3 Flood Risk Management Benefits: Theory and Practice

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OVERVIEW

In this chapter we provide pointers as to how a flood risk management benefit assessment should be conducted. This draws on the theory that should guide this and the sources of data that will be necessary. These are not presented as step-by-step guidance, as in other chapters, but as items that need consideration before and during the work. More detail is provided in Chapter 3 of the MCM (Penning-Rowsell *et al*., 2013).

The theoretical framework presented here remains as valid now as it was in the previous MCM (2005). However:

- Major floods in 2007 have led to research that has altered our understanding of the costs of emergency services in flood incidents, and hence questioned the universality of the 10.7% uplift factor recommended in 2005 (see also Chapter 6 herein);
- The 2007 floods also led to substantial disruption of electricity and water supplies, and these need more emphasis now, especially their off-floodplain effects;
- The land use data available for benefit assessments continues to improve, with updates to the Environment Agency's National Receptor Dataset (NRD). This reduces the need for expensive, time-consuming field-based survey;
- Climate change impacts on flood frequency are more fully understood and need to be factored in to assessments of the return periods of future floods. The latest UK Climate Projections can be accessed at https://www.metoffice.gov.uk/research/approach/collaboration/ukcp and potential impacts of climate change on flooding in the UK are evaluated in the latest Climate Change Risk Assessment (HM Government, 2022).

LESSONS FROM EXPERIENCE

- For schemes resourced from public funds the damages averted by flood risk management schemes should generally be assessed as national economic losses, not the financial losses to the individuals and organisations;

- Close attention should be given to accurate determination of the area potentially affected by flooding (the floodplain). Within that exercise considerable effort should be given to determining the extent and annual probabilities of the lesser floods and the flood at which damage begins;
- The different quality of different data inputs needs recognition, using a Data Quality Score (DQS) systems if appropriate to manage the process of benefit refinement targeted at those data inputs that are of poorest quality yet which contribute most to the variation in benefit totals;
- For major schemes involving considerable investment in low-lying areas (i.e. not steep catchments) close attention should be given to the topographic data that defines the thresholds of property flooding;
- Sufficient potential floods should be appraised so that an accurate picture can be developed of the shape of the loss-probability curve including, where appropriate, such events needed to define and quantify any Above Design Standard benefits.
- Particular attention needs to be given to the return period (or annual probability) at which flood damage begins at the site under investigation, as this will significantly influence the calculated Annual Average Damages (AAD) by properly defining that part of the area under the loss-probability curve.

TYPES OF FLOOD DAMAGE AND FLOOD LOSS

The benefits of flood risk management comprise the flood damage averted in the future as a result of schemes to reduce the frequency of flooding or reduce the impact of that flooding on the property and economic activity affected, or a combination of both.

Direct damages result from the physical contact of flood water with damageable property and its contents. Many items of flood damage loss are a function of the nature and extent of the flooding, including its duration, velocity and the contamination of the flood waters by sewage and other contaminants. All these affect damages and losses, and the location of the flood will affect the networks and social activities disrupted, causing indirect losses.

This situation is summarised in Table 3.1. It is important to ensure that for the purposes of benefit-cost analysis we assess only the national economic losses caused by floods and coastal erosion, and their indirect consequences, rather than the financial losses to individuals and organisations which are affected (Table 3.2). Intangible losses are those which are harder to value. However, these are becoming fewer as methodologies develop to assist in their valuation.

It is also important to ensure that benefits are not double counted, such as counting the loss of trade of a factory as well as the consequent loss of business of the factory's retail outlets.

