W047b B£ST Guidance –

Guidance to assess the benefits of blue and green infrastructure using B£ST

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B£ST Guidance – Guidance to assess the benefits of blue and green infrastructure using B£ST

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Keywords

Sustainable drainage systems (SuDS), natural flood management (NFM), drainage, sewers, SuDS, NFM, multiple benefits, monetary values, blue-green infrastructure (BGI)

Reader interest	Classification	
B£ST is used to assess and monetise many of the financial, social and environmental benefits of blue-green infrastructure. The results enable users to understand and quantify the wider value of drainage and natural flood management measures. This can support investment decisions. Benefits can be used to identify stakeholders and potential funding routes.	**AVAILABILITY**	Unrestricted
	CONTENT	Advice/guidance
	STATUS	Committee-guided
	USERS	Communities, building engineers, civil engineers, drainage engineers, health professionals, highway engineers, ecologists, economists, environmental managers, flood risk managers, landscape architects, spatial planners, consultants, horticulturalists, resilience managers, leaders of adaptation strategies.

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Overview of B£ST Guidance document

This guidance document supports the Benefits Estimation Tool – Valuing the benefits of blue-green infrastructure (B£ST) and is part of the suite of B£ST components. Section 1 of this document provides important background and an introduction to this guidance. Before using B£ST, it is recommended that you read this section.

When applying B£ST, there are four steps to follow. This guidance document is structured around these four steps, which are described here and shown in Figure A below.

1. **Confirm assessment is required and appropriate**
   This is considered in Section 2 of the guidance document. It sets out the reasons for undertaking and key drivers of the assessment. It also helps identify the baseline position and ensures the option(s) to be assessed are suitably understood and specified. *Users should confirm an assessment is required and appropriate before using the tool.*
2. **Screening and qualitative assessment**
   This is considered in Section 3 of the guidance document. It establishes the type, size and scale of the scheme and the temporal and spatial scale of the assessment. It identifies what the likely benefit types will be and provides an indication of their potential significance.
3. **Evaluation of benefits**
   This is considered in Section 4 of the guidance document. This is the main part of the document and supports the assessment of benefits using the tool. It helps to quantify and monetise the most significant benefits of the scheme taking account of scale, location, timing, etc. Non-monetised benefits are also recorded. Jumping between this part of the guidance and the tool is expected.
4. **Summarise and present results**
   This is considered in Section 5 of the guidance document. In this step, the results of the assessment are drawn together across different benefit categories and over time. Sensitivity analysis is also undertaken.

Further detail on how to use this guidance document is provided in Section 1.3. The full structure of the guidance is explained in Section 1.4.

Completing the tool requires input information and data relating to the scheme to be assessed. The more complete and detailed this information and data is, the more robust and comprehensive will be the outputs of the assessment. However, a relatively simple assessment can still be undertaken even if detailed information and modelled outputs are not available (with an allowance for less confidence in the results). Section 1.12 sets out information requirements to complete a benefit assessment.

This version of the guidance supersedes the original (2015) version. The key changes are shown in Table A below.

Table A: Summary of changes to B£ST

2015 version	2019 version
Focused on SuDS measures only	Also includes NFM (natural flood management) and other elements of blue-green infrastructure
Includes evidence up to 2015	Includes evidence up to 2018
Monetary values in 2014 prices	Monetary values in 2017 prices
Includes 19 monetised and 4 non-monetised benefit categories	Following rationalisation and addition of new categories (noise and traffic calming), includes 15 monetised and 3 non-monetised benefit categories
Results presented for ecosystem service and triple bottom line categories	Interactive results dashboard in tool
Detailed information requirements	Information requirements set out more clearly for both simple and detailed assessments

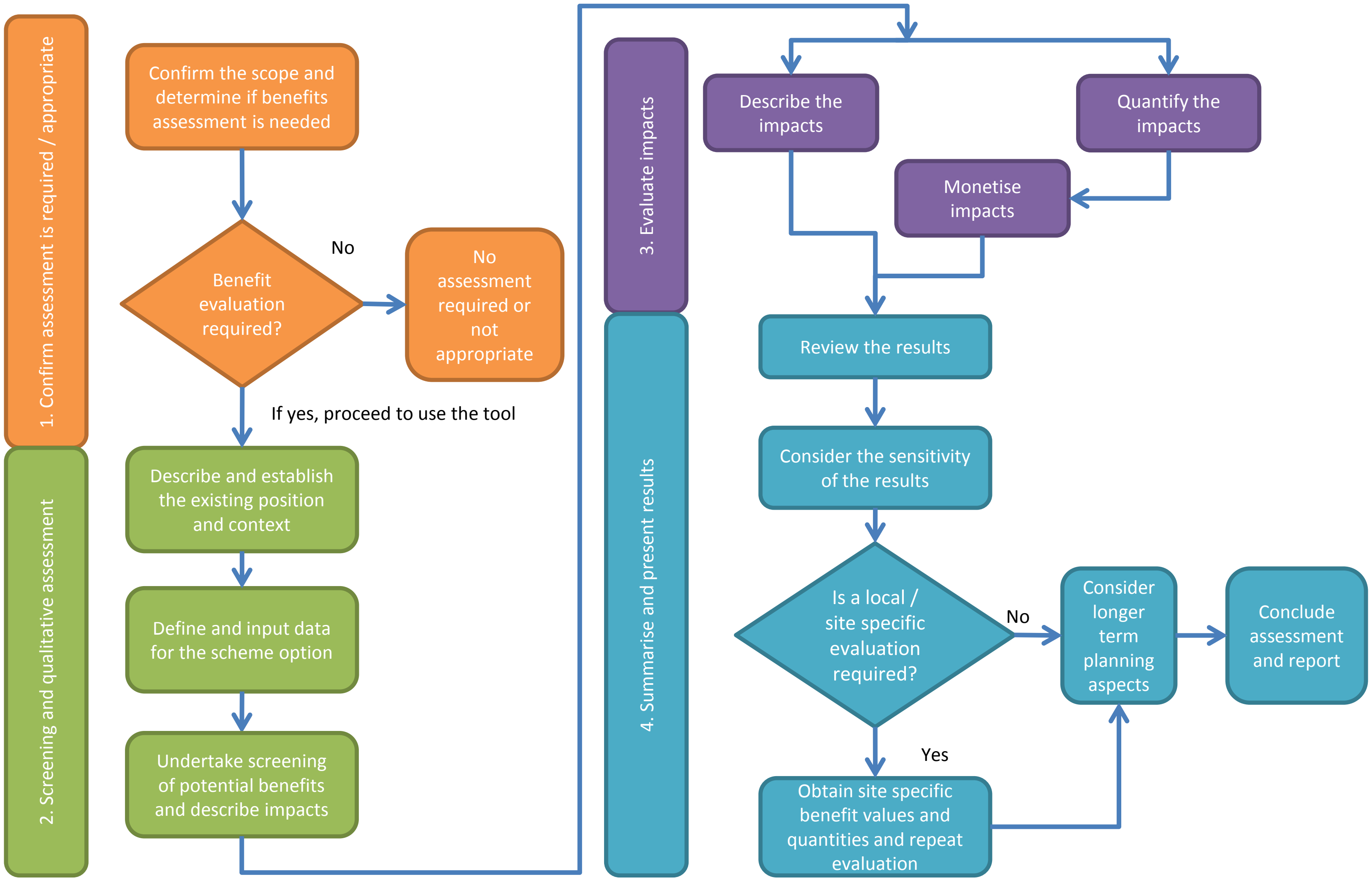

Figure A: Diagrammatic overview of methodology

B£ST: BENEFITS ESTIMATION TOOL – VALUING THE BENEFITS OF BLUE-GREEN INFRASTRUCTURE

Blue-green infrastructure (BGI), including sustainable drainage systems (SuDS) and natural flood management (NFM) consistently provides core fundamental benefits ranging from public health to minimising the chance of flooding. However, some systems can provide far wider and larger benefits. Systems based on NFM and SuDS provide the benefits expected from a conventional, piped approach as well as many others. This is possible because SuDS and NFM invariably enhance the area being developed and contribute to economic development and environmental quality.

Stakeholders are increasingly collaborating to design and build drainage systems within urban or rural improvements. Questions are often asked about the benefits BGI solutions may bring, their size and their value. Understanding these benefits can help to identify interested stakeholders and encourage a partnership approach to funding schemes.

Benefit category	Monetised
Amenity	✓
Asset performance	✓
Biodiversity and ecology	✓
Building temperature	✓
Carbon reduction and sequestration	✓
Crime	×
Economic growth	×
Education	✓
Enabling development	✓
Flooding	✓
Health	✓
Noise	✓
Recreation	✓
Tourism	×
Traffic calming	✓
Water quality	✓
Water quantity	✓

CIRIA has developed a tool and guidance, W047 B£ST to support practitioners to estimate the benefits that BGI can create. Evaluating the type and magnitude of these benefits can otherwise be difficult, often requiring specialist economic inputs.

B£ST provides a structured approach to evaluating a wide range of benefits (in the table right), often based upon the system performance overall. It follows a simple structure, commencing with a screening and qualitative assessment to identify the benefits to evaluate further. Where feasible, it provides support to help quantify and monetise the benefit.

The tool creates summary tables presented under the Ecosystem Services (ESS) framework. It automatically generates a series of graphs for use in reports. An Option Comparison Tool enables data from more than one 'simulation' of B£ST to be copied and compared with the overall net present cost, benefit and value. A 'coarse assessment' sheet is also included in the tool to enable a high-level indication of the potential range of benefits provided by a scheme to be provided quickly and with a limited set of input information. This can help to focus attention on those benefits likely to be of most significance in an analysis and minimise the need to collect and input data about benefits that are likely to be little significance.

The three components of W047 B£ST

W047a B£ST: Benefits Estimation Tool – Valuing the benefits of blue-green infrastructure

W047b B£ST: Guidance – Guidance to assess the benefits of blue and green infrastructure using B£ST

W047c B£ST: Comparison Tool – Enables the comparison of more than one assessment

Figure B shows how the guidance links with the other components of B£ST.

B£ST guidance content	What	Benefits Estimation Tool	Comparison Tool	Suggested audience
1. Introduction	About evaluating benefits	✘	✘	Decision makers, clients, practitioners
2. When an assessment is required	Start using the tool	✓	✘	Clients, practitioners
3. Screening and qualitative assessment	Screen the impacts	✓	✘	Practitioners
4. Evaluating benefits	Evaluate the benefits	✓	✘	Practitioners
5. Summarising and presenting results	Present the results	✓	✓	Practitioners
6. Considering uncertainty and applying sensitivity	Consider sensitivity	✓	✘	Practitioners
7. Using the results	Using and comparing the results	✘	✘	Decision makers, clients, practitioners
8. Using B£ST to support longer term planning	Longer term planning	✓	✓	Decision makers, clients, practitioners

Figure B: How the guidance relates to the other components of B£ST

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PURPOSE OF THE B£ST GUIDANCE

Blue-green infrastructure (BGI), including sustainable drainage systems (SuDS) and natural flood management (NFM) provides a wide range of benefits to society and the environment. Considering these benefits and valuing them often shows that they outweigh their costs or provide greater overall value than a conventional, piped solution. A key challenge in the UK is that the benefits of BGI are not well understood or explained. Benefits typically accrue because of the overall scheme rather than just individual components. B£ST is the first UK tool to help estimate the benefits of BGI by calculating a monetary value.

There are three parts to B£ST:

- **W047a B£ST –** Benefits Estimation Tool – Valuing the benefits of blue-green infrastructure (referred in the guidance as 'the tool' or B£ST). *A structured spreadsheet tool that estimates a wide range of benefits linked with BGI based upon the values and decisions made by the user;*
- **W047b B£ST** Guidance – Guidance to assess the benefits of blue and green infrastructure using B£ST (this document). *Provides background to the tool, data, and how to complete an assessment.*
- **W047c B£ST** Comparison Tool – *A summary spreadsheet that creates graphs and compares options where more than one option is 'run' through the Estimation tool.*

Any decision means considering the pros and cons associated with different courses of action. Decision makers must use the best evidence available to them, recognising that information will never be complete or perfect, and that we live in a world of uncertainty. Many decisions, including those around drainage or flood management infrastructure, have impacts for which there are no readily observable markets or price information. This results in overlooking these (typically social and environmental) impacts and implicitly assigning a zero value. Therefore, the impacts of interventions on these areas (positive or negative) are subsequently excluded from the decision-making process.

The purpose of this guidance is to support clients, decision makers and practitioners in using and interpreting the B£ST evaluation tool to help capture and consider a wide range of benefits related to BGI (financial, social and environmental) in decision making around drainage infrastructure investments. Of course, decisions should, and will also take into account other relevant factors, such as equity and political considerations.

Note that, whilst B£ST is designed to cover the most important social and environmental impacts associated with BGI interventions, it is unlikely to cover every potential impact in every possible situation. Separate guidance is available and may be suitable for identifying and assessing impacts that are not covered here. For example, IAIA (2015) encompasses social impacts such as culture, community and political systems, whilst the HACT Social Value Calculator (https://www.hact.org.uk/value-calculator) enables many of these to be valued.

This document provides detailed guidance to refer to when using the tool, including information needed to complete a benefit assessment, select values and avoid double counting. It is important to note that B£ST does not provide design guidance, nor does it model the physical performance of BGI measures. For SuDS design support, refer to C753 The SuDS Manual (Woods-Ballard et al, 2015). For NFM, refer to the Working with Natural Processes Evidence Directory (Environment Agency, 2018c).

The tool provides users with a practical means of assessing and, where feasible, valuing multiple benefits. It can therefore support broader decision-making tools such as cost-benefit analysis (CBA) and is aimed at all those involved in planning, appraising, designing, funding, selecting and implementing BGI in the UK. This includes communities, environmental bodies, water and sewerage companies, local authorities, land use managers, urban designers, regulators and developers.

When using B£ST, it is advisable to read and refer to this guidance before and whilst assessing the benefits of BGI.

1 AN INTRODUCTION TO ASSESSING THE BENEFITS OF BGI

1.1 Background to the guidance

Blue-green infrastructure (BGI) and other nature-based approaches to water management, including sustainable drainage systems (SuDS) and natural flood management (NFM), described in Boxes 1-1 and 1-2, are multi-beneficial. They can attenuate and treat surface water, reducing the risks of flooding and pollution downstream. They can provide an attractive environment that people value, support the economy and directly benefit wildlife. They deliver multiple ecosystem services and contribute to Natural Capital. Additionally, they provide a flexible infrastructure which is better suited to adaptation at lower overall cost to future uncertainties (such as climate change) than conventional systems. BGI has the ability to deliver these multiple benefits and others (e.g. Ashley et al, 2018).

These benefits mean the provision of BGI in new development and retrofit situations is increasing. However, a key barrier to such approaches becoming mainstream is an apparent or perceived lack of robust evidence to support a business case for implementation and supporting tools to help complete an initial evaluation of the benefits efficiently.

Box 1-1 Sustainable drainage systems

Sustainable drainage is a progression from the practice of draining sites using subsurface pipe and storage systems only conveying runoff below ground up to a fixed design capacity and controlling the rates of runoff discharged into receiving waterbodies. The SuDS philosophy has developed out of recognition that these conventional approaches have not protected waterbodies from degradation and also that runoff and surface water can itself provide society with a vital resource.

The SuDS approach uses natural hydrology as the baseline position against which system performance is evaluated. SuDS aim to manage rainfall close to where it falls (at source); slow and attenuate runoff before it enters receiving waterbodies; allow water to soak into the ground and replenish soil moisture and groundwater levels; promote evapotranspiration; and filter and cleanse runoff of contaminants washed from the land surface. In many cases implementing drainage components that are on the surface (i.e. above ground), and will often incorporate vegetation and surrounding planting, as well as proprietary products will facilitate the delivery of SuDS.

B£ST was developed to overcome this. Working with a representative project steering group including a range of water related stakeholders and disciplines (such as landscape architects, ecologists, drainage engineers) to develop and test the guidance and tool.

Box 1-2 Natural Flood management

Natural Flood Management (NFM) is defined (SEPA, 2015) as (it): “involves techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters.” This aims at Working with Natural Processes (WWNP), defined (EA, 2017) as: “aims to protect, restore and emulate the natural functions of catchments, floodplains, rivers and the coast.” NFM is therefore an interchangeable term alongside and meaning the same as WWNP in the context of flood management. Many SuDS are the same as or equivalent to the measures used for NFM, in seeking to work with natural processes in protecting and restoring the natural functions of catchments.

NFM sets out to utilise and where necessary enhance naturally occurring land and other features in order to reduce the runoff from land surfaces, encourage interception and plant uptake, store or temporarily slow down flows and restore natural functionality to watercourses and ecological systems.

1.2 Aim of B£ST and supporting guidance

This guidance document and accompanying tool will help users to:

1. Undertake a more robust economic appraisal for different drainage and flood management options, supporting decision making for different stakeholders;
2. Adopt a robust, standard approach to assessing the benefits of BGI that is consistent with broader (e.g.

government) economic appraisal guidance and open to scrutiny, thus increasing support from partner organisations;

3. Share information and improve engagement with the widest range of interested stakeholders;
4. Enhance transparency of benefits associated with BGI, increasing potential for partnership working and shared funding opportunities; and
5. Improve understanding of who benefits and hence who may implement, manage, maintain and pay for BGI based drainage and NFM improvements.

1.3 How to use the guidance

This guidance provides knowledge and information to support the user to complete an evaluation using B£ST following a four-stage methodology (Figure 1-1).

Section 1 of this guidance provides an overview of the tool and its development. Sections 2 and 3 provide guidance for completing the first stages of the tool before detailed consideration of selected benefits. It is important to be familiar with these first three sections. Section 4 provides support behind each benefit in the tool. Use these as a resource as and when completing the applicable benefit sheet in B£ST. Sections 5 to 7 provide supporting information for use after completing the assessment of individual benefits.

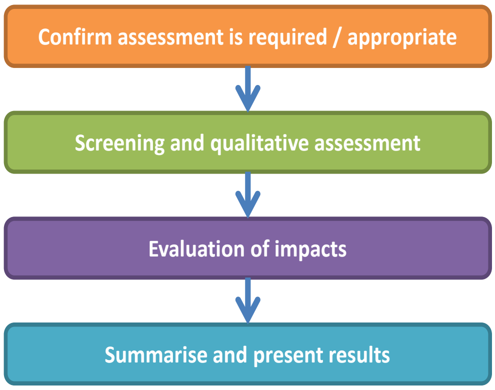


Figure 1-1 Summary of the tool's four stage methodology

This guidance document directly supports B£ST. A short 'User Guide' is provided separately to accompany the tool. However, there are some important points to consider before using the tool to assess the benefits of BGI.

1. A degree of **site-specific information is required** (section 1.9) to complete the tool. The outputs are obviously dependent on the inputs provided, so the more data gathering, monitoring and modelling that have been done, the more robust will be the results.

2. **Apply the tool as early in the decision-making process as possible**. This is most likely to be during the options appraisal stage, whilst opportunities to collaborate and incorporate BGI still exist and before decisions on whether SuDS, NFM, other types of BGI, conventional drainage or flood management approaches, or some combination is preferred. It may be that information and data needed to complete the assessment is not available or very limited at the options appraisal stage. In this case, the best approach may be to undertake an initial high-level screening (with assumptions), followed by a fuller, more detailed assessment. Understand whether long-term planning / scenario assessment forms part of the decision-making process.

3. **Apply the tool at the largest possible spatial level**. Although it is possible to apply the tool at a scheme level (e.g. an individual development or a single street), many of the benefits (e.g. water quality, carbon) will only be realised as scale becomes more significant. Therefore, it is preferable to aggregate individual groups of BGI components or schemes into a broader programme of work, since this is likely to deliver proportionately greater benefits than individual BGI components. When the scheme is small, also consider the impact relative to the scale of investment, since a good business case for a scheme with limited benefits can still be made if the costs of the scheme are similarly small. Further detail on scale is provided in Section 2.4.

4. **Consider the baseline position and the proposed option(s) to assess**. In any economic assessment, it is crucial to understand what the situation would be in the absence of an intervention (BGI or other), since it is the benefit of the intervention *over and above this situation* that needs to be assessed. In a retrofit situation, this is about comparing the option with the existing location and comparing the performance of a proposed option with what happens currently (the baseline).. In new development, this is about comparing the performance (in its widest sense) of a BGI option typically with a conventional drainage or flood management option. Where there are multiple options, run the tool more than once to compare them (e.g. SuDS or

pipes only; NFM or embanked watercourses). Section 2.3 provides further guidance on identifying and specifying the baseline position and the option(s) to assess.

5. **Be transparent**. The tool is not a 'black box' and we have provided information to support assumptions made and added references where appropriate. Transparency is therefore an important aspect of the tool in order to provide an audit trail and to build trust with stakeholders in understanding the results. Discussions with stakeholders may be useful during completion of the assessment and the results of these can be noted within the tool. The tool encourages recording any assumptions made and the confidence in both the information provided and the outputs.

6. Whilst the tool can, with appropriate input information, provide indicative values of the benefits of BGI, **it allows the use of site-specific, locally derived values,** for example, from visitor surveys, local charges or water company willingness to pay (WTP) surveys. It is possible to add in these values in the 'values library' that accompanies the tool, and which includes full details of all the valuation evidence used. In general, locally derived and site-specific quantities and values will provide a more accurate and robust assessment.

1.4 Structure of the guidance

Section 1: **Introduction** - This provides context and introduces the guidance and tool. It includes guidance on when to apply the tool, an overview of the methodology, how we have taken account of uncertainty, some guidance on double counting, an overview of how to use the guidance and sets out information requirements.

Section 2: **When is an assessment required** - relates to the decision-making process and encourages a review of the context of the BGI scheme to ensure that an assessment using B£ST is needed and appropriate.

Section 3: **Screening and qualitative assessment of benefits -** helps to screen the benefit categories to ensure a focused assessment on those areas where significant benefits are likely to occur. This helps to complete a qualitative assessment.

Section 4: **Evaluating the benefits –** is a key part of the guidance since it helps to quantify and value those benefits of most significance. It provides background to the sources of information, how to assess the impact and choosing appropriate confidence scores.

Section 5: **Summarising and presenting the results –** provides guidance on summarising and presenting the results.

Section 6: **Considering uncertainty and applying sensitivity analysis -** helps to identify key areas of uncertainty in the assessment and undertake appropriate sensitivity analysis.

Section 7: **Using the results -** provides guidance on using the results to inform and support decision-making.

Section 8 – **Supporting long term planning** – outlines how to consider the robustness of an option(s) when considering future uncertainties.

1.5 When to apply and use B£ST

There may be many reasons for wanting to demonstrate the benefits of BGI. Even where measures such as SuDS or NFM are a mandatory requirement or are clearly cheaper (lower cost) compared with the alternative (e.g. conventional solution), B£ST can still be used to compare the benefits from different types of interventions. The tool is designed to assess and capture additional benefits (i.e. those over and above the current situation, what would have happened anyway or the alternative). The results can support a business case for investment, and conversations with key stakeholders about the potential for collaborative approaches and funding projects in partnership, including grant-in-aid (GiA) funding applications where national economic benefits are provided. Further detail on working with stakeholders is provided in Section 3.2, and specific guidance on the links between B£ST and flood management GiA assessments is provided in Section 4.1.9.

The tool considers the outcomes resulting from the overall design, rather than the performance of, individual measures, in particular those related to flooding and water quality. Here the performance of the overall drainage design is important due to the interactions between different components (whether SuDS/NFM or conventional). C753 The SuDS Manual (Woods-Ballard et al, 2015) provides support to help design SuDS, whilst Environment Agency, (2017c, 2017d) and West Country Rivers Trust (2016) provide more detail for valuing NFM.

The tool includes a '**Coarse assessment**' sheet. This allows a high-level assessment of ten of the most significant benefits associated with BGI to be undertaken quickly and with very limited input information. As such, it can only provide a very broad indication of the range of potential benefits from any given BGI scheme and should not replace a full assessment. It is based on a number of key questions, responses to which are linked to quantified variables and monetary estimates that are combined to produce an overall value in each of the ten benefit categories. Appropriate confidence scores (see Section 1.10) and a discount rate (see Section 4.6) are applied to a default assessment period of 40 years (see Section 4.4) to produce a total benefit estimate. A simple results dashboard is included in this part of tool and comments can be recorded, e.g. about what decisions have been made and why. Appendix C contains further detail of the assumptions that underpin the 'Coarse Assessment sheet'.

1.6 Where to apply and use B£ST

B£ST can be applied at differing stages of the BGI design and planning process, from strategic assessment to optioneering and implementation. However, its usefulness and effectiveness will be greater the earlier in the decision-making process it is applied. The reason for this is that, once strategic planning or design decisions have been made, the type of option (decision alternatives) to assess and compare becomes more limited, as do the opportunities for collaboration, partnership funding and innovation (see Box 1-2).

When applying the tool, it is likely that larger schemes (either geographically or those with the most BGI components) will lead to the greatest benefits. Smaller schemes (e.g. street level or along one stream) will generally deliver limited benefits (although it is still appropriate to assess such schemes as they may be beneficial if the costs are also small). However, whilst the benefits from small schemes may be small, they may contribute to a larger set of benefits in the longer term as other schemes take place. In such situations, it may still be worth quantifying, valuing and aggregating relevant benefits. Generally, the level of effort used to complete the tool should be proportionate to the size and expected outcome of the scheme.

Box 1-2 Options and schemes

An option is defined here as an alternative for meeting a set requirement. A scheme is a confirmed way of meeting the requirement and may consist of one or several options.

Even a complete assessment using B£ST can only provide an *indication* of the likely benefits associated with a BGI scheme. Where planning significant investment, or where a decision may be contentious, consider completing locally specific, bespoke analysis and surveys. Sections 5 and 7 provide further guidance on interpreting and using the results from an assessment.

When using the tool, the number of assumptions to make will depend upon when it is applied in the design process, the availability of information and the confidence in this information. If the hydraulic performance of the design is unknown and there is little knowledge of the site, then the assumptions made and the values obtained from the tool will be of limited value (although this can be accounted for through the use of confidence scores). Completing hydraulic designs along with landscape character and aesthetic assessments will enable a more robust estimation of the benefits.

Understanding of, and evidence relating to, the value of BGI are constantly evolving. Therefore, B£ST will be periodically updated (e.g. as new valuation evidence emerges). Latest versions are available from the susdrain website (https://www.susdrain.org/resources/best.html).

1.7 Who should use the tool?

Users who complete the assessment may include those undertaking the design (for example drainage designers or landscape architects) or those wishing to make decisions based on an understanding of the economics of BGI compared with a conventional approach (for example local authorities or other organisations looking to approve SuDS). This primarily includes those who are involved with or leading the drainage design and is likely to form part of a multi-disciplinary process involving:

- Drainage engineers
- BGI designers / practitioners
- Master planners
- Flood risk managers
- Landscape architects
- Ecologists
- Engineers
- Economists
- Planners
- Communities

Practitioners using the tool do not need to be experts in each benefit area. This guidance and the user manual provide support to complete an initial assessment. However, where assessed benefits are significant, further evidence may be required. This may require support from practitioners working within specific disciplines related to BGI design and resultant benefits.

1.8 What the tool can and cannot do?

The output from the tool will give an initial evaluation of the wider benefits of BGI over a specified period. Where a more detailed understanding of benefits is important, use the tool to indicate which ones require more detailed assessment, using more specific information.

The tool enables the comparison of different options whether using BGI, conventional drainage/flood management or any base case. Apply the tool in the context of a new development or retrofit where:

- New development enables a conventional drainage or flood management design to be compared with a BGI design of similar scope and purpose (see Box 1-3).
- Redevelopment / retrofit enables a base case (existing) to be compared with the benefits that may arise from a BGI design or strategy.

Box 1-3 Selecting benefits

Carefully consider the benefits to assess, as some conventionally drained sites may still have other above ground non-drainage components and design (e.g. trees, parks), that may provide similar benefits to BGI but were not designed to intercept and manage water in the same way. Only those benefits (or that proportion of benefits) that can be confidently attributed to BGI should be included in the assessment.

The tool enables one comparison with the "base case" at a time. For example, to assess two different retrofit SuDS strategies, 'run' the tool twice to see the change in potential benefits compared with the existing base case. This clearly requires a degree of effort to develop or acquire information to inform the base case and support the subsequent assessment. Different options or strategies can then be compared using the Comparison Tool (W047c).

The tool requires the user to have knowledge of the location and the options and assumes that the BGI design and performance is appropriate for what is required or stipulated. CIRIA's SuDS Manual (Woods-Ballard et al, 2015) provides guidance to support the design of SuDS, whilst Environment Agency, (2018c) covers NFM, along with a toolbox for NFM design. The tool requires the user to think and consider how to apply their specific design proposals and location within the tool. This along with understanding the tool functionality and guidance enables the user to apply it to a wide number of cases. Table 1-1 summarises what the tool and guidance can and cannot do.

1.9 Overview of the methodology supporting the tool

Previous work (Ashley et al, 2013) explores the multiple benefits potentially offered by SuDS and Environment Agency (2018c) considers the specific benefits for NFM. Stakeholder engagement undertaken in developing and revising the tool has supported a focus on those benefits likely to be of greatest significance.

As a result of this process, the tool includes an approach to organising the benefits covered in the tool that is broadly in line with the 'ecosystem services' (ESS) framework widely used for systematically understanding and assessing how changes in the environment affect people (see for example European Commission, 2013). Future development of the tool will enable the results of an assessment to specifically support approaches based on natural capital accounting, the process of calculating the total stocks and flows of natural resources and services in a given ecosystem or area (see for example ONS, 2017). It will also take more explicit account of spatial variability in benefits (see Section 1.10).

Ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living (UK NEA, 2011). They are generally split into four categories:

- **Provisioning services** – goods or products that people consume or are used in the production of other goods. Examples include crops, fruits, fibre, timber, fish, natural medicine;
- **Regulating services** – benefits derived as a result of an ecosystem control of natural processes such as air quality maintenance, water quality and flows, pollination, flood protection, climate regulation and erosion control;
- **Cultural services** – non-material benefits such as recreation, spiritual values and aesthetic enjoyment; and
- **Supporting services** – natural processes that maintain the production of all other ecosystem services such as habitat provision, nutrient cycling, soil formation and water cycling.

Table 1-1 At-a-glance summary of what the tool and guidance can and cannot do

Can do	Can't do
✓ **Play a valuable role as a decision support tool - informing decision makers of the potential benefits of different courses of action**	× Account for every individual site-specific nuance or context. It requires the user to think how to enter their site or catchment information into the tool.
✓ **Estimate monetary value of benefits based upon information provided by the user**	× Estimate the benefits without user input to translate the context of the scheme into the framework of the tool
✓ **For new development compare the benefits of a BGI option with a conventionally drained option**	× Provide great accuracy without local evaluation or similar scoping studies being undertaken
✓ **For retrofit compare an option against the existing baseline position**	× Indicate benefits without some form of drainage or flood management design and performance assessment
✓ **Provide support to help evaluate some benefits in a simplified manner**	× Be a design tool or decision-making tool and say which BGI measures to use and how chosen option will specifically perform
✓ **Investigate the impact of uncertainty in the values being used and applied**	× Provide a detailed distributional analysis of benefits
✓ **Provide summaries, graphs and comparisons (if more than one option considered)**	× Guarantee that the benefits indicated by the tool will be delivered in practice
✓ **Provide an indication of the kinds of benefits that are likely to occur from a given drainage or flood management scheme**	× Guarantee that beneficiaries will want to (or are able to) support funding of BGI
✓ **Provide an indication of which groups may benefit from a given drainage or flood management scheme**	× Determine the costs (capital, operational, whole-life) of the BGI scheme
✓ **Suggest where more detailed analysis or assessment of impacts may be needed**	× Eliminate any potential overlap between different benefits
✓ **Produce simple dataset and graphics to substantiate output information**	× Provide a full life-cycle assessment of all potential drainage or flood management solutions
✓ **Support discussions with partners and potential funders, including grant-in-aid applications**	× Guarantee that benefits assessed will lead directly to additional funding

Table 1-2 shows the benefit categories in the tool, what the benefit covers, and if it can be monetised, along with the ecosystem service category to which the benefits predominantly relate.

BGI may deliver other benefits that are not included here. Currently, B£ST only includes benefit categories where there is a reasonable amount of evidence and data relating them to BGI. The tool does however allow other benefits to be added in (using 'user defined' benefit categories or directly in the values library for impacts included) and additional categories may be included in future versions of B£ST if and when sufficient evidence becomes available.

Whilst most impacts of BGI will be positive (i.e. benefits), some (e.g. noise and disruption caused by construction and maintenance) may be negative (i.e. costs). Such negative benefits can be captured in the tool. They can be considered as 'non-financial costs' and are separate from 'financial costs', which are discussed in Section 5.3.1 and which should be added to the 'Project data' sheet of the tool.

Before assessing and valuing the benefits of BGI, it is important to understand the links between different SuDS components (or groups of components) and each benefit category. A series of impact pathways developed following government guidance (Defra, 2007a), set out these links to allow users to develop quantitative estimates of benefits in each category of relevance to a BGI scheme.

Figure 1-2 illustrates the impact pathway approach linking ecosystems and the provision of services and how these services contribute to human welfare in in the case of BGI.

Figure 1-2 Overview of impact pathway approach (source: adapted from Defra, 2007a)

The tool uses a tiered approach to assess benefits, ensuring that the effort and resources needed to complete an assessment is proportionate to the nature of the decision required (see Section 2.1) and the scale of expected benefits. In practice, this means screening benefits at an early stage to assess only those likely to generate significant benefits in detail.

Economists have derived different ways of seeking to value the impacts of interventions on human welfare where no readily available market data exists (see for example Defra, 2007a). Monetary valuation of benefits in B£ST is based on a range of market and non-market approaches using best available evidence. The main valuation approach adopted is that of adjusted 'value transfer'. This is a widely recognised, cost-effective method for taking values from existing studies (including Willingness to pay (WTP) type studies, see Box 1-4) and applying them, generally adjusted for different circumstances, characteristics, inflation, etc., to a new study site.

