
Report to Council

Date of Meeting: 19 December 2019

Subject: Tillicoultry Flood Protection Scheme

Report by: Strategic Director (Place)

1.0 Purpose

- 1.1. This report provides an update on the outcome of the Tillicoultry Flood Study.
- 1.2. The Council engaged consulting engineers to carry out the study. Tillicoultry was identified as the location for the Council's highest priority flood study within the Forth Flood Risk Management Plan (2016 – 2022).
- 1.3. The Council's consulting engineers have recommended a flood protection scheme. The proposed scheme is economically viable.

2.0 Recommendations

- 2.1. It is recommended that the Council:
 - (i) Notes the completion of the Tillicoultry Flood Study as required by the Forth Flood Risk Management Plan.
 - (ii) Approves the recommended proposal for a flood protection scheme in Tillicoultry.
 - (iii) Agrees that details of the recommended flood scheme to be submitted to SEPA by 31st December 2019 for national prioritisation.
 - (iv) Agrees that the recommended schemes be included in the next Forth Local Flood Risk Management Plan, due for publication June 2022.
 - (v) Agrees that Roads & Transportation Services uses its FRM powers to continue to develop the non-structural measures included in the Tillicoultry Flood Study.

3.0 Considerations

Flood Risk Management Act 2009/Local Flood Risk Management Plan

- 3.1. Under the Flood Risk Management (Scotland) Act 2009, SEPA and lead local authorities published new Flood Risk Management (FRM) Plans in 2016. These documents set out a range of actions that SEPA and responsible local authorities are taking to manage and, where possible, reduce the risk of flooding over a six year period (2016 - 2022).
- 3.2. The Forth FRM Plan identifies the Tillicoultry Flood Study as the highest priority flood study in the Clackmannanshire area of the Forth Local Plan District.
- 3.3. The purpose of the study is to firstly improve the understanding of local flood risk and secondly, to investigate what further action is required to manage flood risk in Tillicoultry. Such action can be implemented by through a flood protection scheme, where this is found to be technically feasible and economically viable.
- 3.4. The 2009 Act provides local authorities with the discretionary powers to promote flood protection schemes. Only those flood schemes which have been included in the Local FRM Plans and the national priority list are taken forward in the following 6 year period.

Tillicoultry Flood Study

- 3.5. Tillicoultry is located in the River Devon catchment within Potentially Vulnerable Area (PVA) 09/04.
- 3.6. The three main potential sources of flooding to Tillicoultry are the River Devon and two burns coming down from the Ochil Hills escarpment, the Tillicoultry Burn and an unnamed burn that meets the River Devon near to Elistoun Drive.
- 3.7. The potential impact of the unnamed burn has been mitigated by the raising of the Mixed Leisure Route adjacent to Elistoun Drive in January 2009 and the addition of a pumping station completed by Clackmannanshire Council in September 2012.
- 3.8. Further mitigation has come through the Council's committed effort to engage with the public on flood risk management issues, resulting in the formation of TIDECO, the local community flood resilience group, which has amongst its partners, the Scottish Flood Forum, SEPA, the Fire and Rescue Service and The Conservation Volunteers. However, fluvial flood risk remains from the River Devon and the Tillicoultry Burn.
- 3.9. In 2017 JBA Consulting was engaged to carry out a flood study for Tillicoultry. The study was published in April 2018 and its conclusions shared with TIDECO and its partners.
- 3.10. The study updated the understanding of the flood risk to Tillicoultry through new and updated surveys, flood hydrology, asset surveys, environmental surveys, National Flood Manual assessments and fluvial and pluvial flood modelling.

