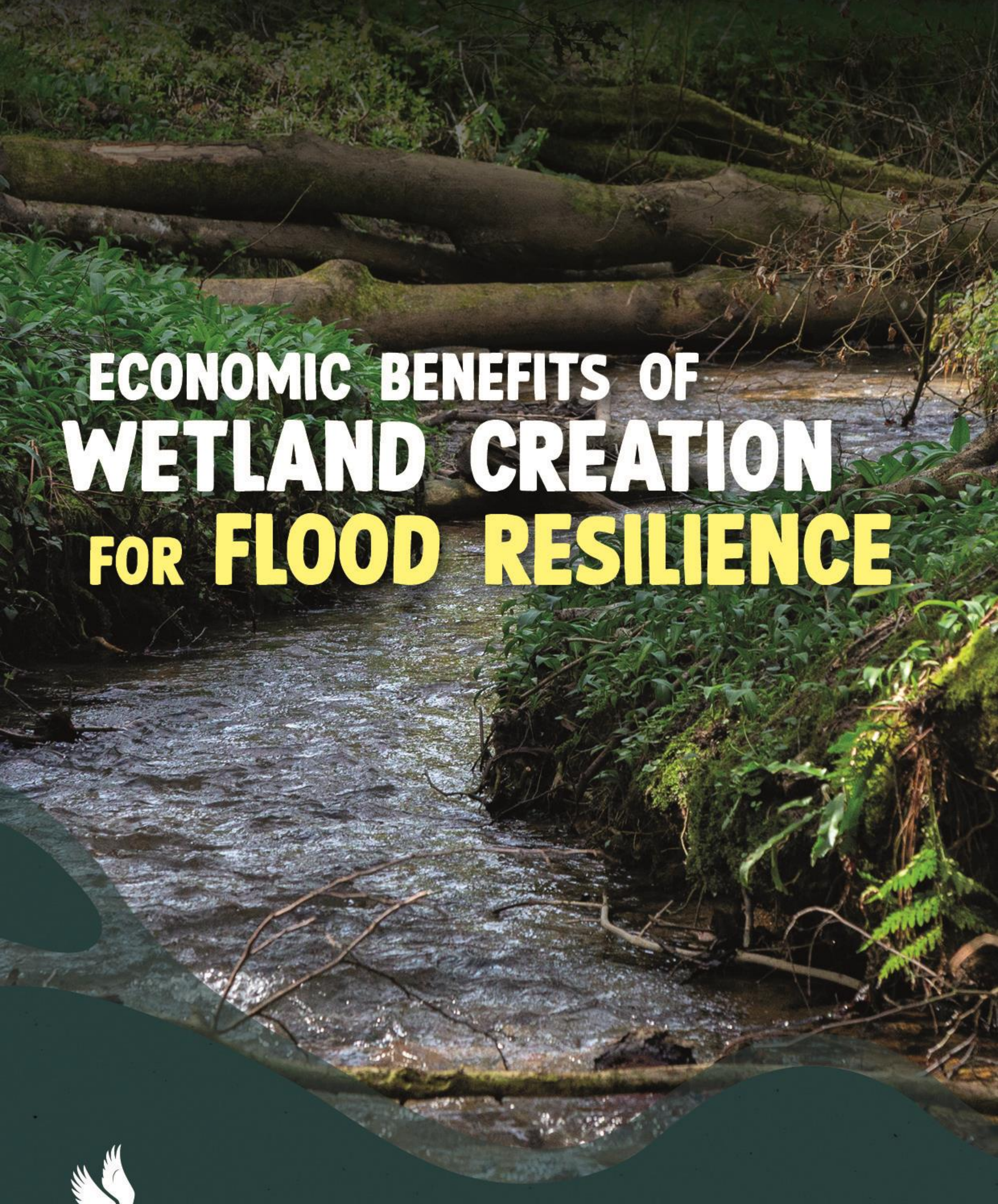

ECONOMIC BENEFITS OF WETLAND CREATION FOR FLOOD RESILIENCE

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economics for the environment

Final report
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Disclaimer

Whilst eftec has endeavoured to provide accurate and reliable information, eftec is reliant on the accuracy of underlying data provided and those readily available in the public domain when the analysis was undertaken in 2023. eftec will not be responsible for any loss or damage caused by relying on the content contained in this report.

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Executive Summary

This report presents a scoping analysis of the natural capital benefits of creating 25,000 hectares of wetlands for flood resilience in Great Britain (GB) by 2050. Creating wetlands for this purpose is known as Natural Flood Management (NFM). NFM is an approach that uses natural features in the landscape, such as wetlands, to slow down or store flood waters. The result is greater resilience to flooding (WWT, 2023). Wetlands for flood resilience are referred to as NFM wetlands in this report[1]. The costs and benefits associated with creating NFM 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 (detailed in this report) and (4) wetlands for water quality.

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 the results and understand a wider

[1] Wetlands for flood resilience are referred to as NFM wetlands for brevity. However, not all types of NFM measures have been considered in this account as the focus has been on the measures that allow for the creation of more permanent wetland habitats. Coastal flood resilience has also been accounted for separately in the accompanying saltmarsh natural capital account.

range of benefits. Nevertheless, the results show substantial potential benefits from NFM 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 £1.2 bn over 60 years. Most of the benefits in this account are public goods, including air quality regulation, recreation, and physical health benefits which reduce costs for public bodies such as health care trusts, the NHS, and local authorities. Flood risk management is also a public good, as it reduces costs of damage to infrastructure and disruption to economic activity, but also a private good, as it would reduce private damage costs of flooding. These benefits could incentivise a range of stakeholders to contribute to NFM wetland creation and maintenance costs, and some benefits have potential market value, such as additional carbon sequestration. Development of these funding approaches requires further research, which can build on the quantification and valuation of NFM wetland benefits in this report.

Table ES. 1 reflects the distribution of benefits and liabilities to businesses and wider society of NFM wetland creation. In this account, the benefits to society amount to £1.3 billion (assessed over 60 years in present value terms), but loss of benefits to businesses (e.g. farms) amounts to £133 million, and therefore the gross asset value over 60 years amounts to approximately £1.2 billion. The main benefits arise from carbon sequestration and recreation. The benefits associated with the protection of agricultural land and buildings against flooding through the creation of NFM wetlands are harder to value. They make up a smaller proportion of the total gross asset value because agricultural land and buildings only benefit from the creation of NFM wetlands in the case of a flooding event. Given that these areas are not at risk of flooding on an annual basis, the benefits accrue to a subset of the total agricultural land and buildings protected by NFM wetlands each year.

The liabilities in this account amount to £318 million over 60 years for the creation of wetlands (although the wetlands are created within the first 27 years of the analytical period) and £74 million over 60 years for the maintenance of NFM wetlands.

The total net asset value of NFM wetlands in GB amounts to £800 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 flood resilience creation in GB (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	Value of avoided damage to agricultural land from flooding (avoided income foregone)	2	-	2
	Opportunity cost of agricultural land changed to NFM wetlands	(248)	-	(248)
	Value of conservation grazing	14	-	14
Carbon sequestration	Value of CO_2e sequestered by wetlands	-	617	617
Air quality regulation	Value of PM2.5 removal by woodland	-	113	113
Flood risk management	Avoided damage costs to buildings from flooding annually	99	37	136
Recreation	Welfare value for created wetland	-	401	401
Physical health	Avoided medical treatment costs	-	158	158
Total gross asset value	**Mix of values**	**(133)**	**1,326**	**1,192**
Liabilities				
Wetland creation costs[2]		(318)	-	(318)
Wetland maintenance costs[2]		(74)	-	(74)
Total gross liabilities		(392)	-	(392)
Total net asset values (monetised)		**(525)**	**1,326**	**800**
Other material unquantified benefits: Water supply, mental health, tourism, volunteering, education, amenity, landscape, water quality, biodiversity				

Table notes:
[1] Value of carbon sequestered increases over time in line with HM Treasury Appraisal Guidance (DESNZ, 2023).
[2] Costs that are necessary to produce benefits (e.g. NFM wetland habitat creation and maintenance costs).

Contents

Tables

1 Introduction

The creation of wetlands can increase flood resilience by managing the flow of water more effectively. Creating wetlands for this purpose is known as Natural Flood Management (NFM) (WWT, 2023). NFM is an approach that uses natural features in the landscape, such as wetlands, to slow down or store flood waters (WWT, 2023).

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.

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 focusses on the carbon sequestration benefit from the creation of saltmarshes in the UK.

