The Economics of Climate Resilience: Appraising interventions to diminish the mental health effects of flooding – a case study of Hull

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1 Introduction

This report is supplementary to the framework analysis *Appraising Flood Management Initiatives*[1]. By applying the framework outlined in this report, we develop a conceptual model for assessing the impacts of interventions on the consequences of flooding. Combined, the flood management appraisal and case study form Phase 2 of the ECR project. Phase 1 focused on the provision of evidence to assist policymakers and wider stakeholders in understanding current adaptation, the effectiveness of adaptation actions, and barriers to implementation.

Given the increasing body of evidence signifying the large mental health costs associated with flooding (Ramsbottom et al., 2012), this report focuses on the mental health impacts of flooding. It briefly explores the nature and consequences of flood events and then reviews the impact of interventions on the mental health effects of floods. As this case study is supplementary, more detailed information on the decision criteria and appraisal methodologies can be found in the main report, *Appraising Flood Management Initiatives*.

This report is likely to be of interest to practitioners and researchers involved in flood management, as well as those interested in appraisal methodologies more broadly.

Note to reader: caution on interpretation of this report

It is important to note that the analysis of this report is illustrative and is intended to provide a sense of scale of potential effects, rather than a definitive figure. The interventions examined here are purely descriptive and not indicative of their importance or applicability. A thorough assessment of the mental health impacts of flooding requires far more evidence and data than has been gathered to-date; as such, the reader should consider this report as exploratory in nature.

A great deal of further work is necessary to fill missing evidence gaps and to expand on available information to provide a meaningful quantitative analysis of the mental health impacts of flooding. Due to the poor quality of available evidence and the paucity of information surrounding mental health, the estimates presented here are illustrative. While this report is based on the most recent evidence in the area, great caution should be applied during interpretation due to the lack of quantifiable information available.

Further, as the results presented here are based solely on an economic framework, it is recommended that more specialist knowledge is acquired in order to gain a comprehensive understanding of the relevant mental health issues

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[1] http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18016

and that any future work would benefit from utilising the combined knowledge of mental health experts and economists.

2 The nature of flooding and responses to it

Extreme levels of rainfall in 2007 led to some of the most severe weather events the UK has ever seen. Homes, commercial properties and services around the country were affected, with Hull being one of most severely affected areas. As 95% of Hull's population reside in 'high flood risk areas' (Pitt Review, 2007), and the city is highly susceptible to further bouts of flooding, it is the focus of our analysis.

Flooding is presently the most common form of natural disaster in the UK, with mental health effects among the most serious of its consequences (Hames et al, 2012; NATO, 2008). Distress is common for those affected but is often temporary. While the size of flood, the capacity of those affected, and the social support mechanisms in place will determine the severity of mental health impacts, only a minority of those affected are at risk of developing a mental disorder.[2] Consequently, the most appropriate means of dealing with the mental health effects of flooding is through 'Psychological First Aid': a set of principles designed to respond to a broad range of consequences post-flooding (DH, 2009; HPA, 2011).

In the immediate aftermath of a flood Psychological First Aid (PFA) can foster adaptive functions, facilitating the processes of recovery without introducing psychological treatments that may not be applicable post-flooding, especially if provided in single or brief series of sessions. The significance of PFA is that it does not assume that those affected develop mental health disorders and long-term difficulties. Rather, PFA can help communities recover by facilitating their response to the emotional, cognitive, social and physical impacts of flooding (DH, 2009; HPA, 2011, NATO, 2008). PFA provides of comfort and consolidation – linking survivors with sources of support, providing immediate physical care, and an enabling environment for the sharing of experiences.

The core components incorporated in the Department of Health's Emergency Planning Guidance (2009) are shown below. This model identifies the key statutory and non-statutory organisations and the importance of individuals, families, communities and informal groups in the processes of recovery.

Adequate planning is crucial in minimising the health effects of flooding; broad approaches to emergency planning should be translated into local plans that incorporate public health and primary care (WHO, 2013).

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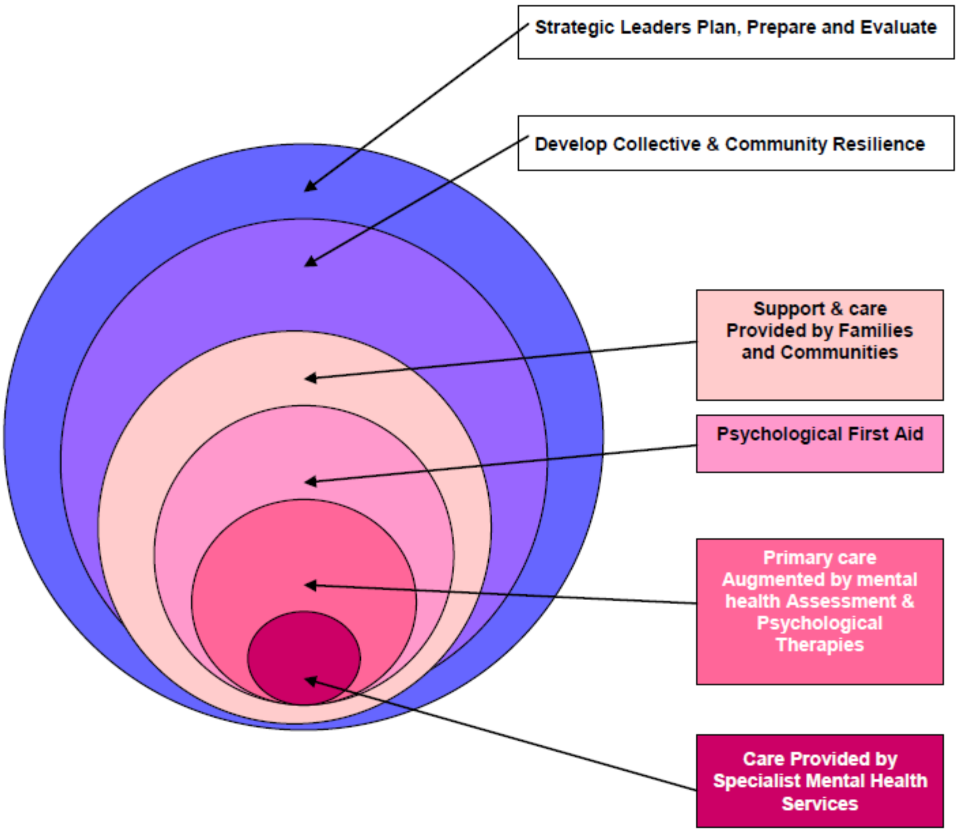
[2] Whilst only a minority of people develop a mental disorder in the wake of flooding, the costs associated with this may be significant.

