THAMES APPRAISAL PACKAGE

ENV0000112C Reading and Caversham Flood Alleviation Scheme

Economic Appraisal Report

Prepared for

Environment Agency

January 2019

CH2M
Elms House,
43 Brook Green,
London,
W6 7EF
United Kingdom

CH2M Project Number: 683722

Document History

Reference Number: ENV0000112C-CH2-ECM-O00-RP-CI-0001

Client Name: Environment Agency

This document has been issued and amended as follows:

Version	Date	Description	Created By	Verified By	Approved By
C01	20/10/2017	Issue	XXXXXXX	XXXXXXX	XXXXXXX
C02	02/02/2018	Update following detailed DN and DM modelling	XXXXXXX	XXXXXXX	XXXXXXX
C03	15/01/2019	Final draft to support OBC	XXXXXXX	XXXXXXX	XXXXXXX

Contents

Acronyms List

AEP	Annual Exceedance Probability
BCR	Benefit Cost Ratio
FCRM-AG	Flood and Coastal Risk Management Appraisal Guidance
iBCR	Incremental Benefit Cost Ratio
OBC	Outline Business Case

Executive Summary

This economics appraisal report outlines the detailed economic assessment for the short-listed options identified for reduction of flood risk in Caversham, Reading, Berkshire.

Short-listed options have been assessed using Defra guidance (FCRM-AG), Multi-Coloured Manual[1] (MCM 2013), and the Multi Coloured Handbook (2017)[2].

Economic assessment has been informed by detailed hydraulic modelling of both the Do Nothing and Do Minimum scenarios, together with an interpolation of damages avoided by each of the Do Something scenarios.

A two step approach to the economic assessment was undertaken. Step 1 assessed each shortlisted option against Do Minimum, to verify the justification to invest in protecting each discrete benefit area. This was used to assist in the identification of a leading option. Step 2 subsequently involved identifying the optimal standard of protection for the leading option, through the assessment of incremental benefit cost ratios.

Of the five "Do Something" options assessed, Option 3 has the greatest BCR at 15.9. However, this is due to the high benefits secured by the Do Minimum scenario, and this being the lowest cost of the Do Something options. The iBCR in comparison to Do Minimum is the lowest of the Do Something options at 1.9. A similar assessment can be made of Option 6, with a BCR of 11.0 and an IBCR of 2.1. These were therefore discounted form being considered as the leading option during Step 1, as protection of these discrete benefit areas was less economically viable than the protection of Benefit Area B (Christchurch Playing Fields to Nire Road).

Option 4 (Defences from Christchurch Playing Fields to Nire Road) has the highest iBCR, compared to Do Minimum, at 4.1. The IBCR of Option 5 (Defences from Promenade Road to Nire Road) is 3.9, whilst Option 7 has an IBCR of 3.6. Option 7 also delivers the greatest value of OM1 benefits (at £137million), OM2 properties (at 739), and has the greatest potential to attract partnership funding.

Option 7 was chosen as the leading option at this point, in line with Stage 5 of the FCERM-AG decision-making criteria, as it has the potential to deliver the highest number of OM2s and the greatest opportunity to deliver wider objectives (in consultation with Reading Borough Council and other stakeholders). The Step 2 assessment subsequently verified the justification of Option 7c (with a target standard of protection of 0.5% AEP including the effects of climate change over a 100 year appraisal period). This option has a benefit cost ratio of 5.9 and a raw Partnership Funding Score of 34%.

This decision will be kept under review, pending further discussion surrounding funding availability and project savings, and Option 4 or 5 may be progressed if the funding required for the preferred option cannot be secured.

[1] Penning-Rowsell, Edmund, ed. Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal. Milton Park, Abingdon, Oxon: Routledge, 2013

[2] Penning-Rowsell, Edmund, Sally Priest, Dennis Parker, Joe Morris, Sylvia Tunstall, Christophe Viavattene, John Chatterton, and Damon Owen. "Flood and Coastal Erosion Risk Management: 2017 Handbook for Economic Appraisal." Flood Hazard Research Centre, 2017. http://www.mcm-online.co.uk.

1 Overview

Purpose of document: This document forms an Appendix to the Outline Business Case (OBC) for the Reading and Caversham Flood Alleviation Scheme (FAS). It provides supporting information on the economic appraisal of options undertaken for future flood risk management of the River Thames in Caversham. It should be read in conjunction with the main business case document and other supporting appendices.

The Environment Agency's Flood and Coastal Erosion Risk Management appraisal guidance (FCERM-AG) with Supplementary Guidance Notes issued by Department for Environment, Food and Rural Affairs (DEFRA) sets out the principles that should be used when undertaking FCERM strategies and projects developed by operating authorities in line with government policy.

For each appraisal, a series of possible options will exist. Benefits and costs for all 'Do More' options need to be compared to those of the baseline 'Do Nothing' case. The 'Do Nothing' case is a 'walk away' scenario whereby all current maintenance activities cease and natural processes occur freely.

An economic assessment has been made for each shortlisted option including the 'Do Nothing' option so that other options may be compared back to it as the economic baseline for economic assessment. This is what Outcome Measure 1 (OM1) is measured against. Outcome Measure 2 (OM2), properties moved to a lower flood risk band, is measured against the existing situation, which in this case is represented by the Do Minimum scenario.

The benefits of an option are the economic damages avoided from 'Do Nothing', taking into account the capital cost for that option. By definition, the 'Do Nothing' option costs nothing to implement.

Flood damages have been determined using the procedures outlined in the Multi Coloured Manual (MCM), Multi Coloured Handbook (MCH), the Green Book (HM Treasury, 2003); and by processing them using a derived spreadsheet from DEFRA.

The economic summary spreadsheet available under FCERM-AG was used as the basis to summarise the damages data and cost processed in individual sheets in order to evaluate the benefits of each option and ultimately to decide which option to recommend using the FCERM-AG decision process. In this assessment no additional economic benefits have been considered such as ecological or social as they were considered to be of minor value compared to the damages avoided.

This appendix sets out the economic appraisal of potential options proposed to reduce flood risk in Caversham. It justifies the decision of selecting Option 7 as the leading option at this stage.

