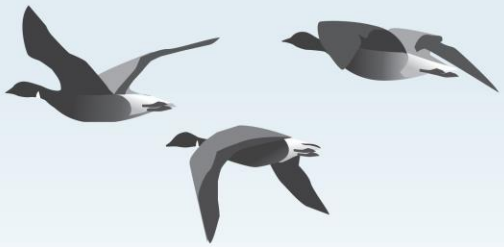

Leigh Expansion and Hildenborough Embankments Scheme (LEHES) OBC

Appendix I
Economics Report

Environment Agency

February 2019

Document history

Job number: 5162844			Document: Economic technical appendix			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
P1	For Client review	BP	CH	AS	AS	12/09/18
P2	Updated for OBC issue	BP	CH	AS	AS	01/02/19

Table of contents

Tables

Figures

1. Introduction

This report describes the economic appraisal of flood risk management options considered as part of the Leigh Expansion and Hildenborough Embankments Study (LEHES) in the River Medway catchment, Kent. The economic appraisal has followed the principals of the Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG) (Environment Agency, 2010), as updated by supplementary guidance on the Environment Agency website. Depth damage data has been taken from the Multi-Coloured Manual Handbook (MCM) (Flood Hazard Research Centre, 2018). In accordance with Treasury guidance a 100-year appraisal period has been used and the Treasury variable discount rate has been applied. This note is intended to supplement the Outline Business Case (OBC), rather than be a standalone report.

The economic appraisal has followed the Treasury Green Book 2003 version as incorporated into Environment Agency Guidance with the Supplementary Note "Revisions to Economic Appraisal Procedures Arising from the New HM Treasury Green Book" March 2003. Although a revised version of the Green Book was published in 2018, this appraisal has not incorporated any changes from the 2018 version as it is deemed appropriate to wait for guidance from the Environment Agency describing how they wish practioners to incorporate any new approaches.

2. Methodology

An overview is first presented, followed by more detailed information about each aspect of the appraisal.

2.1. Methodology overview

The economic flood assessment included calculation of the following:

- Residential and non-residential property damages;
- Evacuation costs for residential properties experiencing above floor level flooding using the MCM data;
- Cost of emergency services, estimated as 5.6% of the total property damages;
- Vehicle damages, using the average value of a UK motor vehicle of £3,100;
- Risk to life, estimated as a 2% addition to the total calculated flood damages; and
- Human Intangible benefits of options which reduce flood risk.

The latter is measured directly as a benefit whereas the others are all measured by the reduction in damages compared to the Do Nothing baseline.

The impact of climate change was fully included in this economic assessment in accordance with current Environment Agency guidance (Environment Agency, 2016).

For the purpose of economic assessment Average Annual Damages (AADs) are discounted over a period of 100 years using a discount factor to generate a Present Value Damage (PVd).

2.2. Options appraised

The River Medway Flood Storage Areas Initial Assessment (VBA, 2016) which informed the Strategic Outline Case (SOC) included a detailed review of flood risk management options in the River Medway catchment. The work concluded that there was a business case to increase the Normal Maximum Operating Water Level (NMOWL) in the Leigh Flood Storage Area (FSA). A separate feasibility assessment was undertaken to appraise a 950m long flood embankment to reduce flood risk in Hildenborough (Capita AECOM, 2016). This Hildenborough Flood Alleviation Scheme (FAS) was included as part of the wider Medway FSA SOC.

This current OBC has built on the work undertaken at the SOC stage, appraising different operating water levels at Leigh and refining the Hildenborough element of the scheme to a much shorter defence alignment along Hawden Lane. The two elements of the scheme (the raised operating water level and the new Hildenborough defence) are designed to work together, with the increased storage at Leigh offsetting the loss

of floodplain storage at Hildenborough. These two scheme elements have therefore been appraised as a single option. The following options have been tested in the hydraulic model and economically appraised:

- Option 1: Do Nothing – No capital funding required. This would result in failure of the Leigh Barrier and FSA. This is the economic baseline and consists of the undefended scenario with no Leigh FSA;
- Option 2: Maintain Leigh FSA + Measures in the Interest of Safety (MIOS) - representative of the existing situation with the current Leigh NMOWL of 28.05m AOD and including the MIOS;
- Option 3a: Improve Leigh FSA (NMOWL 28.6m AOD) + MIOS + Hildenborough defence;
- Option 3b: Improve Leigh FSA (NMOWL 28.85m AOD) + MIOS + Hildenborough defence; and
- Option 3c: Improve Leigh FSA (NMOWL 29.0m AOD) + MIOS + Hildenborough defence.

These options have not been designed to provide a set Standard of Protection (SoP), or to include allowances for climate change explicitly within the design. Instead options have been designed to make best use of the available space, such that any adverse impacts on existing properties or infrastructure can be managed and mitigated.

2.3. Property damages

Residential and non-residential property damages were assessed by using the MCM methodology and depth damage curves (as updated in 2017). The property dataset for the assessment was derived from the National Receptor Database (NRD) (version 4, 2014), combined with Mastermap building outlines. In accordance with the MCM and the FCERM-AG (Environment Agency, 2010), the following properties were excluded from the property dataset: upstairs properties (identified as having a floor level of 'pU' or 'dU' in the NRD); residential properties built after 2012; and non-residential properties with a floor area less than 25m^2.

The approach to calculating economic property damage was as follows:

- Used maximum flood depth extracted at each property location from the hydraulic model results for a range of design flood events and for each option scenario;
- Applied the MCM methodology and depth damage curves (as updated in 2018);
- Calculated internal depth of flooding by applying an assumed threshold uplift of 150mm for residential properties, 400mm for caravans and 50mm for non-residential properties unless other information was available, for example from site visit observations or threshold surveys;
- Assumed no basements in any properties;
- Assumed that no property flooding occurs in the 50% (1 in 2) Annual Probability (AP) event in the present day scenario. This probability increases with climate change to the 100% (1 in 1) AP event in 2070 because of the projected increases in peak fluvial flows;
- Capped residential property damages at their current market value, calculated using average local house prices; and
- Capped non-residential property damages using average rateable values per m^2 for properties in the South East, by business type. This was converted to a market value using a South East yield value. Many of the highest value properties were individually identified and business-specific rateable values obtained from the Valuation Office Agency website.