Figure 1. The core components of the strategic stepped model of care



Source: HPA, 2011

2.1 Primary and secondary stressors

The ECR Health and Wellbeing report highlights the prevalence and potential scale of mental distress associated with flooding. Although there is increasing evidence on the drivers of mental health effects following flooding, this evidence still remains relatively limited, particularly in relation to the causes and scale of associated mental health issues. The extent and nature of flooding on mental health can vary substantially by incident and over time. As the consequences of floods vary, it is important that services can be adapted to accommodate the needs of individuals, families and communities post-incident (HPA, 2011).

Experiencing a flood is the principal cause of strain for those affected, due to major primary stressors such as threat to life and physical integrity. The potential psychological and behavioural consequences from direct impacts include both physical and mental health issues, social and material loss, destruction and death, and any associated bereavement (NATO, 2008).

Primary stressors include all immediate experiences directly related to flood exposure, while secondary stressors generally arise during the recovery process following a flood (HPA, 2011; HPA, 2012a). Secondary stressors predominantly include: economic factors, such as insurance problems, income or job fears, housing and possession issues; poor access to medical services; family and social disruption; loss of purpose and optimism; and, fear of the recurrence of the event (Lock et al., 2012; HPA, 2011; HPA, 2012b).

2.2 The consequences of flooding

Mental health consequences vary significantly with the incidents of flooding. Good mental health is a state of well-being, defined as when individuals can cope with the stresses of everyday life and are able to work productively and contribute to their community (WHO, 2011). Poor mental health can be associated with rapid social, personal and community changes, with impacts potentially including stress, anxiety and depression (Reacher et al, 2007).

Distress is common for those who have experienced a flood, but the majority of those affected have the capacity to cope with such stress; it is only a minority who develop a mental disorder with the needs of most people can being met through social support. Differentiating between those who develop a mental disorder and those who experience mental distress is paramount, with those suffering from mental disorders identifiable by a more intense, sustained and frequent adverse reaction to the event (HPA, 2011; DH, 2009). Whereas distress refers to experiences that challenge the tolerance and adaptation of those affected, mental disorder refers to a more intense and disproportionate experience than that of the broader general population. Differentiating between distress and disorder does not involve objective standards and differences may include cultural considerations and personal perceptions (HPA, 2011).

As the majority of people suffer temporary distress in the wake of a flood, psychosocial care rather than mental healthcare is often more applicable post-flood. Psychosocial care relates to the psychological and social support that occurs between and within people and their social groups. Psychosocial care is essential post flooding for the majority of those affected, as people generally have significant capacity to withstand the consequences of flooding and other catastrophic events, with "up to approximately 75% of people recover[ing] psychosocially without requiring expert intervention given the care, assistance and good relationships with their families and friends and the support of their communities" (HPA, 2011). However, this figure should be interpreted with caution, as it will depend on both the nature of the event and the level of care and assistance available from the support network (NATO, 2008).

2.3 Details of initiatives being appraised

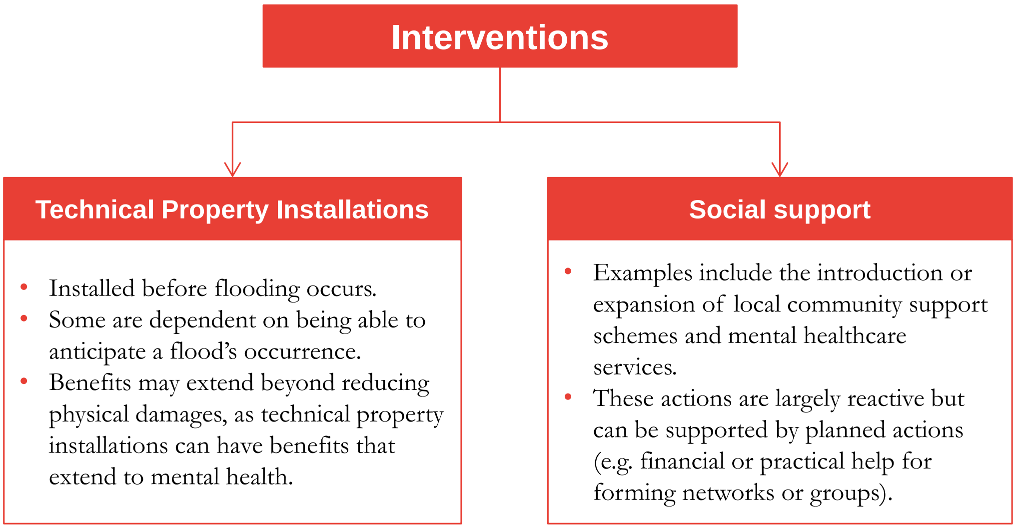
The ECR report *Appraising Flood Management Initiatives* presents a conceptual framework for assessing flood risk adaptation interventions, which is applied to this report's analysis of Hull.

Various interventions reduce the impacts of flooding on mental health. The purely illustrative nature of this cost-benefit analysis means we have elected to focus on two key areas of intervention: technical property installations and community resilience support. Alternative appraisal options are discussed in great detail in the main report although some examination of appropriate methodologies is provided here.

This report anticipates that the individuals and organisations of Hull have adapted in various ways to the health effects of flooding. Due to the extensive history of flooding within Hull, it is assumed that the local community is relatively adaptive and that the population has adapted naturally in light of expected future flooding. Consequently, the baseline is assumed to be a 'business as usual' scenario in which no further adaptation takes place in light of future flooding.

As the nature of flooding can seldom be predicted, interventions vary with each event, and strategic planners will need to be flexible in designing responses. The interventions discussed here are used to illustrate the identified framework, and this analysis is not to be considered a robust assessment. Rather, it is an application of a framework within which adaptation appraisal can be considered, available evidence can be used, and data gaps can be identified. The process of choosing appraisal options is dependent on data availability and the specific context.

Figure 2. Assessed interventions



Technical Property Installations

- Installed before flooding occurs.
- Some are dependent on being able to anticipate a flood's occurrence.
- Benefits may extend beyond reducing physical damages, as technical property installations can have benefits that extend to mental health.

Social support

- Examples include the introduction or expansion of local community support schemes and mental healthcare services.
- These actions are largely reactive but can be supported by planned actions (e.g. financial or practical help for forming networks or groups).

