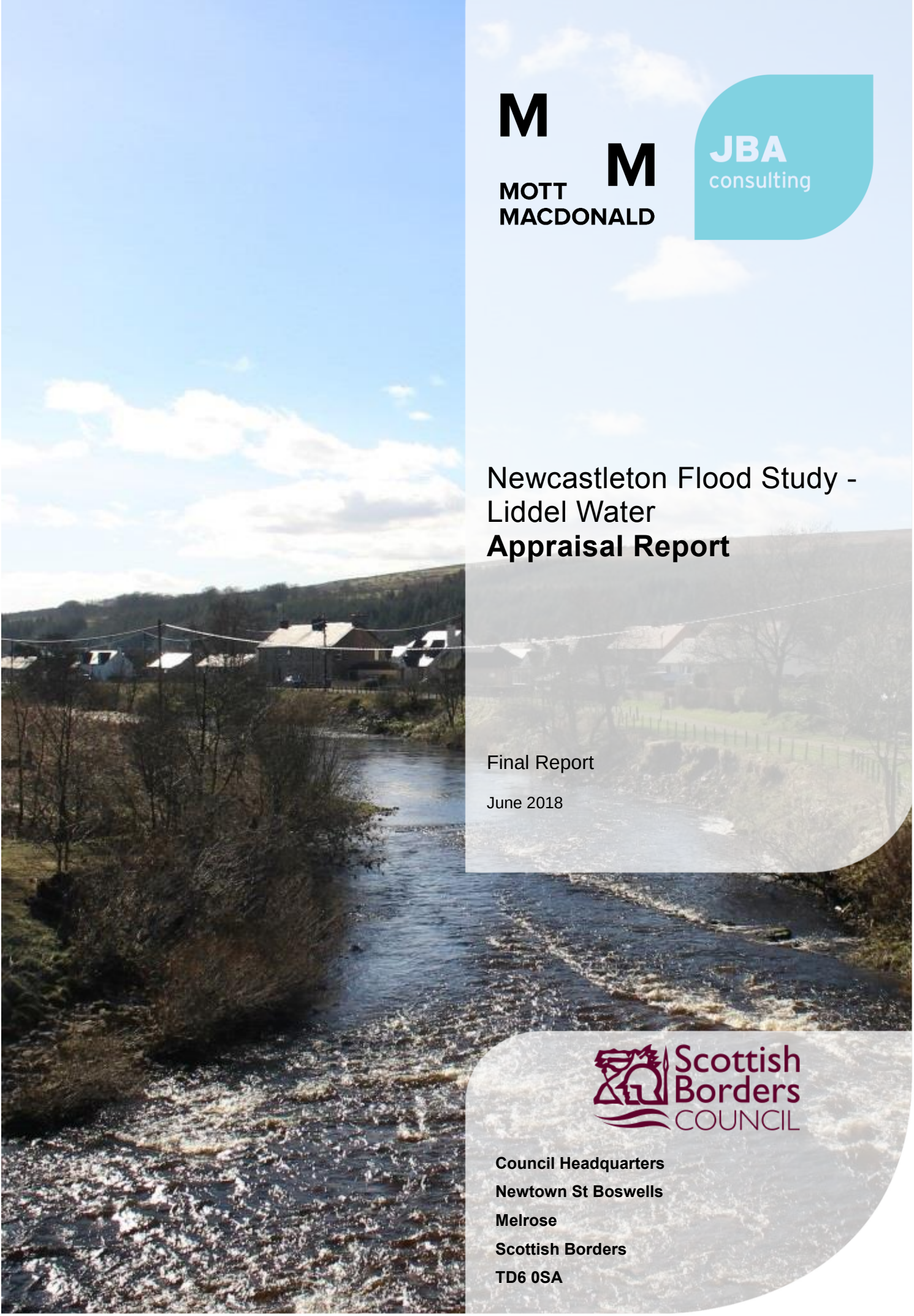

MOTT MACDONALD

JBA consulting

Newcastleton Flood Study - Liddel Water
Appraisal Report

Final Report

June 2018

Scottish Borders COUNCIL

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Revision History

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S0-P01	Minor amendments	
S4-P01 / June 2018	-	Scottish Borders Council
S4-P02 / January 2019	Comments from SBC addressed.	Scottish Borders Council

Contract

This report describes work commissioned by Duncan Morrison, on behalf of Scottish Borders Council, by a letter dated 16 January 2017. Scottish Borders Council's representative for the contract was Duncan Morrison). Alex Woodger and Mark McMillan of JBA Consulting carried out this work.

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Purpose and legislative framework

This document has been prepared as a Final Report for Scottish Borders Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Scottish Borders Council.

Our work has followed accepted procedure in providing the services but given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, we can take no liability for the consequences of flooding in relation to items outside our control or agreed scope of service.

This flood study was commissioned in order to gain a greater understanding of the flood mechanisms in Newcastleton, improve upon SEPA's Flood Risk Management maps, and provide an appraisal of options which could reduce flood risk. In 2015, as part of the Flood Risk Management (Scotland) Act 2009, the Scottish parts of the Liddel Water catchment were designated as the

Solway Local Plan District by SEPA. Flood risk must therefore be addressed by SEPA's Flood Risk Management Strategy (FRMS) and the local authorities' Local Flood Risk Management Plan (LFRMP). Of the 13 Potentially Vulnerable Areas (PVA) defined by SEPA within the Liddel Water catchment, the Newcastleton PVA (reference 14/03) includes Newcastleton. According to this PVA, Newcastleton has a lengthy history of flooding and the potential for approximately £160,000 Annual Average Damages (AAD). A flood protection study is identified as one of the key actions to be taken as a means to reduce this risk and this report presents the findings of part of the study.

Acknowledgements

We would like to thank the Scottish Borders Council, Turner Townsend and Mott MacDonald for the data, supporting information and reviews undertaken throughout the study. We would also like to thank members of SEPA for the review of the hydrological calculations and flood modelling methodologies.

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Newcastleton Flood Risk Management Business Case

Context

Newcastleton in the Scottish Borders has a history of property flooding. JBA was commissioned in 2017 to carry out a review of past flood events, determine the likely risk to different properties and to propose a set of 'options' that may reduce the flood risk to an acceptable level. This report is the culmination of this work and aims to provide a detailed explanation of the various steps carried out in order to identify a preferred set of interventions that offer a sustainable method of flood protection whilst seeking to benefit the environment and the community of Newcastleton.

The Liddel Water is a large watercourse extending from a source 16 km north-east of Newcastleton and which is fed by several smaller watercourses along its length.

A modelling exercise was carried out to estimate river levels on the Liddel Water from upstream of Newcastleton to beyond the southern boundary of Newcastleton. A range of possible flood events were modelled from events with a probability of occurring once in every 2-year period, a 50% Annual Probability (AP) or 2 year event; up to an extremely large event with a probability of occurring once in every 1000 year period, a 0.1% AP or 1000 year event. Increases due to predicted climate change were included for at the 3.3% AP (30 year) and 0.5% AP (200 year) events.

It was found that 179 properties are at risk of flooding from the 0.5% AP (200 year) event and 319 properties are at risk for the same event with a climate change allowance. A range of flood protection options were then reviewed and short listed based on their viability.

Flood Mitigation Options

A range of flood protection options were reviewed and short listed based on their viability. Five options were short listed as potentially viable means of mitigating flood risk. The short-listed options are as follows:

Option 1 - Direct Defences

Option 2 - Partial Flood Defences

Option 3 - Charlie's Sike Restoration

Option 4 - Charlie's Sike Two Stage Channel

Option 5 - Property Level Protection

Improving public awareness and resilience

In addition to these short-listed measures a number of non-structural options and good practice flood risk management measures have been investigated and recommended for implementation by the Scottish Boarders Council. Some of these are already in place and others could be implemented either in the short term or alongside a Flood Protection Scheme. This includes the following:

Improved flood warning on the Liddel Water and Hermitage Water through installation of new gauges would give greater confidence to the size of the estimated peak flows, provide calibration data to increase the confidence of the hydraulic model and could be used to improve the existing Flood Warning System to Newcastleton

The Council should continue to make available its subsidised flood product scheme to property owners in Newcastleton. Property Level Protection (PLP) should continue to be deployed when a flood warning is issued.

Flood action groups, in partnership with the Community Council should seek to establish a network of support between members of the community, Scottish Borders Council and emergency services. Community engagement should be continued to raise awareness of flood risk and potential short- and longer-term options.

Resilient Communities sandbag stores are available in Newcastleton. The Council should consider the use of a flood 'pod' system. Community storage boxes, which contain flood sacks; purpose designed bags with absorbent material. The key advantage of this approach is that they can be distributed before a flood and area ideal for locations with limited warning or response times. They are also light weight so can be positioned without difficulty by a larger number of people. It may also save the Council time in filling, distributing and delivering sandbags to communities when sandbag stores run out.

Expected Benefits

A flood damage assessment has been undertaken for the present-day "Do Nothing", "Do Minimum" and each of the above options. The Present Value flood damages calculated for the Do Nothing and Do Minimum scenarios are estimated to be £7.9m and £4.1m respectively. The damages avoided for each option range from £0.7-6.9m. Total damages avoided for each option are provided in the investment appraisal summary table below

Natural Flood Management

Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved alongside a traditional flood protection option, potentially reducing flood flows within Newcastleton. Opportunities with the upper catchment could to some extent counteract the effects of increasing river flows with climate change. Natural Flood Management opportunities should be progressed where feasible through engagement with land owners and other stakeholders. Should NFM be progressed as part of a scheme funding should be sought through the scheme itself but in the shorter term it may be possible to secure funding through other sources if the focus can be widened from flood risk management to catchment and land management benefit.

The NFM measures which are likely to have the largest influence on reducing flood risk are:

- Upland habitat restoration
- Floodplain woodland upstream of Newcastleton
- Wetland Creation

Costs

Costs for each option have been estimated using the Environment Agency's Long Term Costing Tool (2015). An optimism bias factor of 60% has been added to the total costs to allow for uncertainties in design at this level of appraisal and is typical for schemes at an early stage of appraisal. Whole life present value costs range from £0.25-8.62m. Total costs for each option are provided in the investment appraisal summary table below.

Investment Appraisal

The investment appraisal is provided below. The BCR analysis shows that the two best options for mitigating flood risk in the village is options 2 and 4, both providing a BCR of 1.6. Options 3 and 4 have been assessed against the "Do Minimum" scenario rather than the "Do Nothing" as these options would not promote maintenance of the Liddel Water which has the greatest impact on the "Do Nothing" scenario. Of these two options, Option 4 is the most cost beneficial. However, it should be noted the wider ranging benefits such as provision of green space, community enhancement, educational opportunities have not been monetized and are therefore not reflected in Option 3's BCR.

Option 1 is the only real option for providing a 1 in 200 year standard of protection for the village, that can be adapted to meet the impact of climate change. However, the scale of the works required result in a BCR of 0.8. The benefits of this option have assumed a consistent annual average damage over the appraisal period, however, with the impact of climate change resulting in more frequent flood events, it is likely that annual average damages will increase over the appraisal period. It is therefore recommended that the benefits provided by Option 1 are assessed against the impact of climate change.

Option Number			Option 1	Option 2	Option 3	Option 4	Option 5
Option Name	Do Nothing	Do Minimum	Direct Defences	Partial Direct Defences	Charlie's Sike Restoration	Charlie's Sike Two Stage Channel	PLP
PV Costs (£k)	-	-	5,388	2,599	350	162	2,217
Optimism Bias (60%)	-	-	3,233	1,559	210	84	1,330
Total PV Costs (£k)			8,621	4,158	560	246	3,547
PV Damage (£k)	8,002	3,698	821	1,303	2,556	2,358	2,439
PV damage avoided (£k)	-	4,304	7,181	6,699	1,142	1,340	5,563
Benefit Cost Ratio	-	-	0.8	1.6	1.8	5.2	1.6
* assessed against the Do Minimum as they refer to the Sikes rather than the main river							

For each of the options assessed there are a number of constraints and opportunities that must be considered and discussed with stakeholders and the public before a preferred option is selected. A summary of these is provided in the appraisal summary table overleaf.

Residual Risk and Planning for Future Flooding

Of the shortlisted options, only Option 1 provides a holistic standard of protection to the village of 1 in 200 years. Option 2 mitigates the impact of flooding by reducing the severity but does not impact on the frequency of flooding and, over time, with the impact of climate change the effectiveness of this option will be reduced. Options 3 and 4 mitigate against flooding from the Charlie's Sike but not the Liddel Water.

With direct defences, an exceedance event, where flood waters overtop the defences, flood waters could become trapped in the villages by the defences. It is fundamental that any direct defences do not increase the risk from secondary flooding (flooding behind defences) once they are in place. Any proposed options would be required to mitigate this risk so the town can be drained after excessive rainfall or after an exceedance event, this could potentially be done by using flood gates in the direct defence or by locating pumping stations at the low points behind the defences. The risk of an exceedance event will increase over time with the impacts of climate change. Consideration should be given to designing adaptable walls that can be raised in the future.

Regardless of the chosen option NFM should be integrated into the scheme. The NFM measures recommended are located throughout the catchment. NFM, when implemented correctly, shall have a positive effect on flood flows, helping the soil to absorb more water, slow the flow of water into the watercourse and create more open water bodies on the land and may help to mitigate against the increase in frequent flood flows from climate change.

Conclusions and recommendations

A shortlist of flood protection options was produced and reviewed by comparing the expected benefit of the scheme (property damages avoided) with the estimated costs for scheme implementation and maintenance. The following options were considered:

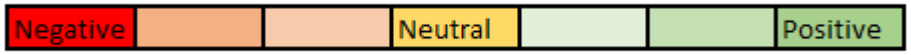
- Direct Flood Defences
- Partial Flood Defences
- Charlie's Sike Restoration
- Charlie's Sike Two Stage Channel
- Property Level Protection (PLP)

Partial flood defences and PLP were considered the most viable financial option each producing a benefit cost ratio of 1.6 for mitigating flood risk from the Liddel Water. Of the options on the Charlie's

Sike, the two stage channel had the best BCR of 3.4 while the Charlie's Sike Restoration produced a lesser but still favourable BCR of 1.2. However, it is noted that the wider benefits that can be gained through a restoration scheme and provision of a community green space have not been evaluated and are therefore not reflected in the BCR.

The option of full direct defences produced a BCR of 0.8 indicating that it is not an economically viable option. However, this assessment has assumed that the average annual damages due to flooding of Newcastleton is consistent throughout the appraisal period. However, with the impact of climate change is likely that the annual average damages will increase over the appraisal period. A reassessment of the likely damages avoided by direct defences is therefore recommended as this will likely result in positive BCR. A full set of direct defences is considered the only viable means of protecting Newcastleton to a suitable standard of protection and the 1 in 200 year standard is achievable.

Option (Standard of Protection)	Damages Avoided (£m)	Environmental Implications	Working with natural processes	Constraints/limitations	Mitigating residual risks	Improved public awareness	Best Use of Public Money	Wider Benefits
Option 1 Hard Defences	7.18	Little impact overall however impact to river wildlife during construction	NFM Measures have been indentified and can be incorporated within the scheme to provide additional benefits.	Average wall height at approximately 1.3 m. Will not obscure view of river. Some areas are constrained which will make construction difficult	Walls can be constuctued so that that an option an increase in height is possible in the future. Linear drainage can be incorporated to mitigate impcat on surface water flooding	Options should be presented to public for comment. Sinage relating to flooding and sand bag stores coul be provided to help defend against more frequent events in the short term. Residents of Newcastleton should be engagaed in the Resilient Communities Programme	BCR 0.8 (5th)	None
Option 2 Hard Defences	6.7	Little impact overall however impact to river wildlife during construction		Average wall height <1.3 and less comprehensive than option 1. Less of a visual impact. Some areas are constrained which will make construction difficult	Walls can be constuctued so that that an option an increase in height is possible in the future. Linear drainage can be incorporated to mitigate impcat on surface water flooding		BCR 1.6 (3rd)	None
Option 3 Charlie Sike Restoration	1.14	Positive increase in wildlife diversity		Disposal of material has potential for large variations in costs	Maximum use of area available to mitigate against further increase in flows		BCR 1.8 (2nd)	Potential to increase wildlife diversity and additioanl green space amenity.
Option 4 Charlie Sike Floodplain	1.34	Positive impact for flora and fauna		Disposal of material has potential for large variations in costs	Maximum use of area available to mitigate against further increase in flows		BCR 5.2 (1st)	Soft option could provide better aesthetic
Option 5 PLP	5.56	No Impact		Intrusive into people's homes, will require reinstallation every 25 years	Some properties may experience flood depths in excess of what PLP can provide and decrease in SOP over time. Additional properties may require PLP over time.		BCR 1.5 (3rd)	None



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Abbreviations

1D	One Dimensional (modelling)

2D	Two Dimensional (modelling)
BCR	Benefit cost ratio
CAD	Computer Aided Design
CAR	Controlled Activity Regulations (2010)
CEH	Centre for Ecology and Hydrology
CIWEM	The Chartered Institution of Water & Environmental Management
DEFRA	Department of the Environment, Food and Rural Affairs (formerly MAFF)
DTM	Digital Terrain Model
EA	Environment Agency
EC	European Community
FCERM	Flood and Coastal Erosion Risk Management (R&D programme)
FEH	Flood Estimation Handbook
FPS	Flood Protection Scheme
FRM	Flood Risk Mapping
FSR	Flood Studies Report
FWA	Flood Warning Area
GIS	Geographical Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HM	High Mileage
HR	Hydraulic Research, Wallingford
ICE	The Institution of Civil Engineers
ISIS	Hydrology and hydraulic modelling software
MAFF	Ministry of Agriculture Food and Fisheries (now part of Defra)
mAOD	metres Above Ordnance Datum
NRA	National Rivers Authority
ODPM	Office of the Deputy Prime Minister
OS	Ordnance Survey
PLP	Property Level Protection
PR	Percentage Runoff
PV	Present Value
PVb	Present Value benefits
PVc	Present Value costs
QMED	Median Annual Flood (with return period 2 years)
R&D	Research and Development
RBMP	River Basin Management Plan
SAC	Special Area of Conservation, protected under the EU Habitats Directive
SEPA	Scottish Environment Protection Agency
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Urban Drainage Systems
TUFLOW	Two-dimensional Unsteady FLOW (a hydraulic model)

US	Upstream
WFD	Water Framework Directive

Return period and probability

For flood frequency analysis the probability of an event occurring is often expressed as a return period. A return period is the average interval (number of years) between two years containing one or more floods of a given magnitude or greater. As an example, the flood magnitude with a return period of 200 is referred to as the 200 year flood.

Another useful term closely linked to return period is a floods annual probability, AP. This is the probability of a flood greater than a given magnitude occurring in any year and calculates as the inverse of the return period. For example, there is a 1 in 200 chance of a flood exceeding the 200 year flood in any one year, so the AP is calculated by 1/200 giving a 0.5% AP for the 200 year flood event.

Throughout this report a flood event will primarily be written as a return period in years, i.e. 200 year event.

Supporting Documents

Hydrology report -AEM-JBAU-NC-00-RP-A-0003-Newcastleton_Hydro_Report-S0-P03.pdf

Asset condition assessment report -

AEM-JBAU-NC-00-RP-A-0002-Asset_Condition_Assessment-S0-P01.01.pdf

RBMP & NFM report - AEM-JBAU-NC-00-RP-E-0002-Newcastleton_NFM_Report-S4-P01.pdf

Preliminary Ecological Appraisal - AEM-JBAU-NC-00-RP-E-0001-PEA-S1-P01.pdf

Modelling report - AEM-JBAU-PB-00-RP-A-0005-Newcastleton_Modelling_Report-SO-P02.pdf

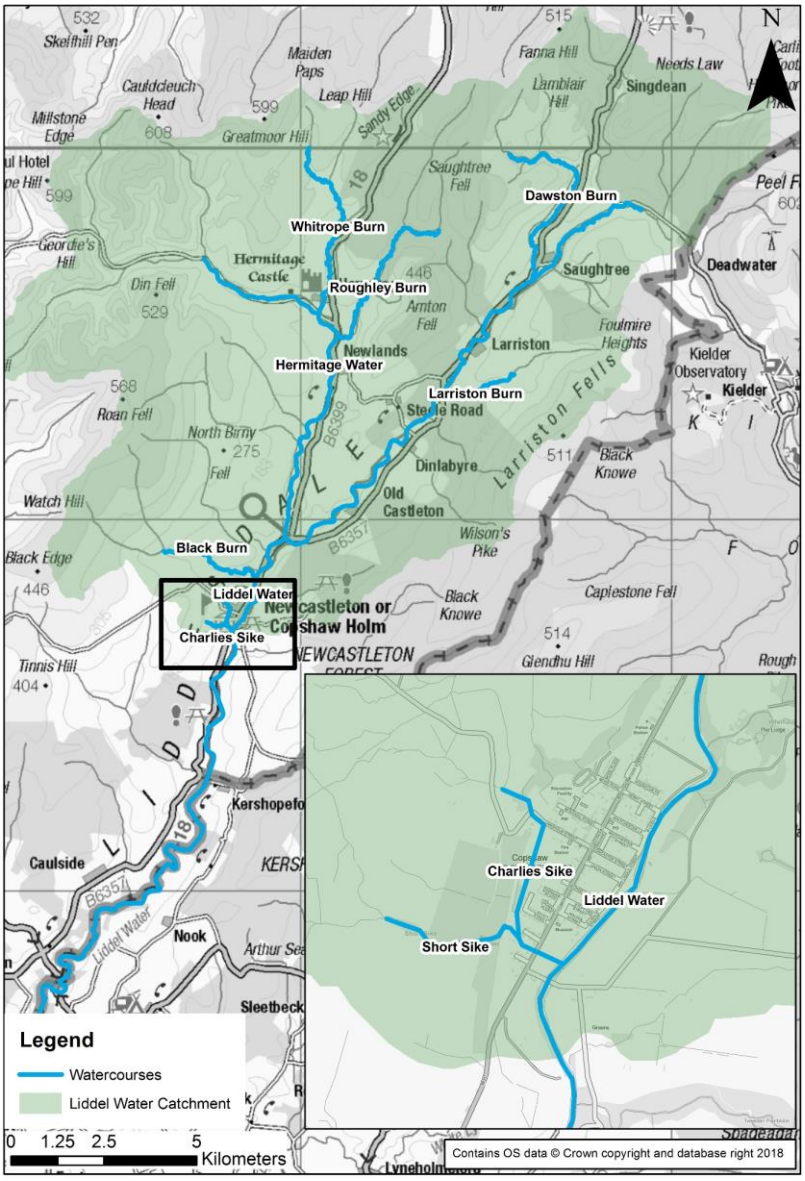
1 Introduction

The Liddel Water flows through the Borders village of Newcastleton as a large channel, extending from its source in the hills to the north-east to its confluence with the River Esk, north of Carwinley approximately 20km south-west of Newcastleton. Newcastleton lies in the bottom of a valley on the banks of the Liddel Water. The village is surrounded by agricultural fields and open countryside peaked by Roan Fell and Larriston Fell.

The Liddel Water originates in the hills above Saughtree in the northeast of the catchment where three smaller burns converge. The Dawston Burn flows into the Liddel Water at the village of Saughtree and approximately 7 km further downstream the Larriston Burn joins. In the western portion of the catchment the Hermitage Water flows east towards Hermitage village where the Whitrope and Roughly Burn's discharge into it. From here the river flows south for approximately 10 km where it joins the Liddel Water. The Liddel Water continues south towards Newcastleton where another tributary, the Black Burn, discharges into the river just outside the town. Within Newcastleton itself a further four small tributaries discharge into the Liddel Water: the Whithaugh Burn, Charlies Sike, Coulter Sike and Short Sike.

The key areas of interest are the reach of Liddel Water directly alongside Newcastleton and where The Short Sike and Charlies Sike pass along the rear of Newcastleton before joining the Liddel Water.

Figure 1-1: Study Area and Liddel Water Catchment



The Liddel Water has a large, rural catchment (approximately 200 km^2 to Newcastleton) which ultimately discharges into the River Esk approximately 20 km downstream of Newcastleton.

Land use within the catchment is dominated by highly grazed grassland. Peat bogs are located at higher elevations and there are large areas of forestry in the headwaters of the Liddel Water, to the northeast and south of the catchment. Newcastleton at the southern extent of the catchment is the only area of urban land use. All watercourses within the Newcastleton catchment were classified as better than good[1]. The SEPA morphological pressures dataset was however, still reviewed to identify significant morphological pressures along the Liddel Water within the modelled extents.

Within the Newcastleton area of the catchment it can be seen that set back embankments and green bank reinforcement are the only pressures affecting the Liddel Water. Additional pressures are in the upper catchment where there is a weir just south of the Dawston Burn confluence, a culvert near Myredykes and small sections of green bank reinforcement. The Hermitage Water has two weirs and a small area of grey bank reinforcement but other than a culvert in its uppermost reach has no other morphological pressures.

1.1 Flooding from the Liddel Water

Newcastleton has a history of flooding due to being built within the floodplain of the Liddel Water. The SEPA flood maps show that a large proportion of properties in Newcastleton are at risk of flooding at the 0.1% level and the majority of properties closest to the Liddel Water are at high risk of flooding at the 10% level. Flood review based on SEPA maps, FRM strategy/Local plan etc and local knowledge

The 'worst in living memory' flood event occurred in October 2005 which was estimated to correspond to a 1 in 15-year event at the time. It was noted that water backed up into the local drainage and flooded the town further rather than conveying the surface water.

Newcastleton has been known to flood at low return period events as stated above which would suggest that changes associated with climate change may increase the frequency and/or the severity of flooding. Climate change has been taken in to account at the 30 and 200-year events, as discussed in Section 2.3.1.

South Hermitage Street, George Street and South Liddle Street and a few others in particular are areas where flooding regularly affects residents.

1.1.1 Previous studies

Halcrow was commissioned by the Scottish Borders Council (SBC) in 1999 to report on flood risk and recommended direct defences of 2-3m in height. This was not well received by local residents. Halcrow was further commissioned by SBC to look into flood protection options and reported that a 1m height direct defence would protect the town against a 1 in 25-year flood event. Halcrow was commissioned again by the SBC in 2005 to investigate the options more fully including direct defences, artificial relief channel, demountable defences and attenuation. The most cost-effective and practical solution found by the report was the direct defences, however, the scheme did not progress.

1.1.2 Watercourse condition and catchment opportunities

All watercourses within the Newcastleton catchment were graded as in good condition by SEPA under the River Basin Management Plan (RBMP) 2015 study.

Opportunities to further improve the physical condition of the Liddel Water within the Newcastleton reach is limited as the river is already relatively sinuous and is not constrained by any physical pressures. NFM potential is high across the entire Liddel Water catchment and would cumulatively benefit the downstream community of Newcastleton. The source regions of the Hermitage and Liddel Water were identified as contributing a high proportional contribution to catchment discharge. These regions have high opportunity for upland habitat restoration, drain blocking and contour tree planting to reduce runoff and increase infiltration.

Within the southern region of the catchment and within the Newcastleton region the greatest opportunities for NFM are within the Short Sike, Charlie's Sike and Coulter Sike sub-catchments.

1 https://ww.sepa.org.uk/data-visualisation/water-environment-hub/ [Accessed: June 2018]

Potential to reduce runoff through upland habitat restoration where the burns originate are high and would directly benefit the Newcastleton community.

Bank protection is recommended near Whithaugh Bridge to prevent further erosion of the left bank, which is resulting in the loss of newly planted woodland. An impact assessment of any works to the morphology of the watercourse downstream would however be required prior to any works. Additionally, any form of bank protection will impact the RBMP status of the Liddel Water. The Hermitage and Liddel Water in the northern extent of the catchment are similarly unconstrained, actively eroding and depositing material; maintaining sinuosity and in-stream morphological diversity. Suggested improvements to the watercourses would be to prevent grazing to the bank edge, riparian woodland planting and buffer strips.

1.2 Aims and objectives

The options appraisal seeks to provide information appropriate to Scottish Borders Council to inform their decision on the most sustainable catchment-wide strategy for flood risk management in Newcastleton that contribute to achieving RBMP objectives and are acceptable to key stakeholders and the community. This report describes the information used to form conclusions on the suitability, feasibility and economic viability of different options for flood risk mitigation.

Proposals and conceptual designs have been developed to:

a. Provide protection from a 0.5% AP (200 year) magnitude flood event if feasible or a lower magnitude event in other cases
b. Deliver multiple benefits to the Liddel Water catchment and local communities
c. Highlight opportunities to reduce river flows through Natural Flood Management practices and quick wins

2 Preliminary investigations

2.1 Flood history

A comprehensive review of historic flood events from the Liddel Water has been carried out and is included in the Hydrology report referenced in the Supporting Documents section at the start of this report. A selection of the most recent flood events is included in Table 2-1 below and includes some medium magnitude events such as Storm Frank, December 2015.

Table 2-1: Table of recent floods

Date	Flood Record	Source
Jul 1927	Very local flooding around the Kershope Burn. Around 10 feet deep flooding behind the railway embankment.	BHS Chronology
20 Aug 1958	"Following very heavy rain, a landslide blocked the main Edinburgh - Carlisle railway line for a distance of more than 100 yards near Newcastleton, Roxburghshire…" [Liddell Water headwater]	BHS Chronology
Jan 1990	60 homes evacuated in Walter Street, Stopford Street and George Street in Newcastleton	SBC data [Sourced from SEPA GIS archive]
Jan 1991	Scottish Borders Council has records of significant flooding of the Liddel Water in the Newcastleton area.	SEPA FRMS
Feb 1997	Newcastleton has suffered from three major floods in recent years, in February 1997, January 2001 and October 2005	SEPA FRMS
Jan 2001	Newcastleton has suffered from three major floods in recent years, in February 1997, January 2001 and October 2005	SEPA FRMS
Feb 2002	Roadway flooding on Liddle Street	SBC data [Sourced from SEPA GIS archive]
Oct 2005	The October 2005 flood event was reported to be the 'worst in living memory' and was estimated to correspond to a 1 in 15-year event at the time. It is the highest flow on record and has not been exceeded since. Local drainage was unable to convey surface water. Water backed-up from the river through the drainage network and flooded the town further, with a resident even describing seeing water escaping a manhole as a fountain. 30 houses flooded during this event, representing around 10% of the local population. Large quantities of gravel built up changing the river drastically	SEPA FRMS
10 Jun 2008	Flood recorded in the Strategic Flood Risk Assessment (SFRA) of the Scottish Borders Council but no details on flooding source.	SBC data [Sourced from SEPA GIS archive]

Newcastleton has a history of flooding. The town has been built on the flood plain of the Liddel Water and is subject to fluvial flooding from this source as well as pluvial sources, particularly from moorland and burns to the west of the town when ditches and the drainage network are overloaded.