The LEHES economic appraisal was divided into three appraisal areas, consistent with the three hydraulic models used by JBA. These areas were as follows:

- JBA model 2: Tonbridge and Hildenborough;
- JBA model 3: Downstream of Tonbridge, including East Peckham and Yalding, communities on the River Teise and River Beult; and
- JBA model 4: East Farleigh to Maidstone.

The extent of properties included in the economic appraisal is illustrated on Figure 2-1.

Under the National Planning Policy Framework (NPPF) (UK Department of Communities and Local Government, 2012), developments built after 2012 are required to demonstrate that they are appropriately flood resilient and resistant. Therefore, any properties built after 2012 are not considered to be at risk of flooding and are excluded from this assessment.

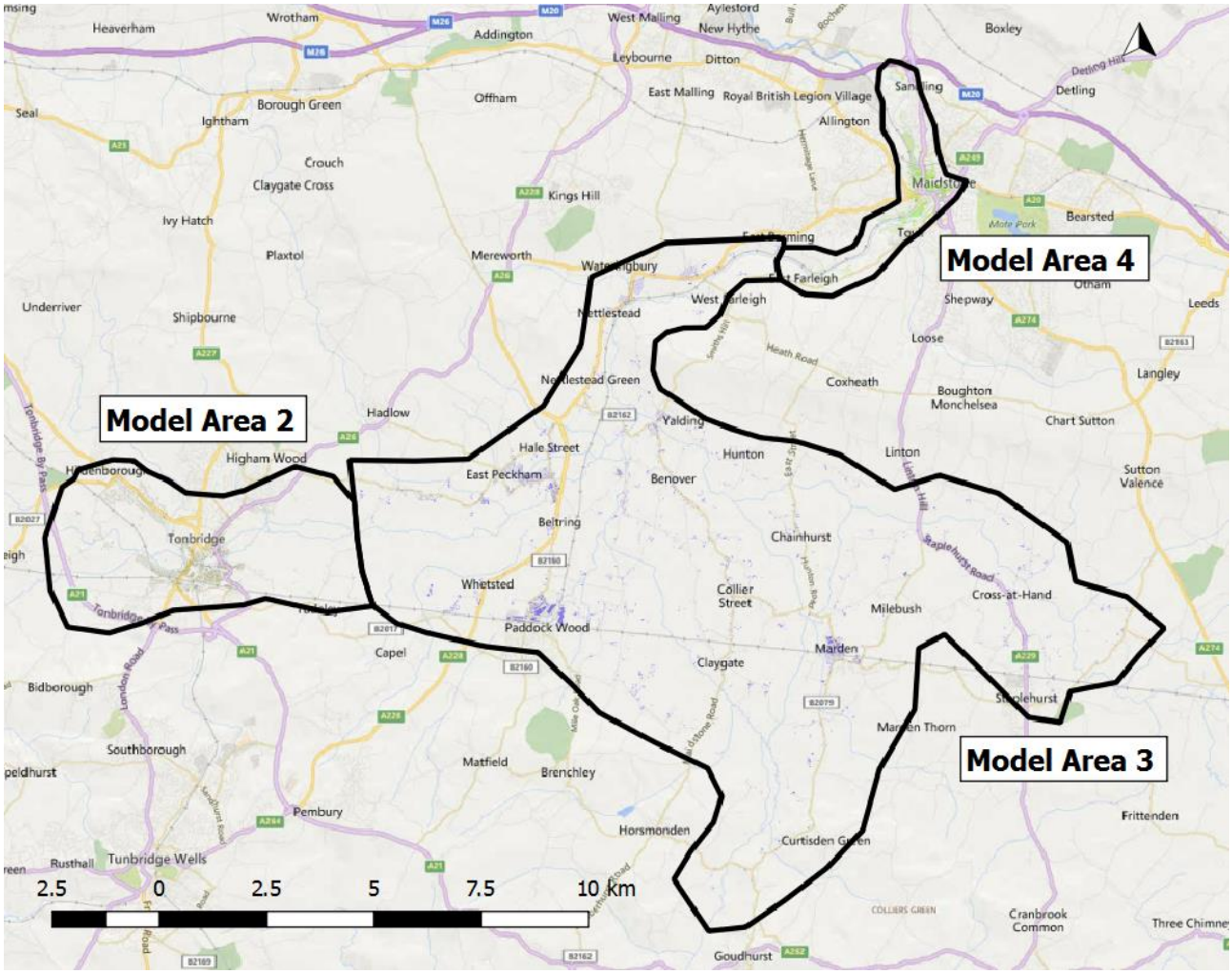

Figure 2-1 Extent of properties included in the economic appraisal

2.3.1. Capping of damages

For the purpose of the economic assessment the Present Value (PV) damages of a property cannot exceed the current capital value.

Residential properties

Residential properties were capped at the current market value, by property type, as detailed in Table 2-1. The market value prices are based on average house prices in Kent, taken from data on property sales prices in November, 2017[1].

Table 2-1 Typical residential property prices within the study area

Property type	Average property price (£k)
Detached	£501,439
Semi-Detached	£334, 576
Terraced	£267, 522
Flat	£204, 938
Caravan	£75,000

[1] House price data obtained from www.home.co.uk. Accessed February, 2018.

Non-residential properties

For non-residential properties, the market value or capping value was derived from the rateable value multiplied by a factor that reflects the added value or percentage rental yield from that property. Rateable values were based on data downloaded from the National Statistics website, regional average rateable values and floor space for a range of business types. This was converted into a £/m^2 for a range of business types and brought to an October 2017 price date, to be consistent with the MCM depth-damage data.