2 Methodology

In order to evaluate the relative benefit of potential options, the whole life costs summed over the 100 year appraisal period are compared to the damages avoided as a result of implementing the scheme. The economic benefits are calculated as the damages avoided compared to the baseline option 'Do Nothing'.

This comparison was achieved by applying the following procedures:

- Detailed 1D and 2D hydraulic modelling of each option was undertaken using Flood Modeller and TuFlow software. The 2D analysis results giving floodwater depth across the catchment were processed against the latest National Receptor Dataset (NRD). Flood depths were given against each of these points and were then interrogated within GIS software so as to derive flood depths at individual properties within the Study Area for specific flood events and flood alleviation options.
- Flood levels were extracted for each of these points and compared against property threshold levels obtained from previous surveys. For properties where surveyed thresholds were unavailable, the economic assessment assumes a threshold level of 150mm above Lidar data at the respective NRD point.

The options that were assessed for the economic appraisal are:

- Option 1: Do Nothing – 'walk away' scenario whereby all current maintenance activities cease and natural process occur freely.
    - Increase in channel roughness of 20%.
    - Increase in siltation in the River Thames of 300mm.
    - 50% blockage of Christchurch Ditch culvert at Reading Bridge (George Street).
- Option 2: Do Minimum – Continuation of existing maintenance and operational activities but no capital investment.
    - Existing assets and watercourses function as per calibrated model.
- Option 3: Do Something – Defences from Promenade Road to Christchurch playing fields (WEST)
    - Flood defences running broadly west to east from Promenade Road, along the northern edge of Christchurch Meadows, to the rear gardens at the southern end of Patrick Road, with a short section to the west of the car park at Abbotsmead Place. The defences will require flood gates, ramps or stoplogs at existing access points and will consist primarily of flood embankments.
- Option 4: Do Something – Defences from Christchurch playing fields to Nire Road (EAST)
    - Flood defences running broadly west to east from Christchurch Playing Fields, through Hill's Meadow, to the south of properties on Mill Green, Paddock Road, Meadow Way and Amersham Road. The defences will then run to the south of properties on Honey Meadow Close and to east of Nire Road, before crossing Berry Brook and terminating east of the properties on Ruskin Close. The defences will require flood gates, ramps or stoplogs at existing access points and will consist of a combination of flood walls and flood embankments.
- Option 5: Do Something – Defences from Promenade Road to Nire Road (WEST & EAST)
    - This option is a combination of Option 3 and Option 4.
- Option 6: Do something – Defences from Waterman Place to Reading Bridge (SOUTH)

    - Flood defences running broadly west to east from Waterman Place alongside the Thames Path to Reading Bridge. The defences will require flood gates, ramps or stoplogs at existing access points and will consist primarily of flood walls.

- Option 7: Do Something – Defences from Promenade Road to Nire Road and Waterman Place to Reading Bridge (NORTH & SOUTH)
    - This option is a combination of Option 5 and Option 7.
- Option 8: Do Something – Bypass Channel at George Street
    - **Discounted.** Economic benefits of this option would be relatively low (as the majority of flood risk is downstream of George Street, an area not benefitting from this option) and temporary works and traffic management associated with the option would result in high cost. Further concerns related to permanent and temporary loss of Hill's Meadow car park and compensatory arrangements, environmental concerns over culverting and public safety concerns.

A bypass channel at Reading Bridge has been included within options 4, 5, and 7 to ensure the proposals do not result in an increase in water levels outside of the benefit area.

It should be noted that the study area can be compartmentalised into three discrete benefit areas, with each option protecting a different benefit area or combination of benefit areas (see Figure 1):

- Area A – Promenade Road to Christchurch Playing Fields
- Area B – Christchurch Playing Fields to Ruskin Close
- Area C – Waterman Place to Reading Bridge

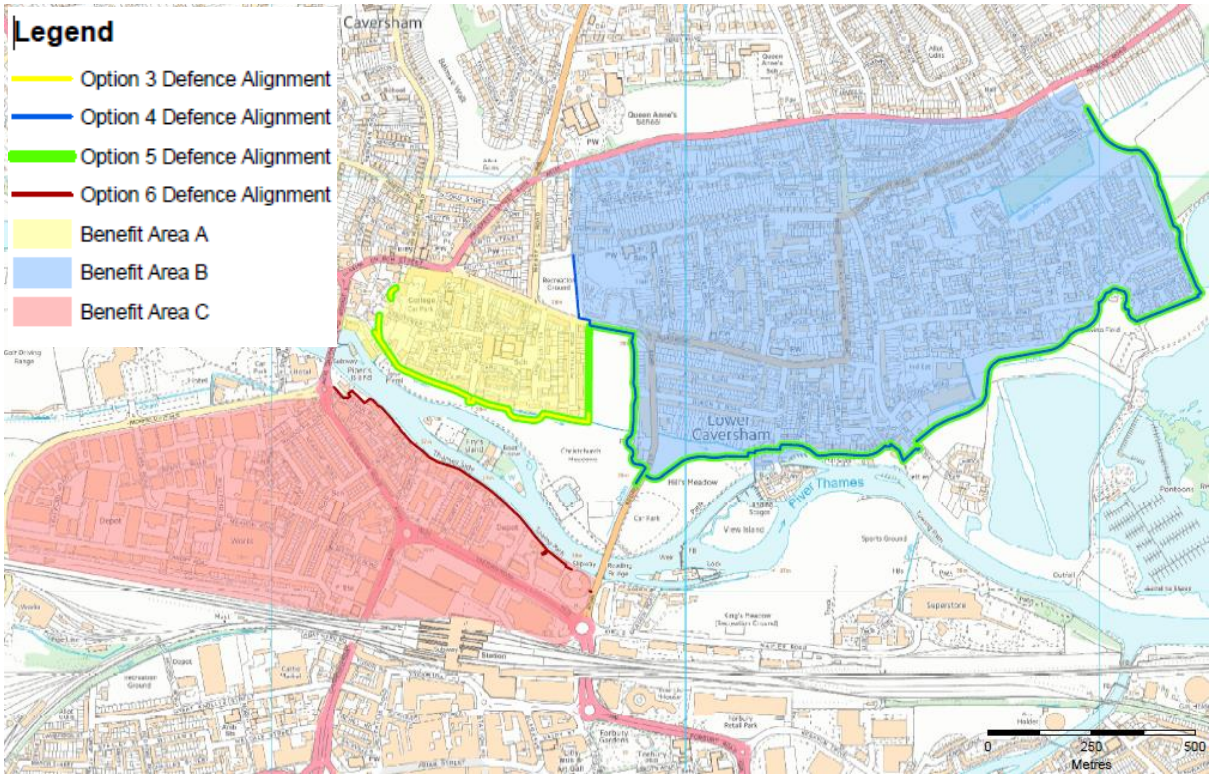


Figure 1 – Illustration of benefit areas located within Reading and Caversham FAS study area