Source: Frontier Economics

2.3.1 Property-level protection

Property-level flood defence measures can improve the resilience of properties to flooding, potentially reducing the mental health consequences of being flooded. A key aspect of this is the extent to which the likelihood of displacement from the home is lowered and, where it is still required, the shortening of its duration.

It should be recognised here that while there are linkages between flooding and the severity of mental health impacts, it is by no means certain that investment will yield protective effects that are proportional to a person's mental health.

Since there are many potential installation measures, they are best assessed when grouped together in the form of 'packages'. We consider three of the main packages here, following the approach outlined in "Assessing the Economic Case for Property Level Measures in England" (Royal Haskoning, 2012).

- **Manual resistance measures** – these are measures that reduce the likelihood of a flood entering a property and have to be physically activated. Examples include demountable door barriers and manual vent covers.

- **Automatic resistance measures** – these are measures that reduce the likelihood of floodwater entering a property but that are triggered automatically. Examples include waterproofing external walls and automatic door guards.

- **Resilience measures** – these are measures that reduce the damages likely if floodwater enters a property by providing internal protection to the property. Examples include raising electricity points and appliances, using resilient plaster and concrete or sealed floors to prevent damage to flooring.

Having examined the data available and given the time constraints faced, the data from the Royal Haskoning (2012) is used to demonstrate the costs and benefits of these interventions.

2.3.2 Community Resilience - social support

Community Resilience refers to "communities using local resources and knowledge to help themselves during an emergency in a way that complements local emergency services".[3] Community Resilience is most effective when measures are in place before, during, and after an emergency.

As discussed in the ECR Health and Wellbeing report, while not an exhaustive list the categories below identify the main community resilience adaptation actions.

- **Planning** – builds community resilience and lessens the impacts of flooding through advanced planning and preparedness. Examples include community emergency plans, local resilience groups, and warning systems.
- **Social support** – this includes forming local volunteer groups, developing social networks and helping neighbours. Social support is usually defined as "resources provided by others" (Cohen and Syme, 1985). This is particularly important for targeting the vulnerable. These actions are largely reactive but can be supported by advanced planning (e.g. financial or practical help for forming networks or groups). Examples include social networks and voluntary groups.
- **Provision of and access to information** – relevant flood information can be provided by leaflets, a national advice line or through online services that provide information on flood risk, insurance, building repairs and longer-term issues. Examples include advice lines and a central website.
- **Health services available specific to mental health effects** – this includes the provision of health care as well as ensuring local GPs have information about the potential impacts of flooding. General counselling approaches are not appropriate in the aftermath of an extreme event where other approaches, such as Psychological First Aid, may be of more benefit. However, certain types of psychological treatment (Trauma-focused cognitive behaviour therapy (TCBT), Eye movement desensitisation and reprocessing (EMDR)) can be effective for treatment post-trauma. Local

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[3] Taken from the Cabinet Office website: http://www.cabinetoffice.gov.uk/content/community-resilience

> authorities should provide information to inform people of the potential psychological consequences of flooding and their treatments (Cochrane, 2010).

This report looks at the impact of social support mechanisms on the mental health of those affected by flooding. Due to data limitations, a selective approach to the analysis has been undertaken. The approach is outlined further in the following sections.

3 Choosing the appropriate appraisal methodology

3.1 Property-level protection

As a sufficient amount of quantitative data was available for property level installations, we used a fully quantitative-based approach to the analysis and omitted the MCA approach from further consideration. Consequently, the suitable methodological approach for assessing property protection measures was either the real options analysis (ROA), the robust decision making (RDM) approach or the scenario-based CBA, with the potential wide range of benefits precluding consideration of cost-effectiveness analysis (CEA).

As discussed in detail in *Appraising Flood Management Initiatives*, ROA and RDM have strengths in dealing with uncertainty, and should thus be considered when assessing the impacts of climate change. However, in the case of this appraisal, a scenario-based CBA would appear to be the most appropriate on the grounds of proportionality. RDM can examine in detail the states of the world in which one option is superior to others, although the key driver in this appraisal is the assumed magnitude of the mental health impacts. To focus in detail on climate change uncertainty in this context would misplace the emphasis of the analysis. Similarly, the ROA approach facilitates examination of delay or learning effects, but in the context of this appraisal these aspects are less important than the magnitude of the mental health impacts. A scenario-based CBA is therefore a pragmatic approach and addresses climate change uncertainty to a sufficient level of detail.

3.2 Community Resilience – social support

For the same reasons as above, a scenario-based CBA approach is used to assess the net benefits of community resilience initiatives. However, there is a lack of high-quality qualitative and quantitative evidence. Information on the costs and benefits of actions exists to some extent for social support, but the robustness of this evidence is weak. Consideration was given to the multi-criteria approach that appraises initiatives in the absence of sufficient quantitative data, but the lack of reliable qualitative evidence of the type required meant a scenario-based CBA approach was applied.

3.3 Property level installations appraisal

The cost-benefit analysis described below uses the figures published by the Royal Haskoning (2012) report. This report provides an appraisal of six different types of interventions (referred to as packages), two of which are combinations of the other four interventions. These six interventions, detailed in Annex 1, are as follows:

- **Automatic resistance measures (package A).** Other than maintenance costs, these installations will protect against flooding without any requirements to manually activate them.
- **Manual resistance measures (package B).** These require both maintenance costs and manual activation to make them effective.
- **Resilience measures without resilience flooring (package C).** These make the internal features of a house e.g. electrics and appliances better protected against a flood that reaches the internal areas of the property.
- **Resilience measures with resilience flooring (package D).** Identical to package C other than the presence of a concrete floor to make it impermeable.
- **Package A + package D (package E)**
- **Package B + package C (package F)**

3.4 Defining the scenarios

The operationalised scenarios in this application use the annual probabilities specific to the Humber region, taken from the CCRA report by Ramsbottom et al. (2012). These are chosen rather than the nation-wide probabilities to form the 'high', 'central' and 'low' risk scenarios that reflect uncertainty over the frequency of flooding. '1-in-100 year' and '1-in-25 year' floods are used to distinguish between the severity of floods. Naturally, analysing more frequent flood events will make preventative measures more attractive to install. The scenario probabilities used (for two flood severities) are specified in **Table 1**. The justification for their usage and explanation of their purpose is further detailed below.

