Integrated planning and natural capital economic appraisal

Methodology Report

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Executive Summary

Aim of the study

The aim of this study is to trial ways in which to enhance services provided by natural capital assets and to optimise the catchment planning process through the use of economic tools. This will then support Defra's 25 year plan for the environment. This study is based on identification of the benefits that would flow from actions taken to improve natural capital within a river catchment in order to secure ecosystem services over the appraisal period. It does this by looking at actions that could restore, improve or maintain natural capital across the catchment as a whole, to address existing water quality, quantity and flood risk issues, while also taking account of the wider benefits that could be delivered by considering actions at the catchment scale.

The study looks to build on existing appraisal processes, such as those used in developing River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs). The aim has been to use the strengths of the existing integrated planning processes to develop a repeatable methodology that enables an integrated appraisal of a different mix of measures and interventions and to capture the wider impacts and benefits. The study was undertaken over a time period of around eight weeks, from the start-up meeting held on 3 February to the delivery of the final outputs on 31 March.

The integrated appraisal methodology

There are six steps in the integrated appraisal methodology, as shown in Figure 1:

1. Identify actions: description of a set of actions that could lead to water quality, quantity, flood risk or other improvements in the catchment, description of the benefits of each action in an Appraisal Summary Table (AST), and identification of the water bodies that could benefit from those actions, including any synergies or antagonisms if actions are undertaken together.
2. Cost actions: estimation of the costs of the actions.
3. Assess benefits to land: estimation of the benefits of the actions to ecosystem services on land using benefits transfer values, based on the ecosystem services that benefit from each action and the area of land that is predicted to benefit.
4. Assess benefits to water: estimation of the benefits to water bodies from an improvement in status from implementation of combinations of actions.
5. Compare costs and benefits: allocation of actions to three options with differing objectives and consideration of the monetised and non-monetised costs and benefits of each option. The three options are:
    a. Option 1: maximise natural capital. This will help ensure that natural capital is more able to adapt to climate change and is more resilient to low frequency, high impact events;
    b. Option 2: maximise water quality, water resources and flood risk management benefits in line with Defra's priorities. Adaptation and resilience to climate change are also important to this option; and
    c. Option 3: balance across all ecosystem services (provisioning vs regulating vs cultural) and across who pays and who benefits (social justice option).
6. Select the preferred option: based on the benefit-cost ratio (BCR) and net present value (NPV) but also non-monetised benefits and dis-benefits recorded in the AST, a distributional analysis identifying who pays and who benefits, and a range of sensitivity tests.

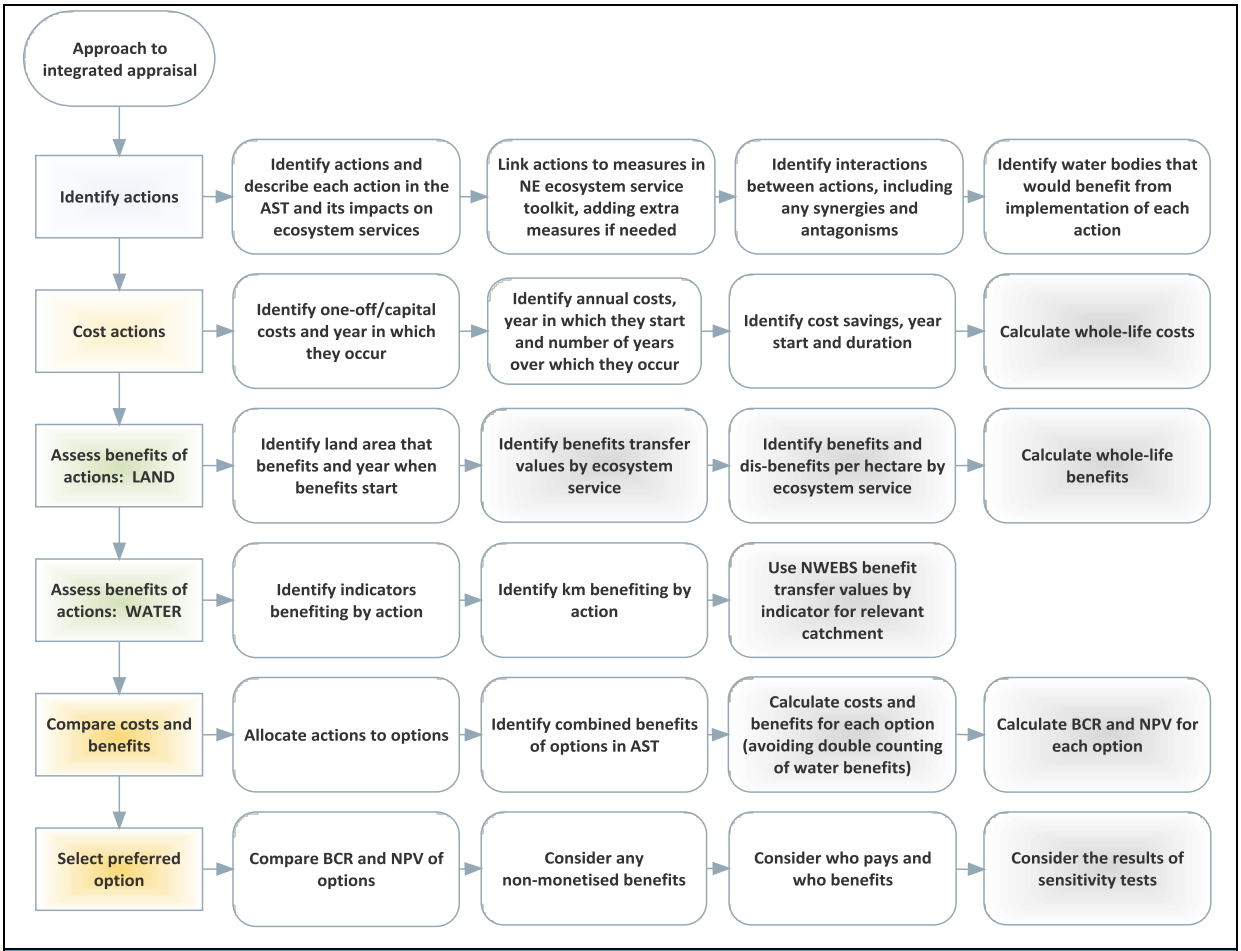

Figure 1: Flowchart showing key steps in approach to integrated appraisal
Note: colours shown down left-hand column match with the colours used for tabs in the supporting appraisal spreadsheet; boxes shown in grey are automatically filled in the spreadsheet when information is entered for each of the white boxes

Comparison of integrated planning approaches with the integrated appraisal

There are more similarities between the approach used in the RBMPs and the integrated appraisal than between the FRMP process and integrated appraisal. This is not surprising since the Stage 1 assessment provided the starting point for development of the integrated appraisal to build upon the strengths of that process. The integrated appraisal uses the same approach to estimating the cost of actions as the RBMP process for identifying the cost of measures. Both processes also use the NWEBS values for estimating the benefits to water bodies. All three processes draw on the economic parameters of the benefit-cost ratio (BCR) and net present value (NPV) when identifying the preferred option.

The integrated appraisal adds an additional dimension to the estimation of benefits by including an approach to estimate the benefits of the actions on land. This reflects the type of actions that have been identified as requiring a change in land use or management of land to deliver benefits in water quality, quantity and flood risk. The integrated appraisal has also been developed so that synergies from combinations of actions can be identified and described and for the monetary benefits to be identified. This can be done by identifying where synergies are predicted and then including an

additional action that combines the synergistic actions. The integrated appraisal also includes a distributional analysis showing who pays and who benefits with this being taken into consideration during selection of actions to be included under Option 3 (social justice), as well as during the comparison of options and selection of the preferred option. One final addition in the integrated appraisal is the potential to use the appraisal spreadsheet to optimise options.

Comparison of results from the integrated planning approaches and the integrated appraisal

Table 1 presents the results from the Stage 1 assessment for RBMPs and the integrated appraisals for the two case studies (note NPVs are shown to the nearest £1 million). The Bristol Avon urban case study includes two appraisals within the integrated approach: one assessing an integrated set of existing actions from other appraisals and one assessing a set of integrated actions. The Wyre case study is based on a vision for the Wyre catchment and focuses on the appraisal of an integrated set of actions intended to help deliver the vision.

Table 1: Comparison of BCR across the three appraisals (costs in £2016; benefits vary between £2014 to £2016[1])

Bundle/option	Unintegrated appraisal				Integrated appraisal			
	Stage 1 assessment		Stage 1+ assessment		Existing actions		Integrated actions	
	BCR	NPV (£m)	BCR	NPV (£m)	BCR	NPV (£m)	BCR	NPV (£m)
Bristol Avon urban								
Full bundle most to good	0.40	-£33	N/a	N/a	-	-	-	-
Bristol Avon catchment permitting pilot	0.75	-£7	1.1	£4	-	-	-	-
Bristol Avon catchment permitting pilot plus what the environment needs	0.69	-£10	N/a	N/a	-	-	-	-
Option 1: maximise natural capital	-	-	-	-	1.25	£12	1.21	£137
Option 2: Defra's priorities	-	-	-	-	1.46	£5	0.66	-£148
Option 3: social justice	-	-	-	-	2.22	£14	3.35	£24
Wyre								
Wyre catchment to good	1.64	£22	N/a	N/a	-	-	-	-
Option 1: maximise natural capital	-	-	-	-	-	-	5.19	£63
Option 2: Defra's priorities	-	-	-	-	-	-	5.88	£52
Option 3: social justice	-	-	-	-	-	-	4.12	£19

Table 1 shows that the BCRs of the integrated appraisal are consistently higher than the BCRs from the Stage 1 assessment. The BCR for the Stage 1+ assessment was only available for the Bristol Avon urban because the Wyre bundle already had a BCR greater than 1.5. Although the bundles and options cannot be directly compared, as they include different sets of actions, it can be seen that the

[1] Ideally the benefits would have been updated to £2016 values but there was insufficient time to enable this to be undertaken. Given the other uncertainties within the appraisal, this is not expected to have a significant impact on the overall results.

integrated appraisal shows a higher BCR than the Stage 1 assessment. This is likely to be partly due to the inclusion of benefits to ecosystem services on land, which were not monetised in the Stage 1 assessment. Both the unintegrated and integrated appraisals use the NWEBS values when estimating benefits to water but the integrated appraisal includes a wider set of actions that enables more of the indicators to be improved across a longer length of water bodies. Again, this will increase the benefits.

Table 1 also shows that the NPVs of options are not always positive under the integrated appraisal, but there is at least one option in each of the integrated appraisals that exceeds the NPVs from the Stage 1 assessment. Therefore, the results from the integrated appraisal show that there is potentially an economic case from looking much more holistically at a catchment and identifying actions that are intended to deliver the maximum improvement to natural capital across the catchment as a whole.

The case study appraisals were undertaken over a very short time period of around eight weeks and have been undertaken using information that was readily available. Where there are data gaps, these have been filled using assumptions. This ensured that the appraisal could be completed within the timeframe. However, this means that there are uncertainties introduced through the assumptions and the results of the case study appraisals are not intended to provide the basis for decision-making.

Value added by the integrated appraisal

The value of the integrated approach is that it enables more holistic actions at the catchment level to be identified, described and assessed. The case studies show that there is potential for actions that are defined and appraised in this manner to provide a better BCR and higher NPV than through existing appraisal processes, including integrated planning processes.

There are some barriers to uptake of an integrated appraisal, not least the data gaps associated with valuing the benefits. Other barriers identified in this study are associated with the level of detail needed for the analysis; these could be addressed by involving experts and stakeholders from the catchment during the development of the vision and during the appraisal. There would be particular benefits in improving the robustness of the cost estimates and in assessing the likely land areas and water bodies that would benefit. This may be more significant in reducing uncertainties than filling gaps associated with the existing set of benefits transfer values since these may vary by say ±100% whereas the areas and lengths benefiting could vary by several orders of magnitude.

There are also opportunities that could encourage uptake of integrated appraisal. The requirement to align RBMPs and FRMPs could help draw these two approaches together. The integrated appraisal approach developed in this study also builds on the existing integrated planning processes using similar methods, such as for assessing costs or estimating benefits to water. Therefore, the process is not an entirely new one and can build upon existing information and existing expertise.

Recommendations

This study shows that integrated appraisal has the potential to deliver wider benefits to natural capital in a cost-beneficial way. The case studies illustrate that it is possible to complete the appraisal using available data from RBMPs and FRMPs, combined with GIS data. There are data gaps in terms of valuation of some of the ecosystem services benefits, but the main uncertainties lie with the scale of the analysis and the specific issues that need to be addressed within a catchment. Use

of greater resolution data would enable actions to be identified more precisely, with this then better informing the assessment of costs and benefits. Likewise, involvement of people with knowledge of the catchments during the appraisal would help to develop actions that are more likely to be deliverable. The use of case studies and discussions with stakeholders would significantly help to reduce uncertainties over the likely uptake and, hence, success of the actions in meeting the environmental objectives.

Rolling out of the methodology could require significant data and resources, especially if there is considerable involvement of stakeholders and experts. There may be benefit from undertaking an initial assessment in-house in the Environment Agency, drawing on the information from the Stage 1 valuation and any existing catchment partnership work. Assessment of more integrated actions, however, will require a revised starting point such as the development of a vision in the first instance. This again could be undertaken in-house by the Environment Agency or catchment partners, supplemented by GIS analysis to develop the maps showing land use change and to measure the areas required under each action to deliver the required improvements to natural capital on land and in water.

In terms of the appraisal framework, there are some elements that would benefit from ground truthing and verification with experts. The identification of benefits and dis-benefits from actions is based on Natural England's ecosystem services transfer toolkit. This provides an evidence-based review of how different actions could lead to benefits and dis-benefits across a series of ecosystem services. As it based on peer-reviewed articles and similar research, it is limited to where research has been undertaken. A review of the findings by experts in how changes in land management could impact on ecosystem services would help to improve the robustness of this dataset.

Recommendations are made for a series of follow-up projects that could help fill data gaps and improve the robustness and reliability of the results of the appraisal, as well as to streamline the appraisal methodology. These include actions to assess whether there are datasets on the current state of natural capital, identify additional benefits transfer values or undertake a valuation study, assess the extent to which recreational benefits may be under-estimated in the current methodology, develop a consistent approach to taking account of qualitative benefits during decision-making, develop a protocol for rolling out the methodology, undertake a full scale trial to assess actual resource and data needs, investigate the potential involvement of experts on the catchment (on actions and on ecosystem services) to improve the underlying assumptions and to develop approaches to enable more detail to be taken into account during appraisal.

List of acronyms

AST	Appraisal Summary Table
BAP	Biodiversity Action Plan
BCR	Benefit-Cost Ratio
CEH	Centre for Ecology & Hydrology
Defra	Department for Environment, Food and Rural Affairs
EVEE	Economic Valuation of Environmental Effects
FBT	Farm Business Tenancy
FCRM	Flood and Coastal Risk Management
FRMP	Flood Risk Management Plan
IPPC	Integrated Pollution Prevention and Control
LIDAR	Laser Imaging Detection and Ranging
LCM2007	Land Cover Maps 2007
MTP	Medium-Term Plan
NE	Natural England
NPV	Net Present Value
NWEBS	National Water Environment Benefits Survey
NVZ	Nitrate Vulnerable Zone
OM	Outcome Measures
RAG	Red, Amber, Green
RBD	River Basin District
RBMP	River Basin Management Plan
RHDHV	Royal HaskoningDHV
RPA	Risk & Policy Analysts Limited
SAMP	System Asset Management Plan
SRC	Short Rotation Coppice
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Urban Drainage Systems
TEEB	The Economics of Ecosystems and Biodiversity
TRaC	Transitional and Coastal water bodies
UK	United Kingdom

WFD	Water Framework Directive
WTP	Willingness to Pay

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1 Introduction

1.1 Aim of the study

The aim of this study is to trial ways in which to enhance services provided by natural capital assets and to optimise the catchment planning process through the use of economic tools. This will then support Defra's 25 year plan for the environment. The study was undertaken over a time period of around eight weeks, from the start-up meeting held on 3 February to the delivery of the final outputs on 31 March. The focus has been on developing a repeatable methodology that enables an integrated appraisal to be undertaken.

This report provides a summary of the approach developed by the study team through trials on two case studies: the Bristol Avon urban and the Wyre catchment. This approach looks to integrate and build on existing approaches to appraisal to encourage a more holistic identification and assessment of options to address issues associated with water quality, water quantity and flood risk.

1.2 Natural capital and ecosystem services

Natural capital is the nation's stock of "environmental assets"; the elements of the natural world such as land, forests, biodiversity, water, soil, air, geodiversity and oceans that provide valuable goods and services (benefits) to people such as clean air and water, food and recreation (NCC, 2013).

Natural capital provides the stocks that lead to ecosystem service benefits (flow) and provide value to people and businesses, as shown in Figure 1-1.

Figure 1-1: The links between natural capital, ecosystem services and benefits (Source: Natural Capital Coalition, nd)

This study is based on identification of the benefits that would flow from actions taken to improve natural capital within a river catchment in order to secure ecosystem services over the appraisal period. It does this by looking at actions that could restore, improve or maintain natural capital across the catchment as a whole, to address existing water quality, quantity and flood risk issues, while also taking account of the wider benefits that could be delivered by considering actions at the catchment scale.

1.3 Development of an integrated approach

The study looks to build on existing appraisal processes, such as those used in developing the 2015 River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs). The potential to which these existing processes could be used to undertake an integrated appraisal is considered. Areas where changes could be made to the existing approaches are identified and these are supplemented by new steps where the current approaches could not be easily modified to enable a more integrated appraisal to be undertaken. Figure 1-2 shows how the approach to integrated appraisal builds on and extends the current approaches to integrated planning. It also illustrates how it could feed into innovative financing and encourage use of different investment streams.

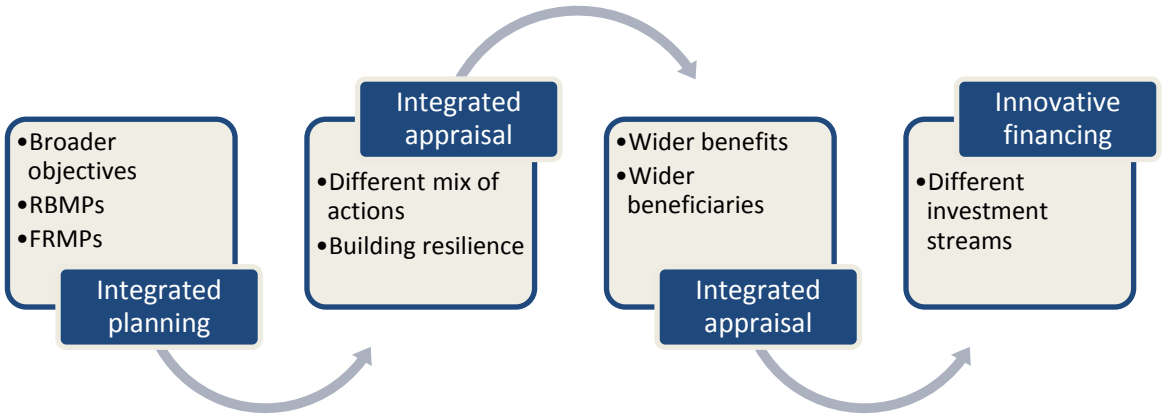

Figure 1-2: Extending integrated catchment management into integrated appraisal

1.4 Structure of the report

This report describes the existing appraisal approaches and the proposed approach for modifying these to enable integrated appraisal. It then presents the methodology developed for the integrated appraisal, step-by-step, illustrating how the appraisal works using examples taken from the two case study catchments:

- Section 2 describes the existing appraisal approaches and their strengths and weaknesses in acting as a basis for integrated appraisal;
- Section 3 presents the integrated approach and sets out the methodology step-by-step, illustrating how it would work using examples from the two case study catchments;
- Section 4 compares the integrated appraisal set out in Section 3 with the results of existing appraisals described in Section 2;
- Section 5 identifies the lessons learned through the study and discusses the value added from the integrated appraisal;
- Section 6 sets out the study recommendations and suggested next steps; and
- Section 7 provides the references for the study.

The report is supported by the integrated appraisal spreadsheet, and the two case study reports:

- Annex 1: report on the integrated appraisal as applied to the Bristol Avon urban catchment; and
- Annex 2: report on the integrated appraisal as applied to the Wyre catchment.

2 Current approach to appraisal

2.1 Overview

This section provides a review of the existing approaches to assessing water quality, quantity and flood risk issues. The focus is on integrated planning approaches to developing the 2015 River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs). These processes are described here and then critically reviewed for their use within an integrated appraisal, with the strengths and weaknesses identified in relation to how these could be used to inform an integrated appraisal.

2.2 Approach to RBMP

2.2.1 The baseline

The baseline is taken as 2014 or 2015 (where planned and funded measures or improvements will be in place) (Environment Agency, 2014). The baseline is the same for both water quality and water quantity (flow) pressures, with the Stage 1 valuation tool being used.

2.2.2 Structure of the appraisal

Figure 2-1 presents an overview of the structure of the appraisal used in River Basin Management Planning (RBMP).

2.2.3 Identify measures and bundles of measures

The RBMP appraisal process focuses on identifying a bundle of measures to improve water bodies in the operational catchment to good status/potential or as near to it as possible. These bundles are built up from individual measures.

First, the most cost-effective measure for addressing each pressure is identified. These are included within the 'bundle sheet' along with information on the type of water body that will benefit from the measure (river, lake, coastal water, TraC, groundwater).

Next, the water bodies within the catchment are listed. The water bodies in which each measure will be implemented are identified. Also identified are the water bodies upon which the measures would impact.

Further information is included on whether the measure has already been funded and is underway and to identify each measure's primary objective. There are two primary objectives for each measure:

- A change from current to 'improved'; or
- No deterioration.

In addition, the approach includes a question on whether the measure's primary objective is to improve a protected area.