Table 3.1 Direct, indirect, tangible and intangible flood impacts, with examples

		Measurement	
		Tangible	Intangible
Form of Loss	Direct	Damage to building and contents	Loss of an archaeological site
	Indirect	Loss of industrial production	Inconvenience of post-flood recovery

Table 3.2 Financial and economic damages related to household flood losses
Financial
Takes the standpoint of the individual household involved
Uses the actual money transfer involved to evaluate the loss or gain (e.g. if a household has a new-for-old insurance policy and they claim for a ten year old television, the loss is counted as the market price of a new television)
VAT is included as are other indirect taxes as they affect the individual household involved
Economic
Takes the standpoint of the nation as a whole – one person's loss can be another person's gain
Corrects the actual money transfer in order to calculate the real opportunity cost (e.g. in the case of the ten year old television, the real loss to the country is a ten year old television; the depreciated value of that ten year old television is taken as the loss)
VAT is excluded, as are other indirect taxes, because they are money transfers within the economy rather than real losses or gains

NB: This is Table 4.2 in the MCM 2013

CALCULATING ANNUAL AVERAGE DAMAGES

The methodology for assessing the benefits of flood risk management combines:

- An assessment of risk, in terms of the probability or likelihood of future floods to be averted; and
- A vulnerability assessment in terms of the damage that would be caused by those floods and therefore the economic saving to be gained by their reduction.

Figure 3.1 provides the classic four-part diagram summarising the inter-relation of hydrology, hydraulics and economics as the basis of calculating the benefits of flood risk management. The annual average flood damage is the area under the graph of flood losses plotted against exceedance probability (the reciprocal of the return period in years).

Figure 3.2 gives a simplified flow chart of the stages that need to be followed in order to calculate the benefits of flood risk management (or, put another way, the stages for calculating the present value of flood damages/losses (PVd) that will occur in the future if a "do nothing" option is adopted).

ADDING EMERGENCY COSTS

Research reported in 2002 (Penning-Rowsell *et al*., 2002) showed that flood incidents in 2000 were accompanied by significant emergency costs:

- Police, fire and ambulance service costs;
- Local Authority costs;
- Environment Agency costs.

These costs were quantified at 10.7% of property damages - see Chapter 6 and the detailed research in the MCM (Penning-Rowsell *et al.*, 2013). Investigations following flooding in 2007 showed proportionately lower emergency costs, resulting in a 5.6% uplift factor (see Chatterton *et al.*, 2010). In any benefit assessment capped annual average property damages should therefore be multiplied by 1.107 (dispersed flood incidents) or 1.056 (concentrated settlements such as large towns and cities) to allow for these costs.

DATA INPUTS: DEFINING THE BENEFIT AREA

The benefit area is the starting point for assessing the benefits of flood risk management; it is the area affected by the flood problem, both directly and indirectly.

Usually the benefit area will be the maximum known extent of flooding in the area or catchment involved. However, it may also be necessary to extend the benefit area beyond the floodplain as conventionally defined by, say, the 1% probability event. This is because the calculation of Above Design Standard benefits generally requires the assessment of the impacts of reducing more extreme flood events beyond any anticipated 'design flood'.

Figure 3.1 *The classic 4-part diagram summarizing the calculation of annual average flood losses*