2.2 Flood Estimation

The methodology used to derive flood estimates for the Liddel Water catchment is explained in the Hydrology report referenced in the Supporting Documents section at the start of this report.

Important inputs into a flood study are the analysis of historic floods (where data are available), and estimation of flood flows for a range of annual probabilities or 'design' events. Flood estimates for catchments of this size and type are undertaken using the Flood Estimation Handbook (FEH). The FEH offers three methods for analysing design flood flows: the Statistical, the Rainfall Runoff, and hybrid methods. The Statistical method combines estimation of the median annual maximum flood (QMED) at the subject site with a growth curve, derived from one of three methods; (a) a pooling group of gauged catchments that are considered hydrologically similar to the subject site, (b) through single site analysis of a nearby gauge, or (c) a combination of the two through the use of enhanced single site. The Rainfall Runoff method combines design rainfall with a unit hydrograph derived for the subject site (the Rainfall Runoff method has recently been updated as ReFH2[2]). Hybrid methods involve a combination of the two. Both the Statistical and Rainfall Runoff procedures

2 Wallingford Hydro Solutions (WHS) The Revitalised Flood Hydrograph, ReFH2: Technical Guidance. 2015

require the derivation of catchment descriptors. For this study these were initially abstracted digitally using the FEH CD ROM v3. FEH13 rainfall values were obtained from the FEH Webservice[3].

Adjustments were then made to catchment area (using OS background mapping). For example, Charlies Sike, Coulter Sike and Short Sike are not well defined in the digitised rivers network (DRN). The final catchment areas (Table 2-3) for Charlies Sike, Coulter Sike and Short Sike were obtained manually within GIS. URBEXT was adjusted using the national growth model through the year of study, 2017, per FEH Volume 5. The FEH CD-ROM BFIHOST values appeared reasonable in comparison to the available geological information[4].

The Statistical method was selected as the most appropriate choice of method of peak flow estimation for the Liddel Water. This was because of the relatively large, rural nature of the catchment. For the other catchments, comparisons were made between the Statistical method and different Rainfall Runoff methods. Following this comparison, it was assumed that the most appropriate approach was to use ReFH2 with donor parameters and FEH13 rainfall for those catchments. Given the small catchment areas of the Sikes, the approach taken was to derive peak flow estimates using ReFH2 for the Charlies Sike catchment derived from the FEH CD-ROM and then scale the estimates (by catchment area) down to the adopted catchment areas. A 33% climate change allowance upon the 0.5% AP (200 year) event was applied, per SEPA guidance for Local Authority studies for the Liddel Water[5]. The results for the main watercourses are summarised in Table 2-2.

Table 2-2: Peak flow estimates upstream of the site of interest

		Liddel Water	Charlie's Sike	Coulter Sike	Short Sike	Whithaugh Burn
Area (km^2)		207.66	0.23	0.13	0.96	4.13
AP(%)	**T (yrs)**					
50	**2**	164.70	0.26	0.15	1.09	4.12
20	**5**	213.79	0.38	0.21	1.57	5.78
10	**10**	249.38	0.46	0.26	1.92	6.98
4	**25**	300.75	0.58	0.33	2.43	8.75
3.33	**30**	311.86	0.61	0.35	2.54	9.14
2	**50**	344.89	0.69	0.39	2.88	10.30
1.33	**75**	373.37	0.76	0.43	3.18	11.30
1	**100**	394.91	0.82	0.46	3.42	12.06
0.5	**200**	451.90	0.98	0.55	4.07	14.11
0.1	**1000**	617.93	1.46	0.83	6.08	20.03

2.2.1 Climate change

SEPA's summary report on Flood Risk Management and climate change concludes that climate change impacts are likely to vary spatially across Scotland. In summarising the different increases in river flows predicted by climate models as we move towards the 2080's a number of estimates for the Liddel Water were provided. The high emissions scenario, 'unlikely to be exceeded' uplift estimate of 33% has been used to enable the impacts of climate change to be integrated into the overall assessment.

This uplift was applied to the 3.33% AP (30 year) and 0.5% AP (200 year) magnitude events only.

2.3 Survey data

Topographic survey data from Halcrow survey in 2000 around Newcastleton was made available for this study and primarily consisted of river cross section data which was used in the 1D hydraulic model. To complete the coverage of cross section data along the full study reach a topographic

3 https://fehweb.ceh.ac.uk/

4 http://mapapps.bgs.ac.uk/geologyofbritain/home.html

5 SEPA - Flood Modelling Guidance for Responsible Authorities, Version 1.0

channel survey was conducted by JBA Consulting in April 2017 along parts of the watercourse. This information was combined with a 1m LiDAR Digital Terrain Model (DTM) supplied by Scottish Borders Council to provide ground levels across the study area and much of the Liddel Water catchment. Combined, this data provides the physical basis for the hydraulic model.

Several site visits were conducted to provide context to the data, to photograph key areas and to provide an assessment of the condition of the watercourse, particularly at structures such as bridges and weirs as is summarised below.

2.3.1 Asset condition assessment

A full report into the condition of assets along the Liddel Water and its tributaries is provided in the Asset Condition Assessment report, referenced in the Supporting Documents section at the beginning of this report.

Table 2-3: Asset Condition Summary

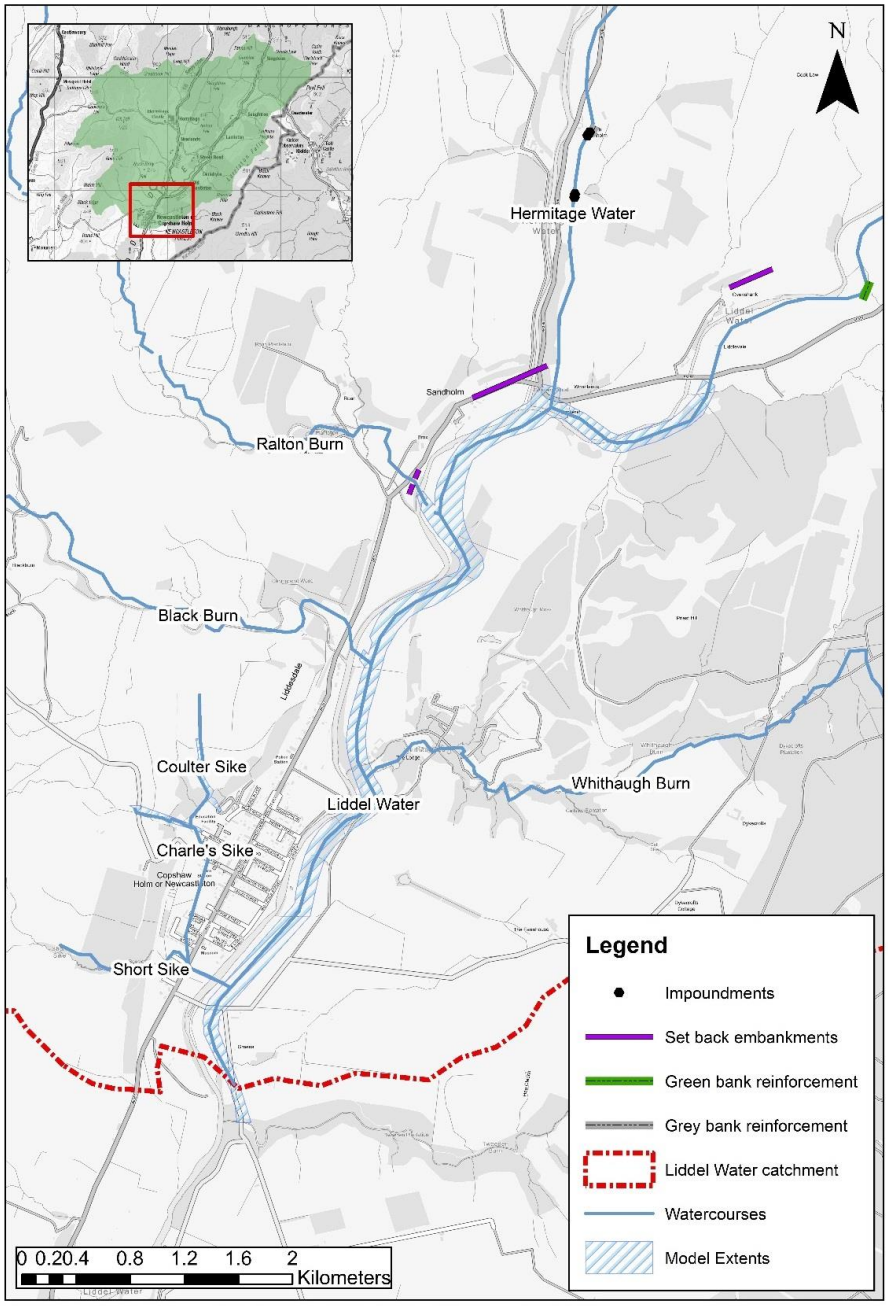
Name of Asset	Type of structure	Upstream Grid Ref	Condition
Whithaugh Bridge	Single span pedestrian bridge	NY 48735 87767	Grade 1 (V. Good)
Pedestrian Bridge	Single span pedestrian bridge	NY 48168 87066	Grade 2 (Good)
Road Bridge	Double span vehicular bridge	NY 48128 86985	Grade 2 (Good)
S Hermitage St Road Bridge	Single span arch bridge	NY 48079 87106	Grade 2 (Good)
Culvert	Culvert	NY 47969 87204	Grade 2 (Good)
Box Culvert	Twin box culvert	NY 48105 87630	Grade 2 (Good)
Vehicular Bridge	Arch bridge	NY 48082 87656	Grade 2 (Good)
Culvert under Langholm Street	Pipe culvert	NY 48066 87670	Grade 2 (Good)

2.4 River Basin Management plan – Summary

A full report into the condition of the watercourse is provided in the Natural Flood Risk Management and River Basin Management Plan report, referenced in the Supporting Documents section at the beginning of this report.

There are minimal morphological constraints on the watercourses within the catchment. It can be seen in Figure 2-1 below, that set back embankments and a small area of green bank reinforcement are the only pressures affecting the Liddel Water within the model extents. Additionally, there is anecdotal evidence of gravel deposition at the bend in the Liddel Water just north of Newcastleton , a potential cause of bank erosion at the top of North Liddle Street. Recent works have been undertaken to provide erosion protection to this area. Additional pressures in the upper catchment are a weir just south of the Dawston Burn confluence, a culvert near Myredykes and small sections of green bank reinforcement. The Hermitage Water within the area shown in Figure 2-1 has two weirs and a small area of grey bank reinforcement but other than a culvert in its uppermost reach has no other morphological pressures.

All watercourses within the Newcastleton catchment are classified as being in good or high condition based on SEPA's 2015 classifications. Opportunities to further improve the physical condition of the Liddel water within the Newcastleton area is limited as the river is already relatively sinuous, actively eroding and is not constrained by any physical pressures. Bank protection near Whithaugh Bridge to prevent further loss of the newly planted woodland and prevent erosion towards the road may be an option. The impact of any bank protection measure to morphological processes further downstream would however be recommended prior to any works. Additionally, bank protection will impact the RBMP status of the Liddel Water. The Hermitage and Liddel Water in the northern extent of the catchment are also unconstrained, actively eroding and depositing material and maintaining a sinuous morphology with in-stream morphological diversity. Suggested improvements to the watercourse would be to prevent grazing to the bank edge, riparian woodland planting and buffer strips.



Contains Ordnance Survey Data (C) Crown Copyright and Database Right 2017

Figure 2-1: Significant Morphological pressures along the Liddel Water at Newcastleton

2.5 Natural Flood Management – Summary

A full report into the NFM opportunities within the Liddel Water catchment is provided in the Natural Flood Risk Management and River Basin Management Plan report, referenced in the Supporting Documents section at the beginning of this report.

In response to the Scottish Government's Land Use Strategy framework, the Scottish Borders Council produced a series of NFM opportunity maps. These highlight areas within the Borders region where runoff could be reduced, or water storage increased through habitat modifications including (i) tree planting (ii) restoration of habitats (iii) wetland creation and (iv) floodplain storage. Runoff reduction, floodplain storage and sediment management opportunities and the Scottish Borders Council data is discussed in turn below.

2.5.1 Runoff Reduction

It can be seen there is catchment wide potential for medium reduction in runoff. The areas of high potential are primarily in the higher elevations e.g. at the western edge of the catchment or correspond to where the land use is predominantly pasture (e.g. the Hermitage Water).

2.5.2 Floodplain Storage

The areas of medium to high potential are located primarily along the Hermitage and Liddel Water north of their confluence, and at the confluence itself. It should be noted that SEPA's floodplain storage mapping was carried out only for areas of floodplain with an annual probability of flooding at least once every 200 years. These areas are adjacent to key transport routes which may restrict the use or extension of floodplain storage.

2.5.3 Sediment Management

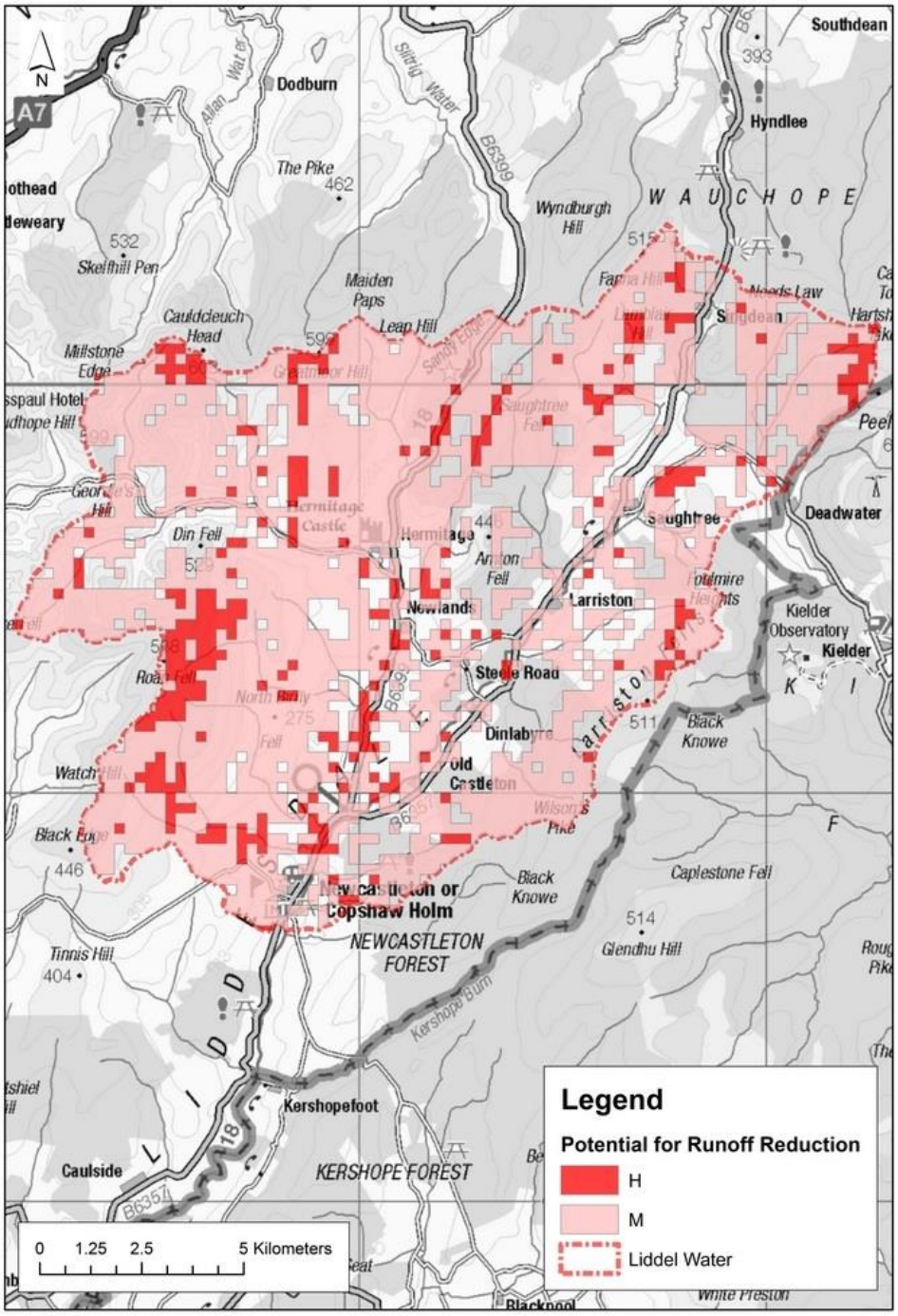
The sediment management mapping indicates moderate erosion is occurring along much of the Liddel Water. In contrast the Hermitage Water is generally moderately depositing or in a balanced state.

2.5.4 Scottish Borders Council opportunities

The areas with the most opportunity for tree planting are primarily in the northeast of the catchment in the headwaters of the Liddel Water and near Hermitage. In addition, the headwaters of the Hermitage Water are indicated as having high opportunity for planting.

Opportunities to increase infiltration is greatest in the northwest near Hermitage and at the Dawston Burn headwaters. Opportunities to increase infiltration in other habitats is generally greatest along the Liddel Water.

The areas indicated for floodplain storage differ slightly from the SEPA data and indicate the greatest potential for floodplain storage is in the town of Newcastleton which is unlikely to be an option. Catchment wide opportunities are indicated for wetland creation.



Contains Ordnance Survey Data (C) Crown Copyright and Database Right 2017

Figure 2-2: Sample NFM opportunities map indicating areas with potential for runoff reduction

2.6 Preliminary ecological appraisal – Summary

A full report into the presence and importance of different habitats along the Liddel Water is provided in the Preliminary Ecological Appraisal report, referenced in the Supporting Documents section at the beginning of this report.

Within the Liddel Water catchment the southwest uplands between Pike Fell and Black Edge are designated as a Scottish Natural Heritage (SNH) designated Site of Special Scientific Interest SSSI) as it contains flora and fauna protected by the Nature Conservation (Scotland) Act 2004. This same region is also a Special Protected Area (SPA) as it contains Hen Harrier which is protected by The

Birds Directive (2009). There is additional SSSI designated areas near Larriston and in the far northeast of the catchment near Peel Fell. Additionally, Hermitage Castle is a protected monument.

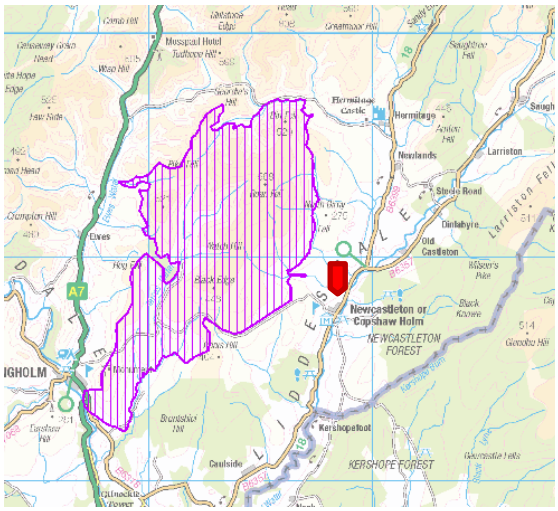


Figure 2-3: Scottish Natural Heritage map showing Special Protection Areas (SPA). Arrow indicates location of Newcastleton

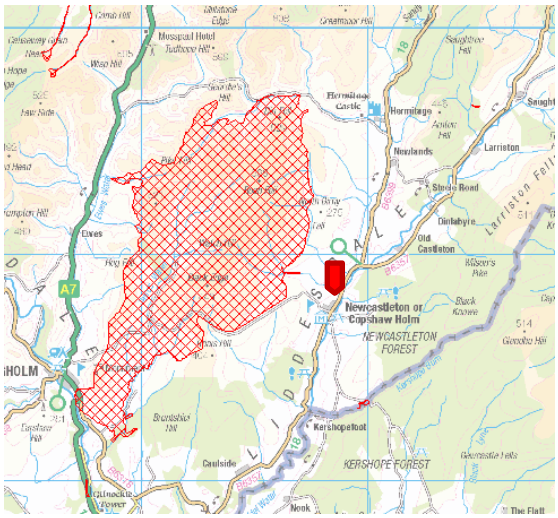


Figure 2-4: Scottish Natural Heritage map showing Sites of Special Scientific Interest (SSSI). Arrow indicates location of Newcastleton

2.7 Hydraulic modelling

A hydraulic model was developed, informed by the above-mentioned datasets, to estimate water levels during simulated floods. Below is a summary of the model structure and the results used to generate flood maps and to calculate the cost of flood damages in the later stages of the appraisal. Further details of the modelling approach, including calibration and sensitivity analysis, is provided in the Model Audit report referenced in the Supporting Documents section at the beginning of this report.

2.7.1 Model setup

The modelling package used was Infoworks ICM, offering the ability to create a 1D-2D model where the river channel is modelled in 1D and the floodplain in 2D. This approach allows for complex floodplain flow routing not possible with a simpler 1D only model.

As noted above, survey data for the 1D model were collated from a number of sources, dating from 2007 to 2017. No bank-top survey was available to inform the link between 1D and 2D model domains but there was enough combined confidence in the LIDAR and surveyed channel cross sections to give a good indication of the elevations at which water should pass from the channel onto the floodplains. The 2D floodplain was formed from 1m LIDAR. The 2D zone extends to cover the urbanised area of Newcastleton and includes the upstream and downstream areas of the floodplain to accurately assess the flood mechanisms.

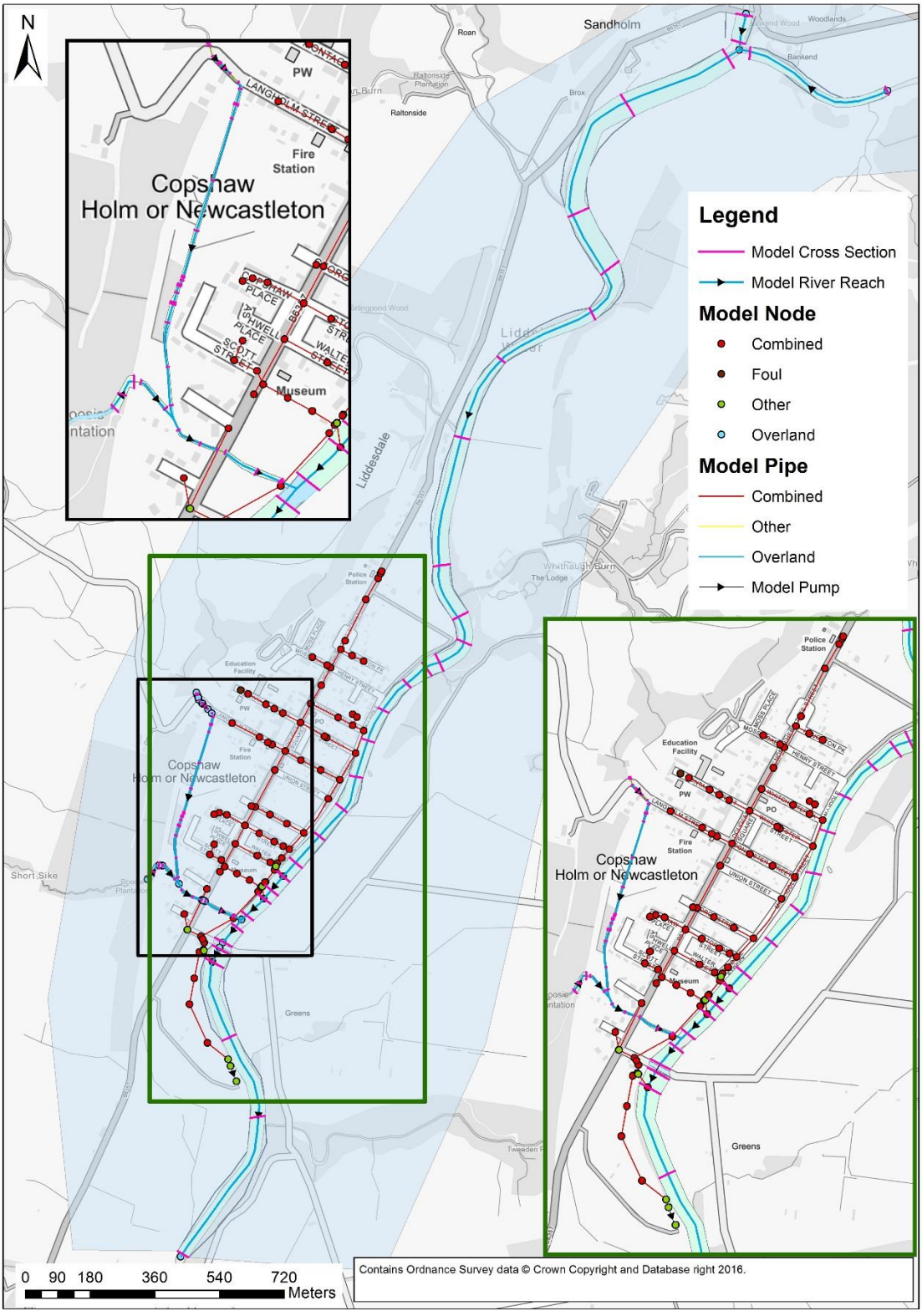


Figure 2-5: Model Schematic

Limited information is available to calibrate the model. There are two gauging stations on the Liddel Water. One at Newcastleton (NGR 348150 58700) and another at Rowanburnfoot located at NGR 341500 575900. The gauge at Newcastleton is not calibrated for high flows and is therefore of limited use to understanding how accurate the model is when assessing extreme events. The gauging station at Rowanburnfoot is better however is "slightly weak" for assessing high flows due to a tendency for high flows to overtop the right hand flood bank.

Throughout the calibration process a close match between observed and simulated water levels at the properties around South Hermitage Street, George Street and South Liddle Street were given high priority due to this areas' history of flooding.

2.7.2 Model scenarios

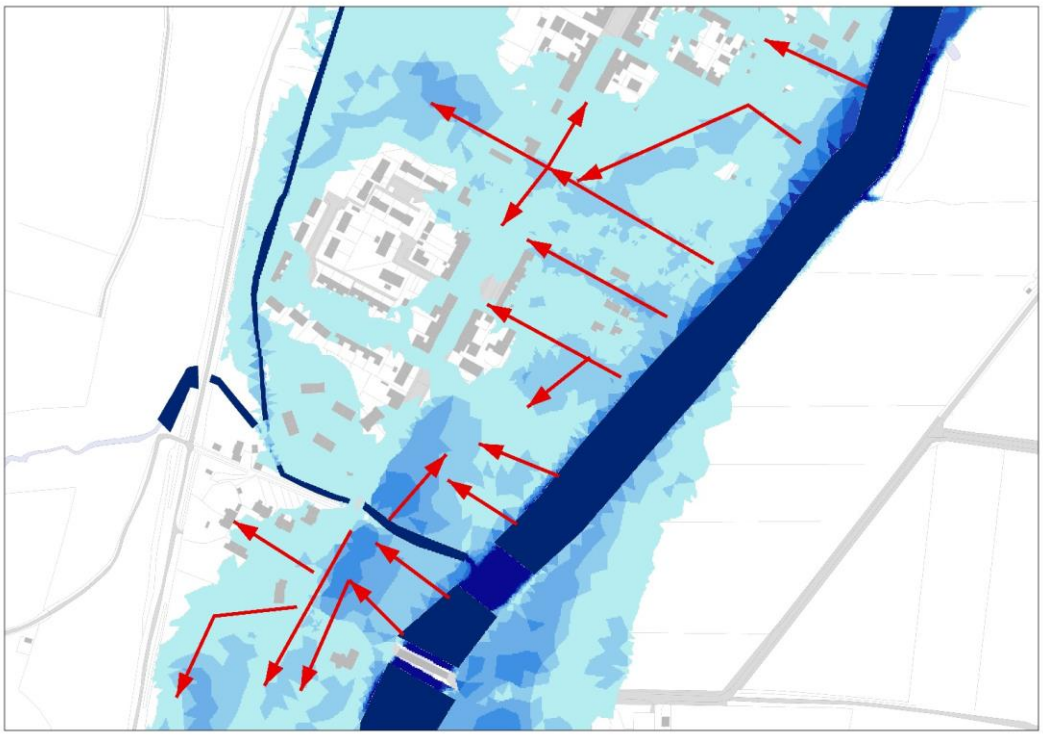
Model simulations were performed covering the full range of AP events for a worst case 'Do Nothing' and present day 'Do Minimum' scenario, with the model being modified slightly between scenarios. A description of the differences between these model scenarios is provided in section **Error! Reference source not found.** below and in the Do Nothing Assumptions report referenced in the Supporting Documents section at the beginning of this report.

Additional model scenarios were used to test the feasibility and successes of different flood protection options that emerged during the options long-listing process described in section 4.5.