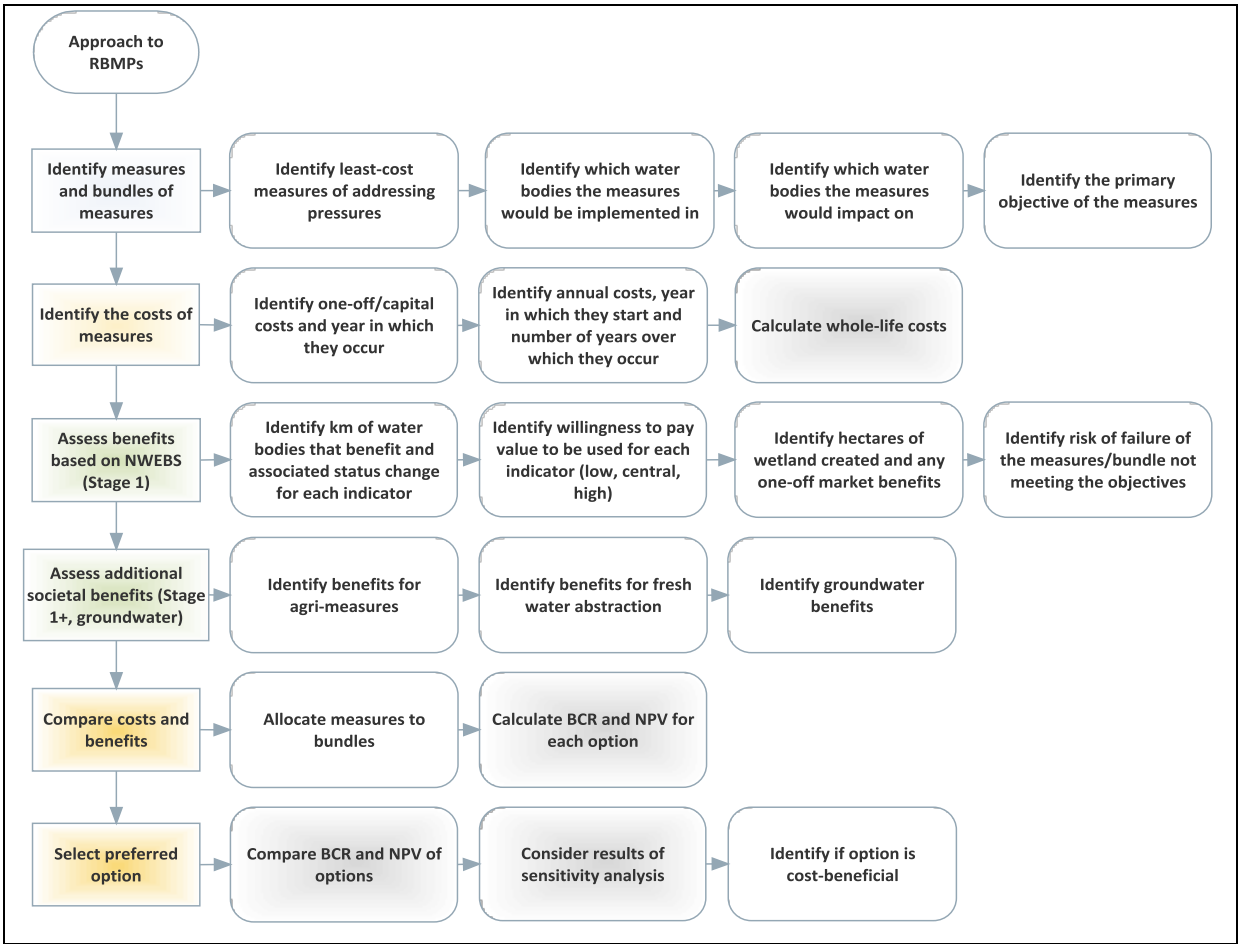

Figure 2-1: Flowchart showing the structure of the RBMP approach to appraisal

Table 2-1 summarises the information from the two case study catchments related to identification of measures.

Table 2-1: Case study application of RBMP appraisal process – identification of measures

Criterion	Case study catchment	
	Bristol Avon urban	Wyre
Number of measures assessed	12[2]	45
Number of measures primarily improving river water bodies	11*	31
Number of measures primarily improving lake water bodies	0	0
Number of measures primarily improving coastal water bodies	0	0
Number of measures primarily improving TraC water bodies	1	14

[2] One measure is greyed out in the bundle sheet for the Bristol Avon urban, but has been assessed fully for the criteria related to identification of measures so is included here. The later criteria that include this greyed out measure are shown with a *

Table 2-1: Case study application of RBMP appraisal process – identification of measures		
Criterion	Case study catchment	
	Bristol Avon urban	Wyre
Number of measures primarily improving groundwater water bodies	0	0
Number of water bodies in which measures would be implemented	59*	55
Number of water bodies impacted upon by measures	64*	88
Number of measures already funded and underway	3*	1
Number of measures whose primary purpose is to improve a protected area	0	1
Number of measures whose primary purpose is a change from current to 'improved'	10*	40
Number of measures whose primary purpose is no deterioration	1	0
Number of measures whose primary purpose is not identified	1	5
Notes: * relates to a greyed out measure in the spreadsheet, which it is assumed is not considered further in the Stage 1 assessment		

2.2.4 Identify the costs of measures

The costs of measures are assessed by identifying:

- One-off and capital costs and the year in which they occur (from 2013/14 to 2026/27); and
- Annual costs, the year in which the annual costs first occur and the number of years over which the annual costs will arise to maintain the environmental improvement or non-deterioration (up to a maximum of 40 years).

The applicable/responsible sector is also identified to provide information on which sector is responsible for delivering the measures.

2.2.5 Assess the benefits

Benefits based on NWEBS

The benefits from measures to address pressures associated with both water quality and water quantity are captured together in the NWEBS valuations. The Stage 1 valuation tool is used as the basis for estimation of benefits. The km of water bodies improved are entered and the benefits are calculated as £ per km improved status for fish, invertebrates, plant communities, clarity of water, river channel and flow of water, and safety of the water for recreational contact (Environment Agency, nd). The estimated value of wetland created is also quantified using a £ per ha per year, with the value of the previous land use (also as £ per ha per year) taken into account. Also added are any one-off or annual market benefits (such as water company treatment costs savings or market value of additional fish sold commercially) (Environment Agency, nd).

The NWEBS benefit values can only be included in the appraisal for a change in classification status (e.g. from moderate to good status) and not a within classification status improvement. As such, they are expected to under-estimate the benefits from improvements that do not result in a change in status, since a benefits value is not allocated in such instances (Environment Agency, 2014).

Benefits using stage 1+

Additional societal benefits from some bundles of measures can also be included using the Stage 1+ valuation aspect of the Stage 1 valuation tool. If the bundle of measures includes agri-measures or fresh water abstraction measures, and the AST suggests that these have an impact beyond the water environment, or are expected to lead to an increase in abstraction for public water supply, then a Stage 1+ valuation can be used to estimate the additional social benefit of these measures.

Benefits to groundwater

Benefits to groundwater are based on:

- water regulation as reduced damages due to flooding in £ per house per year;
- protection of groundwater in £ per m^3 per year (where other specific values have not been used); and
- provision of habitat for groundwater dependent wetlands improved by a groundwater scheme (inland marsh, peat bog, salt marsh, intertidal mudflats) in £ per ha per year and risk of loss of species, reduction/improvement in river flow in £ per household per year.

The groundwater valuation tool covers benefits associated with (Environment Agency, nd-a):

- savings from direct abstraction as £ per m^3 per year for water and wastewater, for different industries (pulp and paper, chemical, and general), with direct industrial savings based on market prices;
- food production (potatoes, carrots, parsnips, leeks, salad onions) in £ per m^3 per year;
- commercial fishing in £ per m^3 per year, based on improvements in surface water quality;
- air quality regulation (NO_x, SO_x, ammonia, PM rural) in £ per tonne per year;
- climate regulation (change in carbon emissions) in £ per tonne per year and thermoelectric use in £ per m^3 per day;
- water regulation as reduced damages due to flooding in £ per house per year;
- water purification and waste treatment (nitrate, protecting clean groundwater, purification/contamination losses, contamination by toxic chemicals) as £ per household per year;
- protection of groundwater in £ per m^3 per year (where other specific values have not been used);
- recreation and tourism (surface water flow) in £ per km per household and surface water quality (birds, fish, trout) in £ per visit;
- aesthetic value (proximity to rivers, waterfront properties) as a percentage of house price;
- social relations (disruption to recreational use) in £ per visit; and
- provision of habitat for groundwater dependent wetlands improved by a groundwater scheme (inland marsh, peat bog, salt marsh, intertidal mudflats) in £ per ha per year and risk of loss of species, reduction/improvement in river flow in £ per household per year.

Monetised benefits

The year in which the environmental improvements (or non-deterioration) start is entered along with the number of years that the resulting improvements/non-deterioration will last. A total of 40 years is used as the default period over which benefits are expected to occur.

Any cost savings that occur as a result of the measures or bundles of measures are also recorded as either one-off or annual savings.

Non-monetised costs and benefits

As well as monetised costs and benefits, qualitative and quantitative information is collated to present the likely impacts of measures on a range of ecosystem services. This information is recorded in an Appraisal Summary Table (AST) (Environment Agency, 2014). Winners and losers, those who will benefit or dis-benefit from the measures, are also identified.

2.2.6 Compare costs and benefits

Measures are combined into bundles by selecting (or not selecting) them under each bundle title. This includes a full bundle to achieve good status in most or all water bodies and a number of alternative bundles. There are four bundles identified for the Bristol Avon urban catchment:

- Full bundle most to good;
- Bristol Avon catchment permitting pilot (an alternative measure for achieving phosphorus reduction from sewage treatment works);
- Bristol Avon permitting pilot plus 'what the environment needs'; and
- Invasive non-native species (these measures are assumed to be implemented at the national level and so are not considered further within the catchment scale appraisal).

The Wyre catchment includes two bundles:

- Full bundle to good. This bundle includes 39 of the 45 measures[3]; and
- Alternative bundle. This bundle includes 20 measures.

The costs and benefits of the bundles are compared through calculation of the benefit-cost ratio (BCR) and net present value (NPV). The risk of failure[4] is taken into account when assessing the benefit-cost ratio and net present value. This is reported as 35% in the Bristol Avon urban and 30% in the Wyre.

2.2.7 Select the preferred option

Compare BCR and NPV

The preferred bundle of measures is selected based on a positive BCR and NPV which indicates that the bundle of measures is not likely to be disproportionately costly. Results of the appraisals enabled the Environment Agency to, where appropriate, consistently apply the disproportionate expense exemption and justify setting alternative objectives under the Water Framework Directive (WFD).

There was no optimisation process undertaken in the assessment. The bundles of measures chosen to be taken forward into the Stage 1 valuation worksheet were based on the list of cost effective measures identified as being required through Environment Agency investigations. An adjustment of this bundle of measures, to create alternative bundles of measures, is possible meaning some measures or types of measures are removed. Alternative bundles of measures are determined using expert judgement. The basis of this judgement is removing those measures which are deemed likely

[3] The measures that are not included are those that are alternative approaches within individual water bodies or water courses.

[4] The risk of measures failing to meet their intended environmental improvement outcome.

to be the least cost-beneficial and aiming to keep measures that provide lots of benefits and have a positive impact to multiple ecosystem services i.e. for flood risk and climate resilience.

For the Bristol Avon urban catchment, the benefit-cost ratios are:

- full bundle most to good: 0.40
- Bristol Avon catchment permitting pilot bundle: 0.75
- Bristol Avon permitting pilot plus 'what the environment needs': 0.69

Since the BCR is between 0.5 and 1.5, the Stage 1+ valuation is applied. With additional societal benefits from the agri-measures, the benefit-cost ratio of the Bristol Avon catchment permitting pilot increases to 1.1. It is also considered that the benefits from phosphorus removal are under-estimated for this bundle since they relate to a within status change.

For the Wyre catchment, the benefit-cost ratios are:

- Full bundle to good: 1.64
- Alternative bundle: not calculated

Consider results of sensitivity analysis

The sensitivity analysis includes a range of different tests to assess how the BCRs and NPVs change under different conditions:

- Whole-life costs x 2
- Whole-life costs x 0.8
- 50% decrease in km benefiting
- Using low WTP value
- Using central WTP value
- Using high WTP value
- Risk of failure is 0%
- Risk of failure is 25%
- Risk of failure is 50%

Table 2-2 shows how the benefit-cost ratios of the bundles vary under the different sensitivity tests.

Table 2-2: Case study application of RBMP appraisal process – sensitivity analysis

Sensitivity test	Case study catchment			
	Bristol Avon urban			Wyre
	Most to good	Catchment permitting	Catchment permitting plus environment needs	All to good
Baseline	**0.40**	**0.75**	**0.69**	**1.64**
Whole-life costs x 2	0.20	0.37	0.35	1.23
Whole-life costs x 0.8	0.50	0.93	0.87	3.09
50% decrease in km benefiting	0.13	0.25	0.23	1.49
Using low WTP value	0.22	0.41	0.38	2.12
Using central WTP value	0.27	0.49	0.46	2.47
Using high WTP value	0.32	0.58	0.55	2.82
Risk of failure is 0%	0.61	1.15	1.07	3.53

Table 2-2: Case study application of RBMP appraisal process – sensitivity analysis				
Sensitivity test	Case study catchment			
	Bristol Avon urban			Wyre
	Most to good	Catchment permitting	Catchment permitting plus environment needs	All to good
Risk of failure is 25%	0.46	0.86	0.80	2.65
Risk of failure is 50%	0.31	0.57	0.53	1.76

2.2.8 Strengths from an integrated appraisal perspective

Benefits to ecosystem services have already been considered and described in the Appraisal Summary Table (AST). This information can be used as the basis for moving to a methodology where the ecosystem service benefits themselves are monetised.

The current appraisal method provides an auditable approach to identifying and estimating the benefits of a change in ecological status or potential within a water body.

The Stage 1 valuation tool captures water quantity benefits so these are already integrated into the appraisal. It also has the ability to capture benefits from hydromorphological measures where these are picked up under the NWEBS categories, especially those relating to the condition of the river channel and flow of water, but also under other indicators such as fish where fish passes are implemented. The NWEBS values are available for each catchment and are considered the best values for assessing the local benefits.

In addition, the structure of the Stage 1 assessment means it could be used for optimisation of the bundles of measures, through including/excluding specific measures from the bundles and assessing how this affects the BCR and NPV.

2.2.9 Weaknesses from an integrated appraisal perspective

The current approach to estimating ecosystem service benefits is descriptive. The inclusion of a description helps to ensure that the full range of ecosystem service benefits can be taken into account in the assessment. Any significant benefits can be highlighted and taken into consideration during the selection of the preferred option. In addition, there is a risk that monetisation of any significant ecosystem service benefits could introduce double counting with the NWEBS benefits. This makes it difficult to expand the current tool to capture monetised values of changes in ecosystem services, as it is not clear whether double counting would then be introduced. The alternative is to move to a system based entirely on ecosystem services to capture the benefits to water bodies.

The description of ecosystem service benefits is based on the bundles of measures as a whole, rather than on individual measures. While this provides a high-level, overall approach to estimating the costs and benefits of changes to ecosystem services at a catchment level, it makes it challenging to disaggregate information. This could be important when looking to optimise bundles of measures to ensure that the best measures are combined to deliver as many synergies as possible, and to avoid antagonisms. It could also make it more challenging for decision-making for specific water bodies and measures, where there may be different funding streams, and where the scale of the environmental objectives varies.

2.2.10 Summary of processes used

Table 2-3 provides a summary of the processes used in river basin management planning.

Table 2-3: Key elements of River Basin Management Planning economic appraisal	
Criterion	**RBMPs**
Key economic parameters:	
- baseline year	2013/14
- appraisal period	40 years
- discount rate	3.5%, based on the social time preference rate as set out in the Treasury Green Book
Tool/source of data	Bundles sheet and Stage 1 valuation worksheet
Source of costs	Using existing tools such as the Cost of Agricultural Measures (CAM) tool, urban diffuse cost calculator tool, national cost-effectiveness database, programmes costs and local experts
Basis for benefit estimates	NWEBS plus Stage 1+ valuation and groundwater valuation (for Bristol Avon urban catchment only)
Scale of benefits	Benefits to water bodies are based on £ per km Benefits from agri-measures are based on number of farms Fresh water abstraction benefits based on m^3 per year abstracted for public water supply Groundwater benefits mainly £ per m^3 but also include benefits as £ per tonne (air quality pollutant removed and change in carbon emissions), £ per household for water purification and waste treatment, £ per km per household for recreation and tourism (surface water flow), £ per visit (surface water quality and social relations), percentage of house price (aesthetics) and £ per ha (groundwater dependent wetlands) or £ per household (risk of loss of species
Approach to sensitivity testing	Variation in costs (x2, x 0.8) and change in one-off costs for BCR to approximate to one 50% decrease in km benefiting Use of low, central and high WTP values Change in risk of failure
Main advantages of approach	Already considers ecosystem service benefits so provide a basis for expanding this to capture wider benefits Already enables integrated appraisal of water quality and water quantity issues and measures to address those issues Enables cumulative effects to be included in a plan and to be compatible with requirements of Strategic Environmental Assessment Directive Already provides a method that could be used for optimisation based on monetised costs and benefits NWEBS values for estimating benefits to water bodies are considered to be high quality values and are available for each catchment specifically
Main disadvantages of approach	Ecosystem service benefits are described at the bundle level, making it difficult to disaggregate benefits for individual measures affecting the extent to which optimisation can take account of the wider (non-NWEBS) values The extent to which the NWEBS values already capture some of the ecosystem service values is not clear. This means there is a risk of double counting if ecosystem service values in water are added to the NWEBS values

2.3 Approach to FRMP

2.3.1 The baseline

For flood risk appraisals, the baseline is usually 'do-nothing', i.e. assume that no action is taken. This results in an increase in flood risk over time and an associated increase in damages to property, businesses, infrastructure and the natural environment. In some cases, it can be beneficial to increase the frequency of flooding to natural habitats, although there can be water quality issues such as contamination of floodwaters that can negate these potential benefits.

2.3.2 Structure of the appraisal

Flood risk management plans (FRMPs) cover flood risk from rivers, reservoirs, the sea, surface water and groundwater (Environment Agency, 2016). Each FRMP covers one river basin district (RBD) and indicates how flood risk will be managed within the RBD over a six year period (Environment Agency and Natural Resources Wales, 2016). The development of FRMPs involves coordination with the production of RBMPs to enable more environmental benefits to be delivered (Environment Agency and Natural Resources Wales, 2014). Furthermore, the use of green (natural flood management) rather than grey flood risk management approaches has encouraged greater consideration of the environmental and social benefits associated with strategies, projects and schemes. This is often driven by desire for lower cost schemes or ones that have less of an impact on the visual amenity of an area (e.g. by enabling lower walls or embankments to be used that do not obscure views of the river or sea). Options such as flood storage can be at odds with environmental benefits associated with wetlands as the flood storage areas need to be kept dry to ensure there is sufficient capacity when a flood is predicted. Some risk management authorities such as Internal Drainage Boards (IDBs) have, however, developed innovative ways of reducing waterlogging of land to enable flood storage while maximising biodiversity benefits. Many IDBs are also considering methods that enable adaptation to changing rainfall and/or drought events, including being able to hold water up in ditches so that it is available for abstraction, but draining ditches in advance of predicted wet weather so that they can be used to drain water from fields following heavy rainfall.

Guidance on FRMPs has been published by the Environment Agency (for England). This identifies the aspects that FRMPs need to consider including (Environment Agency, 2016):

- A map outlining the Flood Risk Area;
- Objectives relating to the management of flood risk;
- Measures to be used to achieve these objectives;
- The way in which the measures need to be monitored;
- Information on the consultation that has occurred; and
- Details on how FRMP measures are to be coordinated with measures under RBMPs (where this is occurring).

Figure 2-2 presents an overview of the structure of the appraisal process used for FRMPs.

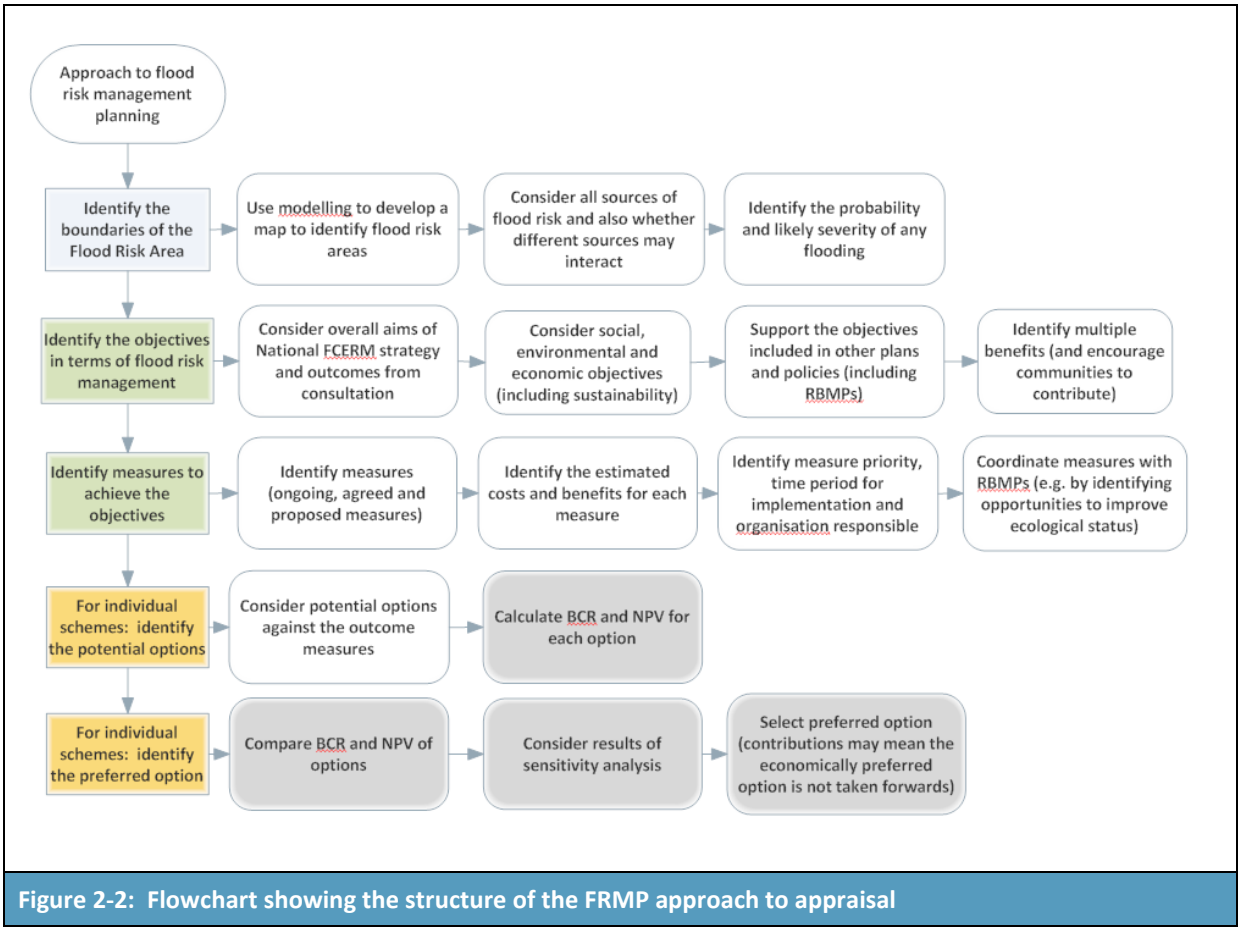

Figure 2-2: Flowchart showing the structure of the FRMP approach to appraisal

2.3.3 Identify measures and options

Measures proposed in FRMPs should be classified as one of the following six types (based on the EU reporting codes) (Defra et al., 2014):

- M1: No measure (for areas where no measure is put forward);
- M2: Prevention;
- M3: Protection;
- M4: Preparedness;
- M5: Recovery and review; and
- M6: Other.