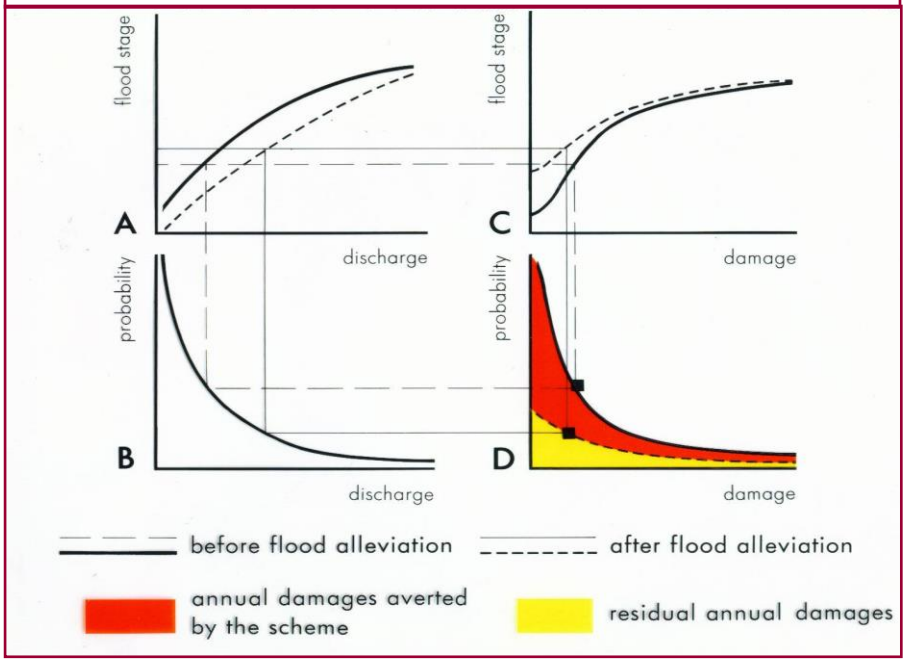
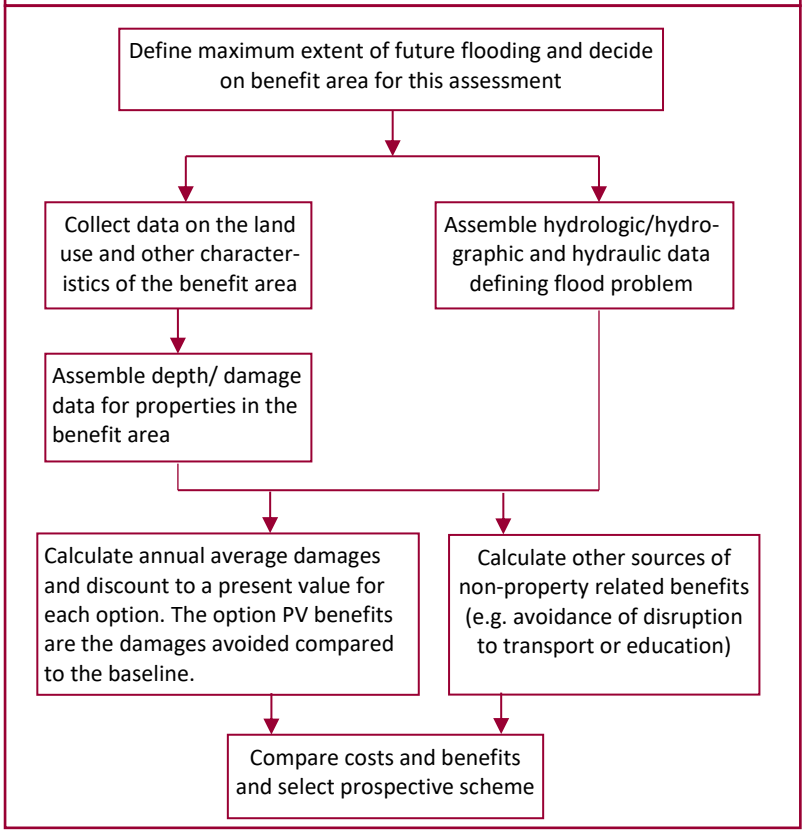


Figure 3.2 *The stages that need to be followed in order to calculate the benefits of flood risk management to compare with scheme costs*



The indirect effects of flooding can also extend well beyond the floodplain. Telecommunications, road and rail traffic disruption can occur many kilometres from the floodplain, as a flood can cause disruption to those communication and economic linkages and that disruption 'spills over' to communication links not themselves flooded. The same can apply to the disruption of water and electricity supplies (see Chapter 6).

In coastal situations it will generally be necessary to assess the floodplain as the area subject to flooding if current defences are breached or overtopped.

DATA INPUTS: ASSESSING VULNERABILITY TO FLOODING FOR THE LAND USE IN THE BENEFIT AREA

The approach to assessing the benefits of flood risk management is through investigating the potential damage to a variety of land uses in the areas to be affected.

A 'classification of land use' is available in the *Additional Resources* section of Chapter 3 on MCM-Online. It is customary within benefit-cost analysis of flood risk management investment to consider only the land use as currently existing (except where the future flood regime is likely to make current use untenable and property is assumed to be 'written off' or subject to change of use, or when agricultural land becomes suitable only for less productive uses).

For a fully comprehensive assessment of property-related benefits it will be necessary to determine:

- The geo-reference of each property (the grid reference);
- The altitude of the threshold of flooding at that property; and
- The area of the property in square metres if the property is non-residential.