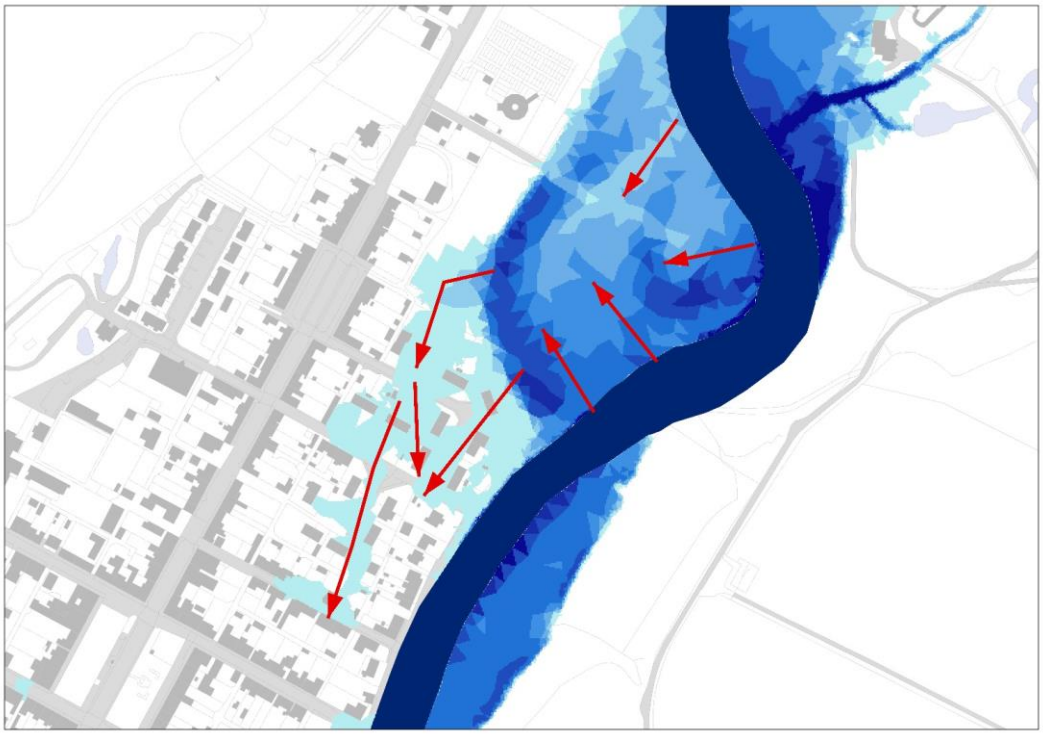
2.7.3 Model results

The modelling of the Liddel Water, Charlie's Sike and Short Sike through Newcastleton shows three key flood mechanisms:

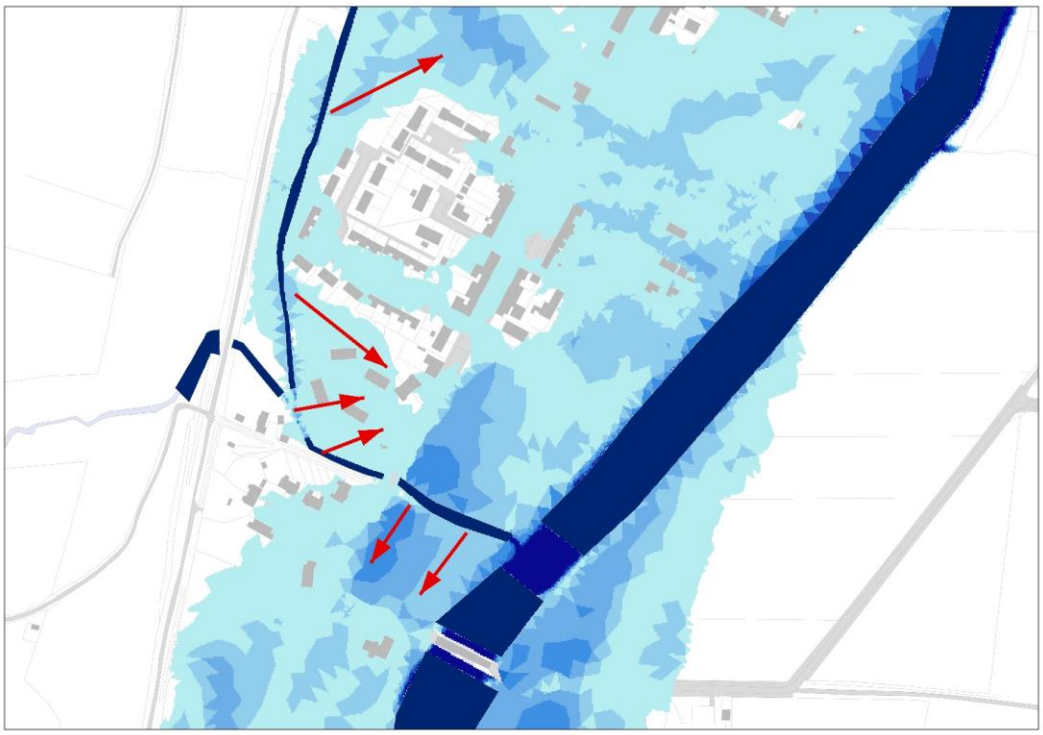
1. Direct overtopping of banks of Liddel Water at Doncaster Street and downstream



2. Upstream floodplain capacity is exceeded before flowing overland into Houghton Park and Henry Street



3. Overland flow from overtopping of Charlie Sike banks onto Buccleuch Terrace



2.7.4 Current standard of protection

Figure 2-6 shows the present day standard of protection for each property in Newcastleton from flooding from the Liddel Water. 'Standard of protection is the largest flood event which is not expected to cause flooding to a property, larger magnitude events would be expected to cause property flooding. For example, a property with a 4% AP (25 year) standard of protection would be expected to flood at the 3.33% AP (30 year flood event.

2.7.5 Current standard of protection

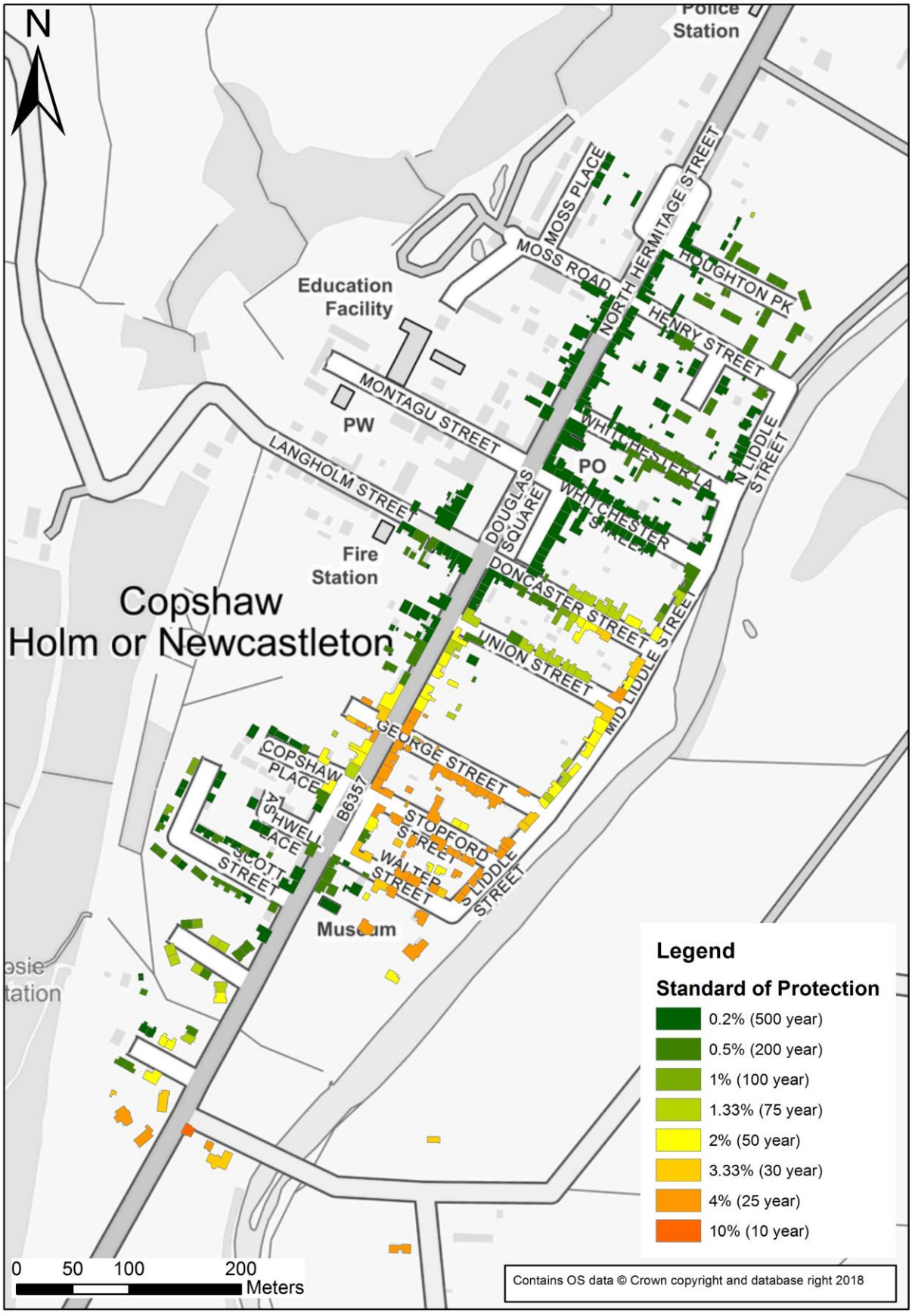


Figure 2-6: Current Standard of Protection for Newcastleton

3 Appraisal approach

3.1 Overview

There are approximately 174 residential properties and 15 commercial properties at risk of flooding during a 1 in 200 year event from the Liddel Water. The flooding is principally caused fluvially by high levels in the Liddel Water. Flooding is likely to occur to properties during a 10 year event.

The Charlie's Sike is a flood nuisance to the town, likely to flood gardens surrounding property from the 10 year event. However, the worst case scenario for properties in this area is flood water from the Liddel Water, backing up through the Charlie's Sike which results in greater flooding.

3.2 Consequences of Doing Nothing

The starting point for a scheme appraisal is always to develop a suitable Do Nothing and Do Minimum option that can be used as a consistent baseline against which other options are compared. The Do Nothing represents the 'walk-away' option; cease all maintenance and repairs to existing defences and watercourse activities. This therefore represents a scenario with no intervention in the natural processes and serves as a baseline against which all other options are compared.

Assessing the level of risk for both the Do Nothing and Do Minimum options needs to consider how the watercourse will change and how any flow controlling assets or flood defences will react or deteriorate over the appraisal period. The following recommendations are therefore used for the Do Nothing and Do Minimum options:

3.2.1 Do Nothing - Liddel Water

Under the Do Nothing scenario the watercourses would not be maintained. This would lead to a gradual degradation of the banks and vegetation growth. However, as the floodplain is used recreationally, it is likely to remain well maintained for non-flood reasons; thus the band and floodplain roughness is not anticipated to increase significantly. The Do Nothing scenario is represented in the model as a 10% increase in Manning's 'n' roughness within the town and a 20% increase for all other areas. This is applied throughout the appraisal period.

There is 1 significant structure on the model reach that will impact the hydraulic capacity of the Liddel Water, a stone arch bridge located at NGR 348133 586982. Recently, a pedestrian cycle bridge over the Liddel Water was constructed immediately upstream of the town at NGR 348740 587771. The design of the bridge took cognisance of previous flood study work undertaken by Halcrow when setting the level of the soffit; 101.1 mAOD on the right-hand bank rising to 103.74 mAOD on the left hand bank. This provided a freeboard of 1.2 m for the 1 in 200-year peak water level as previously assessed. It is considered that this structure is therefore hydraulically insignificant and therefore will not be included in the model, however, a review of peak water levels derived as part of this study will determine whether the structure will be added to the model at a later date. The justification for this decision is that unnecessary compilations to the model may have a detrimental impact in terms of model stability and model run times.

Stone Arch Bridge	Pedestrian Cycle Bridge
	

There are four culverts on the tributaries Short Sike and Charlies Sike that will be assessed for blockage risk during sensitivity testing. There are no other structures within the Liddel Water which would impact on flood risk. Bridge blockage may occur due to the presence of piers within the Liddel Water channel.

3.2.2 Do Minimum - Liddel Water

The Do Minimum scenario effectively represents the current scenario whereby the watercourse and all structures are maintained and replaced if they deteriorate to a point that is unacceptable. Manning's roughness represents current conditions and no bridge blockage is assumed.

3.3 Aims of investment appraisal

The aim of the investment appraisal is to identify the properties that are most of risk, identify flood mechanisms that impact the village, the damage that results from flooding and the cost of mitigating against flood damages to the highest, reasonably achievable standard of protection. The most challenging aspect of the appraisal will be defending properties on the waterfront without impacting on the aesthetic ideal of the village.

3.3.1 Accounting for climate change

Under the Climate Change (Scotland) Act (2009) local authorities have a duty to use an evidence-based approach to develop means to reduce the impact of climate change through mitigation measures (reducing emissions), planning to adapt to a changing climate and acting sustainably. This project appraisal fulfils the ‘adaptation’ and ‘acting sustainably’ duties.

4 Flood risk management options

4.1 Critical success factors (objectives)

The long list of options has been assessed against a number of critical success factors:

1. Options whether in isolation or combination must reduce flood risk providing an appropriate level of protection to people, property, business, community assets and natural environment.
2. Options must be technically appropriate and feasible.
3. Options should help to deliver sustainable flood risk management (e.g. help contribute to amenity and urban regeneration, improve the environment and biodiversity and improve or reduce existing maintenance regimes).
4. Options should not have insurmountable or legal constraints (e.g. land ownership, health and safety or environmental protection constraints).
5. Options should represent best value for money and minimise the maintenance burden and costs as much as possible.
6. Desirable BCR when measured in parallel with other success criteria
7. Should incorporate National, Regional and Local agendas/objectives.
8. Should be deliverable by 2028 or a future agreed funding period when assessed with other success criteria.

4.2 Guideline standard of protection

The Scottish Government do not specify design standards for flood protection schemes. However, the standard of protection against flooding typically used in Scotland is the 0.5% AP flood (1 in 200 year). This standard is the level of protection required for most types of residential and commercial/industrial development as defined by Scottish Planning Policy (SPP).

Whilst design standards are a useful tool in terms of engineering goals and useful benchmarks, as well as in clear communication to stakeholders and the public, there is a general move in Scotland away from design standards to a risk based approach. Restricting options to desired standards of protection can limit consideration of factors that influence defence effectiveness and can limit future responses to external factors.

It is expected that a variety of protection levels are considered during the design process including the 0.5% and 1% annual probabilities and in some cases a lesser level. The guidance also states that options should be tested against a 1% annual probability plus allowances for climate change.

Based on the above guidance the aim of the scheme will be to assess options up to the 0.5% AP (200 year) flood if possible, but to test lower return period events if appropriate. Based on the fact that 2% AP floods (50 year) have been witnessed recently elsewhere in Scotland causing significant flood damage, it is not anticipated that a standard of protection less than this is deemed to be appropriate in terms of the critical success factors for this study.

4.3 Short term structural and maintenance recommendations and quick wins

The structures in and around Newcastleton were given conditions Grade 1 or 2 (Very good or Good). The asset review only identified some basic maintenance and inspection recommendations:

- Minor repairs to cracks in concrete could be carried out as well as removal of vegetation
- Some channel reaches are overgrown and in need of maintenance
- Some culverts inlets/outlets are overgrown with surrounding vegetation or partially blocked with sediment. Vegetation should be trimmed and sediment removed

The sited structures that could have maintenance improved are given in Table 4-1, Asset Reference refers to the Asset Review AEM-JBAU-NC-00-RP-A-0004-Asset_Review-S0-P01.03.

Table 4-1: Short term maintenance recommendations

Ref	Problem	Actions	Structure
8	Small number of cracks and minor vegetation growth through localised cracks	Vegetation to be removed and cracks to be filled.	 ***Upstream face of bridge***  ***Downstream face of bridge***
9	Vegetation overgrown around culvert. Debris partially blocking the inlet	Vegetation to be trimmed and sediment/debris to be removed from the inlet	 ***Culvert inlet with debris across opening***  ***Culvert outlet with overgrown vegetation***

4.4 Non-structural flood risk management recommendations

4.4.1 Flood warning

Newcastleton village already has a flood warning area which uses the Liddel Water @ Newcastleton gauge as part of the Scottish Borders river flood warning scheme which will be maintained. This provides site specific advanced warning of flooding at Newcastleton. SEPA and Scottish Borders Council should continue to monitor the performance of this system particularly during high flow events. Recently, the flood warning system has resulted in the evacuation of the town which transpired to be a false alarm. Another incident showed water levels in the Liddel Water reached close to the top of bank, with no warning being declared. These incidents indicate that improvements to the flood warning could be made with the following actions being taken.

- Review of the warnings given by SEPA and feedback to SEPA if events are missed or come too late to enable action.
- Improve and increase the uptake of the flood warning service.
- Recording of flood levels against stage boards within the reach and survey of wrack marks for flood events, to help build up a long-term record of flood events that could be used to help calibrate the forecast system in the future.
- Consider upgrading the forecast model in the future using available data recorded at the Newcastleton gauge.

The smaller burns could have informal flood warning systems such as RiverTrack implemented to provide a potential flood action group with advanced warning of flood events.

4.4.2 Emergency action plans

Scottish Borders Council continue to review and develop their Emergency Plans as new information becomes available. This also includes the continued use of Community Sandbag Stores located at publicly accessible areas including fire stations and school grounds. Resilient Communities sandbag stores are now also widely distributed across the Scottish Borders in areas that have signed up to the Resilient Communities Initiative. Regular reviews of the community level emergency plan should be carried out to ensure that the following are up to date:

- Flood maps,
- Properties at risk (and any protected by PLP)
- Safe access and egress routes,
- Flood warning actions and escalation plans,
- Dissemination roles and responsibilities,
- Evacuation procedures,
- Onsite and/or temporary refuge locations/planning, and
- Back-up planning.

4.4.3 Community flood action groups

Scottish Borders Council has engaged with the community and has developed a Resilient Communities group in Newcastleton. This included developing and reviewing emergency plans and facilitating resilient communities plans. Community Flood Action Groups will also supplement and inform other actions in this PVA.

Everyone is responsible for protecting themselves and their property from flooding. Property and business owners can take simple steps to reduce damage and disruption to their homes and businesses should flooding happen. This includes preparing a flood plan and flood kit, installing property level protection, signing up to Floodline and the Resilient Communities Initiative, and insuring that properties and businesses are insured against flood damage.

Emergency planning should encourage communication at a community level to ensure good response rates during a flood. Newcastleton has a Resilient Communities group which should be continued to be supported.

4.4.4 Property level protection (PLP)

The number of properties at risk of flooding per return period determined by whether the depth of water is above the finished floor level of each property. The number of residential and commercial properties at risk and could potentially increase their Standard of Protection (SoP) by the uptake of PLP products are presented in Table 4-2.

Table 4-2: Total of properties at risk of flooding per return period

RP (yrs)	No. of Residential properties	No. of Commercial properties	Total No. of properties
2	0	0	0
5	0	0	0
10	1	2	3
25	21	7	28
30	29	7	36
50	55	10	65
75	74	11	85
100	84	11	95
200	166	15	181
500	298	22	320
1000	366	23	389

Newcastleton is a small village which is primarily residential with few commercial buildings, therefore, there are not many potentially difficult properties to protect. The only potentially difficult properties to protect would be Newcastleton Health Centre on Moss Road and the Newcastleton Primary School and Church on Montagu Street.

4.4.5 Natural Flood Management

A full report into the potential for Natural Flood Management (NFM) measures along the Hermitage and Liddel Water and its sub-catchments is provided in the NFM Report, referenced in the Supporting Documents section at the beginning of this report.

The report indicated that the following NFM measures that could be used in the four key areas of the catchment:

Location	Potential interventions
Liddel Water south of confluence	Washland, hedgerows, riparian woodland, buffer strips, stabilisation of banks
Liddel Water and the eastern catchment north of the confluence	Gully woodland planting, upland habitat restoration and tree planting, in-stream debris dams
Hermitage Water and the western catchment north of the confluence	Upland habitat restoration, gully woodland planting, in-stream debris dams, meandering of tributaries
Short Sike, Charlie's Sike and Coulter Sike	Upland vegetation planting, upland drain blocking, leaky bunds, in-stream debris dams

These NFM measures could be undertaken as:

- Incorporation of NFM within a proposed FPS either as a separate option or to supplement other structural options
- Inclusions within any wider Scottish Borders NFM funding mechanism to deliver NFM
- Delivery of measures via an FPS as percentage uplift included within the total FPS costs set aside for local NFM and RBMP measures.

4.5 Long list of options

The following table provides an overview of potential flood alleviation options targeting flood risk from the Liddel Water and its tributaries in Newcastleton. Those with the potential to alleviate flood risk from high magnitude flood events or which offer multiple catchment-wide benefits have been assessed further in the following sections.

Category	Measure	Discussion
Avoid	Relocation	**Technical**: Relocation or abandonment of properties not politically or socially viable. Option not cost effective as purchase costs will be same as capped damages. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Multiple objections likely if carried out via a FPS. **Decision: Option discounted on all watercourses**
Prepare	Flood warning	**Technical**: A Flooding Warning service is in place covering the gauges on the Liddel Water. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: No significant constraints. **Decision: All further options assume that Flood Warning is maintained on the Liddel Water. Recommendation to improve flood warning carried forward.**
	Resistance - means of reducing water ingress into a property to enable faster recovery	**Technical**: All Scottish Borders properties at risk of flooding are covered by the Flood Protection Products Discount scheme operated by the council. The depth and velocity of the Liddel Water may exceed capabilities of retrofit PLP products. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: May not be accepted by the community as the only flood protection measure. **Decision: Option carried forward alongside Flood Warning Option.**
	Resilience - means of reducing the impacts of flood water ingress on a property to enable faster recovery	**Technical**: An extremely costly option when considering the number of property modifications that would be required. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: May not be accepted by the community as the only flood protection measure. **Decision: Option discounted**
Protect	Watercourse maintenance	**Technical**: No technical constraints identified but due to the good condition of the watercourses this option is unlikely to provide a noticeable flood protection benefit. **Environmental**: Channel maintenance may have minor negative impacts if spawning areas are disrupted but these are unlikely to be significant. Sediment removal would likely harm aquatic ecosystems and increase bank erosion. **Constraints**: Possible stretching of council resources to ensure an intensified inspection and maintenance regime is carried out. **Decision: Option carried forward alongside other broader options**
	Natural Flood Management (NFM)	Natural Flood Management options have been assessed in a standalone report and will be carried forward where opportunities have been identified. These include potential riparian woodland planting, upland habitat restoration and debris dams.
	Storage	**Technical**: The Liddel Water has many tributaries, including the Hermitage Water immediately upstream of the village. This will make a single location for storage infeasible on the Liddel Water with many sites being required. Storage options on the Charlie's Sike can be taken forward. **Environmental**: The Liddel Water is not protected by

Category	Measure	Discussion
		environmental conservation designations and thus should not be constrained by specific conservations guidelines. The watercourse is however connected to the River Esk which discharges to the Solway Firth SAC designated for supporting various marine and mammal species. Any storage would have to have minimal effects on these species. **Constraints**: None **Decision: Option carried forward on Charlie's Sike.**
	Control Structures	**Technical**: Large control structures would be required on the Liddel Water. **Environmental**: Could provide wetland habitats. **Constraints**: Unlikely to be cost effective due to the size of the structures required and the lack of floodplain space for useful volumes of water to be held back. **Decision: Option discounted**
	Demountable defences	There would be no real benefit to the use of demountable defences over fixed defences since costs would be greater and reliability lower than their fixed alternatives. **Technical**: Ensuring constant availability of trained personnel capable of deploying defences may put excessive pressure on the council or highlight a requirement for even more costly automatic defences. Defence deployment likely to be unreliable compared to fixed defences. Newcastleton is isolated and difficult to access during times of flood. Deployment of demountable defences would depend on local residents and volunteers. **Environmental**: No significant environmental or RBMP benefits or impacts although likely to be preferred from an environmental standpoint when compared to direct defences. **Constraints**: None **Decision: Option discounted due to cost relative to permanent defences**
	Direct defences	**Technical**: There is likely to be sufficient space available on the Liddel Water for embankments and flood walls making this a sensible option. **Environmental**: Defences may cause an obstruction for some species, especially if walls are constructed rather than embankments. **Constraints**: Some objections likely at public consultation. **Decision: Option carried forward**
	Channel Modification	**Technical**: Unlikely to provide flood protection benefits as an independent option due to the scale that would be required to accommodate the large flows witnessed historically. Space not available for widening of the Liddel Water but there is potential for floodplain creation or channel restoration within the Charlie's Sike. **Environmental**: Environmental benefits likely from wetland creation or enhanced channel suitability for riverine organisms. **Constraints**: Land ownerships constraints likely to be encountered and may be viewed negatively by residents favouring alternative options. **Decision: Option carried forward**
	Diversion	**Technical**: There is no suitable site for channel diversion on the Liddel Water through Newcastleton. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Diversion would be constrained by roads, properties and topography. **Decision: Option discounted**
	Bridge removal or modification	**Technical**: The bridges on the Liddel Water do not impose significant constrictions on the river during high flows so

Category	Measure	Discussion
		modification is unlikely to bring flood risk benefits. **Environmental**: Potential for improvements in line with Water Framework Directive (WFD) targets and improve RBMP. **Constraints**: None. **Decision: Option discounted**

4.6 Short List of Options

Based on the above the following options have been short listed:

- Direct defences on the Liddel Water and Charlie Sike
- Storage on the Charlie's Sike
- Channel modification of the Charlie's Sike
- Property Level Protection

Each of the options have been assessed against a current day standard of protection. If climate change is to be accounted for then additional measures will be needed. For example, additional properties will need PLP, direct defences will need to be taller and run for greater lengths, additional storage will be required within wetlands.

Watercourse maintenance and NFM shall be implemented to some extent with all short listed options. Each option should be taken alongside non-structural options such as flood warning, emergency planning and by working closely with local flood groups to increase preparedness/resilience.

4.6.1 Option 1 – Construction of a suite of direct defences across Newcastleton to provide 1 in 200 year Standard of Protection.

Option 1 – Construction of a suite of direct defences across Newcastleton to provide 1 in 200 year Standard of Protection.

Description

This option aims to provide a high standard of protection through the installation of flood walls and flood embankments. All embankments include a 600 mm freeboard and all walls will include a 600 mm freeboard.

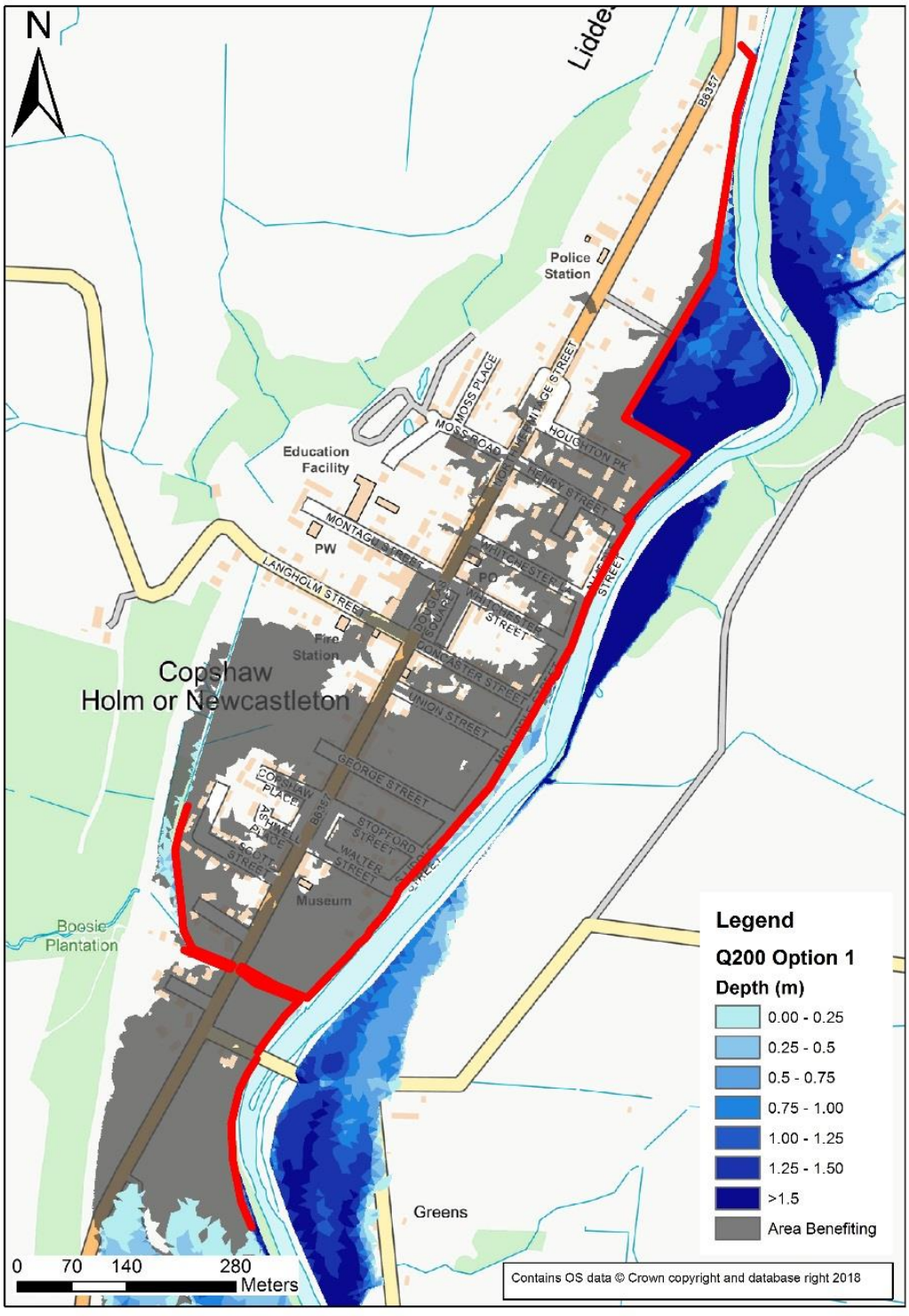
Flood defences are shown as per Figure 4-1. The proposed barrier will run from a high point on the B6357 and follow open grass land towards the town. The geometry of the defences will be such that the existing flood plain will be maintained as much as possible in order to reduce the required height of defences downstream. The northern section of the defences will be suited to embankments rather than walls to maintain a natural aesthetic, maintain walking paths and allow easy access to the watercourse for recreation.

Through the village proper, the defences will be predominately walls with approximate average heights of between 1.3 and 1.5 m. At the southern end of the village wall heights could reach up to 2m. In total, approximately 2.28 km of wall would be required.