Floor areas were extracted from the NRD to provide a total expected rateable value per non-residential property. A yield of 5.18% was assumed based on the Gross annual rental yield as reported by Arla[2]. This results in a multiplier of 19, which was applied to the rateable values to calculate market values.

As part of our property verification process, the non-residential properties incurring the greatest damages were checked against the Valuation Office Agency web site (VOA). The VOA lists rateable values for all properties, and this was used to improve the NRD for the highest contributors.

2.4. Evacuation costs

The appraisal included costs associated with evacuation, including renting of temporary or alternative accommodation, food, transport costs and loss of earnings. The cost of evacuation depends on many variables, one of the most important being evacuation duration. Evacuation of flooded properties can range from a short-term requirement (to limit loss of life, injury and stress) to a much longer-term measure (to allow flood damage to be repaired). The MCM makes a direct link between the internal property flood depth and the evacuation rate and time. In this appraisal therefore, and in accordance with the MCM methodology, evacuation costs for individual properties have been estimated as a function of the flood depth and property type. Evacuation costs have only been included for residential properties experiencing above floor level flooding. Additionally, evacuation costs are only included for residential properties where the losses are still below the capping threshold.

2.5. Emergency services

Flood incidents need to be managed when they occur. These emergency costs come from active services from the police, fire and ambulance services, local authority emergency response team, and the Environment Agency's flood incident teams. The MCM guidance estimates that the emergency costs are 5.6% of the total property damages. This is the percentage applied in this appraisal and it is suitable for moderately urban areas.

2.6. Vehicle damages

Vehicle damages were assessed by using the MCM methodology, which assumes that:

- The average value of a UK motor vehicle is £3,100;
- The average number of vehicles per (residential) household is 1.15; and
- Vehicles are most likely to be damaged (and written off) when flood depths exceed 0.35m.

Vehicle damages were therefore calculated by: £3,100 x 1.15 x number of residential properties where external flood depth > 0.35m.

2.7. Risk to life

Risk to life can be calculated using estimates of number of people, flood hazard rating (obtained from modelling results), area vulnerability and people vulnerability. This is a complex methodology which takes time to complete and is not always proportionate to the scale of the study. For this project, risk to life has been estimated as a broad-brush 2% addition to the total calculated flood damages.

2.8. Human intangibles

The benefits of the human intangible effects on health and stress have been incorporated into the appraisal, in accordance with Defra Supplementary Guidance (Defra, 2004). These were based on the change in

[2] http://www.arla.co.uk/media/908792/Arla-RI-2014Q4.pdf

Standard of Protection offered by each option to each individual residential property according to the modelling results. Human intangible benefits are listed separately in the option comparison tables and are measured directly as a benefit of an option as compared to Do Nothing.

2.9. Additional infrastructure damages

Assessment of flood mapping indicated a relatively significant risk for the existing railway line(s) within Tonbridge under a range of events for the Do Nothing scenario. Approximately 11km of existing embankments would be exposed to flood waters, causing likely damage on a relatively frequent basis should the Leigh FSA not be operated in future. An estimate of the cost of providing protective embankments to mitigate the likely damage was developed as a consequential damage for the baseline option and included within the economic assessment. The total cost (damage) was £12.7m, representing just less than 3% of total damages.

Other key infrastructure such as the A26 and main High Street river bridges and potential traffic disruption has not been included.

2.10. Generation of Average Annual Damages

The damages for a range of design flood events were assessed for each option. The damages for each event were plotted against their annual probability and the area under the curve calculated. This area represents the Average Annual Damages (AAD). AADs were calculated for each of the four climate change scenarios under each option. The rate of damage increases over the 100-year appraisal period as a result of climate change using the method documented in the current guidance (Environment Agency, 2016), as described below.

2.11. Incorporation of climate change

In February 2016 the Environment Agency released new climate change guidance which can be found online[3]. A copy of Table 2 (changes in peak river flood flow) from the guidance is provided in Table 2-2. The guidance suggests that appraisal of flood risk management options should include allowance for the Central estimates, but with sensitivity testing to determine the impact of using the Higher Central estimate.

Table 2-2 Peak river flood flow allowances for the Thames river basin (with 1961 – 90 baseline)

Climate change estimate (percentile) for the Thames river basin	Total potential change anticipated for '2020s' (2015 – 2039)	Total potential change anticipated for '2050s' (2040 – 2069)	Total potential change anticipated for '2080s' (2070 – 2115)
Upper (90th)	25%	35%	70%
Higher Central (70th)	15%	25%	35%
Central (50th)	10%	15%	25%
Lower (10th)	-5%	0%	5%

The economics presented here is based on new hydraulic modelling completed as part of the Medway Catchment Mapping and Modelling Study (JBA, 2015). As part of this study, new model hydrological inflows were derived using a continuous simulation methodology. JBA have advised that the baseline for these hydrological inflows was 1995 – 2015. In contrast, the climate change guidance is based on a 1961-1990 baseline. The model baseline hydrology is therefore assumed to include some climate change impacts, and the peak river flow percentage increases from the guidance have been factored down to take this into account. This factoring has been done as set out below:

[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/504245/LIT_5707.pdf

	Time period	Mid-year		
Baseline from guidance	1961 - 1990	1975		
Model baseline	1995 - 2015	2005		
First epoch (2020s)	2015 - 2039	2027		
Number of years between guidance baseline and first epoch (2027-1975)			52	
Number of years between model baseline and first epoch (2027 - 2005)			22	42%
Number of years between model baseline and guidance epoch (2005 - 1975)			30	58%
Therefore the recent hydrology is already 58% of the way to the first climate change epoch.				
Central estimate: present day modelling includes:		6%	of the 10% climate change allowance	
Higher central estimate: present day modelling includes:		9%	of the 15% climate change allowance	
Upper estimate: present day modelling includes:		14%	of the 25% climate change allowance	

As set out in the calculations above, the current model hydrology is therefore assessed as being 58% of the way through the first climate change epoch. Table 2-3 provides the updated climate change percentage allowances which have been used in this appraisal.