Field surveys can identify land uses in the benefit area. Otherwise, the Environment Agency's National Property Dataset is the first source of data that should be consulted, but field surveys may also be necessary to determine the type of non-residential property in the area and its floor area.

Research evidence indicates that the social grouping of occupants of residential properties is a good indicator of damage potential and these differences are reflected in the standard flood damage tables provided with the MCM-Online. This data allows the application of equity multipliers in a structured and transparent way to better reflect the impact of investment decisions on different groups within society (see Chapter 4).

DATA INPUTS: FLOOD DAMAGE DATA: OUR GENERAL APPROACH

The general approach here to assessing the benefits of reducing the risk for properties affected by flooding encapsulates the following principles:

- Data in the accompanying MCM-Online tables assesses the potential damage in the future from a range of severities of flooding, resulting from different depths of flood waters within the property. Only in this way will the shape of the loss-probability curve be accurately determined;
- Much of the flood damage data presented here is "synthetic" (i.e. from a synthesis of many data items). It is therefore not directly derived from an analysis of properties which have been flooded in the recent past, because evidence suggests that post-flood surveys can be very inaccurate;
- The losses to individual properties must represent national economic losses. Therefore, the damage to property components (i.e. inventory items), is based on their assumed pre-flood value – their depreciated value - rather than the cost of their replacement with new items at current market prices;
- Any taxation element within potential flood losses is subtracted, because these are transfer payments within the economy rather than real resource costs. Therefore, the VAT element in repair costs is not counted;
- For indirect flood losses, it is necessary to separate financial and economic losses by not including, for example, the loss of income in one particular retail shop if the trade this represents is likely to be deferred in time or transferred to another retail outlet.

Current appraisal guidance (EA, 2022) now encourages appraisals to seek to identify gains and losses to different sectors.

DATA INPUTS: TOPOGRAPHIC, FLOOD SURFACE AND FLOOD PROBABILITY DATA

Experience with many project appraisals has indicated that one of the most important inputs to benefit assessments is the topographic data describing the floodplain and the accuracy of the hydraulic profiles that intersect this surface.

In Britain, many floods are relatively shallow, slow-moving, and represent water accumulating towards the lower end of catchments. In these circumstances, accurate delineation of the area liable to flooding and the precise depth of flood waters on that flood plain are both essential to accurate benefit assessments. Sources of topographic data (and hence the threshold of flooding for each property in the benefit area) are:

- LiDAR or SAR data;
- Field levelling data using traditional survey methods or modern GPS methods;
- Digital terrain model data;
- Simpler methods as appropriate (e.g. topographic maps).

The estimation of the probability of flood events contributing to appraisals is also critical, particularly the probability of the threshold of flooding.

DATA INPUTS: DATA QUALITY AND "FILTERING"

Experience indicates that the different data elements have different qualities. Our recommended objective is to improve the quality of the data that makes most contribution to calculated benefits, using a system that is transparent and auditable. The description below is for calculating the benefits of flood risk management; see MCM, Chapter 3 (Penning-Rowsell *et al*., 2013) for other situations.

Step A: Data assembly and DQS scores

Assemble the following for each property in the benefit area. The National Property Dataset (NPD3) is a useful source of land use data.

1. The land use category.
2. The floor area (NRPs only: see Ch. 5).
3. The threshold height of the property.
4. The most appropriate level of detail of depth/damage data (from the MCM-Online).
5. The hydrologic/hydraulic profile data (or similar) for each return period analyses.

Assign Data Quality Scores (DQS) for each of the five elements of dataset above: "1" = good; "4" = poor (Table 3.3).

Step B: Procedure

1. Calculate the Present Value of damages (PVd) for each property and rank all properties by PVd;
2. 'Cap' PVd at each property's market value. Market value data sources include:
    a) Residential: UK House Price Index (HPI) accessed via the Land Registry website (See Chapter 4 for details);

b) Non-residential: Valuation Office Agency (www.voa.gov.uk) to gain an approximation of market or capital value (see Chapter 5 for details).