Table 1. Summary of the operationalised scenarios

Scenario	Severity of flood that can occur	Annual probability of the flood occurring
High Flood Risk	Severe flood	0.032
	Moderate flood	0.104
Medium Flood Risk	Severe flood	0.029
	Moderate flood	0.095
Low Flood Risk	Severe flood	0.025
	Moderate flood	0.082

Source: *Ramsbottom et al. (2012)*

Note: A ‘1-in-100 year’ flood is classified as ‘severe’ and the ‘1-in-25 year’ flood as ‘moderate’.

3.5 Identifying and measuring the costs

The costs of the initiatives can be defined as costs that would not have been incurred without the intervention. The report details the costs of these interventions in three different cost bands – high, medium and low.

The costs vary by the type of property in which they are installed. The total cost of each intervention includes the capital cost of installing the package as well as annual maintenance costs across a 20-year period, discounted at 3.5% per annum based on the Treasury’s Green book (2003). The net present values of the total costs are listed in **Figure 1**.

Figure 3. Cost range for each initiative by property type

Detached property						
Cost Band	Initiative					
	A	B	C	D	E	F
Low	£11,213	£3,358	£32,222	£43,151	£53,964	£35,066
Medium	£15,096	£4,585	£33,968	£45,475	£60,121	£37,975
High	£18,988	£5,689	£35,715	£47,800	£66,288	£40,762

Semi-detached property						
Cost Band	Initiative					
	A	B	C	D	E	F
Low	£7,847	£3,149	£24,812	£34,097	£41,543	£27,447
Medium	£10,809	£4,251	£26,173	£35,946	£46,306	£29,846
High	£13,781	£5,283	£27,534	£37,795	£51,076	£32,176

Terraced Property						
Cost Band	Initiative					
	A	B	C	D	E	F
Low	£6,375	£2,606	£23,219	£30,848	£36,823	£25,312
Medium	£8,616	£3,484	£24,491	£32,517	£40,683	£27,396
High	£10,864	£4,301	£25,762	£34,187	£44,551	£29,421

Flat / Apartment						
Cost Band	Initiative					
	A	B	C	D	E	F
Low	£6,458	£2,629	£26,481	£34,906	£40,963	£28,597
Medium	£8,728	£3,522	£27,920	£36,794	£45,072	£30,864
High	£11,008	£4,347	£29,358	£38,682	£49,189	£33,063

Source: Based on data in (Royal Haskoning, 2012)

Overall, the resilience packages (C and D) are more expensive than the resistance packages (A and B), and the manual resistance measures (B) are the cheapest of all six.

3.6 Identifying and measuring the benefits

The benefits taken into account for the cost-benefit analysis concern:

- Building fabric
- Household inventory replacement
- Clean-up costs
- Temporary accommodation
- Absence from work
- Stress and ill health

Housing and possession damage

Indirect benefits

The first three of these costs relate to housing and possession damage. These are estimated using information from the Multi-Coloured Handbook by the Floods and Hazards Research Centre (FHRC, 2010). They are based on various assumptions regarding the components of each package, their reliability, the insurance replacement terms, the duration of the flood and its severity.

Temporary accommodation and absence from work can be thought of as indirect costs of floods which can be reduced or wholly avoided by implementing interventions which protect properties. Temporary accommodation is valued based on assumptions made in Section 3.8.5 of the Royal Haskoning (2012) report. Absence from work is valued using the average UK wage and an absence of 26 days. The former is a statistic from the 2011 Annual Survey of Hours and Earnings by the Office for National Statistics. The latter was obtained by Royal Haskoning (2012) from Werritty et al. (2007).

3.7 Identifying and measuring mental health benefits

Mental health benefits from avoiding stress are complex to estimate, partly because of challenges faced in identifying and attributing benefits to specific interventions. In addition, valuing intangible benefits – such as avoiding damage or loss to sentimental possessions – is difficult and there is limited available evidence.

Yet it is known that mental health impacts are significant and the channels by which stress can be induced are highlighted in research by Lock et al. (2012) for the Health Protection Agency. A report published by Defra (2005) shows potential solutions to placing a monetary value on such mental health costs. The report suggests that households are willing to pay £225 to avoid the stress brought on by flooding.

However, there are some issues of concern with this estimate. While this can include a variety of the intangible benefits, it is difficult to know which specific factors have been considered by each household. As the report acknowledges, it attempts to capture several aspects of mental health costs through a single estimation process, some of which are not obvious to households when indicating willingness to pay. Further, the cost is assumed to be fixed, implying it is independent of the severity of flooding. However, the severity of a flood invariably influences the period of displacement a household faces, which is known to be a key driver of the mental health costs. In addition, the stress arising from navigating the insurance process and its conflicts can vary with the flood characteristics.

As listed in JBA Consulting (2012) using figures from Bower et al. (2000), the medical resource costs from ill health (treatment and therapy) can be estimated more directly and total £2,289 per household over an average treatment period of 4 months.

The benefits and costs used in this application are from the ‘discretionary retrofit’ measures of Royal Haskoning (2012) which are also used by JBA Consulting (2012). They provide more conservative estimates because they assume higher costs. The benefits in the Royal Haskoning (2012) report also vary by property type (detached, semi-detached, terraced and flat/apartment). From these figures, we draw three important findings:

- The benefits for automatic and manual resistance measures are equal to each other in all scenarios and across all cost bands. This means that out of the two packages, the cheaper package will have the greater net present value. This is the manual resistance package.

- Across all packages, the benefits of the measures fall as the threshold (i.e. the existing level of flood protection, or 'counterfactual') rises. This is because the benefits are weighted by:

  a) the probability the flood is of a certain depth by the time it reaches a property;

  b) the probability the flood is more severe than the level currently protected against (i.e. the threshold) but less severe than the next highest threshold;

  c) the likelihood of a flood that falls within such an interval (above the existing threshold and below the next highest threshold).

  Higher thresholds imply greater damage; however, the likelihood that the flooding will be more severe to a property than the existing protection allows for decreases as the protection level rises. It is this latter 'weight' that exceeds the increased damage. For regions without any flood protection thresholds, the 'no protection' option provides the relevant counterfactual.

- Package C – the resilience measures without resilience flooring – provides the least benefits of all the different initiatives considered across all possible flood thresholds.

The benefits associated with the property installation packages outlined on page 10 comprise of the averted costs associated with flood damage. An average of short and long duration flooding is considered for each element of flood damage, with the majority of data drawn from the Multi-Coloured Handbook (FRHC, 2010).