- 3.11. The study estimated that there are 45 properties at risk of internal flooding from the River Devon and 131 properties at risk from the Tillicoultry Burn for the 0.5% AP (200 year) flood flows. The baseline (Do Minimum) present value flood damages are anticipated to be in the order of £3.8m for the River Devon and £3.6m for the Tillicoultry Burn. These estimates are calculated over 30 years.
- 3.12. The preferred option is the only one that has been found to be cost effective whilst maintaining a 200 year standard of protection. The analysis suggests that the total long term damages avoided by the proposed flood protection scheme on the respective watercourses would be in the region of £3.4m for the River Devon and £3.1m for the Tillicoultry Burn. Detailed breakdowns are in the full report which is included in Appendix 1.
- 3.13. In addition to the above monetary impacts, the following wider benefits should also be noted:
- Tillicoultry has a higher level of social deprivation than other areas and when considered against Scotland as a whole. Thus, protection to Tillicoultry should be in preference to less deprived areas when SEPA prioritises schemes for inclusion in the 2022 FRM cycle.
 - The business disruption financial costs to Sterling Mills and Sterling Furniture cannot be in the economic appraisal but should not be underestimated. These sites are an important source of employment to the town and the business disruption of continued flooding should be noted.
- 3.14. The study makes the following recommendations;
- Clackmannanshire Council should introduce the option of a Flood Protection Scheme to Tillicoultry from both the River Devon and Tillicoultry Burn as a single scheme into SEPA's prioritisation process for the FRM cycle beginning 2022.
 - River Devon: this recommendation involves raising the Mixed Leisure Route by 300mm and replacing the informal Sterling Furniture embankment with a larger and more appropriately designed embankment and constructing a flood wall on both left and right banks adjacent to Sterling Mills. The embankment would extend to 240m and the flood walls to 500m.
 - Tillicoultry Burn: this recommendation involves raising the burn wall by 900mm along the length of the burn and road raising works at the entrance to Hareburn Road.
 - Prior to the next FRM cycle (2022 – 2028), (there is no guarantee that the scheme can be funded or short-listed by SEPA), the Council should also exercise its FRM powers and consider some or all of the non-structural measures outside of a formal Flood Protection Scheme;
 - Regular review of emergency plans to ensure that the community and first responders understand the flood risk, flood mechanisms and evacuation procedures,

- Flood warning on the Tillicoultry Burn using an SMS based alert system,
 - Implementation of a flood pod system and / or property level protection (PLP), and
 - Investigate Natural Flood Management measures.
- 3.15. The information required to submit the Tillicoultry Flood Protection Scheme into SEPA's prioritisation process has been collated and is ready for submission.
- 3.16. The Council is presently making progress with the first three items on the above list of non-structural measures (2.3.11). Natural Flood Management (NFM) is being monitored through the Development Planning process and knowledge of NFM developed by collaboration with Heriot Watt University on a study of the Menstrie Burn catchment.

National Prioritisation Process (SEPA)

- 3.17. SEPA has set a deadline of December 2019 for local authorities to identify new flood protection schemes for inclusion in the second cycle of Local FRM Plans (2022 – 2028). The flood protection schemes across Scotland will then be prioritised and added to the updated prioritisation list.
- 3.18. Therefore proposed that the recommended flood scheme for Tillicoultry is put forward to SEPA for prioritisation and is included in the next Forth Local FRM Plan, which will cover the period 2022 – 2028.
- 3.19. The next Forth Local FRM Plan will set out the proposed implementation arrangements for the flood scheme in Tillicoultry, including timescales and how it will be funded. The next phases of work to develop the flood scheme proposals will therefore not commence until after 2022.
- 3.20. If a Flood Protection Scheme has been added to SEPA's priority list it may be removed at any time, up until it has been included in the next Local Flood Risk Management Plan (2022). After that time, the scheme can be removed for economic viability reasons.
- 3.21. The grant offer from The Scottish Government on the 9 March 2016 to cover the existing 6 year period included an undistributed amount. This component of the grant is to be distributed based on SEPA's prioritisation of flooding schemes. The grant intervention rate is 80% of the tender acceptance for the project.
- 3.22. SEPA's prioritisation is based largely on the flood protection scheme's benefit/cost ratio. In general, the cost of flood damage avoided over time must be greater than the cost of building the flood defences, i.e. they must have a benefit/cost ratio of more than 1.0.
- 3.23. The benefit/cost ratio for the River Devon project is 1.2 and the ratio for Tillicoultry Burn project is 1.0. The recommendation is that we prepare one holistic scheme which would have a benefit / cost ratio of 1.1. As this is not a particularly high benefit/cost ratio it is likely that the Tillicoultry Flood Scheme will have a low priority.