Box 1-4: Water company Willingness to Pay (WTP) studies

Water companies regularly undertake WTP studies to inform investment planning for price reviews. The results could potentially be used for valuing some of the benefits of BGI and are cited as potential sources of value estimates for several categories. There are some important issues to be aware of when using water company studies though as the resultant valuations are more specific to the circumstances in which they were derived than other values (eftec, 2014). They apply to customers in the water company's region, so take care when applying to different populations. They are generally for water company-specific measures that water companies can only deliver. They typically assess WTP for a general improvement for example, in freshwater environments rather than for a specific improvement in a catchment. Nevertheless, given the important role of water companies in promoting and delivering BGI, it is important that values derived from company WTP surveys are not excluded from consideration.

Government guidelines set out steps for the use of value transfer in appraisal (eftec, 2009). The guidelines include criteria for selecting appropriate valuation evidence and applying this to a study site. In summary, the original and the study site should be similar in terms of:

i. The good (benefit) or goods being valued (e.g. physical characteristics and the types of value derived);
ii. The change in the provision of the good (e.g. nature, direction, timing, scale);
iii. Location (e.g. proximity to populations and substitutes/complements);
iv. The affected populations (e.g. type of user, socio-economic characteristics);
v. Number and quality of substitutes; and
vi. Market constructs (e.g. property rights, institutional and social context).

The guidelines recognize that these criteria will rarely be fully satisfied and information on many of the criteria (e.g. substitutes) may not be available in an original study. They therefore propose that many differences between the original site and the proposed study site can be accounted for using the adjusted transfer approach adopted here

A review assessed over 500 values from more than 100 existing valuation studies of potential relevance to SuDS in the UK, screening against the criteria described above. The original literature review completed as part of this project (Ashley et al, 2013) provides further detail on sources of values (e.g. www.evri.ca) as does the evidence review undertaken for NFM (Environment Agency, 2018c). Accompanying the original literature review is a separate 'review of sources' that includes details of the monetary evidence reviewed (www.susdrain.org/resources/best). Whilst many of these sources are not appropriate for inclusion in the tool (e.g. because of age of the study, location or context), the process produced a dataset of relevant and transferable values covering each benefit category and for a variety of different contexts.

The original review undertaken in 2013 was subsequently updated in 2018, when more than 100 further studies relevant to BGI were assessed. A summary of this and an updated spreadsheet are available from susdrain.

The 'Values Library' in the tool contains details of, and references to, values assessed as appropriate to use. Most benefits can also add a 'user-defined' value in this worksheet. Wherever possible, the values contain a low, central and high estimate, although where this information is not available, it is highlighted as *not defined*. Section 4 of this guidance includes details of the values recommended and how they should be used. In each category, select only one value (low and high values from the same source can be used in more detailed sensitivity analysis (see Section 6.3) where available).

In short, the approach to valuation adopted in the tool is in line with good practice, as well as with government appraisal guidance (HM Treasury, 2018) and consistent with other approaches in the water sector (Environment Agency, 2013b).

'Value' is defined in economic assessments as the amount of benefit that is derived from a change (improvement or reduction) in a given good or service, aggregated over the relevant beneficiary population. It is generally calculated by determining the maximum amount of money an individual is willing and able to pay for the good or service. It is not necessarily the same as market price, which is the price that is actually paid, although price is often used as an indicator of value for market goods.

Measuring economic value (see Box 1-5) is difficult and requires information on the demand for a good or service. In addition, economic value should exclude transfer payments (e.g. subsidies), which are simply transfer money between one group and another. Values should also take account of age, wear and tear, etc., rather than be based simply on current market prices for replacement. We have sought to ensure that, as far as possible, the values we have selected for inclusion in the tool are consistent with these principles of economic valuation.

Once benefits have been assessed in all categories, they can be aggregated. To ensure consistency in the monetised benefits assessed, those occurring in the future should be discounted. Discounting is based on the principle that more importance is placed on benefits that occur now than those that arise in the future, although be aware that many benefits from BGI may arise over time (Box 1-6). Note that inflation related to future benefits can be ignored, since in economic appraisal the valuation of costs or benefits should be expressed in 'real terms' or 'constant prices' (i.e. at 'today's' price level) (HM Treasury, 2018).

Box 1-5 Economic or financial benefits?

Economic and financial analyses have similar features, in that both seek to measure the impacts (benefits and costs) of a (drainage or flood management) scheme. The key difference is that financial analysis includes only the costs and benefits to specific organisations (internal impacts), whilst economic analysis considers the costs and benefits to the wider economy or to society as a whole (external impacts). Wherever possible, the benefit categories considered in B£ST are based on economic analysis. Even where this is not possible (e.g. pumping wastewater), any external impacts (e.g. carbon) are still explicitly considered and included. This means that B£ST is able to provide a societal perspective, incorporating impacts that affect the welfare of all those impacted by BGI schemes.

Table 1-2 Benefit categories included in the tool

Benefit category	What it covers	Ability* to monetise?	Ecosystem service category
Air quality	Impact on health from air pollution	✓	Regulating
Amenity	Attractiveness and desirability of area	✓	Cultural
Asset performance	Reduced flows to works and volume to treat from combined systems	✓	Provisioning
Biodiversity and ecology	Sites of ecological value	✓	Supporting
Building temperature	Cooling (summer) or insulation (winter)	✓	Regulating
Carbon reduction and sequestration	Operational (reduced energy use), embodied (reduced water use), sequestration (planting)	✓	Regulating
Crime	Crimes against property or people	×	Provisioning/ Cultural
Economic growth	Business, jobs, productivity	×	Provisioning
Education	Enhanced educational opportunities	✓	Cultural
Enabling development	Headroom for housing/other growth	✓	Provisioning
Flooding	Damage to property/ people	✓	Regulating/ Cultural
Health	Physical, emotional, mental health benefits from recreation and aesthetics	✓	Cultural
Noise	Attenuation of traffic-related noise	✓	Cultural
Recreation	Involvement in specific recreational activities	✓	Cultural
Tourism	Attractiveness of tourist sites	×	Provisioning
Traffic calming	Risk of road accidents or street-based recreation opportunities	×	Cultural
Water quality	Surface water quality improvements to aesthetics, health, biodiversity, etc.	✓	Regulating/ Cultural
Water quantity	Groundwater recharge, rainwater harvesting and improvements to flow	✓	Provisioning/ Regulating

* Note that B£ST enables the user to enter a lump sum or present value if information becomes available or a detailed study is undertaken for the benefits marked with a cross in this column.

Box 1-6 When benefits accrue

Some benefits from BGI are likely to be immediate, whilst others may accrue only after a certain amount of time. In addition, benefits may have different 'profiles', i.e. how they increase or decrease over time. These timing aspects, and how they are accounted for in B£ST, are discussed further in Section 4.4.

For all public policy related economic appraisals, use the standard discount rate set by the Treasury. Currently, this is 3.5%. For long-term projects (over 30 years), the discount rate actually declines gradually. The user can adapt the tool to allow for this in the 'Present Value Calcs' sheet, as outlined in HM Treasury (2018). The discount rate applicable in the private sector, however, may be different. In the water sector, the 'weighted average cost of capital' (WACC) is set by the financial regulator and water companies will apply this in developing their future investment plans. The WACC is used to calculate the revenue required by companies to provide a return to investors. The level of the WACC has a large effect on customer bills (a 1% change in the WACC would change bills by around £20 a year per customer).

There are some important implications of discounting in the analysis of environmental and social benefits. The higher the discount rate used, the lower the importance placed on future costs and benefits. At any positive discount rate, benefits that accrue more than 50 years into the future will have a very small present value. At a rate of 3.5%, benefits occurring in 25 years will have only 42% of the value of those occurring today. Hence, schemes with benefits occurring well into the future are less likely to be favoured than those with near-term benefits.

The decision rules used in economic appraisal are based on the concept of economic efficiency. A proposed action is deemed cost beneficial or to provide efficient allocation of resources (and is therefore justified) if the discounted benefits of the action are greater than the discounted costs. When comparing costs and benefits, consider including those benefits valued in economic terms and those assessed in qualitative or other quantitative terms. The most commonly used decision criteria in economic analysis are:

- ***Net Present Value*** **(NPV)**: used at a policy or project level to identify the optimal solution out of a set of mutually exclusive options; and
- the ***Benefit-Cost Ratio*** **(BCR)**: used at the programme/project level to determine whether or not an option is justified, and which can also be used to determine the best allocation of limited funds amongst a set of competing projects.

Table 1-3 describes the four-stage methodology adopted in developing B£ST.

Table 1-3 The tool's four stage methodology

Purpose	Summary
1. Confirm assessment is required and appropriate	This sets out the reasons for undertaking and key drivers of the assessment. It also provides the baseline position (see Section 2.4) and ensures the option(s) to be assessed are suitably understood and specified. *Users should confirm an assessment is required and appropriate before using the tool.*
2. Screening and qualitative assessment*	This establishes the type, size and scale of BGI to be built and the temporal and spatial scale of the assessment. It identifies what the likely benefits will be and provides an indication of their potential significance.
3. Evaluation of benefits*	This helps to quantify and monetise the most significant benefits of the BGI, taking account of scale, location, timing, etc. Non-monetised benefits are also recorded.
4. Summarise and present results	Here, the results of the assessment are drawn together across different benefit categories and over time. Sensitivity analysis is also undertaken. Where appropriate consider future uncertainty.

* The tool allows the user to enter benefits and values collected from studies not included in the tool. Therefore, if site specific values and estimates are available to support the assessment, use these during stages 2 and 3.

1.10 Considering uncertainty and applying confidence scores

The tool and guidance provide valuable support for decision making around BGI. They will enable users to consistently and systematically identify and assess the multiple benefits of BGI. However, there will be inherent uncertainties in any assessment of this kind (Box 1-7). Of course, such uncertainty is not limited to BGI and is likely to apply equally to all forms of drainage or flood management infrastructure. The principal sources of uncertainty relate to:

> **Box 1-7 Considering confidence**
>
> Given the uncertainties involved, it is important to note that the tool provides an *indication* of the benefits associated with SuDS/NFM (or other drainage/flood management or BGI scheme). Where planning significant investment, or where a decision may be contentious, a locally specific, bespoke analysis may be more appropriate.

1. **Physical data** – the dimensions and attributes of the BGI interventions and related impacted systems, such as receiving water bodies.
2. **Construction and decommissioning (temporary impacts)** – e.g. relating to periods of disruption and for which there may be negative benefits (i.e. costs).
3. **Operational performance** – including how well the BGI manage surface water flows and deliver the expected outcomes.
4. **Valuation of costs and benefits** – including robustness of cost and benefit estimates.
5. **Changes over time** – including those due to climate, growth, future investments in infrastructure and the profile of benefits delivered over time.
6. **Perspectives of users and decision makers** – preconceived or established professional practices can inhibit and introduce bias into their decision making.

B£ST provides support to assess the robustness of the scheme or options by considering potential future states with scenarios (Ashley et al, 2018a; Chapter 8 and Appendix D).

The tool considers uncertainties through the application of a simple user defined estimate of confidence. This confidence score approach is built into the tool and follows a number of standard approaches. It considers and accounts for the two key aspects of potential uncertainty in the tool:

- The quantified performance data, i.e. for the outcomes of whatever option is under consideration, e.g. numbers of properties for which flooding has been reduced or avoided; and
- Monetising these outcomes, e.g. how to assign monetary values to reduce flooding.

For each of these, the tool asks the user to apply a confidence score of 25%, 50%, 75% or 100%. Section 4 provides guidance on selecting an appropriate confidence score under each benefit category.

Optimism bias can apply to benefits or costs, i.e. benefits can be overstated and costs understated. In relation to benefits, the potential for optimism bias is minimised in B£ST through the use of a robust methodology, the screening process (so only assessing benefits where they are expected to be significant), a conservative approach to quantification and valuation, and using confidence scores. In relation to costs, Section 5.3.1 discusses optimism bias.

Another important aspect to consider in relation to uncertainty is that *valuation is not static*. The benefits of BGI will change over time for a number of reasons, including:

- the degree of scarcity associated with each benefit category (e.g. the availability of and access to green space in the area);
- seasonality/weather;
- changes in population (the number of beneficiaries); and
- the degree to which BGI, or the land on which they are cited, is properly maintained and how they subsequently perform.

Values will also vary across space, since BGI and the benefits they deliver are sensitive to their location (catchment type, vicinity to populated areas, nature of adjacent or surrounding area, socio-demographic characteristics of the population, etc.). In particular, there may be regional variations in values. Future development of B£ST will, along with inclusion of a natural capital accounting capability, explicitly consider and incorporate spatial variation in benefits.

While attempting to account for these factors within the tool, for example through careful selection of monetary values, guidance on when/where to use different values and profiling of benefits, it is simply not possible to guarantee that an assessment of the benefits of BGI will remain static over time or is transferable from one location to another. This requires the user to consider and provide reasons when selecting or using values throughout the tool.

Supporting the approach to uncertainty outlined above is a sensitivity approach that enables the user to alter the confidence scores to determine their influence. Section 6 of this guidance provides greater information to this approach.

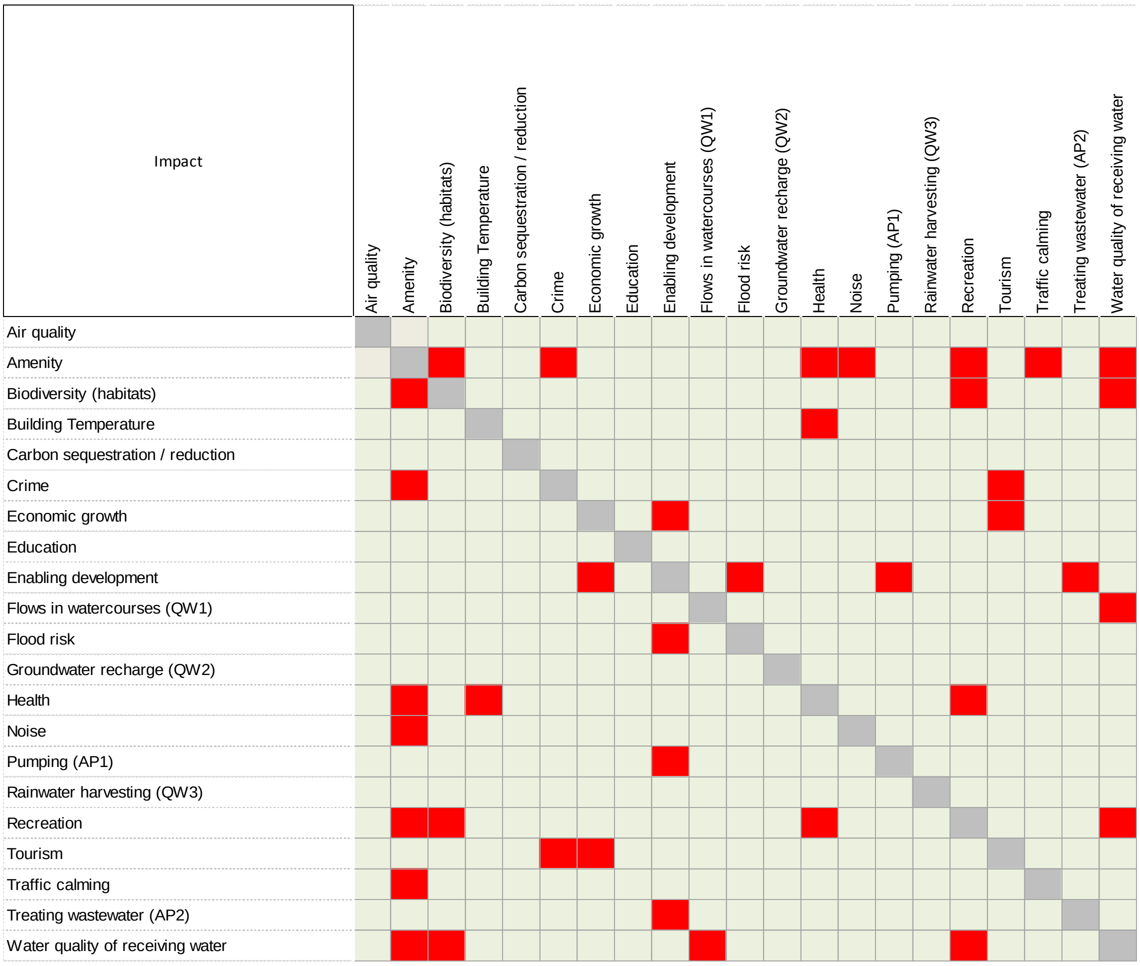
1.11 Avoiding double counting of benefits

There are two potential sources of double counting in an economic assessment:

- overlap between benefit categories; and
- using benefits transfer values that include more than just the specific benefit being valued.

The tool considers the first type of double counting in selecting the categories as shown in Figure 1-3 and on the ‘Potential double counting’ sheet in the tool. Although this cannot identify all potential sources of double counting, use this as a guide to indicate where there is a risk of double counting of benefits. Where it highlights a risk of double counting across different impact categories consult the relevant parts of this guidance and take special care to check that this risk is avoided or minimised. Note that whilst this highlights the risk of double counting, it may still be the case that impacts do indeed exist in more than one of the categories highlighted in red and therefore should be assessed. For this reason, we have not blocked the assessment of multiple benefit categories in the tool.

Figure 1-3 Potential for double counting between categories



It is possible to consider the potential overestimation of benefits due to double counting when reviewing the sensitivity of results (see Section 6.3). In addition, be careful not to attribute benefits to BGI that are wholly or partly driven by non-BGI measures (e.g. wider infrastructure interventions). Only those benefits (or that proportion of benefits) that can be confidently attributed to BGI should be included in the assessment.

This guidance addresses this second type of double counting with warnings and caveats provided for each benefit in Section 4 where there is significant potential to introduce double counting. It is important, therefore, to consider the implications of any assumptions made during the assessment, particularly when selecting the most appropriate monetary value.

1.12 Information requirements and sources

A wide range of data and information may be needed to complete a benefit assessment. This may include for example hydraulic modelling, flood risk assessment, environmental and health impact assessments, population and socio-economic data. This may require the input from a range of professionals, including ecologists, economists, engineers, architects, landscape architects, master planners or flood risk managers in lead local flood authorities designing BGI for new development or retrofitting. Such a multi-disciplinary approach is likely to enhance the quality of an assessment.

In the first instance, and for schemes that are relatively simple or expected to have limited benefits, B£ST provides guidance and support to undertake an initial evaluation without discipline experts. In such cases, uncertainty can be managed using confidence scores and sensitivity analysis.

Where discipline experts and local assessment information are available, use them to provide data and information. Where the benefit estimation is a significant or important proportion of the overall benefits, consider undertaking a more detailed assessment of the impact and/or monetised value. Table 1-4 shows the minimum information requirements and preferred sources of information for each benefit category.

Table 1-4 Example of information requirements for assessing benefits using B£ST

Benefit category	Minimum information requirements	Preferred sources of information
Air quality	Size/type of green components in scheme such as the number of trees and green roofs	Local air quality study, national emission/air quality modelling National Atmospheric Emissions Inventory
Amenity	Number/type of homes/commercial properties and number of people impacted by scheme	Landscape character visual impact assessment MENE (Monitor of Engagement with the Natural Environment)
Asset performance	Change in flows or energy use due to scheme	Pumped flows, pump run times, energy consumption from hydraulic model WwTW assessment including chemical and energy usage
Biodiversity and ecology	Change in size/type of green and blue space due to scheme	Biodiversity Action Plan or local habitat surveys
Building temperature	Area of green roof / number of trees	Energy management plan and assessment of building operational performance (e.g. using BREEAM In-Use)
Carbon sequestration	Number and type of trees	Carbon management plan
Crime	Non-expert qualitative estimation of potential impacts from scheme	Assessment of change in crime indices or deprivation levels
Economic growth	Non-expert qualitative estimation of potential impacts from scheme	Assessment of value added, job creation, productivity, investment
Education	Number of children engaged or educational visits/talks	Engagement with schools and other educational institutions
Enabling development	Avoided infrastructure costs	Local development plan, water cycle study or sewerage management plan
Flooding	Number of buildings or people impacted by the scheme	Flood risk modelling assessment
Health	Number of homes and number of people impacted by scheme	Health management plan
Noise	Size/type of green components in scheme such as number of trees	Local noise management study
Recreation	Change in number of visits and type of recreation due to scheme	Open space provision assessments in Local Env Action Plans (LEAPs)
Tourism	Non-expert qualitative estimation of potential impacts from scheme	Assessment of change in visitor numbers
Traffic calming	Non-expert qualitative estimation of potential impacts from scheme	Assessment of change in vehicle movements, number of traffic accidents
Water quality	Current and projected water quality status and length/area of waterbody impacted	UPM (Urban Pollution Management) modelling or similar Reason for Failure (RFF) dataset
Water quantity (groundwater recharge)	Volume of water infiltrating to groundwater	Ground water study, water cycle study
Water quantity (rainwater harvesting)	Number of properties, household size, water consumption rates	Water demand / use study
Water quantity (flows in watercourse and waterbody)	Current and projected flows in watercourses and waterbodies and length/area of watercourse or waterbody impacted	Flow modelling assessment Scheme designs

2 WHEN IS AN ASSESSMENT REQUIRED?

This section helps to identify whether an assessment using the tool is required and appropriate. By the end of this section, it will be clear whether to proceed or not. When undertaking an assessment, start by completing the 'Project data', and 'Screening questions' sheets in the tool. These sheets require important information to help assess the benefits.

Table 2-1 Examples of drivers for BGI

Primary drivers	**Example**
Reduced costs	• Minimise/share costs (e.g. construction, infrastructure costs, connection charges) • Obtain financial support from partners/stakeholders • Reduce surface water charges
Flood risk management	• Flood and coastal erosion risk management • Surface Water Management Plan • Reduce flood risk to properties • Comply with EU Floods Directive
Natural capital	• Provide assessment of benefit flows associated with natural capital • Contribute to natural capital accounting
Pollution control	• Reduce combined sewer overflows or diffuse pollution • Comply with EU Water Framework Directive, Urban Wastewater Treatment Directive, revised EU Bathing Water Directive, Shellfish Directive • Comply with EU Groundwater Directive
Drainage capacity	• Increase headroom in sewerage systems • Reduce need to increase size of wastewater treatment works • Produce Drainage and Wastewater Management Plans
Biodiversity	• Contribute to Natura 2000 and Biodiversity Action Plan objectives • SSSIs in favourable condition • National Indicator 197 improved biodiversity sites • Support green infrastructure strategy • Contribute to biodiversity/environmental net gain targets
Secondary drivers	Example
Green growth	• Contribute to green economy • New jobs and skills • Support regeneration
Localism	• Obtain community support for drainage and flood risk management plans • Encourage local participation and education
Water availability	• Restoring sustainable abstraction • Reduce mains water demand • Recharge groundwater • Increase water available for use • Maintain environmental flows
Climate change	• Reduction of greenhouse gas emissions • Adaptation to impacts of climate change • Mitigate urban heat island effect
Restore natural processes	• Restore rivers and floodplains • Improve morphological processes • Protect and restore peatlands
Improvements to local infrastructure and quality of place	• Improvements to local highways • Improvements to local public realm and street scene

2.1 Drivers and need for action

In conjunction with project partners, clients/funders and other key stakeholders, it is important to reflect on, agree and record why an assessment of the benefits of BGI may be required. Some schemes are likely to be defined and designed to meet specific objectives or support specific funding applications, so the drivers will impact upon the benefits expected or derived. Table 2-1 sets out the most likely primary and secondary drivers of BGI schemes, together with some examples. For any given BGI scheme, more than one of these drivers is likely to be relevant.

2.2 Deciding whether to complete an assessment

In some circumstances, BGI either may be a statutory requirement or may be the cheapest option to meet the objectives set (e.g. Defra (2011a)) and Committee on Climate Change (2012)). In such cases, a detailed assessment of the benefits is unlikely to be required, although it may help to identify alternative sources of funding or stakeholders to engage and work with. The exception to this may be where there is more than one way of achieving the desired outcome using BGI. In such cases, an assessment of the benefits may be useful to identify which of these provides the greatest value. Where achieving the desired objective includes BGI and/or conventional piped/NFM/SuDS, an assessment of the benefits can help inform the decision.

It is likely that the cost of delivering the desired outcome will be an important factor in making a decision, alongside information on the benefits. B£ST does not estimate costs but does enable the entry of whole life costs to allow for example to make cost-benefit calculations or make comparisons between different schemes. B£ST can still be used even where costs have not been estimated, and there is a separate *'Comparison Tool'* to help compare the benefits (and costs, if available) of up to four options, which contains several automated graphs. See Section 5.3.1 for further information on costs.

2.3 Confirming baseline position and proposed options

In any economic assessment, it is the marginal change in the relevant impact that must be estimated. To be able to estimate this, it is crucial to understand what the situation would be in the absence of a (BGI or other) intervention, since it is the benefit of the intervention over and above this situation that needs to be assessed. In effect, this is a 'do-nothing' or baseline position and should also take account of any known changes to the baseline position unrelated to the BGI scheme.

The baseline position may vary according to whether the scheme involves retrofit, redevelopment or new development. Table 2-2 shows the recommended approach to specifying and comparing options, including the costs of options. In a retrofit situation, the baseline position is the existing condition and performance of drainage in the area, or this may be a 'do-nothing' option. The 'proposed option' is a proposed drainage scheme that addresses one or more drivers. For new development, the baseline position may include a conventional drainage or natural flood management scheme and the option is a BGI proposal. For redevelopment or regeneration, it is possible to select either comparison approach depending upon what the user wishes to compare. In some situations, it may be appropriate to compare present day or future performance, for example including changes to rainfall as a result of climate change. The case study in Box 2-1 shows a retrofit situation comparing a conventional solution with a variety of SuDS-type options (a full summary of this case study, including the results, is available from the susdrain web site).

When considering or comparing more than one option, it is important that the baseline position remains the same within the tool. For example, in a retrofit situation, as in the case study in Box 2-1, the baseline position is the current drainage performance and the options are alternative approaches to drain the catchment. In such cases, run the evaluation tool more than once to generate the benefits for each option. It is also important to think about the changes in the area over the lifetime of the scheme for the baseline position, and for both the do-nothing option and any proposed options (See Section 8).

Table 2-2 Recommended approach to completing the baseline position and proposed case depending upon the scheme type

Scheme Type[a]	**Case Type**	**Recommendation**	**Present Value (PV) Cost**
Retrofit	Baseline	Consider the existing / current situation. This will enable a comparison with the 'proposed' option against the existing situation. For impacts which are not currently relevant to the site(s), leave these values blank.	No value entered.
	Proposed	Consider the drainage or natural flood management intervention proposed and the impacts it will have compared with the existing situation. This may be a conventional or BGI[b] option[c] in a rural or urban context	Enter the PV cost for the scheme.
New development (greenfield)	Baseline	Consider the impact of a conventional drainage option here for the new development and record its impact.	Enter the PV cost for the conventional scheme.
	Proposed	Consider the impact of a BGI option here for the new development and record its impact.	Enter the PV cost for the BGI scheme.
Redevelopment / regeneration	Baseline	Consider either the existing situation or a conventional drainage or natural flood management option.	Enter no value or the PV cost for the conventional scheme.
	Proposed	Consider the impact of any drainage or natural flood management option.	Enter the PV cost for the scheme.

[a] In a situation where there is a combination of scheme types, consider which is most applicable, or sub-divide the sites and repeat the assessment.
[b] This may be an option with a combination of BGI and conventional drainage/NFM.
[c] This may be a proposed scheme, solution, project or study that describes a drainage or natural flood management intervention.

2.4 Dealing with scale

The four-stage methodology described in Section 1.3 helps to target the level of effort required to undertake an assessment, so being proportionate to the significance of the expected outcome. In addition, the screening element of the tool (see Section 3) will help users to focus only on those areas where the benefits of BGI are likely to be significant (i.e. material to the decision which needs to be made).

The consequence of this is that some benefits are only likely to be important above a certain magnitude. Assessments of BGI schemes using B£ST that are focused on small geographical areas, or in places where the impacts are likely to be felt by a small number of people, will not deliver large monetary benefits. However, always consider the size of the benefits relative to the size of the investment, so it may still be appropriate to assess the benefits of small schemes.

However, the impacts of and benefits associated with smaller schemes can be packaged together and aggregated or combined with a broader scheme incorporating other planned works (e.g. foot/highway resurfacing). For example, whilst one urban scheme involving the planting of 5 trees may only have a negligible impact on air quality, a package of 20 similar schemes involving the planting of 100 trees could lead to a tangible and more substantial reduction in air pollution. Similarly, one debris dam in a catchment may provide modest benefits to downstream flooding, whilst many such dams may provide a cumulative effect and have a significant benefit downstream. The relationship of individual benefit categories to scale is highlighted where appropriate in Section 4. One issue that may be important in certain schemes is that of tipping points. It may be some schemes will be implemented in phased stages, and that as a result some benefits will only be realised, or become significant, once the scheme reaches a certain point. Take account of this using B£ST by adjusting the timescales of the assessment (see Section 4.4 for more detail) - when the benefits start to accrue and when they end.

Box 2-1 Example of baseline position and proposed case for SuDS: Roundhay Park *(Courtesy of Yorkshire Water)*

At Roundhay Park in Leeds, Yorkshire Water undertook a study to assess a range of potential options that could address a primary driver, water quality issues. The options were compared to the baseline position – the current drainage performance in the catchment – and included;

1. **Conventional solutions**
   a) Install underground storage tanks to reduce probability of two combined sewer overflows from discharging to watercourses during rainfall (reducing potential for pollution).
   b) Install storage at combined sewer overflows and strategically through the catchment to reduce flood risk to provide a similar level of performance as seen by reducing inflow to the combined system in options 2, 3, and 4.

2. **Infiltration through SuDS**

Large-scale infiltration, including SuDS in highways and rain gardens in residential properties.

3. **Storage/conveyance through SuDS**

Convey and store runoff from public space/commercial, through additional SuDS in highways/public open spaces (but no rain gardens in residential properties).

4. **Storage/conveyance plus infiltration through SuDS**

As above, but with addition of rain gardens in residential properties. This option therefore has the greatest number of SuDS components.

3 SCREENING AND QUALITATIVE ASSESSMENT OF BENEFITS

Following a decision to proceed with an assessment of benefits, this section helps to identify which benefit categories to consider, using the 'Screening Questions' sheet. This sheet opens benefit assessment sheets based upon the choices made, indicates likely interested stakeholders and organisations, and where necessary, opens a 'BGI Used' sheet.

3.1 Identifying significant benefit categories

For each of the benefit categories covered by the tool, decide whether there are likely to be significant benefits (or dis-benefits) arising from the scheme. This may require discussion with stakeholders. Table 3-1 lists the benefit categories and the key question to answer affirmatively in order to proceed. To support this screening, the tool includes sub-questions. For most benefit categories, significant benefits are unlikely unless all of these can be answered affirmatively.

The tool asks the user to state the likely scale of the benefit. For each category, record whether the benefit is likely to be:

Significant positive	**++**	
Minor positive	**+**	
Not significant	**0**	
Minor negative	**-**	
Significant negative	**--**	(i.e. large non-financial cost)
Unknown	**?**	

When answering the questions in Table 3-1 affirmatively, provide some further description or qualitative response to support the answer (and record any disagreement arising during discussions). This is important in providing justification for the assessment that follows, setting confidence levels and providing an audit trail. Text added here is automatically transferred to the 'qualitative' section of the relevant benefit sheet.

After considering each category, decide whether to assess that benefit by selecting 'YES' in the 'Open impact sheet?' column. Typically this is where a significant (i.e. '++' or '- -') impact is expected. For most benefit categories, significant benefits are unlikely to occur unless the scheme is of a reasonable scale (e.g. Pochee & Johnston, 2017). However, for some categories (e.g. amenity) even a fairly small scheme could lead to significant benefits in the immediate or surrounding areas. Therefore, when considering the size of the impact, keep the relative size and cost of the project in mind.

Selecting 'YES' in the 'Open impact sheet?' for each category, and pressing 'enable pages', the tool automatically opens up the relevant benefit category sheets in the tool.

Note that, if after deciding to assess a benefit, and then subsequently reversing this decision (for example due to the potential for double counting); it is important to remove the values in the benefit sheet. If not, the tool still carries these forwards into the results.

Table 3-1: Using the screening questions to select benefit categories for assessment

Benefit category	Question	Generic sub questions to consider (not exhaustive)
Monetised benefits		
Air quality	Will the scheme significantly change the level of air pollution?	- Is the site in an air quality management area? - Will the scheme involve green infrastructure (e.g. tree planting, green roofs)? - Is the scheme in a populated area or a transport corridor?
Amenity	Will the scheme change the attractiveness or desirability of the place?	- Does the scheme involve new/improved surface water bodies/features, landscaping or greening? - Is the scheme in a populated area, or an area used for recreation, work, commuting, tourism, etc? - Will the scheme components be visible to those living

Benefit category	Question	Generic sub questions to consider (not exhaustive)
		nearby or passing by?
Asset performance	Will the scheme change the demands on sewerage systems saving money in pumping?	- Will the scheme lead to a change in the amount of wastewater pumped? - Do proposed schemes require pumping stations to be added that increase energy use?
	Will the scheme change the demands on sewage systems saving money in treatment?	- Will the scheme lead to a change in the amount of wastewater treated? - Is the size of works large and complex enough to make a meaningful impact on treatment costs? - Does the works include pumping stations?
Biodiversity and ecology	Will the scheme lead to a change in habitats for plants and animals?	- Will the scheme involve components that may enhance biodiversity and ecology? - Will the scheme create new sites that support habitats and the growth of biodiversity and ecology? - Will the scheme significantly improve connectivity between sites?
Building temperature	Will the scheme change the potential for high temperatures in summer and cold temperatures in winter?	- Will the scheme involve the installation of green roofs or green walls? - Is the scheme in a built-up area? - Is there a potential for trees to provide significant shading?
Carbon sequestration	Will the scheme change the amount of carbon in the atmosphere?	- Will the scheme involve planting (particularly trees) over and above that which would occur without the scheme? - Will the scheme involve new planting (particularly trees) rather than replacement?
Education	Will the scheme lead to greater awareness of water and surface water management?	- Could the scheme lead to increase in number of children engaged about BGI? - Could the scheme lead to more educational visits/talks? - Could the scheme lead to increase in number of community events or open days?
Enabling development	Will the scheme reduce demands on sewerage systems providing headroom for growth or development?	- Is growth or development currently occurring or expected in the future? - Will improving the drainage capacity in the sewer system support growth or development?
Flooding	Will the scheme change the impact of flooding?	- Are there properties, buildings, areas or infrastructure (including transport) at risk of surface water flooding or flooding from sewers currently? - Is growth or climate change expected to change the risk of surface water flooding or flooding from sewers in the area? - Is the scheme expected to reduce local flood risk?
Health	Will the scheme contribute to the health and wellbeing of local residents?	- Will the scheme involve green infrastructure (e.g. tree planting, green roofs)? - Could the scheme encourage residents or others to spend more time outdoors or participating in physical activity/exercise?
Noise	Will the scheme significantly change noise levels?	- Will the scheme create barriers that will reduce noise, in particular from transportation?