- **Wetlands for urban wellbeing**. The NCA for urban wellbeing wetlands focusses 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 is detailed in this report and focusses 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 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 by wetlands also highlights the beneficiaries from the creation of these wetlands, which informs who could invest in the capital and maintenance costs involved. For example, water companies may be interested in providing capital investment in the creation of wetlands that reduce surface water flooding and hence overflow at wastewater treatment plants, whilst local authorities and agricultural landowners in catchments[2] at risk of flooding may be interested in funding the operational investment required to ensure that a wetland continues to reduce flooding risks in downstream areas.

The remainder of this report provides evidence to demonstrate the value associated with creating NFM wetlands. To do this, a natural capital account has been developed for a target area of potential NFM wetland creation in Great Britain (GB). 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. These benefits are compared to the costs of NFM wetland creation 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 there is:

- **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,

[2] A catchment is a section of a river and the area of land from which water drains before flowing into that section (rather than via upstream rivers). Thus understood, a river basin such as the Severn is made up of multiple catchments along the Severn and its tributaries.

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 the 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 theme. 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 Structure of this report

This report documents the approach taken and the key results, including data gaps and uncertainties, for the wetlands for flood resilience 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 NFM wetland creation.
- **Section 3: Scope of the natural capital account** – defines the spatial boundary, asset register, benefits, and presentation of results.
- **Section 4: Summary of the analysis** – describes the analysis used to build the NCA.

- **Section 5: Results** – presents the NFM wetland creation benefits results.
- **Section 6: Conclusions and recommendations** – summarises the results of the NCA and provides interpretation of the results and next steps.
- **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 NFM 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"[3]. 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 NFM 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[4]. 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?

[3] Source: Natural Capital Protocol https://naturalcapitalcoalition.org/natural-capital-protocol/
[4] 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[5].
- **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 NFM 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 NFM 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

[5] The natural capital asset register is also the basis for scoping the natural capital risk register, and for a materiality assessment (see Section 4) 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.

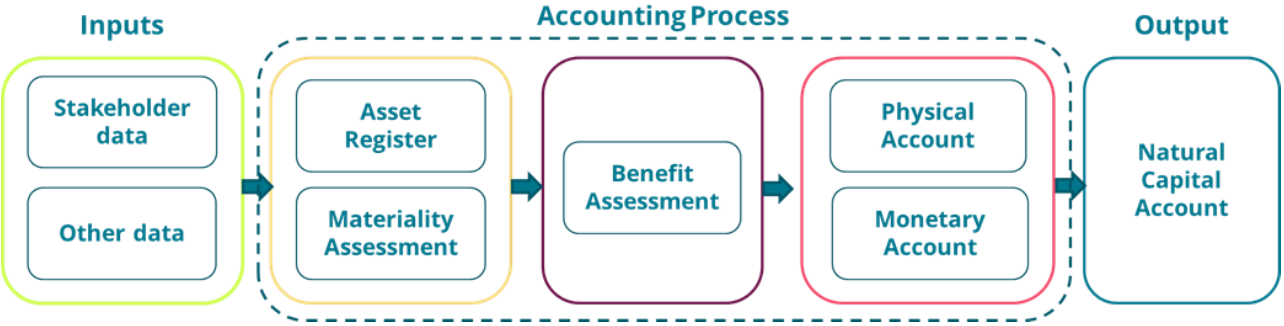

Figure 2.1: Outline of accounting process.

The balance sheets for the creation of NFM 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 NFM wetland creation account is Great Britain (which includes England, Wales, and Scotland). The intended spatial boundary of the account was the UK, but due to limited open-source data for Northern Ireland, the spatial boundary was reduced to only include GB.

3.1.1 Identifying suitable locations for NFM wetlands

The natural capital assets are defined by the extent of areas suitable for NFM wetlands, which has been mapped by WWT. Full mapping methods, including data sources, are available in the accompanying technical guidance document (Section 2; Appendix III). In summary, this involved the following steps:

Step 1: Selecting catchments with high 'demand' for NFM wetlands (wetlands for flood resilience):

a. **Flood risk map processing**. This identified the catchments containing areas at risk of flooding from rivers and surface water and excluded tidal flooding. It included areas of Medium and High risk (see Appendix Table 1 .

b. **Social Flood Risk Index (SFRI) criteria.** SFRI maps flood risk according to the number of people living within the floodplain and the overall social vulnerability of the neighbourhood (Sayers, Horritt, Penning Rowsell, & Fieth, 2017). Areas of medium and high flood risk (step a) which intersected with areas of high-extreme SFRI, and that contained buildings (Ordnance Survey, 2023), were selected.

c. **Upstream contributing areas.** Based on the catchments selected in steps a to b, a watershed analysis was performed to identify upstream contributing catchments: the percentage cover of the watershed area was assigned to any additional catchments (i.e. not including the selected ones) covered by the watershed. Catchments with watershed coverage of 20% or greater were merged with the selected catchments above to identify those contributing a significant amount to flooding in the downstream catchments.

d. **Built-up areas criteria.** Priority areas were selected based on whether ≤50% of a catchment was built-up (Office for National Statistics, 2017), to identify catchments with sufficient land available on which to undertake natural flood management schemes at a catchment-scale. The creation of NFM wetlands in these upstream catchments would be more likely have a more significant impact in reducing flooding downstream.

Step 2: Mapping potential locations for NFM wetlands within 'demand' areas:

a. **Hydrological criteria.** This allowed for the identification of areas which would be suitable for a wetland based on the way in which water moves and accumulates, and included Topographic Wetness Index, flow accumulation and slope surface maps, as well as fluvial and surface water flood risk maps.

b. **Adjustments for individual NFM types.** Five different types of NFM measures have been mapped: *offline storage areas*, *floodplain wet woodlands*, *flood inundation*, *runoff interception bunds*, and *leaky dams/gully-blocking*. Each of these measures have different features and are therefore mapped using different hydrological criteria (see technical report). For example, storage areas require flat ground where water can accumulate, whilst leaky dams/gully-blocking are placed on shallow slopes across drainage features or streams to slow the flow of water where significant water accumulation is not possible.

c. **Constraints applied to NFM maps.** A number of constraints have been applied in order to identify suitable areas for NFM wetlands, some of which are specific to individual NFM types. The constraints applied across all NFM types include a buffer around roads, buildings, railways, and functional sites[6], the exclusion of existing priority wetland habitat, as well as the exclusion of other priority woodlands, grasslands and orchards. A size threshold was also applied at this stage as interventions below a certain size are likely to be less effective, less resilient, and less economically viable to install.

The resulting NFM wetland locations were clipped to the 'demand' catchments layer (Step 1) to identify potential NFM wetland locations in catchments with the highest flood vulnerability. Layers for the different interventions were combined into a single layer, with overlaps removed (order of priority: floodplain inundation, offline storage areas, floodplain wet woodland, runoff interception bunds, leaky dams/gully blocking).

This exercise identified an area greater than the target NFM wetland creation area of 25,000 ha for the UK.

3.1.2 Identifying 'demand' catchments most suitable for target wetlands

For the purpose of this analysis, the creation area for NFM wetlands (25,000 ha) has been distributed across GB 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 GB (across England, Scotland, and Wales), rather than concentrated in a specific region.

[6] Functional sites include, for example, areas for air transport, education, medical care, road transport and water transport.

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

Country	Population	% of population	Target NFM wetland area allocation (ha)
Great Britain	65,185,724	100%	25,000
England	56,550,138	87%	21,688
Scotland	5,466,000	8%	2,096
Wales	3,169,586	5%	1,216

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

Step 3: **Refining the list of priority NFM wetlands to meet the target area for NFM wetland creation.**

The potential areas for NFM wetland creation (identified in steps 1 and 2 above) were refined to meet the target areas for NFM wetland creation in each country, by:

- Increasing the **minimum size threshold** for offline storage areas, floodplain wet woodlands, and flood inundation wetlands: larger interventions are likely to be more effective in defending against flooding and are more cost effective to create and maintain. Potential wetlands less than one ha were excluded for these three NFM types;

- Prioritising wetlands in ‘demand’ catchments with a larger potential area for NFM measures: **catchment-scale NFM** is likely to be more effective at protecting against flooding. Wetlands in catchments where the combined area of flood resilience wetland potential covered less than 10% of the catchment area, were excluded; and

- Prioritising wetland creation on **less productive agricultural land**, thus reducing the opportunity cost associated with lost agricultural capacity. Wetlands in ‘demand’ catchments where over 50% of the flood resilience wetland potential overlapped with high-grade agricultural land, were excluded. Significant overlap between floodplain areas, wetland creation potential, and high-grade agricultural land, means that complete avoidance of high-grade agricultural land is not possible.