- 3.24. In future the expenditure profile for the various flood schemes in the priority list is unlikely to match the funding available in that financial year. Lower priority schemes may not therefore receive grant funding in the year the expenditure is incurred, but in a later year.

4.0 Sustainability Implications

- 4.1. Under the provisions of the Local Government in Scotland Act 2003 the Council has to discharge its duties in a way which contributes to the achievement of sustainable development. Under the Climate Change (Scotland) Act 2009 the Council also has a duty relating to climate change and in exercising its functions must act;

- In the way best calculated to the delivery of the Act's emissions reduction targets,
- In the best way calculated to deliver any statutory adaptation programmes, and
- In a way that it considers most sustainable.

- 4.2. It has been determined that the proposal is likely to contribute positively to the Council's duty to respond to the Climate Change (Scotland) Act 2009 and to the Council's sustainable development principles.

5.0 Resource Implications

5.1. Financial Details

- 5.2. It should be noted that the proposed flood protection scheme will not be implemented at this time. The implementation arrangements will be set out in the next round of Local Flood Risk Management Plans, due for publication in June 2022. At some point during the subsequent six years, consulting engineers will be re-engaged to carry out further investigations and develop flood scheme proposals. As a result, there are no immediate resource implications arising directly from the recommendations in this report.

- 5.3. However, the flood risk management planning process will have future financial implications. The Local FRM Plans will contain the implementation arrangements including a timetable for the proposed flood scheme. These will be co-ordinated by SEPA and the responsible authorities over the next six-year cycle 2022 – 2028.

- 5.4. The 2009 Act requires the Scottish Government to have regard to the Local FRM Plans when allocating funds to SEPA and responsible authorities. The Scottish Government, CoSLA and SEPA will agree the distribution of capital funding to the actions identified nationally in the next FRM Strategies and Local FRM Plans. The following arrangements currently apply;

- Only works and schemes that are prioritised in the FRM Strategies and Local FRM Plans are eligible for capital funding.

- Flood protection schemes attract capital grant assistance of up to 80% of their estimated project cost at tender stage from the Scottish Government. Local authorities are required to fund the remainder of the cost of flood schemes including any increase from the tender value.
- 5.5. The Scottish Government and the Council would therefore have to make capital allocations for these flood schemes. At present, the allocated capital grant is adjusted as the flood scheme proposals are developed.
- 5.6. The proposals and cost estimates for the Tillicoultry Flood Scheme still have to be developed through a long process of further investigations, consultation, outline design, the statutory process, detailed design, tendering and construction. Experience from other local authorities on similar schemes has invariably shown that the costs estimated at the feasibility stage always increase. The scheme costs noted in this report are therefore subject to change and will have to be carefully monitored going forward.
- 5.7. The current estimate for the scheme cost is £6m and if the scheme is selected for SEPA's prioritisation of flooding schemes it will attract Scottish Government Grant funding of 80% of the tender value, leaving the Council to fund the remaining £1.2m. Once a Flood Protection Scheme has been added to SEPA's priority list it may be removed at any time, up until it has been included in the next Local Flood Risk Management Plan (2022). After that time, the scheme can be removed for economic viability reasons.
- 5.8. There are no current revenue funding implications arising from the recommendations in this report.
- 5.9. The full financial implications of the recommendations are set out in the report. This includes a reference to full life cycle costs where appropriate. Yes
- 5.10. Finance have been consulted and have agreed the financial implications as set out in the report. Yes
- 5.11. *Staffing*
- 5.12. There are no staffing implications arising directly from the recommendations in this report.

6.0 Exempt Reports

- 6.1. Is this report exempt? Yes (please detail the reasons for exemption below) No

7.0 Declarations

The recommendations contained within this report support or implement our Corporate Priorities and Council Policies.

