Oxford Initial Assessment
Economic Appraisal Report

October 2014

ECONOMIC APPRAISAL REPORT

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FIGURES

Details of document preparation and issue:

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7	Emily Kenny	David Wilson	David Wilson	27/08/14	Minor Corrections for discussion with Defra
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1. INTRODUCTION

1.1. BACKGROUND

1.1.1. The Western Conveyance Channel (WCC) was one of a number of flood risk management options proposed in the Oxford FRM Strategy (2009). At the time of submission of the strategy, the business case for the scheme was not strong enough to justify the investment in the near future.

1.2. PURPOSE OF REPORT

1.2.1. This report has revisited the strategy economics and updated them to take account of the current climate change guidance, a revised assessment of the return periods of flood flows at Oxford and a new model of the Oxford flood plain to see if these changes have modified the original assessment.

1.2.2. For this reappraisal, we were asked by the Environment Agency to use a new two dimensional model of flooding in Oxford developed by Mott Macdonald[i] in 2013. The model was peer reviewed by Thomas Mackay[ii]; the hydrology was developed by JBA and fully peer reviewed by Mott Macdonald.

1.2.3. This report is confined to considering the economics of the case and attempts to avoid value judgments on environmental and other matters, unless these can be clearly defined without further assessment of the wider scheme. Wider strategy options (eg. Upstream storage) may require investigation at a later stage. This report looks at only the economics of a channel option as discussed in the project brief in Appendix A.

1.2.4. The purpose of this report is assess whether the economic appraisal (business case) is robust enough to justify the Environment Agency and its flood risk management partners proceeding to next step of project appraisal.

1.3. THE STRATEGY

1.3.1. The preferred option from the Strategy was 'Do Minimum Sustain and Additional Measures'. This resulted in a number of minor improvements to the area such as the provision of demountable defences, localised de-silting and culvert replacements. The strategy concluded that the Western Conveyance channel was not economically viable at the present time; however, with increased frequency of flooding as a result of climate change; the project was expected to become viable in the future. The version of the Western Conveyance channel that was recommended as most cost effective was the Medium option which provided an additional channel with a $50m^2$ cross section area.

2. CLIMATE CHANGE GUIDANCE

2.1. INTRODUCTION

2.1.1. The impacts of climate change have been considered in accordance with the current Environment Agency guidance[iii] and supplementary advice on how it can be applied. For this assessment we applied the change factor recommended for river flood flows in the Thames river basin district.

2.2. REQUIREMENTS

2.2.1. The revised guidance makes more explicit the need to consider the potential impacts of climate change on an "epoch" basis, i.e. by considering not only that there is *an* impact of climate change but by considering that there is an *ongoing* change. This is summarised in the table of change factors (Table 2 in the guidance) that it suggests should be used. The changes are plotted in Figure 1 below in blue. These change factors are proportional increases to the volumetric flow in rivers over time.

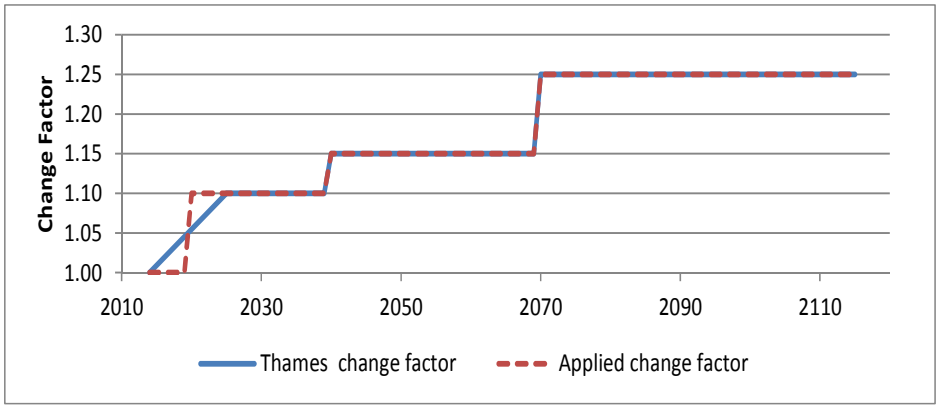


Figure 1 - Climate change factor for Oxford high level reappraisal

2.2.2. The epochs used for assessing economic damages apply the change factors for the Thames River Basin District shown in Figure 1. The only change is that the initial linear increase in change factor between 2014 and 2025 has been represented in the damage assessment by a step change in flood frequencies between 2019 and 2020 as illustrated by the red dashed line to simplify the assessment.

2.3. AN UNDERSTANDING OF CHANGES IN FLOOD FREQUENCY OVER TIME

2.3.1. Climate change factors are expected to increase river flows in the Thames river basin district by 10% in the 2020s, 15% in the 2050s and 25% in the 2080s as shown on Figure 1. Applying these change factors reduces the return period of the floods that have been modelled. Table 1 shows that a 1 in 20 year event in 2014 will become a 1 in 4 year event by the 2080s while a 1 in 1000 year event in 2014 will become a 1 in 30 year event by the 2080s. As the 1 in 1000 flood flows are now only 63% greater than the 1 in 5 flood flows now, climate change of 10%, 15% and 25% makes very significant changes in the flood frequency as described above.

2.3.2. Future return periods have not been estimated for all available events but only for those that will be used in the assessment of annual average damage for the economic assessment or for calculation of outcome measures. These return periods are discussed in Section 3 and Table 1. The economic assessment assumes that a

particular flood will cause the same physical damage in whatever year it occurs. However, the frequency of the flood will increase as fluvial climate change takes place and hence the Annual Average Damages associated with flooding in Oxford are expected to rise significantly over the next century as climate change increases fluvial flows.

3. ASSUMPTIONS OF THE HIGH LEVEL REAPPRAISAL OF THE WESTERN CONVEYANCE 'MEDIUM' OPTION

3.1. MODELLING AND FLOOD FREQUENCY

3.1.1. One of the key requirements of this high level reassessment was that it utilised output from the recently approved ISIS TUFLOW Model (2013) developed by Mott Macdonald. This flood plain model considers flows throughout the flood plain in much greater detail than the original model used in the strategy as discussed in the B&V modelling report[iv]. A more significant change introduced with this new flood plain model was a change in the frequency of occurrence of flood events in Oxford which has almost doubled compared with the strategy as also discussed in the B&V Modelling report[iv].

3.1.2. One of the disadvantages of the new flood plain model is that because of its much greater detail it takes much longer to complete an individual run of a flood event. In order to obtain sufficient results whilst minimising time spent on modelling, it was important to minimise the number of runs carried out by making maximum use of the six runs supplied and also reuse these runs for future epochs increasing their frequency of occurrence as climate change increases flood flows.

3.1.3. The methods for assessing the future frequency of occurrence of flood events and discussion on the choice of two additional runs to supplement the six provided by the Environment Agency are discussed in the modelling report[iv]. These additional runs were needed to provide sufficient event damage information to calculate Annual Average Damages for each epoch with the Existing condition. A separate appraisal detailed in the modelling report[iv] found that a minimum of six runs were required to assess the Western Conveyance option. In the process of minimising the number of runs required, only four of the six flood events (1 in 5, 20, 100 and 1000) coincided with the flood events used for the Existing condition. The flood events modelled and the return periods assumed for these runs in future epochs to assess Annual Average Damages are presented below.

Case	Flow (m^3/s)	2014 (Existing) 2014-2019	2020s (+10%) 2020-2039	2050s (+15%) 2040-2069	2080s (+25%) 2070-2113
		Approximate return period 1 in X years			
Existing condition	**115**	*5*	*3*	*3*	*2*
	142	***20***	*9*	*7*	*4*
	162	***75***	*25*		
	165	*100*		*20*	*10*
	173	***200***	*60*		
	187	*1000*	*160*	*75*	*30*
	198	*>1000*	*425*	*200*	*60*
	215	*>1000*		*850*	*200*
Western conveyance scheme	**115**	*5*	*3*	*3*	*2*
	142	*20*	*9*	*7*	*4*
	165	*100*	*30*	*20*	*10*
	178	*360*	*85*	*50*	***20***
	201	*>1000*	*560*	*260*	***75***
	215	*>1000*		*860*	***200***

Note return periods in bold are used for calculation of outcome measures

Table 1 - Effect of climate change factor on future flood return periods

3.2. DO SOMETHING OPTIONS (INTERIM MEASURES AND WITH WESTERN CONVEYANCE)

3.2.1. For the high level reappraisal of the economics, we have assumed that any of the Do Something options would be completed and commissioned by 2021. We have assumed that, if chosen, for the Interim Measures option design would commence in 2019 and construction completed two years later in 2021. We have also assumed that for the Western Conveyance Channel option appraisal would start in 2016 and construction completed five years later in 2021. All options have an operational life of 100 years, ending in 2115, before major refurbishment is required.