Step 4: **Prioritising wetlands in catchments with ‘high risk’ of future flooding**

The next step involved prioritising the remaining wetlands (in ‘demand’ catchments) that have a high risk of future flooding, or catchments with the largest proportion of their land area feeding into these ‘high risk’ catchments. The process used to identify the ‘high risk’ catchments is described in section 3.1.3.

Steps 3 and 4 identified the target area for NFM wetland creation across GB, which forms the asset register for this account. The asset register includes the areal extent of NFM wetland locations identified in Step 3, as well as the target area of NFM wetland creation identified in Step 4.

3.1.3 Surrounding and downstream flood risk area boundaries

The creation of NFM wetlands aims to protect surrounding and downstream areas from flooding. Flood risk maps in England, Scotland, and Wales were used to estimate the areas with a high and a medium risk of flooding in each catchment. Areas of 'high risk' (i.e. those that could benefit most from flood risk reduction) were derived for 'demand' catchments containing the refined locations for NFM wetland creation, by:

England and Wales

a) Selecting areas of current medium flood risk that currently benefit from flood defences (Environment Agency, 2023; Natural Resources Wales, 2023). These areas currently have a 'medium' risk of flooding *because* of the adjacent flood defences. However, as engineered flood defences age and as climate change increases the frequency and intensity of flood events, it is expected that the risk level in these medium risk areas will increase;

b) Selecting areas of current high flood risk that are not currently defended, and therefore would be likely to benefit from the creation of flood resilience wetlands to reduce flood risk;

c) Combining the outputs of (a) and (b) into a combined *high risk* layer and removing mapped NFM wetland locations, as well as priority wetland habitats (i.e. those of national importance; Natural England, 2023a; Natural England, 2023b; Natural England, 2023c; Natural Resources Wales, 2022), to leave the at-risk areas that could benefit from flood-resilience wetlands; and

d) Calculating the areal extent of the high risk area for each 'demand' catchment containing the refined locations for NFM wetland creation.

Scotland

a) Deriving the percentage increase in the area of medium fluvial flood risk predicted due to climate change for each of the 'demand' catchments containing the refined locations for NFM wetland creation, calculated as the difference in extent between current and future flood risk (SEPA, 2023c)[7]. Mapped areas of flood resilience wetland potential, as well as existing wetlands (NatureScot, 2017; NatureScot, 2020) were deleted from the future flood risk extent layers prior to this analysis;

[7] Data on areas protected by flood defences in Scotland were not publicly available at the time of this analysis, hence why a different approach was taken for Scotland.

b) Clipping areas of current high fluvial flood risk to the refined 'demand' catchments. Areas overlapping mapped NFM wetland locations, as well as existing wetlands (NatureScot, 2017; NatureScot, 2020) were deleted from the flood risk layer;

c) Combining outputs of (a) and (b) into a *high risk* layer for Scotland; and

e) Calculating the areal extent of the *high risk* area for each 'demand' catchment containing the refined locations for NFM wetland creation.

The area covered by buildings (Ordnance Survey, 2023) within these 'high risk' areas was derived and used to estimate the number of buildings this represented, to provide an indication of the number of buildings that could be protected from flooding by NFM wetlands.

It has been assumed that the creation of NFM wetlands in a catchment provides protection to (1) the surrounding areas with a high and medium risk of flooding within the same catchment, and (2) the areas with a high and medium risk of flooding in the catchments immediately downstream. WWT mapped both these areas to identify the areas that could benefit from flood risk reduction by the target NFM wetlands.

3.2 Benefits

The potential benefits of NFM 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 NFM 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. For example, although NFM wetlands would provide water quality benefits, the account being developed for water quality wetlands will have a more material impact on this benefit, so they are not included in this analysis.

The methods used to assess these benefits for NFM wetland creation in GB are described in Section 4.2.1 and Appendix 1. The calculations are linked to the location and extent of natural capital assets, as identified in the asset register, described in Section 4.1. Monetary valuations are prioritised in the accounts, and cover food provision, carbon sequestration, air quality regulation, flood risk management, recreation, and physical health 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 NFM wetland area is reached and therefore provides a snapshot of the benefits and costs of NFM wetlands once they have all been created. Monetary values published in earlier price years are inflated to 2024 values using the latest HM Treasury (2024) GDP deflators. Asset values are estimated using HM Treasury (2022) Greenbook guidance following a declining discount rate and a 60-year assessment period.

3.3 Presentation of results

Information inputted into and results from the account can be presented for different spatial areas and for different beneficiaries. Results can be disaggregated to the three countries, namely England, Scotland, and Wales, in the reporting boundary.

For this account the benefits are divided across two main groups of beneficiaries: ‘Businesses’ (i.e. where the value identified is a financial return to a business (e.g. farms) and ‘the rest of the society’ (i.e. public benefits to wider society).

4 Summary of analysis

This section presents the data for the NFM wetland creation account. The account uses data from the latest available year. It covers the natural capital assets within the scope of the account, described in Section 3.

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 the NFM wetlands that will be created is assumed to be good, given that they are being created with the purpose to provide benefits.

The account is divided between the potential NFM wetland creation area[8] and the target NFM wetland creation area[9]. The target area of 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.

The potential creation area is used to provide context for the target creation area. As shown in Table 4.1, the total NFM potential creation area for NFM wetlands in GB amounts to 225,545ha. This suggests that there are substantial areas of land in GB which are suitable for NFM wetland creation. In practice, the decision to create NFM wetlands will also be based on local information and judgement.

The target creation area for NFM wetlands in GB is 24,591 ha. This slightly exceeds the 25,000 ha figure (i.e. one quarter of the 100,000 ha ambition) ambition due to the size and location of the wetlands that have been mapped. The target creation area includes a greater area than the ambition to create 25,000 ha to ensure the inclusion of all the mapped wetlands within the prioritised 'demand' catchments. The target creation areas are not proportionate to the potential creation area as these target areas were selected using an additional prioritisation step (step 4 detailed in Section 3.1).

The asset register breaks down the potential and target areas of NFM wetland creation by the size range of the wetlands. The five NFM measures are broken down into those with an area under 1ha, between 1ha and 5ha, and over 5ha across Great Britain, an overview of which is shown in Table **4.2**: Overview of Asset Register: Breakdown by size range of potential wetlandsTable 4.2. The asset register further shows how this size distribution is split across England, Scotland, and Wales. Understanding the size distribution is useful when it comes to calculating the costs of the NFM measures: due to economies of scale, smaller wetlands are usually more expensive to maintain and create per ha of wetland than larger wetlands.

[8] This is the area identified during stages 1 to 3 of the prioritisation process detailed in Section 3.1.

[9] This is the area identified from all four prioritisation stages detailed in Section 3.1.

Table 4.1: Overview of Asset Register.

Country	NFM type	Potential creation area (ha)	Target creation area (ha)
England		**173,620**	**21,249**
	Bund	30,035	2,096
	Flood inundation	17,551	2,776
	Storage area	104,048	10,278
	Wet woodland	21,895	6,098
	Leaky dams/gully blocking	92	1
Scotland		**48,077**	**2,099**
	Bund	27,699	1,079
	Flood inundation	456	0
	Storage area	15,113	923
	Wet woodland	4,748	96
	Leaky dams/gully blocking	61	1
Wales		**3,848**	**1,243**
	Bund	1,823	674
	Flood inundation	87	28
	Storage area	1,730	443
	Wet woodland	181	93
	Leaky dams/gully blocking	27	5
Great Britain		**225,545**	**24,591**

Table 4.2: Overview of Asset Register: Breakdown by size range of potential wetlands created by each NFM intervention type.

Size distribution	NFM type	Potential creation area (ha)	Target creation area (ha)
< 1 ha		**19,747**	**941**
	Bund	19,567	934
	Flood inundation	0	0
	Storage area	0	0
	Wet woodland	0	0
	Leaky dams/gully blocking	180	7
1 - 5 ha		**84,905**	**7,065**
	Bund	29,634	2,069
	Flood inundation	2,833	309
	Storage area	42,233	3,172
	Wet woodland	10,205	1,515
	Leaky dams/gully blocking	0	0
> 5ha		**120,894**	**16,585**
	Bund	10,356	845
	Flood inundation	15,261	2,495
	Storage area	78,658	8,472

	Wet woodland	16,619	4,772
	Leaky dams/gully blocking	0	0
Total area of wetlands in Great Britain		**225,545**	**24,591**

The asset register also shows a breakdown of potential and target areas of NFM wetland creation by Agricultural Land Classification (ALC) for England and Wales or Land Capability for Agriculture classification (LCA) for Scotland (ALC and LCA are henceforth referred to as Agricultural Class (AC)). Land can be classified from grades 1 – 5, where AC grades 1 and 2 are the highest quality agricultural land (i.e. few limitations for agricultural land 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 NFM wetlands on lower grade agricultural land to reduce the opportunity cost of foregone agricultural production. The ratio between benefits and costs will be higher if low grade agricultural land could be used for NFM wetlands in order to protect higher grade agricultural land around and downstream of them. Table 4.3 shows the asset resister split into AC grades 1-2 and AC grades 3-5, which is summarised at the GB level. The workbook containing the NCA models also included the breakdown within England, Wales, and Scotland.