The residential model used in this report incorporates information on the monetary damages to building fabric and inventory, clean-up costs, temporary accommodation, inability to work, and the costs of stress and ill health (Royal Haskoning, 2012). The assumptions associated with these benefits are outlined below.

Table 2. Assumption of property level measures

Benefits	Assumptions	Source
Residential Building Fabric and Inventory	MCM data was used to give values for long and short duration flooding with separate assumptions regarding seepage made for each of the property level measure (PLM) packages.	Royal Haskoning (2012) section 3.8 outlines the specific assumptions for the six PLM packages that are outline on page 10 of this report.
Residential Clean Up Costs	Clean-up costs have been derived from the *Multi-Coloured Handbook 2010: A Manual of Assessment Techniques* (MCH). The values in the MCH exclude VAT so for our analysis this has been added.	Royal Haskoning (2012) section 3.8 lists the assumptions for the reduction in clean-up costs for the six PLM packages.
Residential Health and Stress	Damages due to the avoidance of stress and ill heath are valued at £2513 per household per event. This equals £1065 per person, based on the assumption 2.36 persons per household.	The medical resource costs for ill health are taken from Bower et al. (2000), while the willingness to pay to avoid stress is taken from Defra (2005).
Residential Temporary Accommodation	Based on data from the UK's 2007 floods, a mean cost for temporary accommodation of £6,695 per household was calculated. Assumptions regarding the impact of PLM packages on the time spent in temporary accommodation are outlined in Royal Haskoning (2012) table 3.20.	Weathernet insurance-based data taken from the Environment Agency (2010) is used to show the temporary accommodation costs.
Residential Absence from Work	The mean days absent from work are calculated as 26 days. The UK mean weekly wage is £606. This gives an average total loss due to absence from work of £3,149.	Number of days absent from work is obtained from *Exploring Social Impacts of Flood Risk and Flooding in Scotland* (Scottish Executive, 2007). The UK mean wage was taken from the National Office for Statistics (2011)

Source: Frontier Economics

The benefits considered in this report do not incorporate all the health and wellbeing impacts of flooding. Several areas have not been included (such as the costs associated with welfare and social care) due to this publication's focus on mental health issues only. As such, a broader range of health benefits are associated with reductions in the impacts of flooding that are not accounted for here. These include: direct costs to the NHS from increased admissions; increased contact with GPs and social services; loss of school attendance; as well as the costs associated with loss of life.

3.8 Applying scenario probabilities to the benefits

The data on benefits and costs from Royal Haskoning (2012) have been discounted over the same 20-year time horizon as the costs. The benefits are then multiplied by current annual exceedance probabilities in order to obtain annual expected benefits, which are then aggregated to give the present value of benefits.

The Royal Haskoning (2012) study uses the 'baseline' annual exceedance probabilities. The scenarios in **Table 1** are used for the purposes of this illustrative analysis.

To apply the probability scenarios, we multiply the listed present value of benefits with the ratio of operationalised probabilities to the 'baseline' probability. For example, in the 'Low' scenario the operationalised probability of a moderate flood is 8.2% compared to 4% for the calculations in the Royal Haskoning (2012) report. Therefore, we multiply their corresponding benefits by 2.05 to obtain a new expected net present value of benefits.

Then, once these operationalised scenarios have been applied to all the benefit values, the net present value of each intervention for different severities of flood can be calculated; the cost bands can then provide a form of sensitivity analysis.

In this case study, we do not need to apply the scenarios to the costs because the implementation costs do not vary by flood risk. If implementation costs did vary by flood risk, it would be necessary to obtain data or make assumptions on how that occurs.

To reduce the dimensionality of the NPV matrix so that the values no longer vary across scenarios, one further step has to be taken: assigning probabilities to each scenario and then using them to weight each scenario's NPV. In this case study, we use equal probabilities of each scenario (a third). These are purely illustrative and can be easily changed based on informed judgement.

After doing this, there are several factors by which the NPV for a given initiative varies – flood severity, scenario, property type, and cost band. To apply these sets of NPVs to Hull, information is used on Hull's housing distribution (the proportion of terraced and detached housing) from Hull City Council to weight the different property types' NPVs by their prevalence in Hull.

We assumed that the local authority housing proportion provided in Hull refers to flats, while the remainder of housing consisted of semi-detached properties. These assumptions are summarised in **Figure 2**, along with the figures that can be used for scaling the output from a single household to an aggregate level. Flood risk is assumed to apply uniformly across all households.

Figure 4. Hull housing distribution and 2007 flood information

Hull Housing Type	Proportion
Detached	0.06
Semi-Detached	0.18
Terraced	0.53
Flat	0.23

Hull Flood Figures	
Adult flood population	15,470
People per household	2.36
Adults per household	1.89
Households affected	**8,194**

Source: Hull City Council's facts and figures, UK 2001 Census

The number of people per household (2.36) is the same figure used by both JBA Consulting (2012) and Royal Haskoning (2012) from the UK 2001 Census. We multiply this by 0.8 in order to obtain the number of adults per household. This makes it comparable with the adult flood population figure we require for the analysis.

The housing distribution provides weights to the net present value outputs for each housing type. After applying these, a matrix of NPVs for a representative house in Hull is formed. By simply multiplying it by 8,194 households, it can be scaled up to the whole of Hull.[4]

Only adults are considered in this study. There are undoubtedly benefits to the mental health of children from limiting flood damage, but there is a lack of robust evidence to support valuations of the benefits to children from avoiding such events. Contemporary thinking suggests that the impacts on children may or may not be greater than that of adults, with the impact largely dependent on the bearings of events on parents and the affect this has on parenting, emphasising the importance of families in moderation and risk mitigation (Feldman and Vengrober, 2011; NATO, 2008; HPA, 2011).

3.9 Outputs

When considering NPVs, there are two options: present a range of scenario-specific NPVs or apply the scenario probability weights and obtain an expected value for the NPV.

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[4] We do not show these results because they simply magnify the numbers presented.

The scenario-specific NPV estimates for a representative household are shown in **Figure 3**; assigning probabilities to each scenario is not needed to do this. After applying the equal probabilities to each of the scenarios, **Figure 4** shows the weighted NPVs that vary by cost band to form some degree of sensitivity analysis. The costs avoided from the installation of each measure are included in **Annex 2**. Both **Figure 3** and **Figure 4** include an assessment of the monetary damages to building fabric and inventory, the cost of clean-up, temporary accommodation, absence from work, and stress and ill health, as outlined on page 12.