- (1) **Our Priorities** (Please double click on the check box)

- Clackmannanshire will be attractive to businesses & people and ensure fair opportunities for all
- Our families; children and young people will have the best possible start in life
- Women and girls will be confident and aspirational, and achieve their full potential
- Our communities will be resilient and empowered so that they can thrive and flourish

(2) **Council Policies** (Please detail)

8.0 Equalities Impact

- 8.1 Have you undertaken the required equalities impact assessment to ensure that no groups are adversely affected by the recommendations?
 Yes No

9.0 Legality

- 9.1 It has been confirmed that in adopting the recommendations contained in this report, the Council is acting within its legal powers. Yes

10.0 Appendices

- 10.1 Please list any appendices attached to this report. If there are no appendices, please state "none".

Appendix 1 – Tillicoultry Flood Study: Final Report April 2018.

11.0 Background Papers

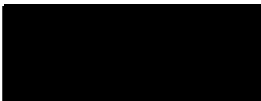
- 11.1 Have you used other documents to compile your report? (All documents must be kept available by the author for public inspection for four years from the date of meeting at which the report is considered)

NO (please list the documents below)

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Approved by

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Tillicoultry Flood Study

Final Report

April 2018



**Clackmannanshire
Council**

Clackmannanshire Council

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Executive Summary

Background

Tillicoultry is included in SEPA's Potentially Vulnerable Area classification along with neighbouring Hillfoots villages due to the populations living and working within flood prone areas. Tillicoultry has a long history of flooding from various sources including the 1877 flood on the Tillicoultry Burn and the 2008 flood on the River Devon. Previous proactive flood risk management measures funded by the Council and third parties have mitigated some of the flood risk and surface water drainage issues around Elistoun Drive. Key to this success was the raising of the Mixed Leisure Route embankment and installation of the adjacent pump station. The Council continues to make a committed effort to engage with the public on flood risk management issues, engaging with local flood risk groups across the Hillfoot towns and helping to liaise with Scottish Flood Forum, SEPA, the Fire and Rescue Service and The Conversation Volunteers to further enhance these links in the future. However, the fluvial flood risk remains from the two watercourses passing through the small urbanised area threatening residents and local businesses. This report therefore aims to assess this residual risk with a view to making recommendations for additional flood management in the town.

Flooding review

Flooding from the River Devon can result in substantial depths of water flowing through the commercial buildings of Sterling Furniture and Sterling Mills outlet village, as occurred in 2008. The mixed leisure route (MLR) embankment which runs parallel to the river has been subject to engineered improvements to mitigate the risk to residents of Elistoun Drive, whilst an informal flood embankment surrounding the Sterling Furniture site offers some informal protection to the commercial site.

The Tillicoultry Burn has not flooded in the recent past but catastrophic floods have historically caused damage to bridges and neighbouring properties. The straight watercourse typically assists in rapidly conveying water to the River Devon yet inconsistencies in the height of raised walls and other informal flood defence assets mean that the standard of protection is varied.

Numerous pluvial (surface water) flood events have occurred in the past yet significant works involving installation of a pumping station adjacent to Elistoun Drive and a schedule of maintenance for surface water drainage assets has more recently reduced the likelihood of flooding in some areas of the town.

Catchment understanding

An improved understanding of the flood risk to Tillicoultry has been undertaken through new and updated surveys, flood hydrology, asset surveys, environmental surveys, RBMP morphological pressures, NFM assessments and fluvial and pluvial flood modelling. These have been used to assess options for flood mitigation to the town through a long and short listing process.

Estimation of river flood flows followed an approved methodology reviewed by SEPA yet uncertainties in river hydrology mean that the annual probability (or return period) of each flood event used in the modelling may not align with public perception of flood risk in Tillicoultry. Continued monitoring (installed by the Council) and future reviews of the hydrology may affect the estimated flood risk for the town.

