Bradford Initial assessment report
Baildon Bridge
November 2016

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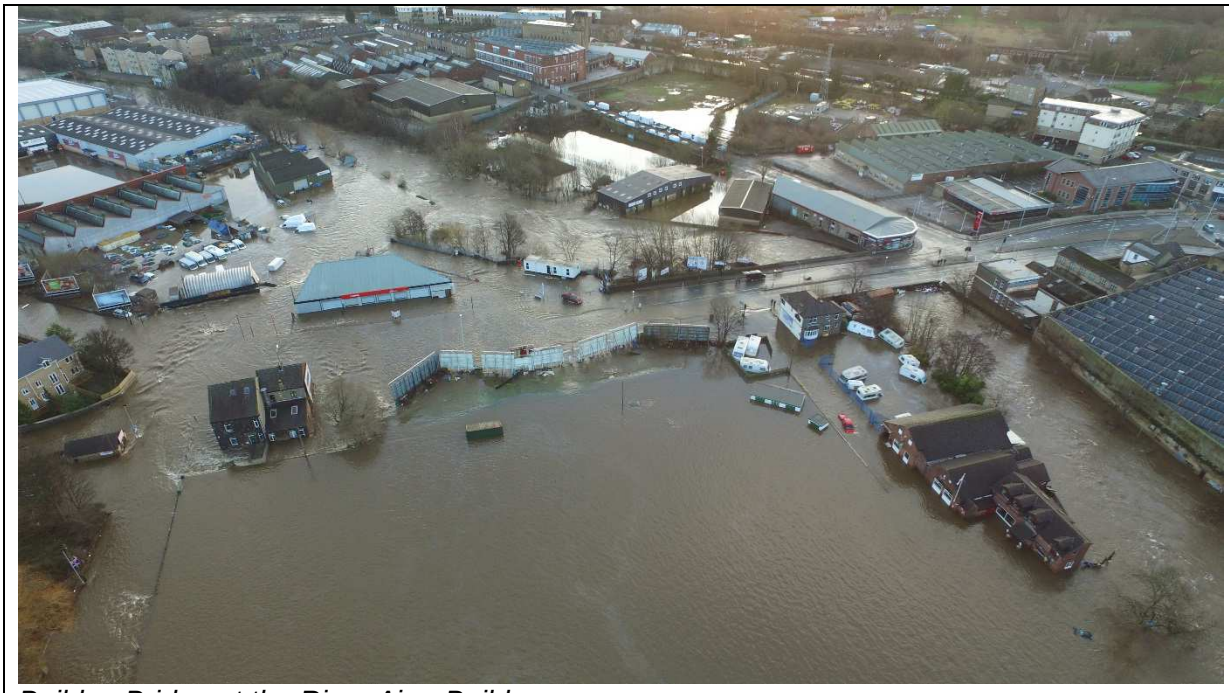
1 Initial Assessment Report

Scheme or project location name	Yorkshire Area Initial Assessment: Baildon Bridge



Baildon Bridge at the River Aire, Baildon

Date	November 2016
Version	1

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Contact Details

Role	Name	Post Title
Project Sponsor		
Senior User		
Senior Supplier		
Project Executive		
Project Manager		

Sign Off

Form completed by:	Name:	Title: Project Manager	Signature:	Date:
Project Executive Approval:	Name:	Title: Project Team Leader	Signature:	Date:
Senior User Approval:	Name:	Title:	Signature:	Date:
Project Sponsor Approval:				

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APPENDICES

1.1 Introduction and background

1.1.1 Background

In May 2016, CH2M were commissioned by the Environment Agency (EA), on behalf of Bradford Metropolitan District Council (BMDC), to undertake a package of initial assessments in the Yorkshire area. This report focuses on an initial assessment for Baildon Bridge, in West Yorkshire, which provides guidance on measures to reduce flood risk and identifies potential funding availability. A site visit for this Initial Assessment was undertaken on 18th of July 2016. This report is based on information from the site visit, previous studies and reports that are relevant to this Initial Assessment.

1.1.2 Description of Location

Baildon is a town located 5km to the north-east of Bradford. It is part of the Metropolitan District of the City of Bradford. The Leeds and Liverpool Canal and the River Aire run through the town. The area is within the River Aire Middle Catchment Flood Warning Area.

The Baildon/Shipley area is comprised of five individual benefit areas; Aire Close, Baildon Bridge, Glenaire Court, Lower Holme and Masons Mill.

Baildon Bridge cell is located on the right bank of the River Aire, starting from Ives Street at the upstream end to the Funopolis Play Centre on Dockfield Road. A location plan of the site is shown in Appendix H.

Upstream of Baildon Bridge, the study area is amongst the 20% most deprived areas within the country. The study area which extends downstream of Baildon Bridge is within the 10% most deprived areas within the country.