Figure 5. Scenario-specific NPVs for different flood severities and property-level interventions

Representative Hull property							
1 in 25 year flood							
Cost Band	Risk	A	B	C	D	E	F
Low Cost	Low	£12,753	£16,948	-£11,287	-£12,619	-£15,882	-£4,437
	Central	£15,876	£20,072	-£9,145	-£9,371	-£12,113	-£854
	High	£18,039	£22,234	-£7,662	-£7,123	-£9,504	£1,627
Mid Cost	Low	£10,277	£16,005	-£12,641	-£14,410	-£20,099	-£6,669
	Central	£13,400	£19,129	-£10,500	-£11,162	-£16,331	-£3,086
	High	£15,563	£21,291	-£9,017	-£8,914	-£13,722	-£606
Upper Cost	Low	£7,793	£15,131	-£13,996	-£16,201	-£24,325	-£8,835
	Central	£10,916	£18,254	-£11,854	-£12,954	-£20,556	-£5,252
	High	£13,079	£20,417	-£10,371	-£10,705	-£17,947	-£2,771
1 in 100 year flood							
Cost Band	Risk	A	B	C	D	E	F
Low Cost	Low	-£4,737	-£541	-£23,191	-£30,652	-£36,845	-£24,401
	Central	-£4,382	-£187	-£22,935	-£30,260	-£36,396	-£23,979
	High	-£4,117	£78	-£22,742	-£29,965	-£36,059	-£23,663
Mid Cost	Low	-£7,212	-£1,484	-£24,546	-£32,443	-£41,063	-£26,633
	Central	-£6,858	-£1,130	-£24,289	-£32,051	-£40,614	-£26,212
	High	-£6,593	-£864	-£24,097	-£31,756	-£40,277	-£25,895
Upper Cost	Low	-£9,697	-£2,359	-£25,900	-£34,235	-£45,289	-£28,799
	Central	-£9,343	-£2,005	-£25,644	-£33,842	-£44,839	-£28,377
	High	-£9,077	-£1,739	-£25,451	-£33,548	-£44,502	-£28,061

Source: Frontier Economics

Figure 6. Probability-weighted NPVs of property-level interventions

Representative Hull property						
1 in 25 year flood						
Cost Band	A	B	C	D	E	F
Low Cost	£15,556	£19,751	-£9,364	-£9,704	-£12,500	-£1,221
Mid Cost	£13,080	£18,809	-£10,719	-£11,495	-£16,717	-£3,454
Upper Cost	£10,596	£17,934	-£12,073	-£13,287	-£20,943	-£5,619

Representative Hull property						
1 in 100 year flood						
Cost Band	A	B	C	D	E	F
Low Cost	-£4,412	-£217	-£22,956	-£30,292	-£36,434	-£24,015
Mid Cost	-£6,888	-£1,159	-£24,311	-£32,083	-£40,651	-£26,247
Upper Cost	-£9,372	-£2,034	-£25,665	-£33,875	-£44,877	-£28,413

Source: Based on assumptions in this report and Royal Haskoning (2012)

3.10 Interpretation and conclusions

The decision rules outlined in *Appraising Flood Management Initiatives* can be used to evaluate the outputs that are formed using the costs and benefits. A net present value above zero indicates a policy that would be worthwhile for generating benefits. The government recommendation is to prioritise projects by the excess of benefits over costs and this is the primary consideration when choosing between policy options. If there is a budget that must be strictly adhered to, then a secondary consideration is to rank by benefit to cost ratio and implement those that fall within the budget.

The results from **Figures 3** and **4** show that, for a moderate flood, the first two packages – the resistance measures – are the only ones which have a positive net benefit. This applies across all the cost bands. As noted earlier, the manual resistance measures are expected to provide greater net benefits because they provide the same benefits as their automatic equivalents at a lower cost.

For properties with a high pre-existing protection level, none of the initiatives are worthwhile, and even the combination packages consistently signal a net cost if implemented.

These results imply that, if only one set of measures is to be implemented, the manual resistance package performs the best and should therefore be recommended. This is consistent with the general results from Royal Haskoning (2012), where manual resistance measures were most effective for residential properties; automatic resistance measures were cost effective only for certain flood severities and cost bands; and no other interventions were worthwhile for floods with a 'baseline' annual exceedance probability of 5% or lower. In fact, the only other cost-effective initiative (automatic resistance) should not be implemented with manual resistance because they both serve the same purpose.

However, there are additional advantages to automatic measures which are not accounted for in the estimated benefits presented here. These advantages centre on the avoidance of human error. Automatic resistance measures are not dependent on flood warning systems' reliability, on the timely receipt of the flood warning, or on the measure's correct installation on each occasion. Based on the likelihood of each of these advantages, the benefits of the two resistance measures can be weighted, as was done by Royal Haskoning (2012). Their report finds that, even after taking reliability factors into account, the preference of both manual to automatic resistance measures persists. The estimates here have not accounted for these reliability aspects, but it is possible to do so using the reliability factors of 90% for automatic measures and 77% for manual measures outlined in Royal Haskoning (2012).

Since these property-level flood defences seem to be justified (in the form of resistance measures) generally for areas with low flood severities, it may be that alternatives are worth considering in areas already protected against high flood severities. These may not have been considered in the shortlist of options, but it may be worth examining in the future.

Evidence gaps and recommendations for future research

The evidence gaps relate to the following issues:

- Finding data to allow other methodologies to not be ruled out of feasibility;
- Finding evidence to support more accurate measurement of the costs and benefits; and
- Finding information on alternative initiatives that can be considered on a revised 'shortlist' alongside resistance measures.

The first point concerns enabling the ideal methodology to be implemented. In our case, the scenario-based CBA was the best suited method and it was applicable because the right data was available. But this may not be the case for all flood defence initiatives. For example, in the case of another shortlist of interventions, real options analysis (or any other) may be most suitable, but whether the application of another method is feasible will be conditional on the available data.

Another area for future research to fill evidence gaps would be cases where the relevant type of data is available, but is incomplete. In the case of property-level flood protection, there are notable gaps in quantifying the benefits due to a lack of information on the mental health impacts of these interventions. While there is evidence to suggest such impacts exist, quantified evidence for them is more difficult to find.

The study by Lock et al. (2012) identifies secondary channels of impact by which floods can worsen well-being and suggests areas for future research to substantiate these, in particular:

- People's response to floods and their recovery from post-traumatic stress
- The changes over time in the psychosocial impacts of flooding
- Separating new mental disorders induced by the flood from the aggravation of existing disorders

Within this area, there are opportunities for further research into the quantified impacts of flooding on the mental health of children.