Table 2-3 Updated peak river flood flow allowances for the LEHES appraisal

Updated climate change estimate (percentile)	Total potential change anticipated for '2020s' (2015 – 2039)	Total potential change anticipated for '2050s' (2040 – 2069)	Total potential change anticipated for '2080s' (2070 – 2115)
Upper (90th)	11%	21%	56%
Higher Central (70th)	6%	16%	26%
Central (50th)	4%	9%	19%

The impact of climate change was not fully included in the hydraulic model simulations. The future change in flood risk because of climate change was instead incorporated at the economic appraisal stage by amending the probability of an event causing a certain amount of damage. This was done for each of the three climate change epochs, but is demonstrated for the long-term '2080s' epoch in Table 2-4.

Table 2-4 Incorporating climate change by changing event probability

2018 event probability	Present day modelled peak flow (m^3/s) from downstream of the Leigh FSA	Assumed 2070 peak flow (m^3/s) (19% increase on present day)	Calculated '2080s' event probability
20% (1 in 5)	91	108	3
5% (1 in 20)	154	183	14
2% (1 in 50)	198	235	28
1.3% (1 in 75)	227	270	45
1% (1 in 100)	260	309	68
0.4% (1 in 250)	325	387	131

Using the model results, the AAD for property, evacuation costs, emergency services, vehicle damages and risk to life were calculated for the present day. The same event damages were then applied to the increased event probabilities to calculate the AADs for the three future epochs with the Central climate change estimate: '2020s' (4%), '2050s' (9%) and '2080s' (19%).

Figure 2-2 is also taken from the Environment Agency guidance and illustrates how climate change should be applied. In line with the illustration, and using the Central allowances, present day (2018) AADs were linearly interpolated to the 4% AADs in year 2025, which then stayed constant until year 2040, when there was a step

up to the next climate change epoch (9% AADs). These then stayed constant until year 2070 when there was a final step up to the 19% AADs.

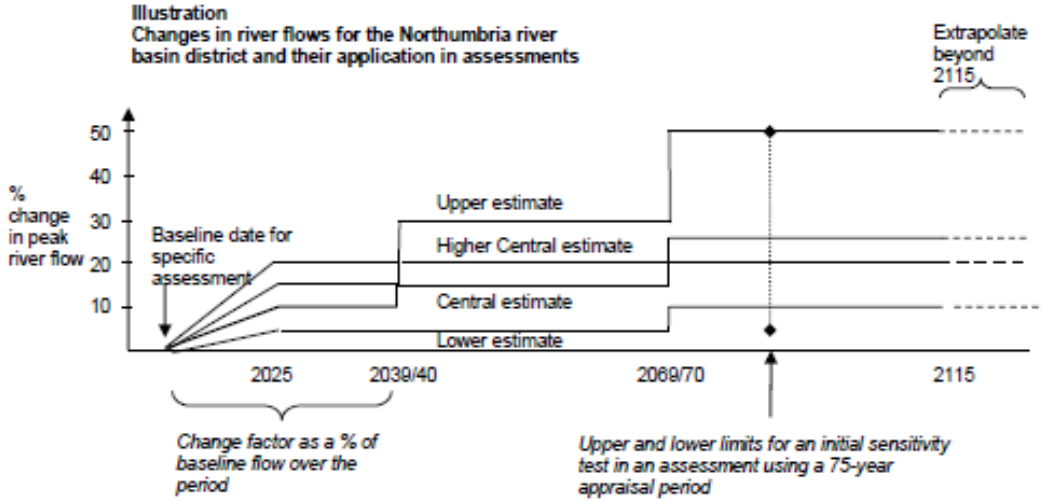

Figure 2-2 Application of climate change in assessments (Environment Agency, 2016)

2.12. Generation of Present Value damages

Under 2003 Treasury guidance, a variable discount rate (starting at 3.5%) was then applied to the AADs to generate the Present Value Damages for each option over an appraisal period of 100 years.

2.13. Valuing the benefits to the local economy

Under the Treasury Green Book, decisions regarding public expenditure should be based on national (UK) economic losses. Existing flood risk management appraisal guidance and the MCM is based on this type of assessment; however, an appreciation of both the financial and the local impacts is key to understanding the full impact of a flood event, or the full benefits of implementing a flood risk management scheme.

The main difference between national and local scale economics is how impacts on property and infrastructure are considered. Under national scale economics it is the cost to the nation which takes precedence. If a supermarket is flooded, although that particular supermarket will lose business, there is no loss to the nation as the customers will go to their next most convenient supermarket or defer their purchases until after flood recovery. There is no net loss to the nation as those groceries are still bought and consumed. As long as the supply of goods can be supplied from within the UK then there is no loss to the nation. However, for an organisation tasked with protecting the local economy, such as a Local Enterprise Partnership (LEP) or the local council, this sort of local orientated information is particularly relevant.

A recent Defra / Environment Agency funded R&D project published the report “TOOLKIT for assessing the impacts of flood and coastal erosion risk management on the local economy” Frontier Economics, Joint Defra / EA FCERM R&D programme, project FD2662. This report provides a starting point for an economic valuation of local losses in terms of Gross Value Added (GVA - value of employment) associated with commercial properties.

Atkins has developed the Toolkit, adjusting the methodology to build a better representation of the local economic aspects related to flooding expressed as a loss of Gross Value Added (GVA). A high-level analysis for Tonbridge has been undertaken to determine an approximate estimate of the potential local economy impacts which could supplement the national economic business case. Tonbridge was selected as this is the main commercial area which benefits from the options being considered. There may be further local economic benefits in the areas downstream of Tonbridge which ae not captured, particularly around East Peckham.