Benefit category	Question	Generic sub questions to consider (not exhaustive)
Recreation	Will the scheme change the available facilities for recreation and leisure?	- Is the site currently used for recreation (e.g. walking, fishing, birdwatching, sports - including water sports)? - Is the scheme expected to improve facilities or opportunities for recreation?
Traffic calming	Will the scheme enable traffic calming measures to be introduced?	- Will the scheme include traffic calming measures that could reduce risk of accidents, improve the liveability of the area or increase journey times?
Water quality	Will the scheme change the water quality of rivers, wetlands, peatlands, lakes or the sea?	- Are there pollution or water quality issues in the water courses? - Is growth or climate change expected to change risk of pollution or water quality in the area? - Is the scheme expected to reduce pollution or improve water quality (and may result in avoided costs)?
Water quantity (groundwater)	Will the scheme increase infiltration into the ground?	- Is the scheme likely to increase the amount of infiltration to groundwater bodies? - Are groundwater bodies currently used for water abstraction, or expected to be used in the future?
Water quantity (rainwater)	Will the scheme harvest or store water so that it can be put to other uses?	- Will the scheme include rain water harvesting that reduces water demand?
Water quantity (flows in watercourse and waterbody)	Will the scheme help retain or increase flows in the watercourse or waterbody?	- Will the scheme help retain or increase flows in the watercourse or waterbody? - Will the scheme slow the flows arriving at the watercourse or waterbody? - Will the scheme protect or enhance the morphology of the watercourse or waterbody?
Non-monetised benefits		
Crime	Will the scheme also change the local environment and thereby contribute to a reduction in crime?	- Could the scheme provide a more pleasant environment that may help to reduce crime? - Could the scheme provide an environment that enables more security (natural barriers, observation etc.)?
Economic growth	Will the scheme unlock barriers to economic growth or provide new employment and business opportunities?	- Could the scheme lead to new jobs or training opportunities (e.g. green economy)? - Could the scheme play a part in regeneration programmes, tourism or other types of economic development? - Could the scheme lead to more productive landscapes or food production?
Tourism	Will the scheme improve tourism to a specific location of area?	- Could the scheme lead to increase in number of visitors? - Could the scheme lead to increase in quality of visitor experience?

3.2 Identifying beneficiaries and stakeholders

For many of the impact categories (e.g. amenity, recreation, health), it is necessary to estimate the number of beneficiaries associated with an improvement brought about by BGI. In most cases, this 'beneficiary population' will be limited to those who will make use of or directly benefit from the improvement (e.g. those living adjacent to or overlooking the BGI scheme) but may include those living downstream of a catchment flood alleviation scheme. In other cases (e.g. river/bathing water quality and biodiversity improvements), the beneficiary population may also include 'non-users', i.e. those who do not directly make use of the improvement but still derive some benefit from it. Guidance on estimating the beneficiary population for each benefit category is provided in the relevant 'quantifying benefits' part of Section 4.

In all categories, there will be different groups or organisations that are likely to benefit in different ways from BGI. Some of these beneficiaries may be involved in funding or implementation, but in many cases, there may be no apparent or straightforward rationale for linking funding, implementation, responsibility and benefits.

In general, economic analysis focuses on efficiency, and accepts the existing distribution of income and that which would prevail following the implementation of an 'efficient' project. Economic theory requires that, for an option to be cost-beneficial, it should result in a situation where those who would gain from an action would theoretically be able to compensate those who would lose, and the gainers would still be better off.

The tool focuses on *what* benefits can accrue because of using BGI (or other drainage/natural flood management) approaches (including the population or number of people who benefit), rather than *the different stakeholder groups* to which the benefits accrue. It is however still important to consider any such distributional issues that arise in decision making.

Nevertheless, it is possible to provide a description of how to distribute benefits over different stakeholder groups. Table 3-2 provides examples of potentially interested stakeholders in the outcomes of building BGI and potential funders and is built into the tool. B£ST does not identify

Box 3-1 Local or national benefits and FD GiA?

The question of whether a scheme delivers locally specific or broader national benefits is of particular interest where national funding sources (e.g. flood defence grant-in-aid, FD GiA)) are being considered. There is currently no specific guidance to help determine which of the benefit categories in B£ST are 'national' and which are 'local'. However, the Green Book (HM Treasury, 2018) and a voluntary Defra toolkit (Defra, 2014) suggest that impacts which do not result in a change in total societal welfare, or which reflect transfers from one part of the economy to another, should be excluded from economic analyses.

With specific regard to FCRM and FD GiA, the English government's approach to funding flood and coastal erosion risk management (FCERM) includes a series of 'outcome measures' (OMs), supported by a partnership funding calculator. This process will be in place until 2021. These are

- OM1 – average benefit to cost ratio of schemes delivering OMs
- OM2 – households moved from one category of flood risk to a lower category
- OM3 – households better protected against coastal erosion
- OM4 – statutory environmental obligations fully met through FCERM

Defra (2011d) notes that "*flood and coastal erosion risk management provides many benefits for the wider economy and society and it is important that risk management authorities continue to ensure these impacts are properly valued in accordance with HM Treasury and Defra appraisal policy. All such benefits arising, where not valued and paid for under OMs 2, 3 and 4, will be rewarded under OM1. Such benefits might include protection for businesses and in terms of enhancing agricultural productivity, ecosystem services, and avoided damages to public and private infrastructure*". The links to FD GiA are further discussed in Section 4.1.9.

Given the above, to ensure benefits assessed using B£ST are recognised and accepted by funding bodies, it is recommended that a conversation about the scheme and assessment process is held with the funding body at the earliest opportunity.

specific beneficiaries. In general, the beneficiaries of BGI schemes tend to be local, whilst those typically funding the schemes tend to include a larger population (e.g. water company customers or council tax payers) (Box 3-1). However, the involvement of specific groups will depend on the context and situation, which will vary from scheme to scheme and from place to place. B£ST provides an indication of the potential stakeholder types or organisations to engage, based on the completed screening questions.

It is important to note that some of the benefits of BGI are likely to be private benefits, i.e. they accrue only to specific groups or organisations. Examples of private benefits include household flood risk reduction and health benefits to recreational users. However, there are also likely to be public benefits arising from any BGI scheme, e.g. mitigation of carbon emissions or reduced burden on the NHS due to health improvements. The exact allocation of public and private benefits will depend on and vary according to the organisations involved, and the tool therefore stops short of a fuller analysis in this area.

Where the distribution of benefits is of specific concern and/or the magnitude of its impact is large, further analysis may be warranted.

Table 3-2: Potential interested stakeholders and organisations

4 EVALUATING THE BENEFITS

This section sets out, for each benefit category included in the tool, the key issues and questions to consider for an estimate of benefits. Consider using this section as a reference when completing the applicable benefit sheet in the tool.

For each benefit category, the guidance summarises:

- **The impact pathway** – a simplified representation and example of the relationship between BGI and outcomes in the benefit category that can be assessed;
- **The method of assessment** – how the tool makes the link between BGI components and beneficial outcomes that can be assessed;
- **Quantifying benefits** – further details to help the assessor determine quantified estimates of change;
- **Monetary values** – details of the monetary values (see box 4-1) recommended for use in the assessment. In some categories, it is only appropriate to apply one monetary value (unless the values relate to different improvements which are both specifically included in the option);
- **Avoiding double counting** – guidance on the risks of and ways of avoiding double counting; and

  Confidence scores – guidance on selecting confidence scores for the quantitative estimate and the monetary value.

Section 4.1 sets out those benefits that are amenable to quantification and valuation. Section 4.2 outlines those more likely to be assessed in qualitative terms only.

> **Box 4-1 Allowing for inflation**
>
> Note that all values have been updated to 2017 prices to take account of inflation, using the government's GDP deflator https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp
>
> This is consistent with a base year of 2018. If a different base year is used, the tool can automatically adjust present values accordingly. This can be achieved by adjusting the 'Gross Domestic Product Deflators' in the "Values Library - Yearly Values" tab.

4.1 Quantifying significant benefits and applying monetary values

4.1.1 Air quality

The impact pathway

Several BGI components (e.g. trees, green roofs, green walls, swales, wetlands, basins) can have a positive effect on local air quality, particularly in areas where air pollution is an existing problem (i.e. air quality management areas). They can absorb or remove certain pollutants, including nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulates (PM_{10}) and ozone (O_3), providing a number of benefits to people that live, visit or pass through the area, as shown in

Figure 4-1.

Figure 4-1 Impact pathway for air quality

It is likely that air quality benefits will only accrue in large retrofit or redevelopment situations in urban areas, or in schemes implemented incrementally over time (or where it is reasonable to consider this will happen). The extent to which BGI components impact on air quality will depend on a range of local factors, including their positioning relative to other structures, land form and sources of pollutants, the nature, quantity and size of nearby buildings, and so on. To go into this detail will require a more in-depth study completed outside of the tool, but the approaches outlined here can be used to give an initial estimate of the impact.

Method of assessment

There are two approaches to assessing benefits in this category.

- Use AQ1 if you have already calculated the impact on air quality from the scheme.
- Use AQ2 if you need to estimate the impact on air quality (in the absence of calculations).

B£ST asks the user to estimate or report existing air quality parameters. Information to support this is available from the National Atmospheric Emissions Inventory (http://naei.defra.gov.uk/data/gis-mapping). This helps to indicate if there is a local air quality issue.

Where a completed air quality study is available, the ‘annual pollutant removal estimates’ can be input directly into cells in the ‘Air quality’ sheet (Section AQ1). As part of an air quality study, it may be appropriate to use more detailed analysis to estimate the impact, such as using “i-tree Eco” (Hambridge, 2014). If not, input information related to the BGI components, e.g. area of green roof or number of trees (along with their expected size at full growth). Complete the remainder of section AQ2 selecting an appropriate ‘pollutant removal level’ and consider the location of the site (since the benefits of reduction in some air pollutants are greater in more built-up areas or where there is an air quality problem).

The assessment in this category is based on the following formula:

$$Reduction\ in\ pollution = \begin{pmatrix} number\ of\ trees \\ area\ of\ vegetative \\ BGI \end{pmatrix} \times \begin{pmatrix} average\ pollution \\ removal\ level \\ (40\ year\ average) \end{pmatrix}$$

B£ST applies a 40-year average to simplify the calculation. In reality, pollutant removal levels increase over time and can be highly variable. However, as long as an evaluation period is greater than 50 years, then this is a reasonable approximation. The tool uses values for different tree size uptake from Western Washington and Oregon Community Tree Guide (McPherson et al, 2002) which shares similar climatic conditions to those seen in the UK. For more accurate pollutant removal estimates, carry out a bespoke assessment or use tools such as i-tree Eco.

Quantifying benefits

The quantified benefit is in terms of *change in level of pollutant (tonnes/year)*. The sources of information used to quantify benefits of BGI components are shown in Table 4-1.

Note that the choice of trees can be an important factor in the type and amount of air pollutants absorbed. For example, some trees emit biogenic volatile organic compounds (BVOCs), notably isoprene, which can enhance the formation of pollutants including PM and ozone (Air Quality Expert Group, 2018).

Further information on PM10 removal by green roofs is provided by Speak et al (2012). This study was based on a relatively short monitoring and sampling period, and caution is therefore required in applying the estimates more generally. However, it provides absorption levels (tonnes per year) for a range of common species used in green roofs. Levels for a large area (50ha) of green roof are as follows.

- A. stolonifera, 0.9 tonnes/year (+/- 0.03)
- F. rubra, 1.61 tonnes/year (+/- 0.05)
- P. lanceolata, 0.25 tonnes/year (+/- 0.01)
- S. album, 0.21 tonnes/year (+/- 0.01)

Table 4-1 Quantifying air quality benefits

Source	Air quality parameter	Av. annual pollutant uptake	Converted
Trees (small) (McPherson et al, 2002)	NO_2	0.08 lbs/tree	0.036288 kg/tree
	SO_2	0.03 lbs/tree	0.013608 kg/tree
	O_3	0.14 lbs/tree	0.063504 kg/tree
	PM-10	0.15 lbs/tree	0.06804 kg/tree
Trees (medium) (McPherson et al, 2002)	NO_2	0.17 lbs/tree	0.077112 kg/tree
	SO_2	0.07 lbs/tree	0.031752 kg/tree
	O_3	0.27 lbs/tree	0.122472 kg/tree
	PM-10	0.29 lbs/tree	0.131544 kg/tree
Trees (large) (McPherson et al, 2002)	NO_2	0.28 lbs/tree	0.127008 kg/tree
	SO_2	0.1 lbs/tree	0.04536 kg/tree
	O_3	0.43 lbs/tree	0.195048 kg/tree
	PM-10	0.45 lbs/tree	0.20412 kg/tree
Green roofs (US EPA, 2014)	NO_2	0.0004770 lbs/sqf	23.290 kg/ha
	SO_2	0.0004060 lbs/sqf	19.823 kg/ha
	O_3	0.0009200 lbs/sqf	44.919 kg/ha
	PM-10	0.0001330 lbs/sqf	6.494 kg/ha

At present, there is insufficient evidence to link green walls of different types/scales to specific improvements in air quality parameters. However, there is evidence (Pugh et al, 2012) that such features could potentially reduce concentrations of NO_2 and PM by up to 40 or 60% respectively.

Monetary values

All the values for air quality benefits come from the UK government's air quality economic assessment methodology (Defra, 2015). The tool embeds these values (based on the damage cost approach, i.e.

damage to health avoided from reductions in air pollution) and estimates the present value automatically based on the quantitative estimates provided. Table 4-2 summarises these. The government's methodology includes several values related to PM (particulate matter) air pollution. Since transport (e.g. roads) is likely to be the key driver of air pollution problems in areas where BGI are considered, the tool defaults to using the PM transport average values which are typically conservative. However, other values for PM (e.g. relating to emissions from industry) are available, as are values for transport within London or other urban conurbations (some of which are significantly higher than those in Table 4-2). If air quality impacts are likely to be significant for the scheme (the government guidance suggests a threshold of around £50 million), this will warrant a more detailed analysis of the impacts. If it is appropriate to use these different values, enter them in the user defined cell next to 'PM transport average' in the values library.

Table 4-2 Monetary values - air quality

Parameter	Value (2015 prices)			Units	Source	When to use
	Low	Central	High			
NO_x (transport)	10,101	25,252	40,404	£/tonne/yr	Defra 2015	Use range if impacts on NO_x are known
NO_x (industry)	5,253	13,131	21,010			
NO_x (domestic)	5,859	14,646	23,434			
SO_x	1,581	1,956	2,224	£/tonne/yr	Defra 2015	Use range if impacts on SO_x are known
NH_3	1,843	2,363	2,685	£/tonne/yr	Defra 2015	Use range if impacts on NH_3 are known
PM (transport)	45,510	58,125	66,052	£/tonne/yr	Defra 2015	Use range if impacts on PM are known
PM (industry)	23,665	30,225	34,347			
PM (domestic)	26,396	33,713	38,311			

Avoiding double counting

The monetary values provided by the government represent the total health benefits associated with air quality improvements arising from reduction in pollution. As such, they are specific to air pollution and are not expected to overlap with other benefit categories. The risk of double counting in this category is therefore considered to be *minimal*.

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty in what the scheme will actually deliver in estimated air quality benefits. For example, if the vegetation/trees are in a location that is currently afflicted by air quality issues, and the area is used (heavily or frequently) by people that will see a noticeable change, select a higher confidence score (75%). If the area has a need to reduce pollution (e.g. Air Quality Management Area) and a local study identifies the performance of different tree types to remove pollutants, then a score of 100% is appropriate. On the other hand, if vegetation in the area is already plentiful, such that additional green infrastructure is unlikely to make much of a difference, or if the green infrastructure is dependent on other parties, therefore being less certain that a significant impact will occur, a lower confidence score may be appropriate.

Since the monetary values come from a reliable source and are based on actual market data, the confidence score for the monetary values is 100%.

4.1.2 Amenity

The impact pathway

Several BGI components (e.g. ponds, restored rivers, swales, basins, wetlands, trees) can have a positive effect on the attractiveness and desirability of an area, particularly when introduced into populated areas, independently of other benefits. This in turn can improve the wellbeing of people that live or work in, or visit or pass through, the area, as

Figure 4-2 shows. Amenity benefits can accrue in new build, retrofit or redevelopment situations and often relate to the pleasure derived from or the usefulness of components provided.

Figure 4-2 Impact pathway for amenity

NB Because of the risk of double counting in this category, when assessing and valuing amenity benefits be very cautious about also assessing benefits in other categories, particularly recreation, health, water quality and biodiversity (see 'Avoiding double counting' section below).

Method of assessment

There are two approaches to assessing benefits in this category.

- Use AM1 if you have already calculated the value as a result of enhancing the amenity / quality of space.
- Use AM2 to help you estimate the impact of changing the quality of space / amenity.

The delivery of benefits in this category depends on the extent to which the BGI will improve the attractiveness of the immediate or wider area. Information to support the assessment may come from a landscape character assessment, a landscape visual impact assessment (LVIA), greenspace audit or survey. There will inevitably be some subjectivity in interpreting how much BGI contributes and creates a benefit. This is acceptable but record any assumptions and be explicit about this.

Quantifying benefits

Begin the quantification process by considering the amount of BGI components that the scheme will include, e.g. increased area of green space, number of trees or length of river restored. Consider the quality of the space being created compared with existing land for a retrofit situation. For new development, when completing the baseline position, consider the likely design of the conventional drainage design which may have similar non-water management components (e.g. planting). Finally, estimate the number of beneficiaries, i.e. the number of visitors or residents (over 18), households or commercial properties that are likely to see a noticeable improvement. To convert residents to households (or vice versa), assume that there are, on average, 1.85 adults per household in the UK. This is based on 2011 census data (ONS), which shows there are 63.2 million people in the UK, approximately 77.4% of whom are adults, and 26.4 million households. More detailed population data (e.g. per ward) is available from the ONS.

Estimates of visitor numbers to green spaces of different types and in different locations can be obtained from MENE (Monitor of Engagement with the Natural Environment) (Natural England, 2017).

Although there is limited evidence around benefits to commercial properties, workers/commuters and visitors from improvements to amenity, estimate the number of potential beneficiaries in these categories when expecting significant benefits to accrue to these groups. However, take care to avoid counting the same beneficiaries twice, so for example estimate the numbers of workers/commuters and visitors where they are *additional* to residents.

Base the assessment of beneficiaries on local knowledge and common sense. However, a good rule-of-thumb is to include those residents/workers/properties either overlooking the feature or (to obtain a high/maximum estimate) those within a five-minute walk (approximately 450m).

Monetary values

There is a large body of evidence to suggest that people enjoy and value the changes to the landscape and visual character of an area that BGI can provide. Table 4-3 includes the most appropriate values that reflect this and that can be applied to the kind of improvements brought about by BGI measures in a UK context. They are generally based on either willingness-to-pay studies, or on 'hedonic pricing' studies, which model the impact on property or land values from enhancements to the local environment.

Consider which one of the values in Table 4-3 most closely matches the proposed scheme and record that value in the tool (do not select more than one). For example, if a scheme involves the creation or significant improvement of local parks or green spaces (including flood plains), use the relevant regional value from the Fields in Trust study. If it includes a new or significantly improved, permanent body of water, use the values for 'new ponds'. If the scheme will impact visually on commercial properties, use the work by Gensler and Urban Land Institute.

Further details around the context of these values are provided in the 'Values Library' within the tool. Note that the RICS figures are not completely 'internally consistent', e.g. it could be expected that values for 'city park' to always be higher than 'local park' since green space is generally scarcer and has a higher premium in cities (e.g. Silvennoinen et al., 2017). However, this information is based on a robust study and is the best available. It is also broadly consistent with the Land Trust (2018) study which found a price premium of 5.4% for every 100 metres (within 500 metres) that a house is closer to a new city park, and with recent work from the 'Green City, Clean Waters' programme in Philadelphia, which found a property premium of 1.7% to 12.7% (best estimate 10.3%), associated with proximity to green surface water infrastructure features.

Table 4-3 Monetary values - amenity improvements

Context	Value (2014 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Creation or improvement of commonly visited park or green space		3.92 (London) 2.31 (Northeast) 2.20 (Northwest) 2.54 (East Mids 2.67 (East Eng) 2.66 (West Mids) 1.68 (Yorks & Humber) 2.23 (South east) 2.56 (South west) 2.33 (Scotland) 2.41 (Wales) 2.33 (N. Ireland)		£ per person per month	Fields in Trust (2018)	Use where local parks or green spaces are created or significantly improved. Values probably also encompass general recreation (e.g. running, dog walking) so **do not** value recreation separately if these values are used.
Street improvements including planting of trees and green verges.	1.72 (small trees)	1.98 (large trees)	2.46 (large trees and planting)	£/ resident/ month	Mell et al (2013)	Use for BGI in streets. Be wary of combining with values for recreation, biodiversity or health
New or significantly improved ponds	5.93	11.56	19.75	£/ house-hold /month	Bastien et al (2011)	Use only where new pond(s) created. Be wary of combining

						with values for recreation, biodiversity, water quality or health
Park enhancement (homes <450m away)	**Flat**	**Non-detached**	**Detached**	% change in house prices	RICS (2007)	Use only where parks will be created or significantly enhanced in quality and there are homes within 450m. Be wary of combining with values for recreation, biodiversity or health
Local park	7.92	9.44	9.62			
City park	7.54	2.93	19.97			
Open space	4.70	0.44	2.71			
Commercial properties	3	3	15	% premium	Gensler & Urban Land Institute (2011)	Use where commercial property is near open space due to scheme.

For more detailed assessments, Gibbons et al (2014) can be used to value benefits by linking change in property prices to land use changes of specific types and over specific areas.

The original valuation studies cited here do not generally discuss the availability of substitute sites in detail, so the impact of substitute sites on the values presented is unknown. Therefore, where a number of potential substitute sites in the locality exist (e.g. streets are already green or there are existing ponds with amenity value), select the low value. Where few or no substitutes exist, the mid or high values will be more appropriate.

The values in Table 4-3 can also be applied to workers/commuters and regular visitors, but only if these are *additional* to residents.

If the value selected relates to house prices, investigate the average house price in the area. This information is readily available from house price tracker web sites. To increase robustness and reliability of results, consider identifying different types of affected homes (e.g. detached, terraced, flats) and apply appropriate average house prices to each of these.

Avoiding double counting
It is likely that the values shown in Table 4-3 cover a range of benefits associated with amenity/visual improvements arising from BGI. In general, economic studies do not explore the reasons or motivations behind willingness-to-pay values and house price differentials. However, it is generally accepted that, apart from the additional satisfaction of living in/looking at a more attractive area, such values also capture elements of other benefits, including:

- recreation (e.g. improved access to or quality of recreational opportunities in the area);
- health (e.g. psychological or physical benefits);
- water quality (especially where BGI includes permanently ‘wet’ components or will improve the quality of existing watercourses); and
- biodiversity (e.g. increased appreciation of or access to nature) which may be due to improvements to habitats.

For these reasons, the risk of double counting in this category is considered to be *high*. Therefore, when valuing amenity benefits, only seek to assess and value benefits in the following categories where there is confidence there are truly additional benefits (or apply to different groups/populations).

- Recreation
- Water quality
- Traffic calming
- Biodiversity
- Health
- Crime
- Tourism

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty of the BGI actually delivering the estimated amenity benefits. For example, if the area is currently visually unattractive and the BGI includes landscaping, river restoration or new water bodies, etc., then a significant improvement in this category could be expected and select a higher confidence score (75%). Where a completed detailed assessment is available, such as a Landscape Character Assessment, then a value of (100%) may be appropriate. On the other hand, if the area is already green/pleasant, such that additional BGI components are unlikely to make much of a difference, or if they are dependent on other parties, then there may be less confidence that a significant impact will occur, and a lower confidence score may be appropriate. Some discussion with stakeholders may be necessary due to the subjective nature of defining amenity.

If the context of the monetary values is similar to the scheme (i.e. similar types of components and improvements expected), then select a higher confidence score for the monetary values (75% or 100%). If the context is very different (e.g. in a mainly non-residential area) or the quality of the improvement is not considered to be as high as that referred to in Table 4-3 (e.g. the scheme involves some green infrastructure but not trees), select a lower confidence score for monetary values (25% or 50%).

4.1.3 Asset performance

1) Pumping wastewater and surface water

The impact pathway

By reducing or attenuating runoff, BGI generally leads to lower volumes of water in combined systems, and therefore reduced flows to sewage treatment works (Figure 4.3). This reduction applies equally to surface water drainage. In pumped networks this results in savings from reduced pumping, primarily in terms of energy use, but also potentially in terms of reduced depreciation and maintenance.

Figure 4-3 Impact pathway for pumping

Method of assessment

There are three approaches to assessing benefits in this category.

- Use AP1-P1 if you have already assessed the impact on pumping stations.
- Use AP1-P2 to estimate the impact on energy use per year for pumping stations (wastewater or surface water) if information is available about the pumps and run times where;

$$Energy\ use\ /\ yr = Pump\ kW\ rating \times Pump\ run\ time\ per\ year$$

- Use AP1-P3 to estimate the impact on energy use per year for pumping stations if information is available about the pumped flows and run times where:

$$Energy\ use/yr = \frac{\begin{pmatrix} Allowance \\ for \\ pump\ motor \\ size \end{pmatrix} \times \begin{pmatrix} flow \\ rate \end{pmatrix} \times \begin{pmatrix} Pump \\ run \\ time \\ per\ year \end{pmatrix} \times \begin{pmatrix} Est. \\ head \end{pmatrix}}{Efficiency\ factor}$$

Where:

- an increase of 5% is used to allow for the pump motor size; and
- an efficiency factor of 80% is used for the pumps which is typically conservative (a lower factor would increase the energy used).

Quantifying benefits

If the pump run time (hrs/year), such as from a hydraulic flow or quantity model and kW rating of the pump under both the baseline position and proposed options (AP1-P2) is known, the tool will automatically calculate the change in energy use (kW/year). If information about the pumps is not available, AP1-P3 provides support to estimate the kW reduction. Enter information related to pump flows (ltrs/second), run times (hours/year) and estimated head (metres) to determine energy use.

Monetary values

The tool automatically values the change in energy use. Select a fuel type and energy tariff type (e.g. residential, industrial) and an energy rate (low, medium or high) (Decc, 2018). See Annex F but note that this provides low and high projections dependent on world markets, energy security, etc., rather than energy price forecasts). Energy values use long run variable costs, as discussed in Section 4.1.4.

In addition, to estimate the value of carbon impacts associated with the change in energy use, select an appropriate traded price of carbon (low, central or high), as discussed in Section 4.1.5.

Avoiding double counting

The energy price projections provided by the government (Decc, 2018) relate specifically to energy use and do not overlap with other benefit categories. Double counting may occur if the impact on the downstream system, such as a WwTW is assessed, and the downstream system contains further pumping stages. To avoid double counting, ensure these pumps are not included in the pumping assessment or only use the gravity assessment in the '*treating wastewater*' section. Aside from this, the risk of double counting in this category is considered to be *minimal*.

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty that the scheme will actually deliver the estimated pumping benefits. If using known pump Kw rating and run times, select a higher confidence score (75% or 100%). If using estimates with only the flow rates known, then a lower confidence score may be appropriate (50% – 75%).

The monetary values come from a reliable source (Decc, 2018) based on actual market data and projections. Therefore, use a confidence score of 100%.

2) Treating wastewater

The impact pathway

By reducing or attenuating runoff, BGI can reduce the volume of surface water to be treated (**Error! Reference source not found.**4). For example, NFM may hold up or reduce flows entering a combined system leading to treatment. This results in savings from reduced treatment, such as better treatment efficiency, reduced nutrient removal or compliance with legislation (e.g. Urban Waste Water Treatment Directive, UWWTD).

Figure 4-4 Impact pathway for wastewater treatment

N.B. It is expected that a change in flows to works, and associated reduced treatment, will only occur for a retrofit or redevelopment scheme.

Method of assessment

There are two approaches to assessing benefits in this category.

- Use AP2-TW1 where an assessment of the impact on treatment due to reduced flows is known; and
- Use AP2-TW2 to estimate the impact by understanding the change in flows to the works.

Quantifying benefits

If the average flow (Ml/day) is known, under both the baseline position and proposed option (ST2), the tool can automatically calculate the quantified impact on treatment. It is important to enter both the baseline and proposed average flow to indicate the potential change in flows arriving at the treatment works.

The tool uses some typical Ofwat categories of works, enabling the user to select the most appropriate works category (3, 4 or 6), size (large, medium or small), application (nutrient removal or UWWTD) and whether the works are gravity or pumped. The tool uses three Ofwat category works to cover the broad range of WwTW and Table 4-4 provides information to help select the appropriate size. AP2-

TW2 requires the daily average volume (including storm flows) in the baseline position and proposed option. Obtain this by using a hydraulic model to predict the flows to treatment.

Table 4-4 Wastewater treatment works Ofwat categories used in the tool

Works Ofwat Category	Size	Application		Typical PE range
6	Large	Urban	Nutrient Removal	> 150k
6	Large	Urban	UWWTD	> 150k
6	Medium	Urban	Nutrient Removal	75-150k
6	Medium	Urban	UWWTD	75-150k
6	Small	Urban	Nutrient Removal	< 75k
6	Small	Urban	UWWTD	< 75k
4	Medium	Rural	Sensitive receiving water	> 5k
4	Medium	Rural	UWWTD	> 5k
4	Small	Rural	Sensitive receiving water	< 5k
3	Small	Rural	UWWTD	< 5k

Monetary values

The tool automatically values the change in treatment based on the volume difference between the baseline position and proposed option. The tool uses monetary values based on proprietary models for a ‘Unit Cost of Treatment’ (simplified further for this application) with the size of the works (defined by the population equivalent) related to a generic treatment works. This means that small changes at small works will not lead to a significant, monetised benefit. The costing models for which the tool predicts values include operational costs (staff, chemical and maintenance), energy and carbon. Energy and carbon costs are estimated in the same way as for other impact categories (i.e. using the long run variable costs of energy and the traded or, for process emissions, the non-traded price of carbon respectively), whilst other costs are assumed to be constant.

Avoiding double counting

Double counting may occur if the WwTW includes pumping and this forms part of the pumping impact. To avoid double counting, ensure pumps in the WwTW (e.g. at the inlet) are not included in the pumping assessment or only use the gravity assessment in this category. Otherwise, the risk of double counting in this category outside of these impacts is considered to be *minimal*.

Confidence scores

Scores for AP2-TW1 will depend on the knowledge of the accuracy behind the values used. In AP2-TW2, the volumes that generate quantities should range between 50 and 75% as it uses a generic model. Where there is greater confidence in the volumes to treatment, e.g. through modelling, then 75% is appropriate. Monetary values typically use Government data and projections (Decc, 2018), therefore 100% is appropriate, since this is the best available data.

4.1.4 Biodiversity and ecology

The impact pathway

There are a number of BGI components that can make a significant contribution to the biodiversity (ecological) value of an area (e.g. river and floodplain restoration, green roofs, ponds, swales, basins, wetlands, trees). Figure 4- shows the potential impact of BGI on biodiversity.

Figure 4-5 Impact pathway for biodiversity

Method of assessment

There are two approaches to assessing benefits in this category. Complete only one section:

- Use BE1 if you have already assessed the present value benefit of the change in biodiversity and ecology.
- Use BE2 if you need to estimate the impact of the proposals on the ecology and biodiversity.

Where possible, undertake an ecological assessment of the proposed scheme. This doesn't have to be detailed or expensive – a simple and quick walkover assessment by a suitably experienced ecologist should be adequate for identifying and assigning 'value' to existing habitats, and how this may change as a result of the proposed schemes.

Information on statutory designated sites of international or national value (e.g. SSSI, SAC, SPA, Ramsar) is available in the form of web-based data (www.magic.gov.uk), which provides accurate locations and descriptions of these sites.

Quantifying benefits

For both BE1 and BE2, there are two separate tables – one for the baseline position and one for the proposed option. For new developments, complete both the baseline position and proposed option tables. For retrofit schemes, only complete the proposed option table.

For each table, enter one row for each type of habitat present within an area of the site. It is important to keep this categorisation of habitats as simple as possible, so record only the *dominant* habitat within a location. To account for the possibility of more than one habitat type being impacted by the scheme, multiple tables are included in the tool under BE2.

For BE2, you need to input the area (hectares) of different habitat types recorded before and after the BGI scheme.

Monetary values

Because of the intrinsic complexity of ecology, applying any monetary value is very difficult and research is still ongoing. However, the systematic review of the available monetary evidence (see 'Review of Sources') indicates some useful work, particularly Christie et al (2011), and Table 4-5 shows the most appropriate monetary values from this study, in terms of willingness to pay for creation or improvement of a range of habitat types (based on UK NEA, 2011). Since the tool only includes these values, there is further functionality within the values library to add in user-defined values that will appear in the tool if added. Select the value for the dominant habitat type that will be improved as a result of the scheme.

Table 4-5 Values for biodiversity improvements

Dominant habitat type (UK NEA, 2011)	Value (2014 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Arable margins		14.78		£ /ha / year	Christie et al (2011), reported in Environment Agency (2018a)	Select the value for the dominant habitat type that will be improved as a result of the scheme.
Blanket bog		302.61				
Hedgerows		117.01				
Limestone pavement		152.36				
Low calc grassland		23.85				
Low dry acid grass		6.25				
Lowland heath		190.24				
Low hay meadow		96.41				
Purple moor, grass		251.12				
Upland calc grass		58.43				
Upland hay meadow		36.68				
Upland heath		162.99				
Coastal floodplain		235.25				
Fens		26.14				
Lowland raised bog		57.93				
Wet reed beds		165.05				
Native woodland		268.62				
Arable fields		2.42				
Improved grassland		36.34				

Avoiding double counting

It is possible that values for biodiversity include elements of value partly covered by the amenity, recreation and water quality categories. This is because people derive a variety of benefits from ‘green’ or environmentally important places and find it hard to differentiate between their motives and reasons for enjoying such places. As a result, the risk of double counting is moderate, and care should be taken when combining valuation here with the amenity, recreation or water quality categories. Only undertake a valuation in more than one of these categories where the benefits derived would be truly additional.