3.2.2. The Partnership Funding Calculator (version dated 08/01/14) uses Existing conditions in 2016 as the 'before' condition for outcome measure and with Western Conveyance Channel in the 2080s as the 'after' condition in line with current guidance.

3.2.3. For the years 2016 to 2020, with the Western Conveyance scheme, we have assumed that damages will be the same as the Existing condition, and so no calculation of Annual Average Damages with the Western Conveyance scheme was required for the 2014 epoch. The capital costs of the Western Conveyance have been spread evenly over the years 2016 to 2020. The benefits of the Western Conveyance are assumed to be realised only when the full scheme is commissioned. In reality phased completion of different parts of the scheme may allow some benefits to be achieved earlier than assumed.

3.3. DO NOTHING

3.3.1. Do Nothing is the baseline against which all other options involving intervention have been compared. No new flood alleviation schemes would be promoted and no maintenance works carried out to channels or existing flow control structures. Do Nothing includes cessation of all flood management activities with respect to operation, flood warning, maintenance and improvement activities within the Study Area. An increasing blockage of channels through debris accumulation as a result of this regime was modelled during the StAR.

3.3.2. The Do Nothing assessment has not used the new flood model. For this assessment, we were asked not to do a full reappraisal of Do Nothing damages; but simply to adjust the Do Nothing damages to account for changes in flood damages as a result of inflation and other changes. This request was made because Do Nothing damages were seen to give a robust benefit cost ratio for all options. In practice, however, because of the major changes that arise both from the changes in flood frequency and also from climate change, we have needed to reappraise the original PV damages to account for these changes.

3.3.3. Since the Do Nothing assessment did not use the new flood model, any change in damages associated with the revised model schematisation have not been included. Such changes are probably less significant than those arising from deterioration of the river channel assumed in the original strategy.

3.3.4. The Do Nothing assessment for the Oxford Strategy was made at a time when no allowances for fluvial climate change were included in the baseline assessment. For Oxford the assessment considered how the conveyance of the channel and other assets would deteriorate over 100 years, but assumed that the frequency of flood flows did not change. The original assessment split the 100 years into 3 epochs with different levels of deterioration. These epochs were 0-19 years, 20-49 years and 50-100 years.

3.3.5. For the reassessment of Do Nothing, we have taken account of the revised flood return periods and the anticipated increases in fluvial flow as a result of climate change from Figure 1. We have mapped the three epochs of deterioration assumed in the strategy as a result of a Do Nothing policy as closely as possible to the four epochs of climate change in Figure 1. The present and 2020s epochs that cover years 0-25 (2014-2039) are best represented by the initial condition that applied in the strategy to years 0-19. The 2050s epoch covering years 26-55 (2040-2069) used the deterioration assumed in the strategy for years 20-49 and the 2080s epoch covering years 56-99 (2070-2113) used the deterioration assumed by the strategy for years 50-99.

3.3.6. This high level reappraisal did not include any additional hydraulic model runs for the extreme flood flows that might be anticipated in later epochs, so the assessment of Do Nothing damages in the 2050s and 2080s epochs may underestimate the true Do Nothing damage as the maximum return period considered explicitly is 1 in 60 years in the 2050s and 1 in 25 years in the 2080s, with a linear extrapolation of damages up to the edge of the flood plain. Fortunately these properties are only flooded infrequently and their contribution to the PV damages of a Do Nothing event is heavily discounted and so likely to be small.

3.3.7. For the strategy nine different flood events were considered for three conditions of channel deterioration. Table 2 indicates how these available runs have been used and the adjustments to the original flood frequency assumptions to prepare the revised estimate of Do Nothing Damages.

Do Nothing River model	Return Period (1 in X years)				
		0 – 19 years		20 – 49 years	50 – 100 years
Flow (m^3/s)	Original strategy	2014 – 2019	2020 – 2039	2040 – 2069	2070 – 2113
79	2				
102	5	3			
115	10	5	3	3	
127	20	8	5	4	3
143	50	21	9	7	4
149	75	32	13	9	5
155	100	48	18	12	7
167	200	125	37	23	11
182	500	540	115	60	25

Table 2 – Effect of climate change factor and changed flood frequency on Do Nothing event return periods

3.4. KEY ASSUMPTIONS

3.4.1. All key assumptions are listed in Appendix B.

4. REVISED ECONOMIC APPRAISAL FOR WESTERN CONVEYANCE 'MEDIUM' OPTION

4.1. FLOOD RISK DAMAGES APPRAISAL

(a) Background

4.1.1. This flood risk economic appraisal has been undertaken in accordance with the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) issued in March 2010 and is for a 100 year appraisal period.

(b) Water Levels

4.1.2. The ISIS TUFLOW Model (2013) was run for five options: the Existing condition (or Do Minimum), Interim Measures and the Western Conveyance (small, medium and large) options. The flood extents and water levels predicted for the Do Nothing option remained the same as for the strategy 'Do Nothing' option. The options and the option numbers used in the strategy are set out in Table 3. All the results in these preliminary findings were initially obtained using ISIS version 3.6 of the flood plain modelling software. Further runs have been done with ISIS version 3.7. The earlier versions of this report[v] used earlier results run with a mixture of ISIS versions (3.5 and 3.6) and hence were inconsistent. In this version, this has been eliminated by using ISIS version 3.7 for all runs. Differences in flood levels of around 20mm were identified between ISIS versions 3.5 and 3.6.

Option	Description
1. Do Nothing	Withdrawal of all maintenance
3b. Do Minimum Sustain	Continuation of maintenance of existing situation
3c. Interim Measures	Continuation of maintenance of existing situation in addition to installation of a series of interim measures proposed by the Oxford Flood Alliance (OFA).
5.Western Conveyance - Small	Installation of the Western Conveyance Channel 'small' Option (18 m^3/s).
6. Western Conveyance - Medium	Installation of the Western Conveyance Channel 'medium' Option (38 m^3/s).
7. Western Conveyance - Large	Installation of the Western Conveyance Channel 'large' Option (58 m^3/s).

Table 3 - Options reviewed

(c) Flood Damages Economics Model (FDEM)

4.1.3. Black & Veatch have used the Flood Defence Economics Model (FDEM) to produce the property damages data. FDEM is a Geographical Information System (GIS) calculation model, produced for use on Environment Agency projects, which uses ESRI GIS software tools to calculate the property damages. FDEM compares flood water levels with property threshold levels to generate flood depths; appropriate depth damages are then applied. FDEM calculates present value (PV) damages over the project life (100 years in this case), applying the latest HM Treasury Green Book[vi] discount rates. Prior to using FDEM on live projects, an extensive series of Quality Assurance checks were undertaken against a more traditional spreadsheet method in order to ensure the results produced were correct.

4.1.4. The required data for FDEM to run includes property type (land use code), property threshold level, property area (for non-residential properties only), property valuation, flood levels and the associated annual exceedance probabilities (AEP) for appropriate extreme flood events.

4.1.5. FDEM is then used to calculate the total flood damage contributed by each individual property which is compared with the market value for each property. The lower of these two values is then taken forward through the economic appraisal in accordance with the FCERM-AG.

4.1.6. The earlier versions of this report[iv] used the 2010 version of the Multi Coloured Manual[vii] and included a sensitivity test to assess the likely effects of moving to the 2013 version of the Manual. Since that time, the FDEM model has been updated to use the 2013 version of the Multi Coloured Manual[viii] (MCM) and this report is based on this most recent version of the manual.

(d) Property Data

4.1.7. Rather than using National Receptor Database (NRD) as the basis for property locations, Ordnance Survey (OS) Mastermap (the best available digital representation of what is on the ground) is used to provide FDEM with the location of buildings. The NRD and Address Layer 2 datasets were then used to update the Mastermap building polygons with land use information using MCM codes and floor areas. This method goes a long way to addressing the problems of missing property information from NRD. Although there are still undefined properties in the area, we can now quantify them and identify where they are. This allows us to decide the most appropriate method to deal with them. Within FDEM, these are classed as “unmatched buildings”.

4.1.8. After classifying properties based on the NRD dataset, all unmatched buildings were queried using an ESRI tool to see if the building polygon neighbours align with the attribute 'Building outline' or ‘Building division’ within the *Topo_Line* layer of MasterMap. If no part of the buildings perimeter is classified as a Building outline or division, the building is classified as a non-habitable, non-permanent structure. This includes structures such as sheds, garages or outbuildings: the value of which should typically be included in the market value of the associated residential or non-residential property.