Option 3 protects Area A only, Option 4 protects Area B only, Option 5 protects Areas A and B, Option 6 protects Area C, and Option 7 protects Area A, B, and C. Developing options which protect each discrete benefit area assists in the justification, or otherwise, of reducing flood risk to each benefit area (described in Section 7 in greater detail).

The options were modelled by building a "glass wall" into the model along the proposed defence alignment. The tie-in locations were determined following a review of model results to determine the

estimated design level of a new defence. Eight flood events were modelled for the Do Nothing and Do minimum scenarios. These model runs replicated the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1.33% AEP, 1% AEP, 0.5% AEP, and 0.1% AEP flood events. All five options are able to offer protection against a 0.5% AEP flood event (including climate change). Higher standards of protection were not considered due to this resulting in increased flood risk outside of the benefit area.

Following review of the modelling results, it was evident that the difference in defence heights between a scheme which offered a standard of protection against a 1.33% AEP flood event and 0.5% AEP flood event was up to a maximum of 190mm. As the options involve the construction of up to 5km of linear defences, it was assumed that the additional benefits (comparative to the additional cost) would likely be justifiable. The five option types have therefore all been designed to offer a standard of protection of 0.5% AEP including the effects of climate change to the end of the 100 year appraisal period, in the first instance.

The benefits and costs of options were compared with those resulting from the Do Minimum scenario, in order to derive an incremental benefit cost ratio (iBCR) that quantifies the value of delivering increased protection. The standard of protection offered was then optimised through detailed economic assessment, taking account of contributions and wider objectives, in line with FCERM-AG.

Climate change has been applied to the fluvial model inflows. The percentage increase applied for each design epoch is informed from the latest guidance (Environment Agency, 2016) and the 'Higher Central' climate change estimate (70th percentile) for Thames River basin district was applied (Table 2 – Environment Agency, 2016).

River basin district	Epoch			
	2017	2026 - 2039	2040 - 2069	2070 - 2116
Thames	+ 0%	+ 15%	+ 25%	+ 35%

Table 1 – 'Higher Central' climate change percentage increase applied to all fluvial model inflows

Flood damages were calculated using an internally developed damage calculator spreadsheet. This applies depth/damage curves (as guided by MCH 2017) to determine for a particular type of property, the monetary damage expected for a specific depth of flood water.
Residential properties were classified using a 2 digit MCM code and non-residential properties were classified using a 1 digit MCM code. Property codes were adjusted where appropriate based on inspection to give a more even appraisal. Damages value capping was also used based on property type and market value.

