Grade | Area of wetlands (ha) |
|---|---|
| ALC/LCA High (Grades 1 – 2) | 6,625 |
| ALC/LCA Low (Grades 3 – 5) | 19,210 |

To calculate the area of agricultural land changed to water quality wetlands annually, the total area of wetlands created on ALC High and Low (Appendix Table 1) is divided by 27, the number of years required to reach the wetland creation target (i.e. the number of years between 2024 and 2050). Due to a lack of data on expected future changes in production, it is assumed that the physical flow remains constant over time.

The type of agricultural production on different agricultural land class (ALC) grades is used as a proxy for the difference in the value of production on different land grades. Appendix Table 2 defines the types of agricultural production on different ALC/LCA grades (ALC/LCA is graded from 1 – 5, where 1 is the highest grade).

Appendix Table 2: Types of production that occur on ALC Grades 1 – 5

<table>
<tr><th>ALC Grade</th><th>Definition</th><th>Type of production</th></tr>
<tr><td rowspan="4">Grade 1 – excellent quality agricultural land</td><td rowspan="4">Land with no or very minor limitations. Yields are high and less variable than on land of lower quality.</td><td>Top fruit (e.g. tree fruit such as apples and pears)</td></tr>
<tr><td>Soft fruit (e.g. raspberries and blackberries)</td></tr>
<tr><td>Salad crops</td></tr>
<tr><td>Winter harvested vegetables</td></tr>
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[8] Agricultural Land Classification (ALC) for England and Land Capability for Agriculture classification (LCA) for Scotland.

| | | |
|---|---|---|
| Grade 2 – very good quality agricultural land | Land with minor limitations that affect crop yield, cultivations or harvesting. The level of yield is generally high but may be lower or more variable than Grade 1. | Cereals |
| Grade 3 – good to moderate quality agricultural land | Land with moderate limitations that affect the choice of crops, timing, and type of cultivation, harvesting or the level of yield. | Cereals |
| | | Grass |
| | | Oilseed Rape |
| | | Potatoes |
| | | Sugar beet |
| | | Less demanding horticultural crops |
| Grade 4 – poor quality agricultural land | Land with severe limitations which significantly restrict the range of crops or level of yields. | Grass |
| | | Cereals |
| | | Forage crops |
| Grade 5 – very poor-quality agricultural land | Land with very severe limitations that restrict use. | Permanent pasture |
| | | Rough grazing |
| | | Pioneering forage crops |

The type of agricultural production on different ALC grades is used as a proxy for the difference in the value of production on different land grades. For example, fruit production is typically done on higher grade agricultural land, and therefore the farming income (i.e. gross margin) of fruit production per hectare is used to estimate the lost income from converting high grade agricultural land to water quality wetlands. The farming income (i.e. gross margin) for each product type is estimated as the average income for that product type between 2019 and 2023 (Redman, 2022). The average income on high- and low-grade agricultural land is estimated based on the types of products cultivated on that land (i.e. the average income from production on Grades 1-2 is based on the income from fruits, vegetables, and cereals whilst the average income from production on Grades 3-5 is based on the income from cereals, grass, oilseed rape, potatoes, grazing, etc.).

The average gross margin per product type cultivated on high- and low-grade agricultural land is then weighted according to the proportion of land area used for that product type. For example, both cereals and soft fruit are produced on high grade agricultural land, but a much greater proportion of land is used for cereal production than for soft fruit production. Therefore, the income per hectare for these product types is weighted according to the amount of land that is used for that product type, and then summed to estimate an overall income for agricultural production on high grade agricultural land. The proportion of land used for different product types are based on the average agricultural land use between 2019 and 2022 (Defra, 2023).

## A1.2 Water quality

### *A1.2.1 Recreational, amenity, and non-use value of water quality*

The water quality benefits from wetlands for water quality are a bundled benefit estimated using the National Water Environment Benefit Survey (NWEBS) values (Environment Agency, 2013). NWEBS includes values for recreation, amenity, and non-use benefits from improving the water environment.

Water quality wetlands filter water and remove pollutants thereby improving the water quality of surrounding waterbodies (i.e. rivers). The length of rivers in target catchments where water quality wetlands are being created in England and Scotland is divided by the number of years to reach the wetland creation target in order to find the length of target rivers which improve to Good status per year. It has been assumed that half of the waterbodies (i.e. rivers) in which there is an improvement in WFD status is attributable to the creation of water quality wetlands, whilst the other half of the waterbodies will have an improvement in status regardless of the creation of water quality wetlands through traditional wastewater treatment plants. The length of the waterbodies in which there is an improvement in WFD status attributable to the creation of water quality wetlands are shown in Appendix Table 3 (Scottish Environment Protection Agency, 2012b, 2007).

Appendix Table 3: Length of target rivers in England and Scotland improving to Good status per year.

| WFD baseline status | Length of target rivers, km/yr |
|---|---|
| Bad | 2 |
| Poor | 49 |
| **Total** | **51** |

*Source:* (Environment Agency, 2024) (Scottish Environment Protection Agency, 2012, 2007).

To estimate the benefit in monetary terms, the annual value of a change in Water Framework Directive status from Bad to Good or from Poor to Good is multiplied by the length of rivers in target catchments. The variables that compose WFD status are shown in Appendix Table 4. It is assumed that 50% of this change in status will be attributable to the creation of water quality wetlands. This assumption is based on how likely it is that wetlands will affect the variables according to which WFD status is determined. For example, the creation of water quality wetlands is likely to greatly impact the water quality of surrounding waterbodies but is unlikely to have as much of an impact on the morphology of a waterbody.