Confidence scores

The confidence score for biodiversity relates to certainty of existing land use, reliability of data used to assess the baseline position and the expertise applied in predicting development or creation of new habitats.

For example, if the area currently consists of only hard-standing areas or mono-culture amenity grassland, then it is appropriate to apply a higher level of confidence to the base position (e.g. 75% or 100%). If however, existing habitat is present (for example unmanaged grass verges), then the confidence level is likely to depend upon the level of ecological expertise applied to the assessment. So, if an experienced ecologist is undertaking the assessment, then a higher level of confidence could be applied (75%-100%), whereas if this is done by a lay-person, a lower confidence level may need to be selected (50% or lower).

For the proposed scheme, ecological expertise will also affect the confidence level. So, if an experienced ecologist is involved in the assessment and subsequent design of the BGI scheme, then a higher confidence level could be applied.

The monetary values available in this category are limited but from a robust study, although it may be difficult to relate these clearly and unambiguously to BGI measures. Therefore, we suggest a confidence score of 75% to the monetary value.

4.1.5 Building temperature

The impact pathway

Some BGI components, particularly green roofs and trees, can moderate the temperature of buildings, helping to regulate thermal comfort by offering a shading/cooling effect in summer and insulation in winter. This can reduce the need for mechanical ventilation/air conditioning and reduce energy costs. For example, a 10% increase in tree canopy could reduce expected surface temperatures in the urban area by 2.5^{0}C (Gill et al, 2007). However, a review of available approaches indicated that assessing the general air temperature changes is difficult. If a detailed study is undertaken, then a 'user defined' benefit can be used to capture the monetary benefit (for example to health or a reduction in energy usage). This impact focuses more on local impacts on buildings using green roofs. Figure 4-6 shows a possible impact pathway.

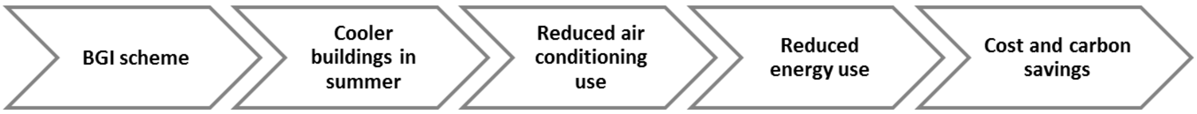


Figure 4-6 impact pathway for building temperature

The heating and cooling impact by trees on properties is highly variable as shown through various 'tree' guides in the US, depending upon the position of the tree, how far away from the house and type. Due to this level of complexity, and the individual relationship of one tree to a property, it has not been included for assessment at this stage. However, as an indication of possible savings, Rawlings et al (1999) (cited in eftec, 2013) found that the sheltering effect of trees could save between 3 and 9 per cent of energy bills, depending on local conditions and context.

There is evidence that green infrastructure, including BGI can have a cooling effect on the environment generally (i.e. not just buildings), contributing to reduced health stress and other benefits. For example, ten Brink et al (2016) find an average temperature reduction of 1 degree Celsius for an urban park compared with a non-green site, whilst Defra (2017) cites evidence suggesting that parks greater than 3ha in size exert a cooling effect on the surrounding area (100m buffer) of 0.52 degree Celsius. Trees are particularly important and can cool cities by between 2 and 8 degrees Celsius (Doick and Hutchings 2013). However, there is insufficient evidence at the current time to robustly link BGI interventions to specific temperature change. Therefore, this impact should only be considered where a detailed assessment is required, and bespoke information is available.

Method of assessment

The tool supports two levels of assessment:

- BT1 – if an assessment is completed of the annual energy savings (Kw/year) for heating and cooling; and
- BT2 – provides support to estimate the impact of green roofs and trees on energy use in buildings.

BT1 calculates the benefits based on the kW/year saved, the proportion of gas/electricity used (estimated by the user) and the associated carbon saving.

BT2 calculates the energy benefits through estimating the change in energy use provided by a green roof on properties, following the approach applied by CNT (2010). It is based on the number of heating or cooling degree days and the potential thermal properties of roofs using the following equation:

$$Energy\ reduction = \frac{Green\ roof\ area}{kWh\ to\ Btu} \times \left(\frac{dd \times 24}{R\ roof} - \frac{dd \times 24}{R\ green\ roof}\right)$$

Where:

- Btu = British Thermal Units

- kWh to Btu = conversion rate
- R = a measure of thermal resistance where R is assumed for (Clark et al, 2008):
  - conventional roofs = 0.585 m^2 °C h / btu
  - green roofs R = 1.208 m^2 °C h / btu
- dd = Degree days = heating or cooling degree days (in °C) and supporting information can be obtained for UK Weather Stations from the University of Oxford's Building Energy Monitoring Tool or other sites such as Degree Days (http://www.degreedays.net/). Note careful selection of sites is required regarding quality of data.

This approach considers that the existing roof has specific properties and may not be insulated to current standards or requirements.

Quantifying benefits

For green roofs, enter the green roof size for buildings using air conditioning (m^2) and the annual number of heating and cooling (using air conditioning) degree days. Enter the type of energy used (gas or electricity) and where unsure about the type of energy used, assume a 50:50 split between gas and electricity.

Monetary values

The tool automatically calculates the change in energy use based on the long-run variable costs (LRVC) of energy supply, rather than the retail price. Using the retail price would introduce distortions, since it includes fixed costs and transfers between groups in society. Decc (2018) provides LRVC estimates.

Select a fuel type, an energy tariff type (e.g. residential, industrial) and an energy rate (low, medium or high). An illustration of the LRVC (central estimate) for electricity and gas from 2018 until 2030 is shown in Figure 4-7. The tool uses the 2030 rate for any future years beyond this period, since this remains unchanged in the LRVC estimates.

In addition, to estimate the value of carbon impacts associated with the change in energy use, select an appropriate traded price of carbon (low, central or high). Section 4.1.6 discusses the traded price of carbon further.

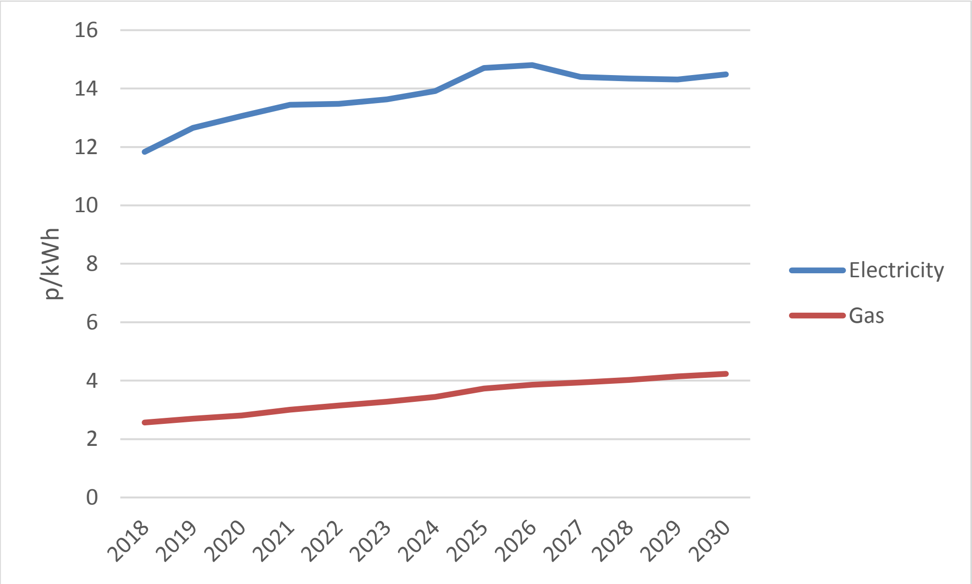


Figure 4-7 Long run variable costs of energy (source: Decc, 2018)

Avoiding double counting

The energy price projections provided by the government relate specifically to energy use and do not overlap with other benefit categories. The risk of double counting in this category is therefore considered to be *minimal*.

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty that the scheme will actually deliver the estimated energy savings. If this has been modelled, select a higher confidence score (75 or 100%). If it based on estimates, then a lower confidence score may be appropriate.

Although the monetary values related to energy costs come from a reliable source and are based on actual market data, they are projections only and therefore a confidence score of 75% is suggested.

4.1.6 Carbon reduction and sequestration

The impact pathway

BGI components can lead to a reduction and/or sequestration of carbon. Other categories cover the *reduction* of carbon and the associated methods of assessment, and include:

- Reduced surface water pumping, wastewater pumping/treatment, leading to reduced energy use and associated carbon emissions (NB: Asset performance: '*Pumping wastewater and surface water'* and '*Treating wastewater'* categories consider such carbon benefits);
- Embodied carbon (avoided) because of reduced consumption (e.g. due to rainwater harvesting) (NB the Quantity of water: '*Rainwater harvesting'* category considers carbon benefits); and
- Building Temperature: Cooling/shading of buildings, leading to reduced energy use and associated carbon emissions (NB the '*Building temperature'* category considers carbon benefits).

Carbon sequestration impacts include sequestration of carbon by newly planted trees and other vegetation, and the creation or restoration of floodplains. Figure 4-8 shows a possible impact pathway for carbon sequestration.

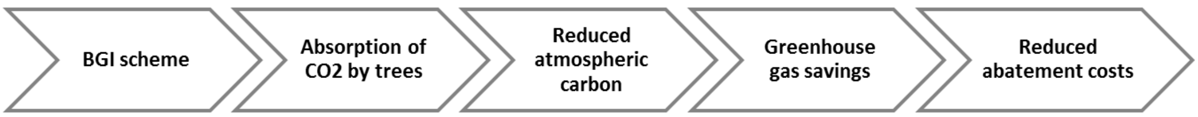


Figure 4-8 Impact pathway for carbon

It is important to note that, since the tool focuses on estimating the *benefits* of BGI, it does not include or take account of the *costs* associated with carbon, such as those embodied in capital investment. These are generally included in carbon costing tools used widely by water companies and others.

Method of assessment

There are four approaches to assessing benefits in this category.

- Use CS1 if you have undertaken an independent or more detailed assessment of carbon sequestration as a result of planting.
- Use CS2 if you require support to assess the carbon sequestration from trees planted as part of the scheme.
- Use CS3 if you require support to assess the carbon sequestration from restoring flood plains.
- Use CS4 if you have assessed the amount of carbon for woodlands (e.g. using the Forestry Commission Woodlands Carbon CO_2De Calculator) and wish to estimate the monetised value.

For carbon reduction, values are determined using Government data (HM Treasury, 2013) tables to convert energy avoided to carbon for example for gas and electricity using long run marginal emission factors.

The i-tree design tool (http://design.itreetools.org/) has been used to approximate the amounts of carbon sequestered by trees of different type and size, under different conditions and over a range of different lifespans. Although this tool was developed in the United States, tree types specific to the UK and in locations with a comparable climate have been used.

The four categories of tree type are:

- Small deciduous, e.g. Wild Cherry, Crab Apple
- Medium deciduous, e.g. Willow, Hawthorn
- Large deciduous, e.g. Birch, Poplar
- Conifer, e.g. Norway Spruce, Scots Pine

The carbon sequestration impact of each of these has been modelled for a range of evaluation periods, up to and including 60 years. Should you wish to use a longer period, a more detailed assessment should be undertaken.

This approach replaces that based on the SMUD Tree Benefits Estimator (SMUD, 2015) and used in previous versions of B£ST. The values derived from the i-tree design tool and used in B£ST should be applied where CS2 is used to estimate the carbon sequestration impacts of planting additional trees specifically associated with the scheme (i.e. not including planting that would have occurred anyway).

B£ST also allows you to include the sequestration benefits from floodplain creation/restoration (CS3). This is based on Zehetner et al. (2009), which found that floodplains can act as a carbon sink by protecting carbon-storing soil. They can rapidly accumulate carbon during the initial 100 years of floodplain soil formation, with rates exceeding 100g per m^2 per year (= 1 tonne of carbon per hectare per year). According to the CCC (2018), floodplain and peatland restoration could reduce net emissions by between 24% and 42% by 2050. This increases to 58% if partial rewetting is included.

Where CS4 is used to estimate the impact on carbon of BGI approaches that include the creation of woodland (in either rural or urban areas), the Forestry Commission's (2018) Woodland CO_2De Calculator provides a simple and detailed approach to estimating the net carbon (https://www.forestry.gov.uk/forestry/infd-8jue9t).

Quantifying benefits

The amount of carbon reduced is automatically calculated. The user identifies the sector type that is most appropriate to the impact by the scheme in each case. Insert the number of trees planted for each tree type, and/or the area of floodplain (ha) created/restored and the tool automatically calculates the amount of additional carbon sequestered per year. For woodland, enter the net carbon over the selected time frame (taking account of any harvesting) and B£ST can calculate the monetary value. When requiring a more detailed estimate, use tools such as i-tree eco, which allow estimates of carbon sequestration for small, medium and large trees (broadleaf deciduous, broadleaf evergreen and conifer evergreen) to be generated (https://www.itreetools.org/eco/).

Monetary values

According to UK government guidance on carbon valuation in policy appraisal (https://www.gov.uk/government/collections/carbon-valuation--2), changes in emissions in the traded sector (i.e. covered by the EU Emission Trading System (EU ETS)) should be valued at the **traded carbon price**, whereas changes in emissions in the non-traded sector (i.e. outside the EU ETS) should use the **non-traded carbon price**. Since reductions in carbon are generally associated with energy use, monetary values here are based on the traded price. Sequestered carbon is based on the non-traded price. The traded and non-traded price of carbon is that which will enable the UK to drive sufficient abatement to meet the targets set out in the Climate Change Act (2008). Figure 4-9 shows the price of carbon over time (central estimate), with the traded price currently lower than the non-traded price. These converge by 2030 and increase steadily until late in the century.

The price of carbon is embedded in the tool with present values calculated automatically using the quantitative estimates provided by the user.

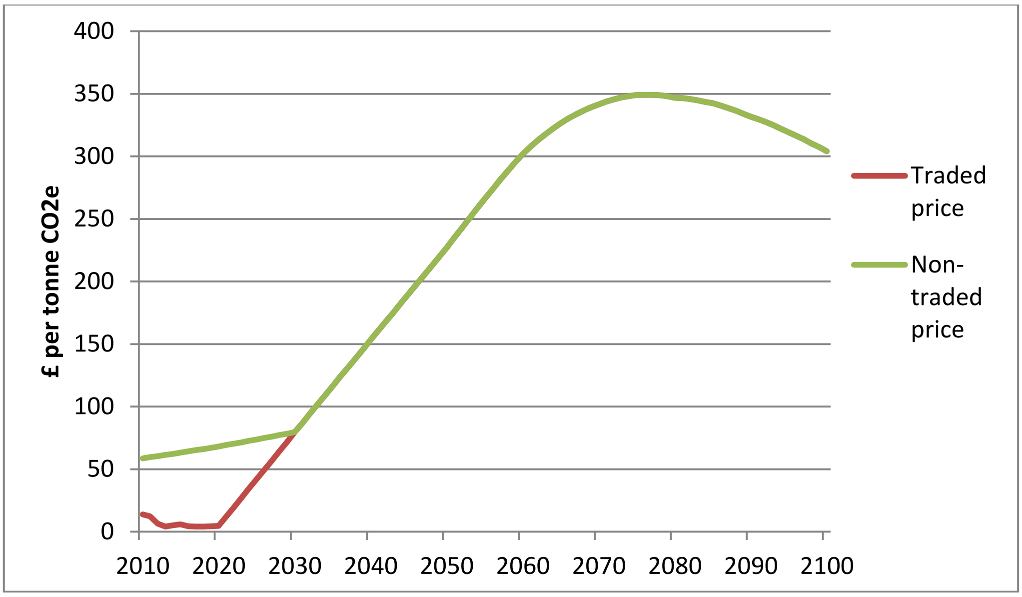


Figure 4-9 Price of carbon (source: Decc, 2018)

Avoiding double counting

The monetary values provided by the government represent the total value associated with changes to carbon emissions. As such, they are specific to carbon and are not expected to overlap with other benefit categories. The risk of double counting in this category is therefore considered to be *minimal*.

Confidence scores

When using this estimation for carbon sequestration of trees, consider using a confidence value of 50% to account for tree mortality and uncertainties related to the type and sequestration potential of trees. For shorter trees or those with a small canopy, 25% may be appropriate, whilst 75% could be used for larger trees or those with a large canopy.

For floodplain creation/restoration, there may be a risk that the land reverts to other uses (e.g. agriculture) that undermine its carbon sequestration potential in the future. Where future land use change is considered a risk, a low confidence score (25%) may be appropriate, otherwise consider using 75%.

For woodland creation, consider using a confidence value of 75% to account for some uncertainty in tree planting, thinning, mortality etc.

The monetary values come from a reliable source based on robust estimates of carbon abatement needed to meet UK reduction targets, apply a confidence score for the monetary values of 100%.

4.1.7 Education

The impact pathway

There is some limited evidence that BGI can play a role in extending or enhancing educational opportunities, enhance attention in classes, reduce absenteeism and improve behaviour, in schools or elsewhere. **Error! Reference source not found.**10 shows a potential impact pathway.

Figure 4-10 Impact pathway for education

Method of assessment

There are two approaches to assessing benefits in this category.

- Use Edu1 if you have undertaken an independent or more detailed assessment of the scheme's contribution to education.
- Use Edu2 if you require support to help calculate the scheme's contribution to education.

The assessment approach adopted here uses the number of additional nature-based school trips created by a BGI scheme to estimate the educational benefits provided by such trips. These trips can be to any location (within the school premises or externally) where learning about nature, catchments, flood risk, BGI and drainage (e.g. SuDS) plays a central role.

Quantifying benefits

To enable potential benefits in this category to be assessed, you should estimate the additional number of nature-based school trips that will be created because of the scheme. Ideally, this will be based on local evidence, consultation with schools in the area or an evaluation study.

Monetary values

There is currently only one source of monetary values to support assessment in this category. This is Mourato et al (2010) and is from the UK National Ecosystem Assessment. This is based on a 'cost of investment' approach. This will not provide an estimate of the welfare benefit of the knowledge gained in nature visits or projects but rather an indication of outlay that is made in its acquisition. Nevertheless, and given the current scarcity of valuation evidence in this category, we can assume that such investment would not be made unless it resulted in educational benefits, and the values from this study therefore provide a reasonable proxy to the welfare benefits delivered. Table 4-6 shows the values.

Table 4-6 Values for educational improvements

Context	Value (2014 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Cost of investing in nature-based school trips	15.94	20.16	24.38	£ per trip	Mourato et al (2010)	Use where new or enhanced BGI features are likely to lead to educational visits that would not otherwise occur.

Avoiding double counting

It is possible that any benefits in the 'Amenity' category may include some values related to education. However, this risk is low and the risk of double counting benefits is therefore *low*.

Confidence scores

Given the current scarcity of clear evidence relating to the impact of BGI on education, a low confidence score is likely to be appropriate for any quantitative estimate of benefits derived in this category (either 25% or 50% depending on the likelihood of such impacts occurring). Given the basis of the monetary evidence presented (related to the cost of investment rather than to welfare) a confidence score of 50% is recommended for the monetary value.

4.1.8 Enabling development

The impact pathway

By reducing the volume and flows of surface water runoff entering into the drainage/sewerage system, BGI can help to create more 'headroom' in the drainage network of a catchment or reduce downstream flood risk. This can allow land that would otherwise be unavailable for development (due to flood risk or lack of drainage capacity say in a combined sewer system) to become 'unlocked'. **Error! Reference source not found.**11 shows a potential impact pathway.

Figure 4-11 Impact pathway for enabling development

Method of assessment

There are two approaches to assessing benefits in this category.

- Use ED1 if you have already estimated the present value benefit in this category.
- Use ED2 where additional support is required for a quantitative assessment.

You should take care to ensure that any benefits estimated in this category are not also reflected in reduced costs of the scheme (e.g. because of avoided or deferred investment in infrastructure), since including both would lead to double counting.

Where the ED2 approach is followed, consider the following:

- The process by which additional land will become available (e.g. a specific drainage scheme that creates the capacity in the drainage network to enable development);
- The amount and location of land that could become available;
- The potential uses of this land and associated values;
- Timing, and the anticipated date when the land could become available (note this is likely to be a one-off, rather than an annual, benefit); and
- Other factors/barriers that may be relevant to enabling development.

Quantifying benefits

To complete a quantitative assessment, you will need to include an estimate of the value of land that could become available.

Monetary values

There are no monetary values to support assessment in this category. You will therefore need to use local evidence or a bespoke evaluation study.

Avoiding double counting

The benefits in this category most likely relate to avoided spend on new drainage infrastructure, through created headroom enabling a development to connect into the drainage network. Benefits estimated in this category may include some element of benefits related to 'economic growth'. However, if no monetary assessment of '*economic growth'* is undertaken, the risk of double counting benefits in this category is limited.

Confidence scores

If you are confident that the impact identified will materialise, and specific local evidence is used, a high confidence score (75% or 100%) may be appropriate. Otherwise, given the lack of clear evidence relating to the impact of SuDS and NFM on enabling development, attach a low confidence score to any estimate of benefits derived in this category (either 25% or 50% depending on the assessment of the likelihood of such impacts occurring).

4.1.9 Flooding

The impact pathway

BGI can reduce flood risk in different ways. Reducing flood risk is the primary objective of NFM schemes (EEA, 2017). One of the functions of SuDS is to manage rain as close as possible to where it falls, reducing the volume and flows of runoff entering the drainage system. Depending upon the design, conveyance and storage techniques, this can reduce the frequency and/or severity of flooding if the scale and size of the measures can accommodate larger rainfall events. This in turn leads to a number of benefits (e.g. reduced damage to property, avoided stress and anxiety), as Figure 4- shows.

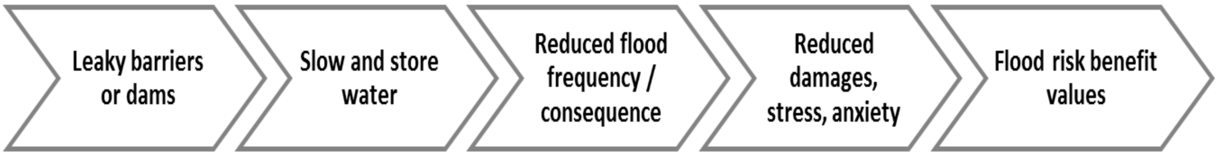


Figure 4-12 Impact pathway for flooding

Note that, whilst flooding is essentially a water quantity issue (see Section 4.1.14), it has its own category in the tool because of the importance of reducing flood risk in schemes involving BGI.

Benefits assessed in this category may be permissible for inclusion in GiA funding applications (see Box 3-2 below where BEST is being used to support a GiA application). Nevertheless, it is advisable to discuss and confirm this with the relevant stakeholders and funding bodies at the earliest opportunity.

Method of assessment

The assessment of benefits in this category will be made considerably easier by modelling the flood risk before and after (drainage interventions). Indeed, it is likely that an assessment based on modelling will have been undertaken where funding for flood risk reduction is being sought. Where no modelling is available, apply engineering judgement based on knowledge of previous flooding to estimate the potential degree of flood risk reduction in terms of the number/type of properties and other buildings, and the change in frequency of flooding.

The tool is designed to accommodate either of these using the following approaches.

- Use F1 if you have already completed a property damage assessment and calculated the present value (e.g. using the Multi-Coloured Manual).
- Use F2 if you are working with a water company and are considering willingness to pay approaches to assess the benefit.
- Use F3 if you have calculated the average annual damages for property and other areas but *have not* calculated the present value.
- Use F4 if you are using the government's FCRM (flood and coastal risk management) partnership funding calculator (PFC) to estimate the impacts.
- Use F5 to estimate wider impacts beyond property flooding (e.g. on travel disruption, intangible health effects).

In certain circumstances, it may be appropriate to combine these approaches. For example, estimating the benefits of flood protection up to a certain standard (e.g. 1 in 20) using the F1 method, and estimating further benefits from exceedance management (e.g. beyond 1 in 20 and up to 1 in 100) using F2 or F3. However, where this is the case, take care to consider the benefits to any individual property/building only once, so as to avoid double counting the benefits.

Quantifying benefits

Where there is a completed flood risk assessment for the scheme, no further quantification of the benefits should be necessary. Proceed straight to valuation. If, however, there is no such modelling or assessment work, provide an estimate of:

- The number of properties of different types at reduced risk;
- The change in risk (flood frequency);
- Any quantitative information relating to non-property impacts (see below); and
- The reduction in time lost by people through flooding (an estimate of the number of people and time).

Environment Agency (2017a) reviews the flood risk benefits from NFM schemes. It concludes that a useful metric for quantifying and comparing this benefit is m^3 water stored, although it recognises that each m^3 storage has a different impact depending on where it is placed within a catchment.

Even where a completed flood risk assessment exists, consider other potential impacts of flooding, e.g. non-residential properties. These are generally harder to estimate, such as loss of business, but can be significant, and may encompass the commercial and retail sectors, other private or public operations (e.g. schools), transport routes/networks and productive land (e.g. agricultural). To help capture such values, e.g. through disruption and time lost, F5 enables an estimate of time to be included.

Monetary values

Values to support assessment in this category need to be obtained from external sources such as the Multi-Coloured Handbook (FHRC, 2018) (for F1, F3 and F4) or the water company's WTP results (for F2). *Note that these values, even if assessed separately elsewhere, will need to be added to the tool to help provide a complete picture of the full range of benefits.*

It is important to note that approaches based on damage costs (F1, F3 and F4) relate predominantly to the physical costs of damage caused by flooding (e.g. to property). As such, they tend to be somewhat lower than those obtained using water company WTP surveys (F2), which encompass a wider range of values (e.g. distress) and motives (e.g. altruism – values of people not affected by flooding but concerned about its impacts on others). However, a further consideration is that water company WTP values have been obtained from a broad population base (all customers within that water company boundary). If this population is greater than that which is likely to benefit from the scheme, this may result in an overestimate of benefits.

The choice between using damage cost and WTP values will probably come down to data availability for the scheme, and the funding stakeholders' requirements. However, where different values are available, it is advisable to consider the impact on the result by applying more than one value (see Section 6 on Sensitivity Analysis). In addition, the risk of overestimation can be minimized by only applying the available values to those impacts (e.g. number of properties) that are likely to see a direct and tangible benefit.

Box 4-2: Using the MCM and Partnership Funding Calculator (F1, F3 or F4)

A common approach for valuing flood risk is that based on the UK's Multi-Coloured Manual (MCM) and Handbook (FHRC, 2018). This license-based software is often used for estimating damage to residential and non-residential property. It can also be used to value other impacts of flooding, including vehicle damage, infrastructure networks and recreation.

If using the MCM to help complete an assessment using F1 or F3, you need to ensure that any impacts assessed and included are not additionally assessed in other B£ST categories. At present, this risk mainly applies to recreation, although future versions of the MCM may also encompass tourism and health. This is shown in the table below.

Impact considered in MCM	Relevant B£ST category	Potential for overlap
Property damage	Flooding	High, but F1 and F3 designed to include outputs from MCM
Emergency cost	-	None. Can be included in F1 or F3
Infrastructure	-	None. Can be included in F1 or F3
Transport	-	High, but F5 designed to be used to include outputs from MCM
Agriculture	-	None. Can be included in F1 or F3
Land use	-	None. Can be included in F1 or F3
Effects on business	-	None. Can be included in F1 or F3
Environmental impacts	Biodiversity and ecology Water quality	Medium. Can occur where these have been explicitly valued using MCM or supporting guidance (Environment Agency, 2010)
Social impacts	Recreation	High, where chapter 8 of MCM has been used to value these

Flood risk benefits to households calculated in B£ST may support the second of the four outcome measures (OMs) described in Box 3-1 (OM2– households moved from one category of flood risk to a lower category). Biodiversity benefits may support OM4 (statutory environmental obligations fully met through FCERM). Other outputs of B£ST may be most relevant to OM1 (average benefit to cost ratio of schemes delivering OMs).

Where B£ST is used to support an application for grant-in-aid funding using F4, you should ensure that any benefits included in the application are directly associated with the flood risk reduction scheme. Benefits related to a change in the flood risk category of households can be automatically input into the PFC (OM2) and the monetary value of these benefits can be included within F4. Benefits derived from the scheme and assessed in the 'Biodiversity and ecology' category may contribute to OM4. Benefits derived from the scheme and assessed in all other categories may contribute to OM1, which includes avoided damage to infrastructure, utilities, public health, etc. However, the rules relating to the PFC may change or be clarified in future, and you should discuss this at the earliest opportunity with the Environment Agency.

Some estimates of the annual average damage costs to property from flooding based on changes in a range of return periods are shown in Table 4-7 (Environment Agency, 2017a). These are provided for illustration only, and it is recommended that the values from modelled assessments developed according to the requirements of funders are added to the tool.

Table 4-7 Illustrative annual values (£) for flood risk improvements (2016 prices)

	Standard or protection (SOP) after intervention											
Existing SOP	**None**	**2 years**	**5 years**	**10 years**	***20 years***	**25 years**	**50 years**	***75 years***	**100 yrs**	***150 yrs***	**200 yrs**	**1000 yrs**
None	0	0	1,947	3,410	4,112	4,219	4,645	4,802	4,883	4,906	4,922	4,962
2 years		0	1,947	3,410	4,112	4,219	4,645	4,802	4,883	4,906	4,922	4,962
5 years			0	1,463	2,165	2,272	2,698	2,855	2,936	2,959	2,975	3,015
10 years				0	702	809	1,235	1,392	1,473	1,496	1,512	1,552
20 years					0	107	533	690	771	754	810	810
25 years						0	426	583	664	687	703	743
50 years							0	157	238	261	277	317
75 years								0	81	104	120	160
100 years									0	23	39	79
150 years										0	16	56
200 years											0	40

This is consistent with government guidance (HM Treasury, 2018) which states that "generic national Weighted Annual Average Damage (WAAD) estimates are available for broader-scale, high-level scoping analysis. These are national average, per property, annual damage estimates and have been developed for residential properties across flood events with different probabilities and levels of flood warning service. The estimates for an average house in 2017 prices range from the following:

- a property with no flood protection and no flood warning service – £5,054 per property, per annum
- a property with existing protection against a "1 in 200 chance" (0.5% annual probability) and no flood warning service of more than 8 hours – £39 per property, per annum."

The tool also includes some values related to non-property impacts for inclusion under F5. The evidence in this area is generally poor and the values are based on experience from specific events (e.g. the 2007 winter floods). Nevertheless, they provide an indication of the scale of impacts that could occur. Where no values are readily available for some of these other impacts that are nevertheless expected as a result of the scheme, they may be estimated using market values. For example, when expecting impacts on productive agricultural land, the value of these impacts can be estimated by multiplying the change in probability (e.g. number of additional 'flood free days' per year as a result of the scheme) by the value of the land. Value of land estimates can be obtained from the Government (https://www.gov.uk/government/publications/land-value-estimates-for-policy-appraisal-2017).

A further potential impact of flooding is on time, because of delays or disruption to transport. This will depend on several factors, including travel purpose (e.g. commuting), mode of transport and location. The approach to valuing travel time is currently being substantially updated by government (https://www.gov.uk/government/publications/values-of-travel-time-savings-for-business-travellers). In the meantime, the easiest way to account for this is to multiply the expected time gained (total hours) because of reduced flooding risk by the average hourly wage (£14.00) (Office for National Statistics, 2017).

The Multi-Coloured Handbook also includes a simple method for estimating the potential damage to vehicles as a result of flooding. This method "assumes that the total number of vehicles likely to be damaged during a flood occurring at any time of the day will equate to 28% of the total number of residential *and* commercial properties at risk (from a flood of any depth). Estimate the number of likely vehicles and multiply this by £3,100 (the value per vehicle, not the value of vehicles per household). This method does not require an assumption to be made on the presumed location of vehicles when a flood occurs". Enter such values (including other flooding impacts if not included overall in an assessment (e.g. in F1) in the user-defined section.

The Handbook also provides a recommended value for the assessment of indirect damages for emergency services and other third-party costs, expressed as a proportion of the direct property damages. This is 5.6% (low) to 10.7% (high) and can be applied where property damages have been estimated.

Finally, the Handbook also considers the intangible health benefits of reducing flood risk. A figure of £285 per property per year is advised (2013 prices), which can also be applied and included under F5.

Avoiding double counting

Values obtained from either damage cost or WTP approaches relate specifically to the benefits of flood risk reduction, and the risk of double counting is therefore considered to be *minimal*. The exception to this where the Multi-Coloured Handbook has been used to value other impacts (e.g. recreation). Where this is the case, it is essential not to also value these categories using B£ST.

Confidence scores

The confidence score relating to the quantitative estimate will depend on the completed level of supporting assessments. For example, if a flood risk assessment models *the change* in risk, select a higher confidence score (75%-100%). Where the change in risk or quantities entered is largely based on judgement, apply a lower confidence score (typically 50% or less).

For monetary values, if the valuation uses a reputable damage cost approach (e.g. the Multi-Coloured Handbook) or a water company WTP survey, *and* the population impacted is likely to be similar to that in the original survey, then select a higher confidence score (75%-100%). If this is not the case, or if a significant proportion of the impacts is not related to properties, select a lower confidence score (50% or less).

4.1.10 Health and wellbeing

The impact pathway

There is significant and growing evidence that BGI can have benefits for physical, emotional and mental health (Ashley et al, 2013) – classed in the tool as health and wellbeing.

Some tangible health benefits (e.g. reduced surface water pollution leading to reduced illness from eating contaminated seafood or swimming in contaminated waters) will be picked up in other categories (water quality in this example). For other health benefits, Figure 4-13 *shows* an example impact pathway

Figure 4-13 Impact pathway for health

Method of assessment

The key health benefits that can be assessed in this category relate to avoided health care costs as a result of increased physical activity, and the impact on emotional wellbeing associated with increased contact with nature. These can be assessed using the following methods.