The walls have been positioned in order to maintain the existing recreational green space adjacent to the river, observed to be well used. This serves to reduce wall heights by allowing the river the greatest possible flow area.

The flood walls will require flood gates to maintain access to green areas. These will also provide an element of resilience. Should the walls the overtopped, there is a risk that the flood water would be unable to escape. In the event of exceedance, the flood gates could be opened to allow water to drain down more quickly.

Figure 4-1: Benefit Map for Option 1 (200 year)



As part of this option the flood plain on the left hand bank of the Liddel Water will be cleared to allow passage of flood waters. Any recently planted trees will be removed.

Standard of Protection (SOP)

Modelling of the above option suggests that a standard of protection of 0.5% AP (200 year) is achievable. This equates to a flow of approximately 452 m3/s in the Liddel Water.

Alternative quick wins / Preliminary investigations

Smaller, strategically placed barriers could be implemented to prevent more frequent flooding in the short term.

Technical issues

Ground conditions around the area can be typified as alluvium with sands and fine gravel. A full GI will be required before proceeding with design. It is likely that a cut-off will be required to prevent seepage.

The area for proposed defences is constrained and may require incursion into the flood bank to achieve the desired geometry.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-NC-00-SK-C-1004-Services_Plan.

Combined sewers and raw water mains run under roads adjacent to flood wall locations. At the southern end of South Liddle Street the flood wall will need to pass an area with multiple services.

Construction Access

Construction access has been considered. Access can be facilitated though South Liddle Street, Mid Liddle Street and North Liddle Street. The village is constrained; heavy plant will impact on the public. Considerate construction may increase construction time. Issues include:

- Construction would entail heavy machinery working near to the bank and properties on the river front.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibration.
- Exclusion of public from working areas - good practice working methods such as alternative access routes and phasing of works to be considered.

Waste

All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

The area of the Charlie's Sike is adjacent to former railway line and may contain contaminants. GI should be undertaken to understand any level of contamination and impact on disposal of material.

Proximity of defence to other **structures**

The flood defences will be in close proximity to properties on South Liddle Street, Mid Liddle Street and North Liddle Street.

Environmental issues

- Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Newcastleton is a conservation area, however this excludes both the Liddel Water and the Charlie's Sike. Some construction will be required within the conservation area.
- Scheduled Monuments: No scheduled monuments within the study area.
- Listed Buildings: A small number of listed buildings are within the village but will not be affected by the works.

Engineering work next to the watercourse could result in pollution. Modification of banks could result in erosion and increased sedimentation.

Trees; TPO: A few trees may need to be removed for the construction of the defences.

Social and community issues

Residents along the river front are likely to object to the presence of a wall between properties and the river.

The river is a heavily used resource in the community and a source of tourism. The proposed works should be designed to enhance the area and add to the aesthetic nature rather than detracting from it.

Impact on downstream water levels

The modelling of this options shows that peak water levels at the downstream boundary are unaffected by the works.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regards to site works.
- Detailed ground investigation.
- Seepage analysis should be undertaken prior to detailed design.

Additional works required to account for increase in flow due to climate change

- The design of the proposed defences has been assessed with resilience in mind. The flood defences will reduce the floodplain and increase water levels within the watercourse. Should the river overtop its banks upstream of the village, there is a risk that the resultant overland flow would inundate the village and become trapped by the defences. Therefore, the proposed scheme will tie into high ground upstream of the village to mitigate this risk and there will be no need to increase the length of defences to account for climate change. However, height of the defences will need to be increased by an average of 0.5 m.
- Adaptable walls that can be raised in the future should be considered.

4.6.2 Option 2 – Construction of a suite of direct defences across Newcastleton with reduced aesthetic impact

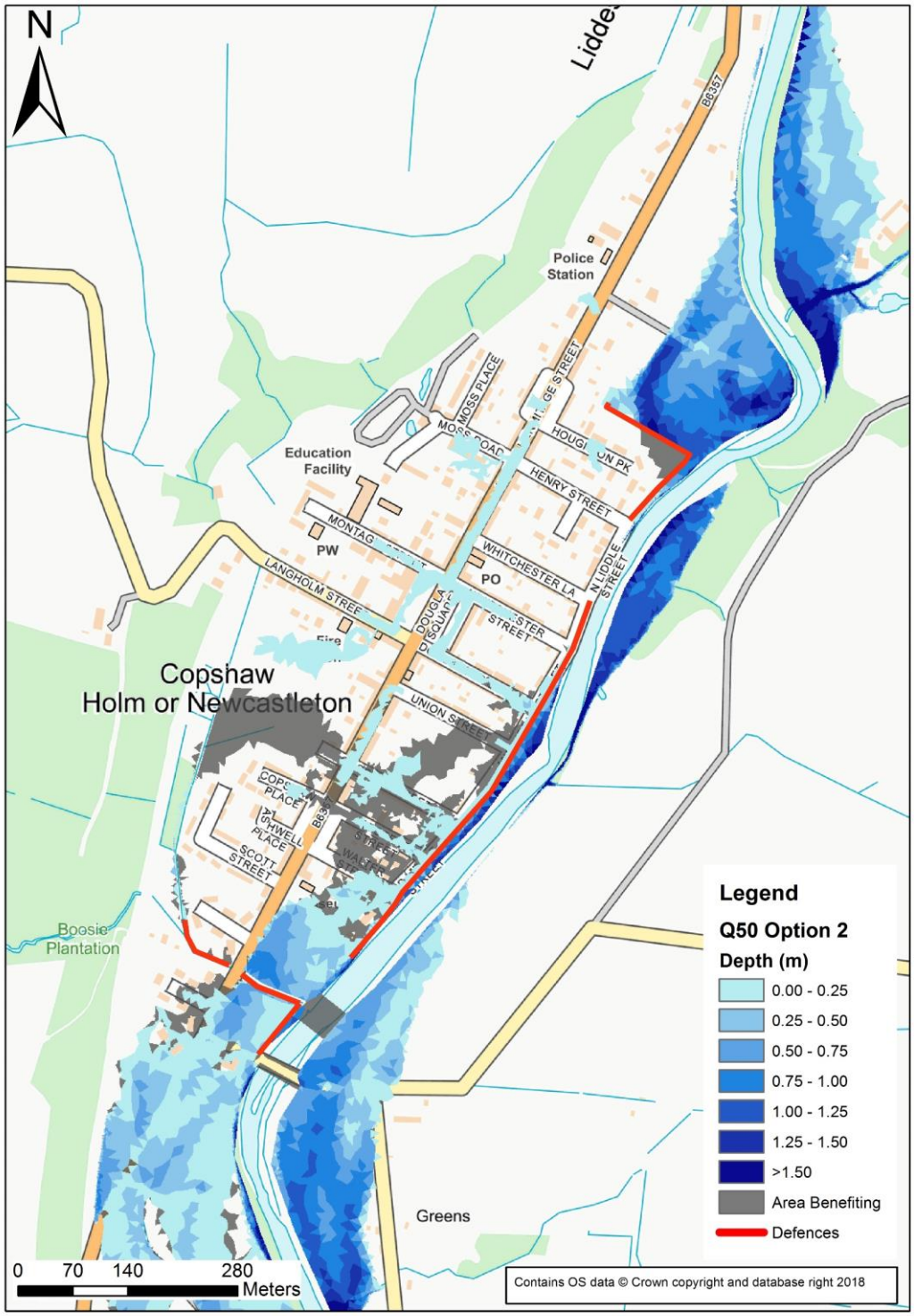
Option 2 – Construction of a suite of direct defences across Newcastleton with reduced aesthetic impact

Description

This option aims to mitigate against the worst impacts of flooding and lower return period events by strategically constructing defences over the known flood routes. This option reduces the frequency and impact of flooding however does not provide an overall SoP, as flooding is reduced but not entirely mitigated. The option will cost less that Option 1 and have a much reduced aesthetic impact on the village. However, it is unlikely to gain funding from the Scottish Government as it will not comply with the requirements of a flood protection scheme which will require funding to be supplied by the Scottish Borders Council.

Option 2 – Construction of a suite of direct defences across Newcastleton with reduced aesthetic impact

Figure 4-2: Benefit Map for Option 2 (200 year)



Standard of Protection (SOP)

This option reduces the impact and frequency of flooding but does not provide an overall standard of protection to the village.

Alternative quick wins / Preliminary investigations

Smaller, strategically placed barriers could be implemented to prevent more frequent flooding in the short term. Particularly taking into account flow paths from past flood events.

Technical issues

Option 2 – Construction of a suite of direct defences across Newcastleton with reduced aesthetic impact
Ground conditions around the area can be typified as alluvium with sands and fine gravel. A full GI will be required before proceeding with design. It is likely that a cut-off will be required to prevent seepage and proposed walls being undermined. The area for proposed defences is constrained and may require incursion into the flood bank to achieve the desired geometry.
Services Overhead and underground services have been identified and their location are shown on drawing AEM-JBAU-NC-00-SK-C-1004-Services_Plan.
Construction Access Construction access has been considered. Access can be facilitated though South Liddle Street, Mid Liddle Street and North Liddle Street. The village is constrained; heavy plant will impact on the public. Considerate construction may increase construction time. Issues include: • Construction would entail heavy machinery working near to the bank and properties on the river front. • Temporary storage of topsoil and subsoil in heaps and stockpiles. • Groundworks and construction vehicles are likely to cause noise and vibration. • Exclusion of public from working areas - good practice working methods such as alternative access routes and phasing of works to be considered.
Waste All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works. The area of the Charlie's Sike is adjacent to former railway line and may contain contaminants. GI should be undertaken to understand any level of contamination and impact on disposal of material.
Proximity of defence to other **structures** The flood defences will be in close proximity to properties on South Liddle Street, Mid Liddle Street and North Liddle Street.
Environmental issues • Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Newcastleton is a conservation area, however this excludes both the Liddel Water and the Charlie's Sike. Some construction will be required within the conservation area. • Scheduled Monuments: No scheduled monuments within the study area. • Listed Buildings: A small number of listed buildings are within the village but will not be affected by the works. Engineering work next to the watercourse could result in pollution. Modification of banks could result in erosion and increased sedimentation. Trees; TPO: A few trees may need to be removed for the construction of the defences.
Social and community issues Residents along the river front are likely to object to the presence of a wall between properties and the river. The river is a heavily used resource in the community and a source of tourism. The proposed works should be designed to enhance the area and add to the aesthetic nature rather than detracting from it.
Impact on downstream water levels The modelling of this options shows that peak water levels at the downstream boundary are unaffected by the works.
Additional information required • A detailed topographic survey. • Detailed buried services survey, plotting their position with regards to site works.

Option 2 – Construction of a suite of direct defences across Newcastleton with reduced aesthetic impact

- Detailed ground investigation.
- Seepage analysis should be undertaken prior to detailed design.

Additional works required to account for increase in flow due to climate change

- This option has been designed to mitigate against known flooding issues. If the village is to be defended against climate change then this option would need to be extended as per Option 1.
- Adaptable walls that can be raised in the future should be considered.

4.6.3 Option 3 – Charlie's Sike Restoration, New Open Channel & Floodplain

Option 3 – Charlie's Sike Restoration, New Open Channel & Floodplain

Description

The Charlie's Sike is a straight channel, that runs adjacent to the back of properties. This option aims to provide additional flood resilience in the channel by undertaking restoration works to generate a more natural, sinuous channel through the area known locally as the lakes. This option would then use the new floodplain of the Charlie's Sike to produce an area of active wetland with enhanced biodiversity while simultaneously providing additional flood storage.

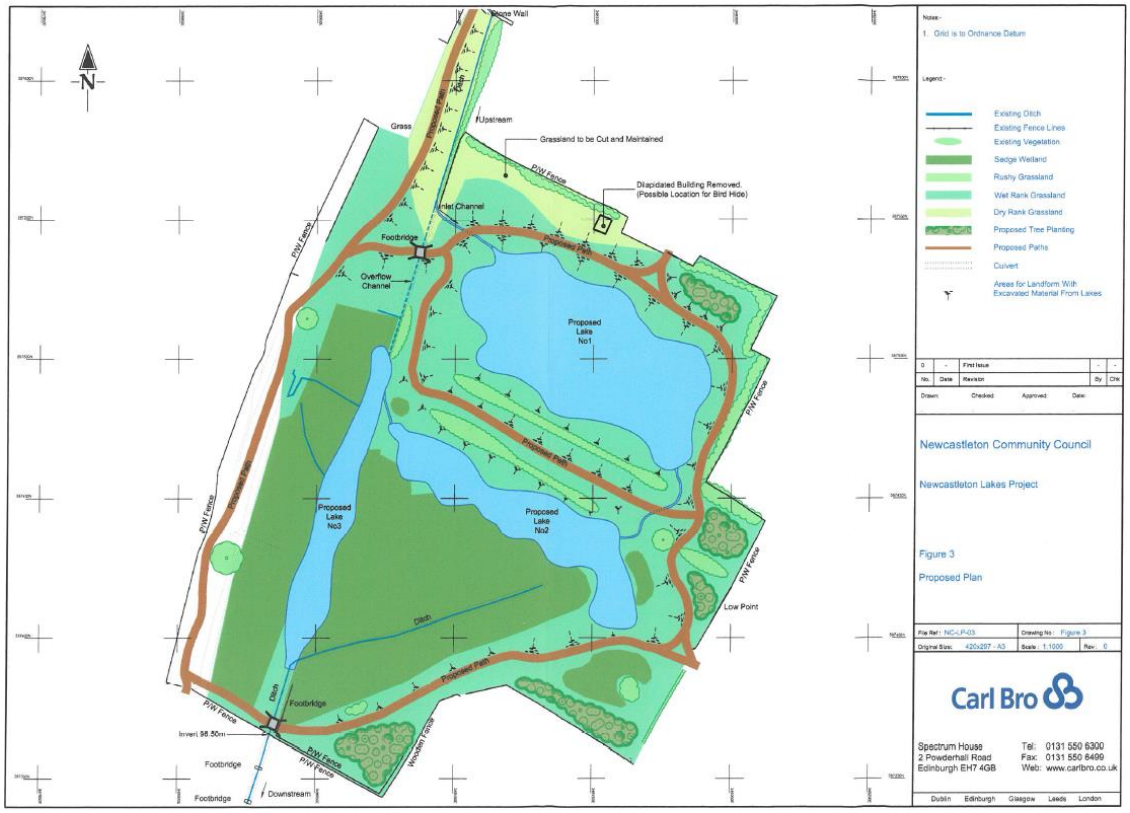
Unfortunately, options on the Charlie's Sike will have limited impact on flood risk as, the principle source of flood risk is from Liddel Water which will not be affected by this option. However, this option will provide resilience against surface water flooding in the village, overland flow from the hills to the north west of the village and allow for enhancement of the village through a flood scheme. The area of the proposed works is shown in Figure 4-3.

In 2004, a scoping exercise to enhance wildlife interest, provide community facilities for all abilities and provide an education resource investigated how the area could be landscaped to create ponds and walkways. A schematic of the proposals is shown in Figure 4-4. The proposals were to be flood neutral, having neither a beneficial or detrimental impact on flood risk.

Figure 4-3 Option 3 Schematic

Option 3 – Charlie's Sike Restoration, New Open Channel & Floodplain

Figure 4-4 Proposed Wetlands from Newcastleton Lakes Project[6]



Standard of Protection (SOP)

Can work in conjunction with Option 1 which will provide a 1 in 200 year standard of protection.

Alternative quick wins / Preliminary investigations

Existing fence lines on properties could be waterproofed or replaced with barriers to prevent flood waters from the Charlie's Sike placing properties at flood risk.

Technical issues

The site is adjacent to the old railway land and therefore, excavated material could be considered contaminated.

Services

Overhead and underground services have been identified and their location are shown on drawing AEM-JBAU-NC-00-SK-C-1004-Services_Plan.

Construction Access

Construction access has been considered. Access can be facilitated though Langholm Street. The village is constrained; heavy plant will impact on the public. Considerate construction may increase construction time. Issues include:

- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibration.
- Exclusion of public from working areas.

Waste

All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

6 Newcastleton Lakes Scoping Project, Preliminary Surveys and Recommendations, Andrew McBride, Iain McDonald, December 2004.

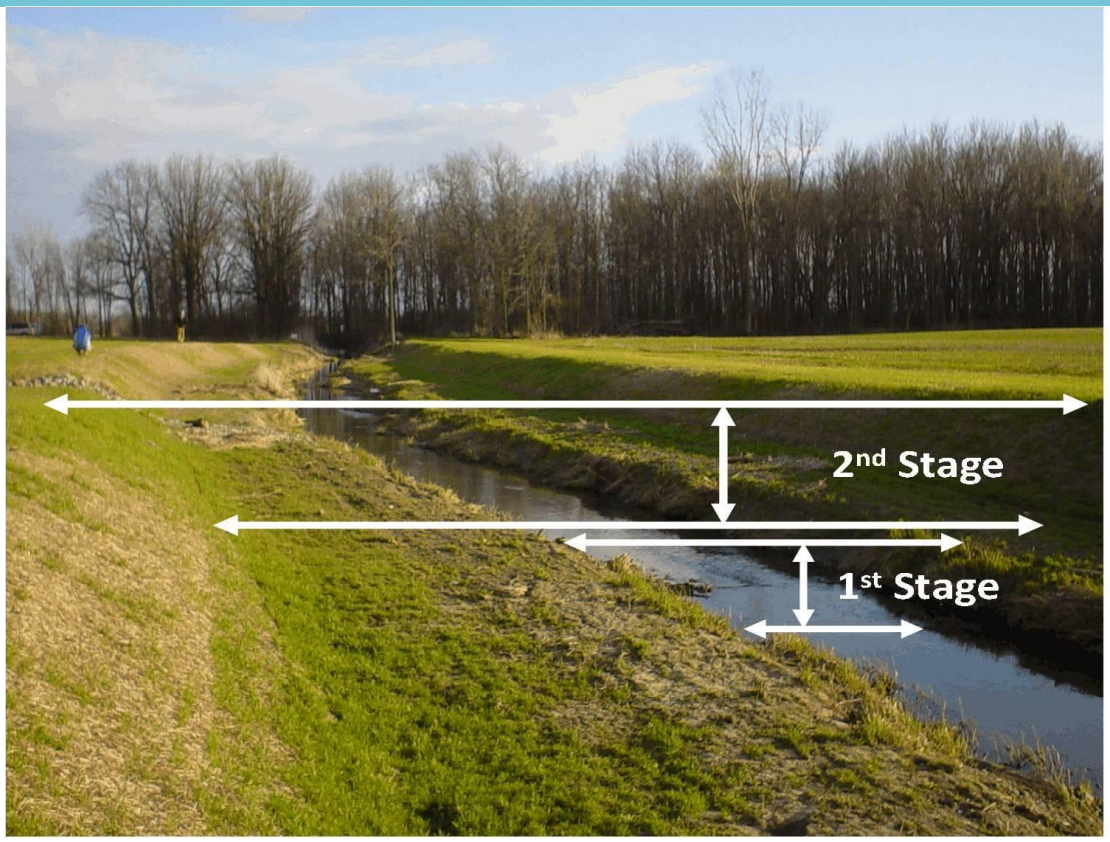
Option 3 – Charlie's Sike Restoration, New Open Channel & Floodplain
The area of the Charlie's Sike is adjacent to the former railway line and may contain contaminants. GI should be undertaken to understand any level of contamination and impact on disposal of material.
Proximity of defence to other **structures** The works would not impact on any structures nor impact any properties
Environmental issues • Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Newcastleton is a conservation area, however this excludes both the Liddel Water and the Charlie's Sike. Some construction will be required within the conservation area. • Scheduled Monuments: No scheduled monuments within the study area. • Listed Buildings: A small number of listed buildings are within the village but will not be affected by the works. Engineering work next to the watercourse could result in pollution. Modification of banks could result in erosion and increased sedimentation.
Social and community issues The works will have negligible negative impact on the community during construction but will provide an enhancement to social and community issues following construction.
Impact on downstream water levels The modelling of this options shows that peak water levels at the downstream boundary are unaffected by the works.
Additional information required • A detailed topographic survey. • Detailed buried services survey, plotting their position with regards to site works. • Detailed ground investigation.
Additional works required to account for increase in flow due to climate change • The proposed works will utilise the entire area available to produce a wetland that will benefit the entire community and, as such, there will be limited opportunity to provide additional volume. Adaptability to climate change should be applied through the use of hard defences.

4.6.4 Option 4 Charlie's Sike Two Stage Channel

Option 4 – Charlie's Sike Two Stage Channel
Description The Charlie's Sike is a straight channel, that runs adjacent to the back of properties. This option aims to provide additional flood resilience by undertaking ground works on the right hand bank to provide additional floodplain storage. Unfortunately, options on the Charlie's Sike will have limited impact on flood risk as, the principle source of flood risk is from the Liddel Water which will not be affected by this option. However, this option will provide resilience against surface water flooding in the village, overland flow from the hills to the north west of the village and allow for enhancement of the village through a flood scheme. The area of the proposed works is shown in Figure 4-5. An example of a two stage channels is shown below

Figure 4-5 Option 4 Schematic

Option 4 – Charlie's Sike Two Stage Channel



Taken from https://blancharddemofarms.org/practices/two-stage-ditch

Standard of Protection (SOP)

Can work in conjunction with Option 1 which will provide a 1 in 200 year standard of protection.

Alternative quick wins / Preliminary investigations

Existing fence lines on properties could be waterproofed or replaced with barriers to prevent flood waters from the Charlie's Sike placing properties at flood risk.

Technical issues

The site is adjacent to the old railway land and therefore, excavated material could be considered contaminated.

Services

Overhead and underground services have been identified and their location are shown on drawing AEM-JBAU-NC-00-SK-C-1004-Services_Plan.

Construction Access

Construction access has been considered. Access can be facilitated though Langholm Street. The village is constrained; heavy plant will impact on the public. Considerate construction may increase construction time. Issues include:

- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibration.
- Exclusion of public from working areas.

Waste

All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

The area of the Charlie's Sike is adjacent to the former railway line and may contain contaminants. GI should be undertaken to understand any level of contamination and impact on disposal of material.

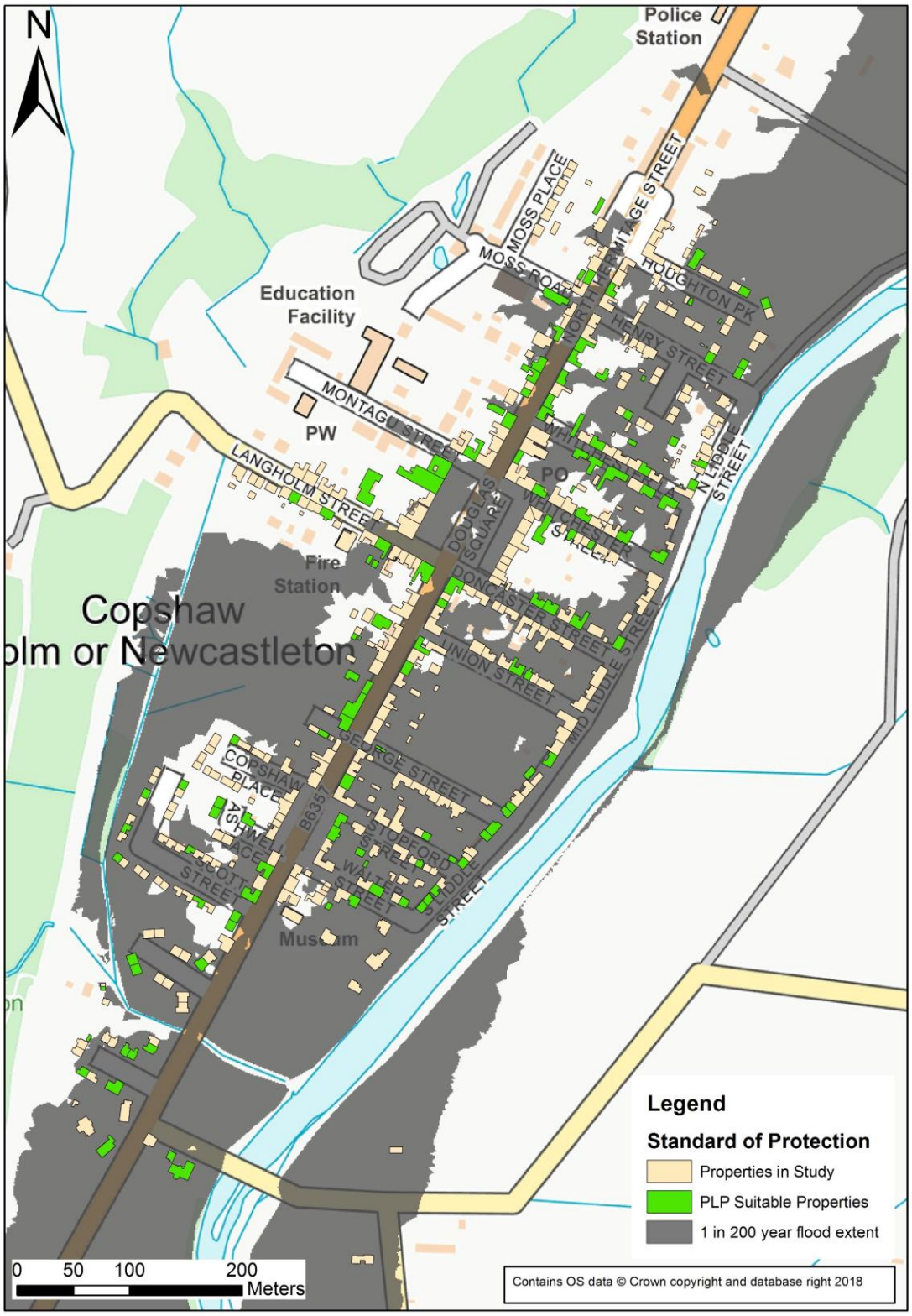
Option 4 – Charlie's Sike Two Stage Channel
Proximity of defence to other **structures** The works would not impact on any structures nor impact any properties
Environmental issues • Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Newcastleton is a conservation area, however this excludes both the Liddel Water and the Charlie's Sike. Some construction will be required within the conservation area. • Scheduled Monuments: No scheduled monuments within the study area. • Listed Buildings: A small number of listed buildings are within the village but will not be affected by the works. Engineering work next to the watercourse could result in pollution. Modification of banks could result in erosion and increased sedimentation.
Social and community issues The works will have negligible negative impact on the community during construction but will provide an enhancement to social and community issues following construction.
Impact on downstream water levels The modelling of this options shows that peak water levels at the downstream boundary are unaffected by the works.
Additional information required • A detailed topographic survey. • Detailed buried services survey, plotting their position with regards to site works. • Detailed ground investigation.
Additional works required to account for increase in flow due to climate change • The works will make use of the reasonably available space to create the channel. Adaptability to climate change should be applied through the use of hard defences.

4.6.5 Option 5 Property Level Protection

Option 5 – Property Level Protection
Description This option aims to provide an increased standard of protection for all properties where relevant by protecting properties up to a maximum depth of 0.6m. Beyond this water depth a buildings integrity can be compromised. This option includes the survey, design and implementation of relevant PLP products to each property experiencing flooding. Some properties are not suitable for PLP given their construction. The number of properties likely to benefit from PLP is 126. There is flood warning on the Liddel Water however this could be improved. There are a number of vulnerable, elderly people in the community who are at risk and therefore automatic PLP is recommended, which will protect the property without input from the property owner.

Option 5 – Property Level Protection

Figure 4-5: PLP option for 200 year event



Standard of Protection (SOP)

Modelling suggests that PLP will mitigate flood risk to 125 properties in Newcastleton up to the 200 year event.

Option 5 – Property Level Protection
Alternative quick wins / Preliminary investigations Continue with the Council subsided PLP scheme for properties which opt for it. Provide stores of flood resilience materials such as sand bags to be utilised in times of flood.
Technical issues All properties would require surveying by competent parties to determine which products are appropriate. Properties with none-standard to large entrances may require bespoke options which can increase costs. The Scottish Government's Blueprint on PLP[7] should be considered when implementing this option.
Construction Issues Some properties may require bespoke PLP products and building remedial works may be required to allow the products to work effectively.
Environmental issues None.
Social and community issues Due to the prevalence of flooding and highly engaged community, PLP alone may not be an acceptable option. Residents are likely to expect more significant measures to be undertaken.
Impact on downstream water levels None.
Additional information required • Public engagement meetings. • Flood risk reviews on each property.
Additional works required to account for increase in flow due to climate change • Some properties identified as suitable for PLP may become unsuitable with increasing river flows. Additionally, some properties that are not expected to flood frequently enough to make PLP worthwhile at present may be expected to flood more frequently in the future.

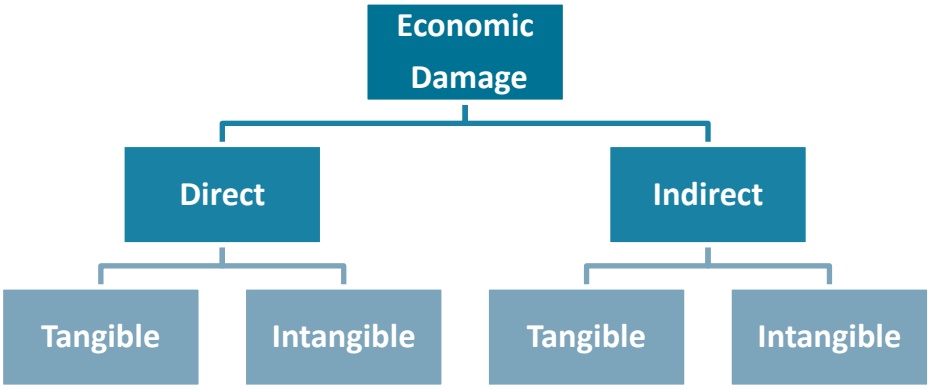
7 Scottish Government (2014). Assessing the Flood Risk Management Benefits of Property Level; Blueprint for Local Authorities and Scottish Water. Final Report v 2.0. 13 November 2014

5 Investment appraisal

5.1 Damage methodology

Flood damage assessment can include direct, indirect, tangible and intangible aspects of flooding, as shown in the Figure 5-1. Direct damages are the most significant in monetary terms, although the MCM and additional research provide additional methodologies, recommendations and estimates to account for the indirect and intangible aspects of flood damage.