The following data and assumptions were used in this assessment:

- Salary information was taken from the ONS Annual Survey of Hours and Earnings (ASHE) provisional 2017 data which is the most up-to-date data available online. UK gross median earnings by sector were locally adjusted to Tonbridge and Malling;
- Average employment densities were taken from the Homes & Communities Agency (HCA) 2010 Employment Densities Guides;.
- Offices and public buildings were assumed to have an average of 1.5 floors of employment space. All other businesses were assumed to be on a single floor;
- A disruption period of four weeks was assumed for all business types;
- Additionality was included as a 30% increase in calculated GVA loss;
- The loss of GVA was only calculated for non-capped non-residential properties;
- The loss of GVA was only calculated for internally flooded properties, with no inclusion of the impact of loss of access due to road flooding / external flooding for those businesses themselves not flooding; and
- Climate change was not included in the calculations - the average annual loss of GVA was assumed to be constant over the 100-year appraisal period & discounted to generate a PV.

3. Results

3.1. Property counts

Table 3-1 lists the number of properties predicted to experience internal (above floor level) flooding, for a range of design flood events for each of the option scenarios in the present day (no climate change). These counts are taken from the large study area described in Section 2.3. In each case, counts are split into residential and non-residential. Non-residential properties include a full range of property types including businesses such as shops, offices and public buildings but also farm buildings. All property counts increase with rising event severity and reduce with increasing intervention.

Table 3-1 Present day count of properties with above floor level flooding

	5% (1 in 20)	1.3% (1 in 75)	1% (1 in 100)	0.4% (1 in 250)
Option 1: Do Nothing				
Residential	620	1,570	1,827	2,349
Non-Residential	973	1,581	1,732	1,981
Total	1,593	3,151	3,559	4,330
Option 2: Maintain Leigh FSA + MIOS				
Residential	337	1,252	1,517	2,203
Non-Residential	635	1,389	1,568	1,989
Total	972	2,641	3,085	4,192
Option 3a: Improve Leigh FSA (NMOWL 28.6m AOD) + MIOS + Hildenborough defence				
Residential	318	1,036	1,269	1,814
Non-Residential	618	1,292	1,526	1,951
Total	936	2,328	2,795	3,765
Option 3b: Improve Leigh FSA (NMOWL 28.85m AOD) + MIOS + Hildenborough defence				
Residential	309	1,001	1,183	1,814
Non-Residential	606	1,253	1,443	1,945
Total	915	2,254	2,626	3,759
Option 3c: Improve Leigh FSA (NMOWL 29.0m AOD) + MIOS + Hildenborough defence				
Residential	308	973	1,052	1,779
Non-Residential	606	1,185	1,306	1,909
Total	914	2,158	2,358	3,688

3.2. Option damages

Table 3-2 to Table 3-6 show the model area 2 (Tonbridge and Hildenborough) event damages and their build up to an annual average damage for the Do Nothing, Maintain and the three Improve options, under present day conditions. In each case the AAD excludes any contribution from properties which are capped. Tables the same as these were produced for each modelled area and for each epoch to calculate the effects of climate change.

Table 3-2 Option 1 Do Nothing 2018 model area 2

		All Flood Cells						Sheet Nr.	1	
Client/Authority										
Environment Agency										
Project name				**Option:**						
Leigh Expansion and Hildenborough Embankment Study (LEHES)				**Do Nothing**						
Project reference		5162844								
Base date for estimates (year 0)		2018						Prepared (date)	Apr-2018	
Scaling factor (e.g. £m, £k, £)		£k						Printed	Apr-2018	
Discount rate		Variable						Prepared by	BP	
								Checked by	CH	
Applicable year (if time varying)								Checked date	18/04/2018	
		Average waiting time (yrs) between events/frequency per year								**Total**
		2	5	20	50	75	100	250	Infinity	**Area**
		0.5	0.2	0.050	0.020	0.013	0.010	0.004	0	**(AAD)**
Damage Category		Damage £k								
Residential Property Direct Damage	£k	0	25	4,778	9,531	12,170	15,469	21,952	26,273	
Non-Residential Direct Damage	£k	0	425	14,793	34,588	46,199	59,724	78,577	91,146	
Evacuation Costs	£k	0	4	966	1,897	2,410	3,119	4,592	5,574	
Emergency services	£k	0	25	1,090	2,457	3,251	4,188	5,599	6,540	
Vehicle Damages	£k	0	7	777	1,348	1,611	1,957	2,631	3,080	
Risk to Life	£k	0	10	448	996	1,313	1,689	2,267	2,652	
Area (damage frequency) Residential	£k		4	360	215	72	46	112	96	**906**
Area (damage frequency) Non-Residential	£k		64	1,141	741	269	177	415	339	**3,146**
Area (damage frequency) Evacuation	£k		1	73	43	14	9	23	20	**183**
Area (damage frequency) Emergency Services	£k		4	84	53	19	12	29	24	**226**
Area (damage frequency) Vehicles	£k		1	59	32	10	6	14	11	**133**
Area (damage frequency) Risk to life	£k		1	34	22	8	5	12	10	**92**
Total damage	£k	0	496	22,852	50,819	66,954	86,147	115,618	135,266	
Area (damage frequency)	£k		74	1,751	1,105	393	255	605	502	**4,685**

				Capping	£k	42,051
				Capping Res	£k	1,003
	Total PV damages	£181,735		Capping Non-Res	£k	41,048