Flood Mitigation Options

The following options came out of the long listing process:

- Do Nothing - Baseline Assessment
- Do Minimum - Current situation
- Quick wins - quick wins to be considered
- Non-structural option 1 - flood action plans and emergency response
- Non-structural option 2 - Property Level Protection
- Non-structural option 3 - flood warning

In addition to the above, 4 flood mitigation options were considered in detail. These include the following:



River Devon:

- Embankment raising and replacement

Tillicoultry Burn:

- Quick win measures including weir and footbridge removal and minor wall raising
- Wall raising
- Bypass channel
- Bed lowering

Expected Benefits

Based on the modelling undertaken there are 45 properties at risk of internal flooding from the River Devon and 131 properties at risk from the Tillicoultry Burn for 0.5% AP (200 year) flood flows. The baseline (Do Minimum) present value flood damages are anticipated to be in the order of £3,792k for the River Devon and £3,556k for the Tillicoultry Burn.

The analysis suggests that the total long term damages avoided by a flood protection scheme on the respective watercourses would be in the region of £3,421k for the River Devon and £3,113k for the Tillicoultry Burn.

In addition to the above monetary impacts the following wider benefits and non-monetary aspects should also be noted:

- Social deprivation. Tillicoultry has a higher level of social deprivation than other areas and when considered against Scotland as a whole. Thus, protection to Tillicoultry should be in preference to less deprived areas when SEPA prioritises schemes for inclusion in the 2021 FRM cycle.
- Consistency of risk - a 200 year standard of protection from both watercourses would provide a more consistent and significantly reduced risk to the community.
- Wider economic benefits. The business disruption financial costs of flooding to Sterling Mills and Sterling Furniture cannot be included in the economic appraisal but should not be underestimated. These two sites are an important source of employment to the town and the business disruption of continued flooding should be noted.

Investment Appraisal

The investment appraisal is provided below for the two watercourses. It suggests that the raised defences on the River Devon and the raised walls option on the Tillicoultry Burn are both independently economically viable as the economic benefits of undertaking the schemes are in excess of the costs. Costs represent whole-life present value costs and include a 60% optimism bias as standard.

River Devon benefit-cost assessment:

	Do Nothing	Do Minimum	Defence option 0.5% SoP	Defence option 0.5% SoP with CC	Defence option 1% SoP with CC
Total Present Value (PV) Costs (£k)	-	27	2,802	3,176	2,912
PV Damage (£k)	4,594	3,792	1,173	1,798	2,051
PV Damage avoided (£k)	-	802	3,421	3,614	3,360
Benefit-cost ratio	-	30.09	1.22	1.14	1.15



Tillicoultry Burn benefit-cost assessment:

	Do Minimum	Quick win	Raised walls	Bed lowering	Bypass channel
Total PV Costs (£k)	-	234	3,121	3,325	4,034
PV Damage (£k)	3,556	2,851	443	443	443
PV Damage avoided (£k)	-	706	3,113	3,113	3,113
Benefit-cost ratio	-	3.0	1.0	0.9	0.8

Combined Tillicoultry-wide benefit-cost assessment:

	Do Minimum	Defended Option
Total PV Costs (£k)	27	5,923
PV Damage (£k)	7,348	1,621
PV Damage avoided (£k)	802	6,611
Benefit-cost ratio	30.1	1.1

The appraisal highlights that a more economically favourable option for the Tillicoultry Burn may be the quick win option which attains a much greater benefit-cost ratio than the options seeking to achieve a 200 year standard of protection. If a 200 year standard option is to be progressed then a combined 200 year scheme addressing flood risk on both watercourses is likely to be the most economic option to provide protection from both watercourses.

Preferred Option

Only one option for each watercourse has been found to be cost effective whilst offering at least a 200 year standard of protection. The defence raising and replacement option to a 0.5% AP (200 year) standard for the River Devon provides a long-term sustainable level of flood protection when compared to the current Sterling Furniture embankment. An assessment of options to protect against the effects of climate change for the 1% AP and 0.5% AP events found them to be cost effective but less-so than the option without an allowance for climate change. Through the centre of Tillicoultry the raising of walls by 400-700mm along the Tillicoultry Burn has been found to be the most appropriate option and should bring significant flood risk benefits to the community. Additional options for climate change adaptation and options to set back defences from the burn have been considered and should be reviewed at the outline design stage once additional information on services and ground conditions is known.