Table 4.3: Overview of Asset Register: Breakdown by AC grade.

Country	NFM type	Potential creation area (ha)	Target creation area (ha)
AC Grade 1-2		**5,266**	**926**
	Bund	442	70
	Flood inundation	817	163
	Storage area	2,956	474
	Wet woodland	1,050	219
	Leaky dams/gully blocking	0.2	0.01
AC Grade 3-5		**220,279**	**23,317**
	Bund	59,115	3,650
	Flood inundation	17,276	2,570
	Storage area	117,934	11,122
	Wet woodland	25,774	5,968
	Leaky dams/gully blocking	179	7
Total area of wetlands in Great Britain		**225,545**	**24,243**

NFM wetlands are designed to mitigate the risk of flooding in the surrounding and downstream floodplain. The asset register therefore also includes the areas being protected by target NFM wetland creation. Table 4.4 provides an overview of the areas at high and medium risk of flooding within or downstream of catchments in which NFM wetlands are being created. These are the areas, and buildings, for which the risk of flooding is reduced by the creation of NFM wetlands. The total area at high and medium risk of flooding (36,057 ha), which is potentially protected by the creation of NFM wetlands, is 1.5 times greater than the area being used for the creation of NFM wetlands (24,591 ha, see Table 4.3).

Table 4.4: Overview of area and buildings in catchments protected by NFM wetlands.

Country	High risk area protected, ha	Medium risk area protected, ha	Total risk area protected, ha	Buildings in floodplain, no. buildings
England	9,806	21,747	31,553	18,635
Scotland	2,510	697	3,207	6,103
Wales	1,203	94	1,297	6,001
Total	**13,519**	**22,538**	**36,057**	**30,704**

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 NFM wetlands in Great Britain, with further details in Appendix 1. The account results represent a sum of the three countries in Great Britain. Where possible, the methods described have been used consistently for all three 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 the account, based on Defra's natural capital guidance (Defra, 2020), as described in Section 3.2. From this list, the benefits shown in Table 4.5Table **4.5** were identified as being material for this analysis. Some material benefits are not quantified (e.g. biodiversity, water quality and supply), and are noted accordingly in the results.

The distribution of benefits between private benefits (e.g. to farms) 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; namely the NFM wetlands themselves (see Sections 3.1.1 and 3.1.2) and the areas at risk of flooding potentially protected by NFM wetlands (see Section 3.1.3 *Surrounding and downstream flood risk area boundaries*). The areas suitable for NFM wetland creation have been subtracted from the areas potentially protected by NFM wetlands to avoid overestimation of the benefits. In reality, there are likely to be potential areas of NFM wetland creation in which wetlands are not ultimately created and therefore would benefit from the protection provided by upstream wetland creation. However, a conservative approach has been taken and these areas have not been included. In part, this is also to reflect the fact that these accounts are not designed to show exactly where to create wetlands. The two spatial boundaries are used to estimate different benefits from the creation of NFM wetlands:

- **NFM wetland boundaries** are used to estimate food provision benefits from conservation grazing (and disbenefits from forgone production), recreation benefit and physical health benefits, and carbon sequestration benefits, from the creation of wetlands; and air quality regulation from the creation of wet woodlands.
- **Surrounding and downstream flood risk area boundaries** are used to estimate food provision benefits from the agricultural land protected from flooding; and flood risk management benefits from the buildings protected from flooding.

Table 4.5: Overview of benefits included in the account.

Benefit	Description	Annual Physical Flow Measure	Monetary Valuation Metric & Method	Beneficiary
Food provision	Benefit estimated according to the agricultural area protected from flooding by potential NFM wetlands and the risk associated with this land being flooded on an annual basis. The national average split between high grade (AC grades 1-2) and low grade (AC grades 3-5) are applied to the agricultural area protected and the annual revenue from agriculture on different AC grades are used to estimate the avoided agricultural revenue lost.	Agricultural land protected from flooding (ha/yr)	Avoided revenue lost (£/ha)	Farmers
	Opportunity cost estimated according to the area of agricultural land converted to NFM wetland, the area of NFM 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 NFM wetland (ha/yr)	Opportunity cost of agricultural production (£/ha)	Farmers
	Potential for conservation grazing on some types of NFM wetlands during dry seasons. Estimated based on stocking densities supported by wetlands (i.e. the number of livestock that can graze on wetlands) and the gross value of livestock production.	Number of livestock units (no. heads/yr)	Gross value of livestock production (£/head)	Farmers
Carbon sequestration	Estimated according to UK average carbon sequestration rate (tonnes CO_2 equivalent per ha) of floodplains, assuming these have a similar carbon sequestration rate to flood inundation wetlands and storage areas, and the average carbon sequestration rate of woodlands, assuming these have a similar carbon sequestration rate to wet woodlands. The CO_2 sequestered by the wetlands created is multiplied by the non-traded price of carbon.	Carbon sequestered in wetlands (tCO_2e/yr)	Non-traded central carbon value DESNZ (2023) £/tCO_2e	Global society
Air quality regulation	Based on CEH modelling on the amount of air pollutant removed by new woodlands in each local authority and the value of air pollutant removal by local authority. Estimated the average air pollution per River Basin District (based on the local authorities in a River Basin District) and the area of new wet woodland	Air pollution removed by woodlands (kg PM 2.5/yr)	Value of air pollution removal (£/kg PM 2.5)	Local population

Benefit	Description	Annual Physical Flow Measure	Monetary Valuation Metric & Method	Beneficiary
	being created in that River Basin District per year.			
Flood risk management	Estimated according to the number of buildings with improved flood protection as a result of NFM wetland creation, and the value of the avoided damages from flooding.	No. buildings protected from flooding (no. buildings/yr)	Avoided damage costs to buildings (£/building)	Local population and businesses
Recreation	Estimated according to (1) the number of additional visits to a created NFM wetland (based on the area of that wetland) and an estimate of the welfare value associated with each visit to fen marshes (as modelled by Day and Smith (2018) in ORVal and applied to wetlands) and (2) the number of existing visits to agriculture and the additional welfare benefit gained from visiting wetlands as opposed to agricultural areas	Recreation visits to created wetland (visits/yr)	Benefit to visitors evaluated as total welfare value from (ORVal) tool.	Visitor population
Physical health	Estimated according to the number of active visits to wetlands per year and the estimated quality adjusted life years (QALY) from these active visits (Claxton et al., 2015). The avoided medical treatment costs are estimated according to the QALYs from active visits.	Active visits to nature (no. active visits/yr)	Avoided medical treatment costs	Visitor population

Table notes:

1. Conservation grazing involves the use of livestock where the primary objective is to manage the site for wildlife. This type of livestock farming therefore involves lower stocking densities than commercial livestock farming.
2. 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 an existing site (i.e. agricultural land) prior to the creation of an NFM wetland.
3. See Appendix 1 for further information on the method used to estimate benefits.

4.2.2 NFM wetlands natural capital asset values

The estimated annual physical and monetary values, and present value of benefits over the 60 years for the NFM wetland creation account is summarised in Table 4.6.

The accounts identify a range of benefits from NFM wetlands in GB, with a particular focus on regulating services, such as flood risk management, air quality regulation, and carbon sequestration benefits provided by NFM wetlands, as well as considering provisioning services (i.e. food provision) and cultural services (i.e. recreation, and physical health).

Table 4.6 shows annual physical flow and monetary values once the target area for wetland creation is reached (i.e. 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 Green Book Guidance (2020). Based on the discount factor applied, values in 2050 are approximately 50% lower than the values would be in the baseline year (i.e. 2024).

The highest values in the NFM wetland creation account (Table 4.6) are generated from the carbon sequestered by wetlands (52% of the total asset value) followed by the recreational benefit provided by wetlands (34% of total asset value) and the physical health benefits (13% of total asset value). Storage areas sequester 48% of the carbon dioxide estimated in the account, wet woodlands sequester 41% of carbon dioxide and flood inundation wetlands sequester 11%. The amount of carbon sequestered by these NFM wetlands largely follows the area of wetlands being created, with storage areas making up 56% of target wetland area, wet woodlands making up 30%, and flood inundation wetlands making up 14%. Wet woodlands have a higher carbon sequestration rate based on the assumption that their sequestration rate is similar to that of woodlands as opposed to that of floodplains.