4.1.9. All remaining unmatched properties were assigned an ‘X’ in order to include them within the assessment. When determining the damages, these are assigned the MCM 999 code which is an averaged damaged value based on the unknown nature of the 999 class.

(e) Depth damage data

4.1.10. The depth damage data was taken from the 2013 Multi Coloured Manual which provides values at January 2013 prices. These prices were updated using the Consumer Price Index to April 2014; beyond this, a target inflation rate of 2% pa (in line with HM Treasury’s target to the Bank of England’s Monetary Policy Committee) was used to inflate the costs to 2016.

4.1.11. Below threshold flooding was included within the appraisal for residential properties; below threshold flooding does not apply to non-residential properties unless they are known to have a basement.

(f) Threshold Levels

4.1.12. Threshold survey data were available for many of the properties in the study area, from data prepared for the strategy, and these levels were applied to the relevant properties.

4.1.13. For the remaining properties in the area a ground level was assigned to each building using filtered LiDAR data provided by Environment Agency. FDEM can add a threshold factor to the ground level, to account for front steps etc, to produce a threshold level for each building – in this case we used +150mm for residential properties and +0mm for non-residential properties after looking at the area in Google Maps.

(g) Capping Values

4.1.14. Capping values for residential properties have been taken from the Land Registry for Oxfordshire April 2014.

4.1.15. Missing commercial property valuations are based on bulk average[ix] and yield data available from the Department of Communities and Local Government.

(h) Flood Duration

4.1.16. The flooding through the Oxford area is assumed to be fluvial with no additional flooding from surface water or groundwater sources.

4.1.17. Depth damage data from the MCM is available for flood durations less than or greater than 12 hours. Since the flooding in Oxford typically lasts longer than 12 hours, the greater than 12 hours damage data has been used.

(i) Non Residential Property – area values

4.1.18. Areas have been taken from the NRD for all matched buildings. Where NRD contained no area value for a building, the area from OS Mastermap was used. Area values are only required for non-residential properties.

(j) Land Use Codes

4.1.19. Property codes have been taken from the NRD for all matched buildings. Where NRD contained no property code information for a building, code 'X' was assigned.

4.1.20. A check showed that around 7.5% of buildings occupying 19.4% of the floor area of all inundated buildings in the Oxford flood plain were unmatched and so initially assigned the MCM 999 code. The difference between the percentages based on number and area indicates that these unmatched properties are on average just over 2.5 times larger than the average property size.

4.1.21. The unmatched properties were reviewed using online web mapping resources. This indicated that of the 727 unmatched properties in the flood plain, half should be described as residential properties and the remainder as various types of commercial properties, particularly shops and educational buildings.

(k) Social Equity/Distributional Impacts

4.1.22. The 2013 version of the MCM explicitly states that Distributional Impact (DI) analysis is included in the weighting used to derive the average damage figures for each residential property age class. The manual states that application of DI analysis, based on census data should only be applied as part of a full analysis using census small output area data to assign the residential properties in each area to different social classes. As this level of analysis has not been applied, the FDEM analysis relies on the DI analysis implicitly included within the residential property depth damage data for each age class of property.

(l) Emergency Services costs

4.1.23. The 2013 MCM recommends that in urban areas such as Oxford, that the value of the economic property losses should be increased by 5.6% to account for the additional emergency and recovery costs incurred by the emergency services and authorities. This factor was based on experience from the 2007 summer floods. The factor of 10.6% which was based on cost incurred in the 2001 floods is considered to be more applicable in more rural areas. In FDEM, the 5.6% uplift is applied to all the uncapped property damages.

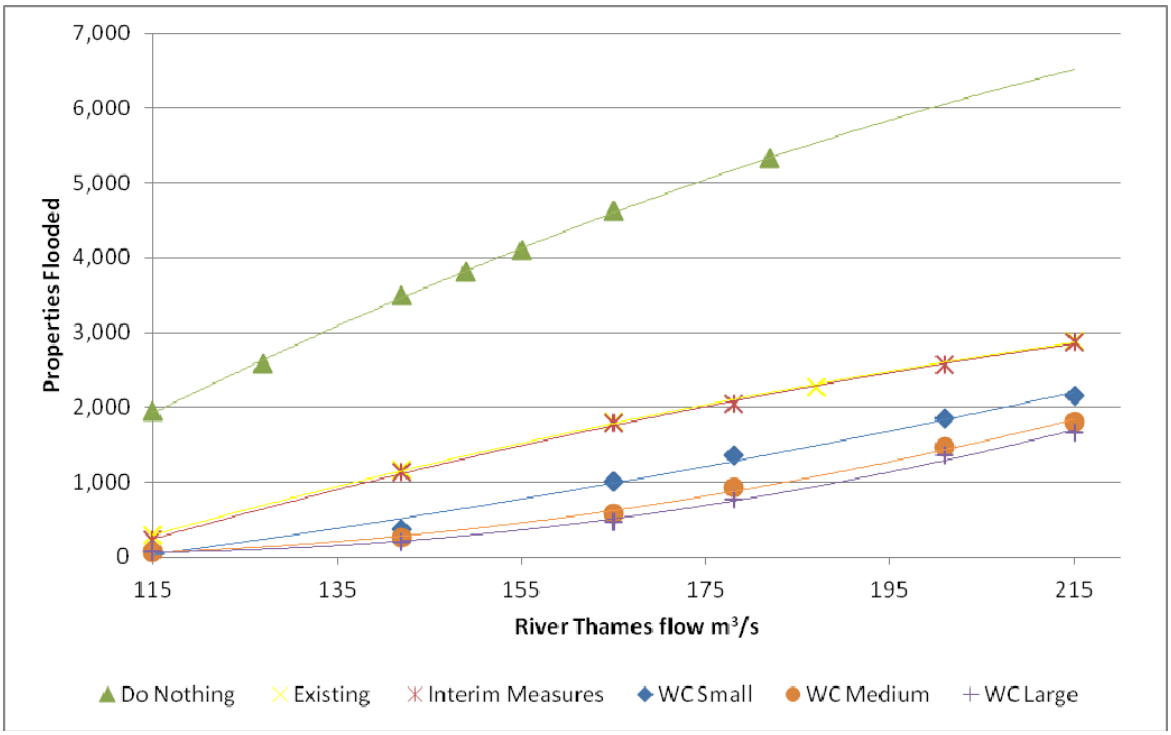
(m) Property count and damages

4.1.24. The number of properties experiencing flood damage during floods of specific magnitude is set out in Table 4. The totals for residential property include many which, although not flooded internally, experience small damages because the flood level was within 0.3m of their threshold. The properties that are not flooded internally do not contribute towards the outcome measures calculated in Table 5 to Table 9 below. Although the frequency of flooding increases as a result of climate change, the number flooded by a particular flood magnitude does not change.

		Flows (m^3/s)			
Thames Flow at Eynsham (m^3/s)		115	142	165	215
		Return Periods (1 in X)			
Flood Return Period in 2014 (1 in X)		5	20	100	>1000
Flood Return Period in 2080 (1 in X)		2	4	10	200
		Property Count			
Existing	**Residential**	230	1018	1616	2551
	Commercial	54	147	195	331
Interim Measures	**Residential**	178	991	1593	2541
	Commercial	50	143	195	331
Small Western Conveyance	**Residential**	61	310	869	1918
	Commercial	27	68	140	238
Medium Western Conveyance	**Residential**	52	208	485	1593
	Commercial	24	46	88	210
Large Western Conveyance	**Residential**	47	159	395	1466
	Commercial	24	45	75	190

*Note this property count includes all properties economically damaged, even if not internally flooded. For those internally flooded only, see Table 5 to Table 9 .