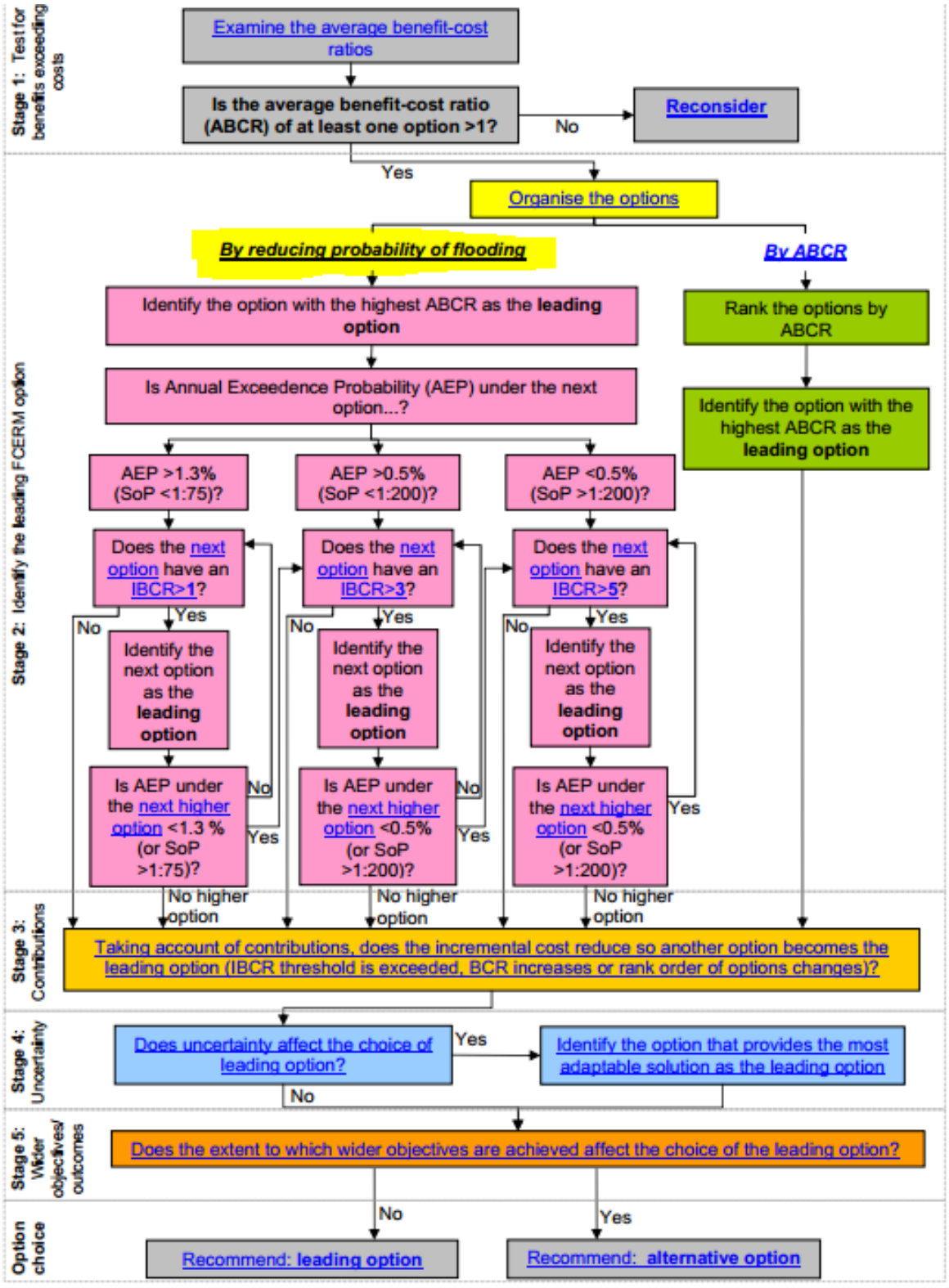


Figure 2 – Calculation of Economic Decision-Making Criteria (For Risk Management Authorities, England) – FCERM-AG 2010

3 Damages Assessment

3.1 Property Damages

The property data and flood depths are required to undertake economic appraisal of each option. The property data is derived from the NRD dataset providing the location of all properties within the study catchment.

A careful inspection of NRD points is required as the NRD dataset contains all defined boundaries (including sheds and garages) and includes double entry of some properties as well as erroneous entries including first floor flats, for example. This was undertaken during the economic assessment, with the NRD data filtered and amended where appropriate.

All residential properties were categorised using a two-digit MCM code to give a more accurate result.

The flood depths within the boundary of each property were obtained by running a GIS query using modelled flood level for each flood event combined with the NRD dataset. The output of this process was a CSV file which required post-processing in order to extract the desired data to input into the damage spreadsheet.

A damage spreadsheet was set up for each option into which the modelled floodwater level from the GIS query at each property, for various flood events, were input. Data from threshold surveys were included in the damage spreadsheet and compared with the flood levels from GIS in order to establish the depth of flooding within each property. Where threshold data was not available, the threshold was assumed as the LiDAR level plus 150mm (approximate height of one step).

Property damages were assigned based on the depth of flooding above the threshold level of the property and the duration of flooding. As the primary source of flood risk is from the River Thames, where flood events last in excess of three days, damages associated with extra long duration flooding were used. This was verified against historic flooding and is consistent with results from hydraulic modelling.

3.2 Damage Capping

The Q3 2018 average value of properties in Reading was taken from land registry data, to correlate the market value of residential properties to their two digit MCM code. The market value of properties was used in order to check that unnaturally high damages for properties was not reported. By multiplying the Annual average damage (AAD) by the sum of the Present Value factors over the appraisal period, a present value of the damages for that property may be obtained. If this is greater than the present day market value of the property, then it is written off at this value and no further damages above the capped value are used in the appraisal.

4 Additional Damages

4.1 Risk to Life

The damage from risk to life was evaluated for each option using guidance from DEFRA published Supplementary Note to Operating Authorities: Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures of May 2008.

The Reference Valuation for a life used is £1,429,114 as at Q3 2018. The value used is adjusted from the original base value set out in June 2000 (at £1,144,890).

4.2 Emergency Services

Costs incurred by Local Authority emergency services and the Environment Agency's emergency and recovery costs associated with flooding have been included within the economic appraisal and have been calculated as 5.6% of damages to residential properties as Caversham is classified as an urban area. This is based on guidance following research into the summer 2007 floods in the MCM 2016 which advises that, "The total property damage calculated in project appraisals of flood alleviation schemes should therefore be multiplied by a factor ranging between 1.107 and 1.056 to allow for the emergency and recovery costs that can be justified as real economic costs, not counted elsewhere in the benefit assessments."

4.3 Health Intangibles

Intangible benefits associated with flood risk management improvements (reduced stress, health improvements) has been assessed in line with guidance provided in the MCM Handbook and using guidance from DEFRA published Supplementary Note to Operating Authorities: Reflecting on Socio-economic Equity in Appraisal and Appraisal of Human Related Intangible Impacts of Flooding of July 2004.

4.4 Other Benefits

Traffic Disruption Benefits

Vehicle access across the River Thames in Reading is provided by Reading Bridge and Caversham Bridge which are vulnerable to flooding in an extreme flood event. The effect of these access routes becoming impassable would be unprecedented, as thousands of properties would be largely cut off from key infrastructure within Reading including the Royal Berkshire Hospital, the train station, the M4 motorway and services and facilities within Reading city centre.

Traffic disruption benefits associated with maintaining access across the River Thames in an extreme flood event have been assessed in line with guidance provided in the MCM Handbook. Damages associated with road disruption would be avoided in the provision of a Do Something option as follows:

- Option 3 and 6 does not provide any benefit as Reading Bridge and Caversham Bridge would continue to flood at the access roads;
- Option 4 and 5 would ensure Reading Bridge remains open during a flood event. This would result in reduced disruption as traffic on **Reading Bridge only** would no longer need to be diverted to Caversham Bridge (in lower magnitude flood events) or the A404 (in higher order magnitude events, when Caversham Bridge is also inundated). Benefits for Caversham Bridge are not claimed;
- Option 7 would ensure Reading Bridge remains open during a flood event. This would result in reduced disruption as traffic on **Reading Bridge only** would no longer need to be diverted to Caversham Bridge (in lower magnitude flood events) or the A404 (in higher order

magnitude events, when Caversham Bridge is also inundated). In addition, reduced disruption for traffic on **Caversham Bridge** is also claimed, as all major access roads on the South Bank and North Bank are protected, enabling traffic to use the protected Reading Bridge (rather than go via A404).

Further details on the calculation of road disruption benefits can be found in Appendix C.

Schools Benefits

Benefits (damages avoided) associated with the loss of education and loss of adult productivity due to schools being closed as a consequence of flooding have been assessed in line with guidance provided in the MCM Handbook.