Each of these types is then considered under different groups of measures: measures that have been proposed and approved for Grant-in-Aid funding; measures that have been identified and appraised but have not secured funding; and measures that have been proposed and are listed in the Environment Agency's medium term plan (MTP) (Environment Agency, 2017). It is however important to note that the inclusion of a particular measure within the FRMP does not mean that it will definitely be delivered (Environment Agency, 2016).

Where measures are included, they additionally need to be categorised according to (Environment Agency, 2016):

- Estimated costs (banded from less than £100,000 to more than £10 million);

- Estimated benefits (utilising the estimated benefit-cost ratio);
- Priority for implementation (low to critical);
- Timing of implementation (from cycle 1 to after 2039, i.e. beyond cycle 4); and
- The lead organisation (this may be the named Risk Management Authority or another organisation such as Natural England).

2.3.4 Identify the costs of measures and options

Costs and benefits associated with maintenance of existing flood risk infrastructure are estimated in the System Asset Management Plans (SAMPs). These are presented as annual costs per year between 2015 and 2060 and annual benefits. Figure 2-3 presents the information on costs and benefits as provided by the Environment Agency for the Bristol Avon catchment as a whole (note that the costs and benefits are plotted on different axes to better show the variation in annual costs over time).

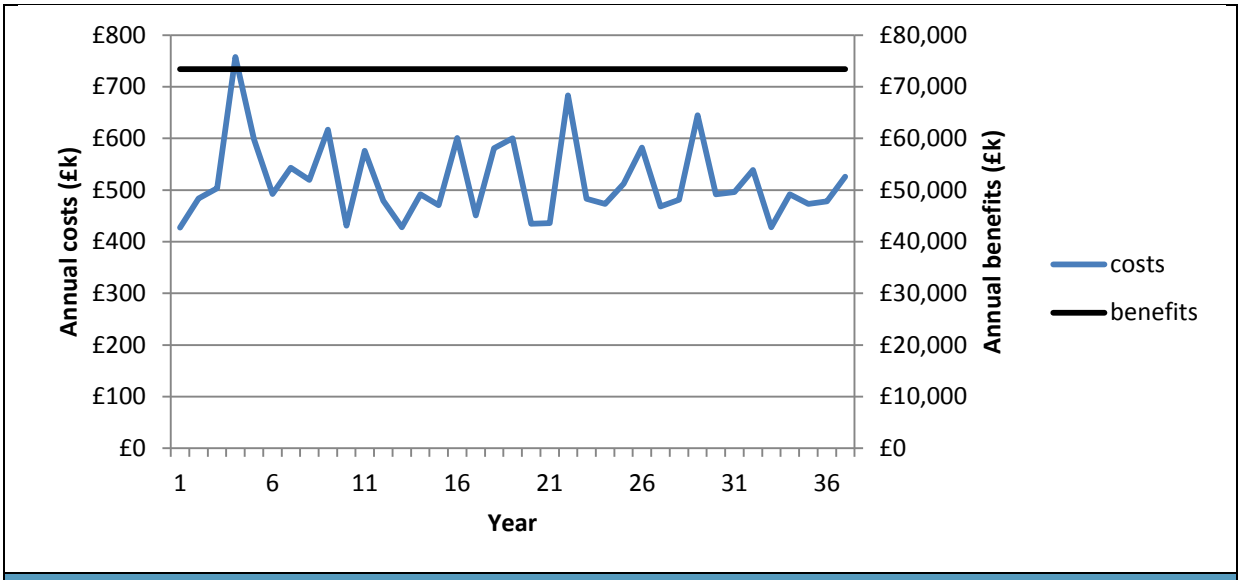

Figure 2-3: Comparison of annual costs and benefits of SAMPs for the Bristol Avon catchment

Similar information is presented in Figure 2-4 for the Wyre catchment. Again the costs and benefits are plotted on different axes to highlight the variation in costs.

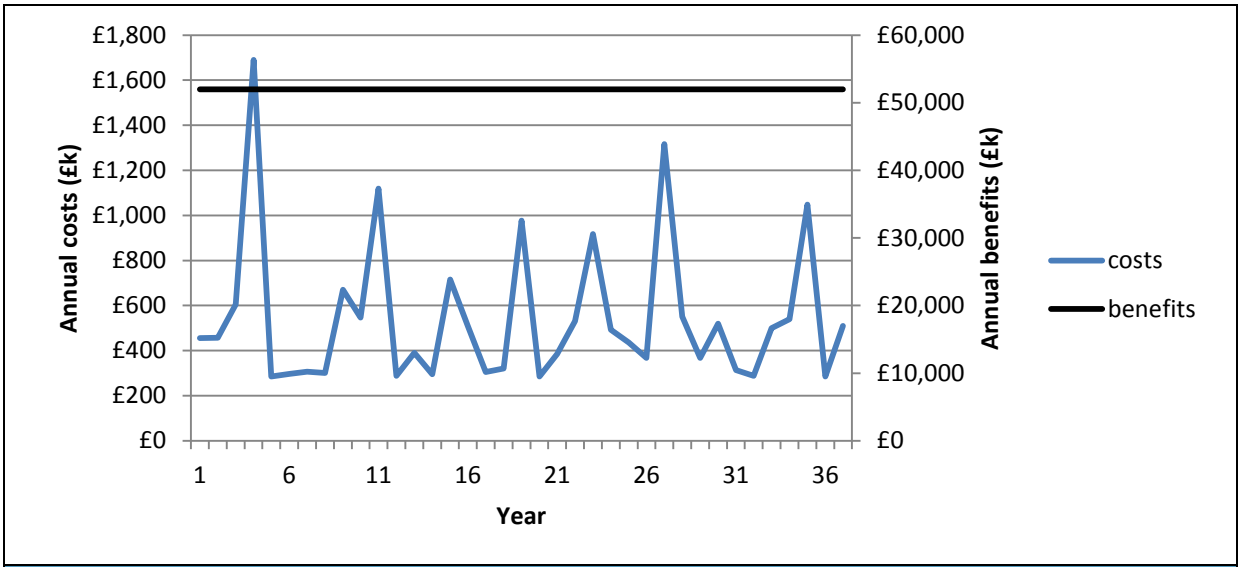

Figure 2-4: Comparison of annual costs and benefits of SAMPs for the Wyre catchment

2.3.5 Assess the benefits

Benefits of measures are assessed in terms of outcomes expected to be achieved by the measure, for example, number of households moved out of a flood probability category to a lower probability category. Other outcomes considered include, but are not limited to, the creation of habitat (Environment Agency, 2015-a). Table 2-4 presents data on the areas of land and number of properties at different levels of flood risk in the two catchments.

Table 2-4: Summary of total area in each flood zone in Bristol Avon urban catchment

Flood zone	Total area (ha, to the nearest ha)			
	Bristol Avon total	Bristol Avon rural	Bristol Avon urban	Wyre
2 (medium probability: land having between 1:100 and 1:1000 annual probability of river flooding)	11,450 (5%)	8,640 (5%)	2,810 (7%)	7,872 (17.6%)
3 (3a high probability: land having 1:100 or greater probability of river flooding; 3b functional flood plain: land where was has to flow or be stored in times of flood)	9,301 (4%)	7,290 (4%)	2,011 (5%)	6,147 (13.7%)
Flood storage areas	73	0.9	72	189
Number and percentage of properties at flood risk (very low to high)	26,421 (4%)	10,038 (3%)	16,368 (4%)	1,507 (15.2%)
Number and percentage of properties at high flood risk (>1:30)	5,415 (0.8%)	2,970 (1%)	2,436 (0.7%)	43 (0.43%)
Number and percentage of properties at medium flood risk (>1:100)	5,218 (0.8%)	2,314 (0.8%)	2,904 (0.8%)	118 (1.2%)
Number and percentage of properties at low flood risk (>1000)	15,734 (2.4%)	4,738 (1.6%)	10,990 (3%)	1,346 (13.6%)
Number and percentage of properties at very low flood risk (<1:1000)	54 (0.01%)	16 (0.01%)	38 (0.01%)	0 (0%)

2.3.6 Compare costs and benefits

The costs and benefits are compared to identify the benefit-cost ratio for each option.

2.3.7 Select the preferred option

Funding of flood risk projects is based on delivery of outcomes and assessed against outcome measures (OMs). OM1 covers the ratio of whole life present value benefits to whole life present value costs. Two other outcome measures (OM2 and OM3) relate to the change in flood or erosion risk faced by residential properties and are the primary delivery drivers. Outcome measure 4 (OM4) relates specifically to environmental performance and is linked to environmental performance indicators:

- Addresses a Water Framework Directive protected area;
- Removal of barriers to migration for fish or eels;
- Kilometres of river habitat (including SSSI) protected or improved;
- Kilometres of WFD water body protected or improved;
- Kilometres of water body opened up to fish or eel passage;
- Hectares of habitat (including SSSI) protected or improved;
- Hectares of habitat created;
- Additional potential for environmental outcomes against Defra performance specification; and
- Need for additional funding to deliver the additional benefits.

Funding is limited to three types of statutory environmental obligations:

- Hectares of net water-dependent habitat created (OM4a);
- Hectares of net intertidal habitat created (OM4b); and
- Kilometres of protected river improved (OM4c).

The choice of preferred option is based on the application of the Flood and Coastal Erosion Risk Management Appraisal Guidance decision-making process. The MTP (Environment Agency, 2017) provides the present value whole-life costs, funding sources and expected outcomes, and BCR of each consented scheme. Project appraisals and business cases are held by project managers and contain a record of the shortlist of options, along with the rationale for selection of the preferred solution.

2.3.8 Strengths from an integrated appraisal perspective

Flood risk appraisals can capture ecosystem service benefits. Indeed, the Economic Valuation of Economic Effects (EVEE) guidance tool is available to enable these benefits to be captured within an appraisal. They therefore provide a good starting point for integrating the impacts associated with other types of measures and at a broader catchment level. Description of wider benefits can be used to identify stakeholders and help leverage partnership funding contributions.

2.3.9 Weaknesses from an integrated appraisal perspective

Individual flood risk appraisals are undertaken on a scheme-by-scheme basis such that they do not adhere to the wider catchment approach, or take into account cross-cutting pressures and measures, or their costs and benefits. The appraisals are very detailed which can make them difficult to replicate at the catchment level, although strategic level assessments are also available.

Unless environmental improvements fall under the funding criteria of OM4, any non-flood risk related benefits would be captured under the whole-life benefits in OM1. Thus, the focus is tailored towards very specific outcomes with the risk that synergies and wider benefits could be missed. These are funded at a rate of 5.56p per £1 of benefit, meaning that there would need to be very significant ecosystem service benefits to have an effect on the amount of Grant-in-Aid funding that is available. The implications of this are that it may not be considered proportionate to develop estimates of benefits to ecosystem services and that opportunities to develop flood risk options that could deliver wider environmental benefits as well as delivering flood risk benefits may be missed. As such, flood risk appraisal and funding routes are not likely to be suitable mechanisms for enabling delivery of integrated catchment-based projects. It also means that measures that deliver water quality or water resources benefits but have only a small impact on flood risk (if any) are unlikely to be pursued through this route as the additional Grant-in-Aid that might be available is likely to be small, and potentially smaller than the cost of the time taken to estimate the benefits.

2.3.10 Summary of processes used

Table 2-5 provides a summary of the processes used in flood risk management planning.

Table 2-5: Key elements of Flood Risk Management Planning

Criterion	FRMPs
Key economic parameters:	
- baseline year	2015 (current FRMPs are for 2015-2021)
- appraisal period	FRMPs cover 6 years to match the RBMP planning cycle
- discount rate	3.5%
Tool/source of data	Based on plans submitted by Flood Risk Management Authorities and others; also modelling data
Source of costs	Based on plans submitted by Flood Risk Management Authorities and others
Basis for benefit estimates	Estimated through identifying the likely benefits of the different measures in terms of performance against the outcome measures
Scale of benefits	Varying dependent on the individual measure proposed
Approach to sensitivity testing	Varying depending on scale of appraisal. For scheme appraisals, account is taken of key uncertainties that affect the differences between options. Assumptions are varied including on costs, timing of impacts, and changes to major beneficiaries. Switching points are calculated to assess what level of change is needed to change the choice of preferred option
Main advantages of approach	It is possible to capture ecosystem service benefits. The outcome measures also take account of habitat creation
Main disadvantages of approach	Assessment of schemes and allocation of funding against outcome measures means that the funding is targeted towards specific aims and may not necessarily enable funding of measures that have wider benefits (unless partnership funding is involved)

3 The integrated approach

3.1 Overview

This section describes the revisions that have been made to the processes described in Section 2 to enable a fully integrated appraisal to be undertaken. It describes changes made to tools, use of different tools and the development of new processes for key stages through the methodology. It also includes short examples from the Bristol Avon urban and Wyre case studies to illustrate the steps. The full case studies are provided in the case study reports, attached as Annex 1 and 2 to this report.

3.2 Building on approaches to integrated planning

The aim has been to build upon the strengths of the existing integrated planning processes to develop a methodology that enables an integrated appraisal of a different mix of measures and interventions and to capture the wider impacts and benefits. The integrated appraisal methodology follows a similar structure to that used for RBMPs and FRMPs, but there are also some differences:

- Identification of measures and interventions: to avoid confusion with terms used in other approaches, the integrated appraisal uses the term 'action' to capture all the measures, interventions and activities that could be undertaken to deliver integrated catchment management;
- Consideration of potential synergies between actions such that they could benefit a longer length of water bodies when combined, or of potential antagonisms such that it may not be beneficial to undertake two actions together;
- Inclusion of cost savings within the costs side of the economic appraisal. This is because any cost savings (e.g. associated with reduced maintenance costs under an action are considered to reflect a change in the costs that would be incurred rather than being picked up as an increase in the benefits);
- Inclusion of benefits to terrestrial ecosystem services from actions that are implemented on land. This is in addition to the benefits that would be achieved from a change in water body status in the water courses themselves, thus capturing wider benefits associated with a change, e.g. to soil quality or the terrestrial environment. Benefits to water bodies use the NWEBS values as these were identified as the best quality values for estimating benefits from an improvement in water body status;
- Actions being grouped into options to reflect different objectives in an in/out approach (optimisation was not formally used in the Stage 1 assessment for RBMPs although the Stage 1 tool does support this) allowing optimisation to identify the most cost-beneficial combinations of actions. The approach to identifying which actions are in/out also draws on the assessment of synergies and antagonisms; and
- Development of a distributional analysis that allows a comparison of the stakeholders responsible for implementing measures with those stakeholders that would benefit from improvement to ecosystem services and water body status.

The structure of the methodology is shown in Figure 3-1. Each step shown in Figure 3-1 is described in detail below. The methodology is supported by an appraisal spreadsheet which can be used to record the results of each step and the specific activities that are undertaken within that step. The

spreadsheet automates some of the activities (those shown in grey in Figure 3-1) to facilitate the appraisal process.

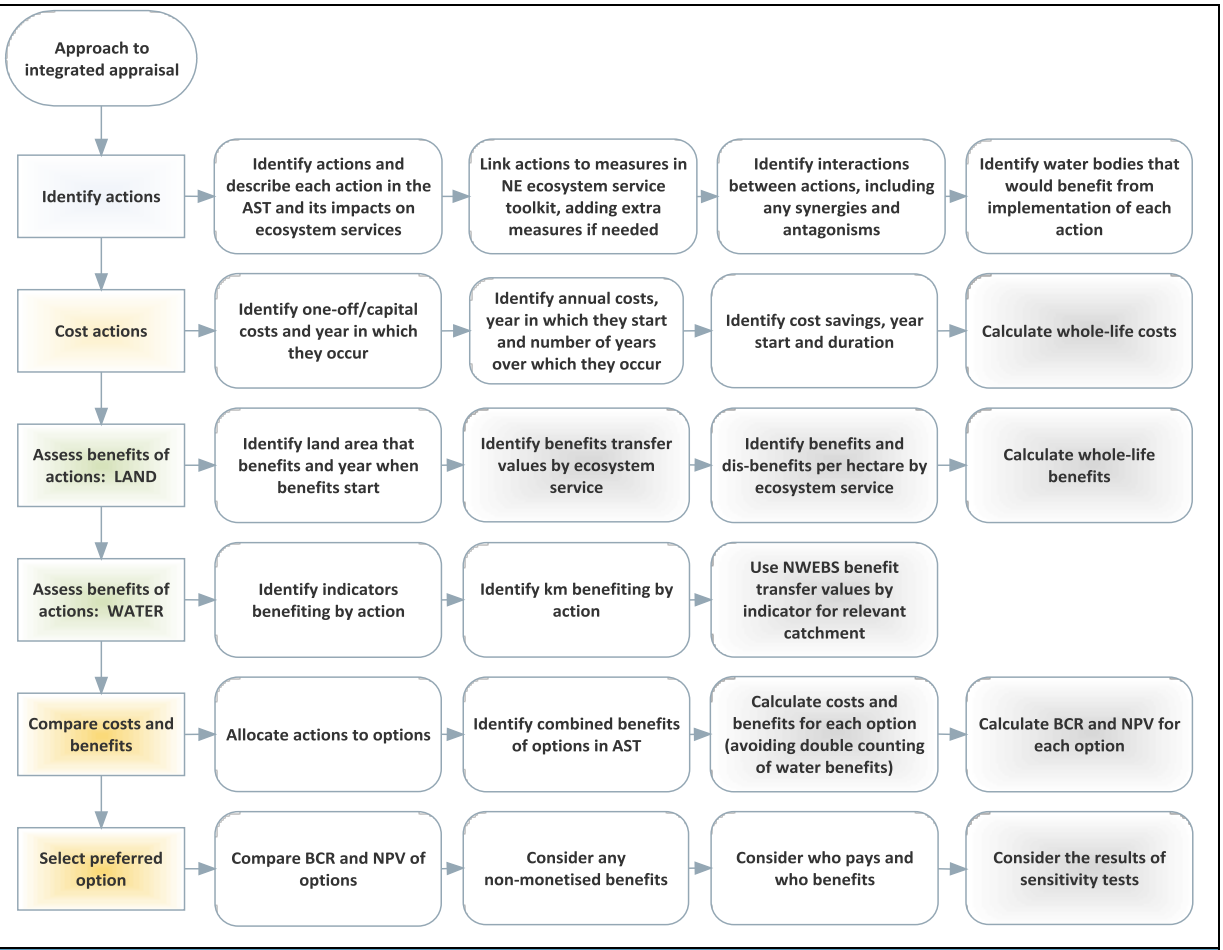

Figure 3-1: Flowchart showing key steps in approach to integrated appraisal
Note: colours shown down left-hand column match with the colours used for tabs in the appraisal workbook; boxes shown in grey are automatically filled in the workbook when information is entered for each of the white boxes.

3.3 Key terminology

The integrated appraisal process uses a number of terms that require some additional explanation. These terms are used to avoid confusion with words used within the existing integrated planning processes (as described in Section 2) and tools and to distinguish them from terms used in the integrated appraisal process (the methodology described in Section 3). The definitions are provided in Table 3-1.

Table 3-1: Definition of key terms used in the integrated appraisal methodology		
Term	**Used in…**	**Definition**
Action	Integrated appraisal	The term used for a measure or combination of measures assessed in the integrated appraisal. This can draw on measures from the RBMP or new measures developed from GIS assessment of where improvements need to be made
Activity	Integrated appraisal	Each step comprises a number of activities that need to be undertaken to complete the appraisal for that step
Indicators	RBMP	These are the six indicators of water quality that were used in the NWEBS survey to estimate the economic value of improvements in water quality
Intervention	Natural England ecosystem services transfer toolkit	Specific activities that results in a change in an ecosystem service as reported in the Natural England toolkit. This includes 112 interventions in total
Measure	RBMP	Specific activities identified as potentially delivering an improvement in water quality or water quantity and which are used as the basis for assessment of benefits to water in river basin management planning
Option	Integrated appraisal	The term used for a combination of actions brought together to meet a specified objective
Step	Integrated appraisal	The appraisal process consists of six steps: identify actions, cost actions, assess benefits of actions (land), assess benefits of actions (water), compare costs and benefits and select the preferred option

3.4 Key economic parameters

The methodology itself follows Treasury Green Book rules, for example all benefits are to UK plc and the discount rate that is used is the declining rate starting at 3.5% in year 0. The appraisal period is for 37 years as this reflects the 12 years for the two RBMP cycles from 2015 to 2027 plus an average asset life of 25 years.

3.5 The case studies

The methodology has been developed using the two case study trials: Bristol Avon urban and Wyre catchments. Separate reports are available on the results of each trial as a whole (see Annex 1 for the report on the Bristol Avon urban and Annex 2 for the report on the Wyre catchment). Key stages of the methodology described below are also illustrated with examples from the two trials included in text boxes.

The two trials involve slightly different applications of the methodology. This has two advantages:

1. It enables the methodology to be tested under different circumstances. The Bristol Avon urban trial includes an appraisal of the integration of a set of already defined measures, from the RBMP and the Bristol Avon Catchment Plan. This reflects the potential benefit of integrating the appraisal of projects that have already been identified as part of the Bristol Avon Catchment Partnership. In addition, a set of integrated measures from land cover and opportunity mapping basis has also been appraised. This approach is used for both the Bristol Avon urban and the Wyre.

2. It enables the benefits of the integrated appraisal to be assessed against an approach whereby there is an assessment of already defined measures as well as against an integrated set of measures. Therefore, as well as using the case studies to help develop and test the methodology, it also means it is possible to comment on the merits of two different types of application of the integrated approach.

3.6 Identify actions

3.6.1 Overview

The first step is to identify the actions that will lead to a benefit to water quality, water quantity and/or flood risk. This step includes four activities, as shown in Figure 3-2. Each of these activities is described in detail below.

