ANNSBOROUGH FLOOD ALLEVIATION SCHEME – FEASIBILITY STUDY

PROJECT No. 105075

Design Section
Capital Procurement Unit
DARDNI Rivers Agency
4 Hospital Road
BELFAST
BT8 8JP

March 2012

ANNSBOROUGH FLOOD ALLEVIATION SCHEME - PROJECT No 105075

CONTENTS **PAGE**

APPENDICES

1. INTRODUCTION

1.1 On 16th August 2008 after a period of exceptionally heavy rainfall the Leitrim River broke its banks and, combined with run-off from roads, flooded 20 homes and the Feedwell Animal Foods Factory in Annsborough, Co. Down.

1.2 The purpose of this report is to investigate the feasibility of a Flood Alleviation Scheme on the designated main watercourse known as the Leitrim River, which flows through the village of Annsborough in County Down. The watercourse has been previously investigated by Rivers Agency and by several consultants carrying out flood risk assessments on the area. Rivers Agency carried out a flood defence scheme in the early 1980s and constructed a flood wall approx. 200m long on the left bank of the watercourse in Annsborough Park and a flood bank approx 150m long along the playing field. This report focuses on the vulnerability of the study area to floods of various return periods and the viability of an alleviation scheme.

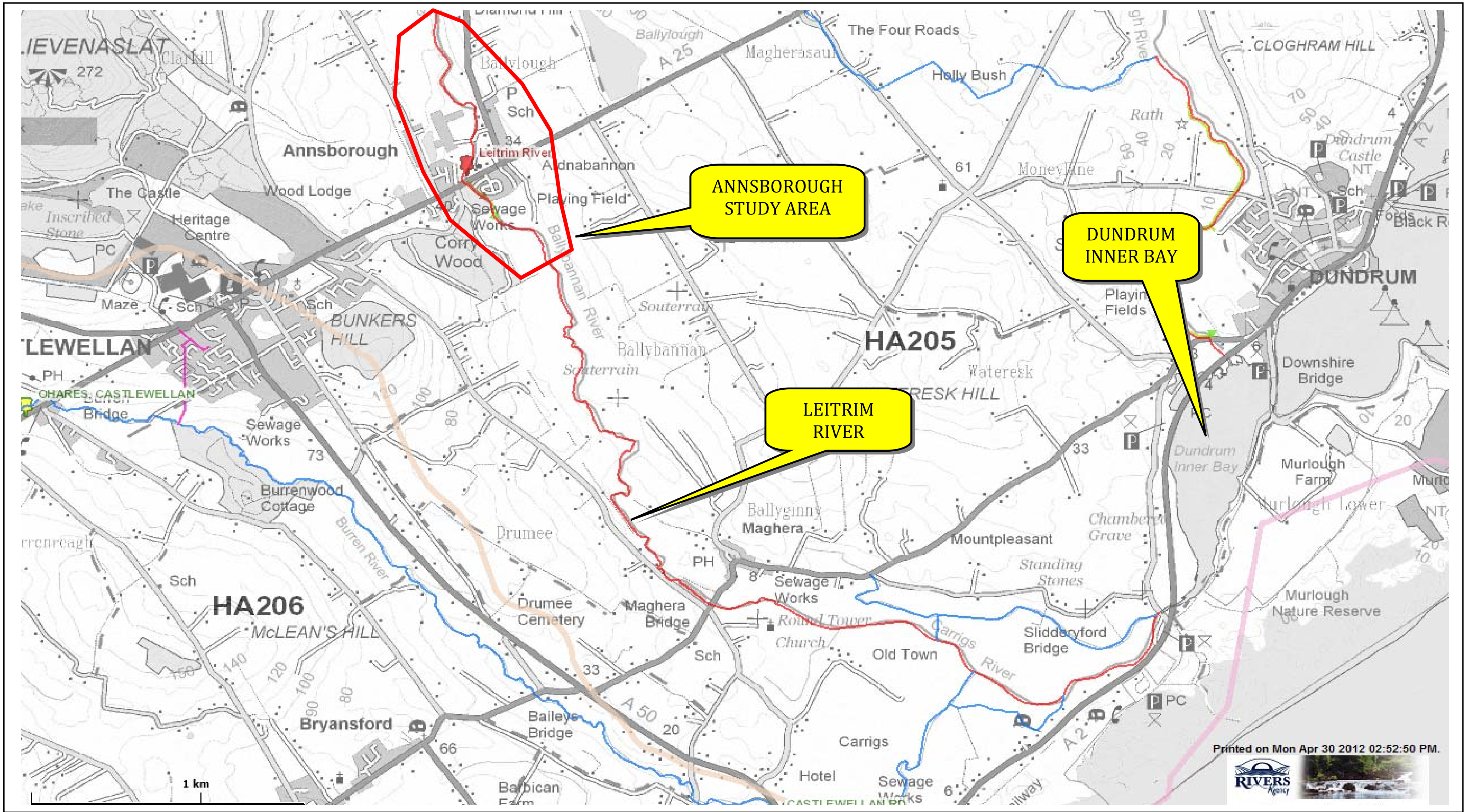
1.3 The Leitrim (or Ballybannon) River rises at the village of Leitrim in County Down and flows through the village of Annsborough and close to the village of Maghera, Co. Down, before discharging to Dundrum Inner Bay on the County Down coast. Locally this watercourse is known by several names. In the upper reaches it is called the Leitrim River and travelling downstream as it passes through Clarkehill Wood it is known as the Clarkehill River until the road crossing at Annsborough from where it is known as the Ballybannon River. When it reaches the village of Maghera it is known locally as the Carrigs River and retains this name until it discharges to Dundrum Inner Bay. For the purpose of this report the watercourse shall be called the Leitrim River. This report focuses on a 1.44km reach of the watercourse from 792m upstream of the A25 road bridge to 651m downstream of the bridge.