3. Consider the scores assigned to each of the five types of data. If the scores are at levels 2 or 3, or (particularly) level 4, and there is evidence to suggest that data can be improved without disproportionate cost, then clearly there is cause for concern with the existing data-set;
4. Attempt to explore the impact of the lower quality of data and whether improvement will affect the final decision. Appraisers need to question, on a case-by-case basis, whether improving data will affect decision-making, using standard sensitivity testing techniques.

Sensitivity tests may demonstrate that improved data quality will not have an effect on the outcome of the appraisal decision. Whether data improvement is achieved or not, the debate raised will be seen in the audit trail, with reviews/actions documented to support any decision on data and its use. The route to improved data quality will be different for each data item. For example, better quality property area data can come from GIS-based measurement from maps or OS Mastermap/Google 'Street View', or from field surveys.

Table 3.3 The system of Data Quality Scores (DQS)

DQS	Description	Explanation
1	'Best of Breed'	No better available; unlikely to be improved on in near future
2	Data with known deficiencies	To be replaced as soon as third parties re-issue
3	Gross assumptions	Not invented but deduced by the project team from experience or related literature/data sources
4	Heroic assumptions	No data sources available or yet found; data based on educated guesses

NB. This is Table 3.6 in the MCM 2013

LOSS PROBABILTY CURVE ISSUES

RESIDUAL FLOODING AND DIS-BENEFITS

The Environment Agency's project appraisal guidance (FCERM-AG) decision rules seek to optimise the spend considering an acceptable standard of protection and maximising the benefit cost ratio. Schemes therefore may not protect wholly or even significantly against the more major floods.

This leaves residual flooding after the scheme has been implemented, and this damage from residual flooding should not be counted towards the benefits of the scheme.

To assess these residual damages (sometimes called 'dis-benefits') requires the assessment of the impact and damage of the major floods that are not avoided by any of the anticipated interventions/schemes. Such assessments will often be time-consuming, particularly for the very low probability floods which may cover large areas. They can be important, however, especially when the standard of protection offered by these interventions is low, such that the residual damages are quite large.

ABOVE DESIGN STANDARD BENEFITS

Above Design Standard (ADS) benefits accrue where engineered flood risk management schemes result in water levels changing for the whole range of floods experienced on a floodplain, not just the events with annual probabilities up to and including a 'design event'.

These ADS benefits will be most important where there is significant urban development at the outer edges of the floodplain, only affected by the most substantial floods, and where modest schemes can reduce flood water levels and therefore extents at these locations, even if only marginally.

However only certain types of schemes have this hydraulic effect; for example raised defences do not. The most obvious schemes where ADS benefits accrue are by-pass channels and, in most circumstances, flood storage reservoirs.

These benefits can be large. For example, in the case of the Datchet to Walton Bridge reach of the Thames, appraisal results showed that the ADS benefits could amount to some 31.5% of total benefits.

DECISION RULES AND OPTIONS

The Environment Agency (2022) provides the framework for undertaking an appraisal for flood and coastal erosion risk management in England and includes the procedures for using the benefits assessment in the decision-making process. It explains which procedure is required in different circumstances and is available on the Gov.uk website (https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-appraisal-guidance). Guidance relevant to Scotland is provided by Scottish Government (2016) (https://www.gov.scot/publications/guidance-support-sepa-responsible-authorities/pages/15/).

For other users we suggest you look to see if there are any appropriate guidance for your situation or follow the steps that are advocated for Agency use and tailor the processes advocated there to your local circumstances. Further information on this topic can be found in MCM 2013 (Section 3.7: "Decision Rules and Options").

WRITE-OFFS AND 'CAPPING'

Properties that are projected to be flooded on average more than once every three years are usually considered to be written-off unless they are flood resilient or water compatible. Write-off values are taken as the risk-free market value of an asset because the actual market value of the at-risk property could be lower (where the risk is known, there may be lower demand for the property or higher insurance costs such that the market value is reduced).

'Capping' is different to write-off and users in England are referred to the details on capping in FCERM-AG (Environment Agency, 2021)[1]. Care should be exercised where the total present value (PVd) of projected flood losses exceeds the risk-free market value of the asset. In the case of residential or commercial property, appraisers should assume that the long-term economic loss cannot exceed the current capital value of the property and to 'cap' the damages if this is likely. Capping will apply to any property if the PVd over the lifetime of the proposed scheme is greater than the market value.