1.1.3 Description of Watercourses and Geology

There are two watercourses in the study; the River Aire flowing west to east and Bradford Beck flowing south to north.

The River Aire is a major watercourse in Yorkshire flowing from Malham in the Yorkshire Dales, through the urban areas of Bradford and Leeds, before joining the River Ouse at Airmyn. The Aire is approximately 114km in length from its source to its confluence.

The River Aire around Shipley and Baildon is heavily urbanised and the floodplain is constrained by development. There is also a large number of structures such as bridges and weirs in this area.

A small watercourse, Bradford Beck, flowing south to north, joins the River Aire downstream of Baildon Weir which is downstream of Baildon Bridge. The beck is culverted beneath the Leeds and Liverpool Canal discharging into the River Aire as an open channel.

The underlying bedrock of the Baildon area is Millstone Grit, overlain by lover coal measures. Ground conditions can be described as slowly permeable, seasonally wet, acid, loamy and clayey soils.

1.1.4 History of Flooding

The properties in Baildon have been flooded several times in the past. During the December 2015 event flooding occurred likely due high river levels in the River Aire overtopped the river banks and flood defences.

Six historic flood events in Shipley have been identified from previous reports and studies – in 1909, 1967, 1980, 2000 and 2008. Shipley is on the south side of the River Aire whilst Baildon

is on the north, opposite bank, Baildon and, it is therefore assumed that both locations were affected at the same time.

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1.1.5 Summary of modelling analysis

In 2008 hydraulic and hydrological modelling of the Upper River Aire was completed by JBA to support the development of the Flood Risk Management Strategy. For this study the River Aire was modelled from High Hill Weir upstream of Gargrave to Fleet Weir downstream of Leeds. The Upper River Aire model is a 1D hydrodynamic ISIS model containing 1922 nodes.

This 2008 study aimed to define flood risk within this area and identify potential flood risk management options. This informed the Flood Risk Management Strategy for the Upper Aire which proposed flood risk management options for the short, medium and long-term. These recommendations included progressing a flood management scheme for defences at Baildon.

Following the December 2015 flood event the detailed modelling is being undertaken by the EA National Flood Modelling Team and it is still subject to confirmation. For the purpose of the Initial Assessment report, initial review of modelled options shown below, have been provided:

- Three Weir Study – Re-run the Aire Model using the estimate December 2015 flows to investigate the removal of three weirs around Shipley and Baildon.
- Baildon Bridge Blockage Analysis – Re-run the Aire Model using the estimated December 2015 flow to complete blockage analysis on Baildon Bridge.
- Wall Scenario Downstream of Baildon Weir – Following the December 2015 event a riparian owner has raised the height of a flood wall on the right bank. Various modelling runs have been carried out to determine the impact of the raise wall on flood risk to the left bank.

1.1.6 Drivers, Constraints and Opportunities

The Aire River falls under the Aire Catchment Flood Management Plan (CFMP) and is covered by sub-area 3 – Worth and Aire. The CFMP can be found here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/289346/River_Aire_Catchment_Flood_Management_Plan.pdf. The designated policy for the area at risk is 'Policy Option 5: Areas of moderate to high flood risk where we can generally take further action to reduce flood risk.

The following drivers, constraints and opportunities have been identified within the study area.

Political Drivers	**Summary Description**
Catchment Flood Management Plan	River Aire Catchment Flood Management Plan
Catchment Flood Management Policy	5 - areas of moderate to high flood risk where we can generally take further action to reduce flood risk
Economic Drivers	**Summary Description**
Funding Time Constraints	Must be obtained within 6 year programme of capital investment
Social Constraints	**Summary Description**
Existing Public Space	Residential and commercial space in the town
Environmental Constraints	**Summary Description**
World Heritage Site	There is Saltaire World Heritage Site about 600 metres to the west. Area in buffer zone
Site of Special Scientific Interest (SSSI)	Trench Meadows (SSSI) are located about 1600 metres to the north west

Ancient Woodland	There is an Ancient Replanted Woodland - Fairbank Wood 200 metres to the north west; Ancient Woodlands - Midgeley Wood and Walker Wood are located about 900 metres to the north west; another ancient woodland - Old Spring Wood located 1.1 kilometres to the south west
Contaminated Land	Historical landfills (Wrose Brow Road Tip and Caststones Quarry) about 1000 metres to the south-east from the site; Another historical landfill (Feriehurst Quarry) 500 metres to the north-east.
Tree Preservation Orders	According to the Bradford Council website none of the trees are protected in this specific area however it is recommended to check that area for TPOs on later stage if necessary.
Ground Conditions	Slowly permeable seasonally wet acid loamy and clayey soils
Scheduled Monument	Scheduled monument 0.5 kilometres to the south; another one 0.8 kilometres to the north
Listed Buildings/Structures	Only one Grade II listed building (Canal Warehouse on Wharf Street) exists within 200m of the benefits area boundary. It is unlikely any of the options will have an impact on this building.
Historical Park & Gardens	Roberts Park 0.9 kilometres to the north west.
WFD Body	River Aire (River Worth to Gill Beck)
WFD Status	Moderate

Refer to Appendix F for the full list of constraints that were considered.