A full appraisal of mental health impacts should also consider the impact of damage to non-domestic properties such as schools, hospitals, and commercial buildings. The Hull 2007 flood was found to have a large impact on schools, with "only 8 out of 99 schools unaffected" resulting in "a large social and economic effect, forcing parents to take time off work, lose earnings and in some cases jobs" (Coulthard et al., 2007).

Finally, given the lack of available information about the net benefits of the interventions considered, it is important to explore an improved range of alternatives in future appraisals of a similar nature. This may include other interventions which, in a separate appraisal, have been deemed effective. Doing this will require research into what measures constitute relevant alternatives to, for example, manual resistance. Such alternatives might include an improved technology for one of the other packages analysed here, or the substitution of a communal level intervention for property-level initiatives. Alternatively, it could involve considering new types of interventions that have not been implemented but which could improve mental health recovery from these events.

4 Community Resilience appraisal

4.1 Interventions explored

As noted above, this section provides an illustrative assessment of community interventions through social support. This includes forming local volunteer groups, developing social networks and helping neighbours. This is particularly important for targeting the vulnerable. Examples include social networks and voluntary groups. Data limitations mean that the following analysis should be considered as illustrative only.

4.2 Defining the scenarios

Having elected to use the CBA approach, a set of scenarios that capture the uncertainty of future flooding was formulated.

Three scenarios, representing high, medium and low future levels of flood risk, were operationalised. Estimates of the potential size of a severe flood were given by the Environment Agency's floods database that indicated the flooded population for Hull in 2007 (a severe flood) was 19,338. Population data from the Office for National statistics suggest that 80% of this population can be assumed to be adults aged 16 years or more, representing an adult flood population of 15,470.

We use the estimated annual probabilities from the CCRA Floods and Coastal Erosion sector report (Ramsbottom et al., 2012) to determine the probabilities of severities of floods. In line with our focus on Hull, we elected to use the report’s flood risk analysis on Humber, which provided us with the annual probabilities of flooding estimates shown in **Table 1**.

Due to the lack of analysis available on the mental health impacts of flooding, where possible, a range of values were used to account for uncertainty in our analysis. Furthermore, the lack of data means that this analysis could only focus on a narrow range of options and as such, some potential benefits may not be fully incorporated in the results.

As with the previous illustration, in estimating the costs and benefits of our initiatives, we explicitly normalise those arising in the counterfactual to zero so that our analysis shows the incremental benefits of each intervention on the mental health impacts of flooding.

4.3 Identifying and measuring the costs and benefits of social support

Benefits

The majority of people affected by disasters face psychosocial problems with varying severity and duration (DH, 2009).

Psychosocial support is usually provided through families and communities who play a significant role in meeting the psychosocial needs of those affected (DH, 2009). Social integration – as well as received and perceived support – serves to build the adaptive capacity of a community and protect those affected by negative life events (Norris et al., 2002).

According to Dalgrad et al. (1995), social support[5] exerts a positive effect on mental health, diminishing the risk of developing a mental disorder when exposed to a negative life event, such as a flood. Specifically, Dalgrad et al. (1995) found that the combination of feelings of powerlessness and low social support led to severe mental distress when exposed to stressors. As such, individual personality constraints as well as interpersonal and social resources must be accounted for when assessing a person's risk of developing a mental disorder.

To measure personal characteristics this report uses the rotter scale, in line with the approach taken by Dalgrad et al. (1995), which determines whether someone is 'internal' or 'external', by referring to their sense of control over their life: an internal believes they are in control of their actions; an external feels powerless).

'Externals' with weak social support have a 0.17 probability of developing a mental disorder when faced with a negative life event, whereas 'externals' with strong social support have a 0.05 probability of developing a mental disorder. For 'internals' exposed to a negative life event, the level of social support makes only a negligible difference to the probability of developing a mental health disorder, so we do not model this within this study.

By assuming that 50% of Hull's population are 'externals' and 50% 'internals', we determine the impact of social support on mental health 'caseness'[6] in Hull. We recognise that there are other approaches to determining the prevalence of mental health caseness post-flood. However, this was the only suitable quantitative method found. 'Mental health caseness' is classified here through the identification of symptoms associated with anxiety, depression and somatisation,

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[5] Dalgrad et al. (1995) measured social support by asking respondents questions about their perception of their relationships with family, friends and neighbours. Feeling of attachment, mutual respect and trust were used as the main sources for their index of social support.

[6] Mental health caseness refers to the development of a common mental health disorder when one was not present previously.

which are common syndromes associated with negative life events (Dalgrad et al., 1995).

The benefits from intervention are calculated as the costs avoided from developing mental caseness. The population affected and the associated mental health burdens are estimated in terms of the monetised equivalent cost to the individual from the impact on quality of life, the treatment cost to the National Health Service, and the cost of lost productivity through additional absence of the working age population. For a more detailed explanation of the methodology used, please refer to the ECR Health and Wellbeing report chapter 4 and associated annexes.

Costs

Social support encompasses a number of actions, from helping neighbours and forming voluntary local groups to developing social networks that help to build the adaptive capacity of a community.

Implementing a strong social fabric in communities is complex, but the costs of implementing such actions are frequently small as the establishment of communication between persons is mutually beneficial. The sharing of information and experiences is done by all parties so that benefits are equally shared and the net costs of actions are zero. Thus the costs of such actions here are assumed to be negligible as benefits are reciprocal and accrue equally to those involved.

However, due to the significance of community resilience in reducing the extent and impact of psychosocial and mental health effects, building the community's capacity to provide practical and emotional support can be facilitated with the provision of financial assistance to help establish support groups. Such financial assistance is not considered here.

Outputs

Having determined the parameters of our scenarios and estimated the costs and benefits associated with them, scenario-specific net benefits and costs were calculated.

For the high, medium, and low flood risk scenarios, the benefits and costs of social support were determined with the net effects shown to be significant at all levels of flood risk. Estimates have been produced building on the ECR's analysis of the prevalence of mental distress post flooding, with the probabilities of flood occurrence identified in table 1 used to calculate the expected annual value of interventions.