Further details on the calculation of school disruption benefits can be found in Appendix C.

Impacts on economic activity

Benefits (damages avoided) associated with losses of economic activity of local businesses and public sector organisations in the study area have been assessed through a Gross Value Added (GVA) assessment. This considers the direct impact of flooding on employment and labour productivity in the project area due to workplace closure and reduced employee access to places of work.

The GVA analysis accounts for labour related impacts on productivity arising from business down time and employee absence form work due to access problems.

The main elements used to estimate the impacts include number of properties inundated, duration of inundation, employee numbers affected by inundation, employee numbers affected by access problems, and the GVA per hour generated by employees.

The benefits are included in this assessment for two reasons:

- Losses due to employees being unable to attend the workplace cannot be mitigated through the provision of support workers, due to the relatively short duration of disruption (in commercial terms) and the requirement for permanent staff to be present to brief / handover to temporary workers (not feasible due to inundation / access issues);
- The majority of local businesses in the assessment are independent or do not have a local alternative workplace with sufficient floor area to accommodate the employees who cannot attend their normal place of work.

Further details on the calculation of impacts on economic activity can be found in Appendix C.

It should be noted that these have <u>not</u> been included within the scheme benefits as they demonstrate a loss to the local, but not national, economy. The assessment has been made to assist in securing partnership funding form affected businesses and organisations.

Additional Benefits

Benefits associated with tourism, infrastructure, and the environment have not been assessed at this stage, however it is anticipated that the proposed environmental enhancements will provide benefits in relation to both environment and tourism.

An initial review of utilities infrastructure in the benefit area was undertaken. This included identification of three foul sewage pumping stations (Cow Lane SPS, Caversham SPS, and Nire Road SPS, as well as one surface water pumping station (Nire Road SWPS). No electricity grid substations have been identified within the benefit area at this stage. These have not been assessed as it is likely they will provide only a small fraction of the cumulative benefits provided by the scheme.

Utility providers will be consulted during the FBC stage. If any asset is identified as being of relative importance (in accordance with MCH) then investigation of the infrastructure asset will be considered and a full monetary quantification of utility damages undertaken where appropriate.

Appendix D provides an overview of the damages included and excluded within the assessment.

5 Benefit Assessment

Following the approach for the damage assessment set out in this report, the Annual Average Damage (AAD) were calculated from a damage/frequency curve taken from MCH 2018 curves which plots the total damage for each event against the probability of that flood event occurring. The event damages were calculated for the modelled flood events. AAD is calculated based on these events and then summed over the appraisal period of 100 years to give the damages for each property to be used in the appraisal.

The calculation of benefits undertaken follows the standard method of using damages for various flood events and integrating the area under the loss probability curve.

6 Project Costs

Project costs were built up for each option using detailed costing from an Early Supplier Engagement (ESE) Supplier, contracted from Lot 4 of the WEM Framework. The ESE Supplier was provided with outline design drawings, attended a site visit, and provided input into the project risk register.

Future operation and maintenance costs were built up using prior experience form similar schemes, with input from the Environment Agency Asset Performance team, and in consultation with Reading Borough Council in relation to existing maintenance regimes.

The project costs for the likely preferred Option 7 are shown below. PV Whole Life Costs of the Project are used for the benefit cost assessment. The full details of options costs can be seen in Appendix B of this report.

Table 1 – Likely Preferred Option Project Present Value Whole Life Costs

Item	Value
Cost to OBC	£507,684
Detailed Design Stage	£3,128,933
Construction Stage	£14,863,248
Risk (50%ile Monte Carlo)	£3,519,928
Inflation (2%)	£366,906
Total Project Costs	**£22,386,700**
Future Costs	**£803,628**
Whole Life Costs	**£23,190,329**

Maintenance costs are estimated based on the following assumptions:

- The inspection of existing assets (1 staff @ 3 days per year)
- The operation and routine maintenance of existing assets (1 staff @ 1 day per month)
- Cutting and flailing of embankments and clearance of structures (2 staff @ 2 weeks per year for new defences, 1 week per year for existing defences)
- The replacement of all flood gate seals and provision of temporary pumps every 10 years
- Pump hire and operation costs every 10 years
- The replacement of all flood gates every 25 years

7 Selection of Preferred Option

The process set out in FCERM-AG is to organise the options by reducing probability of flooding, before comparing the incremental benefit cost ratio (IBCR) to determine the leading option. As each Do Something option is able to provide the same standard of protection, and protects a discrete benefit area, a two step approach was adopted to implement this process:

- Step 1 – Each shortlisted option (Option 3 to 7) was assessed against the Do Minimum scenario, assuming the same target standard of protection (0.5% AEP including climate change over a 100 year appraisal period). Undertaken to determine the justification for works to defend each benefit area and the identification of a leading option.
- Step 2 – The selected leading option was assessed for increasing standard of protection (through IBCR) to determine the optimal standard of protection for the leading option.

Outcome Measures were calculated for each option and a Partnership Funding score generated.

Step 1 – Selection of Leading Option

A summary of the Step 1 assessment undertaken is detailed in table 2 on the following page.

Table 2 – Option costs, Outcome Measures and Partnership Funding score (shortlisted options).

Option	PV Costs	PV Benefits Outcome Measure 1	Average BCR	Incremental BCR (compared to Do Minimum)	Option for Incremental Calculation	Outcome Measure 2 (OM2b)	Outcome Measure 4	Raw Partnership Funding Score
Option 1 (Do Nothing)	£0	£0	N/A	N/A	-	-	-	-
Option 2 (Do Minimum)	£79,876	£54,177,102	678.3	N/A				
Option 3 (Prom. Road to Playing Fields – Benefit Area A)	£ 3,858,423	£61,531,717	15.9	1.9	Do Minimum	43 (10)	-	82% (£752,045)
Option 4 (Playing Fields to Nire Road – Benefit Area B)	£ 14,839,256	£114,936,193	7.7	4.1	Do Minimum	606 (258)	-	45% (£9,043,400)
Option 5 (Prom. Road to Nire Road – Benefit Area A and B)	£ 17,588,660	£122,000,297	6.9	3.9	Do Minimum	649 (268)	-	40% (£11,610,913)
Option 6 (Waterman Place to Reading Bridge – Benefit Area C)	£ 6,070,233	£66,556,176	11.0	2.1	Do Minimum	90 (11)	-	56% (£2,949,561)
Option 7 (Prom. Road to Nire Road & Waterman Place to Reading Bridge – Benefit Area A, B, and C)	£ 23,190,329	£137,891,075	5.9	3.6	Do Minimum	739 (279)	-	34% (£16,878,712)

Note: the Raw Partnership Funding Score has been calculated with inclusion of the 95th %ile risk allowance rather than the 50th %ile risk allowance.