The recreational benefit provided by NFM wetlands includes both the benefit associated with additional visits to newly created wetlands as well as the increase in welfare from existing visits to areas where wetlands are created. This therefore captures the total recreational benefit associated with converting agricultural land to wetlands.

The benefits that have been estimated based on the areas that are protected from flooding through the creation of NFM wetlands include the food provision benefit from avoided damages to agricultural land from flooding (0.2% of the total gross asset value) and the flood risk management benefit from the avoided damage to buildings from flooding (11% of the total gross asset value). These benefits have been estimated based on assumptions on the frequency of flooding (see Appendix 1 Section A1.1.1 for further details on the assumptions made and the method used) in high and medium risk areas, as well as assumptions on the level of protection provided by NFM wetlands (assumed to provide a 10% increase in the protection of surrounding and downstream areas compared to the status quo). The estimated benefits therefore have a high level of uncertainty given that the frequency with which an area is flooded, and the level of protection provided by NFM wetlands cannot be predicted. The avoided damage to agricultural land has been estimated based on the avoided loss of farming income, whilst the avoided damages to buildings have been estimated based on the avoided cost of repairing a building after a flooding event. The benefits associated with the avoided damages to buildings are greater than the benefits associated with avoided damages to agricultural land due to the higher unit cost associated with building damages from floods, which consist of direct damages to building fabric, damage to inventory items and clean-up costs (Environment Agency, 2018).

The account also includes the opportunity cost associated with changing agricultural land into NFM wetlands (Table 4.6), estimated according to the loss of income from agricultural production. The opportunity cost has been reduced by prioritizing the creation of NFM 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 NFM wetlands reduces the total asset value by 21%. The opportunity costs are much greater than the benefit associated with protecting surrounding and downstream agricultural land because this land is only protected in the case of a flooding event (i.e. the total area protected is not flooded every year). The benefits therefore only accrue to a subset of the total area being protected. As shown in Table 4.4, the total area at risk of flooding which is protected by NFM wetlands is approximately one and a half times larger than the total area on which NFM wetlands are being created.

Despite the opportunity costs of converting agricultural land into NFM wetlands, the total gross value of creating NFM wetlands is approximately £29 million in 2050 (as a discounted value) and £1.2 billion in present value (PV) terms over 60 years. Although some of these benefits accrue to businesses, most of these benefits accrue to wider society.

Table 4.6: Summary of benefits values in the NFM wetland creation account for Great Britain

Annual overview	**Physical flow**					**Monetary value**					**PV 60 years (£m)**
Produced at: March 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[1]**
Key monetised benefits											
Food provision	Agricultural land protected from flooding (ha)	1,667	-	1,667	🔴	Avoided loss of agricultural income	0.1	-	0.1	🔴	2
	Agricultural land changed to NFM wetlands (ha)	20,224	-	20,224	🟢	Opportunity cost of agricultural land changed to NFM wetlands	(6)	-	(6)	🟡	(248)
	Livestock production through conservation grazing on NFM wetlands, no. heads	7,368	-	7,368	🟡	Value of livestock conservation grazing	0.3	-	0.3	🟡	14
Carbon sequestration	Total CO_2e sequestered by NFM wetlands[2], tCO_2e	-	82,174	82,174	🟢	Total value of CO2e sequestered by flood management wetlands	-	15	15	🟢	617
Air quality regulation	PM2.5 removal by woodland, kg	-	10,243	10,243	🟡	Value of PM2.5 removal by woodland	-	2	2	🟡	113
Flood risk management	Avoided damage to buildings from flooding annually, no. of buildings	448	1,447	1,894	🔴	Avoided damage costs to buildings from flooding annually	2	1	3	🔴	136
Recreation	Recreation visits to created wetland, visits/yr	-	14,687,522	14,687,522	🟡	Welfare value for created wetland	-	10	10	🟡	401

Economic Benefits of Wetland Creation for Flood Resilience

Annual overview	Physical flow					Monetary value					PV 60 years (£m)
Produced at: March 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[1]**
Physical health	Active visits to nature, active visits/yr	-	2,513,382	2,513,382	●	Avoided medical treatment costs	-	4	4	●	158
Material non-monetised benefits: biodiversity, water quality and supply						**Total gross value**	**(3)**	**32**	**29**		**1,192**

Table notes:

1. PV estimates for air quality regulation and carbon sequestration have trend assumptions included as part of valuation process.
2. Carbon sequestration from NFM wetlands includes sequestration from flood inundation, storage areas, and wet woodlands. Different sequestration rates are applied depending on the habitat type.

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 provide 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

Sensitivity assessment

As has been noted above, there is a high level of uncertainty associated with the value of the benefits provided by NFM wetlands in protecting agricultural land against flooding and protecting buildings against flooding. The low confidence in the physical and monetary flow estimates for these benefits are shown in Table 4.6. Uncertainty in these estimates arises from (1) assumptions on the frequency of flooding and (2) assumptions of the level of protection provided by NFM wetlands against flooding. To test the sensitivity of the resulting account to these assumptions, the value of the two benefits with low confidence (i.e. food provision and flood risk management) have been estimated based on different levels of protection provided by NFM wetlands.

If the level of protection provided by NFM wetlands increased from 10% to 50%, the avoided loss of agricultural income would increase from £2m over 60 years to £12m over 60 years. This would increase the total gross value of the account from £1.19b to £1.20b over 60 years, which is an increase of only 1%. The account is therefore not very sensitive to these changes.

If the level of protection provided by NFM wetlands against flooding to buildings was halved to 5%, the avoided damage costs to buildings from flooding would decrease from £136m to £68m over 60 years. This would amount to a 6% decrease in the total gross asset value of the account, which is still only a fraction of the 50% decrease in the level of protection provided by NFM wetlands. Although the account results are more sensitive to changes in the assumptions for the avoided damages to buildings, sensitivity to these changes remains relatively low.

4.3 Natural Capital Liabilities

The liabilities in the natural capital account reflect the expected costs of NFM wetland creation (i.e. CAPEX) and maintenance (i.e. OPEX). The costs of creating NFM wetlands have been estimated based on the median costs reported by (The Catchment Based Approach, 2023) for different NFM measures (see Appendix 2 for the methodology). The target NFM wetland creation area in the asset register is 24,591 ha created over the next 27 years, which equates to approximately 911 ha of wetland creation each year up to 2050. This amounts to an undiscounted annual cost of approximately £17.8 million per year up to 2050, after which no more wetland is created and hence no additional CAPEX costs are incurred. The present value cost of all wetland creation over 60 years (after 2050, no more wetland is created) is £318 million.

Offline storage areas make up 47% of the NFM wetland area being created but make up almost two thirds (64%) of the annual creation costs. This is largely due to the high costs associated with creating the structures for water storage on wetlands (see Appendix Table 7 for unit costs). To account for this, higher costs are applied to the first hectare of each storage area, and these costs make up 52% of the annual creation costs. Conversely, flood inundation and floodplain wet woodlands make up 11% and 26% of the NFM wetland area being created, but only 3% and 12% of the annual creation costs, respectively.

The costs associated with maintaining the wetlands (i.e. OPEX) increase annually as the area of wetland increases each year up to 2050. The maintenance costs are based on a study by eftec which looked at the average operating costs (OPEX) of freshwater wetlands in England (eftec, 2015). It has been assumed that these costs also apply in Scotland and Wales. The maintenance costs of these wetlands (i.e. OPEX) total approximately £185/ha/year in 2024 prices. After 2050 the undiscounted annual costs amount to approximately £4.6 million per year in 2024 prices. The present value of maintenance costs over the study period is £74 million across all NFM types.

The present value costs of wetland creation and maintenance over a 60-year period total approximately £392 million.

5 Account results

The asset values estimated 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, particularly in relation to future changes in the frequency of flooding (i.e. increases in the frequency and severity of flooding due to climate change), which has not been estimated in this account and which could affect the results. Theses implications are reported in Section 6.

5.1 GB NFM 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 £1.3 billion (assessed over 60 years in present value terms) and the costs to businesses (e.g. farms) amounts to £248 million. The main benefits arise from carbon sequestration, and recreation.

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 5.1 which are expected to be material. As detailed in Section **Error! Reference source not found.**, this NCA is part of wider c ollection of accounts and some of the material unquantified benefits in this account will be valued in subsequent work.
- The geographic boundaries of the account exclude Northern Ireland due to the limited availability of open-source data, but further work should be done to include Northern Ireland.