Figure 5-1: Aspects of flood damage



Flood damage estimates have been derived for the following items:

1. Direct damages to residential properties;
2. Direct damages to commercial and industrial properties;
3. Indirect damages (emergency services);
4. Intangible damages associated with the impact of flooding;
5. Damage to vehicles;
6. Emergency evacuation and temporary accommodation costs.

The following assumptions and additional data were used to improve and provide the necessary information to supplement the above datasets.

5.2 Baseline Damages

The baseline flood damages are provided overleaf.

Do Nothing

Assumptions:

Maintenance ceased, increasing hydraulic roughness due to vegetation growth and accumulation of in-channel obstructions, Manning's 'n' increased by 20%. Bridges assumed to partially block (inverts raised by 33% and bridge piers increased in width by 1m).

Properties at risk:

The total number of properties inundated above threshold level for the "Do Nothing" Scenario in Newcastleton has been assessed and is provided in the table below.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	48	55	93	128	176	217	260	283	388	408	409
Non-residential	5	7	10	14	15	15	18	17	22	25	26
Total	53	62	103	142	191	232	278	300	410	433	435

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. Where repeated likely flooding of properties causes excessive damages over the appraisal period, the assessed damages are capped at the estimated value of the property. Flooding from the river will result in damages that exceed the property value for the majority of the most affected properties over the appraisal period. It can also be seen that the most affected properties account for a small percentage of the likely damages over the appraisal period which implies localised protection of the most affected properties will be ineffective at mitigating overall damages.

Rank	Property address	Pvd (£k)	Percentage of total Pvd
1	Struan, TD9 0TA	120	2.12%
1	THE CRAIG, WALTER STREET, TD9 0QL	120	2.12%
3	5, STOPFORD STREET, TD9 0QW	116	2.05%
4	2 STOPFORD STREET TD9 0QW	113	2.00%
5	TOLLBAR COTTAGE, TD9 0TA	105	1.86%
5	2 GEORGE ST	105	1.86%
5	1 GEORGE STREET	105	1.86%
5	13 SOUTH HERMITAGE	105	1.86%
5	4 SOUTH LIDDLE	105	1.86%
5	5 SOUTH LIDDLE ST	105	1.86%

Event property damages:

JBA's damage calculation method provides event damages based on MCM depth damage curves. A full explanation of the derivation of damages and results is provided in Appendix B. These represent the total potential flood damages based on the modelled flood level. Damages include all direct and indirect property flood damages.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	85	165	471	1014	1933	2918	3620	4957	8260	14787	15865
Non-residential	2	3	5	25	53	84	104	135	350	771	838
Total	87	168	476	1039	1986	3002	3724	5092	8610	15558	16702

The above damages are used to calculate Annual Average Damages (AAD). Plotting the damages against the frequency of flooding (annual probabilities) allows us to determine the AAD as the area beneath the loss probability curve. The above shows that flood damages rise significantly between the 10 and 25 year flood events when flooding is likely to occur under existing conditions.

Breakdown of damages:

A summary of the proportion of total damages by each damage component is provided in the table below. Total AAD's are converted to Present Value damages assuming a 100 year appraisal period and HM Treasury discount rates.

Do Nothing flood damages (£k):

Property PVd	Indirect PVd	Intangible PVd	Total PVd
6,604	495	903	8,002

Do Minimum

Assumptions:

Maintenance carried out as scheduled, present-day hydraulic roughness representative of a winter scenario with no bridge or structure blockage. The small culvert between the Short Sike and the Charlie's Sike is assumed to be 100% blocked.

Properties at risk:

The total number of properties inundated above threshold level for the "Do Nothing" Scenario in Newcastleton has been assessed and is provided in the table below.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	0	0	1	21	29	55	74	84	166	298	366
Non-residential	0	0	1	5	5	8	10	10	13	21	22
Total	0	0	2	26	34	63	84	94	179	319	388

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. Where repeated likely flooding of properties causes excessive damages over the appraisal period, the assessed damages are capped at the estimated value of the property. Flooding from the river will result in damages that exceed the property value for the majority of the most affected properties over the appraisal period. It can also be seen that the most affected properties account for a small percentage of the likely damages over the appraisal period which implies localised protection of the most affected properties will be ineffective at mitigating overall damages.

Rank	Property address	Pvd (£k)	Percentage of total Pvd
1	2, GEORGE ST, TD9 0QP	105	3.18%
1	5, SOUTH LIDDLE STREET, TD9 0RW	105	3.18%
3	STRUAN, TD9 0TA	88	2.65%
4	CAMPEROWN, TD9 0TA	86	2.60%
5	1, GEORGE STREET, TD9 0QP	72	2.18%
5	THE CRAIG, WALTER STREET, TD9 0QL	67	2.03%
5	13, SOUTH LIDDLE STREET, TD9 0RW	63	1.90%
5	13, SOUTH HERMITAGE STREET, TD9 0QN	61	1.86%
5	2, STOPFORD STREET, TD9 0QW	59	1.78%
5	2, WALTER STREET, TD9 0QL	56	1.71%
5	2, GEORGE ST, TD9 0QP	105	3.18%

Event property damages:

JBA's damage calculation method provides event damages based on MCM depth damage curves. A full explanation of the derivation of damages and results is provided in Appendix B. These represent the total potential flood damages based on the modelled flood level. Damages include all direct and indirect property flood damages.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	0	0	37	397	557	1,177	1,949	2,568	4,813	9,007	12,883
Non-residential	0	0	2	5	5	28	53	71	131	437	672
Total	0	0	39	402	562	1,205	2,002	2,639	4,944	9,444	13,555

The above damages are used to calculate Annual Average Damages (AAD). Plotting the damages against the frequency of flooding (annual probabilities) allows us to determine the AAD as the area beneath the loss probability curve. The above shows that flood damages rise significantly between the 10 and 25 year flood events when flooding is likely to occur under existing conditions.

Breakdown of damages:

A summary of the proportion of total damages by each damage component is provided in the table below. Total AAD's are converted to Present Value damages assuming a 100 year appraisal period and HM Treasury discount rates.

Do Minimum flood damages (£k):

Property PVd	Indirect PVd	Intangible PVd	Total PVd
3,031	168	499	3,698

5.3 Options

The flood damages for each option were calculated for each return period up to the 1% AP (1000 year) event. Average annual flood damages were converted to present value damages using the discount factor and the residual damages for each option were compared against the flood damages estimated for the Do Nothing Scenario. This comparison shows the damages avoided as a result of the options; interventions, also known as the benefit.

In line with current guidance[8] the PLP option was factored to account for the effectiveness and performance of measures and availability if homeowners to install and operate the measures. PLP was assumed to be 84% effective.

5.4 Damage Benefit Summary

The table below summaries the damages avoided for each option. The results show that there is potential for significantly reducing the cost of flood damages through mitigation. The "Do Minimum" option avoids approximately £3.8m which highlights the importance of maintaining the channel and mitigating against bridge blockage. Options 3 and 4 synergise with the "Do Minimum" scenario to reduce flood damages however do little on top of the "Do Minimum".

Options 1 and 2 do the most to reduce flood damages. The remaining damages of Option 1 are a result of events greater than the SOP and residual surface water flooding behind the defences. Option 2 has a significant impact on reducing flood damages however fails to provide a standard of protection.

Table 5-1: Option Benefit Summary (£k)

			Option 1	Option 2	Option 3	Option 4	Option 5
Option Name	Do Nothing	Do Minimum	Direct Defences	Partial Direct Defences	Charlie's Sike Restoration	Charlie's Sike Two Stage Channel	PLP
SOP	2	10	200	10	10	10	200
BENEFITS:							
PV Monetised Flood Damages (£K)	8,002	3,698	8,21	1,303	2,556	2,358	2,439
Total PV Damages Avoided/Benefits (£k)		4,304	7.180	6,699	1,142	1,340	5,563
Total PV Damages Avoided/Benefits (adjusted) (£k)		4,304	7.180	6,699	1,142	1,340	4,673

Options 3 and 4 have been assessed against the Do Minimum rather than the Do Nothing, as the implementation of these schemes would not impact flood risk on the Liddel Water or require on-going maintenance of the Liddel Water.

8 Post-Installation Effectiveness of Property Level Flood Protection, Final Report FD2668, 2014, DEFRA

6 Cost estimates

6.1 Price Base Date

The price base date is January 2018. The costs and benefits have been discounted over the 100 year life of the scheme to determine present values.

6.2 Whole life cost estimates

Whole life costs are typically compiled from the following four key cost categories:

1. Enabling costs. These costs relate to the next stage of appraisal, design, site investigation, consultation, planning and procurement of contractors.
2. Capital costs. These costs relate to the construction of the flood mitigation measures and include all relevant costs such as project management, construction and materials, licences, administration, supervision and land purchase costs (if relevant).
3. Operation and maintenance costs. Maintenance of assets is essential to ensure that the assets remain fit for purpose and to limit asset deterioration. Costs may include inspections, maintenance and intermittent asset repairs/replacement.
4. End of life replacement or decommissioning costs. These costs are only required when the design life of assets is less than the appraisal period. Most assets are likely to have a design life in excess of the 100-year financial period; therefore these costs are unlikely.

The Environment Agency's Long Term Costing Tool 2012 was used to derive the whole life costs for each assessed scheme option. This is an interactive excel spreadsheet which determines capital costs based primarily on defence dimensions but also considers other factors that influence costs. Enabling, operation and maintenance costs area also estimated using this spreadsheet. The whole life costs of PLP was costed separately using Scottish Government Guidance "Assessing the Flood Risk Management Benefits of Property Level Protection Technical and Economic Appraisal Report, November 2014".

Whole life (present value) costs have been estimated based on the above enabling, capital and maintenance costs. The following assumptions have been made:

1. The life span of the scheme and appraisal period is 100 years.
2. Discounting of costs are based on the standard Treasury discount rates as recommended by the 2003 revision to the HM Green Book (3.5% for years 0-30, 3.0% for years 31-75 and 2.5% for years 76-99).
3. Capital costs are assumed to occur in year 1 (equivalent to 2019).
4. Enabling costs occur in year 0.
5. An optimism bias of 60% has been applied and is representative of a scheme at the appraisal design stage of development. This provides a significant safety factor for cost implications and risks.

6.3 Maintenance costs

SEPA's 'Costing of Flood Risk Management Measures' 2013 project report was used to determine maintenance costs for the proposed assets. These maintenance costs account for a default set of maintenance regimes for associated annual or frequent operation and maintenance activities.

The costs used assume efforts are made to maintain assets at condition grade 2 (Good) using the grading system described in the Environment Agency's asset condition assessment manual[9]. Average costs were used - between lower and upper bounds reproduced in the report - given the absence of detailed maintenance plans at this early design stage of development.

6.3.1 Optimism bias

An optimism bias of 60% has been applied and is representative of a scheme at the appraisal design stage of development. This provides a significant safety factor for cost implications and risks. This uplift is applied to present value capital and present value maintenance costs after their calculation.

9 Condition Assessment Manual (CAM) (Environment Agency, 2012)

6.4 Option 1 - Direct Defences

The option consists of:

- 313 m of flood wall with an average height of 1 m.
- 1100 m of flood wall with an average height of 1.3 m.
- 429 m of flood wall with an average height of 1.5 m.
- 226 m of flood wall with an average height of 2 m.
- 300 m of flood embankment with an average height of 2 m.
- Approximately 1515m^3 of excavated material.

Table 6-1: Unit and total estimated costs

Component	Typical defence height	Length (m) / Volume (m^3)	Unit cost (£)	Total Cost (£)
Flood Wall	1.0	313	1,428	446,994
Flood Wall	1.3	1100	1,828	2,010,800
Flood Wall	1.5	429	2,229	956,241
Flood Wall	2.0	226	3,231	730,206
Flood Embankment	2.0	4,800	120	576,000
Excavated Material	-	1,515	125	363,770
			Total Capital Cost	5,084,011

Table 6-2: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	425	425
Capital cost	5,084	4,912
Maintenance cost	178	51
Total	**5,687**	**5,388**
	Total incl. Optimism Bias	**8,621**

6.5 Option 2 - Partial Defences

This option consists of:

- 102 m of flood wall with an average height of 1 m.
- 88 m of flood wall with an average height of 1.2 m.
- 887 m of flood wall with an average height of 1.3 m.

Table 6-3: Unit and total estimated costs

Component	Typical defence height	Length (m) / Volume (m^3)	Unit cost (£)	Total Cost (£)
Flood Wall	1.0	102	1,428	145,656
Flood Wall	1.3	88	1,828	143,303
Flood Wall	1.5	887	2,229	1,621,436
Excavated Material	-	1515	125	189,451
			Total Capital Cost	2,463,630

Table 6-4: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	205	205
Capital cost	2,463	2,380
Maintenance cost	50	14
Total	**2,718**	**2,599**
Total incl. Optimism Bias		**4,158**

6.6 Option 3 - Charlie's Sike Restoration

This option consists of:

- 465 m of channel re-alignment/restoration
- 12,545 m^2 of excavated material and floodplain creation

Table 6-5: Unit and total estimated costs

Component	Average Depth	Length (m) / Volume (m^3)	Unit cost (£)	Total Cost (£)
New Channel and floodplain widening	-	12,545	16.46	145,656
Old channel abandoned, backfilled and landscaped	0.7	859	119.64	143,303
			Total Capital Cost	2,463,630

Table 6-6: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	51	51
Capital cost	309	299
Maintenance cost	179	51
Total	**539**	**401**
Total incl. Optimism Bias		**640**

6.7 Option 4 - Charlie's Sike Two Stage Channel

This option consists of:

- Creation of two stage channel along 500 m of existing Charlie's Sike Channel

Table 6-7: Unit and total estimated costs

Component	Average Depth	Length (m) / Volume (m^3)	Unit cost (£)	Total Cost (£)
New Two Stage Channel	-	6,969	16.45	145,656
			Total Capital Cost	2,463,630

Table 6-8: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	23	23
Capital cost	115	111
Maintenance cost	99.5	28
Total	**237**	**162**
	Total incl. Optimism Bias	**260**

6.8 Option 5 - Property Level Protection (PLP)

This option consists of property level protection (PLP) to 125 properties. The PLP will take the form of automatic PLP that will seal the property against water ingress without any input from the inhabitants. Examples of what this will be include door guards, airbrick sealers, non-return valves on plumbing and sump pumps. Costs are based on the Scottish Government Guidance "Assessing the Flood Risk Management Benefits of Property Level Protection Technical and Economic Appraisal Report, Final Report, November 2014".

Table 6-9: Unit and Total Estimated Capital Costs

Property Type	Count	Capital Cost (Mid-Range Automatic) (£)
Detached	52	435,916
Semi-Detached	20	157,160
Terraced	53	238,076
Total	125	831,152

Table 6-10: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	148	148
Capital cost	831	803
Maintenance cost	4953	1266
Total	**5932**	**2217**
	Total incl. Optimism Bias	**3547**

7 Benefit-cost analysis

7.1 Introduction

This section discusses the economic appraisal carried out during this study. The methods of calculating the benefits and costs are outlined together with an assessment of the benefit-cost ratios (BCR) for the range of options assessed. Benefit cost analysis looks at a flood risk management strategy or practice and compares all the benefits that will be gained by its implementation to all the costs that will be incurred during the lifetime of the project. In accordance with the FCERM appraisal guidance, benefits are taken as annual average damages avoided, expressed as their present value using Treasury discount rates. These are compared with the whole life cost of the capital and maintenance costs of selected options, expressed as present value. If the benefits exceed the costs for the option, the scheme is deemed to be cost effective and worthwhile for promotion.

Benefits are assessed as the flood damages that will be avoided by the implementation of a project. To calculate the benefits, it is necessary to assess the damages that are likely to occur under both the "Do Nothing" and "Do Something" scenarios. The benefits of any particular "Do Something" option can then be calculated by deducting the "Do Something" damages from the "Do Nothing" damages.

7.2 Benefit-cost results - Liddel Water

The benefit cost results for the shortlisted options are provided in the table below. A scheme with a benefit cost ratio greater than 1 means that the benefits outweigh the costs and therefore, the scheme is cost effective.

The BCR analysis shows that the two best options for mitigating flood risk in the village is options 2 and 4, both providing a BCR of 1.4. Options 3 and 4 have been assessed against the "Do Minimum" scenario rather than the "Do Nothing" as these options would not promote maintenance of the Liddel Water which has the greatest impact on the "Do Nothing" scenario. Of these two options, Option 4 is the most cost beneficial. However, it should be noted the wider ranging benefits such as provision of green space, community enhancement, educational opportunities have not been monetized and are therefore not reflected in Option 3's BCR.

Option 1 is the only real option for providing a 1 in 200 year standard of protection for the village, that can be adapted to meet the impact of climate change. However, the scale of the works required result in a BCR of 0.8. The benefits of this option have assumed a consistent annual average damage over the appraisal period, however, with the impact of climate change resulting in more frequent flood events, it is likely that annual average damages will increase over the appraisal period. It is therefore recommended that the benefits provided by option 1 are assessed against the impact of climate change.

Table 7-1: Benefit Cost Ratio for Short Listed Options (£k)

Option Number			Option 1	Option 2	Option 3	Option 4	Option 5
Option Name	Do Nothing	Do Minimum	Direct Defences	Partial Direct Defences	Charlie's Sike Restoration	Charlie's Sike Two Stage Channel	PLP
PV Costs (£k)	-	-	5,388	2,599	350	162	2,217
Optimism Bias (60%)	-	-	3,233	1,559	210	84	1,330
Total PV Costs (£k)			8,621	4,158	560	246	3,547
PV Damage (£k)	8,002	3,698	821	1,303	2,556	2,358	2,439
PV damage avoided (£k)	-	4,304	7,181	6,699	1,142	1,340	5,563
Benefit Cost Ratio	-	-	0.8	1.6	1.8	5.2	1.6

Options 3 and 4 have been assessed against the Do Minimum rather than the Do Nothing, as the implementation of these schemes would not impact flood risk on the Liddel Water or require on-going maintenance of the Liddel Water.

7.3 Residual Risks

The modelling undertaken for this report is appropriate for the appraisal stage. Further and more in depth testing, both modelling and engineering, is required at the outline design stage.

Designing for climate change should be assessed further as the there is potential for design exceedance events of direct defences to have a negative impact on flood risk as water could become trapped behind the defences.

Surface water flood risk is not alleviated as part of the proposed measures and will continue to impact the town. At the time of writing a separate surface water management plan for Newcastleton is being prepared that should be implemented in conjunction with the fluvial scheme.

NFM should be integrated into any scheme proposed. The NFM measures recommended takes place through the catchment. NFM, when implemented correctly, shall have a positive impact on flood flows, helping the soil absorb more water, slow the flow of water into the watercourse and create more open water bodies on the land.

8 Public Consultation

As public consultation was held in Newcastleton on the 2nd October 2018 to gauge opinion on the flood mitigation options proposed as part of this study. The public consultation was well attended with approximately 46 people attending with 32 of those responding to questionaires. There is general concensus within Nerwcastleton that a flood protection scheme is suitable, specifically the community engagement aspect.

Whilst several respondents stated that has been affected by flooding in the past, there was a noticable split as to whether direct defences were suitable for the area with many stating that a flood wall would need to have minimal visual impact and be unobtrusive while maintaining access to the water and recreational green space. There was wide support for river restoration of the Charlies Sike (known locally as the "Lakes").

Summary of questionaire

- The Liddel Water is the most significant fluvial flood risk to the town however many are concerned/affected by the Charlie's Sike as well.
- Newcastleton has suffered from flooding previously most notably in 1991 and 2005.
- In general there is strong support for a scheme with 90% in support for flood protection in the village. However it is clear that many residents were opposed to direct defences and wished to see softer less intrusive options. Many were adamant that a wall was not the answer and wished to see material being removed regularly from the river as a solution. Those who agreed that a wall was practical solution stated that is should as unobstrusive as possible, not impact on property and that any scheme should enhance the village.
- Surface water flooding from the drainage network is a concern to some residents who noted that there was improvement after previous works were undertaken but wished to see a continuation of this.
- Residents were supportive of NFM implemented in the catchment.
- The proposed Standard of Protection could be revisited to reduce the wall height.

Views expressed verbally on the day were as follows:

- There is strong support from residents for removing gravel from the river that has built up over time, in particular at the stone arch bridge. There is a general belief that this will solve the flooding problem.
- There was strong critism of direct defenes from residents living on the river front
- There was strong support for works in the Lakes
- There was residual concern about surface water flooding. Some residents noted that during previous flooding, water came from the drainage network without the river overtopping its banks
- Residents would welcome improved flood waring at Newcastleton
- Residents at Riverview Holiday Park were concerned that mitigated flood risk at Newcastleton would result in an increase in flood risk downstream.
- Residents voiced frustration that works in the river could not easily be undertaken because of SEPA and stated the "people and homes are more important than fish."
- Owners of the land north of Newcastleton expressed concern for the wellfare of live stock in the event of a flood event with direct defences in place.
- Residents thought that the alignment of the proposed defences could be improved.
- Residents were keen to see the defences enhance the village and, inparticular, maintain/improve existing walk ways and paths.

9 Conclusions and Recommendations

This report presents the results of the detailed flood risk appraisal for Newcastleton in relation to flooding from the Liddel Water, Charlie's Sike and the Short Sike. Approximately 174 residential properties and 15 commercial properties area estimated to be at risk from fluvial flood risk during the 0.5% AP (200 year) "Do Minimum" flood event.

A detailed set of preliminary investigations was carried out prior to this appraisal such that it was possible to inform discussion of flood protection options for Newcastleton. These investigations involved a review of Newcastleton's flood history; an assessment of the hydrological inputs to the Liddel Water, Charlie's Sike and Short Sike; collection and review of survey data; a River Basin Management Plan review; an assessment of Natural Flood Management opportunities in the catchment; a Preliminary Ecological appraisal; asset condition assessment; and hydraulic modelling of the watercourses.

A hydraulic model was constructed in Infoworks ICM which incorporated the Liddel Water, Charlie's Sike, Short Sike as well as the existing drainage network in Newcastleton. Overland flow as a result of exceedance of these bodies was modelled, concentrating on the populated area of Newcastleton. This allowed generation of flood inundation maps for a range of Annual Probability (AP) flood events ranging from 50% AP (2 year) to 0.1% AP (1000 year). A number of scenarios were modelled to provide sufficient information on which to base the economic appraisal at a later stage in the study. These included the "Do Nothing" and "Do Minimum" scenarios with the former representing a 'walk away' scenario where maintenance of the watercourse ceases, and the latter representing the present-day watercourse condition.

Once these maps were produced it was possible to review flood flow pathways and progress from the wide-ranging long-list of potential flood protection options to a short-list of feasible solutions tailored to Newcastleton's flood risk problem. Flood protection options have been assessed based on the anticipated damages avoided from the implementation of the scheme and compared against the cost of building and maintaining the flood mitigation works. An optimism bias factor of 60% has been added to the total costs to allow for uncertainties in the design at this level of appraisal and is typical for scheme at an early stage appraisal.

A shortlist of flood protection options was produced and reviewed by comparing the expected benefit of the scheme (property damages avoided) with the estimated costs for scheme implementation and maintenance. The following options were considered:

- Direct Flood Defences
- Partial Flood Defences
- Charlie's Sike Restoration
- Charlie's Sike Two Stage Channel
- Property Level Protection (PLP)

Partial flood defences and PLP were considered the most viable financial option producing a benefit cost ratio of 1.6 for mitigating flood risk from the Liddel Water. Of the options on the Charlie's Sike, the two-stage channel had the best BCR of 5.2 while the Charlie's Sike Restoration produced a lesser but still favourable BCR of 1.8. However, it is noted that the wider benefits that can be gained through a restoration scheme and provision of a community green space have not been evaluated and are therefore not reflected in the BCR.

The option of full direct defences produced a BCR of 0.8 indicating that it is not an economically viable option. However, this assessment has assumed that the average annual damages due to flooding of Newcastleton is consistent throughout the appraisal period. However, with the impact of climate change is likely that the annual average damages will increase over the appraisal period. A reassessment of the likely damages avoided by direct defences is therefore recommended as this will likely result in positive BCR. A full set of direct defences is considered the only viable means of protecting Newcastleton to a suitable standard of protection and the 1 in 200 year standard is achievable.

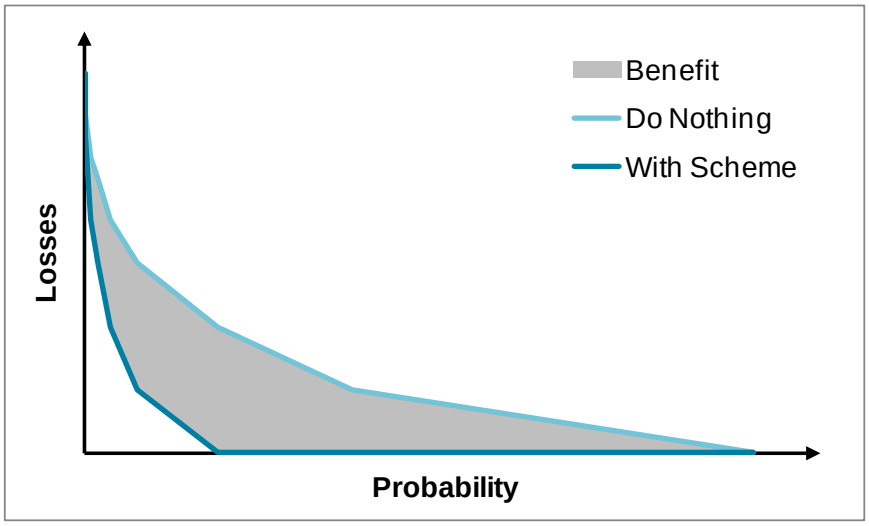
Appendices

A Appendix A - Damages Methodology

A.1 Direct damages - methodology

The process to estimate the benefits of an intervention option is to plot the two loss-probability curves: that for the situation now, and that with the proposed option as shown in Figure B-1. The scale on the y axis is the event loss (£); the scale on the x axis is the probability of the flood events being considered. When the two curves are plotted then the difference in the areas beneath the curve is the annual reduction in flood losses to be expected from the scheme or mitigation approach.

Figure B-1: Loss Probability Curve



To derive these two curves, straight lines are drawn between the floods for which there are data from the threshold event (the most extreme flood which does not cause any damage) to an extreme flood above the intended standard of protection. The greater the number of flood event probabilities, the more accurately the curves can be plotted.

A.2 Flood damage calculation and data

The FHRC Multi Coloured Manual (MCM) provides standard flood depth/direct damage datasets for a range of property types, both residential and commercial. This standard depth/damage data for direct and indirect damages has been utilised in this study to assess the potential damages that could occur under each of the options. Flood depths within each property have been calculated from the hydraulic modelling by comparing predicted water levels at each property to the surveyed threshold levels.

A flood damage estimate was generated using JBA's in-house flood damage tools. These estimate flood damages using FHRC data and the modelled flood level data. Each property data point was mapped on to its building's footprint. A mean, minimum and maximum flood level within each property is derived using GIS tools based on the range of flood levels around the building footprint. The inundation depth is calculated by comparing water levels with the surveyed threshold level. The mean (based on mean flood water level across the building floor's area) flood damage estimates have been calculated and are presented in Table 5-2.

The following assumptions, presented in the Table 5-1, were used to generate direct flood damage estimates.

Table B-1: Damage considerations and method

Aspect	Values used	Justification
Flood duration	<12hrs	Flood water is not anticipated to inundate properties for prolonged periods.
Residential property type	MCM codes broken down by type and age.	Appropriate for this level of analysis.

Aspect	Values used	Justification
Non-residential property type	Standard 2016 MCM codes applied.	Best available data used.
Upper floor flats	Upper floor flats have been removed from the flood damage estimates.	Whilst homeowners may be affected it is assumed that no direct flood damages are applicable.
MCM damage type	MCM 2016 data with no basements.	Most up to date economic analysis data used. Basements are not appropriate for the type of properties within the study area.
MCM flood type	MCM 2016 fluvial depth damages for combined fluvial-tidal scenario.	Best available data used.
Threshold level	Thresholds surveyed by surveyor for the majority of properties in area of interest.	Best available data used.
Socio-economic equity	Distributional Impacts (DI) impacts derived from the 2001 census show no significant difference in "DE" social grades compared to the national average.	As per Treasury Green Book recommendations, analysis of DI is not deemed to be necessary and has been excluded.
Property areas	OS Mastermap used to define property areas	Best available data used.
Capping value	Residential properties based on house prices from Zoopla. Commercial properties valued from rateable values for individual properties (supplied by SAA).	Best available data used.

A.2.1 Property data set

The property dataset was compiled for all residential and commercial properties. The majority of these properties were visited by a JBA Surveyor during the threshold survey.

A.2.2 Capping

The FHRC and appraisal guidance suggests that care should be exercised for properties with high total (Present Value) damages which might exceed the market value of the property. In most cases it is prudent to assume that the long-term economic losses cannot exceed the capital value of the property. The present value flood damages for each property were capped at the market value using average property values obtained from internet sources (e.g. Zoopla).

Market values for non-residential properties were initially estimated from a properties rateable value based on the following equation:

Capital Valuation = (100/Equivalent Yield) x Rateable Value

Rateable values for all available properties in Newcastleton were obtained from the Scottish Assessors Association website[10]. Equivalent yield varies regionally and temporarily, but is recommended to be a value of 10-12.5 for flood defence purposes[11]. A value of 12.5 was used.

However, the resulting property valuations were judged as been undervalued. An alternative approach was used where by the estimated value is 3 times the max depth damage MCM curve damage value for the commercial property type multiplied by the properties ground floor area.

10 www.saa.gov.uk
11 Environment Agency (2009). Flood and Coastal Erosion Risk Management - Appraisal Guidance.

A.2.3 Updating of Damage Values

The MCM data used is based on January 2015 values and therefore do not need to be brought up to date to compare the costs and benefits.

A.3 Intangible damages

Current guidance indicates that the value of avoiding health impacts of fluvial flooding is of the order of £386 per year per household. This value is equivalent to the reduction in damages associated with moving from a do-nothing option to an option with an annual flood probability of 1:100 year standard. A risk reduction matrix has been used to calculate the value of benefits for different pre-scheme standards and designed scheme protection standards.