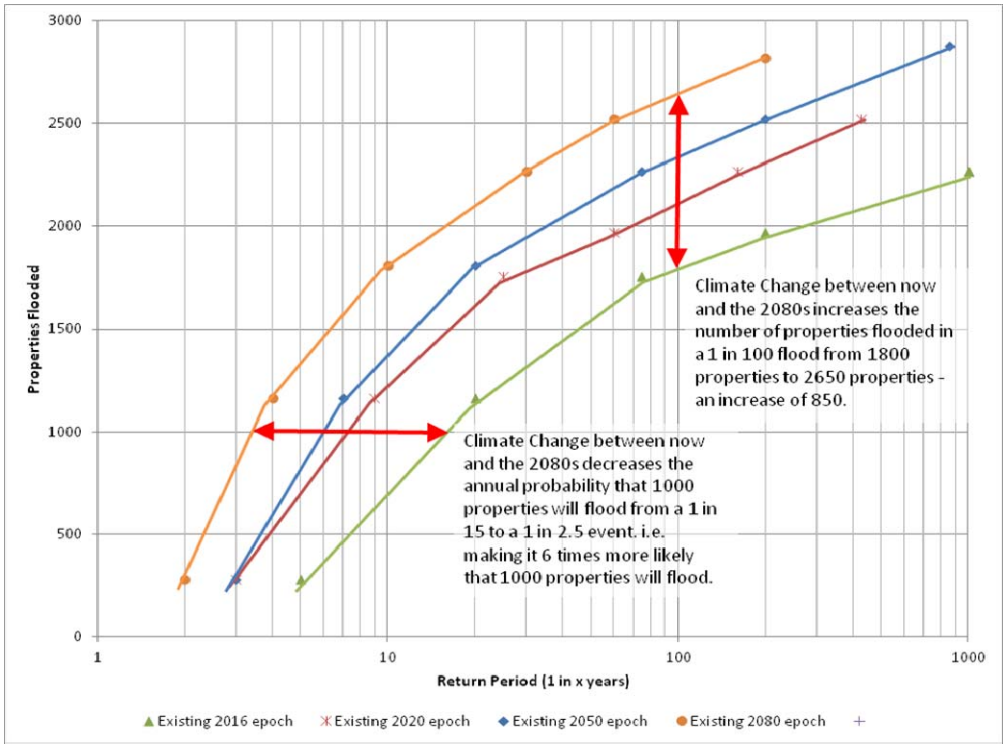
Table 4 – Number of properties flooded by different magnitude floods



*Note this property count includes all properties economically damaged, even if not internally flooded. For those internally flooded only, see Table 5 to Table 9 .

Figure 2 - Total Number of Properties economically damaged by flooding in Oxford in 2014

4.1.25. Table 4 shows that if implemented in 2014, the Medium Western Conveyance Channel reduces the number of properties economically damaged by flooding in a 1 in 20 year event from approximately 1165 to 254.



*Note this property count includes all properties economically damaged, even if not internally flooded. For those residential properties internally flooded only, see Table 5 to Table 9.

Figure 3 - Total number of properties economically damaged in Oxford in the existing situation (i.e. with no scheme implemented) for different climate change epochs

4.1.26. Implementation of the Medium Western Conveyance channel mitigates the effects of climate change. If the Western Conveyance was not constructed, many more properties will experience an increased flood risk as a result of climate change raising the frequency of flooding. Figure 3 gives a good indication of the likely impacts of climate change if the WC channel was not implemented.

4.1.27. In order to assess outcome measures, the numbers of residential properties flooded internally in a 1 in 20, 1 in 75 and 1 in 200 event occurring now are shown in Table 5, these numbers represent the 'Before' figures for OM2.

4.1.28. Outcome measures are assessed in line with Environment Agency guidance for risk management authorities on Partnership funding[x]. The 'Before' risk band is the one prior to the capital investment, i.e. before the works to improve the asset or reinstate structural integrity. The 'After' risk band is the one the households are expected to be in at the end of the claimed duration of benefits period. This will include the expected impacts of climate change increasing risk over time, less any mitigation that is included in the scheme design and proposed investment. The numbers flooded in the 2080s with each of the 'Do Something' options in operation, taking account of the anticipated climate change that has occurred in the intervening years is shown in Table 6, Table 7, Table 8 and Table 9. These numbers represent the 'After' figures. These tables also shows the change in numbers at very significant, significant and moderate risk – these are defined by flood frequencies (often described as return periods or annual exceedance probabilities) detailed in the guidance[x]. The results in each of the tables below have been subdivided to take account of the deprivation ranking of the wards that are affected. Introduction of the Medium Western Conveyance reduces the flood risk band in 2080 for 230 properties overall. It is noticeable that for some options, even with the scheme, the number of properties at risk still increases. This increase relates to climate change and the increase would be much greater without the scheme in place.

4.1.29. The property numbers for 'Low' risk bands are not shown as the 'Low' band is not fully defined in the guidance. As the Partnership Funding calculator does not take account of the 'Low' risk figures, it was not necessary to include them. This was particularly the case as the properties considered are only inside the 1 in 200 envelope in the 2080s epoch and hence no 'Low' risk properties have been considered in the 2080s epoch.

4.1.30. We are unable to add in a table showing the existing situation, assuming that the WC channel has already been constructed and the existing scenario in 2080 as we do not have the correct return periods for this scenario. For this stage of the project, it was understood that it was more important to conduct fewer runs and spend less time than it was to have answers to all risk bands/return periods at all epochs. This will be reviewed further during the full appraisal.

4.1.31. The numbers in tables 5 to 9 show that, in some cases, there are higher property numbers in the after scenario than in the before, this is due to the large amount of climate change expected. In the next stages of the project appraisal, the options considered should be future proof through taking a strategic longer term view. It may be that the design life of the smaller options should be shorter than 100 years currently considered, with another large investment occurring in, maybe, the 2050s epoch, to mitigate the effects of climate change.

	Deprivation ranking			
Risk Rating	0-20%	20-40%	Upper 60%	Total
Very Significant (<=20)	3	198	430	631
Significant (>20, <=75)	8	101	333	442
Moderate (>75, <=200)	0	59	170	229
Total	11	358	933	1302

*Note this property count includes only those properties that are internally flooded. For all properties accruing economic damages, see Table 4

** The 'Low' risk band is not used as the upper (most extreme) boundary is not defined within the guidance.

Table 5 – Residential properties in each flood risk band for Existing condition in 2014.

	Deprivation ranking				Change due to scheme & CC +/-
Risk Rating	0-20%	20-40%	Upper 60%	Total	
Very Significant (<=20)	11	370	982	1363	732
Significant (>20, <=75)	0	54	144	198	-244
Moderate (>75, <200)	0	0	0	0	-229
Total	11	424	1126	1561	

Table 6 - Residential properties in each flood risk band with Interim Measures in 2080s epoch

	Deprivation ranking				Change due to scheme & CC +/-
Risk Rating	0-20%	20-40%	Upper 60%	Total	
Very Significant (<=20)	11	245	493	749	118
Significant (>20, <=75)	0	96	338	434	-8
Moderate (>75, <200)	0	62	178	240	11
Total	11	403	1009	1423	

Table 7 - Residential properties in each flood risk band with Small Western Conveyance in 2080s epoch

	Deprivation ranking				Change due to scheme & CC +/-
Risk Rating	0-20%	20-40%	Upper 60%	Total	
Very Significant (<=20)	3	176	254	433	-198
Significant (>20, <=75)	8	96	306	410	-32
Moderate (>75, <200)	0	65	187	252	23
Total	11	337	747	1095	

Table 8 – Residential properties in each flood risk band with Medium Western Conveyance in 2080s epoch

	Deprivation ranking				Change due to scheme & CC +/-
Risk Rating	0-20%	20-40%	Upper 60%	Total	
Very Significant (<=20)	3	145	183	331	-300
Significant (>20, <=75)	8	105	286	399	-43
Moderate (>75, <200)	0	54	197	251	22
Total	11	304	666	981	

Table 9 - Residential properties in each flood risk band with Large Western Conveyance in 2080s epoch

4.1.32. In addition to the properties listed in table 5, a further 259 properties were identified in the existing condition in 2014 that flood in between a 1 in 200 year and a 1 in 1000 event. This brings the total properties flooding in the existing condition in a 1 in 1000 event to 1561 (i.e. 1302 identified in Table 5 plus 259). Depending on climate change and the scheme implemented, these properties may flood on a more frequent basis in future epochs.

(n) Risk to Life

4.1.33. Risk to Life damages were based on those calculated for the strategy. The original assessments of the number of fatalities and injuries in individual flood events were retained and no account taken of possible changes in the numbers of fatalities and injuries that might occur from the use of the updated flood plain model. The value assigned to injuries and fatalities were updated to January 2014 prices by CPI. These values were combined into an annual average damage arising from risk to life taking account of the climate change factors over the 100 year appraisal period and the revised hydrology, both of which increase the frequency of floods.

(o) Intangible Benefits (due to reduction in stress)

4.1.34. The intangible benefits (due to reduction in stress and from reduced use of medical facilities) associated with flood defence improvements have been included within the results of this economic appraisal. These benefits are based on research carried out to evaluate the benefits to a household of not being flooded, in terms of the associated reduction in stress. The reduction in use of medical facilities has been valued at around £800/residential property/flood event[vii].