The liabilities associated with the cost of creating and maintaining NFM wetlands in GB are estimated at £525 million over the next 60 years, which is approximately 33% of the gross asset value of the benefits. These costs might fall to business or wider society, depending on the responsible stakeholder, but have been allocated to businesses in the account. Accounting for these costs, the total net asset value of NFM wetland creation in GB is approximately £800 million.

Table 5.1: NFM wetland creation natural capital asset valuation for Great Britain, PV60 £m

2024 prices	Valuation metric	Value to businesses	Value to the rest of society	Total
Asset values (monetised)				
Food provision	Value of avoided damage to agricultural land from flooding (avoided income foregone)	2	-	2
	Opportunity cost of agricultural land changed to NFM wetlands	(248)	-	(248)
	Value of conservation grazing	14	-	14
Carbon sequestration	Value of CO2e sequestered by wetlands	-	617	617
Air quality regulation	Value of PM2.5 removal by woodland	-	113	113
Flood risk management	Avoided damage costs to buildings from flooding annually	99	37	136
Recreation	Welfare value for created wetland	-	401	401
Physical health	Avoided medical treatment costs	-	158	158
Total gross asset value	**Mix of values**	**(133)**	**1,326**	**1,192**
Liabilities				
Wetland creation costs[2]		(318)	-	(318)
Wetland maintenance costs[2]		(74)	-	(74)
Total gross liabilities		(392)	-	(392)
Total net asset values (monetised)		**(525)**	**1,326**	**800**

Other material unquantified benefits: Water supply, mental health, tourism, volunteering, education, amenity, landscape, water quality, biodiversity

Table notes:

[1] Value of carbon sequestered increases over time in line with HM Treasury Appraisal Guidance (DESNZ, 2023).

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

6 Conclusions and recommendations

The NFM wetland creation 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 NFM wetland creation, and (2) provide useful information to help manage natural capital assets, but more information on site-specific opportunity costs and benefits of NFM wetlands is needed.

As has been shown in the account results, NFM wetlands have multiple benefits, but the predominant purpose of these wetlands is to mitigate the risk of flooding. Whilst the account has estimated the benefit associated with flood mitigation, this is not the most significant benefit in the account. There are a number of potential reasons for this that warrant further investigation, including:

1. **Unquantified benefits from flood mitigation**. The benefits that have been quantified include the avoided damages to properties (residential and business). However, there are a number of other benefits that have not been quantified, including: social benefit to neighbourhoods of avoided flooding; avoided temporary accommodation costs; avoided emergency services costs; avoided flood risk infrastructure repair costs; avoided transport (i.e. rail and road) disruption and repair costs, etc.

2. **Conservative estimate of the number of buildings at risk of flooding**. The number of buildings at risk of flooding which could potentially be protected by NFM wetlands have been estimated using a mapping tool which counts buildings such as terraces as a single building, therefore underestimating the number of dwellings potentially affected by flooding. The costs associated with flood damages are valued per dwelling and therefore would underestimate the avoided flood damage costs. Using the property asset register data would increase the accuracy of the number of buildings at risk of flooding. However, it was not possible to access this data for this iteration of the account.

3. **Uncertainty in the future risk of flooding**. The avoided damages and costs to properties have been estimated based on a low, central, and high probability of flooding (within the medium and high-risk levels) but it is unknown how frequently a flooding event will occur, and whether the frequency will increase with climate change. Any future increase would increase the flood mitigation benefit value of NFM wetlands as they would be protecting against more frequent flooding.

4. **Uncertainty in the damage costs to properties from flooding**. The value of NFM wetlands in mitigating against flood risk has been estimated using the EA's 'best estimate' for the damage costs per residential and business property. However, the EA do provide a range of costs (i.e. low and high), which highlights some uncertainty in the costs. Damage costs to properties are also likely to vary depending on the intensity of a flooding event. This has not been modelled or accounted for.

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 has not been included in this account. More work could be done to identify the areas in Northern Ireland that would benefit most from the creation of wetlands.

2. **Refine benefit data.** More work could be undertaken to refine certain data, particularly the unquantified benefits associated with NFM wetland creation. More detailed modelling of all the benefits covered in this account would increase the certainty of the results, including improvements to the flood risk mitigation estimates based on the points detailed above. There are several material benefits that have been unquantified in this account, including ecosystem services such as water quality and water supply provided by wetlands. The method for calculating wetland benefits for water quality will be quantified in subsequent work focussing on wetlands with the purpose of improving water quality. Hence to avoid double counting, these benefits have not been estimated in this account, but further work could be done to estimate these benefits in a way that avoids double counting with the subsequent accounts.

3. **Better understanding is needed of future trends in benefits from natural capital, including those caused by climate change.** The economic value of the benefits provided by natural capital assets is the values aggregated over time, based on the assumption that the assets are maintained to provide those benefits. Expected future changes in the quantity and/or value of benefits are reflected in the estimates where relevant data is available (such as factoring in the increasing value of mitigating carbon emissions). However, there is insufficient data to represent some expected future changes (such as increased flooding events caused by climate change which would increase the value of NFM wetlands in protecting agricultural land and buildings) in the account. While management effort is made to maintain natural capital assets, it is not certain that current maintenance costs will be sufficient to maintain the natural capital assets in the long term, particularly in the face of climate change.

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 those 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.

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Appendix 1 – Benefit methodologies

This appendix describes the approach taken to quantify and value the benefits provided by NFM wetlands in the GB accounting boundary. The analysis covers the physical and monetary flows of the benefits listed in Section 4.2.1.

The structure of the account allows the benefit assessment to be designed so that some of the benefits are automatically calculated when asset register information is inputted, for others, asset and benefit data need to be linked manually.

A1.1 Food provision

The benefits and costs to food provision from the creation of NFM wetlands have been estimated based on three indicators, which can be summed to estimate the total cost or benefit (depending on whether the summed total is negative or positive, respectively). The three benefits and costs that have been estimated are: (1) the avoided flood damage to downstream agricultural land protected by the creation of NFM wetlands, (2) the opportunity cost of changing agricultural land into NFM wetlands upstream of flood-prone areas, and (3) the value of conservation grazing on newly created NFM wetlands. The method used to estimate each of these is detailed below.

A1.1.1 Avoided flood damage to agricultural land.

The creation of NFM wetlands upstream of catchments at medium and high risk of flooding, partially protects these areas from the risk of flooding. A proportion of the downstream catchment being protected is agricultural land.

The risk of flooding at each risk category is defined by Environment Agency (2019) for England and Wales and the Scottish Environment Protection Agency (2023) for Scotland. The chance of flooding at each of the risk levels is shown in **Error! Reference source not found.** Medium a nd low risk levels are presented as ranges whilst the high-risk level is greater than 3.3% in England and greater than 10% in Scotland.

Appendix Table 1 Chance of flooding per year according to each risk level

Risk level	Chance of flooding per year	
	England and Wales[1]	**Scotland[2]**
High risk	>3.3%	>10%
Medium risk	1% - 3.3%	0.5 - 10%
Low risk	0.1% - 1%	0.1% - 0.5%

Sources:

1. Environment Agency (2019) *Learn more about flood risk.*

2. Scottish Environment Protection Agency (2023) *Flood Hazard and Flood Risk Information.*

WWT estimated the total area in each catchment with a high and medium flood risk. These included areas of high flood risk that currently do not have flood defences, as these would benefit from NFM measures, and areas of medium risk that currently do have defences but are likely to benefit from NFM measures in future as the frequency and intensity of flooding increases due to climate change. The estimated areas at risk of flooding are shown in Appendix Table 2

Appendix Table 2 Total land area at risk of flooding in catchments within or downstream of the creation of NFM wetlands

Country	Land area at risk of flooding (ha)	
	High risk	**Medium risk**
England	9,806	21,747
Wales	1,203	94
Scotland	2,510	697
Total	**13,519**	**22,538**

The risk of land being flooded each year has been estimated for the medium and high-risk areas according to a low, central, and high estimate. The range of estimates highlights the uncertainty in the frequency of flooding even within a certain risk level. Appendix Table 3 shows the chance of flooding per year according to a low, central, and high estimate in medium and high-risk areas per country. The low and high estimates for the medium risk level have been estimated based on the upper and lower bound of the ranges provided by the Environment Agency (2019) for England and Wales and the Scottish Environment Protection Agency (2023) for Scotland (as shown in Appendix Table 1). The central estimate has been estimated as the central value within the defined range. The low estimate for the high-risk level is based on the lower bound risk provided by the EA and SEPA. However, the EA and SEPA do not provide an upper bound estimate for the high-risk level. The high estimate of the high-risk level has therefore been estimated by estimating the difference in the range provided at the medium risk level and has been multiplied by the low estimate of the high-risk level (i.e. 3.3% or 10%, which is the low estimate of the high risk level, multiplied by 3.3, which is the difference between the low and high estimate of the medium risk level for England and Wales). The difference between the low and high estimate of the medium risk level for England and Wales has also been applied to Scotland as the difference between those estimates for the Scotland-specific medium risk level would have generated an unrealistic high estimate for the high risk level (i.e. an increase of 2,000%). The central estimate for the high risk level has been estimated as the central value between the low and high estimate.