[1] Appraisers are advised to check the specific rules regarding capping in their relevant guidance, as specific rules on capping may vary between countries.

Write-off and capping both use the risk-free Regional average market value to ensure that the risks are not already reflected in the market value of the property. In England, the Environment Agency suggest using the International Territorial Level 1 (ITL1) Regional statistics for capping purposes. For non-residential properties it may be necessary to use its rateable value multiplied by a factor that reflects the added value or percentage rental yield from that property.

Table 3.4 gives prime yields for selected bulk class categories with appropriate rateable value multipliers. It must be recognised that the so-called "market value" does not include 'Goodwill' which is not reflected in the rateable value times the multiplier. Thus, a popular riverside public house with a calculated market value of £200,000, using this method, may have a hefty sales premium to reflect the buoyancy of its trade. Its true market value may be up to 10 times this. However, as per the concept of displacement, according to Green Book rules this 'Goodwill' cannot be included in capping calculations as the trade from the pub's successful business can be transferred to another flood free pub.

Table 3.4 Prime yields of non-residential properties (January 2024)

Commercial property	% yield	Rateable value multiplier[2]
West End Offices	4.00	25
City Offices	5.25	19
South East Offices	7.50	13
Provincial Offices	7.00	14
High Street Retail	7.00	14
Shopping Centres	8.25	12
Retail Warehouse (Open A1)	6.00	16.6
Food Stores	5.50	18
Industrial	5.25	19

Source: Savills Research (https://www.savills.co.uk/research_articles/229130/356159-0 - January 2024)

Appraisers need to proceed as follows:

- Where assets such as properties are flooded more frequently than once every three years - or eroded - they are written-off;
- Where such assets are flooded less frequently than once every three years, it is assumed that damages are incurred on each flood up to the point where the total present value of damages (PVd) equals the risk-free market value of the asset and capped at that value;
- Where such assets are flooded occasionally over the first part of the appraisal period and are written-off at a later date as the frequency of flooding increases (as is usual under the do-nothing scenario), the approach is to determine when properties might be abandoned (i.e. flooded so frequently that their whole value would be lost) and to discount their write-off value, adding to this the present value of damages that would occur in terms of average annual damages up until

[2] The rateable value multiplier is calculated by dividing the 100 by the % yield.

the time of write off. It may be necessary to cap the total damages when they exceed the market value of the property.

- In England, full annual average damages each year should be applied until the present value damages equal the risk free market value of the property and the total damages should be capped. At this point, it is assumed that the property will be abandoned or made resilient and therefore no further damages, including direct or indirect (health effects, evacuation costs and emergency services costs) damages should be added (Environment Agency, 2021).

REMAINING ISSUES

- In locations where there is an efficient flood warning system, or local property resilience and resistance measures which results in significantly lower damage and loss values (e.g. from the kind of sandbagging operations as reported in Chapter 6), the assessment of flood damages must reflect those lower values. The flood damage data at MCM-Online represent the maximum potential damage, ignoring the damage-reducing effects of action taken after flood warnings. Data on this can be found herein in Chapters 4 and 5 and in more detail in the full MCM (Penning-Rowsell et al., 2013). Users are reminded that they should not include the benefits of flood warning unless their option also provides a flood warning service and as such includes the associated costs of implementing flood warnings;

- Sufficient potential floods should be appraised so that an accurate picture can be developed of the shape of the loss-probability curve including, where appropriate, such events needed to define and quantify any Above Design Standard benefits. Usually this means that at least 5 floods need to be appraised (e.g. the 5, 10, 25, 75 and 100+ year floods);

- Appraisers should not assume that stakeholders necessarily want to see implemented the standard of flood risk management that is identified as being optimal by the benefit-cost analyses that are undertaken. Stakeholder views and constraints should be gathered and understood as part of the wider appraisal.

- In addition to property damages, other losses should also be considered where benefits may be realised. This may include the avoidance of disruption to utilities, transportation networks and other critical services (schools, hospitals) (see Chapter 6) and recreation (see Chapter 8) and agricultural (see Chapter 9) and environment impacts (Chapter 10).

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