Recommendations

The following recommendations are made:

- Clackmannanshire Council should introduce the option for a Flood Protection Scheme to protect Tillicoultry from both the River Devon and Tillicoultry Burn as a single holistic scheme into SEPA's prioritisation process for the FRM cycle beginning 2021.
- Prior to this second FRM cycle, and if funding allows, the structural quick win option should be progressed under the Council's FRM powers to implement flood risk measures outside a formal FPS.
- As there is a period of time between now and the 2021 cycle (and there is no guarantee that the scheme can be funded or will be short-listed by SEPA), the Council should also consider some or all of the non-structural measures. This should entail the following:
 - A selection of NFM measures have been recommended for further analysis. The Council should consider these and the longer term findings from the Heriot Watt study on the Menstrie catchment. The Council could consider if there is wider support and funding for NFM from other Council departments, third parties or volunteer organisations within the town.
 - Existing emergency plans should be regularly reviewed (and updated if necessary) to ensure the community and first responders understand the flood risk, flood mechanisms and evacuation procedures.

- Flood warning on the Tillicoultry Burn using either an SMS based alert system from existing telemetry on the gauge or third-party apparatus (i.e. RiverTrack¹) currently being trialled by the Council should be considered. Either approach could be managed by either the Council, community leads or a flood action group.
- The Council should investigate the appeal within the community for property level protection. If there is deemed to be clear need or likely uptake the Council should consider either a flood pod system² or full PLP subsidised scheme here and in other Hillfoot villages.

A summary of the options proposed has been developed and is provided overleaf. It is hoped that this will provide the necessary information to support SEPA's prioritisation process.

¹ <http://www.rivertrack.org/>

² Progress on this has already been made and a floodpod system has already been installed by the Council in conjunction with the local fire brigade.

Option (Standard of protection)	Wider benefits	Proposed non-structural measures	Constraints / Limitations	Climate change adaptability	No. residential properties benefitting (& of baseline)	No. commercial properties benefitting (% of baseline)	PV damages avoided	PV costs	Benefit-cost ratio
River Devon									
Direct Defences (0.5% AP)	Maintain existing businesses and employment locally Minimal impacts to community Provides protection to an area of higher social deprivation.	Emergency action plans exist and will be reviewed in light of the findings of this study. A flood pod has been installed to assist with flood resistance. A SEPA flow gauge has been installed in Tillicoultry. Flood warning is provided for the River Devon and will be reviewed in due course. NFM measures have been identified and can be incorporated within the scheme to provide additional benefits.	Surface water accumulation on Moss Road not considered Impacts of climate change not accounted for	Increased defence extents and heights possible but greater climate change uplifts would be best designed for at outline design	4 (100%)	39 (98%)	£3,421k	£2,802k	1.2
Direct Defences (0.5% AP +CC)	As above with longer-term benefits		Surface water accumulation on Moss Road not considered		4 (100%)	39 (98%)	£3,614k	£3,176k	1.1
Direct Defences (1% AP +CC)			Surface water accumulation on Moss Road not considered		4 (100%)	39 (98%)	£3,360k	£2,912k	1.2
Tillicoultry Burn									
Quick Wins (3.3% AP) -Weir removal -Wall filling -Bridge removal -Kerb raising	Interventions likely to be within Council budget, not requiring external funding Quick to implement Improvement to channel naturalness through weir removal Minimal community disruption Provides protection to an area of higher social deprivation.	Emergency action plans exist and will be reviewed in light of the findings of this study. A flood pod has been installed to assist with flood resistance. A level gauge has been installed in Tillicoultry which may assist with future flood warning. RiverTrack warning system is being developed. NFM measures have been identified and can be incorporated within the scheme to provide additional benefits.	Impacts of climate change not accounted for	Less likely to be able to adapt	21 (100%)	3 (100%)	£706k	£234k	3.0
Wall raising and footbridge removal (0.5% AP)	Provides consistency in standard of protection between Tillicoultry Burn and River Devon. Provides protection to an area of higher social deprivation.		RBM condition further degraded Reduce visual access to the burn by residents/ visitors Will require external funding	Adaptable walls should be considered at outline design stage	57 (100%)	18 (100%)	£3,113k	£3,121k	1.0