2. SCOPE

2.1 The aim of the feasibility study is to carry out an assessment with the objective to develop and consider options to alleviate flooding from the Leitrim River to properties located in Annsborough.

The report considers the existing hydraulic capacity of the watercourse network in the vicinity of Annsborough and aims to establish the flooding footprint for this reach of the Leitrim River. It will also investigate the structural condition of any existing structures, outfalls, any existing back drainage systems and their ability to contain the flows. It considers a range of options to resolve any hydraulic and/or structural inadequacies found in the watercourse systems, including cost estimates.

2.2 The study will include provision of a summary of mitigation works and any anticipated difficulties with householders, landowners, utility providers and statutory bodies, as well as an Environmental scoping. Consideration will be given to a range of solutions to alleviate the threat of flooding to properties, including cost estimates and an Economic Appraisal of all options based on Rivers Agency's current methods. This will be concluded with a recommendation of the most cost effective option.



RIVERS Agency	Map 1.1 – Study Area Date: March 2012	Notes: Annsborough FPS – Feasibility Study	Based upon the Ordnance Survey of Northern Ireland map of 2008 with the permission of the Director & Chief Executive, © Crown Copyright.	Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings.

3. FLOODING HISTORY

3.1 The development of Annsborough Park lies at the bottom of a valley in the village of Annsborough. The development of 66 dwellings was constructed in the 1950s on a site that covers an area of approximately 4.3 Ha. The Leitrim River runs along the Western extent of the development.

Flood Event 16 August 2008

3.2 A major flood event occurred on 16 August 2008 when the Leitrim River broke bank approx. 500m upstream of the development. Overland flow then cascaded in a downstream direction and ponded in the Annsborough Park development causing flooding to the Feedwell Animal Foods Factory and 20 domestic properties. This event is estimated to have a return period of approximately 1 in 40 to 50 years. Additional flooding is known to have occurred as a result of pluvial flows running off the A25 main road and surrounding minor roads in this steep sided valley.