Appendix Table 4: Variables that define Water Framework Directive status and percentages attributable to creation of wetlands for water quality.

| Variable | Sub-categories | % attributable to water quality wetland creation |
|---|---|---|
| Biology | Fish; Invertebrates; Macrophytes and phytobenthos | 50% |
| Physical modification | Morphology; flow regime | 20% |
| Water quality | Dissolved oxygen; ammonia; phosphorus | 100% |
| Hazardous substance | Chemical status; chemical status excluding ubiquitous, persistent, bioaccumulative, toxic substances (uPBTs) | 30% |
| **Total** | | **50%** |

*Source:* (Environment Agency, 2024)

The value of WFD changes in status across catchments is estimated. In the absence of data on Scotland, the annual value of change in status in Till (a catchment at the Scottish border) is assumed to be the same as the annual value of a change in status per catchment for Scottish rivers. The value of the WFD status change across all target catchments is multiplied by the share of the change in status that can be attributed to water quality wetland creation (Appendix Table 4). Finally, the value of the WFD status change in catchments is divided by the total number of years required to achieve the wetland creation target in order to find the annual value of the improvement in WFD status in rivers attributable to water quality wetland creation. There is assumed to be a 3-year time lag between the creation of water quality wetlands and a change in WFD status (i.e. an improvement in water quality).

### *A1.2.2 Avoided wastewater treatment costs.*

Water quality wetland creation provides a benefit by reducing the cost of pollutant removal in water. In this account, part of the water quality benefit is estimated using the amount of P removed by water quality wetlands and the associated avoided wastewater treatment costs from wastewater treatment plants.

Appendix Table 5 shows the kilograms of P removed by water quality wetlands avoided in wastewater treatment plants. It has been assumed that 50% of wastewater treatment (i.e. the removal of P) are avoided through the creation of water quality wetlands. This is based on the assumption that in a baseline scenario in which water quality wetlands are not created, some of the wastewater treatment associated with improving water quality would have been met by wastewater treatment plants, and hence water quality wetlands avoid these costs, but not all wastewater would have been treated (i.e. some water quality would remain in poor condition) and hence costs are not avoided in these cases. The total amount of P removed by water quality wetlands per year is divided by the number of years required to reach the wetland creation target to find the annual amount of P removed by water quality wetlands.

Appendix Table 5: Amount of phosphorus (P) removed by water quality wetlands avoided in wastewater treatment plants.

| Country | Amount of P removed by water quality wetlands (kg P) |
|---|---|
| England | 79,060 |
| Scotland | 7,487 |
| Wales | 0 |
| **Total** | **86,547** |

Appendix Table 6 shows wastewater treatment costs associated with upgrades to existing wastewater treatment plants and associated drainage infrastructure, including reducing flow to Sewage Treatment Works (STWs) through water efficiency measures and/or improvements to sewage discharge quality.

Appendix Table 6: Wastewater treatment costs, 2024 prices

| Range | Wastewater treatment costs, £/kg P |
|---|---|
| High | 1,262 |
| Low | 323 |
| Average | 793 |

*Source:* (Watson et al., 2020)

The amount of P removed by water quality wetlands each year is multiplied by the cost of treating P in wastewater treatment plants to find the avoided wastewater treatment costs from the creation of water quality wetlands.

## A1.3 Recreation

The recreational benefit from water quality wetland creation is measured in terms of (1) the number of additional visits to newly created wetlands and the average welfare value associated with these visits and (2) the number of existing visits to agricultural areas and the additional welfare value from visits to wetlands.

The ORVal tool is used to estimate and measure the number and welfare value of visits to wetlands using fen marshes as a proxy as this is the most relevant habitat provided by ORVal (Day and Smith, 2018). ORVal also breaks down the estimated number of visits and associated welfare value by socio-economic group. Estimates can be produced for various spatial breakdowns within England and Wales, but the data in ORVal is only provided for England and Wales. Due to a lack of data, it is assumed that England visit data can also be applied to Scotland. It is assumed that 20% of water quality wetlands are accessible for visits.

It should be noted that the data from ORVal takes into account the location of the recreation asset, surrounding population, habitat type(s) and local alternatives, but makes the assumption that fen marshes are in average condition for its type. Where this is not the case, areas with better/ worse condition than average will likely have higher/lower values for number and welfare value of visits. Similarly, as the model underlying ORVal is based on MENE data, it does not take into account visits by children or overseas visitors to the UK.

The first element of the recreational benefit estimates the welfare value of additional visits to newly created wetlands based on the assumption that wetlands increase the number of visits compared to agriculture. The number of additional visits to newly created wetlands is estimated using the percentage change in the number of visits to fen marshes as opposed to agricultural areas. This percentage difference in the number of visits is then multiplied by the number of visits to fen marshes per hectare of fen marsh to estimate the number of additional visits to fen marshes. ORVal estimates the total value of visits to fen marshes, which is divided by the total number of visits to fen marshes, to estimate the value per visit. The number of additional visits is multiplied by the value per visit to estimate the benefit from visits to newly created water quality wetlands.

The second element of the recreational benefit estimates the additional welfare value of existing visits based on the assumption that a visitor’s enjoyment of visiting a wetland is higher than their enjoyment of visiting agricultural areas. The welfare value per visit is estimated by extracting from ORVal the welfare values associated with areas of agriculture and areas of agriculture and fen marshes (Day et al., 2018). To estimate the welfare value of fen marshes, the welfare value of agricultural areas is subtracted from the value of agricultural areas and fen marshes. The estimated welfare value per visit of fen marshes is then multiplied by the estimated number of visits to wetlands.

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