Option 3 has the highest BCR of the "Do Something" options, followed by Option 6, however most of the benefits associated with these two options can be attributed with the Do Minimum option. Therefore they have a relatively low Incremental Benefit Cost Ratio (iBCR) compared to Do Minimum, at 1.9 and 2.1 respectively, indicating limited justification in the additional investment. It is noted this is below the required IBCR of 3.0 required to justify a standard of protection against a flood event with a 0.5% AEP (see Figure 2).

Options 4, 5, and 7 each have an IBCR of greater than 3 – ranging between 3.6 and 4.1. Of these options, Option 4 has the highest BCR at 7.7. Option 7 has the lowest BCR of these three options at 5.9, and the lowest IBCR at 3.6. However option 7 does offer the greatest number of OM2 properties in comparison to the options.

It should also be noted that the IBCR of option 5 (compared to option 4) is 2.6, and in turn the IBCR of option 7 (compared to option 5) is 2.9.

None of the options have a raw partnership funding score in excess of 100%, and so require external contributions or project savings to be made. At this stage, the Reading and Caversham Flood

Alleviation Scheme has received an allocation of £5,000,000 within the current levy programme. Agreement of this allocation was given in the Thames Regional Flood and Coastal Committee meeting on 11 October 2017.

In addition, both Reading Borough Council (as a landowner affected by the scheme), and an independent private landowner (also affected by the scheme) have expressed an interest in financial contributions towards the project cost.

A partnership funding assessment has been undertaken to review additional potential sources of funding. This assessment identified four potential funding partners – specifically Reading Borough Council, Thames Regional Flood and Coastal Committee (additional contribution), Thames Valley Berkshire Local Enterprise Partnership, and SSE Networks.

In addition, it is envisaged that Reading Borough Council and local environmental groups (voluntary) will pick up various elements of the maintenance regime as part of their existing practices.

Given the robust BCR and IBCR, coupled with it delivering the highest outcome measures and having the greatest potential to attract partnership funding, **option 7 has been identified as the leading option** in accordance with Stage 6 of the process set out in FCERM-AG (Figure 2).

Options 4 and 5 remain as viable alternatives, if the required partnership funding to deliver option 7 cannot be secured as part of the project.

Step 2 – Selection of the optimal standard of protection

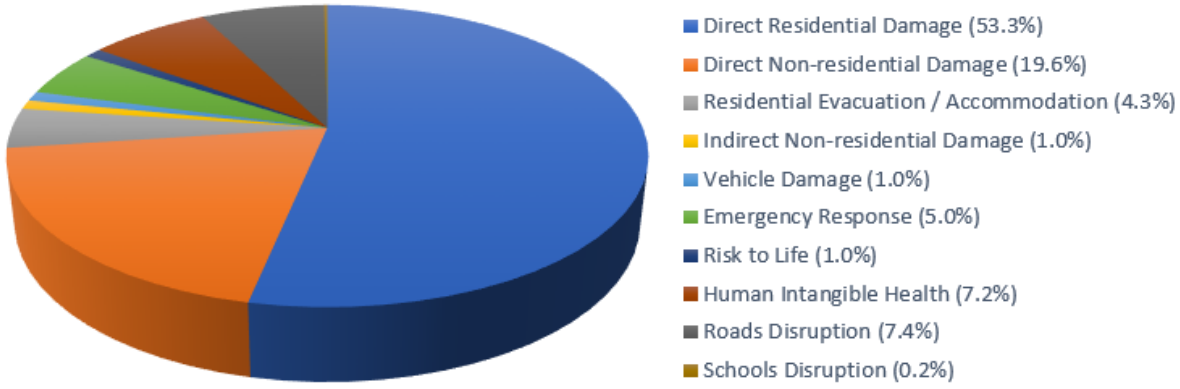
To identify and justify the optimal standard of protection for the leading option, Step 2 of the assessment was undertaken for option 7, considering the costs and benefits associated with different standards of protection. These are shown in Table 3 below.

The results in Table 3 justify the selection of Option 7c - Promenade Road to Nire Road & Waterman Place to Reading Bridge (0.5% AEP) as the leading option. This option secures 739 Outcome Measure 2, 279 Outcome Measure 2b, and in excess of £137million in present value benefits (Outcome Measure 1). A breakdown of the present value benefits is provided in Figure 3.

Table 3 – Option costs, Outcome Measures and Partnership Funding score (Option 7).

Option	PV Costs	PV Benefits Outcome Measure 1	Average BCR	Incremental BCR	Option for Incremental Calculation	Outcome Measure 2 (OM2b)	Comments
Option 1 (Do Nothing)	£0	£0	N/A	N/A	-	-	-
Option 2 (Do Minimum)	£79,876	£54,177,102	678.3	N/A	-	-	-
Option 7a - Prom. Road to Nire Road & Waterman Place to Reading Bridge (5% AEP)	£16,796,675	£89,764,163	5.3	2.1	Do Minimum	17 (0)	IBCR>1. Next higher option has an AEP of 1.3% and an IBCR>1. **Next option (7b) selected as leading option.**
Option 7b - Prom. Road to Nire Road & Waterman Place to Reading Bridge (1.3% AEP)	£20,119,424	£121,057,566	6.0	9.4	Option 7a	279 (279)	IBCR>1. Next higher option has an AEP of 0.5% AEP and an IBCR>3. **Next option (7c) selected as leading option.**
Option 7c - Prom. Road to Nire Road & Waterman Place to Reading Bridge (0.5% AEP)	£ 23,190,329	£137,891,075	5.9	5.5	Option 7b	739 (279)	IBCR>3. Next option has an AEP of >0.5% AEP but is not technically viable due to increase in flood risk outside of benefit area. **Option 7c selected as leading option.**
Option 7d - Prom. Road to Nire Road & Waterman Place to Reading Bridge (>0.5% AEP)	-	£162,328,917	-	-	Option 7c	-	No assessment made. No technically viable option identified due to increase in flood risk outside benefit area.