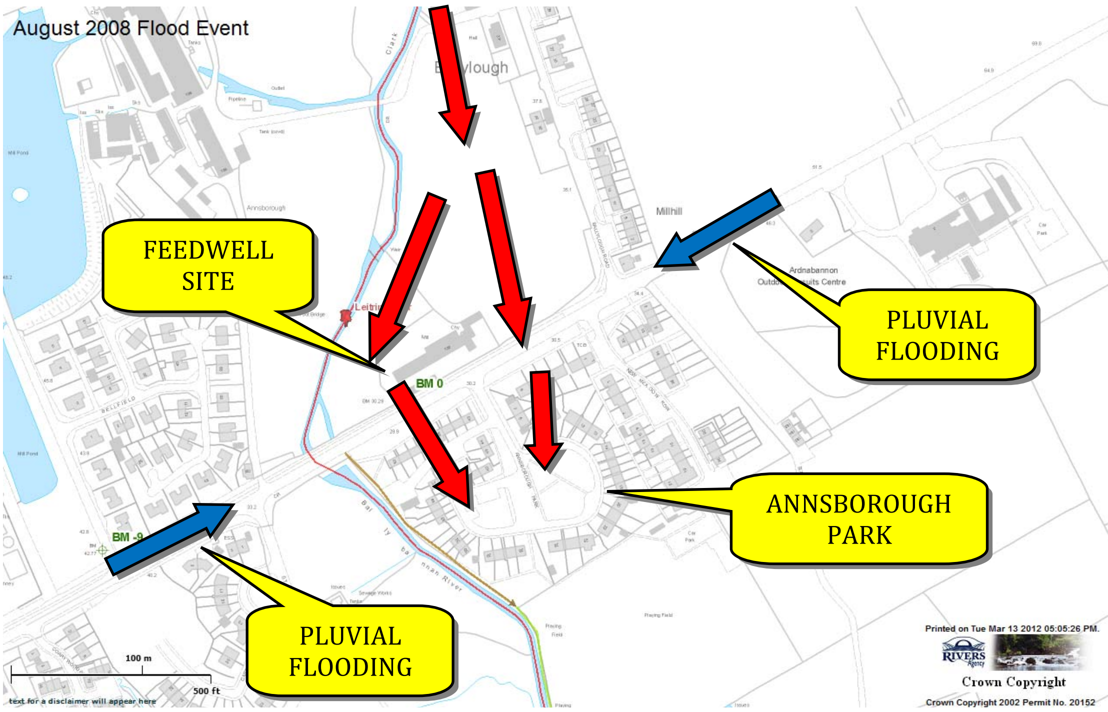


Fig. 3.1 – August 2008 Flood Event.

Flood Event November 1997

3.3 A flood event occurred in November 1997. There are a number of aerial photographs dated 26th November 1997 which show flooding in Annsborough

(Fig. 3.2 shows one of the photographs). It is assumed that the photograph was taken after the peak of the flooding. The return period of this event is not known. Further evidence in the form of a letter from Eddie McGrady MP, dated 11th June 1998, refers to the "Christmas Floods".

Fig. 3.2 – Aerial photograph post November 1997 Flood Event.

Flood Event December 1978

3.4 Little is known about the 1978 event although Rivers Agency has a recorded flood level of 27.858m OD at the southern end of the Annsborough Park development, adjacent to where the flood wall and flood bank now meet; this level was recorded prior to their construction. This event led to the subsequent construction of the flood wall and flood bank in the early 1980s.

4. EXISTING WATERCOURSE NETWORK

Description of the Leitrim River catchment

4.1 The watercourse rises in the hills above the village of Dromara at Slieve Croob and flows in a south-easterly direction, discharging into Dundrum bay and is approximately 19 km in length. The catchment area itself measures approximately 46 km^2. The watercourse is designated from Leitrim Village to Dundrum Bay, some 14.59km of designated watercourse.

Fig. 4.1 - Leitrim (Ballybannon) River

4.2 The Leitrim River catchment area is largely agricultural land. It has very little in urbanised areas; the largest urban areas would comprise Annsborough village and part of the town of Castlewellan. The Flood Estimation Handbook software categorises it as an essentially rural catchment ($URBEXT_{1990}$ is 0.006).