1.2 Problem and objectives

1.2.1 Problem

Based on the evidence provided and local anecdotal knowledge, it is very likely that the flooding during the December 2015 event was predominantly from fluvial sources. There are 15 properties at fluvial risk within the study area.

The current standard of protection for the study area is unknown at the time this report is written however investigations are ongoing and should be used in any future studies.

During the December 2015 flood event, the River Aire overtopped due to high water levels caused by prolonged, heavy rainfall. In additional to the high flows two containers were swept into the river and became stuck under Baildon Bridge constricting the flow in that section.

Based on all the available information, EA had estimated that the December flood event has 1.3% – 1% annual exceedance probability (AEP). It means, that an event has between 1 in 80 and 1 in 100 chance of occurring in any single year.

This report will identify potential solutions to the flooding and determine if there is scope to determine the best cost/benefit solution to manage this flood risk.

1.2.2 Objectives

The primary objective of this initial assessment is to undertake a scope in the area to identify the flood risk issues and viable solutions for the affected properties and to identify any other potential flood risk management measures which are consistent with the current CFMP policy.

The purpose of this report is to lay the groundwork and, where applicable, provide a business case for future more detailed appraisal. The report aims to achieve the following:

- Confirm the need for a project;

- Identify the issues and Political, Environmental, Societal, Technological, Legislative and Economic (PESTLE) drivers and opportunities related to the need;
- Identify the options to address the need and problem;
- Demonstrate that viable options exist based upon the available information;
- Provide sufficient information to allow the packaging and optimisation of packages of future appraisal, design and construction packages;
- Provide sufficient information for the appraisal scope to be prepared;
- Make an assessment on the deliverability of the project;
- Provide a basis/starting point for discussion with communities and partner organisations for use in the development of potential schemes and negotiations regarding funding contributions.

1.3 Benefits

In this area the primary benefit associated with a reduction in flood risk would be the reduction in economic damages to properties. This would result in the reduction of disruption to local transport, businesses and other infrastructure.

Social benefits relate primarily to a reduction in stress, health effects (including risk to life) and loss of memorabilia for those at risk.

An appraisal period of 100 years is assumed, over which the current Standard of Protection of existing assets is expected to decrease as a result of climate change.

Table 1.1 shows the properties at risk within the study area.

Table 1.1 Number of Properties at Risk (based on current outlines)

Property Type	Flood Risk	Number of Properties
Residential	≥1 in 20 year (5% AEP) (Very Significant Risk)	0
	<1 in 20 year (5% AEP) ≥1 in 75 year (1.33% AEP) (Significant Risk)	0
	<1 in 75 year (1.33% AEP) ≥1 in 200 year (0.5% AEP) (Moderate Risk)	0
Non-Residential	≥1 in 20 year (5% AEP) (Very Significant Risk)	0
	<1 in 20 year (5% AEP) ≥1 in 75 year (1.33% AEP) (Significant Risk)	9
	<1 in 75 year (1.33% AEP) ≥1 in 200 year (0.5% AEP) (Moderate Risk)	5

Detail of the methodology used for assessing the benefits of each option is detailed in Appendix C.

1.4 Options

A longlist of options has been compiled. The table below shows the large range of long list options considered and the reasoning for or against them being taken forward to the short list of options for assessment.

Category	Long List Option	Water Course / Areas Affected	Description	Take Forward for assessment?	Reasoning / Notes / Past Study Reference
Do nothing	Do nothing		All operational and maintenance activities cease	Yes	Required to support development of business case and benefit cost ratios.
Do minimum	Do Minimum		Continue with current operational and maintenance activities.	Yes	Required to support development of business case and incremental b/c ratio.
Non-structural (by EA)	Improved flood warning		Enhanced flood warning to allow residents to prepare plus appropriate implementation of flood action plans	No	A flood warning system is already in place for Baildon. Not funded via the capital programme
Non-structural (by EA)	Flood action plans		Improved direction of reactionary flood defence measure (fire crews, temporary pumps, etc.)	No	Recommended as best practice, and a plan must be in place to respond to a breach in defences. Not taken forward for assessment as not part of capital programme of works.
Property level protection	Property level protection		Protection to individual properties (e.g. via air brick covers, door guards etc.).	Yes	Passive solutions to be considered as an option (flood doors, automatic airbricks, pumps, external sealant)
Operational (by Others)	Improve operation/design		Remove or lower Baildon weir.	Yes	Baildon weir is located downstream of the site. Lowering or removing the weir will lower the water levels adjacent to the site.
Urban drainage	Improve urban drainage.		Improve surface water drainage system.	No	Flooding only due to overtopping of defences. This would not have an impact on risk.