(p) Intangible Benefits (due to evacuation)

4.1.35. The medium evacuation costs set out in the 2013 MCM have been applied to residential properties depending on property type and the depth of flooding.

(q) Intangible Benefits (due to evacuation)

4.1.36. The 2013 MCM includes a calculation methodology to assess indirect damages associated with the loss of education if schools are closed as a result of flooding and also the loss of parental income if primary schools are flooded and parents need to make alternative child care arrangements. For this assessment up to six primary schools are within the Do Nothing flood plain, though only one of these is at risk of flooding in the Existing Scenario and with the Western Conveyance in place. Primary schools are assumed to each have 300 pupils.

4.1.37. The methods set out in 2013 MCM were applied. The probability that flooding occurs in term time is assessed as 39/52 since schools are assumed in session for 39 weeks each year. All indirect school damages have been reduced by this factor.

(r) Audit and Data Quality

4.1.38. Once the full analysis had been completed, checks were undertaken on the properties contributing very high or very low damages to the study. We reviewed the data held for them, using the Valuation Office website and online web mapping resources. No changes were made to the number and values of flood properties as a result of this final check.

4.1.39. In order to assess outcome measures, the numbers of residential properties flooded internally in a 1 in 20, 1 in 75 and 1 in 200 event occurring now are shown in Tables 5 to 9.

(s) Other Damages and Benefits

4.1.40. Traffic damages, railway damages, agriculture damages and Income loss have been calculated using the event damages calculated for the strategy. These figures were updated to January 2014 prices by CPI and then on to January 2016 using a rate of 2% pa (in line with HM Treasury's target to the Bank of England's Monetary Policy Committee). The annual average damages associated with traffic and railways were adjusted to account for the climate change factors over the 100 year appraisal period and the revised hydrology, both of which increase the frequency of floods.

4.1.41. Vehicle damages were included as recommended in the 2013 MCM based on a loss of £3100 per residential property whenever it is flooded to a depth exceeding 0.5m.

4.1.42. In the strategy, flood warning benefits were included by reducing the present value of commercial and residential property damage value by 8.8%. However, the 2013 MCM depth damage tables show that the reduction in property damages following flood warning is between 1 and 2%. In this assessment this small reduction in damages has been ignored as it considers the worst case. If it had been included, the value of the benefits would be increased in all options but the Do Nothing, increasing the BCR of each option and therefore marginally improving the incremental score of each option.

4.1.43. Environmental benefits have not been assigned a monetary value as the defences protect predominantly property. These will be reviewed in more detail during the full appraisal.

(t) Overall Damages and Benefits

4.1.44. A summary of all Present value damage values is provided in Table 10 over the 100 year appraisal period.

Option	Damages (£M)								Benefits (£M)	
	Commercial Property	Residential Property	Risk to Life	School Disruption	Rail	Traffic	Agriculture	Income Loss	Flood Warning	**TOTAL (£M)**
1	189.6	768.3	156.9	3.3	9.5	41.5	11.2	0.5	0.0	**1180.7**
3b	27.7	191.3	82.6	0.1	6.6	14.6	10.1	0.2	0.0	**333.4**
3c	27.7	184.1	81.7	0.1	6.4	14.2	10.1	0.2	0.0	**324.7**
5	18.0	81.5	67.9	0.0	3.8	8.4	10.0	0.2	0.0	**189.8**
6	13.1	53.4	63.8	0.0	3.0	6.7	9.6	0.2	0.0	**149.9**
7	12.0	46.2	62.8	0.0	2.9	6.3	9.6	0.2	0.0	**139.9**

Table 10 – Damage build-up for each option

5. COST DATA

5.1.1. Costs for the Western Conveyance Medium Option have been reviewed in detail by Turner and Townsend[xi]. The costs used in this Economic Appraisal are the costs they estimate based on Q2 2018 prices. This price estimate is also used in the assessment of partnership funding contributions as the sum of money that might be required at the time the scheme is constructed.

5.1.2. Costs have been assessed by Turner & Townsend as PV costs in April 2018.

5.1.3. The 100 year PV costs for the medium channel including maintenance of existing channels and assets are estimated to be £141.4M using April 2018 prices and assuming 12.5% increase in the cash costs of maintenance between 2008 and 2014. This cost build up assumes that year 0 is 2016 and that implementation of the project happens over five years from 2016 to 2020 prior to the scheme becoming operational. No major refurbishment was allowed for; as it has been assumed that major refurbishment would happen at the end of the 100 years. Discount factors are applied in accordance with the HM Treasury Green Book[vi] to generate a 100yr economic assessment using Present Values (PV).

5.1.4. In order to update the costs for the large and small Western Conveyance Channels (options 5 and 7), a similar approach was taken factoring the costs prepared by Turner & Townsend[xi].

5.1.5. Table 11 shows the change in PV cost in April 2014 for each of the alternative options using both April 2014 and Q2 2018 prices.

Option		Updated PV Cost (£M) using April 2014 prices	Updated PV Cost (£M) using Q2 2018 prices
5	**Western Conveyance Small & Additional Measures (maintenance)**	**£97.6**	**£108.7**
6	**Western Conveyance Medium & Additional Measures (maintenance)**	**£127.0**	**£141.4**
7	**Western Conveyance Large & Additional Measures (maintenance)**	**£145.3**	**£161.8**

Table 11 – April 2014 PV Cost update of Options 5, 6 and 7

6. SUMMARY OF RESULTS

6.1. BENEFIT COST RATIOS OVER APPRAISAL PERIOD

6.1.1. Table 12 summarises the results based on April 2014 prices; the incremental Benefit Cost ratio (iBCR) is related to the option with the highest Benefit Cost Ratio (BCR) and so is not derived for that option

	Option	PVd (£M) 2014	PVb (£M) 2014	PVc (£M) 2014	BCR 2014	ICBR* 2014	
1	Do Nothing	1180.7	-	-			
3b	Do minimum Sustain & Additional Measures Maintenance	333.4	847.4	19.8	42.9		
3c	Do minimum Sustain & Interim Measures	324.7	856.1	23.4	36.6	2.41	3b
5	Western Conveyance Small & Additional Measures (maintenance)	189.8	991.0	108.7	9.1	1.58	3c
6 (updated costs)	Western Conveyance Medium & Additional Measures (maintenance)	149.9	1030.9	141.4	7.3	1.22	5
7	Western Conveyance Large & Additional Measures (maintenance)	139.9	1040.9	161.8	6.4	0.49	6

Table 12 – Summary of Scheme Benefits & Costs over the 100 year Appraisal period

6.1.2. These results, given over a 100 year appraisal period, show that the Existing condition described as Do Minimum Sustain & Additional Measures has a large BCR of over 40. Moving from this option to the Interim Measures option has an iBCR of 2.41 which is robustly greater than one. Moving to the small Western Conveyance from the Interim Measures option has an iBCR of 1.58, which is also robustly greater than 1. Moving to the medium Western Conveyance from the small Western Conveyance has an iBCR of 1.22 which is greater than 1. All these options meet the FCDPAG-AG criteria for investment as the standard of protection remains less than 1 in 75 for many properties within the floodplain. Proceeding to the large Western Conveyance is not an economic investment as the iBCR compared with the medium Western Conveyance is 0.49.

6.1.3. The original strategy assessment found that the iBCR of the Western Conveyance option was marginally less than 1.0 and so not a worthwhile investment in the baseline circumstances assumed for the strategy. The changes in costs, current flood frequencies and the increased flood frequencies anticipated as a result of climate change have all contributed to this improved iBCR.

6.2. SENSITIVITY TESTS

6.2.1. Sensitivity testing is a useful method for assessing how robust the iBCR is for a project. In this case we have considered two sensitivity tests, each of which is expected to reduce the iBCR. These tests assumed that

- there is a 20% uplift in cost, and
- there is no increase in flood flows after the 2020s.

20% Uplift in Costs

6.2.2. If it is assumed that the project costs over-run by 20% over that estimated the PV cost of the medium WC scheme rises to £169.7M assuming the channel becomes operational in 2020. Table 13 shows this 20% increase in cost reduces the iBCR to 1.02, indicating that the Medium Western Conveyance scheme would continue to have an iBCR of greater than 1 however it is not particularly robust. No change is made to the Do Nothing benefits.