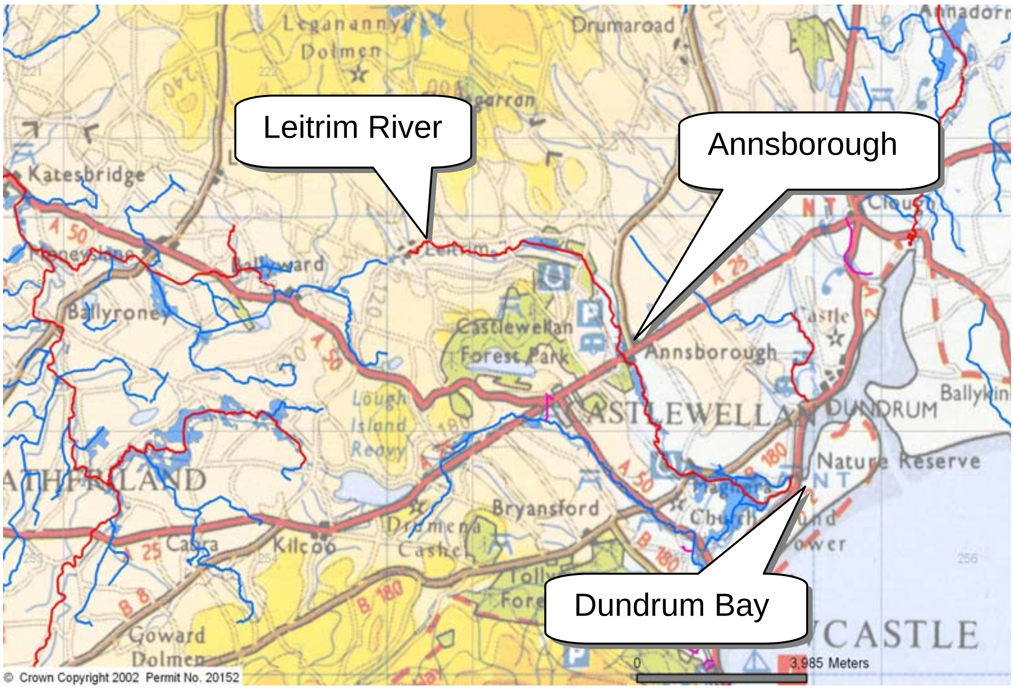


Fig. 4.2 – Designated reach of Leitrim River

4.3 Infrastructure on the Leitrim River at Annsborough

There are three main Bridges and two sections of flood defences in the vicinity of the flooded area of the Leitrim River at Annsborough. Fig. 4.3, below, indicates their locations.