Category	Long List Option	Water Course / Areas Affected	Description	Take Forward for assessment?	Reasoning / Notes / Past Study Reference
Sewer system	Improve sewer system		Improve sewer system	Yes	There is a YW sewer under footpath on right bank, upstream of Baildon Bridge, showed that some of the manhole covers were open. This would allow flood water from the Aire to enter and take up its capacity. So replacing these with a solid cover would allow the sewer to function without contribution from flood waters in the Aire (it is assumed that the outfall in the Aire is flapped)
Structural	Linear Defences		Repair and strengthen existing flood defences.	Yes	The existing defences along the river bank were overtopped. Repair and raise existing flood defences to increase standard of protection.
Structural	Linear Defences		Replace the existing defences flood.	Yes	The existing defence may not be able to be increased in height, in this situation the entire defence will need to be replaced.
Structural	Conveyance		Channel deepening or widening	Yes	Shoal clearance should be made but it should be considered as an additional option rather that a main option.
Structural	Conveyance		Supplementary bypass channel(s, tunnels or floodway	No	The site in an urban location, there is insufficient space for a bypass due to consistent development within that area
Structural	Conveyance		Maintain bridge openings and clear them before high order events.	Yes	Baildon Bridge is a potential pinch point. Clearing the bridge prior to high order events will reduce the risk of blockages.

Category	Long List Option	Water Course / Areas Affected	Description	Take Forward for assessment?	Reasoning / Notes / Past Study Reference
Structural	Conveyance		Raise deck level of Baildon Bridge.	Yes	Baildon Bridge is a potential pinch point. Raising the bridge deck will increase the conveyance and reduce water levels adjacent to the site. Increasing the deck level will also reduce the risk of blockages.
Flood storage area	Online		Use of active structures and re-profiling to store water online. (River Worth).	Yes	Online flood storage area North of Haworth. The Upper Aire SFRA identified two potential storage areas on the River Worth upstream of Keighley. Use of these sites would reduce peak flows in Keighley increasing the standard of protection provided by the Worth scheme.
Flood storage area	Online		Use of active structures and re-profiling to store water online. (River Aire).	Yes	As part of the Leeds FAS Phase 2 study upstream storage is being considered. The storage being proposed can potentially deliver further benefits to Bradford
Flood storage area	Offline		Gravity or pumping to offline storage area	No	Not considered as an option. No suitable areas identified.
Floodplain storage	Washlands-type scheme		Enhance/increase natural floodplain attenuation with cascade of passive storage areas in existing floodplain	Yes	The area upstream Shipley and the cricket ground are possible to be considered as a flood storages.

1.4.1 Shortlisted options description

Do Nothing

The Do Nothing option is defined as taking no action whatsoever; under this option all management activities would cease, including maintenance and repair work to existing assets.

Under this assumption, the natural deterioration of the river channel will occur, leading to an increase in flood risk.

There could be some advantages of this option in the form of habitat creation due to wetting of dry areas and naturalisation of channel, however, this is also likely increase the risk to people and wildlife.

The Do Nothing option is not to be taken forward as a viable option as it results in an unacceptable increase in flood risk to people and property due to failure and deterioration of assets and blockages to the channel, however it is required to be assessed in order to develop the business case.

Do Minimum

The Do Minimum option is defined as the minimum level of action or intervention necessary to maintain defence at their current level presently offered throughout the study area. Under the Do Minimum scenario the existing defences are maintain until the end of their design life but are not replaced.

The advantage of Do Minimum is that it sustains current standard of service within the study area and minimises initial capital outlay.

Option 1 – Property Level Protection

This option considers providing Property Level Protection (PLP) measures for the properties that were affected by the December 2015 flood event. PLP can take the form of barriers in doorways, non-return valves fitted to drains, and airbrick/vent covers. Properties can also be made more flood resilient, using waterproof plaster, solid concrete floors or tiled floor coverings in order to reduce the amount of time and money needed to recover from a flood event. PLP is generally used as an option for properties that experience less than 500mm of flooding.

The EA have requested the use of passive measures to maximise the effectiveness of the protection, ensuring the measures are installed at times of flooding.

Property level protection prevents water entering the property but water will still be retained by the building structure. Furthermore, PLP does not provide any wider environmental benefits and does not prevent the flooding of areas surrounding the property.

There are currently no properties in the very significant flood risk category, therefore this option will not be eligible for FDGiA funding.