Table 3-3 Option 2 Maintain Leigh FSA 2018 model area 2

		All Flood Cells						Sheet Nr.	2	
Client/Authority										
Environment Agency										
Project name				**Option:**						
Leigh Expansion and Hildenborough Embankment Study (LEHES)				**Maintain**						
Project reference		5162844								
Base date for estimates (year 0)		2018						Prepared (date)	Apr-2018	
Scaling factor (e.g. £m, £k, £)		£k						Printed	Apr-2018	
Discount rate		Variable						Prepared by	BP	
								Checked by	CH	
Applicable year (if time varying)								Checked date	18/04/2018	
		Average waiting time (yrs) between events/frequency per year								**Total**
		2	5	20	50	75	100	250	Infinity	**Area**
		0.500	0.200	0.050	0.020	0.013	0.010	0.004	0	**(AAD)**
Damage Category		Damage £k								
Residential Property Direct Damage	£k	0	36	52	855	4,616	8,245	16,672	22,290	
Non-Residential Direct Damage	£k	0	253	1,034	8,197	22,442	36,349	90,208	126,113	
Evacuation Costs	£k	0	5	9	181	928	1,645	3,375	4,529	
Emergency services	£k	0	16	60	504	1,507	2,484	5,953	8,266	
Vehicle Damages	£k	0	4	4	53	663	1,176	2,082	2,686	
Risk to Life	£k	0	6	23	196	603	998	2,366	3,278	
Area (damage frequency) Residential	£k		5	7	14	18	21	75	78	**218**
Area (damage frequency) Non-Residential	£k		38	96	138	102	98	380	433	**1,285**
Area (damage frequency) Evacuation	£k		1	1	3	4	4	15	16	**44**
Area (damage frequency) Emergency Services	£k		2	6	8	7	7	25	28	**84**
Area (damage frequency) Vehicles	£k		1	1	1	2	3	10	10	**27**
Area (damage frequency) Risk to life	£k		1	2	3	3	3	10	11	**33**
Total damage	£k	0	320	1,181	9,987	30,759	50,898	120,656	167,161	
Area (damage frequency)	£k		48	113	168	136	136	515	576	**1,690**

				Capping	£k	5,227
				Capping Res	£k	501
	Total PV damages	£55,620		Capping Non-Res	£k	4,726

Table 3-4 Option 3a Improve Leigh FSA (28.6m AOD) 2018 model area 2

All Flood Cells								Sheet Nr.	3	
Client/Authority										
Environment Agency										
Project name				**Option:**						
Leigh Expansion and Hildenborough Embankment Study (LEHES)				**Improve NMOWL 28.6m AOD**						
Project reference		5162844								
Base date for estimates (year 0)		2018						Prepared (date)	Apr-2018	
Scaling factor (e.g. £m, £k, £)		£k						Printed	Apr-2018	
Discount rate		Variable						Prepared by	BP	
								Checked by	CH	
Applicable year (if time varying)								Checked date	18/04/2018	
		Average waiting time (yrs) between events/frequency per year								**Total**
		2	5	20	50	75	100	250	Infinity	**Area**
		0.5	0.2	0.050	0.020	0.013	0.010	0.004	0	**(AAD)**
Damage Category		Damage £k								
Residential Property Direct Damage	£k	0	36	49	248	982	3,999	7,702	10,170	
Non-Residential Direct Damage	£k	0	253	1,037	4,004	15,509	30,909	71,030	97,778	
Evacuation Costs	£k	0	5	9	52	187	806	1,546	2,040	
Emergency services	£k	0	16	61	237	919	1,944	4,385	6,013	
Vehicle Damages	£k	0	4	4	18	239	677	1,102	1,384	
Risk to Life	£k	0	6	23	91	357	767	1,715	2,348	
Area (damage frequency) Residential	£k		5	6	4	4	8	35	36	**100**
Area (damage frequency) Non-Residential	£k		38	97	76	65	77	306	338	**996**
Area (damage frequency) Evacuation	£k		1	1	1	1	2	7	7	**19**
Area (damage frequency) Emergency Services	£k		2	6	4	4	5	19	21	**61**
Area (damage frequency) Vehicles	£k		1	1	0	1	2	5	5	**14**
Area (damage frequency) Risk to life	£k		1	2	2	1	2	7	8	**24**
Total damage	£k	0	321	1,182	4,649	18,193	39,102	87,480	119,732	
Area (damage frequency)			48	113	87	76	95	380	414	**1,214**

Capping	£k	5,051
Capping Res	£k	501
Capping Non-Res	£k	4,549

Total PV damages £41,246

Table 3-5 Option 3b Improve Leigh FSA (28.85m AOD) 2018 model area 2

All Flood Cells								Sheet Nr.	4	
Client/Authority										
Environment Agency										
Project name				**Option:**						
Leigh Expansion and Hildenborough Embankment Study (LEHES)				**Improve NMOWL 28.85m AOD**						
Project reference		5162844								
Base date for estimates (year 0)		2018						Prepared (date)	Apr-2018	
Scaling factor (e.g. £m, £k, £)		£k						Printed	Apr-2018	
Discount rate		Variable						Prepared by	BP	
								Checked by	CH	
Applicable year (if time varying)								Checked date	18/04/2018	
		Average waiting time (yrs) between events/frequency per year								**Total**
		2	5	20	50	75	100	250	Infinity	**Area**
		0.5	0.2	0.050	0.020	0.013	0.010	0.004	0	**(AAD)**
Damage Category		Damage £k								
Residential Property Direct Damage	£k	0	36	49	187	727	3,144	7,764	10,844	
Non-Residential Direct Damage	£k	0	255	1,037	2,679	13,030	24,411	69,997	100,388	
Evacuation Costs	£k	0	5	9	41	132	608	1,557	2,190	
Emergency services	£k	0	16	61	160	766	1,535	4,331	6,196	
Vehicle Damages	£k	0	4	4	18	196	538	1,109	1,489	
Risk to Life	£k	0	6	23	62	297	605	1,695	2,422	
Area (damage frequency) Residential	£k		5	6	4	3	6	33	37	**95**
Area (damage frequency) Non-Residential	£k		38	97	56	52	62	283	341	**930**
Area (damage frequency) Evacuation	£k		1	1	1	1	1	6	7	**18**
Area (damage frequency) Emergency Services	£k		2	6	3	3	4	18	21	**57**
Area (damage frequency) Vehicles	£k		1	1	0	1	1	5	5	**13**
Area (damage frequency) Risk to life	£k		1	2	1	1	2	7	8	**22**
Total damage	£k	0	323	1,182	3,146	15,148	30,841	86,453	123,529	
Area (damage frequency)			48	113	65	61	77	352	420	**1,136**