- Use H1 where specific information is available, for example through an external assessment.

For physical health impacts where no external assessment is available, use either:

- H2A - Valuing the physical health impacts of new walking and cycling opportunities using the World Health Organisation 'Health Economic Assessment Tool '(HEAT, http://www.heatwalkingcycling.org/) – *this should be used to estimate the health impacts due to interventions that lead to an increase in walking and/or cycling*; or

- H2B – Estimating the impact of increased physical activity on avoided costs.

For emotional health impacts where no external assessment is available, use H3 - Impacts on emotional wellbeing brought about by certain BGI components.

In all other cases, the health benefits from BGI should be described in qualitative terms only (i.e. not quantified).

Quantifying benefits

When using the HEAT tool, estimate:

- The additional number of walking/cycling trips; and
- The average duration or distance of these trips.

The UK government recommends that adults should aim to be active daily. Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more (e.g. 30 minutes on at least 5 days a week). Currently, only around 6% of men and 4% of women achieve the recommended physical activity level (HSCIC, 2014).

The HEAT tool includes a number of default values to help calculate a quantified benefit, although it recommends replacing these by survey or site-specific recorded data where possible. Useful values include:

- A reference volume of cycling per person based on 100 minutes per week for 52 weeks per year at an estimated speed of 14 km/ hour (however, 124 cycling days/year is considered to be a more conservative estimate).
- A reference volume of walking based on 168 minutes per week at 4.8 km/hour.
- 71.5cm per step (walking) and 100 steps per minute (on average).

For an assessment of physical health benefits using H2B, a useful approach is to quantify the utilisation of outdoor space for exercise/health reasons, since this is one of the government's indicators in the Public Health Outcomes Framework. A useful data source is the Monitor of Engagement with the Natural Environment (MENE) survey, which can be used to help quantify changes in physical activity due to the scheme.

You should make conservative estimates of:

- The increase in population being active. For example, Mourato et al (2010) considers a scenario where an intervention (such as a BGI scheme) leads to a reduction of one percentage point in the population of sedentary people. In the UK, roughly 23% of men and 26% of women are estimated to be sedentary;
- The appropriateness of the activity (walking and/or cycling); and
- The likely length/duration of the activity. Use the local population numbers to help make a judgment.

The following information (cited in HM Partnerships, 2011) may be useful to help inform quantitative estimates of health benefits due to increased physical activity.

- Residents in high 'greenery' environments are 3.3 times more likely to take frequent physical exercise as those in the lowest greenery category.
- People with access to attractive and large public open spaces were 50% more likely to have high levels of walking.
- Where people have good perceived and/or actual access to green space they are 24% more likely to be physically active.
- Around 22% of recommended physical activity for the local population can be supported by a local park (BDP, 2015).

Quantitative estimates of emotional wellbeing benefits may come from a Health Impact Assessment (HIA), landscape assessment or similar. To estimate emotional health benefits using the tool, provide at least one of the following:

- Estimated additional numbers of people having a direct view over green space from house or regular place of work; or
- Estimated additional numbers of visits to local park or green space. Note that this can include any green space (e.g. garden, green roof, park, wetland) which people may visit more frequently as a result of the scheme. It is not necessarily related to scale/size of the space, since people can enjoy health benefits even from being in a small outside area.

Whilst the links between access to green space and emotional wellbeing are not well understood, Mourato et al (2010) provides some insight into the potential benefits:

- Having a view of green space from one's house increases emotional wellbeing by 5% and the general health utility score by about 2%;
- Using the garden weekly or more increases physical functioning and emotional wellbeing by around 3.5% and the heath utility score by 2.7%; and
- An increase in 1% of the area of freshwater within the 1 km radius of the home increases health utility by 0.3%.

Although there is limited evidence around health benefits to workers and visitors, the number of beneficiaries in these categories should also be estimated where significant benefits are expected to accrue to these groups. However, take care to avoid counting the same beneficiaries twice, so estimate the numbers of workers and visitors where they are *additional* to residents.

Monetary values

The HEAT tool calculates the monetary value of health benefits associated with additional walking and cycling activity. For example, it estimates that the annual physical health benefits to each additional person regularly walking or cycling (approximately 2-3 hours per week) are in the range €120 - €1,300 per walker/cyclist. At an aggregate level, the average benefit of 100 people starting to walk one kilometre per day is estimated to be £31,000 per year.

The monetary value of physical health benefits is provided by the Environment Agency (2017b) study (Table 4-8). This is based on an estimate of avoided local authority public health costs. Given that public health interventions need to demonstrate value for money (benefits greater than the costs), we can assume that the health benefits of reduced physical inactivity are at least as great as the value cited here.

For emotional wellbeing, use the most relevant monetary value in Table 4-8, using either the Fields in Trust (2018) or the UK NEA (2011) study.

Table 4-8 Values for emotional and physical health improvements

Context	Value (2017 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Emotional health benefit from increased use of local park or green space	8.47	15.77	22.83	£ per visit	Fields in Trust (2018)	Use low value where emotional wellbeing and life satisfaction are expected to improve. Use mid or high estimates for sensitivity only.
Having a direct view over green space from house/regular place of work (move from no view to having any kind of view)	151	329	506	£ per person per year	UK NEA (2011)	Use only where increase in number of homes adjacent to or with view of green space expected as a direct result of scheme.
Avoided local authority public health costs associated with reduced physical inactivity		2.50		£ per active visit	Environment Agency (2017b)	Use where a reduction in physical inactivity is expected as a direct result of scheme.

Avoiding double counting

Health impacts in this category refer to recreational and aesthetic health benefits, so there is no risk of double counting with the health benefits of improved air quality. However, although the values shown in Table 4-9 generally relate to specific health benefits, it is possible that they cover other benefits as well as those specifically related to health. The risk of double counting is *moderate*. Therefore, when valuing health benefits, only seek to assess and value benefits in the following categories where there is confidence that the benefits would be truly additional (or apply to different groups/populations).

- Amenity
- Recreation

Confidence scores

The quantitative confidence scores relate to the estimate of numbers. In the HEAT tool, without any local assessment, apply a 50% confidence score. Add this directly within the HEAT tool. Where it is possible to estimate the numbers of people or visits associated with improved physical or emotional health with a high certainty, apply a 75% to 100% confidence score.

For the monetised confidence score, assume a 100% value for walking and cycling in the HEAT tool. For other values, a confidence score of 75% is reasonable where the scheme context closely matches the evaluation study context. A lower score (25% or 50%) can be applied where this is not the case.

4.1.11 Noise

The impact pathway

A number of BGI components (e.g. trees, green roofs, green walls) with significant vegetation can have a positive effect on noise attenuation locally, particularly in areas where noise (unwanted sound) is an existing problem (i.e. in populated areas adjacent to transport corridors). This in turn can have an impact on health, wellbeing, productivity and the natural environment. An example of the impact pathway is shown in Figure 4-14.

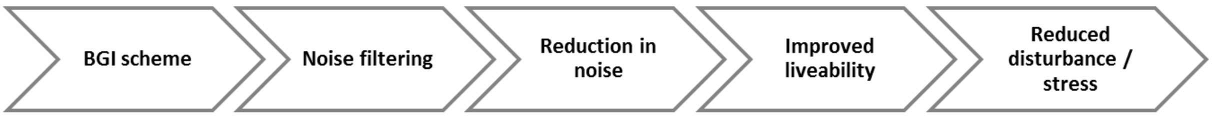


Figure 4-34 Impact pathway for noise

It is likely that noise attenuation benefits will only accrue in large retrofit or redevelopment situations, or in schemes implemented incrementally over time (or where it is reasonable to consider this will happen). Even then, the impacts are likely to be relatively small. The extent to which BGI components impact on noise attenuation will depend on a range of local factors, including the specific characteristics of the component or measure, their positioning relative to other structures, land form and sources of noise, the nature, quantity and size of nearby buildings, and so on. Therefore, the approach described here can only provide an initial estimate of the impact. Where the effect of noise is likely to be substantial or a decisive factor for a proposal, a more detailed and bespoke assessment may be justified.

Method of assessment

There are two approaches to assessing benefits in this category.

- Use N1 if you have undertaken an independent or more detailed assessment of the impacts of the measures on noise.
- Use N2 if you need support to estimate the value of reducing noise through the measures.

Information to support assessment in this category is available from the government (https://www.gov.uk/guidance/noise-pollution-economic-analysis).

According to this guidance, noise-related impacts can be broadly separated into four groups:

1. Amenity - the conscious displeasure of those exposed to the noise. At present two amenity impacts can be quantified and valued; sleep disturbance and annoyance.
2. Health - noise is associated with a range of effects on health. The three health effects currently valued are heart attacks, strokes and dementia.
3. Productivity - through distraction, fatigue and interrupting communication noise can have a negative impact on productivity. It is not yet possible to assess and value these impacts.
4. Environmental - noise can have a notable impact on the natural environment, for example noise may alter bird breeding patterns, disturb wildlife and damage sensitive ecosystems. At this time these impacts have not been valued. The effects of night noise, school attainment and other factors such as the value of quiet areas have not been fully quantified. These cannot be included in full appraisal, but it may be important to include these in future research.

When completing this section, you will need to provide an estimate of:

- The level of daytime and/or night time noise reduction because of the scheme (dB)
- The number of households expected to benefit from a daytime and night time noise reduction.

Quantifying benefits

There is limited information linking particular measures to noise reduction levels. However, the government has developed a strategic noise mapping dataset, and mapping based on this dataset is possible. Where a completed noise management study is available, the noise reduction estimates can be input directly into cells in the ‘Noise’ sheet. If not, the following information may be useful.

- In developing national accounts for the UK, eftec (2018) assumes that small patches of woodland (>200m^2 but less than 3,000m^2) provide a noise reduction service of 1dB.
- A study by ten Brink et al (2016) found the noise reduction potential of various green infrastructure is as follows:
    - Green roadside façade, 2-3 dB
    - Green wall inside courtyard, 4 dB
    - Green roof (ridge), 7.5 dB
    - Green roof (flat), 3 dB
    - Vegetated barrier on motorway bridge, 4 dB
    - Vegetated barrier on tramway bridge, 10 dB
    - Tree belt (at a distance of 50 m for a 15m deep tree belt), up to 6 dB
- Defra (2017) suggests each mitigated building lying within each 5dBA noise band will experience a 2dBA reduction in noise levels due to the presence of trees that cover an area >3,000m^2 and a 1dBA reduction in noise levels due to the presence of trees that cover an area <3,000m^2.
- The Forestry Commission estimates that planting "noise buffers" composed of trees and shrubs can reduce noise by five to ten decibels for every 30m width of tree planting, and this reduces noise to the human ear by approximately 50%.
- A study by Renterghem et al (2013) found that green roofs have the highest potential to enhance quietness in courtyards and may be able to reduce noise by up to 7.5 dB.

Monetary values

The value of noise mitigation from natural capital is significant. Defra (2018a) suggests the overall benefit provided by urban woodlands in terms of reduced road noise is around £245 million per year for the UK.

The government has developed a Noise Modelling Tool which converts changes in noise exposure to estimated monetary values. The values below come from this economic analysis and relate to marginal (small) changes in road, rail and aircraft noise, associated with the amenity, health and productivity impacts of noise. The values in Table 4-9 reflect the monetised impact of a single decibel change in household exposure in an average day/night period per year. You should take the value (or sum of values) that relates most closely to the noise reduction associated with the scheme being assessed.

The 'Total road' values include an element related to sleep disturbance, so in most cases the 'Sleep disturbance night time noise' values for road should not be added separately. These should only be used for detailed assessments and following the Defra guidance. This does not apply to rail or aircraft noise.

Table 4-9: Noise marginal values (£/hhold/dB, central values 2014 prices)

		Total road, rail and aircraft noise			**Sleep disturbance night time noise**		
Change in noise metric by decibel dB(A)		Total Road (inc sleep disturbance)	Total Rail (exc sleep disturbance)	Total Aircraft (exc sleep disturbance)	Road	Rail	Aircraft
From	To						
46	45	11.28	3.90	15.61	29.20	13.59	37.93
47	46	11.23	3.95	17.72	32.07	15.06	40.79
48	47	11.31	4.11	19.82	34.94	16.52	43.65
49	48	11.52	4.40	21.90	37.81	17.99	46.52
50	49	18.41	4.80	23.96	40.68	19.46	49.38
51	50	18.89	12.46	38.71	43.55	20.92	52.24
52	51	19.49	13.13	40.80	46.42	22.39	55.11
53	52	20.23	13.91	42.88	49.29	23.86	57.97
54	53	21.09	14.81	44.94	52.17	25.32	60.83
55	54	47.78	15.84	46.98	55.04	26.79	63.70
56	55	51.22	16.98	49.01	57.91	28.25	66.56
57	56	54.79	18.24	51.02	60.78	29.72	69.42
58	57	58.49	19.62	53.02	63.65	31.19	72.29
59	58	63.86	22.68	56.56	66.52	32.65	75.15
60	59	69.33	25.82	60.05	69.39	34.12	78.01
61	60	74.69	28.85	63.29	72.26	35.59	80.88
62	61	80.21	32.03	66.54	75.13	37.05	83.74
63	62	85.90	35.37	69.83	78.00	38.52	86.60
64	63	91.75	38.87	73.14	80.88	39.99	89.47
65	64	97.78	42.53	76.47	83.75	41.45	92.33
66	65	103.96	46.34	79.82	86.62	42.92	95.19
67	66	110.32	50.32	83.21	86.62	42.92	95.19
68	67	116.85	54.46	86.61	86.62	42.92	95.19
69	68	123.54	58.76	90.04	86.62	42.92	95.19
70	69	130.39	63.22	93.50	86.62	42.92	95.19
71	70	137.42	67.83	96.68	86.62	42.92	95.19
72	71	144.61	72.61	100.48	86.62	42.92	95.19
73	72	151.97	77.54	104.01	86.62	42.92	95.19
74	73	159.49	82.64	107.57	86.62	42.92	95.19
75	74	167.18	87.89	111.15	86.62	42.92	95.19
76	75	175.04	93.31	114.75	86.62	42.92	95.19
77	76	183.07	95.22	116.66	86.62	42.92	95.19
78	77	188.93	97.17	118.62	86.62	42.92	95.19
79	78	190.93	99.16	120.61	86.62	42.92	95.19
80	79	192.96	101.20	122.64	86.62	42.92	95.19
81	80	195.03	103.27	124.71	86.62	42.92	95.19

Avoiding double counting

Noise levels are likely to be associated with the general attractiveness and desirability of a place. Therefore, it is possible that benefits considered in the 'amenity' category may, depending on the context and location, capture some elements of noise and tranquillity. As such, it is recommended that an assessment in this category is only undertaken where a significant reduction in noise from a transport corridor is a key element of the scheme. In all cases, amenity and noise should not be valued separately or added together for the same population (i.e. households affected). Where noise impacts are assessed, impacts in the amenity category should not be assessed for the same households.

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty in what the scheme will actually deliver in estimated noise reduction benefits. For example, if the vegetation/trees are in a location that is currently afflicted by noise issues, and the area is used (heavily or frequently) by people that will see a noticeable change, select a higher confidence score (75%). On the other hand, if vegetation in the area is already plentiful, such that additional green infrastructure is unlikely to make much of a difference, or if the green infrastructure is dependent on other parties, therefore being less certain that a significant impact will occur, a lower confidence score may be appropriate.

Since the monetary values come from a reliable source and are based on robust survey data, the confidence score should be 100%.

4.1.12 Recreation

The impact pathway

A number of BGI infrastructure components can generate recreational benefits, particularly where these are specifically designed with a dual recreational purpose (e.g. river restoration, detention basins, wetlands, rain gardens, swales and planting trees). Figure 4-15 shows the potential impact of a BGI measure on recreation.

Figure 4-15 Impact pathway for recreation

Method of assessment

There are two approaches to assessing benefits in this category.

- Use R1 if you have specific values of recreational activities that are supported through the construction of the scheme.
- Use R2 to calculate some common recreational activities the scheme may enhance.

The delivery of benefits in this category depends on the extent to which the BGI scheme will provide or enhance the opportunity for recreation. This in part will also link to the attractiveness of the area (see Amenity 4.1.2). There will inevitably be some subjectivity in interpreting this, which is acceptable, but it is important to be explicit about this and to record any assumptions made. Where possible, obtaining visitor numbers will support the assessment.

Quantifying benefits

The key parameter needed to estimate in this category is the number of additional or enhanced recreational visits created because of the scheme. Often local research can indicate the number of visits currently being undertaken to help estimate the scale of change. As a guide, the total number of adult recreational visits to a locally important site (one which attracts visitors living within a few kilometres) generally ranges from 10,000 to 30,000 per year. The number of recreational visits to a 'honeypot' site (drawing visitors from several kilometres away) generally ranges from 60,000 to 250,000. A regionally important site may attract between 180,000 and 540,000 recreational visits per year.

Further guidance to support estimates of visitor numbers to green spaces of different types and in different locations can be obtained from MENE (Monitor of Engagement with the Natural Environment) (Natural England, 2017).

The choice of quantitative estimate should be partly guided by the availability of potential substitute sites (other recreational sites in the area) in detail. For example, where a number of potential recreational sites in the locality already exist, apply a low quantitative estimate. Where few or no substitutes exist, a higher quantitative estimate will be more appropriate.

Monetary values

There is considerable evidence to suggest people enjoy and value new or enhanced recreational changes that BGI can provide. Table 4-10 shows the values selected for use and are drawn from studies that are particularly applicable to the kind of recreational activities brought about by BGI in a UK context. They are generally based on either WTP studies, or on so-called 'travel cost' studies, which use costs as a proxy for the value to visitors of different recreational sites. Consider which one of the values in Table 4-10 most closely matches the scheme and record that value in the tool. The key thing to consider is whether the scheme, irrespective of its size, type or location, is likely to lead to an increase in recreational use of the type, or within the habitat type, listed. Further details around the context of these values are provided in the 'Values Library' within the tool. It is likely that other local values may be available or can be used in this category.

Table 4-10 Values for recreational improvements

Context	Value (2016 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Recreational benefits from constructed or restored wetlands	153	421	974	£/ha/yr	Hölzinger (2011)	Use where new or restored wetlands (areas that are moist during an extended period each year) are expected to result in more recreational opportunities.
Willingness to pay for additional angling visit (coarse)	-	4.86	-	£/visit	Defra (2007b)	Use where increased quality/quantity of water as a result of the intervention is expected to result in more coarse angling opportunities.
Willingness to pay for additional angling visit (game)	-	6.12	-	£/visit		Use where increased quality/quantity of water as a result of the intervention is expected to result in more game angling opportunities.
Value of general recreational visit (grassland, greenbelt, urban fringe & urban green space)	2.01	4.03	6.04	£/visit	Sen et al (2014), reported in Environment Agency (2018a)	Use where increased quality/quantity of green space is expected to result in more recreational opportunities.
Value of general recreational visit (freshwater & flood plains)	2.01	6.04	30.21	£/visit		
Value of general recreational visit (woodland)	2.01	10.07	19.13	£/visit	Christie et al (2006); Scarpa (2003); Sen et al (2014), reported in Environment Agency (2018a)	Use where increased quality/quantity of woodland is expected to result in more recreational opportunities.

Avoiding double counting

Although the values shown in Table 4-10 generally relate to specific recreational activities, it is possible that they cover other benefits as well as those specifically related to recreation. For example, values for walking and cycling are also included in the 'Health' category. Of course, walking and cycling could potentially deliver many different kinds of benefits, including health (physical and mental), recreation (spending time outdoors, with family, etc.) and many others. However, it is currently not possible to differentiate these effects.

The risk of double counting is considered to be *moderate*. Therefore, when valuing recreation benefits, only seek to assess and value benefits in the following categories when confident that the benefits would be truly additional (or apply to different groups/populations).

- Amenity
- Biodiversity
- Water quality
- Health
- Tourism

Confidence scores

The confidence score relating to the quantitative estimate will depend on the level of certainty in that the scheme will actually deliver the estimated recreational benefits. For example, if the area currently offers no or few recreational opportunities and the scheme includes specific design components that will facilitate recreation (e.g. cycle paths), then a significant improvement in this category could be expected so select a higher confidence score (75%). Where a completed detailed assessment is available, such as a recreational user survey, then a value of (100%) may be appropriate. On the other hand, if the area is already heavily used for recreation, such that additional BGI components are unlikely to make much of a difference, or if the scheme is dependent on other parties, then a lower confidence score may be appropriate.

If the context of the monetary values is similar to the scheme (i.e. similar types of components and improvements expected), select a higher confidence score for the monetary values. If the context is very different (e.g. a BGI that is in a mainly non-residential area), select a lower confidence score for monetary values.

4.1.13 Traffic calming

The impact pathway

BGI schemes can include measures directly or indirectly related to traffic calming (e.g. build outs such as bioretention areas). These can, in turn, deliver benefits such as reduced risk of road accidents or increased opportunities for street-based recreation. Whilst it is difficult to directly and robustly link BGI to traffic calming, Figure 4-16 shows a potential impact pathway.

Figure 4-16 Impact pathway for BGI and traffic calming

Method of assessment

The size of the benefits in this category will be site specific and it is difficult to specifically link measures to traffic calming. However, where an evaluation has taken place on the benefits of measures (e.g. road build outs), this can be included within TC1. Otherwise, use the information below to complete an assessment using TC2.

Quantifying benefits

Benefits in this category can be quantified using local evidence or an evaluation study (TC1). In other cases, use information from Public Health England & Institute of Health Equity (2018). This suggests that traffic calming measures typically lead to a 15% reduction in road traffic accidents. You will therefore need to obtain or estimate the annual number of accidents. Ideally, this should be broken down by those involving injury (fatal, serious and slight) and those involving damage only, using assumptions where necessary. Annual information on road traffic accidents is published by the government (for latest data available, see https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data).

Monetary values

The government publishes information on the economic value of road accidents (Department of Transport, 2016). These are summarised in Table 4-11. Only values for built-up roads (with a speed limit of 40 mph or less) are included, since these are most likely to be important to traffic calming schemes that include SuDS interventions.

Table 4-11 Average value of prevention of reported road accidents by road type

Accident Type	**Built-up roads (£ per accident, 2016 prices)**
Fatal	1,971,998
Serious	228,149
Slight	23,514
All injury accidents	67,924
Damage only	2,093
All accidents	**5,613**

Avoiding double counting

There is no risk of double counting benefits in this category.

Confidence scores

For quantitative estimates, use a higher confidence score (75%) where local evidence or an evaluation study has been used. Where this is not the case, a lower score (50%) may be appropriate.

Monetary values are based on high quality evidence from a reliable source, so a score of 100% is appropriate and recommended.

4.1.14 Water quality

The impact pathway

A primary function of BGI is to help improve the quality of water discharged from land or drainage networks. This can improve the quality of the receiving water body such as streams, rivers, lakes, bathing or shellfish waters. Furthermore, where BGI reduces flows entering combined sewers, this can lead to reduced combined sewer overflow discharges, again improving the quality of the receiving water body. BGI schemes can also reduce soil and nutrient pollution, reducing sedimentation and improving the quality of waterbodies, e.g. using grip blocking in peatlands or buffer strips next to watercourses. Such water quality improvements (or prevention of deterioration) can lead to a number of benefits including aesthetic, health (e.g. reduced risk of infection from bathing) or enhanced opportunities for wildlife and biodiversity (Figure 4-17).

Figure 4-17 Impact pathway for BGI and water quality

Method of assessment

WQ1 allows the entry of values from a completed assessment outside of the tool that may be relevant to a funding stakeholder. This includes cases where the Environment Agency's Water Appraisal Guidance (WAG) has been applied (Environment Agency, 2013b). WQ1 can also be used to include the impact of BGI schemes where management of catchment impacts and improvements to water quality result in avoided costs at wastewater treatment works (e.g. reducing the need to achieve tighter phosphorous limits). Where this is the case, these impacts should not be included in the 'treating wastewater' category (Section 4.1.3).

WQ2 provides support to estimate the impact of changing water body classification, which is based on the definitions in Appendix E.

Assessing the impact BGI may have on water quality can be difficult. Avoid assuming schemes will deliver significant water quality benefits, for example over several kilometres or hectares without sound evidence and following best practice. In general, small schemes/changes are unlikely to lead to significant or identifiable improvements in water quality. Where it is a small scheme, it may be appropriate to consider the contribution it may make as part of larger catchment schemes, for example by taking a proportion of the overall length or area of improved watercourse.

Wherever possible, use a dynamic water quality model replicating the impact BGI may have on reducing pollutant loads discharged directly (e.g. the surface water through the NFM) or indirectly (e.g. reducing combined sewer overflow spills). This may also include modelling the receiving water, to understand the impact and potential change in classification. For example, a SuDS retrofit scheme that significantly reduces the pollutant load discharged from CSOs and directly from the storm water discharges may not change the water course status, because the receiving water quality is so poor that significant other changes in the catchment need to take place upstream before a change in status can occur.

Table 4-12 Hierarchy of assessment approaches

Assessment approach	Points to consider
Integrated water quality catchment modelling that predicts the change in water quality and the change within or between Water Framework Directive (WFD) class	• Does the modelling indicate a significant change in water quality?
Modelling that indicates the pollutant loads and the impacts a scheme may have	• Does the modelling indicate a significant change in water quality?
Flow only modelling in the water bodies and drainage network or catchment	• What are the flow proportions and how do they change? If the proportion of flow entering is small compared with the watercourse flow, impact will be small or minimal.
Flow only modelling in the drainage network or catchment	• Is it possible to estimate the relative change in flows and the flow in the watercourse or waterbody as a result of the scheme?
Estimate the change in surface area connected to drainage systems and the contributing area to the water body	• Assess the change in contributing area of the scheme as a proportion of the overall area. Will it make a noticeable difference to the watercourse or waterbody flows and potential pollutant loads?

Table 4-12 provides a hierarchal assessment to indicate potential ways to estimate the impact a BGI scheme may have, with the confidence reducing as the assessment method and data requirements become simpler, less stringent and less evidence based respectively. Nationally available information, such as the *Reasons for Failure* (contact the local environmental regulator) will indicate the status of each water body and why it is failing. This provides a sound starting point, along with discussions with local environmental regulators to understand the issues in the watercourse and where the BGI scheme may have a positive impact and over what length or area of watercourse. Take a precautionary approach to the magnitude and scale of the impact.

Where it is not possible to demonstrate a full change in water body status, but a significant shift towards a change may occur, it may be appropriate to include a proportion of what the change would be (see below).

Reduced highway run-off can also lead to improvements in water quality. Whilst there is currently no agreed way of valuing this, guidance is available which can be used to estimate the impact of such schemes on water quality. For further information, see Highways England (2009), Volume 11, Section 3 (Road Drainage and the Water Environment).

Quantifying benefits

Using WQ2 to estimate the impact requires:

- The expected change in water quality for the principal watercourse improved. This should be aligned with the WFD classification system (e.g. poor to moderate, moderate to good) and based on the descriptions of status shown in Appendix E (from Environment Agency, 2013b).
- The number of components that are expected to be improved. These are taken from Water UK (2017) and include:
    - Fish
    - Other animals such as invertebrates
    - Plant communities
    - The clarity of water
    - The condition of the river channel and flow of water
    - The safety of the water for recreational contact

  Note that, in this category, the maximum number of components that can be improved is 5 (from the six above). The ‘condition of the river channel and flow of water’ component should, where improved, be considered in the ‘Quantity of water’ (flow in watercourses) section (4.1.15).
- The region (river basin district). A map of these is available from the Environment Agency; and
- The length (km) or area (ha) of watercourse improved. Guidance on calculating this can be obtained from the Environment Agency (2018c), which also suggests that a simple conversion from length to area can be based on 1km = 1km^2.

Note that, where more than one (stretch or area of) watercourse is improved, the parameters above can be added separately to B£ST, using separate rows in the spreadsheet.

Monetary values

The monetary values in this category are based on the results of the National Water Environment Benefits Survey (NWEBS) by the Environment Agency (2013b). This reports values from a major study for the benefits of improving water bodies and achieving compliance with WFD objectives. This includes low, central and high values for each river basin district in England and Wales. Table 4-13 summarises the monetary values used in this category, which also encompass values related to biodiversity, recreation and amenity benefits of improvements (see double counting section below). Depending on the number of components improved (maximum 5 out of 6) and the other parameters selected, the tool automatically calculates the total benefit based on the value chosen. Separate values are available where an area (e.g. of a lake) is improved.

Where no change in WFD class (or the 6 components above) is expected or can be valued, it may still be possible to value water quality improvements. Most water companies included water quality improvements in their WTP studies. The specification of these improvements varies but they generally include reduction in the number of pollution incidents associated with CSOs or the length of waterbody improved (e.g. Horton & Digman, 2017). Alternatively, complete a user-defined benefit to capture such a benefit.

Where an expected improvement to bathing waters is likely to occur directly through BGI, use WQ1 to capture the benefits, inputting the monetary benefit directly. Adopt values for bathing water improvements provided by the water company. To estimate the improvements to shellfish waters also use the WQ1 approach and input directly into the tool. Note, predicting improvements to bathing and/or shellfish waters is complex, and carefully consider whether the BGI scheme is demonstrably contributing to a significant benefit.

Table 4-13 Monetary values - water quality for watercourse

Change	Value (2014 prices)			Units	Source	When to use
	Low	Central	High			
Bad to poor	9.1 - 25.5	11.1 – 31	13.1 – 36.5	£000/ km/yr	Environment Agency (2013b)	Change in WFD class, bad - poor
Poor to moderate	10.1 – 29.9	12.3 – 36.5	14.5 – 43	£000/ km/yr		Change in WFD class, poor - mod
Moderate to good	11.5 – 35.4	14 – 43.1	16.5 – 50.7	£000/ km/yr		Change in WFD class, mod - good

Avoiding double counting

Values from NWEBS include elements related to recreation, amenity and biodiversity. The risk of double counting is therefore considered to be *high,* therefore only seek to assess the categories below when confident that the values obtained will be additional to those in the water quality category (or apply to different groups/populations):

- Amenity
- Recreation
- Biodiversity

Confidence scores

Table 4-14 indicates potential confidence scores to assess the quantitative impact of BGI on water quality. Note the confidence score to select will be dependent upon the body of evidence available and the appropriateness of the model and assessment technique. For example, if flow only modelling demonstrates a significant reduction in CSO spills or diffuse pollution, and these discharges make up a significant proportion of the watercourse flow, then a 50 to 75% confidence score may be appropriate.

Table 4-14 Confidence scores for assessing the quantitative impact

Assessment approach	Confidence score
Integrated water quality catchment modelling that predicts the change in water quality and the change within or between WFD status	100%
Modelling that indicates the pollutant loads and the impacts a scheme may have	75% to 100%
Flow only modelling in the drainage network and water bodies or catchment	50% to 75%
Flow only modelling in the drainage network or catchment	25% to 50%
Estimate the change in surface area connected to drainage systems and the	25%

Assessment approach	Confidence score
contributing area to the water body	

The monetary values are nationally accepted values, therefore where a full change in classification is likely to occur, apply 100% of the monetary value. If a partial change in classification is expected, use the monetary value confidence score to alter the value to its appropriate value (25% to 75%).

4.1.15 Quantity of water

This category encompasses three specific elements related to potential improvements in the quantity of water available. Flooding is not included here, as it is considered separately (Section 4.1.8). The three elements are

- Flows in watercourse and waterbody
- Groundwater recharge
- Rainwater harvesting

1) Flows in watercourse and waterbody

This benefit can be assessed in the same way as water quality. Specifically, if the "condition of the river channel and flow of water" component is expected to be improved as a result of the BGI scheme, then a proportion of the appropriate monetary value from NWEBS can be applied to the watercourse length or waterbody area over which this improvement is expected to occur. Given that this component is one of six that is included in NWEBS, one-sixth of the total value should be used.

The impact pathway

A watercourse or waterbody can be improved through removing engineered channels or creating pools of water and meandering channels. Holding back water using BGI can help reduce the risk of low flows for example by supporting subsurface hydrological connectivity within the floodplain and ensuring there is water in the channel even in drought periods. A possible impact pathway is shown in Figure 4-18.

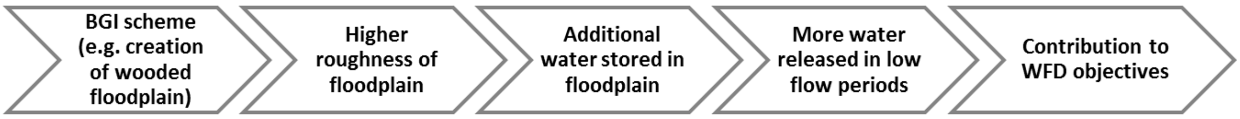


Figure 4-18 Impact pathway for BGI and flow in watercourses

Method of assessment

You should use QW1-F1 if you have already assessed the present value benefit of the impact on the flows in the watercourse or waterbody. Use QW1-F2 if you require some support to estimate the impact (based on the location of the change of flow / improvement in the watercourse or waterbody), classification (based on the definitions in Appendix E) and length (or area) improved.

Quantifying benefits

Using QW1-F2 to estimate the impact is linked to the Water Appraisal Guidance (Environment Agency, 2013b) and requires:

- An understanding of the improvements to the watercourse or waterbody through the proposed designs and modelling.
- The corresponding expected change in the watercourse or waterbody status aligned with the WFD classification system (e.g. poor to moderate, moderate to good) and based on the descriptions of status shown in Appendix E (from Environment Agency, 2013b).

- Only one of the six components 'The condition of the river channel and flow of water' to be included in this category
- The region (river basin district). A map of these is available from the Environment Agency; and
- The length (km) of watercourse or area (ha) of waterbody improved.

Monetary values

As for water quality, the monetary values in this category are based on the results of NWEBS (Environment Agency, 2013b). Depending on the number of components improved (maximum 1 out of 6) and the other parameters selected, the tool automatically calculates the total benefit based on the value chosen.

Where no change in WFD class (or the NWEBS 'flow' component) is expected or can be valued, it may still be possible to value flow improvements. Some water companies included flow improvements in their WTP studies. The specification of these improvements varies but they generally include reduction in the number of low flow events. Alternatively, complete a user-defined benefit to capture such a benefit.