Figure 3 – Breakdown of present value benefits (Option 7c)



8 Sensitivity Checks

In order to understand the potential impact of uncertainties upon the business case of the preferred option, sensitivity checks have been carried out. Sensitivity checks undertaken at this stage are detailed below.

I – 25% increase in present value whole life cost.
This check reduces the partnership funding score to 27% for Option 7, increasing the requirement in partnership funding to £23.5million.

II – 50% of households in Very Significant risk band already in significant risk band.
This check has no impact on the PF score of 34% and the partnership funding requirement increases by £30k. This is due to the number of properties at Very Significant risk (17) being low compared to those at Significant or Moderate risk (722).

III – 100mm increase required in the design water level to achieve the same standard of protection.
This check results in the PV WLC increasing from £23.2million to £24.4million and reduces the partnership funding score to 33% for Option 7, increasing the requirement in partnership funding to £18.2million.

IV – All existing partnership funding contributions reduced by 50%.
This check reduces the current adjusted partnership funding score from 43% to 38% for Option 7, increasing the requirement in partnership funding by £2.5million. The BCR remains unchanged.

The result of these further sensitivity checks was that although the partnership funding scores are diminished in checks I, III and IV, the overall business case for the scheme remains largely unchanged, with an economically viable scheme still evident but with an increased requirement for partnership funding. The scheme would still be considered viable under these conditions.

An increase of 100mm in design water levels is estimated to increase the PV WLC by £1.2million, or approximately 5%.

Appendix A: Economic Summary Sheets

Baseline Economic Case

Costs and benefits of options							
	Costs and benefits £						
Option number	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Option name	Do Nothing	Do Minimum	West only	East only	West & East	South only	West, East & South
AEP or SoP (where relevant)		5% AEP	0.5% AEP	0.5% AEP	0.5% AEP	0.5% AEP	0.5% AEP
COSTS:							
PV capital costs (inc. Monte Carlo risk analysis)	0	0	3,608,786	14,370,859	16,925,425	5,939,115	22,386,700
PV operation and maintenance costs	0	79,876	260,807	513,236	716,060	149,578	803,628
PV other	0	0	0	0	0	0	0
Optimism bias adjustment	0	0	0	0	0	0	0
PV negative costs (e.g. sales)	0	0	0	0	0	0	0
PV contributions							
Total PV Costs £ excluding contributions	0	79,876	3,869,594	14,884,095	17,641,485	6,088,694	23,190,329
Total PV Costs £ taking contributions into account	0	79,876	3,869,594	14,884,095	17,641,485	6,088,694	23,190,329
BENEFITS:							
PV monetised flood damages	162,328,917	108,151,815	100,797,200	47,392,724	40,328,620	95,772,741	24,437,842
PV monetised flood damages avoided		54,177,102	61,531,717	114,936,193	122,000,297	66,556,176	137,891,075
PV monetised erosion damages	0	0	0	0	0	0	0
PV monetised erosion damages avoided (protected)		0	0	0	0	0	0
Total monetised PV damages £	162,328,917	108,151,815	100,797,200	47,392,724	40,328,620	95,772,741	24,437,842
Total monetised PV benefits £		54,177,102	61,531,717	114,936,193	122,000,297	66,556,176	137,891,075
PV damages (from scoring and weighting)							
PV damages avoided/benefits (from scoring and weighting)							
PV benefits from ecosystem services							
Total PV damages £	162,328,917	108,151,815	100,797,200	47,392,724	40,328,620	95,772,741	24,437,842
Total PV benefits £		54,177,102	61,531,717	114,936,193	122,000,297	66,556,176	137,891,075
DECISION-MAKING CRITERIA:							
excluding contributions							
Based on total PV benefits (including benefits from scoring and weighting and ecosystem services)							
Net Present Value **NPV**		54,097,226	57,662,123	100,052,098	104,358,812	60,467,482	114,700,746
Average benefit/cost ratio **BCR**		678.3	15.9	7.7	6.9	10.9	5.9
Incremental benefit/cost ratio **IBCR**			1.9	4.1	3.9	2.1	3.6

Appendix B: Project Cash Costs

Cost Summary of Appraised Options: Reading and Caversham Flood Alleviation Scheme