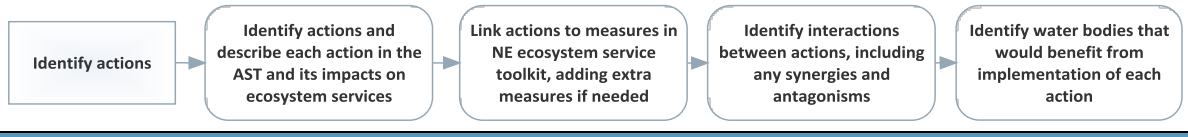

Figure 3-2: Activities included under the step to identify actions

3.6.2 Identify actions and describe in the AST

Actions can be based on existing measures, as well as interventions from other plans and projects, or they can be generated specifically for the integrated appraisal. Once identified, the potential impacts of each action need to be described against a pre-defined list of ecosystem services. The list of ecosystem services used is based on that set out in the Natural England ecosystem services transfer toolkit (Natural England, 2015), henceforth known as the Natural England toolkit. Further detail on the Natural England toolkit is provided in Section 3.6.3.

Table 3-2 shows the key data sources used in each case study while Box 3-1 explains how the appraisal spreadsheet is used for this activity.

The Bristol Avon urban case study includes two appraisals: one on an integrated set of existing actions from the Stage 1 assessment and the Bristol Avon Catchment Plan and one on an integrated set of actions developed specifically for this study based on GIS analysis. The Wyre case study focuses on the development of a set of actions that could deliver a vision for the catchment.

The spatial datasets and the information available listed in Table 3-2 have been compiled and processed using GIS tools. A combination of different spatial processes and analyses (e.g. union, intersect, join, buffer, etc.) were applied to vector data in order to extract the information required from each combination of datasets. Therefore, the different areas in each of the case study catchments could be characterised and grouped according their suitability for woodland creation, possibility to reduce rainfall runoff, mitigate diffuse pollution, productivity and water resource availability. New layers of the new zones were then generated and the total area was calculated.

Table 3-2: Data and information sources for the case study appraisal – identify actions		
Bristol Avon urban		Wyre
Appraisal based on bringing together existing projects	Appraisal based on developing an integrated set of actions	Appraisal based on developing an integrated set of actions
Stage 1 assessment (provides measures that are taken forwards as actions)	Catchment Data Explorer	Catchment Data Explorer
Bristol Avon Catchment Plan (provides projects that are taken forwards as actions)	Spatial Data Catalogue, data.gov.uk: WFD Water body Catchments, River network, Water resource availability, Agricultural land classification	Spatial Data Catalogue, data.gov.uk: WFD Water body Catchments, River network, Water resource availability, Agricultural land classification, Priority habitats
Medium Term Plan (provides flood risk related actions)	Land Cover Map 2007, 25 m resolution shapefile	Land Cover Map 2007, 25 m resolution shapefile
	Bristol Avon Catchment Plan	Opportunity mapping for woodland creation (Forestry Commission)
	Opportunity mapping for woodland creation	

The worksheet Actions-AST is used to identify and describe each action and to record the impacts of each action (positive and negative) against the list of ecosystem services. These services are (see Section 3.6.3 for the reasons for selecting these services and Annex 3 for a definition of the services):

- Climate regulation
- Crops, livestock, fish
- Detoxification and purification in air, soils and water
- Disease and pest regulation
- Environmental settings
- Hazard regulation
- Noise regulation
- Pollination
- Soil quality regulation
- Trees, standing, vegetation, peat
- Water quality regulation
- Water supply
- Wild species diversity

Space is provided in the spreadsheet for assessment of 25 actions. Once the titles of the actions have been entered, these are carried forward to all subsequent worksheets requiring information to be entered for each action.

Box 3-1: Using the appraisal worksheet: Actions-AST

3.6.3 Links actions to interventions from Natural England toolkit adding extra interventions if needed

The actions identified above are mapped against a set of interventions from the Natural England toolkit. This approach is used as the Natural England toolkit provides information on the likely change in ecosystem services associated with each intervention (see Section 3.8 below on assessing

benefits of actions to land and water). Box 3-2 provides more information on the Natural England toolkit and how it has been used to inform the integrated appraisal.

Natural England's ecosystem services transfer toolkit is based on a literature review of the effect of land management interventions on the provision of ecosystem services. The toolkit itself is an Excel spreadsheet and identifies the magnitude of effect that an intervention has on an ecosystem service and the strength of the supporting evidence.

The toolkit's 'Data entry' worksheet has been used as the basis for extraction of information for the integrated appraisal. This provides information on 112 interventions across six habitats (coastal, freshwater, lowland agriculture, marine uplands and urban) across 13 services (climate regulation; detoxification and purification in air, soils and water; disease and pest regulation; crops, livestock, fish; environmental settings; hazard regulation; noise regulation; pollination; soil quality regulation; trees, standing, vegetation, peat; water quality regulation; water supply; wild species diversity).

The toolkit provides a rating for the impact of each intervention on each service for each habitat from - - to ++. The integrated appraisal only uses the direction of impact, i.e. - - and - for dis-benefits and ++ and + as benefits to avoid duplicating with the magnitude of change from the type of action. This approach is used rather than the magnitude from the toolkit since the benefits are estimated at the level of actions (on land). It would not be possible to sum the benefits (or dis-benefits) across all interventions within an action as this is likely to over-estimate the magnitude of the change. Therefore, only the direction of change is taken from the toolkit.

The toolkit includes full references for each of the 2,564 records in the data entry worksheet. Therefore, it provides a good resource for investigating the impacts of different interventions on ecosystem services. It was considered the best available source in terms of linking interventions (and through that actions) to changes to ecosystem services enabling both benefits and dis-benefits to be captured in the integrated appraisal.

Box 3-2: Summary of the Natural England toolkit and its use for the integrated appraisal

Although there are 112 interventions listed in the Natural England toolkit, there are some interventions associated with the actions identified for both the Bristol Avon urban and Wyre catchments that are not covered by the Natural England toolkit. Where there is a gap, additional interventions have been added to the integrated appraisal spreadsheet. This is important as the Natural England toolkit identifies the benefits and dis-benefits from each intervention and this is used as the basis for identifying which actions would deliver ecosystem service benefits or dis-benefits in a later step of the integrated appraisal. Once the need for additional interventions has been identified, these are added to the 'Actions' worksheet with the potential benefits and dis-benefits to land and water also recorded on a number of other worksheets to ensure that the benefits and dis-benefits of these actions are fully included in the appraisal (see Box 3-3).

Four additional interventions have been added for the Wyre case study. They are:

- Improve on-channel morphological diversity;
- Construct roofs on slurry stores;
- Install additional road drainage systems to capture first flush; and
- Re-route whey to be fed to livestock

No specific additional data or information is required at this stage unless an additional intervention needs to be added to the 'Actions' worksheet. Expert judgement has been applied by the project team to identify the benefits and dis-benefits of the additional interventions added for the Bristol Avon urban and Wyre catchments.

The worksheet 'Actions' is used to identify which of the interventions identified in the Natural England toolkit are likely to be used to implement the action. Many actions could involve a number of different interventions. The worksheet uses a 'Y' to indicate where each intervention is relevant to each action.

An uncertainty rating is also applied to the allocation, reflecting the amount of information that was available to enable the best possible match to be identified.

If there are no interventions that are relevant to the action, then an additional intervention can be added. Once added, some additional information is required to ensure that the new intervention is included in the estimation of benefits. This information is:

- Worksheet 'measures by ES change': this worksheet only needs to be viewed where a new intervention has been added. The intervention needs to be identified as to whether it will 'restore' degraded natural capital so it can supply ecosystem services, whether it will 'improve' natural capital to enable it to deliver sustainable and renewable ecosystem services, or to 'maintain' natural capital so that is does not deteriorate and will continue to deliver renewable ecosystem services.
- Worksheet 'measures by payee': this worksheet identifies who is the most likely payee from a list of stakeholders. The new intervention will need to have the payee identified from a choice of: Land owner/manager, Society, Water/sewerage company, Property owner, Developer, Abstractor, Industry, Fisherman (marine fisheries only), and the Highways Agency. This list of payees reflects the range of stakeholders identified from the Bristol Avon urban and Wyre case studies.
- Worksheet: 'NE measures ES benefits-LAND': where an intervention would be implemented on land (rather than water) then the change in ecosystem services associated with the intervention needs to be identified. The worksheet only considers if there is likely to be a benefit (score of 1), a dis-benefit (score of -1) or no effect (N/A). This is because the magnitude of the change is captured under the type of action (restore, improve or maintain) so only the direction of change is considered here to avoid double counting.
- Worksheet: 'NE measures ES benefits-WATER': this worksheet is used to record the impact (benefit, dis-benefit or no effect) on each ecosystem service for those interventions that would be implemented directly in a water body. This includes interventions such as lime freshwater habitat or artificial aeration of eutrophic lakes.

Box 3-3: Using the appraisal worksheet: Actions

3.6.4 Identify interactions between actions

Integrated appraisal requires consideration of how actions could be combined and whether these combinations could lead to synergies or antagonisms. This is important information when combining actions into the option (see Section 3.10.2). The identification of synergies and antagonisms is likely to be based on expert judgement, from either within the project team or from discussions with local experts. Both approaches were applied for the two case study catchments, with the Wyre involving discussions with experts on the catchment from the Environment Agency to underpin the identification and assessment of actions. Box 3-4 explains how to use the 'Actions-Interactions' worksheet when undertaking the integrated appraisal.

Two actions offer potential synergies in the Bristol Avon urban case study: the MOREwoods project and the natural flood management project in Wiltshire. This combination could potentially offer an opportunity to deliver natural flood management measures while also delivering a number of other ecosystem services in combination.

The worksheet 'Actions-Interactions' is used to identify, for each pair of actions, whether they are considered to deliver synergies or antagonisms if combined. The worksheet also identifies where actions are very similar such that, if they are implemented in the same water bodies, they are unlikely to result in any significant additional benefits than if just one of the actions was implemented.

The worksheet provides a dropdown list so the impacts of the combination of actions can be identified. Only those pairs that would results in a synergy, antagonism or are very similar need to be highlighted; other cells can be left blank.

The information on synergies should be considered in the next activity (allocate actions to water bodies). Pairs of actions that would result in antagonisms or that are very similar should be considered when allocating actions to options (see section 3.10.2) to avoid introducing additional negative impacts from antagonisms or incurring costs from implementing two actions that would not deliver any significant additional benefits.

Box 3-4: Using the appraisal worksheet: Actions-Interactions

3.6.5 Allocate actions to water bodies

The actions are next allocated to the water bodies that would be impacted from their implementation. This provides the basis for estimating the benefits of the measures on the water environment. Table 3-3 summarises the data sources used in the case study catchments as the basis for allocation of actions to the water bodies that would be impacted. Box 3-5 explains how the 'Water body-actions' worksheet is used.

Some actions in the Wyre case study are considered to deliver direct benefits to the water bodies in where they are implemented. This is assumed to be the case for actions implemented by the Highways Agency and the cheese manufacturer. Other actions are assumed to deliver benefits in downstream water bodies, such as the actions to 'introduce measures to reduce peat erosion'. This is assumed to benefit water bodies in the whole of the Wyre and Calder operational catchments.

Where actions have been identified as synergistic in the previous activity (Section 3.6.4), it is possible to add these additional benefits by highlighting water bodies that would benefit from the combination of actions. This is most easily done by adding the combined actions as a new action and then highlighting all the water bodies that would benefit. To ensure that the combined actions are picked up right through the appraisal, it is necessary to also add them to the 'Actions-AST' worksheet. Here, the synergistic benefits can be described to provide a record of why these actions have been included.

Table 3-3: Data and information sources for the case study appraisal – allocate actions to water bodies

Bristol Avon urban		Wyre
Appraisal based on bringing together existing projects	**Appraisal based on developing an integrated set of actions**	**Appraisal based on developing an integrated set of actions**
List of relevant water bodies taken from the Stage 1 assessment	List of relevant water bodies taken from the Stage 1 assessment	List of relevant water bodies taken from the Stage 1 assessment
Bristol Avon urban bundles sheet used to identify water bodies that could benefit from each action taken from the Stage 1 assessment	Map generated of integrated actions (based on data listed in Table 3-2)	Map generated of integrated actions (based on data listed in Table 3-2)

The worksheet 'Water body-actions' is used to identify which water bodies would benefit from implementation of each action. Combinations of actions that would result in synergies in the form of additional water bodies benefiting can also be captured here by adding a combined pair of actions to the 'Actions-AST' worksheet.

Each water body benefiting is identified using a 'Y' under the relevant action. This forms the basis for estimating the benefits to water as the appraisal spreadsheet takes the length of each water body from the 'Water body-baseline' worksheet (this is a reference worksheet that does not require any interaction during the appraisal, other than pasting in the appropriate water bodies and associated information). The water body data are taken from the Spatial Data Catalogue (data.gov.uk).

Box 3-5: Using the appraisal worksheet: Water body-actions

3.6.6 Key uncertainties with the approach to identify actions

The key sources of uncertainty in this step are as follows:

- Identify actions and describe in the AST:
  - The key uncertainties reflect the level of information on each specific action and how this may affect (positively or negatively) each ecosystem service. Uncertainty is likely to vary by action and by ecosystem service based on the amount of information available and experience of how each action would affect each ecosystem service.
- Link actions to interventions from NE toolkit adding extra interventions if needed:
  - Not all of the likely/potential interventions are included in the NE toolkit resulting in additional interventions having to be added. This *reduces* uncertainty within this activity by allowing the actions to be more accurately represented. However, it does introduce additional uncertainty into subsequent steps.
  - The interventions from the NE toolkit are only described in a few words, hence the actual action and the intervention described in the reference sources used when the NE toolkit was developed may not match. The uncertainty is likely to vary from intervention to intervention and cannot be quantified.
- Identify interactions between actions:
  - The extent to which synergies and antagonisms can be identified will depend on knowledge of the actions and how they might be applied in the catchment. This is likely to vary from one action to the next with the risk that some synergies and antagonisms are missed. Expert knowledge of the catchment and the actions may be needed when completing this activity to reduce uncertainty.
- Allocate actions to water bodies:
  - The water bodies benefiting may be more obvious for some actions than for others, such that uncertainty is likely to vary from action to action. Again, expert knowledge of the catchment and the actions is likely to be beneficial in helping to reduce uncertainty associated with this activity.

3.7 Cost actions

3.7.1 Overview

The second step is to estimate the costs of each action. This is broken down into the one-off/capital costs, annual costs, and any cost savings that might occur for each action, as shown in Figure 3-3. This approach is based on that used for the Stage 1 valuation, using a worksheet that is structured

similarly. The worksheet used for this whole step in the appraisal spreadsheet is 'Costs of actions'. This worksheet is used for all four of the activities shown in Figure 3-3. Full details of the activities are described below.

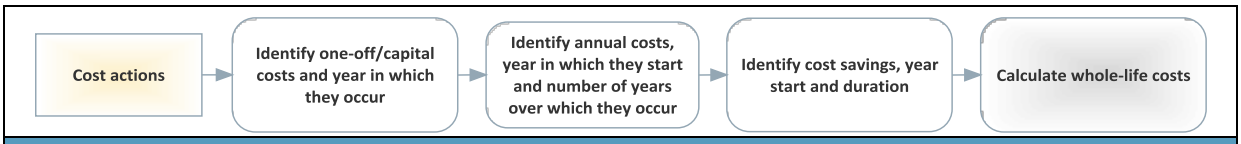

Figure 3-3: Activities included under the step to cost actions

3.7.2 Identify one-off and capital costs

One-off and capital costs are recorded in the year in which they are expected to occur (from 2016/17 to 2053/54 to cover the whole 37 year appraisal period). The spreadsheet will apply the discount factors to the capital costs when calculating the whole-life costs.

3.7.3 Identify annual costs

Annual costs relate to maintenance or revenue costs that recur on an annual basis over all or part of the appraisal period. The year in which the annual costs start and the number of years over which they will arise in order to maintain the environmental improvement or ensure non-deterioration is required. The spreadsheet can then take account of the annual costs when calculating the whole-life costs.

Costs for the Wyre case study include one-off/capital costs associated with costs of buying land, costs of establishing willow (short rotation coppice), costs of installing sustainable urban drainage (SUDS) and costs of re-routing whey so it can be fed to livestock.

They also include annual costs associated with changes in gross margin, costs of managing land, and costs of managing SUDS.

3.7.4 Identify cost savings

Like annual costs, cost savings are based on the annual cost saving (£k per year), the year in which the cost savings start and the number of years over which cost savings are realised. This information is also then incorporated into the calculation of whole-life costs.

3.7.5 Calculate whole-life costs

In order to compare the costs of actions, the costs are estimated in whole-life terms as the discounted costs over a 37 year period. The whole-life costs are calculated automatically in the appraisal workbook (worksheet: costs of measures) once capital/one-off and annual costs have been entered. Table 3-4 identifies the data and information used when assessing the costs of actions in the Bristol Avon urban and Wyre case studies. Box 3-6 explains how the 'Costs of actions' worksheet is used when undertaking the integrated appraisal.

Table 3-4: Data and information sources for the case study appraisal – costs of actions		
Bristol Avon urban		**Wyre**
Appraisal based on bringing together existing projects	**Appraisal based on developing an integrated set of actions**	**Appraisal based on developing an integrated set of actions**
Costs of actions based on measures from the Stage 1 assessment are taken from the bundles sheet	Nix Farm Management Pocketbook	Nix (2017): Farm Management Pocketbook plus expert judgement on approaches to modelling cost estimates
	Countryside Stewardship payments, used as surrogates for costs	Countryside Stewardship payments, used as surrogates for costs
	Areas over which each action will be implemented from GIS analysis	Environment Agency (2015-a) for costs for SUDS and highways drainage
		Areas over which each action will be implemented from GIS analysis

The worksheet 'Costs of actions' is used to record the different cost elements and to calculate the whole-life costs:

- one-off and capital costs are recorded against the year in which they are expected to occur
- annual costs are given as a total (£k/year) with the year in which the annual costs are expected to start and the number of years over which the annual costs are needed to maintain the environmental improvement or non-deterioration
- cost savings are also recorded as an annual cost saving (£k/year), the year in which the cost savings start and over how many years the cost savings will arise.

Both annual costs and cost savings can occur for a maximum of 37 years to fit with the appraisal period.

The worksheet calculates the whole-life costs by applying the discount factors that are shown in column C (discount rate applied to one-off capital costs occurring in that year) or sum of the discount rate (applied to annual costs and cost savings in relation to the year in which they start and the number of years over which the annual costs/cost savings occur).

The whole-life costs for each action are shown in row 2 in £k.

Box 3-6: Using the appraisal worksheet: Costs of actions

3.7.6 Key uncertainties with the approach to cost actions

The key sources of uncertainty in this step are as follows:

- Identify one-off and capital costs:
  - Uncertainties will depend on the extent to which the source documents relate to the specific allocation of actions to the catchment under consideration and whether 'typical' costs apply. If the catchment is atypical or implementation of the action would incur specific one-off costs, then the costs may need to be estimated based on the specific characteristics of the catchment and/or action to help control uncertainty.

- Identify annual costs:
    - As with capital costs, any atypical characteristics of the action as applied to the catchment should be considered and specific annual costs estimated where this is considered appropriate to help reduce uncertainty.
- Identify cost savings:
    - Cost savings will depend on the way that the actions included within an option would change the way that the catchment is currently managed. Again, uncertainty within the estimation of cost savings will depend on assumptions made about how management would change and this is likely to vary from one action to the next.
- Calculate whole-life costs:
    - The main uncertainty with the whole-life costs is when actions would be implemented. Delaying costs reduces the whole-life costs due to discounting but this may also result in a delay to when the benefits start.

A sensitivity test is included during selection of the preferred option (see Section 3.11) that shows how much costs would have to increase by (where the main assessment results in BCRs>1, NPVs>£0) or decrease by (where the main assessment results in BCRs<1, NPVs<£<0) to result in a BCR=1 or an NPV =£0 (where benefits equal costs). Where there are issues with time or resources available to undertake specific costing of actions, then an alternative approach is to use the sensitivity tests and consider if the likely level of uncertainty is within the threshold increase (or decrease) of costs before the BCR and NPV indicate that the option is not economically worthwhile.

3.8 Assess benefits of actions to land

3.8.1 Overview

The third step is to estimate the benefits of the actions to land. There are four activities within this step, as shown in Figure 3-4. This step provides the method for identifying how ecosystem services on land would benefit from the implementation of actions to land and for monetising those benefits. It is important to note that the benefits to water, which are the objective of many of the actions, are assessed separately from the benefits to land (see Section 3.9).

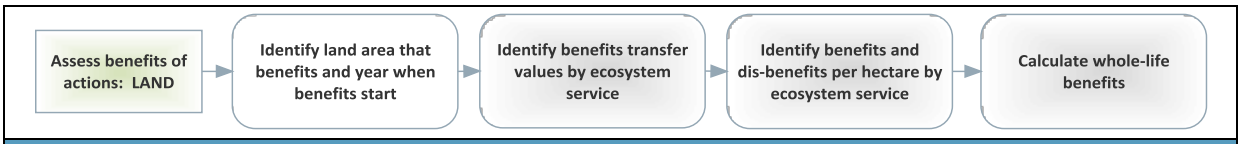

Figure 3-4: Activities included under the step to assess the benefits of actions to land

There may be benefits to other aspects of the environment such as air, for example, from measures to improve slurry storage could result in a reduction in ammonia emissions to air. These have not been included in this version of the appraisal as they are expected to be small in comparison with the benefits to land and to water.

3.8.2 Identify the land areas benefiting and timing of benefits

The Wyre case study assumes that actions that involve improvements to infrastructure, such as construction of slurry stores/roofs or use of water troughs are required over 1% of the area of land identified in the GIS analysis and, therefore, that the benefits to land also occur over 1% of the area.

To assess the benefits to land it is necessary to identify the area of land that would benefit. The area of land benefiting is recorded in the 'Land (area) benefiting' worksheet, see Box 3-7. There is space to type in both the area of land over which the action is implemented and the area of land that would benefit from implementation. It is likely that the two areas will be the same where the action involves a change in land use or land management. The areas might be different where an action involves fencing off watercourses and providing drinking water in troughs. Here, the area over which the fence is constructed and where the water troughs are installed (e.g. on permeable bases) is unlikely to be relevant. The area benefiting is more likely to be areas of previously compacted ground or the areas of poached banks. Care is needed, therefore, when identifying the areas that would benefit. The year in which the benefits are expected to begin are also identified.

Table 3-5 identifies the data sources and information used when identifying the areas of land benefiting for the case study catchments. Box 3-7 describes how the 'Land (area) benefiting' worksheet is used.

Table 3-5: Data and information sources for the case study appraisal – land (area) benefiting

Bristol Avon urban		Wyre
Appraisal based on bringing together existing projects	**Appraisal based on developing an integrated set of actions**	**Appraisal based on developing an integrated set of actions**
Catchment Data Explorer and GIS analysis for sub-catchment areas	Areas over which each action will be implemented from GIS analysis	Areas over which each action will be implemented from GIS analysis
Assumptions on percentage of land benefiting based on area over which action is implemented	Assumptions on percentage of land benefiting based on area over which action is implemented	Assumptions on percentage of land benefiting based on area over which action is implemented

The worksheet 'Land (area) benefiting' is used to record the area of land over which an action is applied and the area of land that would benefit from implementation of the action.