Capping	£k	5,051
Capping Res	£k	501
Capping Non-Res	£k	4,549

Total PV damages £38,911

Table 3-6 Option 3c Improve Leigh FSA (29.0m AOD) 2018 model area 2

				All Flood Cells				Sheet Nr.	5	
Client/Authority										
Environment Agency										
Project name				**Option:**						
Leigh Expansion and Hildenborough Embankment Study (LEHES)				**Improve NMOWL 29.0m AOD**						
Project reference		5162844								
Base date for estimates (year 0)		2018				Prepared (date)			Apr-2018	
Scaling factor (e.g. £m, £k, £)		£k				Printed			Apr-2018	
Discount rate		Variable				Prepared by			BP	
						Checked by			CH	
Applicable year (if time varying)						Checked date			18/04/2018	
		Average waiting time (yrs) between events/frequency per year								**Total**
		2	5	20	50	75	100	250	Infinity	**Area**
		0.5	0.2	0.050	0.020	0.013	0.010	0.004	0	**(AAD)**
Damage Category		Damage £k								
Residential Property Direct Damage	£k	0	0	11	127	295	917	6,964	10,996	
Non-Residential Direct Damage	£k	0	253	1,298	2,325	7,741	15,468	61,048	91,436	
Evacuation Costs	£k	0	0	2	29	56	176	1,400	2,216	
Emergency services	£k	0	14	73	137	448	913	3,788	5,705	
Vehicle Damages	£k	0	0	0	14	21	228	1,034	1,571	
Risk to Life	£k	0	5	28	53	171	354	1,485	2,238	
Area (damage frequency) Residential	£k		0	1	2	1	2	24	36	**66**
Area (damage frequency) Non-Residential	£k		38	116	54	34	39	230	305	**815**
Area (damage frequency) Evacuation	£k		0	0	0	0	0	5	7	**13**
Area (damage frequency) Emergency Services	£k		2	7	3	2	2	14	19	**49**
Area (damage frequency) Vehicles	£k		0	0	0	0	0	4	5	**10**
Area (damage frequency) Risk to life	£k		1	2	1	1	1	6	7	**19**
Total damage	£k	0	273	1,411	2,684	8,733	18,056	75,720	114,163	
Area (damage frequency)			41	126	61	38	45	281	380	**972**
							Capping	£k		3,569
							Capping Res	£k		501
		Total PV damages		£32,559			Capping Non-Res	£k		3,067

3.3. Option benefits

Table 3-7 summarises the option damages and benefits for the options considered in this appraisal. Each option is compared against the Do Nothing baseline. The option benefits are the damages avoided by implementing that option. Some improvements are measured directly as a benefit and these are listed after the total PV damages.

Table 3-7 Present Value damages and benefits in £k

Damage & benefit source (£k)	Option 1 Do Nothing	Option 2 Maintain 28.05m AOD	Option 3a 28.6m AOD	Option 3b 28.85m AOD	Option 3c 29.0m AOD
PV residential property damage	94,882	62,951	56,510	55,713	54,596
PV non-residential property damage	283,530	173,760	159,254	154,924	148,502
PV evacuation loss	17,864	11,484	10,191	10,014	9,827
PV emergency services loss	14,174	8,905	8,025	7,852	7,475
PV vehicle damage	12,694	8,647	8,070	7,990	7,853
PV risk to life	5,984	3,778	3,407	3,337	3,187
PV infrastructure damage	12,754	0	0	0	0
Total PV damages (£k)	**441,882**	**269,526**	**245,457**	**239,830**	**231,439**
PV human intangible benefits	-	3,264	4,957	5,277	5,916
Total PV benefits (£k)	**-**	**175,620**	**201,382**	**207,330**	**216,359**

The Do Nothing option has Present Value damages of £442m, with 22% of this coming from residential property damages, and a further 66% from non-residential damages. 50% of the total Do Nothing damages are from the model 2 Tonbridge and Hildenborough area.

The Maintain option captures £176m of benefits when compared to the Do Nothing option, with residual damages of £270m. About 90% of these Maintain benefits are from the Tonbridge and Hildenborough area.

Option 3a (Leigh NMOWL 28.6m AOD) captures £201m of benefits when compared to the Do Nothing option, with residual damages reduced to £245m. This option converts nearly 44% of the Do Nothing damages into benefits. The 28.6m AOD option captures £26m of additional benefits compared to the Maintain option.

Stepping up from a NMOWL of 28.6m AOD to 28.85m AOD (option 3b) provides a further £6m of benefits. Stepping up from a NMOWL of 28.85m AOD to 29.0m AOD (option 3c) then provides a further £9m of benefits. Option 3c (Leigh NMOWL 29.0m AOD) captures £216m of benefits when compared to the Do Nothing option, and £41m of benefit compared to the Maintain option, with residual damages reduced to £231m. 88% of the Improve 3 benefits are from the model 2 Tonbridge and Hildenborough area, with 8% of the benefits from the model 3 area (including East Peckham and Yalding) and the remaining 4% from the model 4 area (Maidstone).

3.4. Damages and benefits to the local economy

As described in Section 2.12, under the Treasury Green Book, decisions regarding public expenditure should be based on national (UK) economic losses. However, for an organisation tasked with protecting the local economy, such as a LEP or the local council, local orientated information is relevant and of interest. The results of the local economic assessment for Tonbridge are provided in Table 3-8.

Table 3-8 Present Value damages and benefits to the local economy in Tonbridge

	Option 1 Do Nothing	Option 2 Maintain 28.05m AOD	Option 3a 28.6m AOD	Option 3b 28.85m AOD	Option 3c 29.0m AOD
Annual average loss of GVA (£k)	£1,070	£381	£332	£317	£294
PV loss of GVA (£k) over 100-years	£31,898	£11,346	£9,897	£9,441	£8,772
PV local economic benefit (£k) over 100-years compared with Do Nothing		£20,552	£22,001	£22,456	£23,126
PV local economic benefit (£k) over 100-years compared with Maintain			£1,449	£1,905	£2,574

Consideration of local economic impacts in Tonbridge adds a further £32m to the Do Nothing damages, a further £22m to the option 3a (Leigh NMOWL 28.6m AOD) benefits and a further £23m to the option 3c (Leigh NMOWL 29.0m AOD) benefits. For the latter, this is equivalent to a 14% increase in option benefit and while it cannot be quantitatively included as part of the national analysis, it does further strengthen the qualitative business case.