A.4 Indirect damages

The multi coloured manual provides guidance on the assessment of indirect damages. It recommends that a value equal to 10.7% of the direct property damages is used to represent emergency costs. These include the response and recovery costs incurred by organisations such as the emergency services, the local authority and SEPA.

A.4.4 Indirect commercial damages

Obtaining accurate data on indirect flood losses is difficult. Indirect losses are of two kinds:

- losses of business to overseas competitors, and
- the additional costs of seeking to respond to the threat of disruption or to disruption itself which fall upon firms when flooded.

The first of these losses is unusual and is limited to highly specialised companies which are unable to transfer their productive activities to a branch site in this country, and which therefore lose to overseas competitors. The second type of loss is likely to be incurred by most Non-Residential Properties (NRPs) which are flooded. They exclude post-flood clean-up costs but include the cost of additional work and other costs associated with inevitable efforts to minimise or avoid disruption. These costs include costs of moving inventories, hiring vehicles and costs of overtime working. These costs also include the costs of moving operations to an alternative site or branch and may include additional transport costs.

Chapter 5, Section 5.7 of the MCM (2013)[12] recommends estimating and including potential indirect costs where these are the additional costs associated with trying to minimise indirect losses. This is by calculating total indirect losses as an uplift factor of 3% of estimated total direct NRP losses at each return period included within the damage estimation process.

A.4.5 Vehicle losses

Chapter 4, Section 4.5.7 of the MCM (2013) recommends that the average loss associated with vehicle damage during flood events should be determined using a value of £3,600 per property flooding to a depth greater than 0.35m. This value has been applied to all properties flooding to a depth greater than 0.35m within Newcastleton for each return period flood event assessed and the AAD and PVd calculated as normal.

12 Penning-Rowsell et al., 2013. Flood and Coastal Erosion Risk Management - A Manual for Economic Appraisal

Project Summary Sheet

Client/Authority				Prepared (date)	10/09/2018
Scottish Borders Council				Printed	16/01/2019
Project name				Prepared by	MM
Newcastleton FPS				Checked by	MM
Project reference				Checked date	26/11/2018
Base date for estimates (year 0)	Jan-2018				
Scaling factor (e.g. £m, £k, £)	£k	(used for all costs, losses and benefits)			
Year	0	30	75		
Discount Rate	3.5%	3.00%	2.50%		
Optimism bias adjustment factor	60%				

Costs and benefits of options

Option number	Costs and benefits £k		Option 1	Option 2	Option 3	Option 4	Option 5
Option name	Do Nothing	Do Minimum	Direct Defences	Partial Defences	Charlies Sike Restoration	Charlies Sike Two Stage Channel	PLP
AEP or SoP (where relevant)	2	10	200	10	10	10	200
COSTS:							
PV capital costs	0	0	4,912	2,380	299	111	803
PV operation and maintenance costs	0	0	51	14	51	28	1,266
PV other	0	0	425	205	51	23	148
PV Costs			5,388	2,599	401	162	2,217
Optimism bias adjustment	0	0	3,233	1,559	241	97	1,330
PV contributions							
Total PV Costs £k excluding contributions	0	0	8,621	4,158	642	259	3,547
Total PV Costs £k taking contributions into account	0	0	8,621	4,158	642	259	3,547
BENEFITS:							
PV monetised flood damages	8,002	3,698	821	1,303	2,556	2,358	2,439
PV monetised flood damages avoided		4,304	6,032	6,699	5,446	5,644	5,563
PV monetised erosion damages	0	0	0	0	0		0
PV monetised erosion damages avoided (protected)		0	0	0	0		0
Total monetised PV damages £k	8,002	3,698	821	1,303	2,556	2,358	2,439
Total monetised PV benefits £k		4,304	7,181	6,699	1,142	1,340	5,563
PV damages (from scoring and weighting)							
PV damages avoided/benefits (from scoring and weighting)							
PV benefits from ecosystem services							
Total PV damages £k	8,002	3,698	821	1,303	2,556	2,358	2,439
Total PV benefits £k		4,304	6,032	6,699	1,142	1,340	5,563
DECISION-MAKING CRITERIA:							
Based on monetised PV benefits (ex cludes benefits from scoring and weighting and ecosystem services)							
Net Present Value **NPV**		4,304	-1,439	2,541	501	1,081	-2,405
Average benefit/cost ratio **BCR**			0.8	1.6	1.8	5.2	0.3
Incremental benefit/cost ratio **IBCR**			0.3	0.1	1.6	-0.5	9.1
	Options 3 and 4 have been assessed against the Do Minimum rather than the Do Nothing, as the implementation of these schemes would not impact flood risk on the Liddel Water or require on-going maintenance of the Liddel Water.						IBCR>1
Best practicable environmental option (WFD)							

Brief description of options:

	Do Nothing
	Do Minimum
Option 1	Direct Defences
Option 2	Partial Defences
Option 3	Charlies Sike Restoration
Option 4	Charlies Sike Two Stage Channel
Option 5	PLP

Comments and assumptions:

Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Do Nothing

Project reference -

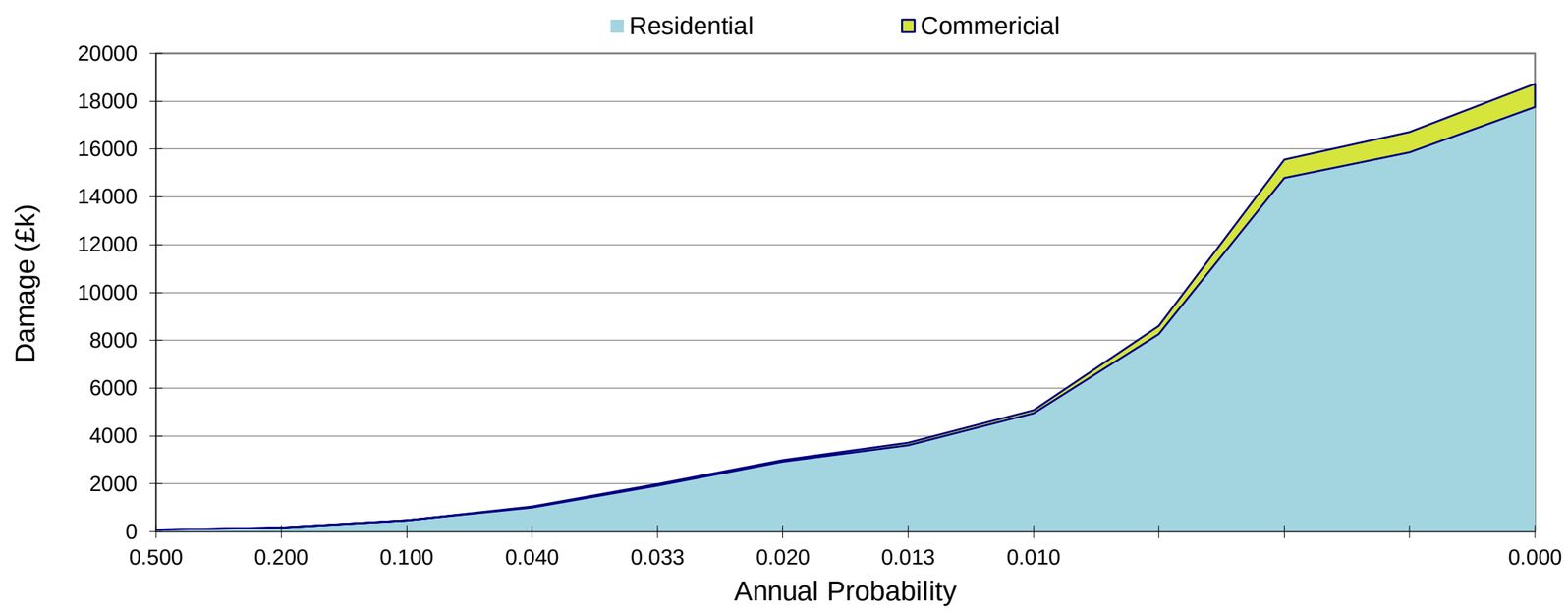
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	84.86293767	164.7	470.6	1014.3	1933.1	2918.2	3619.8	4956.7	8260.0	14787.4	15864.5	17765.6	8,698.30	6348
Ind/commercial (direct)	2.482260608	2.9	5.2	24.5	52.6	83.6	103.8	134.9	349.6	771.1	838.0	960.1	264.76	256
Ind/comm (indirect)	0.074467818	0.1	0.2	0.7	1.6	2.5	3.1	4.0	10.5	23.1	25.1	27.1	7.92	7.92
Traffic related												0.0	-	
Emergency services	4.752324509	9.2	26.4	56.8	108.3	163.4	202.7	277.6	462.6	828.1	888.4	994.9	487.10	487.10
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	903.00	903.00
												0.0	-	
Total damage £k	92.1719906	176.9	502.4	1096.3	2095.5	3167.6	3929.4	5373.3	9082.6	16409.7	17616.0	19747.8		
Area (damagexfrequency)		40.36	33.96	47.96	10.64	35.09	23.66	15.50	36.14	38.24	17.01	72.08		

Total area, as above	370.65		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	11050	10,361.08	8,002.02

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Do Nothing**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Do Minimum

Project reference -

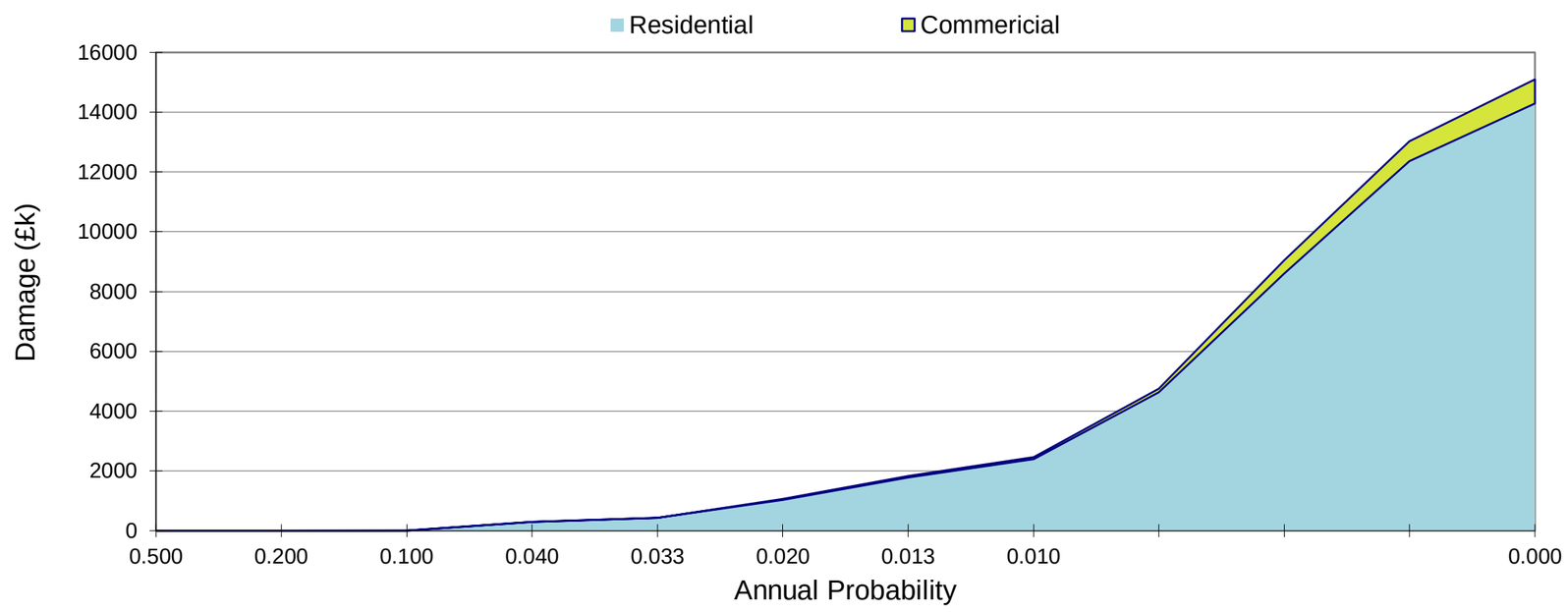
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	7.0	286.6	432.1	1026.1	1784.2	2396.8	4625.2	8615.1	12357.9	14291.1	2,946.60	2920
Ind/commercial (direct)	0	0.0	2.4	4.7	5.3	28.3	52.8	71.1	131.0	436.9	671.6	806.8	110.82	111
Ind/comm (indirect)	0	0.0	0.1	0.1	0.2	0.8	1.6	2.1	3.9	13.1	20.1	27.2	3.37	3.37
Traffic related												0.0	-	
Emergency services	0	0.0	0.4	16.0	24.2	57.5	99.9	134.2	259.0	482.4	692.0	800.3	165.01	165.01
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages	0	0.0	0.3	5.3	2.0	5.0	1.7	0.3	0.6	1.0	0.5	0.0	499.00	499.00
												0.0	-	
Total damage £k	0	0.0	9.9	307.5	461.7	1112.7	1938.6	2604.3	5019.2	9547.6	13741.7	15925.3		
Area (damagexfrequency)		0.00	0.49	9.52	2.56	10.50	10.17	7.57	19.06	21.85	11.64	52.36		

Total area, as above	108.20		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	3226	3,724.80	3,698.38

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Do Minimum**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Direct Defences

Project reference -

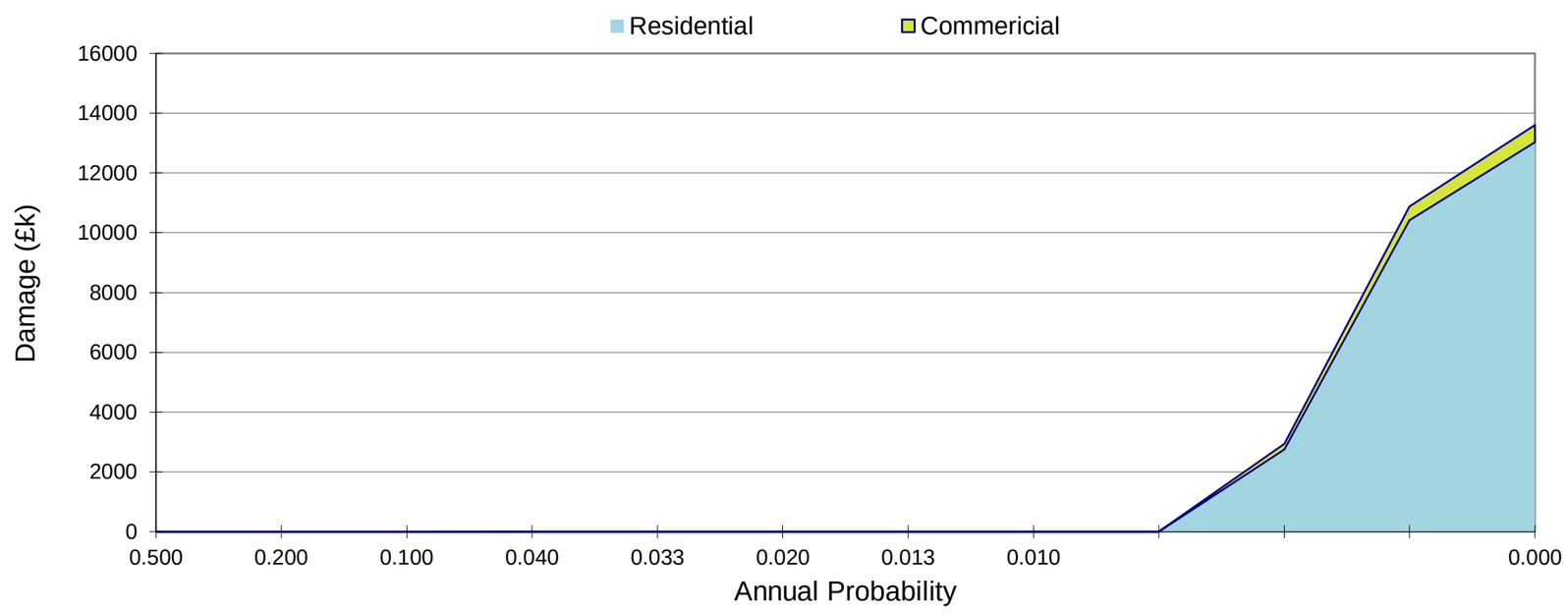
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2749.5	10423.3	13029.1	668.90	669
Ind/commercial (direct)	0	0.0	0.0	1.6	1.7	5.8	2.3	2.5	3.1	190.8	460.2	574.5	38.49	38
Ind/comm (indirect)	0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	5.7	13.8	21.9	1.22	1.22
Traffic related												0.0	-	
Emergency services	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	154.0	583.7	729.6	37.46	37.46
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	75.00	75.00
												0.0	-	
Total damage £k	0	0.0	0.0	1.6	1.8	6.0	2.4	2.6	3.2	3100.0	11481.0	14355.2		
Area (damagexfrequency)		0.00	0.00	0.05	0.01	0.05	0.03	0.01	0.01	4.65	7.29	35.90		

Total area, as above	48.00		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	1431	821.08	820.68

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Direct Defences**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Partial Defences

Project reference -

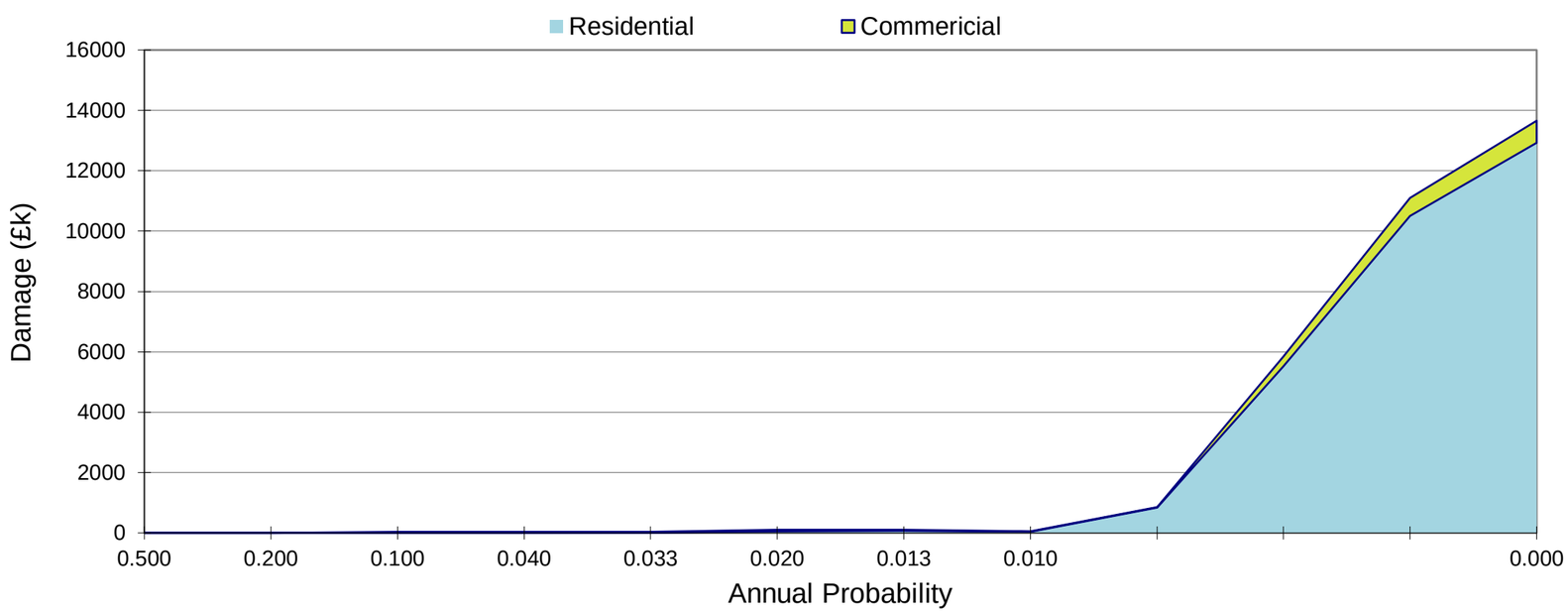
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	0.0	0.0	4.7	57.7	65.5	40.9	841.8	5522.1	10504.4	12920.1	968.84	969
Ind/commercial (direct)	0	0.0	39.1	40.5	40.8	41.3	41.6	6.4	11.7	311.4	592.1	737.2	213.67	168
Ind/comm (indirect)	0	0.0	1.2	1.2	1.2	1.2	1.2	0.2	0.4	9.3	17.8	26.2	6.47	6.47
Traffic related												0.0	-	
Emergency services	0	0.0	0.0	0.0	0.3	3.2	3.7	2.3	47.1	309.2	588.2	723.5	54.26	54.26
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	105.00	105.00
												0.0	-	
Total damage £k	0	0.0	40.3	41.7	47.0	103.5	112.0	49.7	901.1	6152.0	11702.6	14407.0		
Area (damagexfrequency)		0.00	2.01	2.46	0.30	1.00	0.72	0.27	2.38	10.58	8.93	38.27		

Total area, as above	66.92		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	1995	1,348.24	1,302.73

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Partial Defences**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Charlie's Sike Restoration

Project reference -

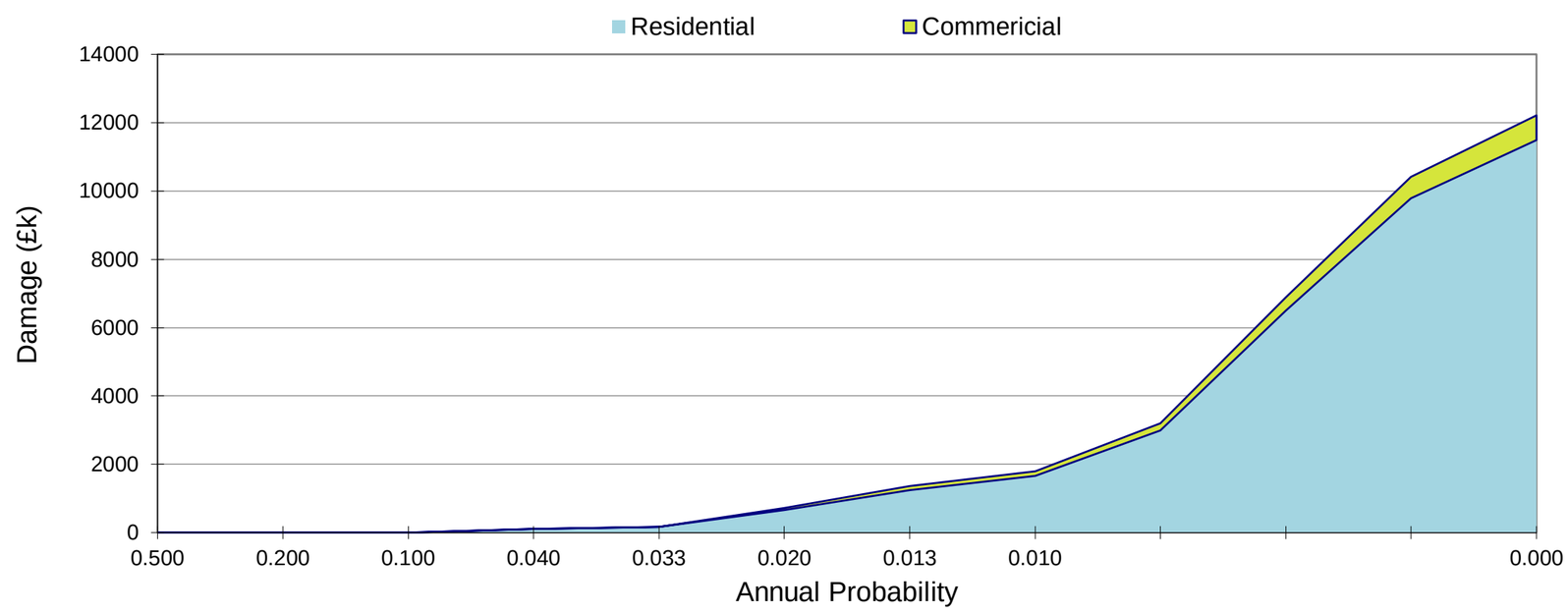
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	0.0	103.4	168.2	664.2	1246.2	1662.2	2995.2	6497.4	9793.2	11492.7	1,951.05	1934
Ind/commercial (direct)	0	0.0	0.0	0.6	1.3	62.7	112.6	140.0	210.8	395.9	618.6	720.6	131.81	132
Ind/comm (indirect)	0	0.0	0.0	0.0	0.0	1.9	3.4	4.2	6.3	11.9	18.6	25.2	4.01	4.01
Traffic related												0.0	-	
Emergency services	0	0.0	0.0	5.8	9.4	37.2	69.8	93.1	167.7	363.9	548.4	643.6	109.26	109.26
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	377.00	377.00
												0.0	-	
Total damage £k	0	0.0	0.0	109.9	179.0	766.0	1432.0	1899.4	3380.0	7269.0	10978.8	12882.1		
Area (damagexfrequency)		0.00	0.00	3.30	0.96	6.30	7.33	5.55	13.20	15.97	9.12	40.66		

Total area, as above	102.39		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	3052	2,573.13	2,556.27

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Charlie's Sike Restoration**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
Charlie's Sike Two Stage Channel

Project reference -

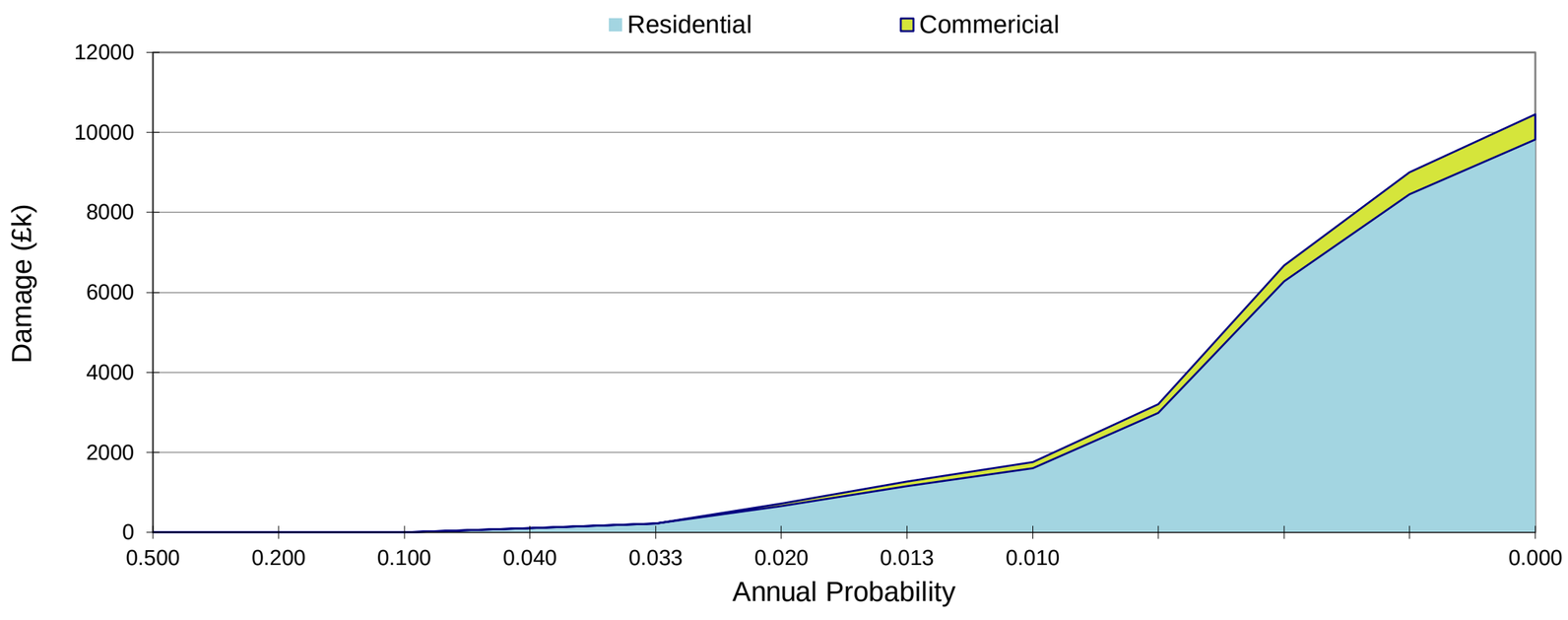
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	0.0	108.9	214.6	657.1	1153.9	1608.4	2988.7	6276.5	8453.6	9819.8	2,331.00	1851
Ind/commercial (direct)	0	0.0	0.0	0.7	1.4	65.5	115.7	143.5	208.5	390.7	547.6	632.4	267.00	130
Ind/comm (indirect)	0	0.0	0.0	0.0	0.0	2.0	3.5	4.3	6.3	11.7	16.4	21.1	3.92	3.92
Traffic related												0.0	-	
Emergency services	0	0.0	0.0	6.1	12.0	36.8	64.6	90.1	167.4	351.5	473.4	549.9	104.66	8.09
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	365.00	365.00
												0.0	-	
Total damage £k	0	0.0	0.0	115.7	228.0	761.4	1337.7	1846.3	3370.8	7030.4	9491.1	11023.3		
Area (damagexfrequency)		0.00	0.00	3.47	1.15	6.60	7.00	5.31	13.04	15.60	8.26	35.99		

Total area, as above	96.41		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	2874	3,071.58	2,358.01

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: Charlie's Sike Two Stage Channel**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Newcastleton FPS

Option:
PLP

Project reference -

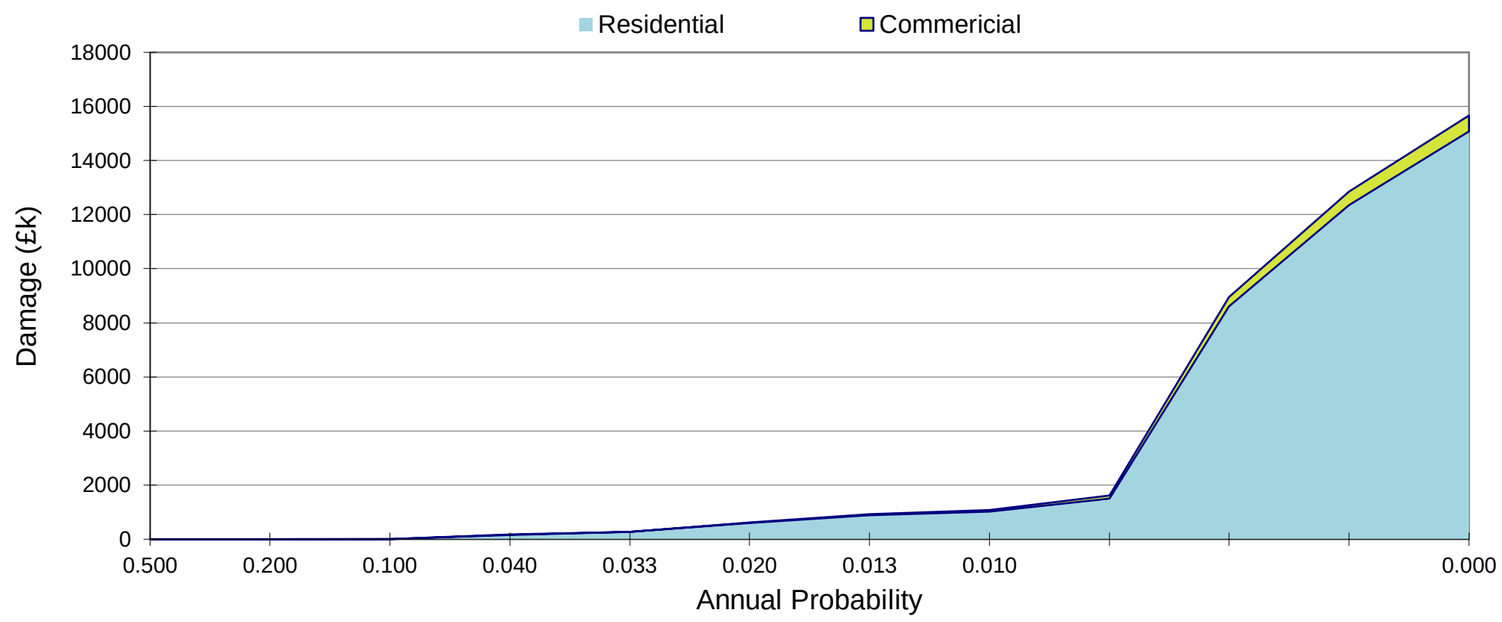
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	10/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	16/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	MM
				Checked by	MM
Applicable year (if time varying)				Checked date	26/11/2018

	Average waiting time (yrs) between events/frequency per year												Total PV	Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k	(Capped) £k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0		
Damage category	Damage £k													
Residential property	0	0.0	7.0	164.5	269.1	599.4	877.8	1019.4	1504.3	8615.1	12357.9	15071.3	1,982.65	1982
Ind/commercial (direct)	0	0.0	0.0	2.2	2.8	25.8	50.4	68.6	117.4	344.0	500.4	596.2	85.07	85
Ind/comm (indirect)	0	0.0	0.0	0.1	0.1	0.8	1.5	2.1	3.5	10.3	15.0	19.7	2.58	2.58
Traffic related												0.0	-	
Emergency services	0	0.0	0.4	9.2	15.1	33.6	49.2	57.1	84.2	482.4	692.0	844.0	111.03	111.03
Other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	
Intangible damages												0.0	258.00	258.00
												0.0	-	
Total damage £k	0	0.0	7.4	176.0	287.0	659.5	978.8	1147.1	1709.4	9451.8	13565.4	16531.2		
Area (damagexfrequency)		0.00	0.37	5.50	1.54	6.31	5.46	3.54	7.14	16.74	11.51	45.60		

Total area, as above	103.72		
PV Factor, as above	29.813		
Present value (assuming no change in damage or event frequency)	3092	2,439.33	2,438.61

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Newcastleton FPS **Option: PLP**



Summary of costs

Client/Authority		Prepared (date)	10/09/2018
Scottish Borders Council		Printed	14/01/2019
Project/Option name		Prepared by	MM
Newcastleton - Direct Defences		Checked by	MM
Project reference		Checked date	26/11/2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£424.82
Capital Costs	£5,084.01
O & M Costs	£177.65
Other Costs	£0.00
Total Real Cost	£5,686.48
Total Cost PV	£5,387.39
Total Cost PV + OB	**£8,619.82**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.

Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

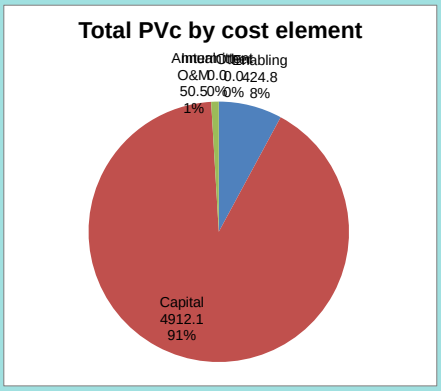
Additional user notes:

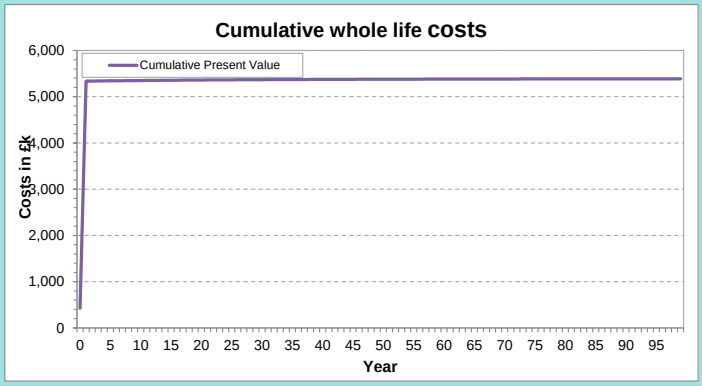
Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£51.84	£576.00	£99.07	£0.00	£726.91	£636.51
	Wall			£372.98	£4,144.24	£78.58	£0.00	£4,595.80	£4,399.41
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various								
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various			£0.00	£363.77	£0.00	£0.00	£363.77	£351.47
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	5387.4	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	424.8	5084.0	177.6	0.0	0.0	5686.48	5387.4	
	Total PV cost	424.8	4912.1	50.5	0.0	0.0		5387.4	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	424.8	0.0	0.0	0.0	0.0	424.8	424.8	424.8
1	0.966	0.0	5084.0	0.0	0.0	0.0	5084.0	4912.1	5336.9
2	0.934	0.0	0.0	1.8	0.0	0.0	1.8	1.7	5338.6
3	0.902	0.0	0.0	1.8	0.0	0.0	1.8	1.6	5340.2
4	0.871	0.0	0.0	1.8	0.0	0.0	1.8	1.6	5341.8
5	0.842	0.0	0.0	1.8	0.0	0.0	1.8	1.5	5343.3
6	0.814	0.0	0.0	1.8	0.0	0.0	1.8	1.5	5344.8
7	0.786	0.0	0.0	1.8	0.0	0.0	1.8	1.4	5346.2
8	0.759	0.0	0.0	1.8	0.0	0.0	1.8	1.4	5347.6
9	0.734	0.0	0.0	1.8	0.0	0.0	1.8	1.3	5348.9
10	0.709	0.0	0.0	1.8	0.0	0.0	1.8	1.3	5350.2
11	0.685	0.0	0.0	1.8	0.0	0.0	1.8	1.2	5351.5
12	0.662	0.0	0.0	1.8	0.0	0.0	1.8	1.2	5352.7
13	0.639	0.0	0.0	1.8	0.0	0.0	1.8	1.2	5353.8
14	0.618	0.0	0.0	1.8	0.0	0.0	1.8	1.1	5355.0
15	0.597	0.0	0.0	1.8	0.0	0.0	1.8	1.1	5356.0
16	0.577	0.0	0.0	1.8	0.0	0.0	1.8	1.0	5357.1
17	0.557	0.0	0.0	1.8	0.0	0.0	1.8	1.0	5358.1
18	0.538	0.0	0.0	1.8	0.0	0.0	1.8	1.0	5359.1
19	0.520	0.0	0.0	1.8	0.0	0.0	1.8	0.9	5360.0
20	0.503	0.0	0.0	1.8	0.0	0.0	1.8	0.9	5360.9
21	0.486	0.0	0.0	1.8	0.0	0.0	1.8	0.9	5361.8
22	0.469	0.0	0.0	1.8	0.0	0.0	1.8	0.9	5362.7
23	0.453	0.0	0.0	1.8	0.0	0.0	1.8	0.8	5363.5
24	0.438	0.0	0.0	1.8	0.0	0.0	1.8	0.8	5364.3
25	0.423	0.0	0.0	1.8	0.0	0.0	1.8	0.8	5365.0
26	0.409	0.0	0.0	1.8	0.0	0.0	1.8	0.7	5365.8
27	0.395	0.0	0.0	1.8	0.0	0.0	1.8	0.7	5366.5
28	0.382	0.0	0.0	1.8	0.0	0.0	1.8	0.7	5367.2
29	0.369	0.0	0.0	1.8	0.0	0.0	1.8	0.7	5367.9
30	0.356	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5368.5
31	0.346	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5369.1
32	0.336	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5369.7
33	0.326	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5370.3
34	0.317	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5370.9
35	0.307	0.0	0.0	1.8	0.0	0.0	1.8	0.6	5371.5
36	0.298	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5372.0
37	0.290	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5372.5
38	0.281	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5373.0
39	0.273	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5373.5
40	0.265	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5374.0
41	0.257	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5374.5
42	0.250	0.0	0.0	1.8	0.0	0.0	1.8	0.5	5374.9
43	0.243	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5375.4
44	0.236	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5375.8
45	0.229	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5376.2
46	0.222	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5376.6
47	0.216	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5377.0
48	0.209	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5377.4
49	0.203	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5377.7
50	0.197	0.0	0.0	1.8	0.0	0.0	1.8	0.4	5378.1
51	0.192	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5378.5
52	0.186	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5378.8
53	0.181	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5379.1
54	0.175	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5379.4
55	0.170	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5379.7
56	0.165	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5380.0
57	0.160	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5380.3
58	0.156	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5380.6
59	0.151	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5380.9
60	0.147	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5381.2
61	0.143	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5381.4
62	0.138	0.0	0.0	1.8	0.0	0.0	1.8	0.3	5381.7
63	0.134	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5381.9
64	0.130	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5382.1
65	0.127	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5382.4
66	0.123	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5382.6
67	0.119	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5382.8
68	0.116	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5383.0
69	0.112	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5383.2
70	0.109	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5383.4
71	0.106	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5383.6
72	0.103	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5383.8
73	0.100	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.0
74	0.097	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.2
75	0.094	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.3
76	0.092	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.5
77	0.090	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.7
78	0.087	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5384.8
79	0.085	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5385.0
80	0.083	0.0	0.0	1.8	0.0	0.0	1.8	0.2	5385.1
81	0.081	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5385.3
82	0.079	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5385.4
83	0.077	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5385.6
84	0.075	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5385.7
85	0.074	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5385.8
86	0.072	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.0
87	0.070	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.1
88	0.068	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.2
89	0.067	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.3
90	0.065	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.4
91	0.063	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.6
92	0.062	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.7
93	0.060	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.8
94	0.059	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5386.9
95	0.057	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5387.0
96	0.056	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5387.1
97	0.055	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5387.2
98	0.053	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5387.3
99	0.052	0.0	0.0	1.8	0.0	0.0	1.8	0.1	5387.4

Whole life cost charts





Summary of costs

Client/Authority		Prepared (date)	10/09/2018
Scottish Borders Council		Printed	14/01/2019
Project/Option name		Prepared by	MM
Newcastleton - Partial Direct Defences		Checked by	MM
Project reference		Checked date	26/11/2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£204.68
Capital Costs	£2,463.71
O & M Costs	£49.51
Other Costs	£0.00
Total Real Cost	£2,717.90
Total Cost PV	£2,599.14
Total Cost PV + OB	**£4,158.63**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.

Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

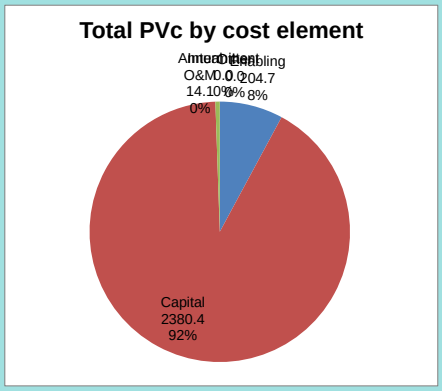
Additional user notes:

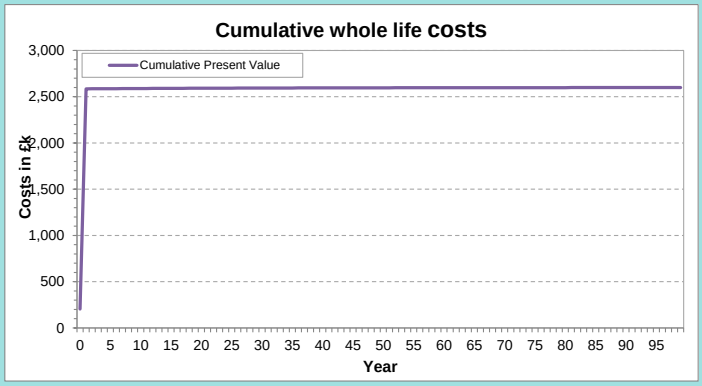
Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall			£204.68	£2,274.25	£49.51	£0.00	£2,528.45	£2,416.10
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various								
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various			£0.00	£189.45	£0.00	£0.00	£189.45	£183.04
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	2599.1	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	204.7	2463.7	49.5	0.0	0.0	2717.90	2599.1	
	Total PV cost	204.7	2380.4	14.1	0.0	0.0		2599.1	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	204.7	0.0	0.0	0.0	0.0	204.7	204.7	204.7
1	0.966	0.0	2463.7	0.0	0.0	0.0	2463.7	2380.4	2585.1
2	0.934	0.0	0.0	0.5	0.0	0.0	0.5	0.5	2585.5
3	0.902	0.0	0.0	0.5	0.0	0.0	0.5	0.5	2586.0
4	0.871	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2586.4
5	0.842	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2586.9
6	0.814	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2587.3
7	0.786	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2587.7
8	0.759	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2588.1
9	0.734	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2588.4
10	0.709	0.0	0.0	0.5	0.0	0.0	0.5	0.4	2588.8
11	0.685	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2589.1
12	0.662	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2589.5
13	0.639	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2589.8
14	0.618	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2590.1
15	0.597	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2590.4
16	0.577	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2590.7
17	0.557	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2591.0
18	0.538	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2591.3
19	0.520	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2591.5
20	0.503	0.0	0.0	0.5	0.0	0.0	0.5	0.3	2591.8
21	0.486	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2592.0
22	0.469	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2592.2
23	0.453	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2592.5
24	0.438	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2592.7
25	0.423	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2592.9
26	0.409	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2593.1
27	0.395	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2593.3
28	0.382	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2593.5
29	0.369	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2593.7
30	0.356	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2593.9
31	0.346	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.1
32	0.336	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.2
33	0.326	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.4
34	0.317	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.5
35	0.307	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.7
36	0.298	0.0	0.0	0.5	0.0	0.0	0.5	0.2	2594.9
37	0.290	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.0
38	0.281	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.1
39	0.273	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.3
40	0.265	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.4
41	0.257	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.5
42	0.250	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.7
43	0.243	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.8
44	0.236	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2595.9
45	0.229	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.0
46	0.222	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.1
47	0.216	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.2
48	0.209	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.4
49	0.203	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.5
50	0.197	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.6
51	0.192	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.7
52	0.186	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.7
53	0.181	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.8
54	0.175	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2596.9
55	0.170	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.0
56	0.165	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.1
57	0.160	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.2
58	0.156	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.3
59	0.151	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.3
60	0.147	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.4
61	0.143	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.5
62	0.138	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.5
63	0.134	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.6
64	0.130	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.7
65	0.127	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.7
66	0.123	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.8
67	0.119	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.9
68	0.116	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2597.9
69	0.112	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2598.0
70	0.109	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2598.0
71	0.106	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2598.1
72	0.103	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2598.1
73	0.100	0.0	0.0	0.5	0.0	0.0	0.5	0.1	2598.2
74	0.097	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.2
75	0.094	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.3
76	0.092	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.3
77	0.090	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.4
78	0.087	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.4
79	0.085	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.5
80	0.083	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.5
81	0.081	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.6
82	0.079	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.6
83	0.077	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.6
84	0.075	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.7
85	0.074	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.7
86	0.072	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.7
87	0.070	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.8
88	0.068	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.8
89	0.067	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.8
90	0.065	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.9
91	0.063	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.9
92	0.062	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2598.9
93	0.060	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.0
94	0.059	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.0
95	0.057	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.0
96	0.056	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.1
97	0.055	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.1
98	0.053	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.1
99	0.052	0.0	0.0	0.5	0.0	0.0	0.5	0.0	2599.1

Whole life cost charts





Summary of costs

Client/Authority		Prepared (date)	10/08/2018
Scottish Borders Council		Printed	14/01/2019
Project/Option name		Prepared by	MM
Newcastleton - Charlie's Sike Restoration		Checked by	MM
Project reference		Checked date	26/11/2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£50.53
Capital Costs	£309.16
O & M Costs	£179.11
Other Costs	£0.00
Total Real Cost	£538.81
Total Cost PV	£400.14
Total Cost PV + OB	**£640.22**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.

Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

Additional user notes:

Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£9.24	£102.71	£0.00	£0.00	£111.96	£108.48
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various			£41.29	£206.45	£179.11	£0.00	£426.85	£291.65
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	400.1	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	50.5	309.2	179.1	0.0	0.0	538.81	400.1	
	Total PV cost	50.5	298.7	50.9	0.0	0.0		400.1	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	50.5	0.0	0.0	0.0	0.0	50.5	50.5	50.5
1	0.966	0.0	309.2	0.0	0.0	0.0	309.2	298.7	349.2
2	0.934	0.0	0.0	1.8	0.0	0.0	1.8	1.7	351.0
3	0.902	0.0	0.0	1.8	0.0	0.0	1.8	1.6	352.6
4	0.871	0.0	0.0	1.8	0.0	0.0	1.8	1.6	354.2
5	0.842	0.0	0.0	1.8	0.0	0.0	1.8	1.5	355.7
6	0.814	0.0	0.0	1.8	0.0	0.0	1.8	1.5	357.2
7	0.786	0.0	0.0	1.8	0.0	0.0	1.8	1.4	358.7
8	0.759	0.0	0.0	1.8	0.0	0.0	1.8	1.4	360.0
9	0.734	0.0	0.0	1.8	0.0	0.0	1.8	1.3	361.4
10	0.709	0.0	0.0	1.8	0.0	0.0	1.8	1.3	362.7
11	0.685	0.0	0.0	1.8	0.0	0.0	1.8	1.3	363.9
12	0.662	0.0	0.0	1.8	0.0	0.0	1.8	1.2	365.1
13	0.639	0.0	0.0	1.8	0.0	0.0	1.8	1.2	366.3
14	0.618	0.0	0.0	1.8	0.0	0.0	1.8	1.1	367.4
15	0.597	0.0	0.0	1.8	0.0	0.0	1.8	1.1	368.5
16	0.577	0.0	0.0	1.8	0.0	0.0	1.8	1.1	369.6
17	0.557	0.0	0.0	1.8	0.0	0.0	1.8	1.0	370.6
18	0.538	0.0	0.0	1.8	0.0	0.0	1.8	1.0	371.6
19	0.520	0.0	0.0	1.8	0.0	0.0	1.8	1.0	372.5
20	0.503	0.0	0.0	1.8	0.0	0.0	1.8	0.9	373.5
21	0.486	0.0	0.0	1.8	0.0	0.0	1.8	0.9	374.3
22	0.469	0.0	0.0	1.8	0.0	0.0	1.8	0.9	375.2
23	0.453	0.0	0.0	1.8	0.0	0.0	1.8	0.8	376.0
24	0.438	0.0	0.0	1.8	0.0	0.0	1.8	0.8	376.8
25	0.423	0.0	0.0	1.8	0.0	0.0	1.8	0.8	377.6
26	0.409	0.0	0.0	1.8	0.0	0.0	1.8	0.7	378.3
27	0.395	0.0	0.0	1.8	0.0	0.0	1.8	0.7	379.1
28	0.382	0.0	0.0	1.8	0.0	0.0	1.8	0.7	379.8
29	0.369	0.0	0.0	1.8	0.0	0.0	1.8	0.7	380.4
30	0.356	0.0	0.0	1.8	0.0	0.0	1.8	0.7	381.1
31	0.346	0.0	0.0	1.8	0.0	0.0	1.8	0.6	381.7
32	0.336	0.0	0.0	1.8	0.0	0.0	1.8	0.6	382.3
33	0.326	0.0	0.0	1.8	0.0	0.0	1.8	0.6	382.9
34	0.317	0.0	0.0	1.8	0.0	0.0	1.8	0.6	383.5
35	0.307	0.0	0.0	1.8	0.0	0.0	1.8	0.6	384.1
36	0.298	0.0	0.0	1.8	0.0	0.0	1.8	0.5	384.6
37	0.290	0.0	0.0	1.8	0.0	0.0	1.8	0.5	385.1
38	0.281	0.0	0.0	1.8	0.0	0.0	1.8	0.5	385.7
39	0.273	0.0	0.0	1.8	0.0	0.0	1.8	0.5	386.2
40	0.265	0.0	0.0	1.8	0.0	0.0	1.8	0.5	386.6
41	0.257	0.0	0.0	1.8	0.0	0.0	1.8	0.5	387.1
42	0.250	0.0	0.0	1.8	0.0	0.0	1.8	0.5	387.6
43	0.243	0.0	0.0	1.8	0.0	0.0	1.8	0.4	388.0
44	0.236	0.0	0.0	1.8	0.0	0.0	1.8	0.4	388.4
45	0.229	0.0	0.0	1.8	0.0	0.0	1.8	0.4	388.9
46	0.222	0.0	0.0	1.8	0.0	0.0	1.8	0.4	389.3
47	0.216	0.0	0.0	1.8	0.0	0.0	1.8	0.4	389.7
48	0.209	0.0	0.0	1.8	0.0	0.0	1.8	0.4	390.0
49	0.203	0.0	0.0	1.8	0.0	0.0	1.8	0.4	390.4
50	0.197	0.0	0.0	1.8	0.0	0.0	1.8	0.4	390.8
51	0.192	0.0	0.0	1.8	0.0	0.0	1.8	0.4	391.1
52	0.186	0.0	0.0	1.8	0.0	0.0	1.8	0.3	391.5
53	0.181	0.0	0.0	1.8	0.0	0.0	1.8	0.3	391.8
54	0.175	0.0	0.0	1.8	0.0	0.0	1.8	0.3	392.1
55	0.170	0.0	0.0	1.8	0.0	0.0	1.8	0.3	392.4
56	0.165	0.0	0.0	1.8	0.0	0.0	1.8	0.3	392.7
57	0.160	0.0	0.0	1.8	0.0	0.0	1.8	0.3	393.0
58	0.156	0.0	0.0	1.8	0.0	0.0	1.8	0.3	393.3
59	0.151	0.0	0.0	1.8	0.0	0.0	1.8	0.3	393.6
60	0.147	0.0	0.0	1.8	0.0	0.0	1.8	0.3	393.9
61	0.143	0.0	0.0	1.8	0.0	0.0	1.8	0.3	394.1
62	0.138	0.0	0.0	1.8	0.0	0.0	1.8	0.3	394.4
63	0.134	0.0	0.0	1.8	0.0	0.0	1.8	0.2	394.6
64	0.130	0.0	0.0	1.8	0.0	0.0	1.8	0.2	394.9
65	0.127	0.0	0.0	1.8	0.0	0.0	1.8	0.2	395.1
66	0.123	0.0	0.0	1.8	0.0	0.0	1.8	0.2	395.3
67	0.119	0.0	0.0	1.8	0.0	0.0	1.8	0.2	395.5
68	0.116	0.0	0.0	1.8	0.0	0.0	1.8	0.2	395.7
69	0.112	0.0	0.0	1.8	0.0	0.0	1.8	0.2	395.9
70	0.109	0.0	0.0	1.8	0.0	0.0	1.8	0.2	396.1
71	0.106	0.0	0.0	1.8	0.0	0.0	1.8	0.2	396.3
72	0.103	0.0	0.0	1.8	0.0	0.0	1.8	0.2	396.5
73	0.100	0.0	0.0	1.8	0.0	0.0	1.8	0.2	396.7
74	0.097	0.0	0.0	1.8	0.0	0.0	1.8	0.2	396.9
75	0.094	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.1
76	0.092	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.2
77	0.090	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.4
78	0.087	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.5
79	0.085	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.7
80	0.083	0.0	0.0	1.8	0.0	0.0	1.8	0.2	397.9
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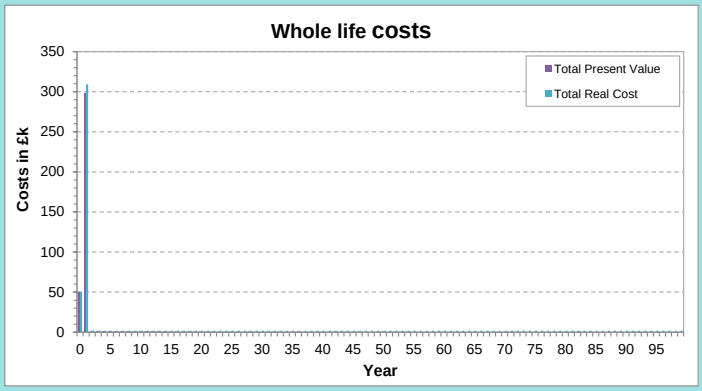
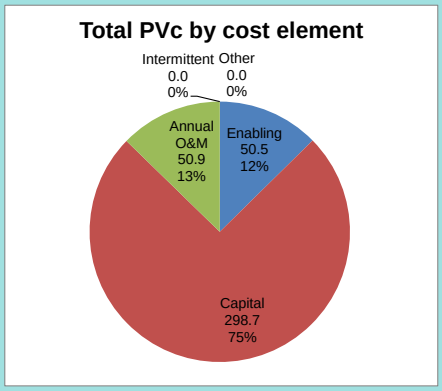
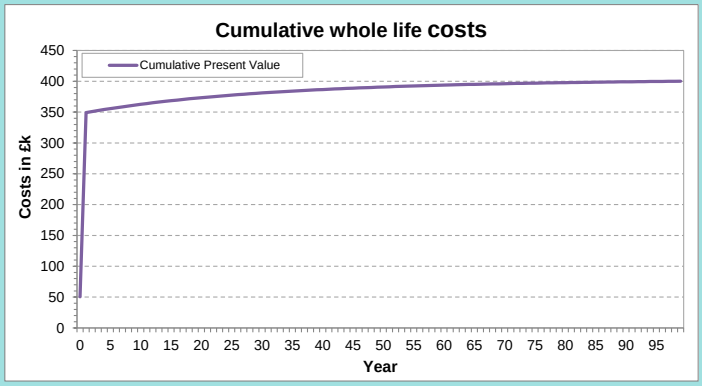
83	0.077	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.3
84	0.075	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.4
85	0.074	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.6
86	0.072	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.7
87	0.070	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.8
88	0.068	0.0	0.0	1.8	0.0	0.0	1.8	0.1	398.9
89	0.067	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.1
90	0.065	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.2
91	0.063	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.3
92	0.062	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.4
93	0.060	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.5
94	0.059	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.6
95	0.057	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.7
96	0.056	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.8
97	0.055	0.0	0.0	1.8	0.0	0.0	1.8	0.1	399.9
98	0.053	0.0	0.0	1.8	0.0	0.0	1.8	0.1	400.0
99	0.052	0.0	0.0	1.8	0.0	0.0	1.8	0.1	400.1

Whole life cost charts







Summary of costs

Client/Authority		Prepared (date)	10/08/2018
Scottish Borders Council		Printed	14/01/2019
Project/Option name		Prepared by	MM
Newcastleton - Charlie's Sike Two Stage Channel		Checked by	MM
Project reference		Checked date	26/11/2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£22.94
Capital Costs	£114.69
O & M Costs	£99.50
Other Costs	£0.00
Total Real Cost	£237.13
Total Cost PV	£162.02
Total Cost PV + OB	**£259.23**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

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Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

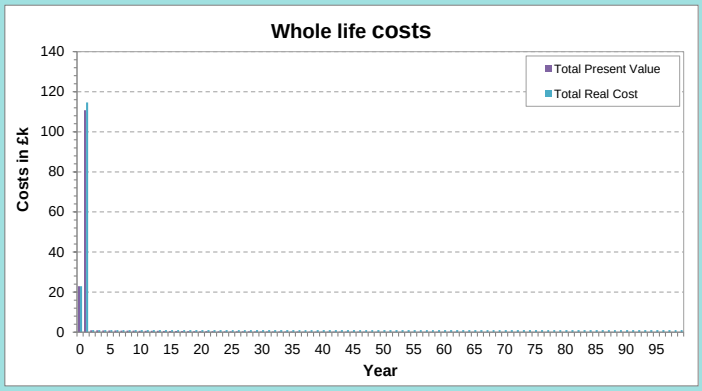
Additional user notes:

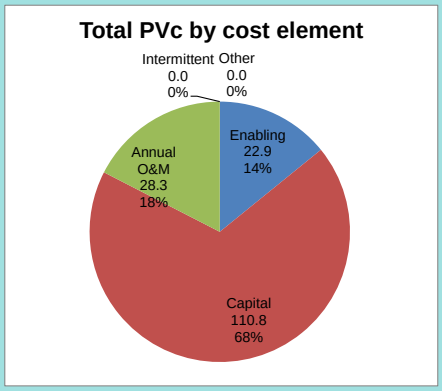
Add additional user notes here.