The year in which the benefits are expected to start is recorded in row 3 of the worksheet. This is used as the basis for estimating the number of years over which benefits would occur and is an important part of the estimation of the whole-life benefits (see Section 3.8.5).

The area of land over which the action is applied needs to be entered into row 4 of the worksheet, with one area required for each action. The area of land benefiting also needs to be added if this is different from the area of land over which the action is implemented. The spreadsheet allows for a percentage of the area over which the action is assumed to be implemented to be taken into account if this is different from 100%. This is a useful assumption where an action involves infrastructure improvements (e.g. slurry stores, slurry roofs, livestock drinking troughs) that would not be implemented across the whole area even though they may benefit the whole area.

The spreadsheet divides the benefits across each of the interventions that have been included under each action. This is to avoid double, treble, etc. counting of the area that would benefit. Without this correction, an action with four interventions identified as being required to deliver it would result in four times the benefits. Dividing by four helps to ensure that the benefits are not over-stated.

It is possible to type in the actual areas that would benefit from each intervention if this information is available instead of taking an average.

Box 3-7: Using the appraisal worksheet: Land (area) benefiting

3.8.3 Identify benefits transfer values by ecosystem service

Monetary benefits are assigned to the change in ecosystem services on land. These are based on benefits transfer values that are relevant to each terrestrial ecosystem service. In addition, consideration is taken of the magnitude of the change. The change is based on whether the actions are classified as 'restore', 'improve' or 'maintain'. Actions to 'restore' natural capital are expected to result in the greatest change as they would look to take a habitat that is currently degraded in terms of ecosystem service provision and restore it to a state where ecosystem services are provided sustainably and renewably. Actions identified as 'maintain' are assumed to look to ensure that there is no deterioration in the quality of the natural capital such that it can continue to deliver a sustainable stream of ecosystem services; these actions are associated with the smallest change. Actions to 'improve' natural capital provide an intermediate change.

The benefits transfer values used for the case study appraisals have been taken from the benefits inventory. Box 3-8 describes the approach used to extract the relevant benefits transfer values from the benefits inventory. Although the benefits inventory provided 19 relevant benefits transfer values, there were 20 gaps. Some ecosystem services have values for 'restore' but not for 'improve' or 'maintain', and some ecosystem services have no values:

- Values for all three ('restore', 'improve' and 'maintain') are available for climate regulation, water quality regulation and wild species diversity;
- Values for 'restore' are available for detoxification & purification in air, soils and water; disease and pest regulation; hazard regulation; soil quality regulation; trees, standing vegetation, peat; and water supply;

- Values for 'improve' and 'maintain' are available for crops, livestock and fish[5]; and environmental settings; and
- No benefits transfer values were found for noise regulation and pollination.

Gaps in the benefits transfer values are filled through the use of logistic regression. This uses the values for restore, improve and maintain across all of the ecosystem services to estimate the ratio between the three sets of values. This ratio is then applied to where there are no specific values for either 'restore', 'improve' or 'maintain'.

The benefits transfer values used are specific to benefits to land. Transfer values have been selected that are expressed in terms of £/ha/year, to ensure that the values can be assigned to the area that has been identified as benefiting from the measure.

Table 3-6 identifies the data sources and information used when identifying the areas of land benefiting for the case study catchments. Note that any additional benefits transfer values identified during the case study appraisals have been fed back into the benefits inventory[6] such that this is the identified source for all benefits transfer values used within the integrated appraisal. Box 3-9 describes how the 'Benefits transfer values-land' worksheet is used.

Table 3-6: Data and information sources for the case study appraisal – Benefit transfer values-land

Bristol Avon urban		Wyre
Appraisal based on bringing together existing projects	**Appraisal based on developing an integrated set of actions**	**Appraisal based on developing an integrated set of actions**
Benefits inventory	Benefits inventory	Benefits inventory

[5] Due to concerns over the risk of double counting with changes in gross margin which are often used as the basis for assessing the costs of measures, especially in relation to measures on agricultural land, the values for crops, livestock and fish relate to changes in wild food and non-food products.

[6] The benefits inventory and case study appraisals were undertaken in parallel with the case studies identifying values that were then fed back to the benefits inventory. In some cases the values were not added to the benefits inventory as there was insufficient information from the source document to complete the required information. Other values were added to the inventory but have been updated to £2016 values in the inventory. As a result, the values in the inventory may vary slightly from those used within the case study.

A search was made of the benefits transfer values that are available in the benefits inventory for each ecosystem service covered by the Natural England toolkit (see Section 3.8.4 for a full list of the ecosystem services and Annex 3 for a definition of these services).

The values selected for use within the appraisal were chosen based on the type of change and the units in which the benefits were presented:

- For actions identified as relating to a change equivalent to 'restore', values were taken as the total value of the ecosystem service when it is delivered by fully functional natural capital. These values were commonly taken from the TEEB dataset (The Economics of Ecosystems and Biodiversity, 2013).
- Values for measures that would 'improve' natural capital such that it would be able to deliver ecosystem services in a sustainable and renewable way were taken from the UK BAP study (Christie et al, 2011) based on the values elicited for increasing spend on BAP habitats in order that the BAP was fully implemented.
- Values for measures that would 'maintain' ecosystem services, i.e. would not result in any deterioration of natural capital, were also based on the UK BAP study (Christie et al, 2011). All benefits transfer values used were in £/ha/year to fit with the estimate of hectares of land that would benefit.

Box 3-8: Obtaining benefits transfer values from the benefits inventory

The worksheet 'Benefits transfer values-land' is populated with values taken from the benefits inventory. No changes need to be made to this worksheet unless a more appropriate benefits transfer value has been found for a specific ecosystem service and magnitude change (restore, improve or maintain).

The yellow coloured cells show where extrapolation has been applied to fill gaps, based on the logistic regression.

There were no appropriate benefits transfer values found for the noise regulation and pollination services. Therefore, any benefits to these services are not included in the monetary estimate of benefits to land (see Section 3.8.5).

Box 3-9: Using the appraisal worksheet: Benefits transfer values-land

3.8.4 Identify benefits and dis-benefits by ecosystem service

The Natural England toolkit is used as the basis for estimating changes in ecosystem services (positive and negative) for measures that are applied to land[7]. The NE toolkit provides information on the level of change to each ecosystem service with each specific measure (scored from - - to ++). This information is used to identify where there would benefits (+ or ++) or dis-benefits (- or - -) for each ecosystem service under each action. The spreadsheet includes a calculation worksheet to do this ('NE measures ES benefits-LAND'). This worksheet is used by the spreadsheet when estimating the whole-life benefits to land. No information needs to be added to the

The 'new floodplains' action from the Bristol Avon case study includes five interventions and shows net dis-benefits to crops, livestock and fish, and disease and pest regulation. Benefits and dis-benefits for trees, standing vegetation and peat are equal, while there are small dis-benefits but much larger benefits, hence net benefits, for water supply.

[7] Some of the measures listed in Natural England (2015) would be applied directly to water. For these measures, it is assumed that there are no ecosystem service benefits to land.

worksheet to enable the benefits to be estimated but it is described here as a key stage in the approach to identifying whether there are benefits or dis-benefits from each action on the each ecosystem service. Use of this worksheet is also described in Box 3-10.

The worksheet 'NE measures ES benefits-LAND' records, for each intervention, whether the Natural England toolkit identifies a benefit (a score of + or ++) or a dis-benefit (a score of – or - -) across the thirteen ecosystem services. This information is taken directly from the Natural England toolkit such that there is no need for any information to be added during the integrated appraisal. This activity is undertaken automatically by the appraisal spreadsheet (see Box 3-3 for more details on how this is done in the spreadsheet).

Box 3-10: Using the appraisal worksheet: NE measures ES benefits-LAND

3.8.5 Calculate whole-life benefits

The monetary benefits from each action on ecosystem services on land are estimated by multiplying the area benefiting (from Section 3.8.2) by the relevant benefits transfer value for each ecosystem service (from Section 3.8.3). The appraisal also takes account of whether the change identified from the NE toolkit reflects a benefit (positive impact) or a dis-benefit (a negative impact). This enables whole-life benefits and whole-life dis-benefits to be estimated for each action. These are summed separately since the extent to which an ecosystem service experiences benefits or dis-benefits from each action is used when identifying who pays, who benefits and who loses; it is also used in determining whether an action should be included within the social justice option (Option 3), see Section 3.10.2.

Whole-life benefits are estimated by multiplying the annual benefits by the sum of the discount factors from the year in which the benefits are expected to begin to the end of the 37 year appraisal period. This is simply identified as 'restore' where an action contains at least one 'restore' measure, as 'improve' if an action contains no 'restore' measures but at least one 'improve' measure or, if none of the former conditions applies, then the action is identified as 'maintain'.

The worksheet 'Benefits of actions-LAND' shows the annual benefits and dis-benefits on land by ecosystem service for each action. Benefits are highlighted in green while dis-benefits are shown in red. The total annual benefits are also presented as a sum across the benefits and dis-benefits. The discounted (whole-life) benefits are also presented for each action. These are calculated based on the year in which the benefits are expected to start (as recorded in the 'Land (area) benefiting' worksheet and the sum of the discount factors from the year when benefits are expected to start up to year 37 (the sum of the discount factors is taken from the 'Costs to actions' worksheet). The whole-life benefits are calculated automatically once the area of land benefiting has been entered.

Box 3-11: Using the appraisal worksheet: Benefits of actions-LAND

3.8.6 Key uncertainties with the approach to assess benefits of actions to land

The key sources of uncertainty in this step are as follows:

- Identify the land areas benefiting and timing of benefits:
    - The land area benefiting can be a source of uncertainty. The case study appraisals generally assume that the area of land benefiting is the same as the area of land over which an action is implemented. There are some exceptions, for example actions that involve fencing land so livestock cannot drink from water courses and providing troughs for drinking water instead. As a result the level of uncertainty is

likely to vary from action to action and can be managed to some extent by ensuring that the areas reflect the potential for ecosystem service benefits to be delivered. Discussions with experts who know how the actions would work on the ground could be useful in managing this uncertainty.

- Identify benefits transfer values by ecosystem service:
    - The benefits transfer values incorporate a number of uncertainties:
        - Lack of values for each ecosystem service. No values were found for noise regulation or pollination.
        - Lack of values for each change that occurs from implementation of each action. Values to capture three different levels of change were only available from the benefits inventory for climate regulation and wild species diversity. Assumptions had to be made to fill the remaining gaps introducing additional uncertainty into the benefits values that are used.
        - Applicability of the original value estimate to the transfer scenario, and on-going validity of an estimate derived many years ago.
- Identify benefits and dis-benefits by ecosystem service:
    - The NE toolkit is used as the basis for identifying where there are benefits (positive impacts) or dis-benefits (negative impacts) from each intervention. There are data gaps within the toolkit while assumptions have had to be made using expert judgment on which ecosystem services might be affected by interventions that have been added to better describe the actions included within the case study appraisals. As a result, it is uncertain whether all ecosystem service benefit and dis-benefits are captured within the appraisal. It is assumed here that the toolkit is the best current evidence on which ecosystem services might be impacted. To assess the magnitude of these uncertainties it would be necessary to check each assumption within the NE toolkit.
- Calculate whole-life benefits:
    - The key uncertainty for whole-life benefits to land is the year in which the benefits are predicted to start. Uncertainties will be highest where the benefits are predicted to begin near the start of the appraisal period (due to discounting).

As with costs, there is a sensitivity test that assesses how much benefits to land would have to decrease by or increase by to make the BCR=1 and NPV=£0 (benefits equal costs). The sensitivity tests takes account of benefits to water at the same time but, as with costs, this sensitivity test could be used to identify if the uncertainty within the benefit estimates is considered to exceed the threshold or not.

3.9 Assess benefits of actions to water

3.9.1 Overview

The fourth step is to estimate the benefits of the actions to water. There are three activities within this step, as shown in Figure 3-5. This step provides the method for identifying how the actions would help to deliver benefits in water bodies. Unlike benefits to land, the benefits to water only accrue once a combination of actions has been put in place and a change in water body status occurs. The step, therefore, presents information that enables the benefits across the options to be estimated where the options include a number of actions (see Section 3.10.2).

Figure 3-5: Activities included under the step to assess the benefits of actions to water

3.9.2 Identify indicators benefiting by action

Benefits to water are calculated differently from those to land and are estimated for each option (rather than for each action). This is because there are very few benefits transfer values that can be applied to ecosystem services delivered by water bodies. In addition, the NWEBS values are identified as being the best values currently available to measure benefits from changes to water quality and flow, and they currently form an important tool for benefits assessment within the Environment Agency. Use of the NWEBS values also means that much of the work that has been undertaken in the Stage 1 valuations can be taken forwards into the integrated appraisal.

The first step in identifying the benefits to water is to identify the indicators that would benefit under each action. The indicators are (based on the NWEBS benefits values):

- Fish;
- Other animals such as invertebrates;
- Plant communities;
- Clarity of water;
- Condition of the river channel and flow of water; and
- Safety of the water for recreational contact.

The Bristol Avon urban assessment identifies that the 'new floodplains' action would benefit three of the indicators: clarity of water, condition of the river channel and flow of water, and safety for recreation.

When aggregating measures in the options, it is assumed that each parameter can only benefit once, i.e. the benefits to fish only occur once even if more than one measure would deliver benefits to fish. This is to avoid double counting. This correction could lead to under-estimation of benefits where the combination of actions, through synergies or cumulative effects, would result a greater than expected status change (where a number of 'improve' measures could lead, for example, to an overall change equivalent to 'restore'). These can be recorded in the AST of benefits by options (see Section 3.10.3).

3.9.3 Identify km of water body benefiting by action

The length of water body benefiting from each action and the year in which the benefits begin are also identified. The NWEBS categories benefiting, the year in which benefits would begin and the length of water body benefiting are all recorded in the workbook (worksheet: water (components) benefiting) as described in Box 3-12. The spreadsheet avoids double counting of benefits to the same lengths of water bodies by ensuring that the benefits to each length are only counted once. However, this correction could also lead to under-estimation of benefits where the combination of actions, through synergies or cumulative effects, would result in additional length of water body benefiting. This can be addressed by identifying synergistic combinations of actions in the 'Actions-interactions' worksheet (see Section 3.6.4) and then in the 'Water body-actions' worksheet to include the additional length of water body that would benefit.

The worksheet 'Water (indicators) benefiting' is used to record the year in which the benefits are expected to start and the indicators that would benefit under each action.

The year in which benefits are expected to start is selected from a drop-down list. This may be the same as the year in which benefits to land are expected to start unless there is likely to be a delay between the action being implemented and benefits being seen in the water body.

The length of water body benefiting from each action is automatically filled in the worksheet based on the water bodies identified as benefiting in the 'Water body-actions' worksheet. A 'Y' is entered for each indicator that is expected to benefit from each action. The spreadsheet takes account of combinations of actions that are included within each option (see Section 3.10.2) to ensure that there is no double counting of benefits where more than one action would deliver benefits to the same indicator.

Box 3-12: Using the appraisal worksheet: Water (indicators) benefiting

3.9.4 Calculate benefits to water using NWEBS values

The benefits transfer values are taken from the NWEBS values per indicator per km per year for the catchment being considered, i.e. here the values are taken for the Bristol Avon and North Somerset Streams and Wyre for the two case studies. The central values have been used in the main appraisal; the low and high values can be used in sensitivity analysis.

Table 3-7 identifies the data sources and information used when identifying the benefits values for water for the case study catchments. Note that any additional benefits transfer values identified during the case study appraisals have been fed back into the benefits inventory such that this is the identified source for all benefits transfer values used within the integrated appraisal. Box 3-13 describes how the 'Benefits transfer values-water' worksheet is used.

Table 3-7: Data and information sources for the case study appraisal – Benefit transfer values-water

Bristol Avon urban		Wyre
Appraisal based on bringing together existing projects	**Appraisal based on developing an integrated set of actions**	**Appraisal based on developing an integrated set of actions**
NWEBS Bristol Avon and North Somerset Streams	NWEBS Bristol Avon and North Somerset Streams	NWEBS Wyre

The worksheet 'Benefits transfer values-water' presents the values that are used for each indicator.

The benefits of restoring ecosystem services to water bodies are based on the NWEBS values for a change in status from poor to good.

The benefits of improving the ecosystem services in the water bodies are based on the NWEBS value for a change from moderate to good.

The benefits of maintaining services in the water bodies is based on the ratio used for benefits to land, i.e. the difference between the value for improve and maintain. This is assumed to reflect the benefits of maintaining the status at good.

The NWEBS values are used for the specific catchments and so are specific to each of the case studies.

Box 3-13: Using the appraisal worksheet: Benefits transfer values-water

The spreadsheet considers the current status of the water bodies when identifying which of the benefits transfer values to assign. Where the current status of the water body is poor (from the Stage 1 valuation workbook) and where the action being implemented is identified as 'restore' then the benefit value used is assumed to reflect restoration of the water body from poor to good. Where the current status is moderate and the action being implemented is identified as 'restore' or 'improve', then the benefits transfer value applied assumes an improvement from moderate to good. If the current status is good, then the benefits transfer value applied is for 'maintain'. Here the value is based on the NWEBS value for a change from moderate to good but an adjustment factor is applied based on the results of the logistic regression used to fill gaps for the value of benefits to land. The ratio for the difference between benefits transfer values associated with improving services compared with the values associated with maintaining services is used. This is an assumption used to provide a value for an improvement that maintains the water body status at good; otherwise no value would be available and these benefits would not be monetised.

The annual benefits for each option are estimated as the benefits transfer value multiplied by the length of water body that will benefit. The spreadsheet checks and corrects for any duplication of water bodies, e.g. where additional actions could result in benefits to the same indicators over the same water body length. This avoids double counting of water body benefits. The annual benefits are then multiplied by the sum of the discount factors from the year in which the benefits are expected to begin to the end of the 37 year appraisal period.

3.9.5 Key uncertainties with the approach to assess benefits of actions to water

The key sources of uncertainty in this step are as follows:

- Identify indicators benefiting by action:
    - The allocation of which indicators benefit from each action is based on expert judgement linked to understanding of the type of benefits that would be seen in the water body. Uncertainty, therefore, is likely to vary based on the level of information available about the action and knowledge/experience of that action. Expert knowledge and understanding of the actions, especially where actions have been implemented, would be useful in managing this uncertainty.
- Identify km of water body benefiting by action:
    - The km of water body that benefit is based on expert judgement to highlight which water bodies would experience benefits from implementation of an action. Synergies can be picked up by including combination of actions that would benefit a longer length of water bodies, including water bodies downstream of those directly benefiting. Uncertainties are likely to be introduced where only part of the length of a water body would benefit or where additional water bodies could benefit but this has not been identified, or has not been included to avoid over-estimation of benefits.
- Calculate benefits to water using NWEBS values:
    - The NWEBS values are the best available values on which to base estimates of benefits to water. They have had to be used here to reflect the magnitude of change due to restore, improve or maintain. This means some further assumptions have been added in the appraisal to reflect the expected status change in the affected water bodies. The spreadsheet takes account of the current status of each water body so this should reduce the potential for over-estimation of benefits. However, an assumption has had to be made to enable a value to be assigned where water bodies are already at good or where the magnitude of the change is small

(equivalent to maintain). It is not clear whether these assumptions would result in an over- or under-estimation.

As with benefits to land, the sensitivity tests can be used to assess whether uncertainty from the above points is considered to exceed the threshold increase in benefits needed (where BCR<1) to make an option economically worthwhile or the decrease in benefits that would have to occur (to reduce BCR to <1) to make the option economically not worthwhile. For the benefits to water, a test related to risk of failure is also included. This takes account of the uncertainties associated with whether implementation of the actions would deliver the change in water quality that is assumed within the benefits transfer values, e.g. all water bodies achieve good status. This test always results in a reduction in the whole-life benefits to water as it is given as a percentage reduction. This percentage can be used to consider whether the confidence in success of the option exceeds the suggested risk of failure.

3.10 Compare costs and benefits

3.10.1 Overview

The fifth step is to estimate and compare the costs and benefits. There are four activities within this step, as shown in Figure 3-6. This step provides the method for combining actions into options, assessing the likely synergies and any possible antagonisms from these combinations, and then calculating the costs and benefits of each option and key economic parameters such as the benefit-cost ratio (BCR) and net present value (NPV). Each of these activities is described in more detail below.

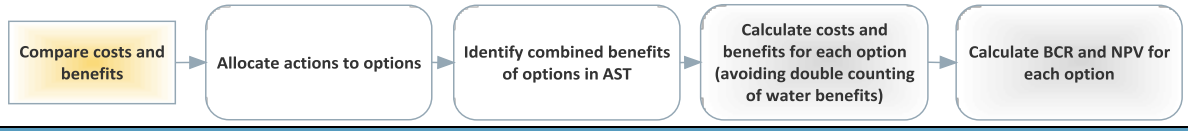

Figure 3-6: Activities included under the step to compare costs and benefits

3.10.2 Allocate actions to options

Benefits to water only occur when there is a change in status or to maintain status once all the water bodies have achieved good status. To enable such a change to occur, it is necessary to group actions such that they can deliver the improvements required in the water bodies. Three broad options have been identified by the steering group for this study as providing a range of objectives that reflect different possible outcomes from the integrated appraisal. These options are:

- Option 1: maximise natural capital. This will help ensure that natural capital is more able to adapt to climate change and is more resilient to low frequency, high impact events;
- Option 2: maximise water quality, water resources and flood risk management benefits in line with Defra's priorities. Adaptation and resilience to climate change are also important to this option; and
- Option 3: balance across all ecosystem services (provisioning vs regulating vs cultural) and across who pays and who benefits (social justice option).

When combining actions, it is suggested that the following 'rules' be applied in order to meet the objectives of each option:

- Option 1: maximise natural capital. Include all actions except those that are very similar and so would introduce additional costs but no (or very limited) additional benefits. These should be identified in the 'Actions-interactions' worksheet;
- Option 2: maximise water quality, water resources and flood risk management benefits in line with Defra's priorities. Consider those actions that deliver benefits specifically to the services of hazard regulation, water quality regulation and water supply. These can be seen in the worksheet 'Benefits of actions-LAND';
- Option 3: balance across all ecosystem services (provisioning vs regulating vs cultural) and across who pays and who benefits (social justice option). Consider who pays and who benefits. Identify those actions where the payee closely matches the beneficiary and avoid those actions that result in dis-benefits to those who are paying for the action.