Avoiding double counting

Values from NWEBS include elements related to recreation, amenity and biodiversity. The risk of double counting is therefore considered to be *high,* therefore only seek to assess the categories below when confident that the values obtained will be additional to those in the quantity of water category (or apply to different groups/populations):

- Amenity
- Recreation
- Biodiversity

Confidence scores

Refer to Table 4-14 for potential confidence scores to assess the quantitative impact of BGI on quantity of water.

The monetary values are nationally accepted values, therefore where a full change in classification is likely to occur, apply 100% of the monetary value. If a partial change in classification is expected, use the monetary value confidence score to alter the value to its appropriate value (25% to 75%).

2) Groundwater recharge

The impact pathway

BGI can increase infiltration to groundwater and help to remove contaminants. Where infiltration is possible and allowed, this can help maintain natural hydrology, increase availability of water for abstraction or reduce treatment costs, as **Error! Reference source not found.**19 shows. It is likely to be relevant only where groundwater is over-abstracted, where the groundwater body is in an area of moderate or serious water stress (Environment Agency, 2013a) or during very dry/drought periods.

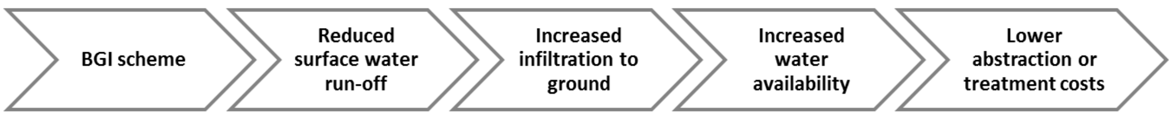


Figure 4-19 Impact pathway for groundwater

Method of assessment

Where there is a detailed assessment of the impact that infiltration has on groundwater recharge, complete QW2-GW1. Where this is not available, QW2-GW2 provides a simple way to estimate the benefit in the following steps.

<u>Step 1 - Does the infiltration to ground from the BGI scheme constitute 'additional' groundwater recharge?</u>
For the scheme to bring a significant benefit to groundwater, it will need to deliver 'additional' groundwater recharge. For example, a SUDS scheme introduced to a greenfield site is unlikely to provide additional groundwater recharge under normal circumstances. The baseline position in the location of the area intended for the BGI will need to be examined in order to determine the answer to this question. Consider the following questions:

Question 1:

a) Will the BGI measures be located on an area that is currently covered with impermeable hardstanding (e.g. concrete, buildings, road/pavement surfaces etc), or where more infiltration can occur? and
b) Are the ground conditions intended for the BGI components suitable to permit infiltration to the underlying groundwater (Woods-Ballard et al 2015)?

Question 2:
If the location for the BGI component is currently on a greenfield site, are the ground conditions beneath the surface significantly more permeable than the topsoil layer? (excavating to create BGI components may encourage additional recharge by 'tapping' in to more permeable sub-surface strata – for example where clay-rich, less permeable topsoil overlays gravel-rich more permeable sub-strata layers).

Note: the information required to answer the above questions can often be found in the geotechnical report for the site in question; if in doubt consult a ground conditions specialist.

If the answers to either Question 1 or 2 above is 'yes', then it is likely that the BGI scheme would deliver additional groundwater recharge, proceed with the remainder of the costing exercise. If the answers to either Question 1 or 2 above is 'no' then it is unlikely that the BGI scheme will deliver additional groundwater recharge, therefore stop at this point.

Quantifying benefits

<u>Step 2 - What is the average annual total Hydrologically Effective Rainfall (HER) for the site?</u>

Hydrologically Effective Rainfall (HER) represents the remaining rainfall in any one year after considering the demands of evaporation and water uptake by vegetation. The HER that remains is available to work its way into the groundwater system via infiltration. Average annual total HER is, therefore, a useful measure of average annual total recharge in groundwater dominated catchments and total runoff in surface water dominated catchments.

An average annual total HER value is available for any location in the UK through the Meteorological Office (Met. Office) for a small charge. The data is available through the Meteorological Office Rainfall and Evapotranspiration Calculation System (MORECS). The HER value will normally be provided for a user specified standard climatological period such as 1961-1990.

Alternatively, it is possible to approximate the HER value by applying a reduction factor to the average annual total rainfall value for the site, although this approach is less reliable than obtaining HER data as above.

An estimate of typical annual rainfall for anywhere in the UK can be found on many publicly available websites (such as http://www.metoffice.gov.uk/learning/rain/how-much-does-it-rain-in-the-uk). Reduce the rainfall total by the following factors depending on location to provide an estimate of average annual total HER in Table 4-15.

Table 4-15 Hydrologically effective rainfall estimates across the UK (CEH, 2004)

Location	England and Wales	Scotland	Northern Ireland	United Kingdom
Rainfall Reduction Factor	0.49	0.73	0.60	0.62

Note, the use of the reduction factors will provide considerably less reliable estimates of site-specific HER than will be obtained using MORECS data. This is because there is considerable regional variation in the relationship between rainfall and runoff in the UK. In addition, the above factors represent the difference between aggregated observed runoff and recorded rainfall. The observed runoff includes runoff from urban areas which to a degree will also reduce the reliability of estimating HER using the above reduction factors.

Step 3 - What is the total area that the BGI scheme is infiltrating?

This is the total area drained by the BGI scheme. For the purposes of this calculation, this will be the area directly drained by and infiltrated by BGI scheme. Calculate the volume by multiplying the impermeable area and the HER.

Step 4 - What is the start and end date during which the BGI based infiltration scheme would be operational?

Determine these using estimates of when the BGI component will become fully operational and when it will be decommissioned. For new BGI components serving new residential schemes the design lifetime should be 100 years. For retrofit developments, the design lifetime will be stipulated by the scheme designers although where this is unclear consider using 50 years as a default. Some BGI schemes (e.g. restored floodplains) may only increase infiltration at certain times (i.e. when wet), so you should also account for the proportion of time in which infiltration is likely to increase.

Table 4-16 Values for groundwater improvements

Context	Value (2014 prices)			Units	Reference	Guidance on use
	Low	Mid	High			
Average incremental social costs of groundwater schemes	0.48	1.21	1.94	£/m^3	Environment Agency (2018b)	Use in areas of serious water stress (generally areas covered by Affinity Water, Essex & Suffolk Water, South East Water, Southern Water, Sutton & East Surrey Water and Thames Water)
Average incremental social costs of groundwater schemes	0.40	0.48	0.56	£/m^3	Environment Agency (2018b)	Use in all other areas

Monetary values

Step 5 - What is the Monetised Value to be used for every cubic meter of 'additional' groundwater recharge delivered by the scheme?

The monetary values for benefits to groundwater are drawn from the Environment Agency's revised Groundwater Appraisal Guidance (2018, unpublished), part of the wider suite of WAG (Water Appraisal Guidance) documents. This is based on the cost of schemes to provide groundwater from new or existing sources and is drawn from (average incremental social cost estimates in) Water Resource Management Plans. Table 4-16 shows the appropriate values.

Avoiding double counting

Provided the guidance above is followed, the risk of double counting in this category is considered to be *minimal*.

Confidence scores

Base the quantitative confidence scores on the approach and assumptions taken to evaluate the volume of groundwater recharge. Therefore, it may be appropriate to use 75% to 100% for the quantities in QW2-GW1. In QW2-GW2, as this is using a simplified estimate, it will be appropriate to use 50% to 75%.

Monetary values are based on latest available evidence but draw on water company cost estimates. Therefore, where the scheme would result in an increase in groundwater available for water company abstraction, a confidence score of 100% is suitable. Where the groundwater may be used by other abstractors, or left in the environment, a score of 75% is appropriate.

3) Rainwater harvesting

The impact pathway

Capturing or storing surface water runoff locally and using it (for example for toilet flushing or irrigation) reduces the amount of potable water required for such activities. It can, as part of an integrated surface water management strategy, provide localised storage which when available and across a large scale, can help to attenuate flows lowering flood risk and the potential for pollution to water bodies. Such measures are likely to most relevant to SuDS schemes, although certain NFM may also provide local irrigation opportunities. Using less water can provide a benefit to the consumer with lower bills and to the water company in abstracting, treating and supplying potable water (**Error! Reference source not found.**20).

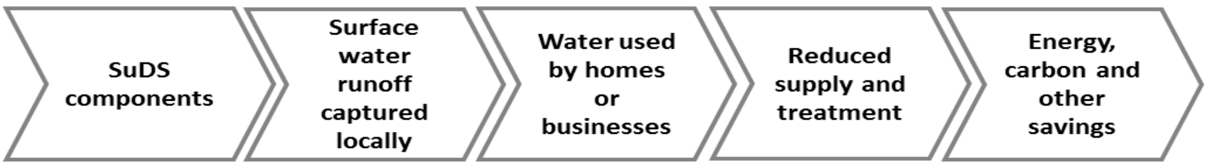


Figure 4-20 Impact pathway for rainwater harvesting

Method of assessment

The tool provides three levels of support to estimate the present value of rainwater harvesting (RWH) on reducing potable water:

- QW3-RWH1: an assessment is complete of the impact of potable water reduction and the present value calculated;
- QW3-RWH2: the volume of potable water reduced per annum is known; and
- QW3-RWH3: helps to estimate the volume of potable water reduced per annum.

Other wider benefits such as reducing in-flows to the sewer that can help to lower flood risk or pollution of water bodies are not included here. Account for these in the wider outcomes BGI may bring e.g. to reducing flood risk.

Quantifying benefits

If as part of the detailed design an assessment of the benefits present value is available, enter them in QW3-RWH1. Where the reduced volume of water is known in properties as a result of RWH, use QW3-RWH2 to estimate the present values of benefits. Note that a benefit may accrue to both the water company (lower costs to treat and supply) and the customer (lower bills), and both are estimated here. However, only the benefit to the water company (including carbon reduction) is carried forward (as this would introduce double counting and because the benefit to the customer from reduced bills will be offset by a loss of revenue to the water company).

QW3-RWH3 provides support to assess the impact. This requires more information to understand the level of potable water reduction including the annual average rainfall, number of properties, typical usage of RWH and number of people per property or business. QW3-RWH3 provides an estimation of the impact in the same way as QW3-RWH2.

The quantity of carbon used to treat water is taken from Water UK (2010) at 0.34 tonnes CO_2 emitted per megalitre. This value is used to determine the total quantity of carbon reduced based upon the volume of water not supplied.

Account for the costs to run the pumps including the energy usage when calculating the whole life costs.

Monetary values

The value of rainwater harvesting systems can be estimated in two main ways:

- The avoided cost of obtaining water by a different means (e.g. from the public water supply). This provides a minimum estimate of the benefit; or
- The benefit associated with leaving water in the natural environment (e.g. using WTP estimates to avoid low flows) (see section on 'flow in watercourse and waterbody' above).

Given that rainwater harvesting will generally deliver small, localized benefits, the first of these approaches is more appropriate. Information on the cost to treat water is commercially sensitive and these values tend not to be published for UK applications. Whilst the operating costs are in the 'pence'/m^3 range, total cost to treat will be higher (e.g. including capital works). Where appropriate, individual water companies may supply this data. Obtain the benefit to the customer by reviewing local water pricing data that are freely available, although do not use estimates based on bills in addition to avoided cost estimates as this would introduce double counting. To estimate the value of carbon impacts associated with the change in energy use, select an appropriate traded price of carbon (low, central or high), as discussed in Section 4.1.5.

Avoiding double counting

Provided the guidance above is followed, the risk of double counting in this category is considered to be *minimal*.

Confidence scores

The quantitative confidence scores depend on the approach to evaluate the volumes, and the assumptions made. Therefore, it may be appropriate to use 75% to 100% for the quantities in QW3-RWH1 and QW3-RWH2. In QW3-RWH3, as this is using a simplified estimate, it will be appropriate to use 50% to 75%.

Since the monetary values for customer charging, cost to treat and carbon come from a reliable source and are based on actual market data, the confidence score for the monetary values is 100%.

4.2 Non-quantified benefits

The tool contains a number of benefits where it is currently difficult to quantify and monetise the impact of BGI. To support the estimation of these benefits, in particular when comparing more than one option, B£ST contains a simple approach to assess the benefits qualitatively. This enables such benefits to be recorded and not overlooked, even if they are not monetised. Where local evaluations have taken place, the tool provides the facility to capture these.

The tool uses a matrix approach to consider the magnitude and area of the impact of the BGI. A potential impact score can be estimated, and a single confidence value applied to alter the values. Given the lack of evidence to support a more detailed approach, it is not possible to provide specific guidance on how impact scores for the magnitude and area of impact should be derived.

Each non-quantified benefit sheet provides the opportunity to add in a monetised assessment, if local data (or new information) is available.

4.2.1 Crime

The impact pathway

Some studies have found a meaningful relationship between increased greenery and reduced crime. For example, Kuo and Sullivan (2001) found that levels of reported property and violent crime tend to be higher amongst people living in barren buildings compared with those in greener buildings. Compared with buildings with low levels of vegetation, those with medium levels had 42% fewer total crimes, 40% fewer property crimes, and 44% fewer violent crimes. The comparison between low and high levels of vegetation was even more striking: buildings with high levels of vegetation had 52% fewer total crimes, 48% fewer property crimes, and 56% fewer violent crimes than buildings with low levels of vegetation.

However, the location of this study (Chicago) and the socio-demographic characteristics of the population are very different to the UK.

Following restoration of the River Ravensbourne, south London, visitors to Ladywell Fields urban park increased by over 250%, and 78% of visitors felt ‘safe’ or ‘very safe’ in the park after restoration compared with 44% before (Environment Agency, 2018c).

However, there is as yet no comprehensive and conclusive evidence that clearly links BGI and crime levels. Indeed, poorly maintained green spaces can be the focus of anti-social behaviour (Dunse et al, 2007, cited in Natural England, 2014) such as littering, loitering with intent, noise pollution and vandalism. Nevertheless, a potential impact pathway is shown in Figure 4-21.

Figure 4-21 Impact pathway for crime

Method of assessment

Given the observations above, there is no need to assess potential benefits in this category, beyond a simple qualitative assessment or description of possible benefits based on the matrix in the tool, using Cr1. The impact contains a subjective scoring approach that considers the scale of the likely reduction in crime and the size of area/number of people affected. These are summarised for all relevant non-quantified benefits to enable a comparison when more than one option is being considered.

Quantifying benefits

Benefits in this category should not be quantified without local evidence or evaluation study. Where this is available, use Cr2 to record the results.

Monetary values

There are no monetary values to support assessment in this category.

Avoiding double counting

It is likely that any benefits in the ‘Amenity’ category will include some values potentially related to reduced crime or fear of crime. However, if no monetary assessment is undertaken, there is no risk of double counting benefits in this category.

Confidence scores

Given the lack of clear evidence relating to the impact of BGI on crime, attach a low confidence score to any estimate of benefits derived in this category (either 25% or 50% depending on the likelihood of such impacts occurring).

4.2.2 Economic growth

The impact pathway

There is some evidence that BGI can help stimulate local economic growth, through increased consumer spending, enhanced attractiveness of an area to new businesses, creation of green jobs or improved productivity of workers or land (Figure 4-22).

Figure 4-22 Impact pathway for economic growth

Research from the United States (reported in Natural England, 2014) found that shoppers were willing to travel further to visit, stay longer once there, and more frequently visit, business districts with trees. In addition, green infrastructure has been credited with significant positive employment impacts (Stratus Consulting, 2009). In the UK, a £15 million investment in the Glasgow Green project led to an estimated £30 million worth of net additional sales in the local economy. There is (largely anecdotal) evidence that SuDS can unlock developable land, thereby creating opportunities for future growth, and that green areas used for food can increase the productivity of landscapes. There is certainly evidence that increasing the attractiveness of an area through investment in high-quality parks, increases inward investment (eftec, 2013).

It is also possible that BGI schemes lead to an increase in employment opportunities or contribute to a more highly skilled local economy.

However, it is very difficult to identify whether these effects are truly additional, or whether they are simply displacing economic growth and job creation elsewhere. It is also very difficult to attribute such effects to specific kinds of green infrastructure. This may change in the future, and there have been attempts for example to link flood risk management to benefits to the local economy such as increases in gross value added (Frontier Economics, 2014). An opportunity may be to link BGI to regeneration, measured in terms of different indices of deprivation, currently being updated by government.

Method of assessment

Given the observations above, there is no need to assess potential benefits in this category, beyond a simple qualitative assessment or description of possible benefits. The impact contains a subjective scoring approach that considers the magnitude that the scheme may contribute to supporting economic growth and the size of area impacted. These are summarised for all relevant non-quantified benefits to enable a comparison when more than one option is being considered.

Quantifying benefits

Benefits in this category should not be quantified without local evidence or evaluation study.

Monetary values

There are no monetary values to support assessment in this category.

Avoiding double counting

It is likely that any benefits in the ‘health’ and tourism categories will include some values related to increased economic growth (via enhanced wellbeing and productivity). It is also likely that economic development is reflected in higher property/land prices used in the ‘amenity’ category, and that any benefits in the ‘enabling development’ category also contribute to economic growth. However, if no monetary assessment is undertaken, there is no risk of double counting benefits in this category.

Confidence scores

Given the lack of clear evidence relating to the impact of BGI on economic growth, attach a low confidence score to any estimate of benefits derived in this category (either 25% or 50% depending on the likelihood of such impacts occurring).

4.2.3 Tourism

The impact pathway

BGI can potentially, through enhancing the attractiveness of an area, lead to an increase in visitors and visitor spending, and contribute to specific areas of tourism such as nature-based holidays (Natural England, 2014). A potential impact pathway is shown in Figure 4-23.

Figure 4-23 Impact pathway for tourism

Method of assessment

This work identified no studies rigorous enough to quantify and value the contribution of BGI to tourism to include in the tool. BDP (2015) suggests that, providing clear assumptions are made and recorded, the contribution of environmental enhancements (including those provided by BGI) to tourism can potentially be estimated by multiplying the number of additional visits by average expenditure per visitor.

However, unless this type of information can be obtained, there is currently no need to assess potential benefits in this category, beyond a simple qualitative assessment or description of possible benefits using T1. The impact contains a subjective scoring approach that considers the magnitude of the scheme to tourism and the size of the area impacted. These are summarised for all relevant non-quantified benefits to enable a comparison when more than one option is being considered.

Quantifying benefits

Benefits in this category should not be quantified without local evidence or evaluation study. Where this is available, use T2 to record the results.

Monetary values

There are no monetary values to support assessment in this category.

Avoiding double counting

It is possible that any benefits in the ‘Amenity’, ‘Economic growth’ and ‘Recreation’ categories may include some values related to the potential for increased tourism. However, if no monetary assessment is undertaken, there is no risk of double counting benefits in this category. Nevertheless, if benefits to tourism are important for the scheme, consider setting out where any overlap in benefits between these categories may exist.

Confidence scores

Given the lack of clear evidence relating to the impact of BGI on tourism, attach a low confidence score to any estimate of benefits derived in this category (either 25% or 50% depending on the likelihood of such impacts occurring).

4.3 User defined benefits

Other local benefits may arise that the tool currently does not account for. To support this, a separate sheet is provided in the tool that enables up to five other benefits to be included. In this situation, add the annual impact and it will calculate the present value.

4.4 Defining timescales

The date assumed at which benefits start and end, and the profile of change in benefits over this period, can have a significant impact on the results of the assessment. Figure 4-24 illustrates this.

A key assumption in the tool is that in any given benefit category, benefits begin at some point in the near future (perhaps after construction of the scheme and with a possible delay before they accrue) and end after a certain amount of time (the end of the assessment period). The user can select the start and end period by selecting any year up to 2125.

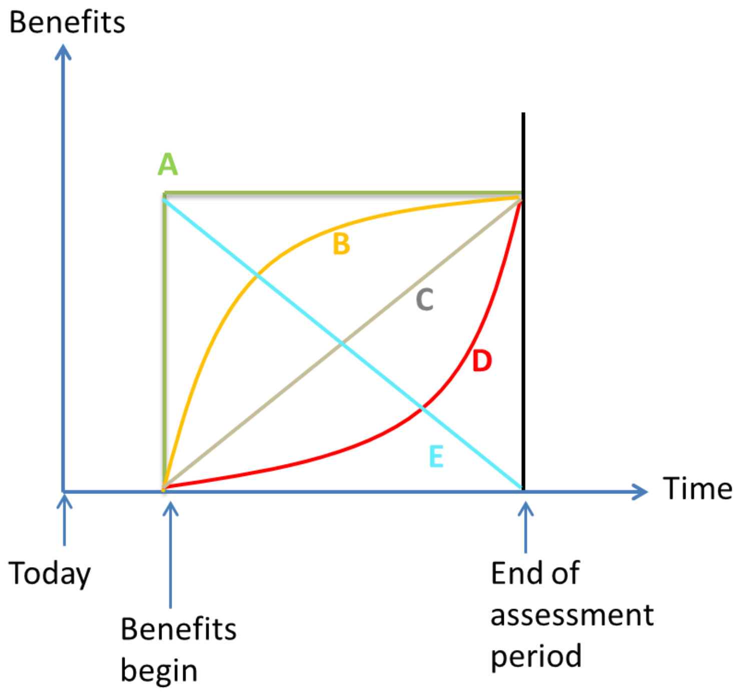


Figure 4-24 Impact of benefits profile

If benefits are expected to start accruing later than half-way through a year, select the following year as the start date. The tool applies the profile automatically based on selection of start and end dates. It typically assumes that the full amount of benefits accrues from the start of the assessment period until the end (line A), although some increase gradually (line C) and others linked to trees (e.g. carbon sequestration) are variable (line D). However, it may be that benefits in fact increase more gradually, for example in either a linear (line C) or non-linear (lines B and D) fashion. This may be the case for amenity-type benefits in particular, since the attractiveness of the scheme may take time to develop as vegetation becomes established. It could also be the case that benefits decay over time (perhaps to reduced effectiveness of BGI components). This case is shown as line E.

In each benefit category, select the evaluation period (start year and end year, although a period of time for plants to mature may be appropriate before the impact truly starts therefore entering a later start date). In most cases, the start year will be the first or second year following construction of the scheme. Typically, consider matching the end year with the life of the asset. In the absence of information on the life of the asset, consider using a default value of 40 years, with a suggested range of 20 to 60 years. It is possible that some benefits will only extend over a short time period, in which case enter shorter time horizons. Likewise, some will extend well beyond this (and indeed may continue indefinitely), although the discounting process (see Section 4.6) limits the impact of such long-term benefits.

4.5 Applying B£ST retrospectively

The tool allows for the assessment of schemes with a start date prior to 2018. This requires monetary values to be deflated (reduced to take account of past inflation) and the discounting process applied in reverse. This can be adjusted on the 'Present Value Calcs' page.

Retrospective application of B£ST is probably only worthwhile if there is a significant divergence between inflation over recent years and the discount rate applied. However, inflation since 2000 has generally been between 1 and 5% and has been broadly similar to the default discount rate of 3.5%.

For example, £1 million in 2013 prices is, after taking account of inflation, about £750,000 in 2000 prices. Applying reverse discounting to this at 3.5% per year gives a 2013 value of £1.018 million. So, taking a start year of 2013 rather than 2000 is unlikely to make a significant difference to the final result.

4.6 Discounting future benefits and calculating present values

As discussed in Section 1.3, *all* benefits occurring in the future need to be discounted to today's prices, so that present values can be estimated. The tool automatically carries out the discounting process in the *'Present Value'* sheet, recommending a default discount rate of 3.5%, based on the information provided relating to the start and end year of benefits in each category. The default discount rate can be changed on the '*Project data*' sheet. Furthermore, it is possible to introduce variable (declining) discount rates by directly amending the discount rate in the *'Present Value'* sheet. Note that this overwrites the formula linking to the *'Project data'* sheet.

5 SUMMARISING AND PRESENTING RESULTS

5.1 Summary results pages and dashboard

The tool automatically summarises and presents the results of the assessment based on an assumed 2018 base year (this can be adjusted by the user). Several graphs, tables and other information are automatically generated. These are offered to help the user and can be copied directly into presentations and reports.

Results are collated under:

- **Summary of outputs – Monetised:** this brings together all the key information for all benefits (whether evaluated or not) including the present value of the benefits (pre and post confidence), confidence values and the start/end year of the evaluation for each benefit. This includes a colour coding (described in the Notes section of this sheet) that indicates which benefits are greater than 10% of the overall monetised values;
- **Summary of outputs** – **Qualitative**: this tabulates the non-monetised impacts that have been subjectively scored; and
- **B£ST Results Dashboard**: this provides automatically generated graphs and tables, which summarise the key outputs of an assessment, and can be manipulated to suit users' needs. This is through bespoke menus or through graph functionality within excel.

Where the tool is run more than once (for example to assess the benefits from different options), save these assessments individually and copy the results into W047c Comparison Tool. This provides a comparison of up to four options, creating a small number of graphs.

In some cases, it may be appropriate to obtain more detailed, locally based information, perhaps to increase the robustness of the assessment or to incorporate new information. This is likely to be the case where benefits in one (or a few) particular categories appear to be very important in terms of the final result. Where this is the case, identify what information or data can be improved and re-run the tool.

5.2 Bringing in costs

Enter the cost of the option in the 'Project data' sheet in the evaluation tool and 'Scheme Comparisons Tool'. These may include both financial costs (e.g. capital equipment, operating expenditure and opportunity cost of providing land for BGI) and other costs (e.g. social or environmental costs such as embodied carbon in materials). B£ST does not calculate costs, but information is available to support cost estimation (e.g. Environment Agency (2017c), the SuDS Manual, HR Wallingford (2004) and the SuDS for Roads Whole Life Costs Tool (http://www.scotsnet.org.uk/good-practice.html).

Enter whole life costs, that include capital and operational (maintenance) costs of each option. The costs should cover the total, combined costs of all BGI components related to the option, since this will ensure comparability with the benefits. For example, if it is necessary to include specific design components (e.g. paths, benches) in the option to help realise certain amenity type benefits, then capture these in the costs and bring into the tool.

Crucially, the cost information should be in the same format as the benefits. This means that the base year (generally 2018) and timescales should be equivalent with the same discount rate should be used. If this is not the case, the costs and benefits will not be comparable.

Just as there is uncertainty around any benefits from BGI that are valued, there is likely to be uncertainty around costs. Where sensitivity analysis using different (e.g. low and high) cost estimates is required, simply re-run the tool using the alternative estimates.

One important aspect to consider when bringing costs into the assessment is the potential for optimism bias, i.e. systematically underestimating costs or the duration of works. The Green Book (HM Treasury, 2018) provides supplementary guidance on optimism bias. This recommends the adjustment of costs for a variety of project types. For example, capital expenditure costs for standard civil engineering projects should be adjusted by 3 per cent (lower) to 44 per cent (higher). The guidance also includes a discussion on reducing optimism bias and applying the concept to operating costs and benefits. There are different methods for taking account of optimism bias (e.g. the

Environment Agency uses Monte Carlo analysis in flood and coastal risk management, but a flat rate such as that recommended by the Treasury in other areas).

5.3 Decision rules

Decisions around drainage investment will generally take account of a range of considerations, including social acceptance, political will and economic efficiency. The two main decision rules automatically generated by B£ST relating to economic efficiency are Net Present Value (NPV) and Benefit Cost Ratio (BCR).

The NPV is calculated as: *NPV = PV of benefits - PV of scheme costs*

The NPV is the basic measure of the economic gains (or losses) resulting from a BGI scheme (see Figure 5-1 for illustrative example). A positive NPV indicates that a project is justified as it yields a rate of return which is greater than the discount rate. When comparing alternative options, that with the highest NPV becomes preferred (as the greater the NPV, the greater the benefits to society). In the (unlikely!) case of an unlimited budget for BGI, it would be economically desirable to undertake all of the projects for which the NPV is greater than zero. When the budget is limited, such that only one or a few projects can be undertaken, investment funds are scarce (because there are still projects yielding a rate of return in excess of the discount rate). In these cases, project selection includes the use of the BCR.

The BCR is calculated as follows: $BCR = \frac{PV\ scheme\ benefits}{PV\ scheme\ costs}$

The BCR demonstrates which scheme provides the largest benefit per pound of expenditure. This is valuable information when trying to prioritise between schemes. Because of the revenue competing character of the decision, it is typically important to obtain the largest benefit for every pound of money spent.

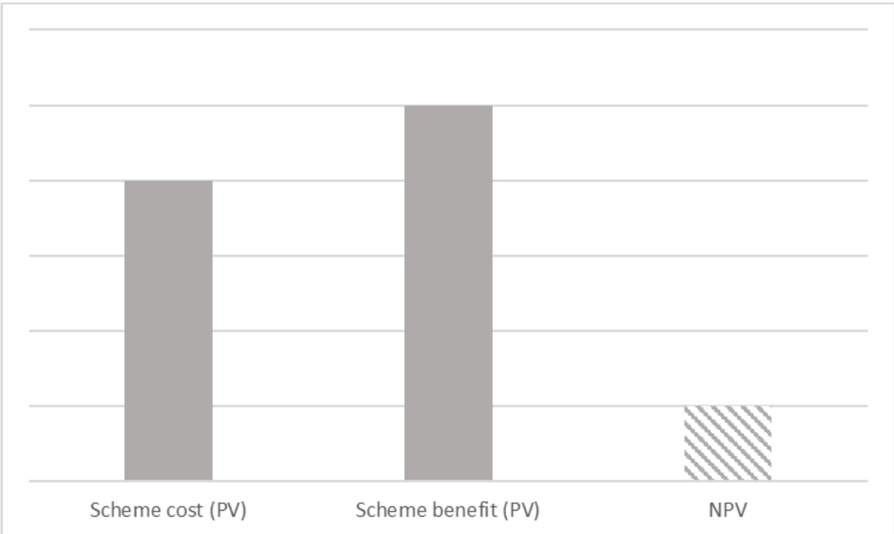


Figure 5-1 Determining NPV

5.4 Dealing with non-monetised benefits

It is likely that some of the benefits associated with BGI schemes are not amenable to valuation, and particular benefit categories have been included in this guidance where valuation is difficult or not possible (see section 0). However, these could be important and non-valued effects should remain part of the decision-making process.

There may also be other potential benefits that are not currently captured by the tool, including knowledge building, building a skilled workforce, speeding up building for developers, ease of auditing and controlling contractors work (since it is above ground and visible).

Finally, there may also be benefits of wider infrastructure initiatives of which BGI form a part but are not the principal component. This may include programmes to develop sustainable transport or to green urban areas. In these cases, it may be possible and appropriate to allocate a certain proportion or percentage of the benefits of the whole programme to the BGI component.

For these categories, use the qualitative ranking score generated by completing the relevant sheet in the tool. Where this score is 4 (high benefit) or 5 (significant benefit), consider explicitly bringing these into the assessment. There are two possible ways of doing this:

- Calculating ‘switching values’ or ‘implied values. For example, for a scheme costing £10 million with valued benefits of £9 million, any non-valued benefits would need to have an implied value of at least £1 million to switch the NPV to positive and make it worthwhile for the scheme to go ahead. It may be necessary for a group of key stakeholders to determine whether such implied values are realistic and whether any further investigation or assessment is required; and
- Formal use of non-quantitative assessment techniques. There are several methods of formally scoring and weighting non-valued impacts, the most notable of which is multi-criteria analysis. The government has provided detailed guidance on this (Defra, 2011b, 2011c; CLG, 2009). The use of such techniques may be appropriate if non-valued impacts are particularly important or significant, or of specific concern to some stakeholders.

6 CONSIDERING UNCERTAINTY AND APPLYING SENSITIVITY ANALYSIS

6.1 Sources of uncertainty

As discussed in Section 1.4, there are various sources of potential uncertainty in assessments of benefits, although generally these are not specific to BGI and may equally apply to any type of drainage infrastructure, flood management or other investment (e.g. Hamell & Bryant, 2017). Indeed, most uncertainties are ubiquitous in the design, function and operation of traditional drainage or flood management systems, and in this respect BGI are no different.

Figure 6.1 illustrates examples of the areas where there are uncertainties in BGI design, operation and performance. There are also uncertainties in the systems and processes that BGI interacts with. This figure considers the four attributed and established benefit categories:

- water quantity;
- water quality;
- amenity; and
- biodiversity.

However, there is also uncertainty in financial benefits and costs and hence Figure 6-1 also includes this aspect.

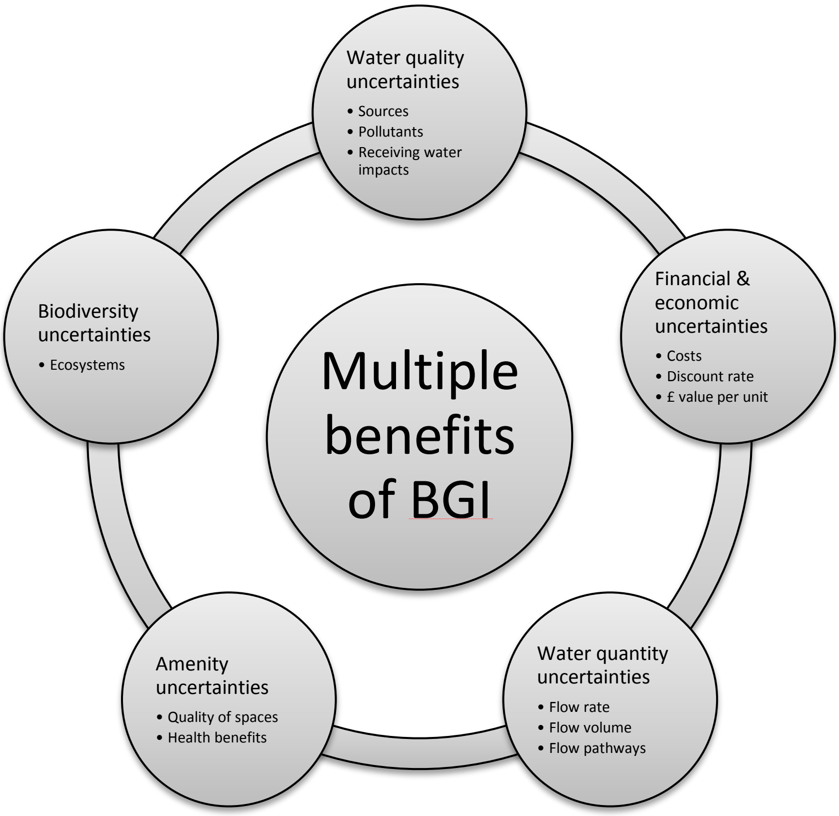


Figure 6-1 Examples of areas of uncertainties in relation to valuing the multiple benefits of BGI (note: this is not an exhaustive list)

There are uncertainties in the main areas of interest for those using BGI and seeking to create the greatest benefits as illustrated in Figure 6-1. Here generic aspects are considered that allow primary areas of uncertainty to be defined; there are six main aspects considered here under which uncertainties in valuing the impacts of BGI are being addressed:

1. **Physical data** – the dimensions and attributes of the BGI and related impacted systems, such as receiving water bodies. This also includes how these dimensions change over time – with staged investments, expansion etc. Significant uncertainties may relate to the location and extent of BGI, especially where a single or local development is part of a wider catchment.