This option is repeated for the other sites in Baildon, however the costings are based on the number of properties at risk in each individual benefit area. Therefore the costs will be different for each benefit area.

Option 2 – Removal Baildon Weir

Baildon Weir is located downstream of Baildon Bridge and is owned by a 3rd party. This option involves removing the weir to lower the upstream water level. It is recommended that further

detailed hydraulic modelling of this option is undertaken to confirm the changes in water levels as the bridge upstream and confluence with the Bradford Beck downstream makes the hydraulics complex.

The EA have already completed modelling for the 3 Weirs Project. The modelling involved running the estimated December 2015 flows with the removal of three weirs in the River Aire; Hirst Weir, Saltmill Weir and Baildon Weir. The results show that the removal of Baildon Weir has a small impact on water levels around Baildon. However the modelling completed to date only considers one flood event and the removal of the weir could be more beneficial at lower order events.

This option is repeated for the other sites in Baildon, the costing for the option will be the same for all the benefit areas.

Option 3 – Repair Linear Defence

The Baildon Bridge cell is already protected by flood defences. The existing flood defence runs along the river frontage. Directly downstream of Baildon Bridge, the landowner has raised the level of the flood wall. No construction details have been provided for the wall therefore it cannot be determined if the wall is suitable for a flood defence.

This option looks at repairing and maintaining the existing defences upstream of Baildon Bridge throughout the 100 year appraisal period. As it cannot be determined if the 3rd party walls are built to acceptable standards they have been excluded from this option.

This option is repeated for the other sites in Baildon, however the costings are based on the length of river frontage along individual benefit areas. Therefore the costs will be different for each benefit area.

Option 4 – Improve Linear Defence

The Baildon Bridge cell is already benefitting from flood defences. This option proposes providing a uniform standard of protection of 1% (1 in 100 year) AEP and maintain the standard over the 100 year appraisal period. This option includes extending the existing flood wall along the left bank of the Bradford Beck and tying into high ground to prevent the defences being outflanked.

As mentioned in option 3, a 3rd party has already raised the flood wall. As the construction detail of the wall is unknown it has been assumed that a new wall will be required.

Raised defences at Baildon were proposed as part of the long-term plan for the Upper Aire Flood Risk Management Strategy (2009).

Limited water level data was available for this assessment, therefore a nominal defence height of 1m was assumed for this option, further analysis will be required to refine the defence height if the option is carried forward.

This option is repeated for the other sites in Baildon, however the costings are based on the length of river frontage along individual benefit areas. Therefore the costs will be different for each benefit area.

Option 5 – Raise Baildon Bridge

During the December 2015 flood event, Baildon Bridge became blocked by debris, reducing flows under the bridge and increasing upstream water levels. The bridge was also blocked by two shipping containers, constricting the flow in that section.

This option proposes to raise the height of the bridge deck by 1m to increase the conveyance under the bridge and reduce the chance of blockages.

This option requires hydraulic modelling to confirm its viability and effectiveness, passing more water beneath the bridge is likely to reduce upstream flood risk but could also increase flood risk downstream. The standard of protection provided by this scheme is uncertain until further modelling is carried out.

Blockage scenario modelling has been completed by the EA following the December 2015 flooding. The modelling estimated the flows experienced during the December 2015, and tested it against various blockage scenarios. The model results suggested an increase in upstream water levels of circa 200mm for a 75% blockage, however this is only for a single return period.

This option is repeated for the other sites in Baildon, the costing for the option will be the same for all the benefit areas.

Option 6 – Clear debris from Baildon Bridge

The blockage analysis report at Baildon Bridge recommended to monitoring of the bridge and channel be undertaken when there are high flows in the River Aire. This option is proposed to meet that recommendation. The proposal is to carry out localised channel clearance directly upstream of the bridge to maximise the existing conveyance at the location.

This option requires hydraulic modelling to confirm its viability and effectiveness. The standard of protection provided by this scheme is uncertain until further modelling is carried out.

This option is repeated for the other sites in Baildon, the costing for the option will be the same for all the benefit areas.

Option 7 – Flood storage areas (River Worth)

The 2014 Upper Aire SFRA identified a site near Lord Lane north of Haworth that could potentially be used as a flood storage area. This option provides a reduction in flood risk from the River Aire further downstream. The SFRA estimated that the use of this area could potentially result in a 7% reduction in peak Aire flow and a 50mm reduction in flood depths in Leeds.

The impact of the storage area on Baildon will be a reduction in flood risk, however the magnitude of the impact is uncertain. This option can be used in conjunction with other options, for example repairing the flood defences.

The scheme will also provide a reduction in flood risk beyond the study area. As a result the benefit-cost ratio for the option will be artificially low, being limited to the Baildon benefits. Therefore the economic analysis for this option is not presented in this report but the option should be considered in any future studies.