Description	*Item*	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**
		Do Minimum	*Defences from Promenade Road to Christchurch playing fields (West)*	*Defences from Christchurch playing fields to Nire Road (East)*	*Defences from Promenade Road to Nire Road (West & East)*	*Defences from Waterman Place to Reading Bridge (South)*	*Defences from Promenade Road to Nire Road and Waterman Place to Reading Bridge (West, East & South)*
Cost to OBC	Early Supplier Engagement		£15,000	£15,000	£15,000	£15,000	£15,000
	Ground Investigation		£184,000	£184,000	£184,000	£184,000	£184,000
	EA Time		£93,184	£93,184	£93,184	£93,184	£93,184
	Other Consultants		£7,500	£7,500	£7,500	£7,500	£7,500
	Outline Business Case production		£208,000	£208,000	£208,000	£208,000	£208,000
	Total cost to OBC (Sub-total-1)	**£0**	**£507,684**	**£507,684**	**£507,684**	**£507,684**	**£507,684**
Detailed Design and Construction	CH2M costs - Design, CDM duties, Consultation & contracts. Planning, Supervision		£256,475	£1,219,148	£1,441,793	£464,599	£1,932,509
	Environment Agency Staff/ncpms/NEAS		£57,078	£271,321	£320,871	£103,397	£430,080.00
	Engineering and Construction Contract personnel (site supervisor, project manager and cost manager		£117,600.00	£134,400.00	£193,200.00	£117,600.00	£243,600.00
	Estates/Land purchase/Compensation		£13,272	£63,086	£74,607	£24,041	£100,000.00
	Surveys e.g. GI, GPR, Ecological and Environmental		£68,747	£326,787	£386,466	£124,534	£518,000.00
	Early Supplier Engagement		£5,000	£20,000	£25,000	£15,000	£30,000
	Sub-total-2	**£0**	**£518,172**	**£2,034,743**	**£2,441,937**	**£849,171**	**£3,254,189**
Construction Base Cost	Staff		£367,989	£987,609	£1,313,444	£678,532	£1,991,977
	Preliminaries		£158,332	£424,932	£565,127	£291,948	£857,075.00
	General Foreman		£49,242	£132,156	£175,757	£90,797	£266,554.75
	Site Clearance		£25,000.00	£75,000	£100,000.00	£15,000.00	£100,000.00
	North Bank:						
	Section AA		£214,589		£214,589		£214,589
	Section BB		£408,648		£408,648		£408,648
	Section CC		£503,983		£503,983		£503,983
	Section DD		£158,887		£158,887		£158,887
	Section EE		£78,138	£599,056	£520,918		£520,918
	Section FF			£290,292	£290,292		£290,292
	Section GG			£243,335	£243,335		£243,335
	Section HH			£1,455,715	£1,455,715		£1,455,715
	Section JJ			£338,892	£338,892		£338,892
	Section KK			£254,174	£254,174		£254,174
	Section LL			£238,051	£238,051		£238,051
	Section MM			£241,843	£241,843		£241,843
	South Bank:						
	Section NN					£113,812	£113,812
	Section PP					£35,218	£35,218
	Section QQ					£475,289	£475,289
	Section RR					£338,683	£338,683
	Section SS					£869,646	£869,646
	Section TT					£653,772	£653,772

	Section UU/VV					£29,099	£29,099
	Reading Bridge Bypass Channel			£4,448,574	£4,448,574		£4,448,574
	Environmental enhancements/ landscaping		£45,000	£75,000	£75,000	£45,000	£75,000
	Contractor Fee		£121,297	£325,536	£432,939	£223,658	£933,610
	Sub-total-3		**£2,131,103**	**£10,130,165**	**£11,980,167**	**£3,860,456**	**£16,057,636**
Base cost	***Subtotal (1+2+3)***	**£0**	**£3,156,959**	**£12,672,592**	**£14,929,788**	**£5,217,311**	**£19,819,509**
Risk	**Risk (50%ile Monte Carlo risk analysis)**		£603,388	£2,422,108	£2,853,525	£997,183	£3,788,096
	Capital cost of scheme (including to OBC, including monte carlo risk)		£3,760,347	£15,094,700	£17,783,313	£6,214,494	£23,607,605
Inflation	**Inflation at 2%**		£63,139	£253,452	£298,596	£104,346	£396,390
Total estimated scheme cost	***Base cost + Monte Carlo 95%ile + inflation***	**£0**	**£3,823,487**	**£15,348,152**	**£18,081,909**	**£6,318,840**	**£24,003,995**
Maintenance	Yearly maintenance	£2,080	£3,120	£3,120	£4,160	£3,120	£5,200
	10 yearly maintenance	£2,080	£58,700	£84,992	£143,412	£9,148	£150,480
	25 yearly maintenance	£27,080	£63,920	£334,842	£396,683	£63,400	£458,003

Appendix C: Additional Benefits

ENV0000112C-CH2-000-O00-TN-C-0003 Traffic Disruption

ENV0000112C-CH2-000-O00-TN-C-0004 Schools Disruption

ENV0000112C-CH2-000-O00-AS-C-0001 Impacts on Economic Activity

Appendix D: Types of Damage considered

MCH Chapter	Type	Sub-type	Included in this assessment	Approach or Reason for not including
4	Residential	Building, content and clean up (Direct)	Yes	Property Type (two digit codes) and floor area only, insufficient reliable data for age and social class. Fresh Extra Long Duration depth damages Capping and Write Off at Regional Average Market Values from Land Registry
		Health: Intangible	Yes	"Flood and Coastal Erosion Risk Management: 2017 Handbook for Economic Appraisal." Flood Hazard Research Centre, 2017 Assessed for residential population only.
		Vehicle damages	Yes	Number of vehicles at risk x £3,100
		Temporary and alternative accommodation	Yes	Standard percentages of households evacuated and duration of evacuation. Mid band costs per property type and flood depth
		Socio-economic equity	No	Only where it is deemed 'necessary' and 'practical'. Requires detailed reliable information on property age and social class. Such information is rarely easily obtainable. By using the two digit codes we are already using nationally averaged social-equity neutral damage data.
5	Non-Residential	Building, content and clean up (Direct)	Yes	Remove non-buildings Saline Long Duration depth damages Capping and Write Off at Regional Average Values, estimated from rateable value x 12.5 (based on a Yield of 8%)
		Indirect	Yes	3% of NRP Direct Damages
N/A	Risk to life		Yes	"Supplementary Note to Operating Authorities Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures", Defra, May 2008 Assessed for residential population only.
6	Other Flood Losses	Electricity and gas	No	By inspection not significant/ proportional
		Water & waste water	No	By inspection not significant/ proportional
		Telecommunications	No	By inspection not significant/ proportional
		Road	Yes	"Flood and Coastal Erosion Risk Management: 2017 Handbook for Economic Appraisal." Flood Hazard Research Centre, 2017
		Rail	No	Tested, but not significant/ proportional
		Schools	Yes	"Flood and Coastal Erosion Risk Management: 2017 Handbook for Economic Appraisal." Flood Hazard Research Centre, 2017
		Hospitals	No	N/A
		Emergency response and recovery	Yes	Using 5.57% of Direct Damages as this is an urban area
8	Recreation		No	Tested, but not significant/ proportional
9	Agricultural		No	N/A
10	Environmental		No	Tested, but not significant/ proportional
N/A	Holiday Parks	Caravan Relocations	No	N/A
		Park Homes	No	N/A