2. **Construction and decommissioning** (temporary impacts) – e.g. relating to periods of disruption and for which there may mainly be negative impacts (as with any drainage scheme). However, there are some potentially beneficial impacts e.g. reuse or recycling of decommissioned components of BGI.

3. **Operational performance** – including how well BGI manages surface water flows and volumes, enhance environmental quality, deliver amenity and enhance biodiversity. Key to operational performance is satisfactory and expected outcome(s) regarding the level(s) of performance (overlaps with 5 below).

4. **Valuation of benefits** – includes how robust the monetary benefits estimates are, related to the performance (in 3) above and if these benefits are actually realised in practice (overlaps with 5 below). In particular, the uncertainties of monetary value transfer from 'standardised' or base data, such as ecosystem services valuations or other deemed similar schemes.

5. **Changes over time** – the external drivers (those outside the control of the decision maker and system operator, such as environmental factors) for the urban drainage or flood management system will alter with time due to climate etc. as will the internal drivers (e.g. corporate strategy) and processes regarding e.g. expected and required levels of performance long term (overlaps with 3 and 4 above). Here the particular uncertainties relate mainly to the external drivers and the timing of investment stages, e.g. has/will the climate alter /change as anticipated; the system been/be maintained, upgraded or modified as planned and in the stages envisaged?

6. **Perspectives of users and decision makers -** There are significant cultural aspects of how benefits and uncertainties are perceived (Kenter et al, 2014; Church et al, 2014; Alves et al., 2018). Furthermore, there are in-built bias in the way decisions are arrived at (Jonas et al, 2008; O'Hagan et al, 2006). Often, preconceived or established practice in ways of delivery of professionals in their practice inhibits their ability to see better ways of delivery. This is sometimes termed the 'Einstellung Effect' and refers to the blocking effect of the first or usual idea as to how to deliver an outcome inhibiting innovative ideas being taken up (e.g. Biliac et al, 2008). It is often recommended that group deliberation is a better way of addressing the need to avoid individual bias, but this depends upon the group, as groups may also have in-built bias.

In each of the above areas, there are varying degrees and scales of uncertainty, depending upon the criteria, attributes and processes involved. For example, 'performance' in (3) will in many cases be assessed beforehand by using appropriate computational models. Therefore, the model assumptions, performance and limitations as well as the data input will contribute to the overall uncertainties. Following construction and commissioning, the BGI performance can be verified by post-project monitoring (against the predicted value).

Figure 6.2 illustrates an example of an impact assessment process, showing where the uncertainty groups above are relevant. This shows only an illustration of the quantitative impacts and some of the key components of the process where uncertainties exist.

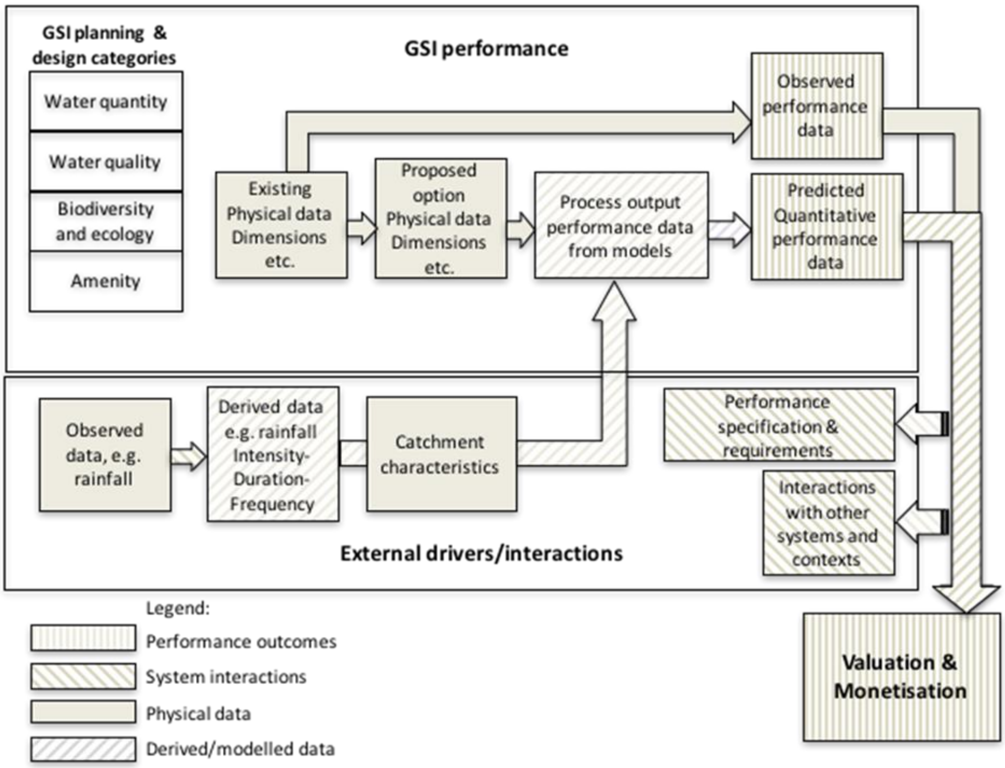


Figure 6-2 Illustration of areas of uncertainties in assessing the impacts of using SuDS/NFM, and other types of BGI

There are uncertainties to a lesser or greater extent in each of the boxes shown. Note also that some boxes overlap, for example, models have originally been developed using data from one context and a particular application may not necessarily be similar to the data and assumptions used in the model development. How the above overview of potential uncertainty sources is considered in B£ST application, and the limitations, is explained in Ashley et al., (2018b) and set out below.

6.2 Dealing with uncertainty

There are a number of components in the tool where uncertainty is considered (Ashley et al., 2018b). These relate to two main areas:

(i) Assumed performance data and financial valuation; considered using confidence scoring and sensitivity analysis

(ii) Maintaining performance over time; considered using flexibility assessment and robustness assessment

Addressing the first of these, the tool includes two primary sets of information:

- the physical base data relating to performance of the BGI defined in the various criteria and parameters (see outline of impact assessment tool); and
- numerical values related to these and the monetisation or valuation of this data.

For example, a new development using BGI may lead to avoided emissions or the sequestration of many tonnes of CO_2 – the numerical data is therefore X tonnes of CO_2. The impact value of this may be determined by standardised, nationally set monetary benefit estimation – monetisation of the benefits shown by the physical data – i.e. £ per unit of CO_2 sequestered multiplied by X tonnes.

The tool considers uncertainty in two ways for monetised benefits, using confidence scores (as outlined in each benefit category in section 4) as a surrogate. It is built into the spreadsheet tool accordingly:

1. Ranges of quantitative estimates and monetary values are permitted and/or recommended (before selecting a single value);
2. User-defined confidence scores relating to both quantified estimates and monetary values.

For non-monetised benefits, a single confidence score is used to apply to the subjective scores developed.

This approach complies with a number of the standard approaches, amending the format in a way to suit the application. The use of ranges and confidence scores helps to ensure outputs are grounded in reality and consistent with expectations. However, for greater investments, such as the use of BGI in major developments, strategic retrofitting (over a period of time) masterplanning or costly 'showpiece' investments like the Olympic Park, more complex techniques to assess the uncertainty and manage its consequences on the decision process are recommended.

Addressing the second area of uncertainties above, ideally the BGI option selected should be that which is most economically advantageous, but also with the greatest capacity for adaptive change in response to future pressures (e.g. Dong et al., 2017). Hence a potentially important area of uncertainty in the valuation of BGI schemes is the robustness of the BGI performance over time and the need to, or ease with which, a scheme can be adapted in the future, i.e. how flexible it is in terms of ability to be modified into the future (this is a major consideration for FCERM in the Environment Agency's planning). In view of this, the tool provides an indicative estimation of flexibility based on an assessment of the range and relative magnitude of the individual benefits for an option as explained below.

When evaluating an option, the tool automatically generates a 'Benefit distribution score', which is shown in the 'B£ST Results Dashboard'. This provides a measure of the balance or distribution of the benefits in the medium to longer term. It indicates the flexibility of the option's performance statistically using the monetised present values. The approach uses a simplified version of an established tool called COFAS (Comparing the Flexibility of Alternative Solutions) as developed by Eckart et al (2012). It provides an assessment of flexibility on a range of A-E where A is most flexible (100-80), B (79-60), C (59-40), D (39-20) and E (19-0) is least flexible. Details are given in Ashley et al., (2018) Supplemental Materials. The tool shows these values on the Summary Results pages and in the scenarios assessment.

This method is equally applicable to conventional, BGI and grey/green approaches as it focuses on the size and distribution of the benefits. The evaluation considers the relative homogeneity of the selected benefits, i.e. it considers the uniformity across the various benefits in monetary terms. Therefore, where there are large differences in the size of the individual benefits, such as one benefit dominating the overall benefit value, then the flexibility rating will be low. It can help to indicate the risk that if a dominant benefit was to reduce substantially, or become less important in the future, then the overall benefit value will also decrease substantially.

When an option provides a small number of benefits, the methodology becomes less applicable. For example, if an option generated only two benefits (as is possible for a piped option), then the tool calculates internal homogeneity for these two benefits only (with such benefits likely to occur in the short term). The flexibility rating will be high if they are comparable in value. However, given the uncertainties of the future, where an option had very few benefit categories, or a number of relatively low value benefits it would not, by definition, be very flexible. The most flexible options are those with a wide number of benefits each of comparable value. This is because particular benefits may become more or less valuable in the future.

Flexibility is likely to be more important for the medium to long-term performance of the option. Assessment of the option using the tool in the short term may not necessarily be significant in decision making now. However, the flexibility rating gives an indication as to how the option may be modified in the future to ensure it continues to provide benefits in the longer term. Sustaining BGI benefits from any option into the future depends on who maintains the individual measures or scheme and how this maintenance is allocated, funded and undertaken. Who takes responsibility in the future is one of the most significant uncertainties about the ongoing use and performance of BGI. The reliability and changing roles of the various stakeholders connected with the BGI over time need to be considered, especially responsibilities for maintenance and operation. B£ST includes guidance on, and a means to include robustness in the analysis using scenario planning as explained in Section 8, whereby the implications of different pathways into the future are considered.

6.3 Sensitivity analysis

Sensitivity analysis involves testing the robustness of the result by changing one or more of the key parameters in the assessment. When undertaking sensitivity analysis, it is important that the user carefully considers which parameters are having the most impact on the results of the assessment, and whether there is a justification for adjusting these to test the robustness of the result.

The tool includes a separate sheet to help users undertake simple sensitivity analysis, and illustrate whether categories form >20% or 10-20% of the total value of benefits (before confidence applying scores). It carries forward a number of key parameters from the main assessment and allows the user to alter the confidence scores (25%, 50%, 75%, 100% and 125% values). Where more detailed sensitivity analysis is required, then the tool can be re-run and the results used to consider a wider variety of changes such as amending:

- **the discount rate** - (for comparability, the discount rate used should be applied throughout the assessment, i.e. to all monetised benefit categories and to all costs)
- **assessment period** (when benefits start and end)
- **quantified estimates of physical impacts** - to keep the tool as simple and user-friendly as possible, the sensitivity sheet only carries forward the final 'quantified value'. Where a number of separate quantities or components go to make up this final number, the user has the choice to either: (a) override the quantified value from the main assessment and insert a lower or higher number, or (b) run the assessment again using different 'sub components' to come up with a new final quantity. In any case, the approach taken and assumptions made should be recorded in the final column of the sensitivity sheet.
- **alternative monetary values** (or use of high and low values where available)
- **alternative cost estimates**
- **confidence scores**

One particular consideration when undertaking sensitivity analysis is the risk of double counting, a risk which is highlighted throughout this guidance. For example, when valuing impacts for a scheme where the risk of double counting is high (e.g. amenity, recreation and biodiversity), a useful approach can be to set impacts in all but one of these categories (that with the largest monetary value) to zero. Achieve this by setting the confidence score to 0% in the sensitivity sheet. View the results of the assessment having essentially eliminated any risk of double counting across impact categories.

Finally, note that where the user has brought in values relating to the above parameters from elsewhere (e.g. from modelling work), any changes to these as part of sensitivity analysis will mean the tool has to be run again, since there is no mechanism by which the sensitivity sheet can incorporate these values and automatically update the results.

7 USING THE RESULTS

7.1 Using and applying the results to support decisions

The guidance highlights throughout that the tool can only provide an *indication* of the likely benefits associated with BGI (or other drainage/flood management scheme). There are many potential sources of uncertainty, relating to both benefit and cost estimates. Whilst we have attempted to adopt a conservative approach throughout (so that benefits are not exaggerated), actual benefits could be higher or lower than those estimated using the tool. Therefore, where significant investment is planned, or where a decision may be contentious, consider completing a locally specific, bespoke analysis.

7.2 Equity and distributional issues

As discussed in Section 2.3, B£ST does not currently include an assessment of distributional impacts (i.e. who benefits). However, some points that may inform a distributional assessment are worth noting.

- For some impact categories (e.g. amenity, recreation, health), the 'beneficiary population' will be limited to those who will make use of or directly benefit from the improvement (e.g. those living or working nearby or visiting). In other cases (e.g. water quality and biodiversity improvements), the beneficiary population may also include 'non-users', i.e. those who do not directly make use of the improvement but still derive some benefit from it.
- Whilst some beneficiaries may be involved in funding or implementation, in many cases there may be no apparent or straightforward rationale for linking funding, implementation, responsibility and benefits.
- In general, the direct beneficiaries of BGI schemes (as with many drainage and flood management interventions) tend to be local, whilst those typically funding the schemes tend to include a larger population (e.g. water company customers or council tax payers).
- Some of the benefits of BGI are likely to be private benefits, i.e. they accrue only to specific groups or organisations. Examples of private benefits include household flood risk reduction and health benefits to recreational users. However, there are also likely to be public benefits arising from any BGI scheme, e.g. mitigation of carbon emissions or reduced burden on the NHS due to health improvements.
- Where the distribution of benefits is of specific concern and/or the magnitude of its impact is large, it may warrant further analysis.

7.3 Stakeholders and funders

Section 2.3 highlighted the key issue of beneficiaries related to BGI and the different stakeholder groups to which these beneficiaries may or may not belong (for a review of some UK case examples considering funders and beneficiaries see Dolowitz et al., 2018). At the end of the assessment, consider revisiting the list of potential stakeholders and the expected benefits that different groups or organisations may derive from the BGI scheme. It may be possible to identify potential new funding routes based on the assessment (e.g. Ashley et al, 2018a). Further possibilities and case studies are available from Defra (see https://www.gov.uk/government/publications/payments-for-ecosystem-services-pes-best-practice-guide, also Valderrama et al, 2013).

Potential funding routes might include:

- Flood Risk Management funding schemes, including Local Levy and GiA
- Water industry asset management planning (AMP)
- Natural capital stakeholders at local, national and European level
- Recent totex-based changes to water company accounting rules, which mean that BGI components no longer need to be automatically treated as opex;
- Biodiversity offsetting schemes, where organisations offer financial contributions to schemes that deliver biodiversity benefits;
- Public private partnerships;
- Community or crowd financing;
- Credits for and trading of surface water management;

- Funding from third parties (e.g. health service providers); and
- New business models for delivering drainage solutions (e.g. surface water service companies).

8 USING B£ST TO SUPPORT LONGER TERM PLANNING

This section, combined with Appendix D, can be used to complete the 'Scenarios Assessment' part of the spreadsheet tool.

8.1 Considering future uncertainty

Uncertainty about the future requires new ways to approach the planning and design of systems and infrastructure that have a long life such as BGI schemes. One way of doing this is to take an adaptive approach whereby the system can be modified (or adapted) in response to new knowledge or changes in conditions during its lifetime (e.g. Manocha & Babovic, 2017). This is often termed 'flexibility' – the ability to change the system - see for example: Spiller et al., (2015) and as outlined in Section 6.2.

A BGI scheme may be a one-off or part of a process that sees stages of implementation over time, as illustrated in Figure 8.1. Such adaptation over time, where there are foreseen or expected changes in the future, can be planned for in the design of a BGI scheme using the guidance provided in Appendix D. Where this forms part of the decision-making process, complete this 'futures assessment' at the design or planning stage. This enables the assessor to consider how the system will respond under possible future changes in conditions (e.g. climate) or in what society expects the system to provide (e.g. arising from economic or behavioural changes).

The guidance in Appendix D sets out the steps in applying B£ST for a BGI scheme designed today in order to ensure the scheme has maximum value and acceptable performance whatever future changes occur during its' lifetime. See also Ashley et al, 2018a for case examples. The process set out is also useful for considering the value of staging implementation over time or in extent, and in identifying possible future stakeholders. These may or may not be the same as today. In the future some of the original stakeholders and funders may no longer be involved and new stakeholders may be engaged with the scheme. The approach considers longer-term uncertainty by evaluating scheme robustness, assessed against future changes, including the scheme's flexibility and adaptability (meaning that it can be adapted to changing future conditions) to foreseen and unforeseen future conditions (Brisley et al., 2015; Environment Agency, 2018d). Note that 'robustness' refers here to an outcome or a measure that is as insensitive as possible to uncertainties in the future like climate change. Robust approaches do not assume a single climate or other change projection (e.g. Dittrich et al, 2016).

Figure 8.1 Staged implementation of a SuDS development (courtesy of A Duffy)

The guidance aligns with Environment Agency standard practice for FCERM schemes and is set out step-by-step to provide a template for including longer-term considerations for BGI designers, planners and those advising policy and decision makers. It includes consideration of alternative future states using scenarios and evaluation of the performance and benefits of the scheme against the different scenarios. This approach can help support the engagement of stakeholders and communities if these stakeholders can identify that potential future benefits are important to them.

8.2 Overview of the longer-term assessment process

The process of applying B£ST to include future uncertainties in the design of BGI follows the equivalent procedures for design and planning for Flood and Coastal Erosion Risk Management (FCERM) in England and Wales. This includes the valuation of benefits, robustness against future uncertainty and consideration of the adaptation potential of any scheme (Brisley et al, 2015; Environment Agency, 2018d).

BGI schemes will vary in size. Many will not be of a large enough scale to warrant a fully detailed analysis. Figure 8.2 outlines the process that includes three levels of analysis, selected dependent upon the scale or complexity of the proposed scheme:

- Level 1 – Assess the robustness of the proposed schemes;
- Level 2 – Simple approach where weighting can be applied to the existing benefit values; and
- Level 3 – Detailed approach requiring in-depth review of the data and re-runs of B£ST.

Whichever level is appropriate, the process comprises of the three steps illustrated in Figure 2, with Level 1 analysis always undertaken in order to reduce the number of options looked at in more detail in Level 2 or Level 3 analysis.

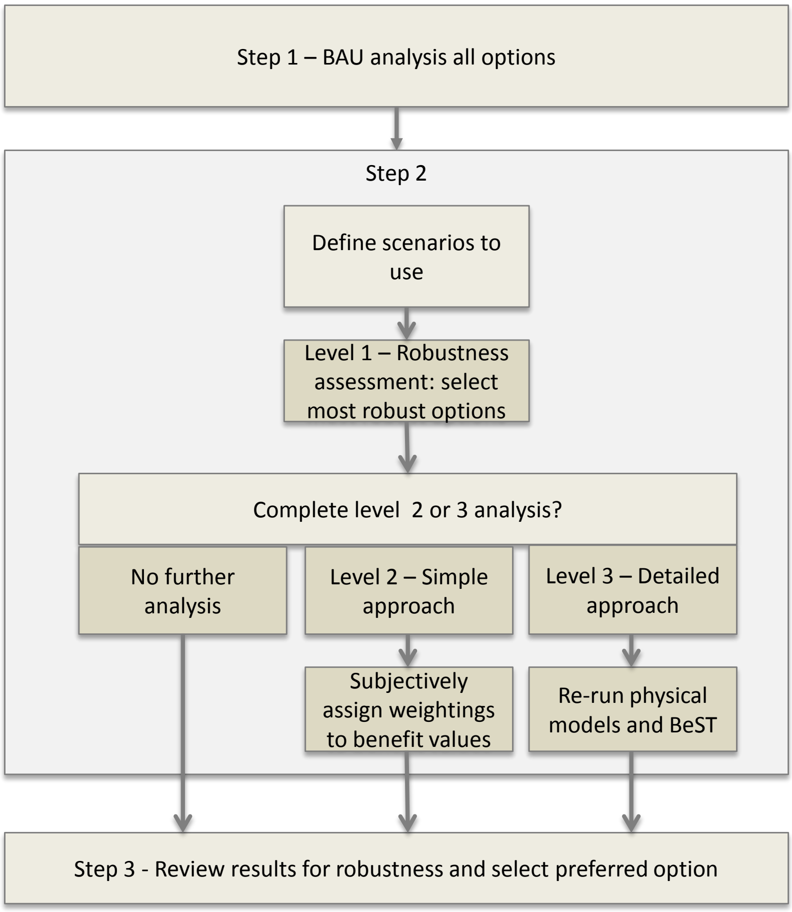


Figure 8.2 – Three step process for using the B£ST for including long term planning

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APPENDICES

APPENDIX A – GLOSSARY OF TERMS

Baseline	The actual or assumed position at the present time, often used as a starting point for comparisons or future projections.
Benefit category	A classification used to group benefits.
Capital costs	The monetary costs required to establish a project such as purchasing equipment and land. It includes all costs such as construction, equipment and labour to the point of operation, after which costs become maintenance and operation costs.
Confidence	A value attributed to the method to estimate a quantity or the monetary value to indicate the confidence in the values being used / applied.
Cost savings	An action that will result in the desired outcome at a lower cost than previous or projected costs.
Discount rate	The rate at which future costs and benefits are discounted to bring them into today's prices (present values). The social discount rate recommended by HM Treasury is currently 3.5%.
Discounting	A method for converting future costs or benefits to present values using a discount rate.
Ecosystem goods and services	The benefits that people get from the natural environment.
Long run variable cost	The cost of providing (in this case) energy in the long run, based on retail prices but excluding fixed costs (that will not change in the long run despite a sustained marginal change in energy use) and transfers between groups in society.
Maintenance costs	The costs required to keep a project or enterprise working as intended, such as repairs.
Option	Action available to deal with improving an asset. For example, reducing flood risk by introducing SuDS.
Millennium Ecosystem Assessment	A project which assessed the consequences of ecosystem change for human wellbeing. Carried out between 2001 and 2005, the Millennium Ecosystem Assessment provided an appraisal of the condition and trends of the world's ecosystems and the services they provide.
Operating costs	The costs required to administer a project or business on a day to day basis. These include things such as overheads and materials.
Present value	The value of a future amount of money today.
Value	The contribution of an action or object to user-specified goals, objectives or conditions
Valuation	The process of expressing a value for a particular good or service in a specific context, usually measured by something that can be counted, such as money

APPENDIX B – ABBREVIATIONS

AAD	Annual Average Damage
AMP	Asset Management Planning
B£ST	Benefits Estimation Tool – valuing Blue-Green Infrastructure
BAU	Business as Usual
BCR	Benefit Cost Ratio
BGI	Blue-green infrastructure
Btu	British Thermal Unit
Capex	Capital expenditure
CBA	Cost Benefit Analysis
CSO	Combined Sewer Overflow
ESS	Ecosystem Services
EU ETS	European Union Emissions Trading Scheme
FCERM	Flood and Coastal Erosion Risk Management
GiA	Grant in Aid
HEAT	Health Economic Assessment Tool
HER	Hydrologically Effective Rainfall
HIA	Health Impact Assessment
LEAPs	Local Environment Action Plans
LNRs	Local Nature Reserves
LRVC	Long Run Variable Cost
MENE	Monitor of Engagement with the Natural Environment
MORECS	Meteorological Office Rainfall and Evapotranspiration Calculation System
MCM	Multi-coloured Manual
NFM	Natural Flood Management
NPV	Net Present Value
NWEBS	National Water Environment Benefits Survey
OM	Outcome Measure
Opex	Operational expenditure
PFC	Partnerships Funding Calculator
RFF	Reasons for Failure

RICS	Royal Institute of Chartered Surveyors
SINCs	Sites of Interest for Nature Conservation
SMUD	Sacramento Municipal Utility
SuDS	Sustainable Drainage Systems
Totex	Total expenditure
UPM	Urban Pollution Management
WACC	Weighted Average Cost of Capital
WAG	Water Appraisal Guidance
WFD	Water Framework Directive
WTP	Willingness to Pay
WWNP	Working with natural processes
WwTW	Waste Water Treatment Works

APPENDIX C – ASSUMPTIONS APPLIED IN COARSE ASSESSMENT

Summary of the assumptions made that underpin the coarse assessment. Note the central estimate is an average of the lo and high estimate, unless stated.

Benefit category	Relevant coarse assessment question	Sub-category	Quantity				Value			
			Low estimate	High estimate	Conf score	Units/ notes	Low estimate	High estimate	Conf score	Units/ notes
Air quality	How many trees are being planted in urban and suburban areas (not as woodland)?	SO2	0.000031752	0.000031752	75%	tonnes/tree/yr, medium trees, McPherson study	1771	2492	100%	£/tonne, Defra values
		NO2	0.000077112	0.000077112			11318	45272		
		PM10	0.000122472	0.000122472			50994	74011		
Amenity	How many people will benefit from the improvements to green space?	Commonly visited local park or green space	Number per month	Number per month	50%	Creation or improvement of commonly visited park or green space	1.68	3.92	75%	£/person/month, Fields in Trust study
Biodiversity and ecology	What area of land is being enhanced that improves biodiversity? (ha)	Ha of habitat improved for biodiversity	Ha	Ha	50%	-	37.04	273.79	50%	£/ha/yr, low value relates to improved grassland, high to native woodland, Christie et al
Carbon sequestration	How many trees are being planted in urban and suburban areas (not as woodland)?	Benefit number of from trees	Tonnes (small trees)	Tonnes (large trees)	50%	Tonnes CO2e, over 40-year period (medium trees used for central estimate)	£	£	100%	£/tonne, Defra values
	How many trees (in hectares) are being planted as woodland?	Benefit from trees as woodland (ha)	Yield Class 4	Yield Class 10	50%	Tonnes per CO2e, over 40 year period. Beech trees, no thinning. Forestry Commission, Carbon Calculation Spreadsheet. Yield Class 6 used for	£	£	100%	£/tonne, Defra values

Benefit category	Relevant coarse assessment question	Sub-category	Quantity				Value			
			Low estimate	High estimate	Conf score	Units/ notes	Low estimate	High estimate	Conf score	Units/ notes
						central estimate				
Education	How many people will benefit from the improvements to green space?	Educational trips	Number of visits per year	Number of visits per year	50%	No. of visits is a proportion (1/4) of the number of people benefiting from green space question.	16.57	25.35	50%	£/trip, from Mourato et al
Flood risk	How many properties are likely to flood less frequently/severely?	AAD Damages Assessment	Number of properties	Number of properties	50%	Number of properties with additional flood protection	5054	5054	50%	£/property/yr, Weighted Annual Average Damage (WAAD) estimate for a property with no flood protection and no flood warning service (HM Treasury, 2018)
Flows in watercourses	What length of watercourse (km) or area of water (km2) is being improved?	Receiving water - quantity	km & or Km^2	km & or Km^2	25%	length of watercourse with condition of channel or flow of water improved due to scheme	3383	4853	50%	£ per km, based on one-sixth of lower/upper value for moderate to good for Eng & Wales, Env Agency (2013)
Health	How many people will benefit from the improvements to green	Physical activity avoided cost	Number per year	Number per year	50%	Additional number of active adult visits to green space as a	2.5	2.5	50%	£ per active visit, from Environment

Benefit category	Relevant coarse assessment question	Sub-category	Quantity				Value			
			Low estimate	High estimate	Conf score	Units/ notes	Low estimate	High estimate	Conf score	Units/ notes
	space?	(no. of visits)				result of scheme				Agency (2017)
		View over green space - emotional well-being (no. of visits)	Number per year	Number per year	50%	Additional number of visits to local park or green space	8.47	22.83	50%	£ per visit, from Fields in Trust (2018)
Recreation	How many people will benefit from the improvements to green space?	General recreation activities	Number per year	Number per year	50%	Additional number of recreational visits as a result of increased quality/quantity of green space	2.05	6.16	50%	£ per visit, value of general recreational visit (grassland, greenbelt, urban fringe & urban green space), Sen et al (2014)
Water quality in watercourse	What length of watercourse (km) or area of water (km2) is being improved?	Receiving waters	km & or Km^2	km & or Km^2	25%	length of watercourse with water quality (assumed 3 of 6 elements from Water UK, 2017) improved due to scheme	10149	14559	50%	£ per km, based on three-sixth of lower/upper value for moderate to good for Eng & Wales, Env Agency (2013)

APPENDIX D – APPLYING B£ST WHEN CONSIDERING THE FUTURE

This appendix provides an overview of the steps and process to use B£ST when assessing the benefits of BGI under future scenarios. It builds on a previously used case study, provided by Yorkshire Water, to demonstrate this process.

D.1 Step 1 - Business As Usual (BAU) analysis of all options

When designing BGI, follow the normal design and planning processes outlined in Woods-Ballard et al (2015) or in CBEC/EA (2017). These will include defining a vision, principles and objectives for the scheme design and then using suggested future projections and societal demand conditions for urban growth, climate and other changes. For example, this may include a 10% growth in paved surfaces and a 20% increase in rainfall intensity over the lifetime of the scheme.

The early sections of this guidance outlines BAU analysis to assess the benefits. This may provide a favoured BGI design or a number of possible options to consider in making the final decision. In using B£ST as part of this process, users will wish to maximise the value provided by the BGI beyond its' core function; e.g. the main objective may be to manage flooding; but by careful design achieve water quality, biodiversity, amenity and other benefits (e.g. Silva and Costa, 2016; Ashley et al, 2018). This is where B£ST provides the assessment framework and essential information about the potential overall value of schemes considered both now and into the future.

Box D1. Main stakeholders involved in the Killingworth and Long Benton SuDS design and planning

Stakeholder	Benefits of main interest
Environment Agency	Flood alleviation
Northumbrian Water	Flood alleviation, climate change, water quality, growth
North Tyneside Council	Flood alleviation , growth
Newcastle City Council	Land ownership and joint working
Wildlife Trust	Environment and ecology
Private landowners	Societal, flood alleviation, enhanced land value

The B£ST results will highlight which individual benefits are significant for each option considered, the overall benefit and, by considering costs, the NPV and BCR for each option under BAU. This normally assumes a single design life and discount rate in the BAU part of the process in Step 1. For this step, the beneficiaries, key funders, stakeholders and decision makers (the partners) will be those who come together at the start of the design/plan – see for example Box D1. Even when considering options for BAU in Step 1, it is important to understand that the stakeholders may potentially change during the BGI design life as the balance of individual benefits may change over time. Consider this change in potential stakeholders such as who takes responsibility for future maintenance and periodic replacement of components.

The benefit distribution score (%), a surrogate for flexibility (Section 5.1.2) provided by B£ST gives an indication of the relative distribution of benefits for each scheme with a higher ranking (A-E) indicating a more balanced distribution across benefit categories. Consider this distribution throughout the SuDS design life, as explained in Step 2 below (Section D.2). A scheme with a wide range of individual benefits of comparable magnitude is likely to be more flexible, adaptable and able to cope with future uncertainties, for example where one or more benefit categories may become more or less important to stakeholders in the future.

The distribution of benefits provided in the future also has bearing on the stakeholders and funders who may or may not be prepared to engage with the scheme. It may be possible to increase the range or scale of benefits provided by the scheme through marginal additional investment. This may often be termed leveraging, to create greater returns either as soon as the scheme is built or at some time in the future (e.g. Abson et al, 2016). Box D2 shows an example of how a marginal additional investment could attract new stakeholders and investors into a BGI scheme.

Box D2 Example of how additional marginal investments in the Roundhay Case Study could bring additional stakeholders into funding a scheme.

Investing in additional SuDS will not only have greater water management benefits above that required for a scheme but 'switch on' other benefits that are important to other stakeholders and may leverage extra funds.

In Roundhay, considering 3 situations beyond the BAU case with the inclusion of extra trees results in switching on the following benefits; air quality, carbon sequestration and health. Blank cells indicate no change in the benefit value. Values in () show the benefit in the BAU case if air quality and carbon were considered. Health was not valued under BAU.

Benefit	BAU	+250 Trees	+750 Trees	+1000 Trees
Wastewater treatment	£31,714			
Air quality	(£10,958)	£48,691	£69,206	£110,234
Carbon reduction	£3,223 (£11,010)	£63,433	£90,163	£143,622
Flooding	£4,470,371			
Water quality	£767,399			£767,399
Amenity	£4,743,902			
Health		£677,949	£1,694,871	£3,389,743
Recreation	£379,686			
Biodiversity and ecology	£14175			
Benefit (PV)	£10,410,471 (£10,429,216)	£11,197,321	£12,261,487	£14,050,846
Cost (PV)	£8,953,663	£8,337,729	£9,101,458	£9,249,691
Benefit : Cost	1.2	1.3	1.3	1.5
Flexibility	C	C	C	B

For some funders, demonstrable returns on investments are required over a set period of time, whereas for others, potential added benefits may develop some time after a scheme, or after a part of a scheme is functioning. Using the B£ST to evaluate the potential for any new or enhanced benefits in the future may bring in new funders later on if these stakeholders can identify that these benefits are important to them. It is therefore important to understand how B£ST estimates the value of the individual benefit categories and what this will mean over time. Box D3 provides some examples of benefit changes over time.