Option 8 – Flood storage areas (River Aire)

The Leeds FAS Phase 2 scheme has identified three locations that could be potentially used as flood storage areas; Keighley Holden Park, Marley Bridge and Rodley. The Rodley site is downstream of our study area but the other two sites could potentially provide benefits for Baildon. The Upper Aire FRMS has estimated a reduction of 300mm to 400mm for a 1% (1 in 100 year) AEP event at Leeds Station. The impact at Baildon, however, is uncertain but it is expected to be significant on peak water levels.

The scheme will also provide a reduction in flood risk beyond the study. As a result the benefit-cost ratio for the option will be artificially low, being limited to the Baildon Bridge benefits. Therefore the economic analysis for this option is not presented in this report but the option should be considered in any future studies.

Option 9 – Floodplain storage

This option considers maximising the potential floodplain storage. There is currently one designated washland site identified by the EA; the sports ground and adjacent area on the left bank of the River Aire, opposite Masons Mill, upstream of Baildon Bridge

The proposal is to lower the existing ground level of these washland areas to allow the areas to fill earlier and store a larger quantity of floodwater, therefore reducing water levels. The option is to reduce the existing levels of the site by 1m and create circa 38,200m3 of additional storage.

This option requires testing in the hydraulic model to confirm its viability and effectiveness. The option is technically feasible, however there are risks associated with gaining land owner consent. The standard of protection provided by this scheme is highly uncertain until further modelling is carried out.

This option is repeated for the other sites in Baildon, the costing for the option will be the same for all the benefit areas.

1.4.2 Costs of options

The costs for the options were calculated using the Environment Agency's Project Cost Tool and Long Term Costing Workbook. The maintenance and operation costs relate to mechanical maintenance of the assets to Target Condition 3.

It is assumed that a major replacement of assets will be required at some point during the appraisal period after the initial construction phase. The timing of these replacements is based on the EA's Asset Deterioration Guidance (2013), and the assumptions are outlined in Appendix B.

An appraisal period of 100 years has been used. A detailed breakdown of costs across this period is included in Appendix B.

Table 1.2 shows the build-up of costs for all options.

Table 1.2 Project costs (£k)

Item	Do Minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 9
Construction Costs		59	2,456	1,268	190	958	113	1,551
Environment Agency staff		9	182	94	30	151	18	115
Consultant fees (appraisal)		4	128	66	12	61	7	81
Consultant fees (design)		13	349	180	41	208	24	220
Consultant fees (construction)		3	145	78	11	54	6	92
Site investigation & survey		1	98	51	3	14	2	63
Land purchase		0.1	12	7	0.2	1.0	0.1	8
Optimism Bias (44%)		39	1,482	765	126	634	75	937

Item	Do Minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 9
TOTAL		**129**	**4,851**	**2,505**	**414**	**2,084**	**245**	**3,065**
Annual Operation and Maintenance Costs (including optimism bias)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

1.5 Initial environmental assessment

The main impacts of each option are summarised in Table 1.3:

Table 1.3 Key environmental impacts, mitigation and opportunities

Key positive impacts	Key negative impacts	Mitigation/ enhancement opportunity
Option 1		
Reduced risk of flooding.	Option only protects properties and not surrounding land.	
Option 2		
Reduced risk of flooding. Reduces future maintenance costs for properties at risk	Construction work takes place in a watercourse. Risk of pollution incidents and disruption to area during construction. Construction work takes place in a watercourse. Risk of health hazards - possibility of contaminated water and water borne diseases.	Best practice should be followed including referring to EA Pollution Prevention Guidance. The designer should give consideration to any options which may reduce the effect of the identified hazards.
Option 3		
Reduced risk of flooding. Reduces future maintenance costs for properties at risk	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction.	Best practice should be followed including referring to EA Pollution Prevention Guidance.
Option 4		
Reduced risk of flooding. Reduces future maintenance costs for properties at risk	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction. Visual impact of raising wall	Best practice should be followed including referring to EA Pollution Prevention Guidance.
Option 5		
Reduced risk of flooding. Reduces future maintenance costs for properties at risk	Construction work takes place in a watercourse. Risk of pollution incidents and disruption to area during construction. Construction work takes place in a watercourse. Risk of health hazards - possibility of contaminated water and water borne diseases.	Best practice should be followed including referring to EA Pollution Prevention Guidance. The designer should give consideration to any options which may reduce the effect of the identified hazards.
Option 6		
Reduced risk of flooding. Reduces future maintenance costs for properties at risk	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction.	Best practice should be followed including referring to EA Pollution Prevention Guidance.
Option 7		

Key positive impacts	Key negative impacts	Mitigation/ enhancement opportunity
Reduced risk of flooding.	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction.	Best practice should be followed including referring to EA Pollution Prevention Guidance.
Option 8		
Reduced risk of flooding.	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction.	Best practice should be followed including referring to EA Pollution Prevention Guidance.
Option 9		
Reduced risk of flooding.	Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction.	Best practice should be followed including referring to EA Pollution Prevention Guidance.