There are nine actions assessed in the Wyre case study. Option 1 includes all nine actions. Option 2 includes five actions and focuses on delivering maximum benefits to hazard regulation, water regulation and water supply. Option 3 includes six actions and is focused on matching, as far as is possible, the distribution of who pays with the distribution of who benefits.

In all cases, combinations of actions that would result in antagonisms should be avoided. Combinations of actions that would lead to synergies should be included in Option 1 and also potentially in Options 2 and 3 where they help to meet the specific objectives of those two options. Box 3-14 provides more details on how to identify which actions should be included within each option.

3.10.3 Identify combined benefits in options AST

Once the actions to be included within each option have been identified, the 'AST of benefits by option' should be completed. This should draw on the information entered into the 'Actions-AST' with consideration given to any additional benefits that might be delivered from the combination of actions. Additional lengths of water body that benefit can be captured within the appraisal spreadsheet in the 'Water body-actions' worksheet, so the focus in the AST should be on any synergies that result from changes being greater than is reflected by the calculations. This can be a larger change in status or wider benefits that could be generated.

The 'AST of benefits by options' also needs to highlight any antagonisms that could occur under each option. There may be significant benefits from combining particular actions that are considered important but some antagonisms may occur to other services. It is important to record these potential dis-benefits so they can be considered when selecting the preferred option (see Section 3.11).

3.10.4 Calculate costs and benefits for each option

The whole-life costs, whole-life benefits to land and whole-life benefits to water for each option are calculated automatically by the spreadsheet as actions are identified as 'In' when completing the 'Costs and benefits by option' worksheet.

The worksheet 'Costs and benefits by option' is used to identify which actions are 'In' and which are not 'In' under each option. All of the actions identified and assessed through the appraisal are listed in column A. They can then be identified as 'In' where they are to be included under each option.

The spreadsheet includes some default 'rules' that begin the process of identifying which actions could be included under each option. These rules are:

- Option 1: all actions are 'In'. Some actions may be very similar to others or may introduce antagonisms when implemented with specific other actions. The information from the 'Actions-interactions' worksheet should be considered when confirming which actions are 'In'. Any combinations that involve implementing very similar actions should be changed to reduce duplication of actions (since this will increase the costs but not the benefits). Similarly, any combinations that would introduce antagonisms should also be avoided. If there are wider benefits from including combinations that would introduce synergies, then the synergies resulting from the combination under the option should be recorded in the 'AST of benefits' worksheet (see Box 3-13).

- Option 2: the spreadsheet identifies as 'In' those actions that deliver more benefits than dis-benefits to each of the Defra priority services (hazard regulation, water quality regulation and water supply). Again, any combinations that would result in similar actions or combinations that introduce antagonisms should be treated as for Option 1. Actions that do not directly benefit hazard regulation, water regulation or water supply could also be excluded here. The 'Costs and benefits by option' worksheet also provide the results of a simple distributional analysis (see Section 3.11.4 for more detail on how this has been undertaken). This shows which ecosystem services benefit from the combination of actions. Actions could be selected 'In' or not in to maximise benefits across Defra's priority services.

- Option 3: the spreadsheet identifies as 'In' those actions that deliver more benefits and dis-benefits across each ecosystem service. Thus, only those actions that result in greater benefits than dis-benefits across every ecosystem service are included. The 'Costs and benefits by option' worksheet also provides the results of a simple distributional analysis (see Section 3.11.4 for more detail on how this has been undertaken). The results of the distributional analysis could also be used when identifying which actions to include 'In' the option. For example, the focus could be on actions that deliver benefits to the stakeholder that pays for the action.

Each action can be identified as 'In' or not in. This means that the 'Costs and benefits by option' worksheet can be used to optimise the selection of actions and to maximise the benefits and minimise the costs. Further discussion on the potential for optimisation is given in Section 3.11.2.

Box 3-14: Using the appraisal worksheet: Costs and benefits by option

The worksheet 'AST of benefits by option' is used to record the overall benefits of each option for each ecosystem service. The AST should be completed once the actions to be included within each option have been selected in the 'Costs and benefits by option' worksheet.

Once the combinations of actions are known, then the information entered into the 'Actions-AST' can be used to help populate the 'AST of benefits by option'. It is important to record any wider benefits, synergies and antagonisms resulting from the combinations of actions within the 'AST of benefits by option'.

The information included within the AST can then be used to help identify the preferred option (see Section 3.11).

Box 3-15: Using the appraisal worksheet: AST of benefits by option

The whole-life benefits are the benefits minus any dis-benefits. The whole-life benefits to land are calculated for each of the actions that form part of each option and are aggregated across all actions that are included within the option, while the whole-life benefits to water are calculated for the option as a whole. The whole-life benefits for water include adjustments to avoid double counting across the same indicators that would benefit within the same water bodies. Thus any benefits from actions that are implemented in the same water body and would benefit the same indicators are only captured once.

The whole-life costs for the option are the sum of the whole-life costs of each action that is included within the option. This is why it is important to identify any actions that are very similar as the costs will be increased but the benefits may not.

The Wyre case study estimates whole-life costs of £15 million for Option 1, £11 million for Option 2 and £6.1 million for Option 3.

The whole-life benefits to land are £46 million for Option 1, £41 million for Option 2 and £4.9 million for Option 3.

The whole-life benefits to water are £32 million for Option 1, £21 million for Option 2 and £20 million for Option 3.

Both whole-life costs and benefits are calculated over the 37 year appraisal period based on the timing of specific cost elements and the year in which the benefits to land and water are predicted to start.

The worksheet 'Costs and benefits by option' presents the whole-life costs and whole-life benefits to land and to water. These are calculated automatically as actions are identified as being 'In' under each option.

Box 3-16: Using the appraisal worksheet: Costs and benefits by option

3.10.5 Calculate BCR and NPV for each option

The benefit-cost ratio (BCR) is calculated as the total of the whole-life benefits (sum of whole-life benefits to land and to water) divided by the whole-life costs. The net present value (NPV) is calculated as the total of the whole-life benefits minus the whole-life costs.

The Bristol Avon case study shows BCRs of 1.2 for Option 1, 0.66 for Option 2 and 3.4 for Option 3 for the appraisal of integrated actions.

The NPVs are £137 million for Option 1, -£148 million for Option 2 and £24 million for Option 3.

The worksheet 'Costs and benefits by option' automatically calculates the BCR and NPV for each option. The BCR and NPV will change are actions are added or removed from the option, with this offering the opportunity for optimisation (see Section 3.11.2).

Box 3-17: Using the appraisal worksheet: Costs and benefits by option

3.10.6 Key uncertainties with the approach to compare costs and benefits

The key sources of uncertainty in this step are as follows:

- Allocate actions to options:
  - Actions can be included within options (or excluded) such that there is no uncertainty introduced within this activity specifically. There may be uncertainty as to the number of actions that need to be included to achieve the objective. This

could be tested by adding and excluding actions to identify what the maximum benefits are for Option 1, for example.

- Identify combined benefits in options AST:
  - There may be uncertainty associated with the description of the qualitative and quantitative benefits of the actions, especially where the results of interactions between actions is not well known. Discussions with experts could help to explore what the potential synergies and antagonisms might be when a number of actions are implemented together.
- Calculate costs and benefits for each option:
  - The calculation of whole-life costs and benefits does not introduce any uncertainty in itself. However, it could compound over- and/or under- estimates of the individual costs or benefits and the timing of those costs and benefits.
- Calculate BCR and NPV for each option:
  - Again, the calculation of the BCR and NPV do not in themselves introduce any additional uncertainty but they will reflect all of the uncertainties associated with the estimates of the costs and benefits. The results of the sensitivity tests can be useful in exploring how the economic performance of each option could change in terms of what would cause the BCR=1 and NPV=£0.

3.11 Select preferred option

3.11.1 Overview

The sixth and final step is to compare the results for each option and select the preferred option. There are four activities within this step, as shown in Figure 3-7. This step provides the method for comparing the BCRs and NPVs of the options, taking account of any non-monetised benefits recorded in the AST, considering the results of the distributional analysis on who pays and who benefits, and assessing the implications of sensitivity testing. Each of these activities is described in more detail below.

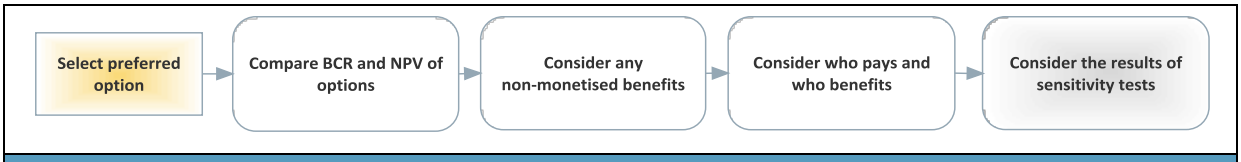

Figure 3-7: Activities included under the step to select the preferred option

3.11.2 Compare BCR and NPV of options

The approach to comparing costs and benefits is based on the benefit-cost ratio (BCR) and the net present value (NPV). These are automatically calculated in the 'Costs and benefits by option' worksheet, as described in Box 3-18.

Since the BCRs and NPVs are automatically calculated, it provides the opportunity to investigate what happens if an action is included (or excluded) from the option. Actions can be added or removed in turn to assess how this impacts on the overall BCR and NPV. Optimisation could involve identifying the combination that provides the highest BCR and NPV. This may be different from the objectives of the three suggested options and could give an Option 4 where the objective is to maximise the BCR or NPV.

It is also possible to use the 'Costs and benefits by option' worksheet to identify other options. For example, options with objectives associated with one specific stakeholder paying or avoiding a specific stakeholder having to pay could be assessed. Care is needed with these types of options though as there could be other mechanisms for reducing the economic burden on a sector, such as use of grants or a move to payments for ecosystem services.

The worksheet 'Costs and benefits by option' automatically calculates the BCR and NPV for each option. Different combinations of actions can be tested to see how the BCR and NPV changes. One option could be to maximise the BCR, for example.

Box 3-18: Using the appraisal worksheet: Costs and benefits by option

3.11.3 Consider additional non-monetised benefits and dis-benefits

The 'AST of benefits by option' records the non-monetised benefits of the options, plus any synergies or antagonisms associated with the combinations of actions that cannot be picked up in the monetised benefits. These form an important part of the decision-making process and should be considered when choosing between options. It is also important since monetary values could not be identified for all ecosystem services (noise regulation and pollination). The 'Option selection dashboard' presents the economic parameters (whole-life costs, whole-life benefits to land and water, BCR and NPV) and identifies where the BCR of an option exceeds one and where the NPV of an option exceeds £0.

The Wyre case study identifies that all options deliver additional non-monetised benefits to recreation and pollination. The non-monetised benefits are expected to be greatest for Option 1.

The 'Option selection dashboard' also allows a selection from a drop-down list to reflect the relative importance of the information on non-monetised benefits from the AST. Four choices are possible reflecting how the non-monetised benefits might influence the selection of the preferred option, all in response to the question 'are there sufficient additional qualitative benefits':

- Yes, sufficient to give BCR>1
- Yes, but not sufficient enough to make BCR>1
- Yes, sufficient to potentially change from the option with the highest BCR/NPV
- No, small qualitative benefits only

The choice of which statement is the most appropriate needs to be based on judgement from a comparison of the description of the qualitative benefits against the description of the monetised benefits in the AST. This could be done by considering the direction of change (positive benefit or negative dis-benefit) plus information on the likely scale of the change. The reasoning behind the choice of selection should be recorded to maintain transparency within the appraisal.

The worksheet 'Option selection dashboard' allows for consideration of the likely impact of the non-monetised benefits and dis-benefits recorded in the 'AST of benefits by option' to be recorded alongside the economic information on whole-life costs and benefits, BCR and NPV and the outcomes of the distributional analysis. This then provides the basis for selection of a preferred option taking account of all the information recorded during the appraisal.

Box 3-19: Using the appraisal worksheet: Option selection dashboard

3.11.4Consider who pays and who benefits

As well as the benefit-cost ratio and net present value, it is also important to consider who pays and who benefits. This is done through consideration of a distributional analysis to identify who pays, who benefits and who incurs dis-benefits as a result of each option. The analysis is built from the interventions from the NE toolkit with the stakeholder most likely to pay for each intervention identified. This gives the following list of likely payees (note fisherman relates to fishing at sea and is not relevant to the Bristol Avon urban or Wyre case studies as there are no marine measures being put into place):

- Land owner/manager
- Society
- Water/sewerage company
- Property owner
- Developer
- Abstractor
- Industry
- Fisherman
- Highways Agency

The Bristol Avon urban appraisal of integrated actions shows that land owner/manager would pay for 83% of actions but would receive just 11% of the benefits under Option 1.

Under Option 3 land owner/manager would pay for 40% of the actions and receive 8% of the benefits. This is the closest match possible of who pays and who benefits.

The payees are aggregated across each of the actions and then each of the options. The results are calculated as the percentage of interventions by number that each stakeholder is considered likely to pay for rather than percentage of interventions by value. The percentage by value cannot be estimated since the costs are given per action and not per intervention.

The same list of stakeholders is used when identifying who benefits from each of the ecosystem services. This is then used as the basis for identifying who benefits and who incurs dis-benefits, again drawing on the information on the impacts of each intervention on each ecosystem service (see Section 3.8.3). The beneficiaries and dis-beneficiaries are then aggregated across each of the actions and then across each of the three options. The results are shown as the percentage of total ecosystem service benefits and dis-benefits that each type of stakeholder would experience. This is different from the percentage of the monetary benefits and dis-benefits as, like costs, these could not be estimated for each measure (especially in terms of benefits from improvements to water bodies).

The distributional analysis is therefore given as a guide to the likely spread of costs and benefits, but it does not reflect the actual spread in terms of costs that would be paid by each stakeholders or the overall magnitude of benefits or dis-benefits that they would accrue. However, this approach means that the distributional analysis can be automatically calculated from the spreadsheet and be updated as actions are added or removed from inclusion under each option. In this way, the distributional analysis can also be considered if optimisation is undertaken.

The worksheet 'Option selection dashboard' provides a series of spider charts showing who pays and who benefits by option. There is also a chart showing the distribution of benefits by ecosystem service. The charts provide a visual representation of the share of costs and benefits. The percentages upon which the spider charts are based are presented in the 'Costs and benefits by option' worksheet.

Box 3-20: Using the appraisal worksheet: Option selection dashboard

3.11.5 Sensitivity testing

Three sensitivity tests are included within the appraisal spreadsheet:

- Identification of the change in whole-life costs needed to make the BCR equal to 1;
- Identification of the change in total whole-life benefits (land and water) needed to make the BCR equal to 1; and
- Identification of the risk of failure that results in the BCR becoming equal to 1 for water related benefits only.

The first two sensitivity tests take account of the BCR and NPV from the main assessment. Where the BCR is less than 1 and the NPV less than £0 (negative), the sensitivity test looks at how much the costs need to decrease by (test 1) and how much the benefits would have to increase by (test 2) to result in a BCR equal to 1 and an NPV equal to £0. Conversely, where the BCR is greater than 1 and the NPV is greater than £0 (positive), the sensitivity tests identify how much the costs would have to increase by (test 1) and the benefits decrease by (test 2) to result in a BCR equal to 1 and an NPV equal to £0. Each test is independent of the other so only the costs change in test 1 and only the benefits change in test 2.

All of the options in the Bristol Avon urban appraisal of existing actions have a BCR>1 and NPV>£0. The costs of option 1 would have to increase by 25% or the benefits to land and water decrease by 20% to give a BCR equal to 1 and NPV equal to £0. Or, if the risk of failure for water benefits is greater than 27% then Option 1 would see its BCR reduce to 1 and the NPV become £0.

The third test considers what the risk of failure could be to reduce the BCR to 1 and NPV to £0. Thus, this test only applies where the BCR from the main assessment is greater than 1 and the NPV is greater than £0 (positive). The third test considers a change in the whole-life benefits to water only.

The sensitivity tests can be used to consider whether the uncertainties surrounding the costs, the benefits, or the likelihood of failure to deliver the benefits to water are within the ranges shown. If not, then there may be uncertainty as to whether the option would be considered economically worthwhile.

The worksheet 'Sensitivity tests' considers how much the costs, benefits and risk of failure might have to change to give a BCR=1 and NPV=£0.

Where the BCR<1 and NPV<£0, the sensitivity tests show how much costs would have to decrease or benefits increase to result in a BCR=1 and NPV=£0.

Where the BCR>1 and NPV>£0, the sensitivity tests show how much costs would have to increase or benefits decrease to result in a BCR=1 and NPV=£0.

Sensitivity test 3 only applies where the BCR>1 and NPV>£0 from the main assessment. This is because it considers the risk of failure to deliver the water body benefits. If the BCR<1 and NPV<£0 from the main assessment, then the option is already identified as not economically worthwhile. Any further decrease in the benefits will further reduce the BCR.

All of the tests are automatically calculated once the actions to be included in each option have been identified in the 'Costs and benefits by option' worksheet. The tests will change as more or fewer actions are included so the results of the sensitivity tests can also be used during optimisation.

Box 3-21: Using the appraisal worksheet: Sensitivity tests

3.11.6 Key uncertainties with the approach to select the preferred option

The key sources of uncertainty in this step are as follows:

- Compare BCR and NPV of options:
    - It is important to consider uncertainties within the costs and benefits when comparing BCRs and NPVs. Where the BCRs and NPVs of options are similar, then a small change in the costs or benefits of either option could change that which might be preferred from an economic perspective (highest BCR, highest NPV). Consideration should be given to all of the sources of uncertainty in both costs and benefits and how these might vary between options.
- Consider additional non-monetised benefits and dis-benefits:
    - Uncertainties within the amount of information available, level of understanding, and experience of the actions within each option may affect the description of benefits and dis-benefits. Again, it is important to consider what these differences might mean in terms of how the benefits and dis-benefits are described for each option and why the descriptions may vary.
- Consider who pays and who benefits:
    - The distributional analysis reflects who pays for the percentage of actions, not the percentage of costs. This is a key uncertainty that could under-estimate the distribution across payees where one action is particularly costly; and
    - The distribution of benefits is based on the percentage of ecosystem service benefits identified for each stakeholder, not the distribution of monetary value of benefits. This uncertainty is unlikely to be as significant as for costs since the variation in benefits per ha (for land) or per indicator (for water) do not vary as much as the potential range in costs of actions.
- Sensitivity testing:
    - Three sensitivity tests are provided to assess how costs, benefits and risk of failure need to change to make the BCR=1 and NPV=£0. This provides information on what level of increase/decrease in costs and benefits and what risk of failure can be supported before the option becomes uneconomic (costs exceed benefits).

4 Comparison of current process with the integrated appraisal

4.1 Comparison of approaches

Each of the existing tools has been investigated in detail to identify how and where the approaches and/or information could be used within an integrated appraisal.

The steps required within each approach (RBMPs, FRMPs and the integrated appraisal) are similar, as shown in Figure 4-1. Table 4-1 summarises the key findings based on a comparison of the existing approaches to RBMP and FRMP and the methodology developed here for integrated appraisal.

There are more similarities between the RBMP approach and the integrated appraisal than between the FRMP process and integrated appraisal. This is not surprising since the Stage 1 assessment provided the starting point for development of the integrated appraisal to build upon the strengths of that process. The integrated appraisal uses the same approach to estimating the cost of actions as the RBMP process for identifying the cost of measures. Both processes also use the NWEBS value for estimating the benefits to water bodies. All three processes draw on the economic parameters of the benefit-cost ratio (BCR) when identifying the preferred option.

The FRMP process is particularly useful for identifying where there are issues with flood risk that need to be addressed. The integrated appraisal then looks at how those issues could be addressed in ways that would help to restore, improve or maintain natural capital, identifying actions that can deliver a suite of ecosystem service improvements. This moves the focus from an issue by issue identification of actions to one that looks across the catchment as a whole, identifying actions that could deliver outcomes that attempt to address a number of issues at the same time. This is the principle underlying the 'identify actions' step in the integrated appraisal and illustrated in the assessment of integrated sets of actions in the Bristol Avon urban and Wyre case studies.

The integrated appraisal adds a further dimension to the estimation of benefits by including an approach to estimate the benefits of the actions on land. This reflects the type of actions that have been identified as requiring a change in land use or management of land to deliver benefits in water quality, quantity and flood risk. These changes in land use or to land management also deliver benefits by restoring, improving or maintaining natural capital and the flows of ecosystem services from the natural capital. Inclusion of benefits to land, therefore, captures many more of the benefits from the actions than is possible in RBMP. FRMP can capture some of these benefits through use of the Economic Valuation of Environment Effects (EVEE) tool, but this approach may only be undertaken where 'greener' (rather than grey) measures are proposed.

The integrated appraisal has also been developed so that synergies from combinations of actions can be identified and described and for the monetary benefits to be identified. This can be done by identifying where synergies are predicted and including an additional action that combines the synergistic actions. Such an approach allows both the wider benefits to land and water from the combination of actions to be explicitly recorded in the appraisal spreadsheet. Synergies to land are identified through an increased area of land that would benefit while synergies to water are captured through highlighting the additional lengths of water body that would benefit. Some synergies can be picked up in the Stage 1 assessment by highlighting that additional water bodies may benefit beyond just the water body where an action is implemented, but it is more difficult to record where there are synergies from the combinations of actions.