18 Conclusions and recommendations

This report presents the results of a detailed flood risk appraisal of Tillicoultry from the River Devon and Tillicoultry Burn. Tillicoultry has historically flooded from both watercourses with the River Devon causing flooding to properties predominantly around Sterling Furniture and Sterling Mills commercial sites, and the Tillicoultry Burn causing flooding to properties around Upper and Lower Mill Street. A Flood Protection Scheme provides protection in the area surrounding Elistoun Drive yet no Tillicoultry-wide Flood Protection Scheme is in place. At the 200 year flood a total of 45 properties are estimated to be at risk from the River Devon and 131 properties are estimated to be at risk from the Tillicoultry Burn.

A detailed hydrological assessment of the two watercourses has been undertaken to derive flow inputs into hydraulic models of the two watercourses through Tillicoultry. A number of estimates have been provided giving a final 200 year peak flow of 149m³/s for the River Devon and 24m³/s for the Tillicoultry Burn without an allowance for climate change. With an allowance for climate change these flow estimates increase to 179m³/s for the River Devon and 29m³/s for the Tillicoultry Burn. These peak flow estimates carry some uncertainty, particularly for the ungauged Tillicoultry Burn. A future review of this hydrological assessment should be carried out when further data from the recently installed gauges on both watercourses has been collected, preferably prior to detailed design of any prospective flood defence assets.

Topographic survey data and model files from previous flood studies in Tillicoultry were used as a basis for the development of two 1D/2D Flood Modeller/TUFLOW hydraulic models, simulating the two watercourses separately. Further cross section survey data, top of bank levels and property threshold levels were collected in 2016 for this study. The models were run for a range of return periods and scenarios to model the present day "do minimum", undefended, 'embankment breach', defended and 'partial bridge blockage' scenarios. With some data available from a January 2011 River Devon flood event this model was validated and deemed suitable for use. No such data were available with which to validate the Tillicoultry Burn model.

The generated flood inundation maps show that properties along the River Devon currently have a 100 year standard of protection, apart from the Sewage treatment works which has a lower 75 year standard of protection. Some properties along the Tillicoultry Burn have only a 5 year standard of protection according to the model results yet the historic trend for flooding from the burn shows flooding is less frequent. Future reviews of the hydrological peak flow estimates are therefore likely to be critical in refining the estimate of the burns standard of protection.

The flood inundation maps for all return periods modelled were analysed to identify a range of possible flood alleviation measures. Flood maps were prepared for each event and include the 2, 5, 10, 30, 50, 75, 100, 200, 200 plus 21%, 27% and 40% climate change uplifts, and 1000 year return periods. For the River Devon the majority of properties affected are commercial whereas the majority on the Tillicoultry Burn are residential.

There are a number of short term measures that could benefit Tillicoultry prior to a flood protection scheme being constructed. These include:

- Weir removal upstream of the A91 High Street Bridge on the Tillicoultry Burn²⁷
- Raise low points in wall on Tillicoultry Burn to ensure uniform standard of protection
- Maintain and update emergency action plans as and when required
- Flood warning on the Tillicoultry Burn
- Community flood action groups
- Raise ground levels slightly in small area between Mixed Leisure Route and Sterling Furniture embankment on the River Devon
- Vegetation management on the Tillicoultry Burn and control invasive species
- Maintain walls on Tillicoultry Burn
- Monitor sediment accumulation through community volunteering programme
- Provide signage at key locations to enhance public awareness of flood risk

²⁷ This was completed by the Council in June 2017



A number of flood mitigation options have been considered mainly comprising direct defences and channel modifications. Each option is discussed further below:

- River Devon Option - This option involves raising the Mixed Leisure Route by 300mm and replacing the informal Sterling Furniture embankment with a larger, more appropriately designed embankment and flood wall on both left and right banks adjacent to Sterling Mills. The embankment would extend for 240m whilst the flood wall would extend over 500m including alongside the Sterling Mills site to give a 200 year standard of protection. Minor increases in these embankment and wall heights could achieve a 200 year plus 21% allowance for climate change standard of protection.
- Tillicoultry Burn Quick Win option - A 30 year standard of protection could be offered by removing a sloping weir upstream of the High Street bridge, removing the lower park footbridge, filling in some gaps in the raised walls alongside the burn and raising the kerb and road at the entrance to Hareburn Road.
- Tillicoultry Burn Option 1 - The wall raising option would include the above quick win measures and further wall raising by up to 900mm. Given the extent of constriction at the Oakmills industrial access bridge some overland flow would be expected down Lower Mill street, contained by the kerb and road raising at the entrance to Hareburn Road.
- Tillicoultry Burn Option 2 - As with option 1 this option incorporates the quick win measures with a bypass channel extending from the right bank in the lower park.
- Tillicoultry Burn Option 3 - The quick win option measures are here combined with bed lowering in the vicinity of the Oakmills industrial access bridge to increase channel capacity, particularly below the access bridge itself.

A benefit-cost analysis has been undertaken for the baseline (Do Minimum) option and each of the above options. Flood damages for the current situation have been assessed and include a number of indirect damages on top of the direct property damages. The total flood damages from the River Devon are estimated to be £127,000 per annum with a Present Value estimate of £3,792,000 (it is the present value estimate that is compared with the costs in a benefit-cost analysis). The total flood damages from the Tillicoultry Burn are estimated to be £119,000 per annum with a Present Value estimate of £3,556,000.

Costs for each option and a range of standards of protection have been assessed based on unit costs from SPONS, the Environment Agency and SEPA. 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 schemes at an early stage of appraisal.

The benefit cost analysis for the defence options assessed provides the following recommendations:

- The River Devon option has sufficient benefits to outweigh the costs of construction and long-term maintenance with a benefit-cost ratio of 1.2. This option is therefore preferred and is a suitable means to protect some populated areas of Tillicoultry from the River Devon. The same option, adapted to account for flow increases due to climate change at the 1% and 0.5% AP events could be cost-effective and should also be considered.
- The quick win option for the Tillicoultry Burn is cost effective with a benefit-cost ratio of 3.0 yet only protects against a 30 year flood. As a short term measure and basis for the other options offering greater protection this option offers substantial benefit, particularly if a hydrological review shows that the 30 year flow used herein in reality represents a higher return period.
- The wall raising option for the Tillicoultry Burn is cost effective with a benefit-cost ratio of 1.0 despite the construction works required to reconstruct some lengths of wall along the burn.
- The bypass channel option for the Tillicoultry Burn does not have sufficient benefits to outweigh the costs of construction with a benefit-cost ratio of 0.8. If the material excavated to create the bypass channel were reused locally to avoid tipping charges this option would become cost effective with a benefit-cost ratio around 1.2. This option does offer multiple benefits through its potential for wetlands creation further downstream.
- The bed lowering option is not cost effective due to the high construction costs, with a benefit-cost ratio of 0.9. Possible bridge replacement and buried services diversion are likely to make this option the most complex.



- The socio-economic consequences of flooding should be considered as a pound spent at Tillicoultry is likely to have a greater benefit than that spent at an alternative location with a lower social impact.

To summarise, the River Devon option and Quick Win option for Tillicoultry Burn are cost effective with the Quick Win option forming a sound basis for further cost-effective wall raising works on the Burn to increase the standard of protection to the 200 year flood level. Progressing the preferred 200 year options for both watercourses concurrently is likely to offer some cost savings.

Whilst flooding from the River Devon is most easily managed by direct defences a combination of smaller scale works appears to best manage flows passing along the Tillicoultry Burn as well as offering an acceptable strategy for flood risk management for the community. Ongoing monitoring, maintenance and minor works to increase its efficiency are likely to assist in the short term.