1.6 Consultation

The options in this appraisal were developed in consultation with the Environment Agency and Bradford MDC. No public consultations were held at this stage as the work is a high-level assessment of potential options. Stakeholder engagement will take place at subsequent stages of the project.

If this project is taken forward for further appraisal it is recommended that consultation is focused on, but not limited to, the following:

- Residents in the area at risk
- Landowners and developers for the upstream storage options.
- Riparian landowners, especially owners of riverside walls acting as informal defences

1.7 Economic summary and preliminary preferred option

Table 1.4 summarises the economic assessment carried out for all options. The calculations for PV benefits area shown in Appendix D. The options are ordered by benefit (lowest benefit first).

The benefit values are estimates based on the methodology detailed in Appendix C. There is significant uncertainty in these estimates, which are based on Weighted Annual Average Data (WAAD) from the Multi-Coloured Manual (MCM, 2015/16). If this project progresses to further appraisal the benefits of these options should be more accurately assessed though hydraulic modelling and use of the more detailed flood depth / damage data from MCM.

Table 1.4 Benefit-cost assessment

	PV costs (£k)	PV benefits (£k)		Av. BCR	Incr' BCR	Option for iBCR calc	Comments
Do Nothing							
Do Minimum	14	Low Mid High	24 33 41	1.8 2.3 2.9	-		
Option 3	747	Low Mid	226 302	0.3 0.4	0.3 0.4	Do Minimum	

		High 377	0.5	0.5		
Option 6	510	Low 425 Mid 567 High 709	0.8 1.1 1.4	0.8 1.1 1.3	Do Minimum	Positive ABCR
Option 5	2,098	Low 425 Mid 567 High 709	0.2 0.3 0.3	0.1 0.2 0.2	Option 3	
Option 1	273	Low 531 Mid 709 High 886	1.9 2.6 3.2	1.9 2.6 3.2	Do Minimum	Highest ABCR
Option 9	3,079	Low 531 Mid 709 High 886	0.2 0.2 0.3	0.0 0.0 0.0	Option 1	
Option 2	4,857	Low 531 Mid 709 High 886	0.1 0.1 0.2	0.0 0.0 0.0	Option 9	
Option 4	2,497	Low 610 Mid 814 High 1,017	0.2 0.3 0.4	0.0 0.0 0.1	Option 1	

Option 1, Property Level Protection, is the option with the highest ABCR. The option can be carried forward to the next stage however it is not eligible for FDGiA funding. The Flood and Coastal Resilience Partnership Funding (EA) document states that property level protection can be funded under OM2 for residential properties only if they are within the very significant risk category. There are no residential properties in the very significant category in the benefit area therefore the option will need to be wholly funded by another funding stream e.g. local levy funding.

Option 6, Clear debris for Baildon Bridge also has an ABCR above parity but offers a standard of protection less than Option 1. However Option 6 offers community wide protection compared to Option1, which only protects the properties and should be taken forward. The option is based on improved conveyance in the channel. This will have a greater impact on lower order events but will not be as effective on the higher order events. It is assumed that the works will be consider as separate discreet schemes and been classed as Capital Maintenance.

Option 4, improve existing defences, offers the highest standard or protection (1% (1 in 100 year) AEP) and has an ABCR lower than option 1 and 6.

1.7.1 Funding and contributions

Preliminary estimates for Partnership Funding scores for Options 4 and 7 has been calculated as shown in Table 1.5. Due to the FDGiA funding rules option 1 is not eligible for GiA funding so no funding calculation has been undertaken.

Table 1.5 FDGiA Funding Calculator

Contributions to outcome measures	**Option 4**
OM1 – Economic Benefit:	
Benefit period used for Partnership Funding calcs	*100*
PV Benefits (£k)	*813,854*
PV Costs (£k)	*2,483,057*
Benefit/Cost ratio	*0.3*
OM2 – No. of households moved out of any flood probability category to a lower category	0
OM2b – No. of households for which the probability of flooding or coastal erosion is reduced from the very significant or	0

significant category to the moderate or low category	
OM2c – No. of households in the 20% most deprived areas moved from the very significant or significant flood probability category to the moderate or low category	0
Partnership Funding (PF) Score	2%
Contributions required for a PF score of 100%	2,451,701
Contributions required for a PF score of 120%	2,459,247

Other potential funding sources identified include:

- Community Infrastructure Levy
- Benefitting local businesses
- Council Tax
- Local Enterprise Partnerships

1.7.2 Key delivery risks (economic, social and environmental)

Key delivery risk and recommendations for mitigating these risks are shown in the table below.