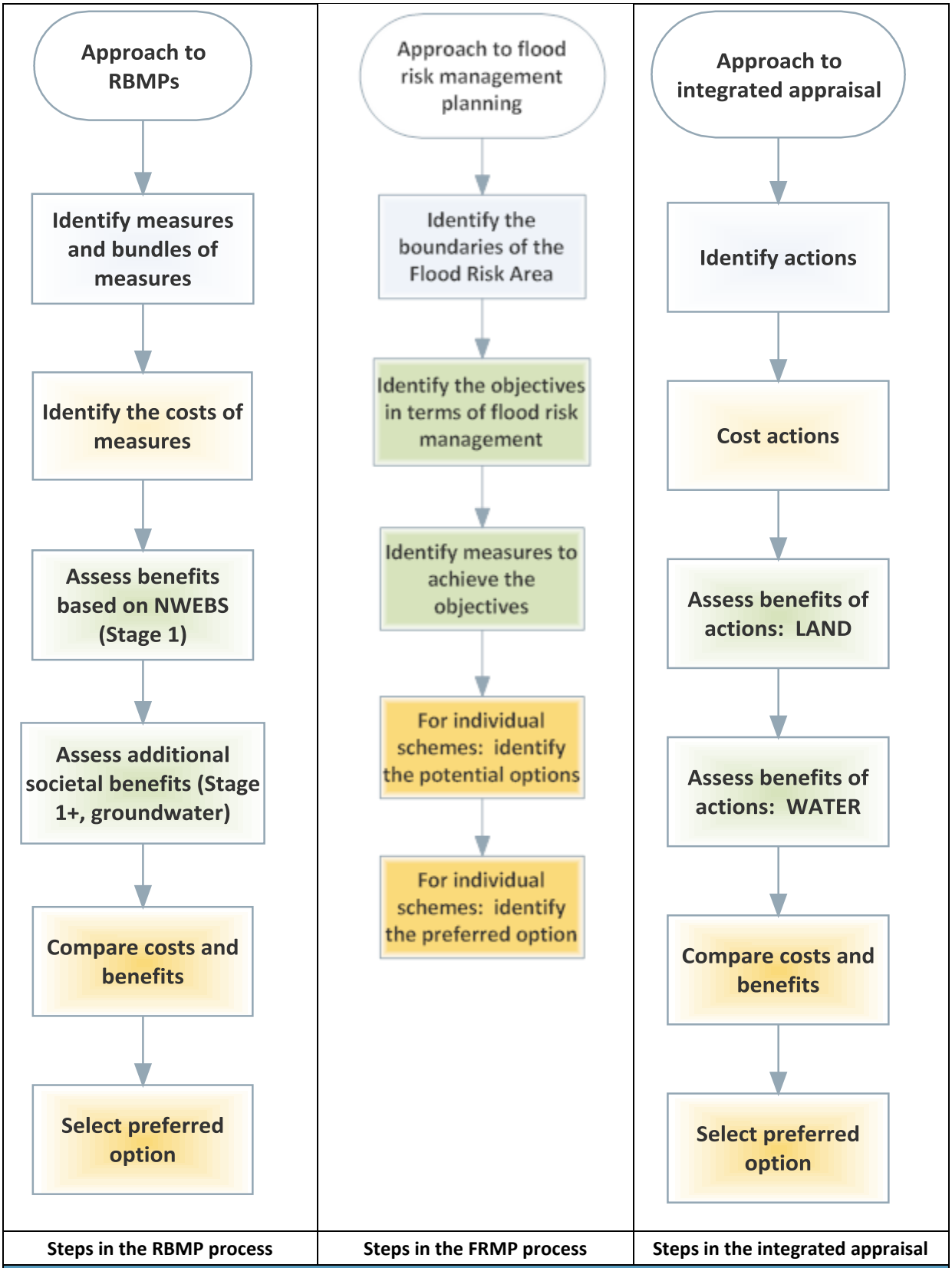

Figure 4-1: Main steps in approaches to appraisal for RBMPs, flood risk management planning and integrated appraisal

Table 4-1: Comparison of existing approaches to appraisal			
Criterion	**RBMPs**	**FRMPs**	**Integrated approach**
Key economic parameters:			
- baseline year	2013/14	2015 (current FRMPs are for 2015-2021)	2016/17
- appraisal period	40 years	FRMPs cover 6 years to match the RBMP planning cycle	37 years (to align with RBMP planning periods)
- discount rate	3.5%	3.5%	3.5%
Summary of approaches:			
Tool/source of data	Bundles sheet and Stage 1 valuation worksheet	Based on plans submitted by Flood Risk Management Authorities and others; also modelling data	Integrated appraisal spreadsheet developed drawing on approaches from RBMP and FRMP and GIS analysis
Source of costs	Using existing tools such as the Cost of Agricultural Measures (CAM) tool, urban diffuse cost calculator tool, national cost-effectiveness database, programmes costs and local experts	Based on plans submitted by Flood Risk Management Authorities and others	Use of existing cost tools as with RBMP and FRMP, plus sources specific to types of actions being considered such as Nix Farm Management Pocketbook, Countryside Stewardship payment rates GIS analysis to identify areas of land over which actions would be implemented
Basis for benefit estimates	NWEBS plus Stage 1+ valuation and groundwater valuation (for Bristol Avon catchment only)	Estimated through identifying the likely benefits of the different measures in terms of performance against the outcome measures	Natural England toolkit for benefits and dis-benefits to land by ecosystem service Benefits inventory (TEEB and UK BAP) for benefits to ecosystem services on land NWEBS for the benefits to water

Table 4-1: Comparison of existing approaches to appraisal			
Criterion	**RBMPs**	**FRMPs**	**Integrated approach**
Scale of benefits	Benefits to water bodies are based on £ per km Benefits from agri-measures are based on number of farms Fresh water abstraction benefits based on m^3 per year abstracted for public water supply Groundwater benefits mainly £ per m^3 but also include benefits as £ per tonne (air quality pollutant removed and change in carbon emissions), £ per household for water purification and waste treatment, £ per km per household for recreation and tourism (surface water flow), £ per visit (surface water quality and social relations), percentage of house price (aesthetics) and £ per ha (groundwater dependent wetlands) or £ per household (risk of loss of species	Varying dependent on the individual measure proposed	Benefits to ecosystem services on land are based on £ per ha Benefits to water bodies are based on £ per km
Approach to sensitivity testing	Variation in costs (x2, x 0.8) and change in one-off costs for BCR to approximate to one 50% decrease in km benefiting Use of low, central and high WTP values Change in risk of failure	Varying depending on scale of appraisal. For scheme appraisals, account is taken of key uncertainties that affect the differences between options. Assumptions are varied including on costs, timing of impacts, and changes to major beneficiaries. Switching points are calculated to assess what level of change is needed to change the choice of preferred option	Extent to which costs have to change to result in a BCR of 1 (increase where BCR>1 in main appraisal or decrease where BCR<1) Extent to which benefits have to change to result in a BCR of 1 (decrease where BCR>1 in main appraisal or decrease where BCR>1) Change in risk of failure to result in a BCR of 1 (only applies where BCR>1 and only changes benefits to water)

Table 4-1: Comparison of existing approaches to appraisal			
Criterion	**RBMPs**	**FRMPs**	**Integrated approach**
Main advantages of approach	Already considers ecosystem service benefits so provide a basis for expanding this to capture wider benefits Already enables integrated appraisal of water quality and water quantity issues and measures to address those issues Already provides a method that could be used for optimisation based on monetised costs and benefits. NWEBS values for estimating benefits to water bodies are considered to be high quality values and are available for each catchment specifically	It is possible to capture ecosystem service benefits. The outcome measures also take account of habitat creation	Enables holistic actions identified at the catchment scale to be assessed right down to specific actions such as those taken from the Stage 1 assessment for the RBMP or flood risk schemes Appraisal spreadsheet allows optimisation of options and can take account of synergies between actions, including where this will benefits longer lengths of water bodies Builds on Stage 1 assessment so some aspects will be familiar (e.g. approach to estimating costs of actions) Uses NWEBS values for estimating benefits to water bodies which are considered to be high quality values and are available for each catchment specifically

Table 4-1: Comparison of existing approaches to appraisal			
Criterion	**RBMPs**	**FRMPs**	**Integrated approach**
Main disadvantages of approach	Ecosystem service benefits are described at the bundle level, making it difficult to disaggregate benefits for individual measures affecting the extent to which optimisation can take account of the wider (non-NWEBS) values The extent to which the NWEBS values already capture some of the ecosystem service values is not clear. This means there is a risk of double counting if ecosystem service values in water are added to the NWEBS values	Assessment of schemes and allocation of funding against outcome measures means that the funding is targeted towards specific aims and may not necessarily enable funding of measures that have wider benefits (unless partnership funding is involved)	Simplification of estimate of benefits using NE toolkit may result in over-estimation of benefits to land Assumptions needed to be made to fill gaps in available benefits transfer values for benefits to land Simplification of magnitude of change to restore, improve or maintain for each action may result in benefits being over-estimated where an option includes just one action to restore, for example, and this being assumed to result in 'restoration' of ecosystem services. This is addressed in the water benefits where the current status is taken into account by the spreadsheet when estimating the magnitude of change. No similar data have been found on the current status of each terrestrial ecosystem service in the case study catchments to allow the same approach to be used

All three processes provide mechanisms for taking account of uncertainty within the appraisals and sensitivity of the results. The RBMP process looks at changes to costs (x2, x0.8), a decrease in the kilometres of water bodies that benefit (50% reduction), a change in the benefit values used (low, central or high), and a change in the risk of failure (0%, 25% and 50%). The integrated appraisal considers switching points. The appraisal spreadsheet calculates how much costs, benefits and the risk of failure would have to increase or decrease by to result in a BCR of 1 and NPV of £0. This allows the robustness of the economic case to be considered for each option individually and by comparing options.

The integrated appraisal also includes a distributional analysis showing who pays and who benefits with this being taken into consideration during selection of actions to be included under Option 3 (social justice) as well as during the comparison of options and selection of the preferred option. The RBMP process includes discussion on who benefits and who loses as part of the AST. Therefore, this information can also be considered when identifying the preferred option. All three appraisal processes use an AST, with this providing information on the non-monetised benefits of options. Again, this information is used when selecting the preferred option. For individual flood risk management schemes, identification of beneficiaries is important since it enables discussions on Partnership Funding, where beneficiaries contribute towards the costs of measures.

One final addition in the integrated appraisal is the potential to use the appraisal spreadsheet to optimise options. This can also be undertaken within the Stage 1 valuation spreadsheet with the ability to include/exclude measures from bundles. The integrated appraisal allows actions to be included/excluded from options with the whole-life costs and benefits, and BCR and NPV recalculated as each action is added or removed.

Overall, therefore, there is a number of similarities between the three processes. The integrated appraisal looks to build upon the RBMP and FRMP approaches, using the same overall structure and key elements such as the AST and the NWEBS values as the basis for estimating benefits to water bodies. The integrated approach aims to capture more of the benefits of actions to reflect that more holistic approaches tend to include change to land use or land management. The integrated appraisal also looks to explicitly take account of potential synergies during definition of actions and when combining actions into options to help ensure that as many as possible of the benefits from restoring, improving and maintaining natural capital can be captured.

4.2 Comparison of results

The above discussion explores how the RBMP, FRMP and integrated appraisal processes vary. From this discussion it would be expected that the integrated appraisal, which attempts to capture more of the benefits and to enable synergies to be taken into account, would result in higher benefits than the RBMP and FRMP appraisals. The Bristol Avon urban and Wyre case studies look more holistically at actions than was possible in the Stage 1 assessment for the RBMP, but comparisons of the BCRs and NPVs can be made[8]. It has not been possible to compare results with the FRMP since the economics is focused more at a scheme-by-scheme level and the case studies have not looked in detail at any specific flood risk management schemes.

[8] The Bristol Avon urban case study also includes an appraisal of the existing measures from the Stage 1 assessment and the Bristol Avon Catchment Plan as an intermediary 'integrated appraisal' between the existing appraisals and the integrated appraisal of integrated actions; see also Annex 1.

It is important to acknowledge when comparing the results that the integrated appraisal has been developed and applied to the two case studies over an eight week period. As a result, assumptions have had to be made to fill data gaps or to simplify the assessment such that it could be completed within the available timeframe. This means that the integrated appraisal results are likely to be much more uncertain than those from the Stage 1 assessment. The options assessed for the integrated appraisal are in effect hypothetical scenarios where the desired outcomes are set using overall, broader social and policy objectives. These scenarios include use of wide scale actions that would result in changes in land use or land management over a wide area and, as such, would require significant buy-in from the affected stakeholders, in particular the agricultural community. It is likely, therefore, that the costs of the integrated actions are under-estimated as they are based on typical costs and may not reflect the potential increased costs that could occur when actions are implemented on a catchment scale.

Table 4-2 presents a summary of the types of measures that have been included within each appraisal, based on the sector that would be responsible for those measures. The distribution of responsibility for measures for the full bundles, i.e. to improve all water bodies to good, is shown for the unintegrated appraisal. The distribution of responsibility for measures for each of the three options is shown for the integrated appraisal. The Table shows that the integrated appraisal tends to have a higher proportion of actions that are the responsibility of land owners and managers. This is true for both the Bristol Avon urban and Wyre case studies. Actions that are the responsibility of water and sewerage companies tend to be less common in the integrated appraisal.

Table 4-2: Comparison of types of measures and distribution of responsibility for actions

Type of measure	Unintegrated appraisal	Integrated appraisal					
		Existing actions			Integrated actions		
	Full to good	Opt 1	Opt 2	Opt 3	Opt 1	Opt 2	Opt 3
Bristol Avon urban							
Measures implemented by land owners/managers	14%	55%	23%	22%	83%	63%	40%
Measures implemented by Government agencies or NGOs on behalf of society	71%	35%	69%	75%	13%	38%	60%
Measures implemented by water and sewerage companies	14%	1%	0%	0%	0%	0%	0%
Measures implemented by developers	0%	1%	0%	0%	0%	0%	0%
Measures implemented by property owners	0%	5%	6%	3%	0%	0%	0%
Measures implemented by abstractors	0%	2%	3%	0%	4%	0%	0%
Measures implemented by industry	0%	1%	0%	0%	0%	0%	0%

Type of measure	Unintegrated appraisal	Integrated appraisal		
	Full to good	Opt 1	Opt 2	Opt 3
Wyre				
Measures implemented by land owners/managers	13%	50%	56%	33%
Measures implemented by Government agencies or NGOs on behalf of society	55%	42%	38%	56%

Table 4-2: Comparison of types of measures and distribution of responsibility for actions				
Type of measure	Unintegrated appraisal	Integrated appraisal		
	Full to good	Opt 1	Opt 2	Opt 3
Measures implemented by water and sewerage companies	24%	0%	0%	0%
Measures implemented by developers	0%	0%	0%	0%
Measures implemented by property owners	0%	0%	0%	0%
Measures implemented by abstractors	0%	0%	0%	0%
Measures implemented by industry	5%	4%	0%	6%
Measures implemented by Highway Agency	3%	4%	6%	6%
Note: Total may not sum to 100% due to rounding; distribution is based on number of actions that each sector is responsible for not the proportion of cost				

Table 4-3 presents the benefits by type for each appraisal, including a breakdown of benefits by options for the integrated appraisal; the Stage 1 valuation worksheets does not present the total benefits hence the potential source of benefits only is shown in Table 4-3 for the unintegrated appraisal. The non-monetised benefits are shown as one of the four possible selections (see Section 3.11.3). For the Bristol Avon urban integrated appraisal of integrated actions, the qualitative benefits are identified as being small because most of the benefits are captured in the monetary estimates. Only benefits to noise regulation and pollination are not thought to be captured and these are not expected to be significant. Time constraints meant that the ASTs have not been completed for the Bristol Avon integrated appraisal of existing actions so it is not possible to comment on the non-monetised benefits. For the Wyre, there may be benefits to food provision from use of slurry on land and due to new recreational opportunities. Option 1 offers new recreational opportunities across the whole catchment, while Option 2 does not offer these opportunities on moorland areas but does over the rest of the catchment. Consideration is needed as to whether these recreational benefits are likely to be sufficient to give Option 1 the largest BCR; it does have the largest NPV so consideration of the additional qualitative benefits may suggest that Option 1 is preferred over Option 2.

Table 4-3: Comparison of benefits by option across the three appraisals							
Benefits (as whole-life benefits in £ millions)	Unintegrated appraisal	Integrated appraisal					
		Existing actions			Integrated actions		
	Full to good	Opt 1	Opt 2	Opt 3	Opt 1	Opt 2	Opt 3
Bristol Avon							
Benefits to land	Stage 1+ covers agri-measures	£16	£7	£9	£778	£279	£31
Benefits to water	Based on NWEBS	£42	£9	£16	£25	£4	£
Non-monetised benefits	In AST for preferred bundle	-	-	-	Small	Small	Small

Table 4-3: Comparison of benefits by option across the three appraisals				
Type of measure	**Unintegrated appraisal**	**Integrated appraisal**		
	Full to good	**Opt 1**	**Opt 2**	**Opt 3**
Wyre				
Benefits to land	Stage 1+ covers agri-measures	£46	£41	£5
Benefits to water	Based on NWEBS	£32	£21	£20
Non-monetised benefits	In AST for preferred bundle	Potential to change from option with highest BCR	Small	Potential to change from option with highest BCR

Tables 4-4 and 4-5 present the results from the Stage 1 assessment for RBMPs and the integrated appraisals for the two case studies. The Bristol Avon case study includes two appraisals within the integrated approach: one assessing a set of existing actions from other appraisals and one assessing a set of integrated actions. The Wyre case study is based on a vision for the Wyre catchment and focuses on the appraisal of an integrated set of actions intended to help deliver the vision.

Table 4-4: Comparison of BCR across the three appraisals				
Bundle/option	**Unintegrated appraisal**		**Integrated appraisal**	
	Stage 1 assessment	**Stage 1+ assessment**[9]	**Existing actions**	**Integrated actions**
Bristol Avon				
Full bundle most to good	0.40	N/a	-	-
Bristol Avon catchment permitting pilot	0.75	1.1	-	-
Bristol Avon catchment permitting pilot plus what the environment needs	0.69	N/a	-	-
Option 1: maximise natural capital	-	-	1.25	1.21
Option 2: Defra's priorities	-	-	1.46	0.66
Option 3: social justice	-	-	2.22	3.35
Wyre				
Wyre catchment to good	1.64	N/a	-	-
Option 1: maximise natural capital	-	-	-	5.19
Option 2: Defra's priorities	-	-	-	5.88
Option 3: social justice	-	-	-	4.12

Table 4-4 highlights that, although the bundles and options cannot be directly compared as they include different sets of actions, it can be seen that the BCRs from the integrated appraisal are generally higher than the BCRs from the Stage 1 assessment. This is likely to be partly due to the

[9] The BCR for the Stage 1+ assessment was only available for the Bristol Avon catchment permitting pilot because the Wyre bundle already had a BCR greater than 1.5.

inclusion of benefits to ecosystem services on land, which were not monetised in the Stage 1 assessment. Both the unintegrated and integrated appraisals use the NWEBS values when estimating benefits to water but the integrated appraisal includes a wider set of actions that enables more of the indicators to be improved across a longer length of water bodies. Again, this will increase the benefits.

Table 4-5: Comparison of NPVs across the three appraisals (£m)				
Bundle/option	Unintegrated appraisal		Integrated appraisal	
	Stage 1 assessment	Stage 1+ assessment	Existing actions	Integrated actions
Bristol Avon				
Full bundle most to good	-£33	N/a	-	-
Bristol Avon catchment permitting pilot	-£7	£4	-	-
Bristol Avon catchment permitting pilot plus what the environment needs	-£10	N/a	-	-
Option 1: maximise natural capital	-	-	£12	£137
Option 2: Defra's priorities	-	-	£5	-£148
Option 3: social justice	-	-	£14	£24
Wyre				
Wyre catchment to good	£22	N/a	-	-
Option 1: maximise natural capital	-	-	-	£63
Option 2: Defra's priorities	-	-	-	£52
Option 3: social justice	-	-	-	£19

Table 4-5 shows that the NPVs of options are not always positive under the integrated appraisal, but there is at least one option in each of the integrated appraisals that exceeds the NPVs from the Stage 1 assessment. Therefore, the results from the integrated appraisal show that there is potentially an economic case from looking much more holistically at a catchment and identifying actions that are intended to deliver the maximum improvement to natural capital across the catchment as a whole.

It is important to note that uncertainty in the benefits and costs is high within the integrated appraisal of integrated actions (for both the Bristol Avon urban and Wyre) and more detailed costings would be required given the scale of the changes that are being proposed.

4.3 Comparison of data and resource needs

The integrated appraisal draws on a series of GIS datasets and other tools to inform and develop the appraisal. These are listed in Table 7-1 in the references section. Table 7-1 also shows the owner of the datasets and tools.

Some data gaps still exist and have had to be filled with assumptions. These include:

- Benefits transfer values to ecosystem services on land for noise regulation and pollination (no values available), plus specific values for different magnitude changes for the other ecosystem services. These have been filled using logistic regression.

- Benefits and dis-benefits across ecosystem services for interventions not listed in the NE toolkit. These have been filled using expert judgement based on comparison with benefits and dis-benefits shown for similar types of interventions.
- Specific measures of areas of land benefiting. In many cases the area of land benefiting is assumed to be the same as the area over which an action is implemented. This does not hold for actions such as infrastructure improvements so assumptions have had to be made.
- Magnitude of change to both land and water is based on the likely level of improvement delivered by an action as restore, improve or maintain. This is a simplification to fill a gap since data were not available on the current status of each ecosystem service for the case study catchments. The current water body status is taken into account for benefits to water.

The resources needed for the integrated appraisal are difficult to analyse in detail given that the case studies involved the use of assumptions to fill data gaps where information was not readily available within the timeframe for the study. The appraisal spreadsheet provides a format for recording the outcomes of each step of the appraisal and automates a lot of the appraisal requirements helping to make the approach more cost-effective. Both case studies were completed within an eight-week period, but this time period also involved development and refinement of the methodology. There was therefore an iterative process whereby the case studies were used to develop the methodology steps and then these were refined using information specific to the Bristol Avon urban and Wyre catchments.

The appraisal process is the same for both case studies although the type of actions considered varies. The Bristol Avon urban case study includes appraisal of existing actions from existing studies and plans as well as an integrated set of actions. The Wyre case study involves appraisal of actions developed to deliver a vision for the catchment based on an understanding of the issues that need to be addressed. The integrated appraisal process has been shown to work in all of these situations suggesting it is flexible enough to be adapted to different types of catchments and different catchment needs.

Overall, the integrated appraisal developed in this study has:

- Enabled different types of actions to be identified and appraised;
- Produced BCRs and NPVs that suggest that integrated approaches could provide a more cost-effective way of addressing water quality, quantity and flood risk issues;
- Been completed even with significant data gaps through the use of assumptions that can be recorded and tested through more detailed assessment as required to minimise the risk that the approach is unable to proceed due to uncertainties; and
- Resulted in a repeatable methodology supported by a spreadsheet.

5 Lessons learned and value added

5.1 Overview

This section draws together the lessons learned from the comparison of the unintegrated and integrated approaches as applied to the Bristol Avon urban and Wyre case studies. It also summarises the value added from the integrated approach over and above the unintegrated approach.

5.2 Lessons learned

The lessons learnt from this study are set out in Table 5-1. This shows the issue that was encountered and how it was addressed and then any issues that remain or alternative approaches that could have been used had there been additional data or time available. The aim is to provide a summary of the problems that were overcome during development of the methodology and application to the case study catchments but also to demonstrate if and how these problems could affect future use of the methodology. If so, potential solutions are identified that could improve the reliability of the methodology and the robustness of the results moving forwards.