	Option	PVd (£M) 2014	PVb (£M) 2014	PVc (£M) 2014	BCR 2014	ICBR* 2014	
1	Do Nothing	1180.7	-	-			
3b	Do minimum Sustain & Additional Measures Maintenance	333.4	847.4	23.7	35.7		
3c	Do minimum Sustain & Interim Measures	324.7	856.1	28.0	30.5	2.00	3b
5	Western Conveyance Small & Additional Measures (maintenance)	189.8	991.0	130.4	7.6	1.32	3c
6 (updated costs)	Western Conveyance Medium & Additional Measures (maintenance)	149.9	1030.9	169.7	6.1	1.02	5
7	Western Conveyance Large & Additional Measures (maintenance)	139.9	1040.9	194.2	5.4	0.41	6

Table 13 – Sensitivity test 1: increased scheme cost by 20%

No climate change after the 2020s

6.2.3. The second test assesses the sensitivity to climate change by assumes that climate change leads to the 10% increase in flows assumed for the 2020s, but that there are no further increase in fluvial flood frequencies for the remainder of the appraisal period. This is a reasonable test as it is between the change factor and the lower end estimate specified in the Environment Agency's guidance – see Table 14; it is included to give an understanding on what happens if the climate change predictions used are over estimates.

	Total potential change anticipated for the 2020s	Total potential change anticipated for the 2050s	Total potential change anticipated for the 2080s
THAMES RIVER BASIN DISTRICT			
H++	40%	55%	90%
Upper end estimate	30%	40%	70%
Change factor (as used in this appraisal)	**10%**	**15%**	**25%**
Lower end estimate	-15%	-10%	-5%

Source: Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, Environment Agency

Table 14 - Changes in river flow for climate change

6.2.4. This sensitivity tests assumes that the flooding frequency does not increase as assumed in the base case, which leads to a 40% reduction in Do Nothing damages with a one third reduction in the number of properties flooded. Table 15 shows that the effect on the damages with the Western Conveyance scheme reduces the overall BCR for the Interim measures to 21.2 and the iBCR to 3.30. Moving to the Small WC option from the Interim measures the BCR drops to 5.7 and the iBCR to 1.45, a score robustly greater than 1. Moving to the medium option, from the small, moves the BCR to 4.6 and the iBCR to 0.85, an answer less than one. It would hence indicate that the smaller channel was more preferred. This highlights the sensitivity of the overall BCR to the assumptions made about climate change and by implication the assessed frequency of flooding.

	Option	PVd (£M) 2014	PVb (£M) 2014	PVc (£M) 2014	BCR 2014	ICBR* 2014	
1	Do Nothing	779.8	-	-			
3b	Do minimum Sustain & Additional Measures Maintenance	296.5	483.4	19.8	24.5		
3c	Do minimum Sustain & Interim Measures	284.5	495.3	23.4	21.2	3.30	3b
5	Western Conveyance Small & Additional Measures (maintenance)	161.0	618.8	108.7	5.7	1.45	3c
6 (updated costs)	Western Conveyance Medium & Additional Measures (maintenance)	133.2	646.7	141.4	4.6	0.85	5
7	Western Conveyance Large & Additional Measures (maintenance)	122.1	657.8	161.8	4.1	0.54	6

Table 15 – Sensitivity test 2: No increase in flood flows after 2020s

6.2.5. No sensitivity test has been done for climate change above the recommended change factor in the Environment Agency's guidance. This should be done at the next stage of appraisal.

7. PARTNERSHIP FUNDING ESTIMATE

7.1.1. The Partnership Funding Calculation requires an estimate of the benefit cost ratio over the period until the next major investment is planned. In the case of the Western Conveyance, the wider Environment Agency Project Team has agreed this to be 100 years after the scheme is commissioned..For the Partnership Funding calculation, costs and benefits have been appraised from year 0, when implementation starts, until year 100. As the major capital investment will take place in the years 2016-2020, anticipated costs in Q2 2018 prices from section 5 have been adopted for this assessment.

7.1.2. The cash values of benefits are likely to be greater in 2016 than currently. The wider project team has therefore agreed that benefit values should be inflated at 2% pa (per annum) for the two year period April 2014 to April 2016 in line with anticipated increases in CPI (Consumer Prices Index). This CPI inflation rate is set out in HM Treasury's Remit to the Bank of England Monetary Policy Committee contained in the Chancellor's letter to the Governor of the Bank of England[xii] of March 2014. This gives 4.04% inflation over the two years 2014 to 2016, which has been applied to all flood damages and capping values and implicitly assumes that property capping values (house prices for residential property and Valuation Office values for commercial properties) in Oxfordshire will increase at the same compound rate of 2% pa. The Bank of England in their May 2014 Inflation report[xiii] note that actual CPI inflation rates over the next two years could fall in a wide band centred around a value of approximately 2% pa.

7.1.3. Because of time constraints this preliminary assessment has made the following simplifications and assumptions:

- Investment period of 100 years with capital investment starting in year 0 of appraisal (2016);
- benefit values have been inflated 4.04% for the period April 2014 to April 2016;
- benefit assessment assumes the scheme comes into service in 2021;
- benefit assessment will assume climate change accords with current guidance;
- cost assessment uses estimated Q2 2018 prices to estimate PV costs in Q2 2016.

7.1.4. Feeding the figures into the Environment Agency Partnership Funding Calculator indicates that £83.7M of third party funding is required to achieve 100% funding for the Medium channel, though a greater level of third party funding might be necessary to achieve the necessary priority to access the FDGiA contribution. For the small channel, a lower figure of £55.5M of third party funding is required to achieve 100% funding.

7.1.5. In any consideration of Partnership Funding, changes in the benefit cost ratio affect the FDGiA available and hence the amount of partnership funding required. Any increase in capital cost as a result of a revised cost assessment or because of a change in capital or maintenance cost inflation before the scheme is ready for construction will reduce the BCR and indirectly increase the partnership funding and also directly increase the partnership funding pound for pound. The standard *Sensitivity 1 - Change in PV Whole Life Cost (25% increase)* included with the Partnership Funding Calculation shows how significant the impact of increased costs is.

7.1.6. As a consequence the risk of cost escalation falls fully on the third party funders. Conversely if costs are reduced, the benefit is experienced by the third party funders.

7.2. PARTNERSHIP FUNDING SENSITIVITY TESTING

Sensitivity to OM2 figures

7.2.1. The Partnership Funding has two key inputs: the benefits and the number of households benefitting. To understand the sensitivity to these two inputs, the sensitivity test described below has been undertaken.

7.2.2. The sensitivity test assumes that the scheme made no change in the number of households affected (i.e. the channel exactly mitigated the effects of climate change); this would slightly alter the level of FDGiA contribution. For the medium channel the third party funding required would increase to £85.0M from £83.7M. For the small channel (currently showing negative effects) the partnership funding required would reduce to £54.6M from £55.5M.

7.2.3. These changes are only altering the level of partnership funding required by 1.5%, a negligible amount in the scheme of the project. This also shows that the vast majority of the partnership funding is dependent on the economic benefits of the scheme (i.e. OM1).

8. CONCLUSIONS

8.1.1. The results of the economic analysis show that the baseline economic case for the Western Conveyance channel has improved since the Oxford StAR was prepared. If the underlying assumptions are correct the small channel option provides an incremental benefit cost ratio of 1.58. The medium option provides an incremental benefit cost ratio (iBCR) of 1.22 when compared with the small variant and the large variant has an iBCR of 0.49 when compared with the medium variant.

8.1.2. The analysis shows that contributions totalling £83.7M are required to allow the medium Western Conveyance Channel to proceed or £55.5M of contributions to allow the small channel to proceed.

8.1.3. It is noticeable that for some options, even with the scheme, the number of properties at risk still increases in the 'After' scenario within the outcome measures. This increase relates to climate change and it is important to note that without the scheme in place this increase would be much greater.

8.1.4. The findings show that iBCR is relatively sensitive to the construction cost and alternate climate change scenarios. The size of the channel is likely to be very sensitive to climate change, the effects will greatly vary dependant on the option chosen.

8.1.5. This Initial Assessment has demonstrated that there is now an option to provide flood protection to Oxford that is sufficiently economically viable to move to the next stage of project appraisal. Additional appraisal will be required in the next phase of the project to determine the economically preferred option and the exact size of the channel – likely to be somewhere between the medium and small channel sizes.

8.1.6. The significant falling of benefits over the 100 year appraisal period due to climate change may not be acceptable; future project appraisals should determine whether the chosen option should future proof through taking a strategic longer term view. It may be that the design life of one of the smaller options should be shorter than 100 years with a further large investment happening later to mitigate the effects of climate change.