3.5. Benefit cost ratio

Option costs are discussed in a separate appendix to the OBC. Only the total costs are included here to document the process of calculating the Benefit Cost Ratios (BCR).

For a scheme to be considered viable for funding, the economic benefits have to be greater than the scheme costs. Economic viability can therefore be described using BCR where the ratio between the benefits (PVb) and the scheme cost (PVc) needs to be greater than 1. The BCR has been calculated for each option, the results of which are provided in Table 3-9. The final row in the table is the Incremental Benefit Cost Ratio (IBCR) which is calculated as the additional benefit achieved by a scheme option (over and above the previous option), compared with the additional cost that would be incurred.

Table 3-9 Summary of option costs and benefits

	Option 1 Do Nothing	Option 2 Maintain 28.05m AOD	Option 3a 28.6m AOD	Option 3b 28.85m AOD	Option 3c 29.0m AOD
Total PV costs (£k) including risk (50%ile)	**0**	**6,068**	**23,181**	**29,103**	**29,259**
Total PV benefits (£k)		**175,620**	**201,382**	**207,330**	**216,359**
Net Present Value (NPV)		169,553	178,200	178,227	187,100
Benefit cost ratio (BCR)		28.9	8.7	7.1	7.4
Incremental benefit cost ratio (IBCR)			1.5	1.0	2.5

3.6. Sensitivity testing

The FCERM-AG (Environment Agency, 2010) states that sensitivity testing should be undertaken to determine whether the choice of the economically preferred option is sensitive to the main sources of uncertainty. The following sensitivity tests have been undertaken:

- Sensitivity test 1: Climate change - increases more rapidly than forecast – tested by using the Higher Central estimates for changes in peak fluvial flows instead of the Central estimates; and
- Sensitivity test 2: Cost of improve works increase as a result of additional Network Rail requirements, delays & track possession costs not currently budgeted for - assumed additional cost of 30% on all Improve options.

The results of the sensitivity testing are provided in Table 3-10 and Table 3-11 and are discussed in Section 3.7 below.

Table 3-10 Sensitivity testing: climate change

	Option 1 Do Nothing	Option 2 Maintain 28.05m AOD	Option 3a 28.6m AOD	Option 3b 28.85m AOD	Option 3c 29.0m AOD
Total PV costs (£k)	**0**	**6,068**	**23,181**	**29,103**	**29,259**
Total PV benefits (£k)		**187,007**	**214,576**	**221,709**	**232,080**
Net Present Value (NPV)		180,939	191,395	192,606	202,821
Benefit cost ratio (BCR)		30.8	9.3	7.6	7.9
Incremental benefit cost ratio (IBCR)			1.6	1.2	2.9

Using the Higher Central allowances for future increases in peak fluvial flows increases damages by 10 – 12% and increases option benefits by approximately 7%. The increase is similar across all options and therefore does not affect decision making. The increase in option benefit will increase the BCR, strengthening the business case.

Table 3-11 Sensitivity testing: option costs

	Option 1 Do Nothing	Option 2 Maintain 28.05m AOD	Option 3a 28.6m AOD	Option 3b 28.85m AOD	Option 3c 29.0m AOD
Total PV costs (£k)	**0**	**6,068**	**30,135**	**37,834**	**38,037**
Total PV benefits (£k)		**175,620**	**201,382**	**207,330**	**216,359**
Net Present Value (NPV)		169,552	171,247	169,496	178,322
Benefit cost ratio (BCR)		28.9	6.7	5.5	5.7
Incremental benefit cost ratio (IBCR)			1.1	0.8	1.9

3.7. Identification of preferred option

The choice of economically preferred option should be based on the FCERM-AG decision rule (Environment Agency, 2010). This rule consists of six decision stages which have been applied to this study in Table 3-12 and in the discussion below.

Table 3-12 Application of the FCERM-AG decision rule

Decision stage	Analysis and outcome
1. Test for benefits exceeding costs.	The BCRs of all the options are greater than 1, indicating that the benefits outweigh the costs.
2. Identify the leading option using BCR and IBCRs.	Highest BCR is option 2 Maintain. IBCR for option 3a (NMOWL 28.6m AOD) is greater than 1 and provides a standard of protection between 2% (1 in 50) and 1.3% (1 in 75) Annual Probability (AP). Options 3b and 3c provide a standard of protection in excess of the 1.3% (1 in 75) AP event. IBCRs of these options (against option 3a) are less than the required 3. Leading option is therefore option 3a (NMOWL 28.6m AOD).
3. Consider how contributions could affect the BCRs and the IBCRs.	Contributions have been provided (see below) but none are conditional on option selection. Therefore, no impact on BCR or IBCRs.
4. Consider whether uncertainty could affect the choice of option.	Sensitivity tests do not change selection of the economically preferred option.
5. Consider whether wider objectives are met by the leading option	Wider objectives are met by the leading option.

The sixth stage of the decision rule is to make an option choice, recommending either the leading option or an alternative option. As set out in Table 3-12, the leading economic option is option 3a (NMOWL 28.6m AOD). Based on the 5-stage decision process in Table 3-12, this is also selected as the preferred option.

3.8. Funding

Funding information is included in the Financial case of the OBC and the partnership funding calculators are provided in Appendix J and K to the OBC. This information is not repeated here.

4. References

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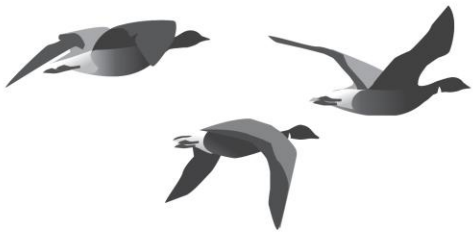

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