From the Step 1 Process described here, the BAU results provide one vision of the future and one assessment of the distribution of the benefits, for however many options are considered. Box D4 illustrates an example of the typical results from the Step 1 Analysis.

Box D3 Examples of the B£ST valuation of SuDS/NFM benefits and how these may change over time

Taking two B£ST benefit categories as examples, there is consensus from many studies that improving local environments by greening, as many BGI measures do, will for example, have a major impact on human health (Watts et al, 2015) and improve amenity, which is often revealed through increased property values (Zhou et al., 2013). Health benefits come about in a number of ways, including the performance of the green infrastructure in reducing air pollution, lowering ambient temperatures and due to the perceptions of those who access or have a view of the green areas, improving mental health and wellbeing. These benefits are included in the B£ST health category and will continue under most visions of the future while the scheme is functioning. It is possible therefore to see that investors in health benefits may be willing to fund the aspects of BGI that provide these benefits into the future as the return on investment will continue until the BGI are removed or replaced by an alternative.

In contrast, the amenity value estimated in B£ST is based on a single one-off addition to property value due to its proximity to new/improved green spaces and on local perceptions of householders and others of a better living environment. In contrast with the health benefits above, this added value may not continue over time. Under some visions of the future this increase in value will diminish or disappear as green areas become more common.

Box D4 Roundhay Park CSO case study – results for Net Present Value of benefits from using B£ST for five options for Business As Usual (BAU).

Option description	Present Value of Benefits	Distribution of benefits
1. Conventional approach to store stormwater in tanks at the CSOs.	£542,530	E
2. Conventional option that also deals with predicted flooding in the catchment.	£4,227,903	E
3. Infiltration using SuDS	£9,295,334	D
4. Public area disconnection of surface water from combined sewers with a sequence of conveyance and storage SuDS.	£11,100,652	D
5. As Option 3 with additional infiltration measures in residential private locations.	£11,216,132	D

D.2 Step 2 - Selecting the appropriate level of analysis

Step 2 assesses the robustness of the options considered in Step 1 (BAU) further. In addition, Step 2 also considers the relative distribution of the individual benefits under future conditions for each option and how, by judicious initial or later marginal investment in the original design or the scheme, future benefits may be enhanced and additional value leveraged by potentially attracting new stakeholders. The greatest opportunities to add value from any leveraging by marginal investments will depend on the scheme design and longer-term performance and crucially, the values desired in future states by future stakeholders – which may differ from today.

Using 'Scenarios' to consider alternative futures

When considering design and planning over the lifetime of a BGI scheme it is important to consider more than one 'possible future'. Scenario planning is one way of formalising this process and provides the means to ask the question "*if this was the future state, how would this option perform and would it be robust*?"

The scenarios used in this type of planning are consistent depictions of social, economic and environmental conditions in a future that may or may not come about. They are therefore not predictions of future states as such. There are many sets of such scenarios in use, and the selection of which set of scenarios is the most appropriate to use in the B£ST analysis will depend on the circumstances and context of the proposed development/amendment and the information available to define these scenarios.

It is essential that the set of scenarios used is wide-ranging and inclusive if it is to be appropriate for assessing the longer-term performance of different BGI options. Using individual scenarios with only minor differences in attributes, such as urban extents differing in the future by only a few percent, will not provide the variability required to test the robustness of the options.

The set of scenarios selected should be consistent with those used by the project stakeholders, if any, and collectively agreed with their characteristics defined. B£ST includes the ability to assess any number of separate plausible and consistent individual scenarios. Four is the minimum number recommended in order to cover as wide a range of futures as possible. Where feasible, create the scenarios from national, institutional or organisationally agreed sets of scenarios, such as the UK Foresight Future scenarios (Box D5) (Ashley et al., 2018a) or similar (e.g. http://www.foresight-platform.eu/community/forlearn/what-is-foresight/). Ensure that the defining attributes of whichever scenarios selected include climate change.

Selecting the appropriate level of analysis

There are three possibilities to follow in Step 2 (Figure 1), depending upon the required outcomes of the analysis. These alternatives apply to increasing (Levels 1-3) complexity/size of BGI scheme and corresponding needs for analysis:

Level 1 – for the smallest scale BGI and also used for initial screening for larger developments;

Level 2 – intermediate scale BGI; and

Level 3 – for the largest scale and most complex of BGI schemes.

Whatever the complexity of the scheme, undertaking a Level 1 Analysis to assess robustness should be the starting point. Robustness in this application follows that defined by Brisley et al (2015) and is the proportion of possible futures in which a given option has the highest performance. This is measured by estimating under how many of the scenarios considered does an option perform the best (i.e. has the highest benefit value). Level 1 Analysis alone may be sufficient, as it will indicate the most robust options to support decision-making made in Step 3 (Section D3).

It may be appropriate to consider taking forward the more robust options for further Level 2 or Level 3 analysis. However, this may not always be the case and the user should understand the context and the overall value of the benefits created by a scheme to facilitate such a decision. Where possible, reduce the number of options to consider during the more detailed analysis. The following (i – iii) summarises all three levels of analysis and Section D.3 explains further.

(i) Step 2 - Level 1 analysis - Robustness assessment

Where the scheme is relatively small and where the effects of uncertainties in future changes to conditions are likely to be minimal, the simple robustness assessment (Step 2 - Level 1) will be adequate to consider how it may work in the future. For this, the B£ST results from Step 1 above will be good enough for the final analysis.

Box D5 Example of a set of scenarios – Foresight Futures (UK Climate Impacts Programme (UKCIP2000)

- **World Markets (WM):** Privatised services - personal independence, material wealth and mobility and not wider social goals or environmental protection other than as natural capital. Wealthy secure, increasing numbers of vulnerable poor. Global markets frame conditions for functioning of domestic markets. Innovation high and growth >3%; wealth gap between richest/poorest 10% is large (6 times); >35 million households; >63 million people by 2030. Highest rate of climate change impacts.
- **National Enterprise (NE):** Relatively low growth so funds low for innovation investment and capacity building. Regulation of markets and services. Limited cooperation on environmental issues. Reliance on traditional approaches and personal responsibilities for risks. Water companies' main interest is in existing asset maintenance so limited innovation. Growth 1%; wealth gap between richest/poorest 10% is 3 times; 25million households; >60 million by 2030. Second highest rate of climate change impacts.
- **Local stewardship (LS)**: Networked communities with degrees of independence and small-scale and decentralised service provision in denser 'self-sufficient' communities. Growth low so aspirations cannot all be fulfilled and innovation constrained. Larger households (less houses) with stable (low) population growth. Low-scale technologies and reduced energy use, with precautionary principle. Water companies adapt to changed market conditions, in some cases services taken back by communities. Growth <0.5%; wealth gap between richest/poorest 10% is 5 times; 30million households with circa 58 million people by 2030. Low rate of climate change impacts.
- **Global Sustainability (responsibility) (GS):** moral, equitable and ecological society, with high levels of welfare within a global community. Strong planning and other controls and regulations for high density communities using green infrastructure. Medium economic growth, low population growth, Water companies strongly regulated or nationalised. Growth circa 1%; wealth gap between richest/poorest 10% is 4 times; 27.5million households; 65 million people by 2030. Lowest rate or no climate change.

(ii) Step 2 - Level 2 analysis - Simple approach

Where the scheme is larger and/or the consequences of future uncertainties and possible changes may be of greater significance then it may be necessary to reconsider the B£ST results from the Step 2 - Level 1 Analysis in a qualitative way. This decision may ultimately rest with the funding organisations. This analysis applies subjective stakeholder judgements to the B£ST BAU results for each scenario and each time period (epoch) by applying weightings. As part of Level 2, it is important to keep open options for system change or modification to ensure that future adaptation potential of the scheme will not be compromised.

(iii) Step 2 - Level 3 analysis - Detailed approach

Where the scheme is such that there may be significant future risks or uncertainties, then there will be expectations that adaptation is going to be required, and a Level 3 Detailed Analysis may be appropriate. This requires detailed re-analysis of the original designs and their performance under each scenario. This will generate new quantities to enter into B£ST with a new B£ST simulation for each scenario and epoch.

In most cases, a Level 1 followed by a Level 2 Analysis will be adequate. Box D6 provides a matrix to help decide which levels of analysis is appropriate.

D.2.1 Step 2 – Applying the approach

The user-defined confidence scores in B£ST (see section 1.10), for BAU in Step 1 will potentially differ between options and under each of the Levels set out in Step 2 in the following Sections.

Box D6 Step 2 – Level of analysis required to consider future uncertainties

Level of analysis required	Degree of uncertainty and scale of development		
	Minor uncertainties about future conditions/ minor scale of development	Intermediate uncertainties about future conditions/ intermediate scale of development	Major uncertainties about future conditions/ major scale of development
1 - Robustness assessment	X	X	X
2 – Simple approach		X	
3 – Detailed approach			X

D.2.1.1 Step 2 - Level 1 - Robustness assessment

In Step 2 – Level 1 assess the robustness of the BGI qualitatively and reject options (effectively screened) not sufficiently robust in future individual scenarios. In simple terms ask the question:

"*Would this scheme work under this type of future*?"

Ideally, consider more than one epoch. For example, how well would it work in 25 years and also in 50 years? (Note these timescales will vary depending upon funder requirements). Assign robustness scores to each option under each scenario in both of these epochs.

Begin by drawing up a table that provides a list of the most important drivers under each future scenario and for each separate epoch being considered. The stakeholders who are carrying out the scenario analysis should decide on the drivers and their consequences. Box D7 shows an example of drivers and their consequences under the four scenarios in Box D5.

In Step 2 Level 1 analysis, use the BAU results from the B£ST from Step 1 (Section 2.1). The assumed design life in the BAU analysis may or may not correspond to the time epochs being considered in Step 2 and may need to be reconsidered.

The BAU results may include some estimates of system performance under a predicted future, with urban growth and changes in climate. Where these future conditions conform to one or other of the selected scenarios (Section 2.2) then the BAU results may be used directly. Otherwise use the BAU results for today's conditions.

Stakeholders, keeping in mind the drivers and consequences; subjectively evaluate each of the options to develop a consensus as to how they perform under each of the given scenarios and for each epoch considered. The simplest way to do this is to award a score: yes, would work (or fully deliver the service or benefit) – 1; no, will not work – 0. Where the assessment is 'not sure' or 'maybe', use ½ scores. The overall robustness score is then the sum of the individual scores for each separate scenario added together, with the option scoring the highest being the one most likely to provide a continuing service whatever the future holds. There may be separate robustness scores for each epoch considered as well as for each scenario. For example, the initial design life may have been set at 50 years in Step 1, but the stakeholders may be of the view that under the scenarios being considered in Step 2, there may be important changes after say, only 25 years. In which case, there is a need to assess robustness in the intermediate time periods (e.g. 0-25 years and 26 -50 years) separately.

Box D7 Example illustrating the drivers and their potential consequences for four scenarios (only one epoch shown 2055-2095)

Driver/ consequence	**What are the consequences of this driver under this scenario?**			
	WM	NE	LS	GS
Planning requirements (e.g. NPPF; GI strategy etc.)	Relaxed regulations, mix of land use types, less local industry	Highly regulated planning, but environment less important; local (national) rather than trans-national regulations	Strong controls, denser communities	Low (national), high local. Simpler lifestyles and lower costs
Regulation in water sector: WFD; WQ	Relaxed regulations, mix of land use types, less local industry	Less international, more national	Highly regulated and enforced	Locally determined
Rainfall –runoff – urban growth, flooding; increased runoff, more surface water, more sewerage	High CC and rainfall/ richest in society protected	More catchment management planning and maintenance of sewers	Flooding (less worse than other scenarios) with lower impacts – adapt and mitigate	Wide and varied– overall society more resilient

An example of the robustness scoring under the four scenarios shown in Box D7 is given in Box D8. This includes all of the drivers and consequences (Box D7 only shows some of these).

Once the overall robustness scores have been determined, review the B£ST results subjectively to see if the individual benefits are likely to remain the same under each of the scenarios, especially for the most robust of the options. Consider whether or not the distribution of the benefits is likely to change from the percentages determined in the BAU analysis, as an indication of the relative flexibility of the option(s) under future conditions and as regards interested stakeholders. In the example given in Box D8, under BAU the tank option scored E for the distribution of benefits (i.e. one benefit dominated) and the SuDS option scored D, as although one of the benefits dominated, two other benefits were also significant. Under the four different scenarios, the distribution scores (flexibility) for the SuDS option for the 2055-2095 epoch were E (WM), E (NE), D (LS) and D (GS), indicating a possible reduction in the range of the types of main benefits after 2055 compared with the period from 2015-2055.

In Step 2 – Level 1 it is important to consider if the originally assumed stakeholders would still be the main or only actors and whether or not there may be fewer or additional players in the future, based on which benefits are more or less important. Where there are additional stakeholders, perhaps due to additional benefits becoming available in the future, this may help attract additional funding over the lifetime of the system. The potential for such leveraging of further benefits by marginal additional investments should also be considered as outlined in Section D.1 under BAU (see Ashley et al., 2018a).

Following Step 2 Level 1 analysis, the options are: (a) to move to Step 3 without any further analysis based on the robustness scores; (b) undertake a Level 2 analysis considering only the most robust options from Level 1 analysis; (c) undertake a Level 3 analysis considering only the most robust options from the Level 1 analysis. The Level 2 and Level 3 analyses are described in Sections D.2.1.2 and D.2.1.3 respectively and Step 3 in Section D.3.

Box D8 Example illustration of robustness scoring under four scenarios for two of the options considered (only one epoch considered)

In this case the SuDS option scores 3½ and the tank option 1½, therefore the SuDS option is the more robust.

Option	Scenario				Summed score
	WM	NE	LS	GS	
Tank	Local flooding important in wealthier areas like this. Willing to pay more and have more cash.	Fewer people willing to pay; expect Govt to deal with issues Less cash and more flooding – some SuDS	Lowest flood risk of any scenario Option not needed from FRM, expect more use of SuDS/GI	Flood resistant/ resilient buildings. Tank not needed, nor FRM. Localised SuDS and resource focus	
Score	1	½	0	0	1½
SuDS	No pollution regulations to speak of, so no value. Although lake is a business opportunity	Lack of money means there are maintenance issues for SuDS. Also a lack of experience. Unclear responsibilities. High failure risk.	Govt/LA maintained and funded, with compulsion to use SuDS	Big local SuDS networks. But decentralised. Clear split between urban and rural areas and SuDS use.	
Score	1	½	1	1	3½

D.2.1.2 Step 2 - Level 2 Analysis - Simple approach

Apply this step where there are potentially significant future risks and/or the scheme/proposal is of an intermediate scale, but the risks are not so significant that a fully detailed analysis is required.

Step 2 - Level 1 analysis above (Section D.2.1.1) reviewed the robustness of each of the options, therefore in Step 2 – Level 2, it is only necessary to consider the options found to be the most robust.

When considering more than one epoch it will be necessary to carry out further B£ST runs for the BAU case by adjusting runs to correspond with the time periods for the epochs selected.

In Step 2 – Level 2 Analysis the B£ST results from the BAU or additional runs above for the individual benefit categories are assigned weights according to their likelihood to be different in the future under the scenarios and epochs considered. The stakeholders involved in the scenario analysis should agree the weightings subjectively for each benefit, recording their reasons.

Use these weightings to modify each benefit present value obtained from the BAU analysis on the Scenarios (ESS) page. Open this page from the *screening* page. As an example of applying the weightings, where water quality has significant value under the BAU analysis, then for each scenario and for each epoch, agree and assign weightings between 0 and 2 with integers of 0.25 to scale the BAU estimated monetary values. Consider their relevance and value in each of the future scenarios; for some there may be more or less interest in the value of water quality than there is today. This will result in a new set of B£ST benefit values, one for each scenario adjusted using these weightings and, where used, for each epoch. The distribution of benefits will also vary between the scenarios and epochs, represented in the flexibility rating. *Note where the weighting applies to a single year value as for amenity (property values), extra care is required when using B£ST to consider the weighting in subsequent epochs.*

Box D9 Example showing Step 2 – Level 2 assignment of weightings to examples of individual benefit values for different scenarios for two epochs

Epoch 2030 - 2055

Benefit category	BAU Value (£)	Scenario							
		WM		NE		LS		GS	
		weight	Value (£)	weight	Value (£)	weight	Value (£)	weight	Value (£)
Treating WW	12,059	1	12,059	0.75	9,044	1	12,059	1	12,059
Carbon reduction & sequestration	1,265	1.25	1,581	1.25	1,581	1	1,265	1	1,265
Biodiversity & ecology	5,330	1	5,330	1	5,330	1	5,330	1.25	6,662

Epoch 2055 - 2095

Benefit category	BAU Value (£)	Scenario							
		WM		NE		LS		GS	
		weight	Value (£)	weight	Value (£)	weight	Value (£)	weight	Value (£)
Treating WW	6,525	0.5	3,262	0.5	3,262	1	6,525	1	6,525
Carbon reduction & sequestration	1,347	2	2,694	2	2,694	0.5	673.5	1	1,347
Biodiversity & ecology	2,884	0	0	0.5	1,442	1	2,884	1.5	4,326

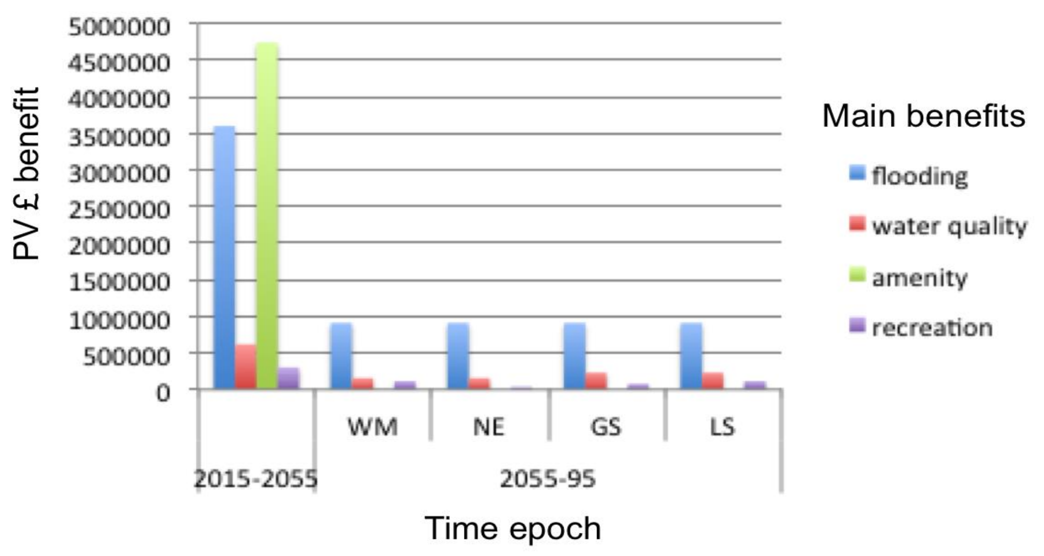
Box D9 shows some examples of BAU benefits, weightings and consequent revised benefit values under four scenarios and for two consecutive epochs. Some benefits, for example, Biodiversity and Ecology under the second epoch (2055-2095), will no longer have value for scenario No.1. This is due to changes in the value put on these benefits by society under that type of future. Hence, any stakeholders currently interested in these benefits may no longer have a stake in this version of the future.

Box D9 is an illustration of how the weightings will apply to the benefit categories identified under the BAU analysis. In future conditions, there may be other benefits not considered important under BAU. In the stakeholder deliberation process of determining the weightings, it is also necessary to consider if there may be additional benefit categories to be added to the B£ST analysis for certain scenarios and time epochs. Identify these and include them in B£ST prior to carrying out any further runs.

Box D10 Roundhay Park CSO alleviation scheme Step 2 - Level 2 Simple approach analysis results

PV benefits in epoch	Scenario			
	WM	NE	LS	GS
2015-2055	£9,303,276	£9,303,276	£9,303,276	£9,303,276
2055-2095	£1,187,616	£513,344	£1,271,933	£632,732

The chart below shows how the benefits in the table above are made up by different individual benefits in the two epochs considered. Only the main benefits are shown. Note that amenity is comprised mainly by a one-off increase in property values that occurs immediately once the SuDS have been constructed. Hence the added value does not continue beyond the first epoch.



In Step 2 – Level 2 it may also be necessary to consider the discount rate used in assessing the BAU benefit values and whether or not this would change for the individual scenario assessment, especially where this is over a number of time periods as in Box D9. These will need to be included in further runs of B£ST. Where costs are considered, the changes to these for each scenario also need to be included if the BCR is to be assessed.

Box D10 shows the results from a Step 2 - Level 2 analysis for the Roundhay Park case study outlined in Box D1. As for Step 1 and Step 2 (Sections D.1 and D.2.1), further consideration needs to be given at this point to changes in both future stakeholders and the potential for leveraging of future benefits. The benefit distribution scores under each scenario and epoch will help to inform the selection of the preferred option in Step 3 (Section D.3).

For each scenario and epoch considered, match stakeholders to the benefits identified (some of which may be additional to those for BAU). This will help identify the potential for marginal investments to bring in added benefits. It will need to be done by the stakeholders who are undertaking the analysis considering the relative magnitude and distribution of benefits and agreeing where this may be feasible. This can be informed by referring to the way in which the individual benefits are determined in B£ST (refer to Table.3-2). Any additional benefits identified at this stage may require a re-run of B£ST to determine the new distribution of benefits and overall benefit value of the scheme.

The results of the Step 2 – Level 2 analysis can be taken forward to the option selection process in Step 3 (Section D.3).

D.2.1.3 Step 2 – Level 3 Detailed assessment

This Step usually follows Step 2 - Level 1 analysis (Section D.2.1.1) and is required where there are potentially significant future risks or the development proposed is of a significant scale. In this detailed analysis, re-run B£ST using data and model results from additional physical modelling of the future system states and conditions defined from the scenario drivers and consequences as illustrated in Box D7.

The Step 2 - Level 1 analysis will have identified the most robust options. In most cases it will be sufficient to only consider these options in the Level 3 analysis. For each option, review the original data used in the BAU analysis for each scenario and each time period applied. For example, many schemes will have flood risk management as a main objective. The BAU analysis will have produced results for the status quo and including projections of urban development and climate changes. These BAU results are for only one perspective of the future – the BAU prospective future. In the detailed analysis here, each scenario needs to be considered as an alternative to the BAU prospective future, together with separate time epochs where considered. As an example, when considering how flood risk will change in the future, physical inundation models will need to be run for each scenario, for each epoch and for each option to obtain the data needed to analyse the benefits using B£ST.

The defined drivers, consequences and how the BGI options are able to address these (Box D7) are considered by altering the physical model parameters to the conditions defined for the individual scenarios. For example, under the WM Scenario in Box D7, the rainfall intensity may increase by as much as 40%, urban development will be largely unchecked and paved surface areas may increase by up to 30% compared with BAU. There may be little funding to provide flood risk protection in many areas of society and hence large scale measures are unlikely. Some BGI may be feasible, but many urban areas may have to tolerate a higher level of flooding than today. As many communities will also be less wealthy, the damage costs may be smaller than today's equivalent. These attributes would be those used to set up and run a revised set of physical models to assess the impacts of future drivers on flooding under each option. The results would then be used to re-run B£ST to assess future benefits provided by each option. Equivalent physical and economic modelling would be needed for each of the individual scenarios and time epochs being considered.

The B£ST analysis needs to consider possible changes in other parameters for each of the scenarios, e.g. the discount rate and economic growth rate. The screening and selection of benefit categories may also be different for each of the scenarios and these may vary across time periods.

The results from the analysis will provide different values for NPV and also, where costs are examined, different BCR for each scenario considered.

As for Step 2 – Level 2 (see Section D.2.1.2), stakeholders should be matched to the benefits identified (some of which may be additional to those for BAU) for each scenario and epoch considered.

The results from the Step 2 – Level 3 Detailed Analysis will be the B£ST outputs for each option under each individual scenario.

As this level requires multiple re-runs of B£ST, it is expected the user will compile the results into their own summary (e.g. using a table) to meet the individual needs of the project.

D.3 Step 3 – Selection of preferred option

From the analyses outlined above, the overall benefit value of each option will have been determined, along with the distribution of benefits and (where appropriate) costs. Depending on the analysis, the NPV and BCR will have been determined for each option under each scenario and over each epoch. Normally, the results from individual epochs should be aggregated together to obtain combined benefits and costs over the full lifetime of the scheme

Whichever level of analysis is undertaken, in Step 3 consider the results for each of the options to help select the preferred option. Whilst there may be other factors to consider, the preferred option should be that which fulfils the vision and objectives of the scheme, addresses the primary needs and at the same time is sufficiently robust (or reliable) that it will continue to be effective in the future. The preferred option may or may not also provide the greatest benefits when first constructed or over time into the future, and may or may not deliver additional benefits not initially envisaged in the BAU analysis. This option may also be that which has the most uniform distribution of benefits, i.e. the option that has the greatest flexibility in terms of adaptability in the future.

It will be up to the decision maker(s) to decide which of these various attributes and others are considered to be the most important in the selection process. Box D11 provides a simple check-list to help in making the decision as to which is the preferred option.

Box D11 Step 3 – check-list to support the selection of a preferred option

Consideration	**Yes**	**No**
Does this option fulfil the originally defined vision, principles and objectives?		
Does this option address additional and desirable objectives to the original ones above?		
Is this option sufficiently robust under the scenarios considered?		
Does the option provide an acceptable NPV and BCR?		
Does the option leverage additional benefit categories and potentially attract additional financial or other support?		
Is the option sufficiently flexible in that it can be adapted whatever the future scenario, based on the relative distribution of benefit categories?		

APPENDIX E – WATER BODY CLASSIFICATION DEFINITIONS

Applied NWEBS Status	Survey description		Clarity	Fish	Inverts & other animals	Plants	Flow and Channel	Safety for recreational contact	(Other)	Main types of uses and benefits associated with this status
Good	Good	Rural rivers	Generally clear but may be murky after periods of rain/high flow	A good and varied fish population including salmon/trout and coarse fish	Insects such as caddis and mayflies will be common during spring/summer	Wide range of plants and mosses on bank and in the water.	Mixture of deeper pools and shallow lengths of faster flowing water. Meanders and backwaters in lowland.	Water safe for contact	Edges and banks well covered by plants. No bare areas of banks trodden down by animals. Semi-natural channel with only infrequent reinforcements.	Drinking water abstractions with some treatment required. High amenity value. Good for angling. Suitable for contact activities.
		Urban rivers	Generally clear but may be murky after periods of rain/high flow	A good and varied fish population of coarse fish	Insects such as caddis and mayflies will be common during spring/summer	Flowering plants, shrubs and trees on banks and plants in water.	Periodic and large increases of water due to storms but no resulting deaths of fish etc	Water safe for all contact except bathing	No sewage derived litter in banks. Physical modifications include environmental enhancements.	Drinking water abstractions with some treatment required. High amenity value. Good for angling. Suitable for contact activities except bathing.
		Lakes	Clear water. Bed visible in shallows.	Varied fish population, mainly coarse but possibly trout in uplands	Insects such as caddis and mayflies will be common during spring/summer. No non-native species	Beds of underwater plants. Reeds etc round edges	No description	Water safe for contact	Clean shorelines, with exposed areas clean of fine muds and silt.	Drinking water abstractions with some treatment required. High amenity value. Good for angling. Suitable for contact activities.
		Estuaries and coastal	Some waters naturally murky, but other waters clear. Only occasional foams from natural algal blooms	Abundant and diverse fish population; good spawning and nursery areas. No barriers to fish migration.	Abundant shellfish and worm in muds and sediments. May be diverse bird population	Naturally diverse plantlife. Few occurrences of excessive algal growth. Brown seaweeds common in rocky waters	No description	Water safe for contact, industrial or agricultural use, mariculture, shellfisheries .	Natural physical shape and characteristics.; Mitigation of physical modifications on ecology present	Contact sports; recreational angling including salmon and sea trout; industrial and agricultural uses; mariculture and shellfisheries.

Applied NWEBS Status	Survey description		Clarity	Fish	Inverts & other animals	Plants	Flow and Channel	Safety for recreational contact	(Other)	Main types of uses and benefits associated with this status
Moderate	Adjusted for less than good	Rural rivers	Less clear than good, murkier after rainfall/high flow	Possible salmon/ trout and abundant coarse fish	Dependent mammals and birds such as voles and kingfishers occasionally spotted	Some luxuriant plant growth.	Mainly unmodified banks	Water safe for some contact (e.g. boating)	Banks intermittently covered by flowering plants shrubs and trees with rare occurrences of reeds and rushes	Drinking water abstractions with advanced treatment required. Moderate amenity and recreational values Suitable for some contact activities like angling, boating.
		Urban rivers	Less clear than good, murkier after rainfall/high flow	Coarse fish	No description	Some plant growth in and alongside river. Some invasive species	No description	Water safe for some contact activities where there is access	Possible sewage-derived litter after storms. Few measures to enhance physical habitat	Some amenity and recreational value. Suitable for some low-grade abstraction for industry.
		Lakes	Less clear than good. Possible spring/summer algal growth	Some coarse fish present, but no trout	Some mayflies/ caddis flies	Reduced areas of reed beds and limited growth of underwater plants. Non-native species may be present	No description	Water safe for some contact (e.g. boating)	Natural shoreline may be partially lost	Moderate amenity and recreational value. Low-grade abstraction possible (e.g. irrigation).
		Estuaries and coastal	Occasional periods of murkiness and/or visible surface slicks. Some algal blooms.	Some barriers to fish migration. Reduced diversity of fish and fish nurseries.	Abundance of snails and mud shrimps but reduced diversity of other animal and bird.	Seagrasses uncommon. Fewer brown seaweeds and increased green seaweeds. Increased frequency of algal blooms and resulting foam, slime and odour.	No description	Water safe for some contact (e.g. boating)		Moderate amenity and recreational value. General angling but not salmon/sea trout); boating, walking, bird watching. Some low grade abstractions. Occasional closure of shellfisheries due to algal toxins

Applied NWEBS Status	Survey description		Clarity	Fish	Inverts & other animals	Plants	Flow and Channel	Safety for recreation al contact	(Other)	Main types of uses and benefits associated with this status
Poor	Adjusted for less than good	Rural rivers	Low clarity, but some good clarity if flow levels allow	No salmon/ trout, limited coarse. Periodic fish kills	Dependent mammals and birds such as voles and kingfishers not supported	Either poor plant growth or over-luxuriant growth which blocks the channel. invasive species	Some modifications such fords or reinforcements.	Water safe for limited contact	Some banks trodden down by animals. Low amounts of bankside vegetation.	Drinking water abstractions with advanced treatment required. Low amenity and recreational values Suitable for occasional contact activities
		Urban rivers	Low clarity, but some good clarity if flow levels allow	Some coarse fish, particularly pollution tolerant, but fish kills after storm flows	No description	Either poor plant growth or over-luxuriant growth which blocks the channel. invasive species	No description	Water safe for limited contact where there is access	Sewage derived litter after storms. No measures to enhance habitat	Limited amenity and recreational value. Suitable for some low-grade abstraction for industry.
		Lakes	Low clarity particularly in spring/ summer due to algal growth	Some coarse fish. Occasional fish kills	Rarely seen caddis/ mayflies	Reduced areas of reedbeds and very limited growth of underwater plants. Non-native species present	No description	Water safe for limited contact	Natural shoreline partially lost	Poor amenity and recreational value. Low-grade abstraction may be possible (e.g. irrigation). Occasional amenity loss due to algal growth
		Estuaries and coastal	Increased periods of murkiness and/or visible surface slicks. Increased occurrence of algal blooms.	Probable barriers to fish migration. Decrease in diversity of fish and fish nurseries.	High abundance of snails and mud shrimps; increased reduction in diversity of bird/ animal populations. Possible "gender-bending" in dogwhelk populations	Seagrasses rare. Much fewer brown seaweeds and increased green seaweeds. Greatly increased frequency of algal blooms and resulting foam, slime and odour.	No description	Water generally safe for some contact (e.g. some boating)	No description	Moderate to low amenity and recreational value. General angling but not salmon/sea trout); boating, walking, bird watching. Few low grade abstractions. Some closure of shellfisheries due to algal toxins

Applied NWEBS Status	Survey description		Clarity	Fish	Inverts & other animals	Plants	Flow and Channel	Safety for recreational contact	(Other)	Main types of uses and benefits associated with this status
Bad	Far from Good	Rural rivers	Cloudy – green or brown coloured. Slimy or sludgy bed	Mostly no fish present	Only pollution-tolerant species (e.g. sludge worms). No caddis/mayflies	Localised occurrence of in-stream plants and little tree/shrub cover on banks	Obviously modified river channel	Grossly polluted waters with no safe contact		Unsuitable for all uses, with no amenity or recreational value. Offensive and odorous.
		Urban Rivers	Cloudy – green or brown coloured. Slimy or sludgy bed. Odour	Possible pollution-tolerate coarse fish but mainly no fish at all	Only pollution-tolerant species (e.g. sludge worms).	Localised occurrence of in-stream plants and little tree/shrub cover on banks	Hard engineered channel. Few natural features	Grossly polluted waters with no safe contact	Visible sewage-derived pollution.	Unsuitable for all uses, with no amenity or recreational value. Offensive and odorous.
		Lakes	Very murky for most of the year. Blanket weed may cover the surface	Usually no fish present.	Only pollution-tolerant species (e.g. sludge worms). Periodic mass kills of small water animals and any fish present	No submerged water plants and sparse shore-lining plants e.g. reeds	No description	Grossly polluted waters with no safe contact. May be unsafe for animals to drink	No description	Unsuitable for all uses, with no amenity or recreational value. Offensive and odorous.
		Estuaries and coastal	Greatly reduced visibility; discoloured water. Sewage slicks; spots on sediment surface; common algal blooms; visible faecal matter	Very low diversity of fish. No sustainable fish breeding. Periodic and extensive fish kills. No fish migration through estuary.	Low diversity of small animals in sediment. Periodic and extensive shellfish kills. Pollution-tolerate species (e.g. red sludge worms) may be present in very large numbers.	Absence of rooted or attached plants.	No description	Serious odour problems near inputs and pipes into waters. Unsuitable for all uses.	No description	Unsuitable for all uses. Serious public nuisance from odour and visual problems. No recreation or amenity value. Frequent closure of shellfisheries due to algal toxins.

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