Appendix Table 3 Annual chance of flooding in high and medium risk areas based on range of estimates.

Country	Risk level	Chance of flooding per year		
		Low estimate	Central estimate	High estimate
England and Wales	High risk	3.3%	7%	11%
	Medium risk	1%	2%	3.3%
Scotland	High risk	10%	15%	21%
	Medium risk	0.5%	5%	10%

It has been assumed that 99.6% of the area at risk of flooding (shown in Appendix Table 2 which would potentially be protected by NFM wetlands is agricultural land, based on the total area at risk of flooding minus the area of buildings in the floodplain as mapped by WWT. The agricultural area at risk of flooding each year is estimated according to the probabilities shown in Appendix Table 3 . It is assumed that NFM wetlands would reduce the damages to agricultural land by 10%, based on expert judgement. Appendix Table 4 presents the agricultural land potentially protected from flooding each year by the creation of NFM wetlands. The creation of NFM wetlands increases incrementally between 2024 and 2050 until the target area of NFM wetlands is reached. Therefore, the area potentially protected by NFM wetlands also increases incrementally. Appendix Table 4 presents the agricultural land potentially protected from flooding once the total target area of NFM wetlands has been created.

Appendix Table 4 Agricultural land area potentially protected from flooding per year according to a low, central, and high estimate of the risk of flooding.

Risk level	Agricultural land area potentially protected from flooding per year (ha)		
	Low estimate	Central estimate	High estimate
Medium risk	61	116	171
High risk	22	50	79
Total	**83**	**167**	**250**

Table note: the central estimate (highlighted in pink) is reported in the account results reported in Section 5.

The value of NFM wetlands is therefore estimated as the farming income that is protected from flooding. Farming income is estimated according to the value of production on high grade agricultural land (i.e. agricultural land classification (AC) Grades 1 and 2) and lower grade agricultural land (i.e. AC Grades 3-5). In England, 19% of agricultural land is classified as Grades 1 and 2, whilst 81% is classified as Grades 3-5 (Natural England, 2019). This split between high and lower grade agricultural land has been applied to the total agricultural land area potentially protected from flooding (shown in Appendix Table 3). Agricultural production on different AC grades varies both in the type of production (e.g. soft fruit is typically grown on AC Grade 1 land) and varies in the level of yield (e.g. AC Grade 1 land has a higher yield of cereals than AC Grade 3 land) (Natural England, 2021). Agricultural production on AC Grades 1 and 2 therefore generates a higher revenue than production on AC Grades 3-5, based both on the production of higher value produce and higher yields. 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 monetary value of NFM wetlands has therefore been estimated by multiplying the gross margin of agricultural production on high grade and low grade agricultural land by the agricultural land area being protected from flooding.

A1.1.2 Opportunity cost of NFM wetlands

The opportunity cost associated with the creation of NFM wetlands is the loss of agricultural land which is being changed to wetlands, and the foregone income from agricultural production on that land. It has been assumed that the target NFM wetlands are all created on agricultural land (given that they cannot be created on built-up land or protected land). It has also been assumed that only flood inundation, floodplain wet woodland, and offline storage area wetlands would replace agricultural land. Runoff-interception bunds and leaky dams/gullies could be created within agricultural areas without replacing production.

A proportion of the agricultural land being converted to NFM wetlands would not have generated agricultural output due to flooding. It has been assumed that all the areas on which NFM wetlands are being created (and replacing agricultural land) are at high risk of flooding. The area of agricultural land on which NFM wetlands would be created but which would not have generated agricultural output was estimated based on the range of estimates for high flood risk areas shown in Appendix Table 3 . These areas were subtracted from the total agricultural area being converted to NFM wetlands. The resulting range of estimated agricultural area converted to NFM wetlands is shown in Appendix Table 5 .

As part of Stage 3 of the prioritisation process to identify target NFM wetlands (see Section **Error! Reference source not found.** for more details), NFM wetlands were prioritised if <50% o f the wetland was created on high grade agricultural land (i.e. AC Grades 1 and 2). This is to minimise the opportunity cost of creating NFM wetlands, by creating wetlands on lower grade agricultural land whilst protecting higher grade agricultural land. As shown in Appendix Table 5 , 4% of NFM wetlands are created on AC Grades 1-2 and 96% of NFM wetlands are created on AC grades 3-5. NFM wetlands are created on a lower share of high grade agricultural land than the national average, where 19% of agricultural land is high grade, and are created on a greater share of lower grade agricultural land than the national average, where 81% of agricultural land is lower grade (Natural England, 2019).

Appendix Table 5 Agricultural land area converted to NFM wetlands based on estimates of flood risk and subdivided by AC Grades

AC Grade	NFM type	Agricultural land area converted to NFM wetlands, ha			% agricultural land on AC grades
		Low estimate	Central estimate	High estimate	
Grade 1-2	Flood inundation	159	153	147	4%
Grade 1-2	Storage area	469	463	457	
Grade 1-2	Wet woodland	230	229	228	
Grade 3-5	Flood inundation	2,553	2,453	2,352	96%
Grade 3-5	Storage area	11,064	10,903	10,742	
Grade 3-5	Wet woodland	6,051	6,024	5,997	
Total		**20,525**	**20,224**	**19,922**	

Table note: the central estimate (highlighted in pink) is reported in the account results reported in Section 5.

The foregone farming income on agricultural land that is converted to NFM wetlands is estimated based on the gross margin of agricultural production on high grade and low grade agricultural land, using the same gross margin estimates as used in estimating the value of avoided flood damages (detailed in Section A1.1.1).

A1.1.3 Conservation grazing on NFM wetlands.

Although commercial agriculture is no longer feasible on the agricultural land being converted to NFM wetlands, less intensive conservation grazing could replace commercial agriculture on bunds, flood inundation and storage area wetlands for half of the year (i.e. not during the wet season).

The stocking density of cattle on NFM wetlands is assumed to be 2 livestock unit per ha on bunds and storage areas, based on the stocking densities permitted under the Environmental Land Management Schemes (ELMS) (Defra, 2021), and 0.4 livestock units per ha on flood inundation wetlands, based on the average annual stocking density of rush pastures reported by SRUC (2007). It is assumed that storage areas and bunds are able to support a higher stocking density than flood inundation wetlands given their lower retention of water over a given period of time. The number of livestock units grazing on these wetlands was estimated based on the share of these livestock populations that are mature/breeding and young (Defra, 2023). Livestock grazing on wetlands depends on the grazing regime of individual wetlands, the design of the wetland, and the frequency of flooding. The design of raised bunds, for example, can provide a refuge to livestock during flooding events. The capacity to graze livestock on wetlands will also depend on the frequency with which an area is flooded. In this account it has been assumed that livestock are able to graze on wetlands for half the year, which is a conservative estimate of the proportion of the year in which wetlands are likely to be flooded. The stocking densities used in this account are also considered to be conservative.

The value of conservation grazing was estimated based on the gross value per unit of livestock production (i.e. the value per livestock head) and the number of livestock that can graze on wetlands. The value per unit of livestock was uplifted by 25% to account for an organic premium placed on the sale of beef.

A1.2 Carbon sequestration

Carbon sequestration from created wetlands is estimated according to the amount of carbon sequestered by floodplains and woodlands, and the non-traded price of carbon.

Flood inundation and offline storage wetlands are assumed to sequester the same amount of carbon as floodplains, which amounts to 3.4 tonnes of carbon dioxide equivalent (CO_2e) per ha per year (Gregg et al., 2021). A carbon sequestration rate of 5.3 tonnes of CO_2e per ha, the UK average rate for woodland (Office for National Statistics, 2022), is taken to be the closest proxy to the carbon sequestration rate of wet woodland. These carbon sequestration rates are multiplied by the area of the wetlands created each year. The sequestration rates are assumed to remain constant over time.

The amount of CO_2e sequestered is then valued following the BEIS (2021) for the non-traded central price, £252 per tonne of CO_2e in 2024. This is multiplied by the estimated tonnes of CO_2e sequestered. Future flows of carbon are valued using the BEIS (2021) carbon values series until 2050. Following BEIS (2021) advice, a real annual growth rate is then applied starting at the most recently published value for 2050 and into the future.