Table 2. Scenario-specific NPVs of community resilience

		Expected Annual Value of Intervention			PER FLOOD EVENT
		HIGH FLOOD RISK	MED FLOOD RISK	LOW FLOOD RISK	
Intervention	Severity of flood	Benefits - Costs (accounting for flood probability)	Benefits - Costs (accounting for flood probability)	Benefits - Costs (accounting for flood probability)	Benefits - Costs
Social support	1 in 25 years*	£ 2,000	£ 1,000	£ 1,000	£ 15,000
Social support	1 in 100 years**	£ 80,000	£ 70,000	£ 60,000	£ 2,550,000
*Figures rounded to the nearest 1,000					
**Figures rounded to the nearest 10,000					

Source: Frontier Economics

4.4 Interpretations and conclusions

The outputs produced above indicate the net benefits/costs of the identified interventions are positive for all levels of flood risk. To determine whether the implementation of such measures is worthwhile, we consider the decision rules outlined in *Appraising Flood Management Initiatives*.

Due to the positive, significant nature of the estimates generated, under the 'expected value', 'least regret' and 'maximin' decision rules identified in the framework, the initiative is worthy of implementation. The decision to implement the intervention is thus robust under the values generated by this report. However, these results are predicated on a number of strict assumptions, due to the lack of appropriate data. As such, the findings are somewhat speculative and should be considered as illustrative only. For a more robust and comprehensive analysis, further research is necessary.

4.4.1 Evidence gaps and recommendations for future research

As noted throughout this appraisal, the work conducted here is purely illustrative and intended to demonstrate how to apply the framework developed in *Appraising Flood Management Initiatives*.

Due to the lack of information available, the research necessary for a comprehensive analysis was not possible. Instead, readily available information was used to determine the parameters of our analysis. Consequently, this approach is by no means comprehensive or definitive. A more robust and informative piece requires that evidence gaps are filled and data issues overcome.

Where gaps in methodology or evidence exist, further research is necessary. Substantial research is required across the majority of issues discussed in this report, with clear evidence gaps on a broad range of the health and wellbeing impacts of flooding.

To produce a comprehensive analysis, the following suggested areas for future research should be explored:

- The **implications of flooding on mental health for those with an established mental health disorder**. This analysis should consider the type of mental health outcome experienced (ranging from stress and anxiety up to the more severe forms of mental health disorder) and their duration.
- The **net benefits of a full range of community support measures** and the conditions under which they are more effective.
- **Optimal intervention and treatment tolerability.** Future research should explore the optimal time for interventions as well as consider the impact of further adverse events and treatment tolerability, as well as control for potential additional interventions (Cochrane, 2009).
- **The costs of proactively introducing social support measures**, including the costs and benefits of (i) establishing voluntary groups (e.g. through funding) and (ii) developing social networks.
- **The effectiveness of a range of mental healthcare measures**, including CBTs or other recovery services. This should include the types of measures, the associated costs and benefits, and the conditions under which they are more effective.

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Annex 1 – Flood resistance packages

The four packages listed in the property-level installations appraisal are detailed below. The final two packages mentioned in the report are simply combinations of the measures detailed in each of the separate packages.

Table 3. Flood resistance packages

Flood Resistance Package	Individual Measures
Automatic (Package A)	Automatic door guards
	Smart airbricks and vents
	Non-return valves on main sewer pipe
	Waterproof external walls
	Silicone gel sealant around cables passing through external walls
	Sump pump
Manual (Package B)	Demountable Door Guards
	Manual Airbrick and Vent Covers
	Sewerage bungs/toilet pan seals
	Waterproof external walls
	Silicone gel sealant around cables passing through external walls
	Sump pump

Source: Royal Haskoning (2012)

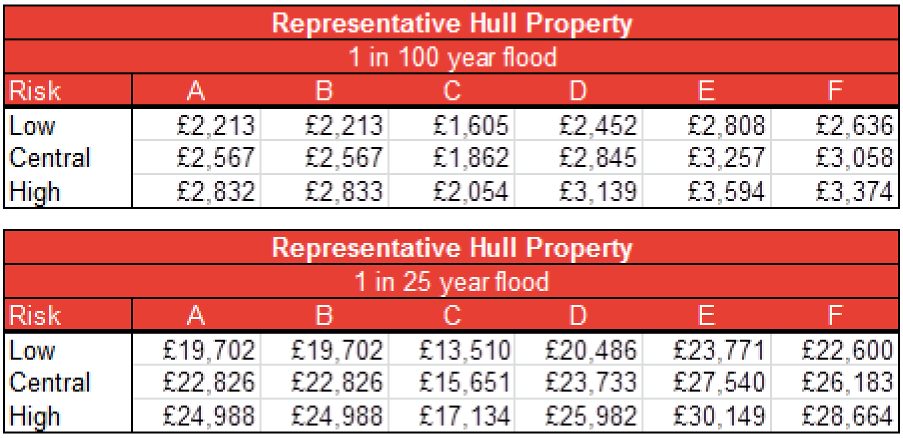
Table 4. Flood resilience packages

Flood Resilience Package	Individual Measures
Resilience without resilience flooring (Package C)	Replace gypsum plaster with water resistant material, such as lime
	Replace doors, windows and frames with water-resistant alternatives
	Mount boilers on wall
	Move washing machine to first floor
	Replace ovens with raised, built-under type
	Move electrics well above likely flood level
	Move service meters well above likely flood level
	Replace chipboard kitchen/bathroom units with plastic units
Resilience with resilience flooring (Package D)	All measures above and replace timber floor with solid concrete

Source: Royal Haskoning (2012)

Annex 2 – Avoided costs from each measure by level of existing flood protection

Table 5. Costs avoided from each measure by level of existing flood protection



Representative Hull Property						
1 in 100 year flood						
Risk	A	B	C	D	E	F
Low	£2,213	£2,213	£1,605	£2,452	£2,808	£2,636
Central	£2,567	£2,567	£1,862	£2,845	£3,257	£3,058
High	£2,832	£2,833	£2,054	£3,139	£3,594	£3,374

Representative Hull Property						
1 in 25 year flood						
Risk	A	B	C	D	E	F
Low	£19,702	£19,702	£13,510	£20,486	£23,771	£22,600
Central	£22,826	£22,826	£15,651	£23,733	£27,540	£26,183
High	£24,988	£24,988	£17,134	£25,982	£30,149	£28,664

Source: Frontier Economics

The benefits of the initiatives are described in Table 5 above. They show that the avoided costs are lower if the property is already well protected against floods. The combination packages (E and F) are best at preventing flood damage, but as the NPVs in Table 4 show, the cost of installing them outweigh their benefits.

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