8.1.7. Viable options do not protect all properties at risk; therefore the next stages of appraisal need to identify alternative measures to manage the flood risk in the other properties, where possible.

9. REFERENCES

[i] Oxford Flood Risk Mapping Study – January 2014 – Mott Macdonald – Final_v1

[ii] Oxford Flood Mapping Study – Modelling Review – Thomas Mackay 17th Dec 2013

[iii] Environment Agency undated; Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities. Accessed September 2013

[iv] Oxford Initial Assessment Modelling report – Black & Veatch – 8th August 2014

[v] Black & Veatch May 2014. Oxford Initial Assessment Economic Appraisal Report to the Environment Agency, May 2014.

[vi] HM Treasury, 2003. The Green Book Appraisal and Evaluation in Central Government

[vii] Multi Coloured Manual (MCM) more formally The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques, E Penning-Rowsell et al, 2010

[viii] Flood and Coastal Erosion Risk Management A manual for Economic Appraisal E Penning-Rowsell et al, 2013

[ix] http://www.communities.gov.uk/planningandbuilding/planningbuilding/planningstatistics/livetables/tablescommercialindustrialfloors/

[x] Environment Agency [2014]. Calculate Grant in Aid funding for flood and coastal erosion risk management projects, Guidance for risk management authorities, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297377/LIT_9142_dd8bbe.pdf. February 2014.

[xi] Turner & Townsend, 2014. Oxford Western Conveyance Channel 50m² Scheme - Cost Review (4 July 2014)

[xii] HM Treasury 19 March 2014. Remit of Monetary Policy Committee

http://www.bankofengland.co.uk/monetarypolicy/Documents/pdf/chancellorletter140319.pdf

[xiii] Bank of England, May 2014. Inflation Report fan charts

http://www.bankofengland.co.uk/publications/Documents/inflationreport/2014/ir14mayfc.pdf

Appendix A – Project Brief

Scope for additional Works for Oxford Initial Assessment – CE12

This additional item of work has been requested by the Environment Agency in order to help them close out this stage of the project and move onto the appraisal stage of the project as smoothly as possible.

Work from 28th April to end of 9 May and submitting this CE:

In order to define the exact Scope of this compensation event there has been substantial work involved to ensure that we do not need a further compensation event at a later date. The work that has been done from 28th April to 9th May in preparing this compensation event includes:

- Telecon on 7th May to discuss the scope
- An initial review of the Redbridge briefing note produced at the strategy has been carried out and comments produced for inclusion in an email.
- In order to understand the current flood mechanism, an animation of the 1 in 100 year flood was produced showing the flow arrows, demonstrating where the flood waters move, this was discussed with URS on the site visit.
- Site meeting with EA and URS on 8th May
- Updating and Issuing rev 3 of the economic report, providing answers to queries to assist with LEP meeting and issue of report.
- Project Management (Production of CE, phone calls, answering queries, 1 no. Progress Report)

Project Management:

B&V will attend one meeting at the EA offices in Reading; to be attended by the B&V project manager only. B&V will attend two teleconferences involving 3 B&V attendees, not to total more than 5 hours per person for all calls. EA will prepare minutes of meetings / teleconferences. The teleconferences will be used to discuss the scope of work for this stage, the approach to take with Network rail and our concluding findings from this stage of the project. If any more meetings or teleconferences are required a CE will be submitted for additional work.

Production of a list of resources available:

B&V will look through the archives of the previous projects and will record all relevant information held and where possible record the accuracy and source of than information.

The projects we will review are:

- Towles Mill
- Short Term Measures 1
- Short Term Measures 2
- Oxford Strategy

We will copy all existing electronic copies of data and reports to a PC hard-drive and allocate to specific folder with assign unique “data” reference; this reference will be included within the spreadsheet of data. We will also record file size. We will group relevant separate files and

reference as one; for example an SI report may contain many individual documents / appendices which we shall reference as one single item.

We have priced to upload all of this information onto an external hard drive in its folder system to match the spreadsheet. If we are required to upload this information to Asite, a CE will be submitted once the volume and size of the data is known. We suspect that given the likely volume of data we hold that uploading files to Asite may be far more expensive than copying to a portable hard-drive however we do recognize the EA's long-term desire for all information to be held on Asite.

Railway crossing

B&V will update the Redbridge conveyance note to the best of our knowledge, however because we are unable to model the flow of water through this area, the note will be based primarily on those findings from the strategy. The high level discharge calculations appended to the Redbridge Conveyance note, to calculate approximate flows through each of the structures, will be updated in-line with the recent culvert survey from Network Rail (EA to provide this information to us). We have assumed that there will not be more than an additional ten culvert calculations to carry out. The constraints plan will not be updated as this is based on the whole environmental report put together at the strategy stage and is unlikely to change with the exception of the Scheduled Monument. This environmental work will need to be re-done at the next stage of the project.

In order to fully understand the way that the flow of water moves through the Redbridge area, modelling needs to be carried out using the latest model. If B&V are required to do this work, this will be a CE for additional work.

Output Hydrographs

B&V are in a position to produce the output hydrographs for the options with the Western Conveyance channel installed and for two, high order events for the existing scenario. The other events were not modelled by B&V however the output hydrographs should already be held by the EA. In order to produce a comparison note between the two to determine likely downstream effects, we will need to await issue of the remaining hydrograph information by the EA.

Run FDEM with the latest MCM guidance

For the Existing and with WC conveyance, our FDEM model will be re-run (to include the latest updates to the Multi-coloured Manual (MCM) that we previously could not due to time constraints) with a minimum of four events, but usually five, in each epoch to assess AAD and PV benefits of the WC scheme. The events chosen will allow the number of properties in very significant, significant and moderate risk bands to be estimated at present and in the 2050s. We will not be undertaking any additional hydraulic modelling for this so will use the model runs we currently hold.

Information held in the National Receptor Database (NRD) is known to have data anomalies. We therefore recommended that two days will be spent by the GIS team on carrying out checks to ensure that the damage estimates are as accurate as possible.

As a result of the MCM update the economics for the property damages will need to be updated. The time allowed will enable us to update the previous calculations. If any additional calculation work is required, this will be a CE.

Confirmation of Preferred Option

Two people will attend a meeting in Wallingford in order to discuss the StAR options and the best way to do a thorough check to ensure that we are still looking at the preferred option.

This can be done through using a pro-rata method to update the damages for the other options looked at in the StAR; a couple of sensitivities will be tested in order to determine the accuracy of the results. If the likely outcome of the preferred option shows option 6 then no further testing

will take place. If the preferred option is not the western conveyance medium channel, partnership funding calculations will be done to determine the funding contribution that can be given by central government and hence the funding contribution that will have to be given by Oxford.

In order to calculate the partnership funding contributions, three model and FDEM runs will be required to input numbers into the OM2 table in the PF calculator. Any more modelling than this has not been priced for and will be a CE. The partnership funding calculations will only be undertaken one time.

Update Report

The Oxford Initial Assessment Economic Appraisal Report has a number of outstanding comments and queries. The time allowed will give opportunity to address each of those comments, update the economics with the updated calculations and to check that the conclusions are still accurate. Once these have all been addressed, the report will be issued as final, we have not allowed for any further updates beyond this point. If there are further queries / comments, this will be a CE.

Additional Items

Advise the EA of the best way to reappraise the other options from the StAR to check that this is still the preferred option. The time estimated here is purely for an advisory cost and does not allow anything for carrying out calculations or in any way updating the options. Any additional time will be a CE.

Assist the EA in developing the scope for the detailed appraisal – We have allowed one day of project manager time plus another half day of senior advisor time; any time in excess of this will be a CE. We would undertake this work on the basis that this would not create a conflict of interest that would prohibit GBV from tendering for any future work on the project that was tendered through Lot 4.

One day has been allowed to assist Turner and Townsend with anything they need clarification on. Any more time than this required will be a CE.

Again, one day has been allowed to assist with the production of the form A. Any more than this will result in a CE.

Programme

The programme will be updated and agreed once the Scope of work has been confirmed. B&V do recognise the importance of getting the above information pulled together as quickly and cost effectively as possible.

CE13 Methodology (Version 03, Dated 2 July 2014)

We have come up against a couple of issues when comparing the output hydrographs for the existing and the Western Conveyance Options. These issues are:

1. We are getting different model results between the existing and Western Conveyance options; the most likely cause is that B&V and Motts are using different ISIS model versions (Motts using ISIS 3.5 and B&V using ISIS 3.6). The implication of this for the overall project is that we are not comparing like for like when comparing the existing situation with the proposed options in the economic analysis and hence the benefit-cost ratios, partnership funding scores, etc would not be robust.