Table 1.6 Risks and mitigation

Risk	Key Mitigation
Insufficient 3rd party Funding available to allow scheme to progress	Assess potential funding options before progressing scheme appraisal further.
Risk of reducing the aesthetics of buildings (PLP)	When considering resistance measures keep in mind their impact on aesthetics of buildings (PLP)
Risks associated with gaining land owner consent.	Early consultation with landowners should be undertaken.
Inaccurate benefits assessment due to limited understanding of flood risk hence unreliable approach to economic damage calculations used for IA's.	A more accurate damages assessment based on hydraulic modelling and flood depth damage data should be considered before progressing to further appraisal.

1.8 Project Scoring

The data used in this assessment has been subjected to a RAG assessment. RAG status reporting is used to indicate the level of confidence in the data used in each aspect of the assessment, using the traffic light system. This gives a three figure score with the first number

being the number of reds (showed as a letter R)), where there is significant uncertainty or challenges. The second and third numbers are the numbers of amber (A) and greens (G). The results are shown below:

- A – Problem Definition: The fluvial flooding mechanism are well understood but the other sources of flooding are currently unknown – **AMBER**
- B – Economic Case: The benefits assessment has been based on moving properties from flood risk bands and weighted average annual damages – **RED**
- C – Funding: The options are likely to require external funding. Alternative funding sources have been identified – **AMBER**
- D – Engineering case: Solutions taken to outline design and are tried and tested defence options, however may need significant change due to other flooding sources – **RED**
- E – Permissions & Consents: Solution are unlikely to require unusual permissions or consents – **GREEN**
- F – Environmental sensitivities: Initial environmental assessments has been completed based on outline options – **AMBER**
- G – Opportunities: Some potential opportunities for partnership working but minimal environment opportunities – **AMBER**

Model. A	Econ. B	Funding C	Eng. D	Permission E	Env. F	RAG	Opps. G
2	3	2	3	1	2	231	2

1.9 Further work requirements

If the project is taken forward for further appraisal it is recommended that the following work is carried out:

- Investigate the impacts of upstream storage options proposed by the Leeds Phase 2 PAR and Upper Aire SFRA. The findings should be used to review and update the economic assessment.
- Option 2 – Further investigation and hydraulic modelling of the removal of Baildon weir, including lower order return periods. The impacts of the scheme should also be investigated outside of the Aire Close benefit area to identify additional benefits.
- Option 5– Further investigation and hydraulic modelling on blockage analysis at Baildon Bridge, including lower order return periods. The impacts of the scheme should also be investigated outside of the Aire Close benefit area to identify additional benefits.
- Option 9 – upstream storage will have benefits outside of the study area. Hydraulic modelling of this option should be carried out to assess if the changes in downstream water level potentially provide additional benefits.

1.10 Conclusions and Recommendation

The conclusions and recommendations made in this section are based on the limited data available at the time. It is strongly recommended that further investigation into all sources of flooding are undertaken

Based on the evidence provided it is believed main risk of flooding within Shipley/Baildon is fluvial from the overtopping of river banks. The existing fluvial flood risk is moderate to high. There was significant flooding in the area during Boxing Day 2015 from the River Aire.

Option 1, property level protection is the highest scoring Do Something option, however due the funding rules is unable to gain any FDGiA funding. There is uncertainty over the effectiveness of a PLP scheme, further investigation into suitability of the properties to be fitted with property protection measures.

Option 6, clearance of debris from Baildon Bridge is the next highest scoring option, and offers community wide protection, unlike Option1. However this option is unable to gain any FDGiA funding, as it is maintenance of an existing asset. It is recommended that inspections and maintenance programme of Baildon Bridge are reviewed to reflect the importance of the structure.

Option 4, improve existing defences provides the highest standard of protection. The option is eligible for 2% of the costs being funded by FDGiA funding.

It is recommended that the flood storage options are considered further in a wider strategic assessment as they could benefit a large areas on the Upper Aire.

The Baildon/Shipley area is comprised of five individual benefit areas; Aire Close, Baildon Bridge, Glenaire Court, Lower Holme and Masons Mill. It is recognised that there is potential to manage flows upstream and provide further benefits to all areas. Potential storage sites have been identified between Hirst Mill and Baildon Bridge, see figure 2 in Appendix H. It is recommended that further hydraulic modelling be undertaken to investigate the impact of these storage areas on water levels within the Baildon/Shipley area and further downstream.

Based on the limited information we have available, we advise the Do Minimum scenario, to be the most appropriate. However, we recommend further investigation to be undertaken to determine all flood risk sources and how they can be managed.

Appendices