A1.3 Air quality regulation

Air quality regulation from the creation of floodplain wet woodlands is estimated according to the amount of air pollutant (PM 2.5) removed by new woodlands each year and the value of avoided health impacts from air pollution.

The amount of air pollutant removed by new woodlands has been modelled by CEH for each local authority in the UK (eftec and CEH, 2019a). The amount of air pollutant removed by woodlands changes annually based on two factors: 1) pollutant concentrations and their transport across the UK, taking into account pollutant emissions, chemical interactions in the air, and the weather, and 2) the age of the woodland which affects the amount of pollutant removed where the amount of pollutant removed increases as the woodland ages, and then stagnates once the woodland has reached maturity.

The amount of air pollutant removed by new woodlands in each of the River Basin Districts in GB was estimated by averaging the air pollution removed by new woodlands in each of the local authorities within a River Basin District. The target area of wet woodland creation in each River Basin District was estimated and used to calculate the air pollution removal by these woodlands.

The amount of wet woodland created increases linearly each year[10] until the target wet woodland area is reached in 2050. As mentioned above, the age of a woodland affects the amount of air pollutant removed. The amount of air pollutant removed therefore had to be modelled for each individual parcel of wet woodland created each year in each of the River Basin Districts and projected over a 60-year time horizon.

The value of air pollutant removal is based on the health benefits of such removal and has been estimated based on avoided cases of respiratory hospital admissions, cardiovascular hospital admissions, and life years lost (reduced life expectancy as a result of long-term exposure) associated with changes in the concentration of PM2.5 (eftec and CEH, 2019b). The value of air pollution removal per area of woodland varies between local authorities based on factors such as population, and therefore number of avoided health impacts.

A1.4 Flood risk management.

Flood risk management benefits from the creation of NFM wetlands are estimated for agricultural land and built property. The method for agricultural land is described in A1.1.1. The benefit for built property is estimated from the number of buildings protected by NFM wetlands from flooding and the avoided damage costs to those buildings.

WWT estimated the number of buildings at risk of flooding in each catchment (i.e. the number of buildings in the floodplain). The number of buildings with a medium risk and the number of buildings with a high risk were estimated based on the share of total floodplain area at medium and high risk. In catchments being protected by the identified NFM wetland opportunities, across GB, 63% of the area has a medium risk of flooding, and the remaining 37% has a high risk of flooding.

The number of buildings at risk of flooding on an annual basis were estimated according to the low, central, and high probabilities shown in Appendix Table 3 . The share of residential to non-residential properties protected from flooding are based on figures taken from an EA study ‘Estimating the economic costs of the 2015 to 2016 winter floods’ (Environment Agency, 2018). The estimated number of residential and non-residential buildings at risk of flooding

[10] The area of wetland created increases each year for all types of NFM measures, until the target is met in 2050.

each year that are potentially protected by NFM wetlands are shown in in Appendix Table 6 for 2050 (i.e. the year in which the target area of NFM wetlands is reached).

Appendix Table 6 Number of residential and non-residential buildings at risk of flooding each year potentially protected by NFM wetlands.

Building type	No. buildings potentially protected by NFM wetlands per year, reporting year 2050		
	Low estimate	Central estimate	High estimate
Residential	758	1,447	2,136
Non-residential	234	448	661

Created NFM wetlands are assumed to lower the risk of flooding to the buildings reported in Appendix Table 6 by 10%. The avoided building damage costs from flooding is estimated based on the EA's best estimate of costs to residential and business properties from the 2015 to 2016 winter floods (Environment Agency, 2018). The costs are uplifted to 2024 prices. These costs are applied to the number of buildings protected from flooding by NFM wetlands.

A1.5 Recreation

Recreational benefit 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. "Welfare" refers to the sense of well-being or utility that an individual feels from their experiences (B. Day and Smith, 2018), such as the sense of well-being from visiting a green or blue space. A welfare value is a monetary estimate of the sense of well-being or utility experienced by individuals.

The ORVal tool is used to estimate the number and welfare value of visits to wetlands in the account boundary, using fen marshes as proxy as this is the most relevant habitat provided by ORVal. 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.

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.

ORVal estimates the number of visits by land type (e.g. woods, moors, fen marshes, etc.), which in itself makes an assumption on the accessibility of these land types in England and Wales (i.e. visits are only possible if an area is accessible). However, ORVal does not provide the area (i.e. size) of each land type that is being visited. In this account, to estimate the number of visits per ha of fen marsh in England and Wales, the total number of visits to fen marshes as reported by ORVal has been divided by the total area of fen marshes in England and Wales. The total area of fen marshes in England and Wales includes accessible and inaccessible fen marshes. Estimating the number of visits per ha of fen marsh in this way therefore has embedded within it an assumption of the national average accessibility of fen marshes in England and Wales.

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 ha 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 NFM 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 (B. H. Day and Smith, 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.

A1.6 Physical health

There are physical health benefits associated with 'active' visits to nature, where an 'active visit' is defined as those that meet recommended daily physical activity guidelines either fully, or partially, during visits. White et al. (2016) estimate that 51.5% of visits to nature are 'active'.

The White et al. (2016) proportion of active visits is applied to the additional visits to wetlands within the account boundary (estimated in ORVal as detailed in the 'Recreation' method), producing the number of annual active visits which is assumed to remain constant over time.

The benefit is valued as the health benefits of active recreation (in terms of improvements in Quality Adjusted Life years – QALYs) and the economic value of health improvement (in terms of the avoided health cost due to improvement in QALY).

Beale et al., (2008) analysed Health Survey for England data, estimating that 30 minutes a week of moderate-intense physical exercise, if undertaken 52 weeks a year, would be associated with 0.0106768 QALYs per individual per year. Beale et al., (2008) assume this relationship between physical activity and QALYs is both cumulative and linear. Claxton et al., (2015) estimate a cost-effectiveness threshold of a QALY to be roughly £12,900/QALY in 2008 prices. This figure is used as a proxy for health costs, reflecting the avoided health costs when QALY is improved by one unit. Based on this information, the avoided health cost per active visit is estimated as £3.66 in 2024 prices. The monetary unit value is assumed to remain constant over time.

Appendix 2 – Liabilities methodology

The liabilities in this account (i.e. the cost of NFM wetlands) are estimated based on the costs of creating the NFM wetlands (i.e. CAPEX) and the cost of maintaining the NFM wetlands (i.e. OPEX). The costs of creating the wetlands are one-off costs whereas the maintenance costs recur each year. In this account, the area of NFM wetlands created each year increases linearly, starting in Year 0 (i.e. 2024) up until the target wetland area is reached (i.e. in 2050). Therefore, an equal area of new wetland is created each year up to 2050, after which no new wetland is created. The cost of creating wetlands reflect this trend whereby the costs remain constant annually up to 2050, after which there are no creation costs. Conversely, the area of wetland that needs to be maintained increases each year as additional wetland areas are created up to 2050, after which the area of wetland that needs to be maintained remains constant.

The costs of creating NFM wetlands have been estimated based on the median costs reported for different NFM measures (The Catchment Based Approach, 2023). Appendix Table 7 shows the creation costs per ha of wetland created for each of the relevant NFM types reported in this dataset. The NFM types reported have been coupled to the NFM types included in this account. The Catchment Based Approach did not include information on bunds, therefore the costs associated with leaky barriers have been applied to the bunds being created. The dataset only had information on the cost of creating offline storage areas that were smaller than 1ha. In this NC account all storage areas are greater than 1ha. Therefore, the costs for creating offline storage areas were used to estimate the cost of creating the first hectare of each of the storage area wetland parcels. The cost of creating the remainder of the storage area wetland parcel have been calculated based on the costs of floodplain wetland restoration. It is assumed that creating the first hectare of storage areas will be more costly than creating the remaining hectares since the engineering required to ensure that a storage area can retain some flood water would be required in the first hectare and increasing the size of a storage area would not add as much to the cost.

Appendix Table 7 NFM types in this account and corresponding NFM type costs

NFM type	Sub-division	Corresponding NFM type reported by The Catchment Based Approach[1]	Creation cost/ha[1]
Bunds	All	Leaky barriers	23,645
Flood inundation	All	Floodplain wetland restoration	5,471
Storage area	1st hectare	Offline storage areas	133,912
	Remaining hectares	Floodplain wetland restoration	5,471
Wet woodland	All	Floodplain woodland creation	9,112
Leaky dams/gully blocking	All	Leaky barriers	23,645

Table notes:

1. Information in these columns is based on the information reported in (The Catchment Based Approach, 2023).

The cost of maintaining NFM wetlands is assumed to be the same across all NFM types, due to a lack of data on differing prices. The maintenance costs are based on a study by eftec (2015b).

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