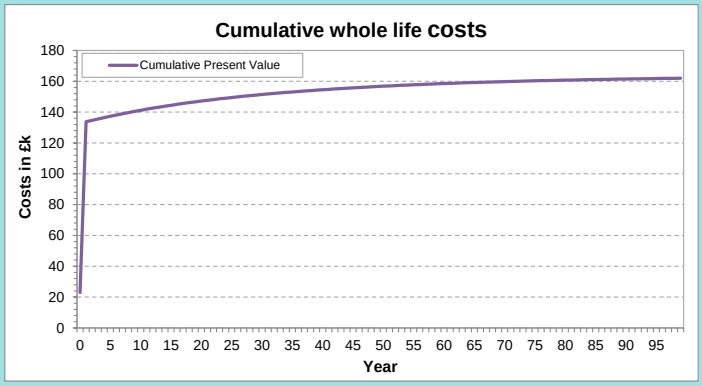
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various			£22.94	£114.69	£99.50	£0.00	£237.13	£162.02
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	162.0	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	22.9	114.7	99.5	0.0	0.0	237.13	162.0	
	Total PV cost	22.9	110.8	28.3	0.0	0.0		162.0	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	22.9	0.0	0.0	0.0	0.0	22.9	22.9	22.9
1	0.966	0.0	114.7	0.0	0.0	0.0	114.7	110.8	133.7
2	0.934	0.0	0.0	1.0	0.0	0.0	1.0	0.9	134.7
3	0.902	0.0	0.0	1.0	0.0	0.0	1.0	0.9	135.6
4	0.871	0.0	0.0	1.0	0.0	0.0	1.0	0.9	136.5
5	0.842	0.0	0.0	1.0	0.0	0.0	1.0	0.9	137.4
6	0.814	0.0	0.0	1.0	0.0	0.0	1.0	0.8	138.2
7	0.786	0.0	0.0	1.0	0.0	0.0	1.0	0.8	139.0
8	0.759	0.0	0.0	1.0	0.0	0.0	1.0	0.8	139.7
9	0.734	0.0	0.0	1.0	0.0	0.0	1.0	0.7	140.5
10	0.709	0.0	0.0	1.0	0.0	0.0	1.0	0.7	141.2
11	0.685	0.0	0.0	1.0	0.0	0.0	1.0	0.7	141.9
12	0.662	0.0	0.0	1.0	0.0	0.0	1.0	0.7	142.6
13	0.639	0.0	0.0	1.0	0.0	0.0	1.0	0.6	143.2
14	0.618	0.0	0.0	1.0	0.0	0.0	1.0	0.6	143.9
15	0.597	0.0	0.0	1.0	0.0	0.0	1.0	0.6	144.5
16	0.577	0.0	0.0	1.0	0.0	0.0	1.0	0.6	145.0
17	0.557	0.0	0.0	1.0	0.0	0.0	1.0	0.6	145.6
18	0.538	0.0	0.0	1.0	0.0	0.0	1.0	0.5	146.2
19	0.520	0.0	0.0	1.0	0.0	0.0	1.0	0.5	146.7
20	0.503	0.0	0.0	1.0	0.0	0.0	1.0	0.5	147.2
21	0.486	0.0	0.0	1.0	0.0	0.0	1.0	0.5	147.7
22	0.469	0.0	0.0	1.0	0.0	0.0	1.0	0.5	148.2
23	0.453	0.0	0.0	1.0	0.0	0.0	1.0	0.5	148.6
24	0.438	0.0	0.0	1.0	0.0	0.0	1.0	0.4	149.1
25	0.423	0.0	0.0	1.0	0.0	0.0	1.0	0.4	149.5
26	0.409	0.0	0.0	1.0	0.0	0.0	1.0	0.4	149.9
27	0.395	0.0	0.0	1.0	0.0	0.0	1.0	0.4	150.3
28	0.382	0.0	0.0	1.0	0.0	0.0	1.0	0.4	150.7
29	0.369	0.0	0.0	1.0	0.0	0.0	1.0	0.4	151.1
30	0.356	0.0	0.0	1.0	0.0	0.0	1.0	0.4	151.4
31	0.346	0.0	0.0	1.0	0.0	0.0	1.0	0.4	151.8
32	0.336	0.0	0.0	1.0	0.0	0.0	1.0	0.3	152.1
33	0.326	0.0	0.0	1.0	0.0	0.0	1.0	0.3	152.5
34	0.317	0.0	0.0	1.0	0.0	0.0	1.0	0.3	152.8
35	0.307	0.0	0.0	1.0	0.0	0.0	1.0	0.3	153.1
36	0.298	0.0	0.0	1.0	0.0	0.0	1.0	0.3	153.4
37	0.290	0.0	0.0	1.0	0.0	0.0	1.0	0.3	153.7
38	0.281	0.0	0.0	1.0	0.0	0.0	1.0	0.3	154.0
39	0.273	0.0	0.0	1.0	0.0	0.0	1.0	0.3	154.3
40	0.265	0.0	0.0	1.0	0.0	0.0	1.0	0.3	154.5
41	0.257	0.0	0.0	1.0	0.0	0.0	1.0	0.3	154.8
42	0.250	0.0	0.0	1.0	0.0	0.0	1.0	0.3	155.0
43	0.243	0.0	0.0	1.0	0.0	0.0	1.0	0.2	155.3
44	0.236	0.0	0.0	1.0	0.0	0.0	1.0	0.2	155.5
45	0.229	0.0	0.0	1.0	0.0	0.0	1.0	0.2	155.8
46	0.222	0.0	0.0	1.0	0.0	0.0	1.0	0.2	156.0
47	0.216	0.0	0.0	1.0	0.0	0.0	1.0	0.2	156.2
48	0.209	0.0	0.0	1.0	0.0	0.0	1.0	0.2	156.4
49	0.203	0.0	0.0	1.0	0.0	0.0	1.0	0.2	156.6
50	0.197	0.0	0.0	1.0	0.0	0.0	1.0	0.2	156.8
51	0.192	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.0
52	0.186	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.2
53	0.181	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.4
54	0.175	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.6
55	0.170	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.7
56	0.165	0.0	0.0	1.0	0.0	0.0	1.0	0.2	157.9
57	0.160	0.0	0.0	1.0	0.0	0.0	1.0	0.2	158.1
58	0.156	0.0	0.0	1.0	0.0	0.0	1.0	0.2	158.2
59	0.151	0.0	0.0	1.0	0.0	0.0	1.0	0.2	158.4
60	0.147	0.0	0.0	1.0	0.0	0.0	1.0	0.1	158.5
61	0.143	0.0	0.0	1.0	0.0	0.0	1.0	0.1	158.7
62	0.138	0.0	0.0	1.0	0.0	0.0	1.0	0.1	158.8
63	0.134	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.0
64	0.130	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.1
65	0.127	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.2
66	0.123	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.3
67	0.119	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.5
68	0.116	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.6
69	0.112	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.7
70	0.109	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.8
71	0.106	0.0	0.0	1.0	0.0	0.0	1.0	0.1	159.9
72	0.103	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.0
73	0.100	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.1
74	0.097	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.2
75	0.094	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.3
76	0.092	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.4
77	0.090	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.5
78	0.087	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.6
79	0.085	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.7
80	0.083	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.8
81	0.081	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.8
82	0.079	0.0	0.0	1.0	0.0	0.0	1.0	0.1	160.9
83	0.077	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.0
84	0.075	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.1
85	0.074	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.1
86	0.072	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.2
87	0.070	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.3
88	0.068	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.4
89	0.067	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.4
90	0.065	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.5
91	0.063	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.6
92	0.062	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.6
93	0.060	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.7
94	0.059	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.7
95	0.057	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.8
96	0.056	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.9
97	0.055	0.0	0.0	1.0	0.0	0.0	1.0	0.1	161.9
98	0.053	0.0	0.0	1.0	0.0	0.0	1.0	0.1	162.0
99	0.052	0.0	0.0	1.0	0.0	0.0	1.0	0.1	162.0

Whole life cost charts







Whole life cost and PVc analysis example - with replacement costs

Enter enabling, capital, annual O&M and other costs in table below
Enter frequency of other (or replacement) works in table below

Enabling cost (£k)	£148.0
Year of capital works (year)	1
Capital cost (£k)	£831.2
Annual maintenance cost (£k)	£16.6
Other cost (£k)	£0.0
Other works frequency (years)	1
Other cost (£k)	£0.0
Other works frequency (years)	1
Replacement (£)	831.152
Replacement frequency (years)	20
Optimism Bias	60%

Key

	Information
	Calculation
	Cost input
	Default

		Total PVc (£k) with Optimism Bias:					**3548**
Initial discount rate		**3.5%**	**29.813**		**Total PVc (£k):**		**2217**
		Cost Elements				**TOTALS:**	
		Enabling	**Capital**	**Maint.**	**Interm.**	**Cash**	**PV**
	Cash sum	148	4156	1629	0	5933	**2217**
year	**Discount Factor**						
0	1.000	148.0			0	148.0	148.0
1	0.966		831		0	831.2	803.0
2	0.934			17	0	16.6	15.5
3	0.902			17	0	16.6	15.0
4	0.871			17	0	16.6	14.5
5	0.842			17	0	16.6	14.0
6	0.814			17	0	16.6	13.5
7	0.786			17	0	16.6	13.1
8	0.759			17	0	16.6	12.6
9	0.734			17	0	16.6	12.2
10	0.709			17	0	16.6	11.8
11	0.685			17	0	16.6	11.4
12	0.662			17	0	16.6	11.0
13	0.639			17	0	16.6	10.6
14	0.618			17	0	16.6	10.3
15	0.597			17	0	16.6	9.9
16	0.577			17	0	16.6	9.6
17	0.557			17	0	16.6	9.3
18	0.538			17	0	16.6	8.9
19	0.520			17	0	16.6	8.6
20	0.503			17	0	16.6	8.4
21	0.486		831	17	0	847.8	411.7
22	0.469			17	0	16.6	7.8
23	0.453			17	0	16.6	7.5
24	0.438			17	0	16.6	7.3
25	0.423			17	0	16.6	7.0
26	0.409			17	0	16.6	6.8
27	0.395			17	0	16.6	6.6
28	0.382			17	0	16.6	6.3
29	0.369			17	0	16.6	6.1
30	0.356			17	0	16.6	5.9
31	0.346			17	0	16.6	5.7
32	0.336			17	0	16.6	5.6
33	0.326			17	0	16.6	5.4
34	0.317			17	0	16.6	5.3
35	0.307			17	0	16.6	5.1
36	0.298			17	0	16.6	5.0
37	0.290			17	0	16.6	4.8
38	0.281			17	0	16.6	4.7
39	0.273			17	0	16.6	4.5
40	0.265			17	0	16.6	4.4
41	0.257		831	17	0	847.8	218.2
42	0.250			17	0	16.6	4.2
43	0.243			17	0	16.6	4.0
44	0.236			17	0	16.6	3.9
45	0.229			17	0	16.6	3.8
46	0.222			17	0	16.6	3.7
47	0.216			17	0	16.6	3.6
48	0.209			17	0	16.6	3.5
49	0.203			17	0	16.6	3.4
50	0.197			17	0	16.6	3.3
51	0.192			17	0	16.6	3.2
52	0.186			17	0	16.6	3.1
53	0.181			17	0	16.6	3.0
54	0.175			17	0	16.6	2.9
55	0.170			17	0	16.6	2.8
56	0.165			17	0	16.6	2.7
57	0.160			17	0	16.6	2.7
58	0.156			17	0	16.6	2.6
59	0.151			17	0	16.6	2.5
60	0.147			17	0	16.6	2.4
61	0.143		831	17	0	847.8	120.8
62	0.138			17	0	16.6	2.3
63	0.134			17	0	16.6	2.2
64	0.130			17	0	16.6	2.2
65	0.127			17	0	16.6	2.1
66	0.123			17	0	16.6	2.0
67	0.119			17	0	16.6	2.0
68	0.116			17	0	16.6	1.9
69	0.112			17	0	16.6	1.9
70	0.109			17	0	16.6	1.8
71	0.106			17	0	16.6	1.8
72	0.103			17	0	16.6	1.7
73	0.100			17	0	16.6	1.7
74	0.097			17	0	16.6	1.6
75	0.094			17	0	16.6	1.6
76	0.092			17	0	16.6	1.5
77	0.090			17	0	16.6	1.5
78	0.087			17	0	16.6	1.5
79	0.085			17	0	16.6	1.4
80	0.083			17	0	16.6	1.4
81	0.081		831	17	0	847.8	68.9
82	0.079			17	0	16.6	1.3
83	0.077			17	0	16.6	1.3
84	0.075			17	0	16.6	1.3
85	0.074			17	0	16.6	1.2
86	0.072			17	0	16.6	1.2
87	0.070			17	0	16.6	1.2
88	0.068			17	0	16.6	1.1
89	0.067			17	0	16.6	1.1
90	0.065			17	0	16.6	1.1
91	0.063			17	0	16.6	1.1
92	0.062			17	0	16.6	1.0
93	0.060			17	0	16.6	1.0
94	0.059			17	0	16.6	1.0
95	0.057			17	0	16.6	1.0
96	0.056			17	0	16.6	0.9
97	0.055			17	0	16.6	0.9
98	0.053			17	0	16.6	0.9
99	0.052			17	0	16.6	0.9

B Public Consultation Questionnaire

Newcastleton Flood Questionnaire Report

Purpose

In order to gain an insight into the reaction of the public to proposed flood protection schemes, a questionnaire was available to be filled in at the Newcastleton Flood Study Exhibition on 2nd October 2018. Local knowledge and feedback is key to influencing decisions on flood protection schemes and out of 46 people who attended the exhibition, 32 questionnaire responses were received (70%).

Questionnaire Format

The anonymous questionnaires that were available to the local public of Newcastleton consisted of 10 questions which could be circled 'yes' or 'no' and also included a comments box to elaborate on each answer. This simple layout allowed the questionnaires to be filled in quickly while still giving the option to voice opinions and feedback in greater detail. Below are all the questions which were on the questionnaire sheet:

1. Please name the watercourse(s) which impacts upon you?
2. Have you previously experiences flooding?
3. Do you want to see a flood protection scheme in the site of interest?
4. Do you approve of the approach that we are taking in developing a Flood Protection Scheme in your community?
5. Are there any flood related issues that you feel that we have missed?
6. Do you use the river for recreational purposes?
7. Do you have any concerns about how the flood mitigation options proposed may affect recreation activities at the river?
8. Currently are there any access issues to the existing river infrastructure, including issues which effect individuals with a disability?
9. Are you particularly concerned with any of the proposed options?
10. Do you have any other issues that you would like to raise?

Questionnaire Analysis

****Council responses within red*

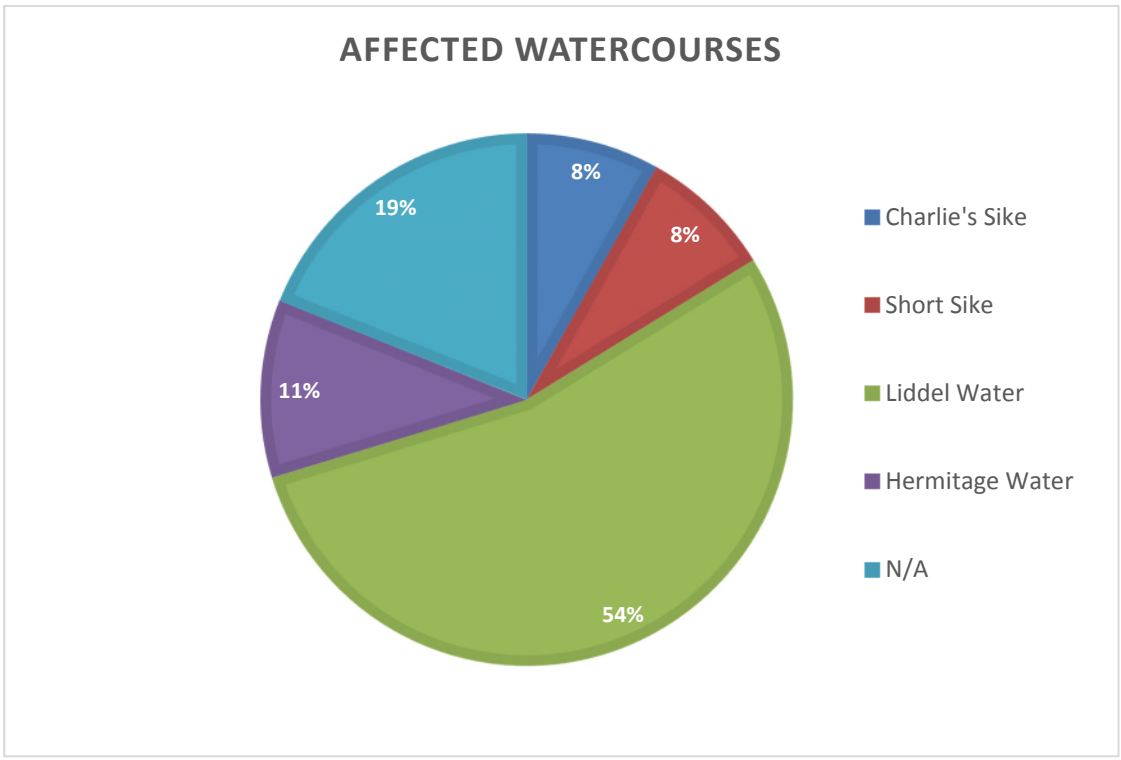
Question 1

Please circle the watercourse/s which impact upon you?

In Newcastleton there are four main water courses which are of concern and may impact upon different people depending on where they live in the town. The watercourses that were available to circle on the questionnaire were **the Liddel Water, Short Sike, Charlie's Sike and Hermitage Water.** There was also an 'N/A' option to circle if you were not affected by any of these or would rather not say. Some residents who may have been affected by a few different watercourses circled multiple answers which are reflected in the table below.

Affected watercourse	Number of people affected
Liddel Water	20
Short Sike	3
Charlie's Sike	3
Hermitage Water	4
N/A	7

As shown from the data collected, the members of the public who took part in the questionnaire were mostly affected by the Liddel Water.



Question 2

Have you previously experienced flooding?

Out of the 32 participants, 15 answered yes to this question and the remaining 17 answered "No". Of those that answered "Yes", there were a variety of comments, many of which highlighted the dates they experienced flooding. Several respondents highlighted the 1991 and 2005 floods as affecting their property and this was also highlighted by those that said "No"; one stating "I have witnessed neighbours properties messed up". These two events have been the most significant in recent years but the floods of 1956 and frequent problematic flooding from the Lakes area was also highlighted.

Question 3

Do you want to see a flood protection scheme in the site of interest?

In general, respondents showed a strong desire and support for a flood protection scheme within Newcastleton – 26 of the 29 [90%] that answered this question were in support of flood protection in the village. One respondent stated that they have *"seen the devastation caused to properties"* and that a scheme is essential to mitigate this risk.

Although respondents were supportive of a scheme, it was clear from the comments that any scheme should ensure the protection of properties but that the scheme is not too obtrusive, specifically along the banks of the Liddel Water. Many of the comments revolved around the heights of the walls, with comments such as;

- *"No 6ft wall in front of my property, 2-3ft would be tolerated"*
- *"Unobtrusive as possible"*
- *"Not a wall, bank of 6-12 inches would be enough"*
- *"But not a wall"*
- *"Something needed with minimal visual impact"*

The proposals in Option 1 have an average height of 1.3m [4.3ft] and would seek to be as unobtrusive as possible within areas next to property. The proposals in Option 2 have an average height of less than 1m [3.3ft].

A 1.8m [6ft] wall along the banks of the Liddel Water is not being proposed and was not considered as an option due to the obtrusiveness of this height of wall.

Flood gates are proposed along the wall to allow access to the riverside and these proposals would be outlined within the detailed design phase of the project.

Question 4

Do you approve of the approach that we are taking in developing a Flood Protection Scheme in your community?

24 of the 31 participants answering this question approved of the Council's approach in the development of a flood protection scheme in Newcastleton, with 7 stating they were not supportive. Those that approved of this approach were encouraged by the amount of consultation with members of the public and their involvement within the development of a potential scheme. Positive comments welcoming a scheme are shown below;

- *"Yes, because SBC is consulting with locals"*
- *"Listening to local people is important"*
- *"If involving people then yes, it must be the only approach"*
- *"Carried out sympathetically, it will secure properties and residents"*
- *"Long time coming"*

There were however concerns about some aspects of the approach, again involving the building of a wall, these included comments such as;

- *"Biased towards the solution of a wall"*
- *"Protect houses not the fish"*

Several solutions were assessed for flood protection in Newcastleton, a long-list of options was drawn up and assessed, including direct defences, channel modification, diversion and many more. As outlined at the public meeting, options were assessed and those that were not viable were ruled out. The most effective options after this appraisal process was presented within the five options outlined at the meeting; Options 1 and 2 involved direct defences in the form of walls.

Question 5

Are there any flood related issues that you feel we have missed?

There was a divided response to this question, with 12 residents answering highlighting areas that they felt had been missed, with 17 answering that they did not feel anything pertinent had been missed. The key areas that were raised were the issues of tree planting on the left bank of the Liddel Water, on the Whithaugh side and the potential long-term flood risk problems arising from this, the flood risk from the Lakes, surface water drainage and dredging the watercourse.

Comments from respondents highlighting areas missed are shown below;

Whithaugh Tree Planting

- *"Planting of trees across flood plain on Whithaugh side of the river. This may cause a future problem and if tubes washed away this could be an environmental issue"*
- *"Planting of trees (Spring 2018) on other side of river at North Liddel Street.*

This tree planting has already been assessed within the modelling phase of our study and it has been decided that any newly planted trees on flood plains in the village boundary that interfere with flood risk would be removed to facilitate flood protection scheme works.

Flood Risk from the Lakes

- *"Drain the Lakes"*
- *"I think the Short Sike should be re-aligned where it enters the Liddel Water"*
- *"Lakes…need to be cleaned out and diverted to where the road goes into the Sewage Works"*
- *"Water in the Lakes needs to be diverted down the Old Railway as far as the Muckle Knowe"*

Surface Water Drainage

- Issue with *"Existing Drainage and Waterway"*
- Need more *"Cleaning of existing surface water gullies in roads etc. which becomes blocked with debris"*

Dredging

- *"I think dredging the stone below the Holm Bridge would help"*

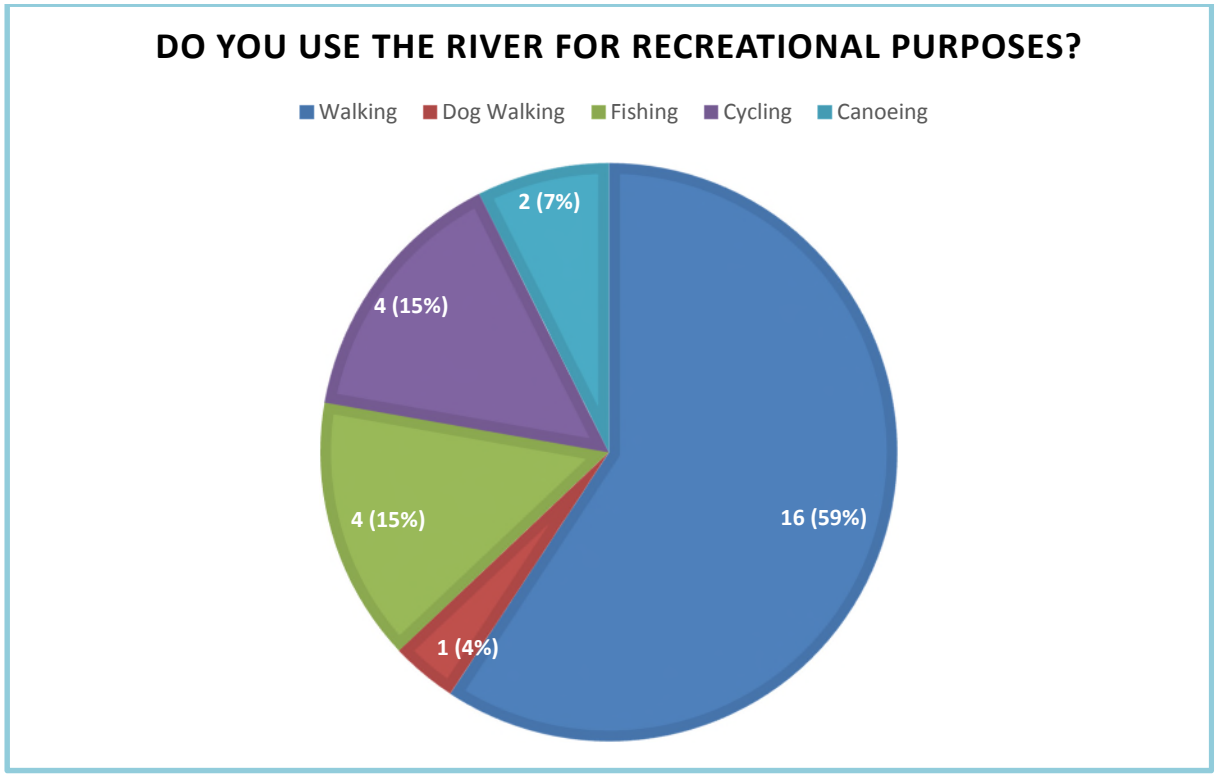
Others

- *"I do not want to lose too much of the grass bank walkway"*

Question 6

Do you use the river for recreational purposes?

Responses made it apparent that the majority of residents in Newcastleton use the river for recreational purposes and that the river is one of the features of the village that residents feel is part of their daily life. 23 of the 32 respondents stated that they used the river for recreational purposes, with the main activities being walking, dog walking, fishing and cycling, as shown in the chart below.



Question 7

Do you have any concerns about how the flood mitigation options proposed may affect recreation activities at the river?

Out of the 29 participants that responded, only 10 were concerned about how the scheme would affect any of the recreational activities they partake in close to the river. The key issues raised by multiple participants that answered yes included access to the river and the existing walkway and the visual impact of the proposed flood defence options. Key comments are shown below;

Access to the river

"This will affect activities on the riverside, will there be easy access to the riverside at all? There is a large number of elderly people in the village [that cannot scale a wall]"

"Issues with access to the waterside for visitors and residents"

Visual Impact for walking

"Impact on the landscape and walking parts"

It was accepted by some members of the public that although they have concerns, there was an acceptance that *"we need to protect property"*.

Question 8

Currently are there any access issues to the existing river infrastructure including issues which effect individuals with a disability?

Although this was not highlighted as a major issue, 5 of the 29 responses to this questioned stated that there were specific issues with regards to accessing the existing river infrastructure.

Particularly with regards to disabled access, the main issue highlighted was the lack of wheelchair access currently available at the steps from the Holm Bridge to the river walkway. This issue will also affect non-disabled residents with pushchairs or similar.

The answers to this question are useful as if there are any issues of accessibility, we can work to address these and consider the issues in the detailed design phase of any flood defences.

Question 9

Are you particularly concerned with any of the proposed options?

Key concerns were raised with the proposed options within this question, with 14 of the 29 residents expressing concern at aspects of the proposed options. The primary concern for residents was within Option 1 and 2, specifically regarding the wall height. Other concerns raised included the issue of how water would escape from the street side back into the river if a wall was to be built and how the Short Sike issue would be dealt with.

Key comments from residents included;

Direct Defences (Walls) – Option 1 & 2

"Option 2 – Do not build flood walls along the waterside"

"Flood Walls are restrictive and ugly"

"High Wall outside my house"

"I do not think the wall is the right answer – a small sod wall would be as good as anything"
Several also just stated that the "wall heights" were a concern.

Concerns with regards to wall heights will be considered. Wall heights will seek to be as unobtrusive as possible. However, at this stage a wall will continue to be progressed as one of the primary potential options for flood mitigation in Newcastleton.

Surface Water within Defences

"If there is a wall keeping the river out, how does the water from inside escape?"

"A wall would keep surface water in rather than keep water out"

If a wall is to be taken forward, a mechanism such as a pumping station, would be put in place to ensure that water on the inside of the flood defences will not be "stuck" on the "dry" side – this would be decided at the detailed design phase but it would be essential that some form of mechanism to manage this water is in place within any design.

Short Sike Option – Options 3 & 4

"Don't like the idea of storing water from Short Sike/Charlie's Sike behind Buccleuch Terrace and Scott Street"

Other

"Flood Plains Improvement and Widening Sikes a better option"

Question 10

Do you have any other issues that you would like to raise?

The final question on the questionnaire gave participants the opportunity to voice any issues they had, which may not have applied to the other questions. 11 respondents took the opportunity to raise issues, these additional points included dredging the river, clearing surface water drains more often, looking at previous drainage proposals, the negative effect on tourism and the effects of commercial forestry on flood risk.

Notable comments included;

Dredging

This issue was raised by several residents, including *"Dredge the rivers where gravel gathers. If this was done on a regular basis this would stop a lot of flooding"*

Dredging was assessed within the long-list of mitigation options but it was assessed to be an unsustainable option that required a costly long-term maintenance regime and was not cost-effective. Dredging was assessed as not being a viable option to protect against flood risk in Newcastleton.

Forestry

"Endless amounts of commercial forestry affecting the hill which soaks up a considerable amount of rainwater and releases it gradually"

Drainage

"Drains should be cleaned more often and inspected for faults"

Tourism

"Attracting visitors has becoming a big push for the business forum. Not sure the wall adds to visitor engagement of our beautiful river – especially when the floods have never been seen in living memory"

Outcome / Conclusion

As shown from the data collected within the questionnaires, there is a general consensus within Newcastleton that a flood protection scheme is required within the area and that the approach being taken to progress a potential scheme is suitable, specifically the community engagement aspect.

A vast majority of Newcastleton is shown to be at risk of flooding during major flood events and several respondents stated that they had been affected by flooding in the past – most notably in 1991 and 2005. This recent history of flooding and the community's understanding of how devastating flooding can be is likely to have contributed to their appreciation of the benefit of having their properties protected by a formal flood protection scheme.

However, the community was split as to whether the proposals for direct defences were suitable for the area, with many stating that a flood wall would need to have a limited visual impact and be unobtrusive. Other issues such as access to the watercourse were also highlighted by the community.

In conclusion, the process which has led the study to this stage has been well received by the community but careful consideration of the comments by members of the community will be required as the study progresses, specifically regarding wall heights.

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