The key issues when taking the results of this study forward are the need for a much better understanding of the catchment and the specific details of the catchment to address the uncertainties that are inherent within the case study appraisals. The methodology as developed provides a repeatable and workable approach but more work is needed to ensure that the assumptions and uncertainties that have been made in both development of the process and its applications can be improved upon. In terms of the methodology, the key steps where issues remain are:

- Identification of actions:
    - The need for greater resolution data to enable actions to be identified more precisely, including areas over which actions would be implemented and the potential for synergies from combinations of actions;
- Identification of benefits:
    - The potential to investigate other ways of measuring the magnitude of change to natural capital from the actions and whether this can be reflected as a change from the current state of natural capital and associated ecosystem services. This is likely to require data on the current state of natural capital and/or ecosystem services throughout the catchment;
    - Gaps in terms of available benefits transfer values across actions to restore, improve and maintain natural capital and to reflect how these changes affect delivery of ecosystem services. Filling of these gaps would require new valuations, probably through new valuation studies;
    - The reliability and robustness of the NE toolkit in identifying benefits and dis-benefits across interventions, especially when these interventions are combined into actions. The appraisal spreadsheet avoids double counting but there may be some issues with the benefits and dis-benefits that are shown to occur. This is because the NE toolkit is based on existing references and these may not be available for all ecosystem services reducing reliability of the data. This requires validation of the suggested benefits and dis-benefits.

Table 5-1: Lessons learnt during the study and implications for use of the integrated approach moving forwards		
Issue/problem encountered	**How the issue/problem was addressed**	**Implications for future use of the methodology**
Issues with data		
The time taken to receive baseline datasets is (as was expected) quite long	The work was rearranged such that integrated appraisals for the case studies were primarily undertaken within the final few weeks of the study. This means that there was less time for checking and verifying assumptions such that the appraisal results include considerable uncertainty	The methodology includes details of the data sources used and that were of most value to the study. Internal use of data within the Environment Agency may also mitigate some of the time delays. The key is ensuring that the data are requested at the earliest possible stage
There is a lot of baseline information but quite often this does not quite give the information needed	Where possible we have built upon the existing tools and information but often there were a lot of gaps that needed to be filled through additional Internet searches for information or additional requests to the Environment Agency	Table 7-1 lists out the data sources that were of greatest value to this study. Involvement of experts who know the catchment, know the issues and know the stakeholders will be important when undertaking integrated appraisal 'for real' as this could provide a much more robust way of filling data gaps
Data available were useful for the case study appraisals but greater resolution may be required to refine the appraisals	The Land Cover Map 2007 and the Opportunity Mapping for Woodland Creation were ideal for this catchment scale integrated assessment, but higher resolution data are needed to map (and quantify the area of) actions in urban environments	The Mastermap topography series would be the best dataset for more detailed study
Issues with identifying actions		
The extent to which actions are likely to be deliverable is expected to vary considerably depending on the individual farmer (and landlord) according to their level of environmental engagement; their ability to see opportunity in change (for example gaining value from fishing lakes); their land occupation/ownership status and how long the arrangements are in place for; and how accommodating they are to new ideas	It was not possible to consider these subtleties within the case study appraisals. The case studies identify actions and assume that they are deliverable across the catchments at a 'typical' cost (see also issues with identifying costs of actions). In some cases, the development of integrated actions at the catchment level can result in actions that are not defined in enough detail to facilitate costing. Costs were applied in the case studies based on an interpretation of what these integrated actions might mean on the ground	Generation of realistic actions that are deliverable at the catchment level will require dialogue with stakeholders. A lot of this work is likely to have already taken place during the Stage 1 assessments or work associated with delivering catchment sensitive farming. There may be a need to take a more catchment-based approach and to develop a vision with stakeholders that can demonstrate how each stakeholder may benefit. Such an approach would help to develop actions that are deliverable but would still look to retain a focus at the catchment level with the aim of delivering the benefits of integrated appraisal to the advantage of all

Table 5-1: Lessons learnt during the study and implications for use of the integrated approach moving forwards		
Issue/problem encountered	**How the issue/problem was addressed**	**Implications for future use of the methodology**
There were some limitations with the existing GIS data in terms of identifying potential synergies between actions	Synergies are captured in terms of identifying where combinations of actions could work together to deliver benefits over longer lengths of water bodies	If a geospatial dataset of barriers (e.g. weirs and dams) is available and proposed barrier removals are georeferenced, these measures can be incorporated into future assessments, for which the length of river opened up to migratory fish populations is calculated
Issues with identifying costs of actions		
The costs of actions will depend considerably on the quality of the soil/ field size/shape/access and overall value coupled with the local demand (or not) for alternative land	The costs of actions within the case studies are based on 'typical' or 'average' costs so do not reflect any of the characteristics that would affect the cost estimates at a more local level. As such it is likely that the cost estimates used in the case studies are an under-estimate	The methodology developed in this study sets out the framework for an integrated appraisal and can take account of more specific cost estimates. Typical cost estimates could be used in the first instance to identify which actions might be most worthwhile in terms of their benefits to natural capital. The costs could then be refined taking account of the specifics of the catchment
Issues with identifying benefits and dis-benefits of actions		
The Natural England ecosystem service transfer toolkit is a good resource but it needs to be used with care	Some modification of the ecosystem services was required to rationalise the dataset. For example, services were recorded under 'crops, livestock & fish' and under 'crops, livestock, fish'. This was easily amended. Detailed investigation of the toolkit shows that there are some interventions that were shown as not resulting in any benefits (or dis-benefits) across any of the ecosystem services. These gaps were filled based on expert judgement and consideration of similar interventions within the NE toolkit for consistency	There is a need for validation of the benefits and dis-benefits identified for each intervention. This could be done by identifying a set of common actions that may be applied in many catchments and identifying which interventions these are best described by. The benefits and dis-benefits shown by the NE toolkit could then be discussed by experts on the actions and ecosystem services to improve the reliability of the assessment

Table 5-1: Lessons learnt during the study and implications for use of the integrated approach moving forwards		
Issue/problem encountered	**How the issue/problem was addressed**	**Implications for future use of the methodology**
Issues with valuation of benefits		
There is a limited number of relevant ecosystem service benefits transfer values	The benefits inventory provides information on more than 500 benefits transfer values. However, many of these do not relate to the types of ecosystem services or the type of change being considered within the integrated appraisal. The appraisal currently relies heavily on two main sources of valuations: TEEB (the economics of ecosystems and biodiversity) and the UK BAP (Christie et al, 2011). This is because these sources provide values in £/ha/year, which fits with the units used when identifying the extent of measures associated with benefits to ecosystem services on land. These two sources also provide values for total ecosystem service value (TEEB) which fits with 'restore' type actions, or an improvement to current ecosystem services or no deterioration (UK BAP) which fit with the 'improve' and 'maintain' type actions. Gaps remain for noise regulation and pollination as no values were available for these ecosystem services	The TEEB is a meta-analysis so is considered to be a high quality source of benefits transfer values. Likewise the UK BAP study also considers a range of benefits transfer values. There are gaps that remain that have had to be filled using logistic regression so there is an opportunity to improve the robustness of the valuation of benefits to land if specific benefits transfer values become available
Benefits to water bodies cannot be expressed in terms of a change in ecosystem services as almost no benefits transfer values are available	There appear to be almost no values associated with changes to ecosystem services within water bodies. As a result, the benefits to water from each individual action could not be estimated. It was considered that the most reliable approach would be to measure the change in status based on the type of actions that would be implemented under each option and the current status in each water body. This approach enables the NWEBS values to be used when placing a monetary value on the change in water body status	The NWEBS values are considered to be robust values for use when placing a monetary value on a change in water body status. Hence, use of these benefits values should help when explaining the approach to stakeholders

In terms of application of the methodology, the key steps where changes could be made are:

- Identification of actions:
  - Actions should be developed by those who know the catchment, the issues and the stakeholders. The people involved also need to be able to take a catchment-scale approach and to look at how a vision could be developed for the catchment. This will help to ensure that the most effective actions are identified and that those actions will have the potential for implementation on the ground;
- Identification of costs:
  - The need for more detail on the actions to enable these to be modelled and costed more accurately. This could be obtained through dialogue with experts on the catchment and stakeholders and from site visits;
- Identification of benefits:
  - The area of land that will benefit from an action is a key variable in the estimation of the benefits. It could vary much more significantly than the benefits transfer values. Discussion with experts on the actions will be an important step in ensuring that the benefits to ecosystem services are not over-stated;
- Selection of the preferred option:
  - It is essential that stakeholders are involved through the appraisal process to help ensure that the preferred option is deliverable, that the actions are delivered, and that changes are maintained over time. This will require a transparent record of all assumptions made and of the uncertainties feeding into the appraisal such that the robustness of the results can be fully tested;
  - The distributional analysis (who pays and who benefits) can be used as the basis for investigating if there are innovative funding mechanisms that could be used to transfer the costs to the stakeholder(s) that benefit. This could include payments for ecosystem services or approaches that look to incorporate natural capital accounting at the business or even catchment scale; and
  - Consideration of qualitative benefits needs to be undertaken alongside the monetary benefits so a judgement can be made as to whether the qualitative benefits are likely to be sufficiently significant to influence the selection of the preferred option. One way to approach this is to consider whether the non-monetised benefits, as recorded in the ASTs, if valued would be sufficient to increase the BCR so that it would be greater than one (and the NPV so it is greater than £0) or to change which option has the highest BCR or NPV. This will be a judgement based on the descriptions of the qualitative benefits. Further detail could be added to the ASTs, including ratings in terms of direction of change (positive benefits or negative dis-benefits) and perhaps some indication of likely significance as a qualitative rating. These could then provide a more consistent basis for taking the qualitative benefits into account during selection of the preferred option.

Overall, therefore, there are some changes that could be made to the methodology if data gaps are filled. There are also approaches that could be used when applying the methodology that would improve the robustness and reliability of the results and increase the potential that the suggested changes are made on the ground.

Rolling out of the methodology could require significant data and resources, especially if there is considerable involvement of stakeholders and experts. There may be benefit from undertaking an initial assessment in-house in the Environment Agency, drawing on the information from the Stage 1 valuation and any existing catchment partnership work. Assessment of more integrated actions, however, will require a revised starting point such as the development of a vision in the first

instance. This again could be undertaken in-house by the Environment Agency or catchment partners supplemented by GIS analysis to develop the maps showing land use change and to measure the areas required under each action to deliver the required improvements to natural capital on land and in water.

5.3 Value added from an integrated approach

The value of the integrated approach is that it enables more holistic actions at the catchment level to be identified, described and assessed. The case studies show that there is potential for actions that are defined and appraised in this manner to provide a better BCR and higher NPV than through existing appraisal processes, including integrated planning processes.

The assessment of similar actions in the integrated appraisal to those included in the Stage 1 assessment and catchment partnership plan for the Bristol Avon showed that inclusion of the benefits to natural capital in terrestrial environments and the associated ecosystem service benefits provides a stronger economic case for combining actions. The appraisal of a very different set of actions designed to deliver a vision for the catchment in the Wyre case study also showed that the economic case appears to be strong. Again, this is linked to the ability to capture the benefits to terrestrial natural capital within the appraisal.

There are some barriers to uptake of an integrated appraisal, not least the data gaps associated with valuing the benefits. Other barriers identified in this study are associated with the level of detail in the analysis; these could be addressed by involving experts and stakeholders from the catchment during development of the vision and during the appraisal. There would be particular benefits in improving the robustness of the cost estimates and in assessing the likely land areas and water bodies that would benefit. This may be more significant in reducing uncertainties than filling gaps associated with the existing set of benefits transfer values since these may vary by say ±100% whereas the areas and lengths benefiting could vary by several orders of magnitude.

There are also opportunities that could encourage uptake of integrated appraisal. The requirement to align RBMPs and FRMPs could help draw these two approaches together. The integrated appraisal approach developed in this study also builds on the existing integrated planning processes using similar methods, such as for assessing costs or estimating benefits to water. Therefore, the process is not an entirely new one and can build upon existing information and existing expertise.

6 Recommendations and next steps

6.1 Overview

This section focuses on the changes that could be made to existing tools and methodologies to better enable an integrated approach to be implemented. Also included is an assessment of wider changes that are needed (including data availability) to help reduce uncertainty and improve robustness. The recommendations are identified in terms of the time and effort that would be required to provide a plan in terms of next steps.

6.2 Recommendations

The suggested recommendations draw on the discussion on lessons learnt from the study and are intended to address those steps where there is the greatest uncertainty. Table 6-1 presents the recommendations describing what is suggested, how this will address existing uncertainties and the likely resources that would be required. Resource requirements are also assessed in terms of time and cost implications and are rated as low (L) to high (H). In terms of time requirements, low relates to a few weeks; medium to a few months; and high to at least a year. In terms of costs, low relates to up to £10,000; medium relates to up to £50,000; and high relates to costs exceeding £50,000.

Table 6-1: Suggested recommendations and resource requirements

Recommendation	Uncertainty that would be addressed	Resource requirements	Time	Costs
Use Master Map topography series when identifying and mapping actions, especially in urban environments	Lack of precision of actions and the areas over which they are implemented (important for estimation of costs and benefits)	Access to the dataset and processing time from GIS experts	L	L
Identification of whether there are data that would allow mapping of the current status of natural capital and ecosystem services	This would provide a better basis for measuring the benefits of actions on land by providing a similar approach as is used in assessing the change status in water bodies	Some datasets appear to be available that provide some of this information (e.g. opportunity maps) but these need to be explored further at both the local and national levels. This will require research time plus GIS expertise	M	M
Identification of additional benefits transfer values	To fill data gaps for noise regulation and pollination and for other services in terms of magnitude of change (currently restore, improve and maintain but this could change if the status of natural capital can be used as the baseline)	Considerable effort has been put into identifying existing values during development of the benefits inventory. Effort may be required in searching the wider literature and monitoring the economic literature for new values, or through more informal discussions with researchers who may be undertaking valuations in this area	L	L

Table 6-1: Suggested recommendations and resource requirements				
Recommendation	**Uncertainty that would be addressed**	**Resource requirements**	**Time**	**Costs**
Commission of a valuation study to assess the benefits of changes to ecosystem services	To provide a new data set specifically elicited to value the benefits likely to be delivered from integrated appraisal (this could draw on changes from the state of natural capital were such data identified)	This would likely require a contingent valuation study requiring use of specialist researchers	M	H
Review of the NE toolkit with specific reference to the needs of integrated appraisal. It is suggested that this is done by identifying common actions (i.e. those that may be required in many catchments) and mapping these against interventions and then validating the benefits and dis-benefits with experts on the actions and on ecosystem services	This would look to ensure that there is consistency in terms of benefits and dis-benefits identified for actions, thus improving the reliability of the benefit estimates	An approach could be taken to develop an 'actions inventory' identifying the interventions typically included and the ecosystem service benefits and dis-benefits that are delivered. This would require research and input from experts on the actions and from experts on ecosystem services. It could be achieved through a workshop or series of workshops with key experts	L	M
Further exploration of the extent to which recreational benefits may be under-estimated in the current approach	The Wyre case study involves creation of new recreational opportunities but this is not captured within the interventions within the NE as such recreational benefits could be under-estimated	A review is needed of the references included in the NE toolkit that relate to benefits to the ecosystem service of 'environmental setting'. This then needs to be compared against the benefits transfer values that are used to assess whether recreational benefits are already captured or, if not, what additional measures are needed to ensure that recreational benefits can be captured	M	M
Further development of the assessment of qualitative benefits	This would still be judgement based but inclusion of ratings could help improve consistency with which qualitative benefits are taken into account during decision-making	Review of approaches to incorporating qualitative benefits in other appraisal processes and development of definitions of ratings for each ecosystem service based on expert knowledge of the likely range of benefits that could be delivered	L-M	L-M

Table 6-1: Suggested recommendations and resource requirements				
Recommendation	**Uncertainty that would be addressed**	**Resource requirements**	**Time**	**Costs**
Development of a user friendly appraisal spreadsheet	Further development of the spreadsheet created for this study such that it is fully tested for use in other catchments	Input from a spreadsheet expert who could add a data entry/input sheet or simple worksheet interface to allow users to move through the steps of the appraisal more easily. Potential testing of the spreadsheet with a user group	L-M	L-M
Development of a protocol for undertaking integrated appraisal	This would specify who would be involved and how, and so would enable the resource needs to be identified. This would address issues associated with how the methodology should be applied and could help identify the catchments in which the approach may be most beneficial or where the types of actions being proposed would be significantly different with an integrated approach; this could help reduce the need to roll out the methodology across all catchments	The protocol would need to be developed by experts with knowledge of Environment Agency planning and appraisal processes and with local teams. A draft protocol may be needed that is tested in a catchment identifying who needs to be involved in each step and how. The research should be evaluated as it proceeds to enable the benefits of different levels and type of involvement to be identified	M-H	M-H
Identification of potential funding arrangements that could help transfer costs to those who benefit	The extent to which actions might be deliverable on the ground is likely to be affected by whether the stakeholder paying for the action also benefits from it or whether the benefit is felt by another stakeholder	Research to confirm who benefits and how much they benefit based on proportion of monetary benefits received versus proportion of costs paid. This could be undertaken as part of the test catchment, above. Experts in funding mechanisms would also be required to help identify what funding opportunities might be available to enhance uptake of actions	L	L

6.3 Next steps

This study shows that integrated appraisal has the potential to deliver wider benefits to natural capital in a cost-beneficial way. The next steps need to test that the assumptions made during development and application of the appraisal are reliable and that the results produced in the case studies are sufficiently robust to encourage roll-out of an integrated approach more widely. This could require additional research and testing or application of in-house expertise to test the assumptions within the case studies on the Bristol Avon urban and Wyre and the appraisal spreadsheet.

7 References and table of datasets and tools

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Table 7-1: Datasets and tools used in the integrated appraisals

Datasets/tools	Used to	Data/tool owner
Stage 1 assessment and supporting workbooks (e.g. bundles sheets)	Inform baseline/counterfactual on existing measures including costs and benefits	Environment Agency
Flood Risk Management Plan	Inform baseline/counterfactual on existing measures including number of properties at risk	Environment Agency
Medium-term plan	Inform baseline/counterfactual on existing measures including costs and benefits	Environment Agency
Systems Asset Management Plans (SAMPs)	Inform baseline/counterfactual on existing measures including costs and benefits and cost savings	Environment Agency
WFD Cycle 2 - Ecological status classification: Classifications_MC_3005	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Catchment Data Explorer
WFD Cycle 2 – Measures: Measures_MC_3005	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Catchment Data Explorer
WFD Cycle 2 – Reasons for not achieving good: reasons_for_not_achieving _good_MC_3005	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Catchment Data Explorer
WFD Water bodies: WFD_River_Waterbody _Catchments_Cycle2	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
WFD Waterbody Catchments: WFD_River_Canal_SWT _Waterbodies_Cycle2	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Land cover: Land Cover Map 2007, 25 m resolution shapefile	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Licenced to the EA by the Centre for Ecology and Hydrology
Areas benefiting from flood defences: nat_areasbenefit_v201702.shp	Inform baseline/counterfactual on existing measures including number of properties at risk and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Areas to benefit from flood defences: Capital_Schemes_AmberGreen _Poly_14_15.shp Capital_Schemes_AmberGreenPt s_v2013_14.shp Capital_Schemes_RedPts_14_15.shp Recondition_Schemes_14_15.shp	Inform actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Spatial Flood Defences: nat_defences_v201702.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Flood storage areas: nat_fsa_v201702.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk

Table 7-1: Datasets and tools used in the integrated appraisals		
Datasets/tools	**Used to**	**Data/tool owner**
Flood Zone 2: nat_floodzone2_v201702.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Flood Zone 3: nat_floodzone3_v201702.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
River network: WFD_River_Canal_SWT_ Waterbodies_Cycle2	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Catchment Flood risk management policy options: Bristol_Avon_Catchment_Flood_ Management_Plan.pdf Wyre_Catchment_Flood_Management _Plan.pdf	Inform baseline/counterfactual on existing measures including number of properties at risk	Publications gov.uk
Water resource availability: ResourceAvailability_Sept15.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Opportunity mapping for woodland creation: WfW_England.gdb	Inform actions for integrated appraisal	Datasets forestry.gov.uk Provided under licence by the EA
Agricultural land classification: agri_land_class.shp	Inform GIS analysis of baseline/counterfactual and actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Priority habitats: PHI_v2_1_North.shp, PHI_v2_1_Central.shp and PHI_v2_1_South.shp	Inform actions for integrated appraisal	Spatial Data Catalogue, data.gov.uk
Natural England ecosystem services toolkit	Inform assessment of benefits and dis-benefits of actions to ecosystem services	Natural England
Benefits inventory	Identify benefits transfer values for terrestrial ecosystem services	Environment Agency
NWEBS	Identify benefits transfer values for benefits to water	Environment Agency
Nix Farm Management Pocketbook	Identify costs of actions	Agro Business Consultants
Countryside Stewardship payment rates	Identify costs of actions	Gov.uk

Annex 1 Bristol Avon urban case study report

See Bristol Avon - Task 1 report final

Annex 2 Wyre catchment case study report

See Wyre - Task 2 report final

Annex 3 Definition of ecosystem services

Table A3-2: Definition of ecosystem services used in the integrated appraisal	
Ecosystem service	**Definition**
Climate regulation	Carbon accumulates where production of plant litter exceeds decomposition and generally under waterlogged, predominantly anaerobic conditions. The deposition of organic sediments within lakes, ponds and reservoirs is an important component of the carbon budget. Water bodies may also regulate the microclimate including temperature and precipitation. This is because temperature and humidity may be different within the habitat and without. The degree to which this occurs will depend on the size of the habitat. Water bodies can also develop important moist microclimates
Crops, livestock, fish	Grazing by livestock and arable production. Water bodies also support commercially significant fisheries (salmon, trout, crayfish, etc.). Other harvested crops may include: fruit, berries, fungi and nuts
Detoxification & purification in air, soils and water	Ecosystems can dilute, store and detoxify waste products and pollutants. Purification and waste treatment include the decomposition/capture of nutrients and contaminants and the prevention of eutrophication of water bodies
Disease and pest regulation	The role that ecosystems play in mitigating or reducing the impact and propagation of diseases and pests
Environmental settings	Includes waterscapes, landscapes and other areas valued for their beauty or local distinctiveness and the recreational activities that take place within them
Hazard regulation	Protection or mitigation against the adverse effects caused by storms, floods, landslides, etc.
Noise regulation	The role that ecosystems can play to reduce the propagation of noise throughout the landscape
Pollination	The opportunities offered within the ecosystems for pollination and pollinators
Soil quality regulation	The regulation or prevention of negative effects of erosion (such as impoverishing of soil and increased sedimentation of water bodies) by promoting sediment stabilisation and soil retention
Trees, standing vegetation, peat	The amount, diversity, type and structure of the vegetation
Water quality regulation	The potential impacts on water quality within water bodies and the extent to which this can be managed within the ecosystem
Water supply	The influence the ecosystem has on the timing and magnitude of storage and retention of water for domestic, industrial, agricultural and other use by current and future generations
Wild species diversity	The diversity of species and habitats within the ecosystem
Source: Based on Natural England (2015) combined with definitions from the Water Appraisal Guidance, CICES, etc.	

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