   This has come to light when comparing flows and water levels associated with the existing and WC output hydrographs. As a result of these differences we did some investigative work and have modelled the 1 in 100 event for the existing scenario in version 3.6. In theory, these results should be the same as the results Motts produced, however we are finding a difference of 5 m^3/s at the peak flow – this is substantially more than would or should be expected and supports our conclusion that the most likely cause is the model versions.

   Unfortunately at the time of modelling the WC channel we had not received the model report so did not realise the difference in model versions used to run to model.

2. The second issue is linked to the downstream boundary condition of the model. We are finding that the model internally set up a different downstream boundary condition for the WC option than it used for the existing situation. This is an unintended consequence of Motts using a 'NC boundary' that was unable to perform in the correct way once the WC channel was inserted into the model. This differing boundary condition is resulting in a difference in water levels of around 300mm in the model at the downstream boundary which is clearly incorrect and is likely to have a significant effect on the economic assessment of the Western Conveyance.

These issues were discussed with you as our Client on Monday 16th and Wednesday 18th June and the first draft of this CE13 was issued to you for your comment and review. At that time with the information available at the time, we considered that a full re-calibration exercise was needed.

Following these meetings, we carried on investigations of the modelling differences and means of resolving them in the most efficient manner; this highlighted that:

- The model differences related to software version differences were more accurately quantified at only 2cm on average. This is well within the existing calibration uncertainties (see Mott MacDonald January 2014 report) and therefore re-calibration is not needed. The differences in model results resulting from the different ISIS versions are not significant in themselves but this assessment confirmed that it is essential that all economic comparisons are done using the same model version to avoid skewing the economic assessment by incorporating model version differences with them. For

instance, a 5cm difference in depth at a residential property can result in a £5,000 or so difference in damage (MCM 2014)

- To produce a robust economic assessment at this stage and accurately reflect the downstream impact, it is strongly recommended that both existing and proposed options are run using the same model software versions. This is particularly important as differences in flow ($5m^3/s$) between the two versions are noted and a comparison between models using different software versions would exaggerate the increase in flow downstream.

- The issue with the downstream boundary (i.e. the ISIS NCBDY unit) was investigated and a solution identified that built on the previous B&V and MM modelling.

Further to the above points, the Environment Agency and Black & Veatch on Thursday 26th and Friday 27th June discussed a reduction in the scope of modelling to remove the need for re-calibration; from these discussions, it is clear that the wider Environment Agency team needed to understand the implication of software versions on the calibration reported by Mott MacDonald.

Reflecting on these discussions, we understand that the Environment Agency has three potential objectives for the Oxford re-modelling:

1 To provide the information needed to reassess the economics of the Western Conveyance and OFA schemes – to help at the meeting on 17th July and subsequently.

2 To revise the flood mapping model to make it compatible with the latest modelling software.

3 To improve the representation of the channels within Oxford to make it suitable for assessment of development proposals that affect conveyance through the Abingdon Road causeway or the Network Rail embankment.

There are a variety of ways of meeting these objectives. We have identified five approaches to partially or fully meeting these objectives, set out below:

Approach	Description	Acceptable to EA
1	As scope of 26/6/14. Meets objective 1 but does not meet 2 or 3	✘
2a	In addition to 1, rerun the calibration using ISIS 3.7 and recomputed Tables 6.1 to 6.5 of MM report. This meets objectives 1 & 2, but economic (E) model and flood mapping (FM) model may not be the same, and no new flood mapping results provided.	✘
2b	As 2a but in addition rerun existing condition runs to give new FM results. Meets objectives 1 & 2, but FM & E models are different. Also enables a check if there are any significant differences between ISIS 3.6 and 3.7 and between E and FM model.	✘
3	Rerun calibration using ISIS 3.7 and then rerun all runs for FM and E model using ISIS 3.7. This ensures there will be no differences between E and FM models. This fully meets objectives 1 & 2 but does	✓

Approach	Description	Acceptable to EA
	not address objective 3.	
4	Redo the calibration, improving the representation of the Abingdon Road and rail embankments to provide a model that is suitable for PAR modelling of the WC and also for modelling Network Rail proposals. Then re-run all the economic runs. This meets Objectives 1, 2 and 3.	✘

These potential approaches were discussed between the Environment Agency and Black & Veatch on Monday 30th June and the Environment Agency requested that we prepare our proposal using Approach 3 together with where possible improving the information available for the meeting on the 17th July.

This has led us to propose the following tasks to achieve Approach 3:

1. Gain understanding of model differences and causes
2. Prepare preliminary economic results using FDEM prior to meeting on 17th July using ISIS 3.6 for all hydraulic model results with corrected downstream boundary conditions
3. Set up ISIS version 3.7 and link to Tuflow
4. Receive calibration model details from Environment Agency and re-run six calibration runs using ISIS 3.7 software
5. Re run eight Existing conditions modelling using ISIS 3.7 and process results.
6. Re run seven WC (medium) modelling using ISIS 3.7 and process results
7. Re-run six OFA Options 1, 4 & 10 modelling using ISIS 3.7 and process results
8. Model WC Small Option (model set up, six runs with ISIS 3.7 and process results)
9. Model WC Large Option (model set up, six runs with ISIS 3.7 and process results)
10. Produce flow hydrographs at downstream end of the model for WC medium and Existing conditions for 1 in 5, 1 in 20, 1 in 75, and 1 in 100 conditions in 2014 and 1 in 200 conditions in 2080
11. Revise sections 6.1and 6.2 of Mott MacDonald Modelling report to report calibration results using ISIS 3.7.
12. Produce short modelling report & QA modelling
13. Update economics report

Items 2 and 5 to 9 also include running the model outputs through FDEM to produce flood damages to feed into the economic assessment. Items 8 and 9 have been included as requested by Environment Agency's Project Executive.

Please note that this proposal does not include for preparing revised mapping of flood extents using existing conditions in accordance with flood mapping protocols. All the runs will be

completed and provided to the Environment Agency. If mapping is required we recommend this is commissioned through a separate CE.

We will endeavour to provide preliminary results before the meeting with stakeholders on 17th July. If approval is given before midday on Thursday 3rd July, we anticipate that preliminary results will be available prior to the meeting providing we do not experience significant currently unforeseen delays in their preparation. If approval is delayed beyond this time, delivery of results will become progressively more risky and there may be insufficient time to carry out full QA checks. If approval is not given before 7th July, though we will use our best endeavours to provide as much reliable information as possible before the meeting, we will only be able to provide partial results.

The programme proposed is to achieve as quickly as delivery as possible and is based on our current understanding that the re-calibration will not be a major exercise but more a demonstration that the existing calibration is acceptable (with or without minor amendments).

We attach below a list of information that we require from the Environment Agency to allow us to re-run the model calibration using ISIS 3.7 and report the results.

ISIS data:

- ISIS run file (*.ief) for 6 calibration events
- ISIS boundary file (*.IED) for 6 calibration events

TUFLOW data:

- TUFLOW control file (*.tcf) for 6 calibration events
- TUFLOW geometry file (*.tgc) for 6 calibration events
- TUFLOW boundary file (*.tbc) for 6 calibration events
- GIS layers:

  2d_zsh_rivers_pre2008_Oxford_20121129_GM01.mif

  2d_lfcsh_culverts_pre2008_Oxford_20130130_GM01.mif

  2d_zsh_defences_Oxford_20140115_GM01.mif

July 2007 and January 2008 level hydrographs at:

- Kings Lock
- Godstow Lock
- Osney Lock
- Iffley Lock
- Sandford HWL
- Sandford TWL

In our programme, we have assumed that you can provide this data within 8 days.

Appendix B – Key Assumptions

(a) The hydrology developed to accompany the model is correct;

(b) The cost estimate done by Turner & Townsend is correct;

(c) The model has been calibrated using the correct method (same method was repeated to recalibrate the model), flood levels in the flood plain were not used for this;

(d) The Model shows the appropriate level of detail for this stage of the project;

(e) The scheme costs are based on 2018 prices, inflated using CPI;

(f) The damage costs are based on 2016 prices, inflated at 2% p.a. for the next 2 years in line with Bank of England recommendations;

(g) Year 0 in the economic appraisal is assumed to be 2016;

(h) It is assumed that the design life of the scheme is 100 years;

(i) Design and construction of the WC channel is likely to take 5 years from 2016 to 2020;

(j) Design and construction of the Interim Measures option is likely to take 2 years from 2019 to 2020;

(k) Benefit assessment will assume climate change accords with current guidance.