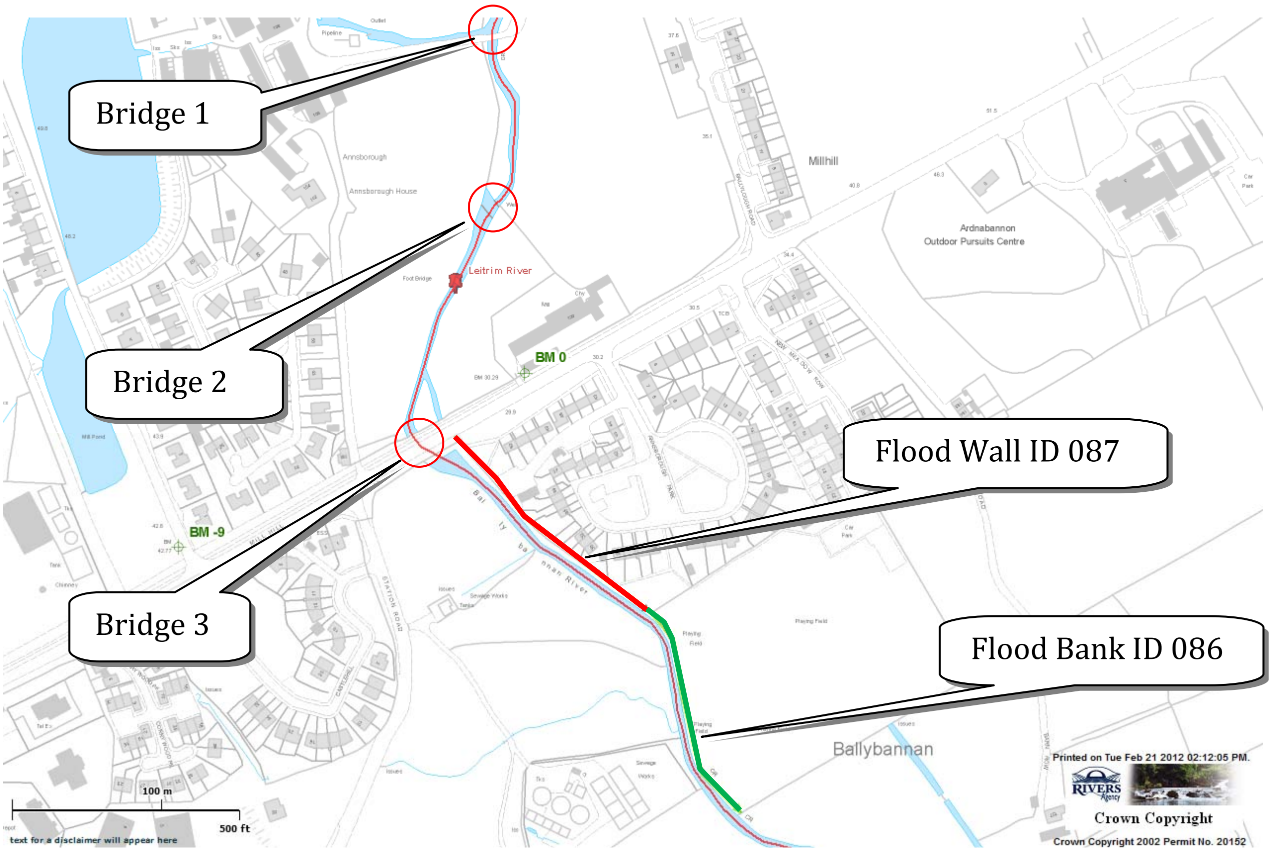


Fig. 4.3 – Infrastructure Locations in Annsborough

4.3.1 Bridge 1

Fig. 4.4 – Bridge 1

This Bridge was originally built to provide access across the river into Annsborough Mill. Although the Mill is no longer in service the bridge is still occasionally used for vehicle access. The bridge and attached watch chamber are NIEA listed structures, and as a result, any options to remove the bridge to alleviate flooding will require the structure to be delisted. The bridge looks to be satisfactory structurally however no formal inspection has been carried out to date.

4.3.2 Bridge 2

Fig. 4.5 – Bridge 2

Bridge 2 provides access to farm land that is separated from the farm by the river. There is no information regarding the structural integrity of this bridge. The small cross-sectional area of this bridge structure means that during a flood it has does little to impede flows. Therefore removing it will achieve little benefit for the river hydrologically.

4.3.3 Bridge 3

Fig. 4.6 – Bridge 3

Bridge 3 is a composite structure beneath the main A25 Clough to Castlewellan road. Its maintenance is the responsibility of DRD Roads Service. This bridge is structurally in good condition. In 2000 Roads Service replaced one of the three Armco culverts with a concrete pipe, see far right photograph. The remaining two Armco culverts on the left are showing some signs of corrosion, however Roads Service have no plans to replace them in the near future.

This is a main A25 road bridge therefore removal of this bridge as part of any flood alleviation measures would cause significant traffic disruption and is therefore likely to be expensive to upgrade.

4.3.4 Flood Wall ID 87

Fig. 4.7 – Designated Flood Wall

This concrete flood wall (Fig 4.7) is situated on the left bank downstream of Mill Hill. It ties into a flood bank at its downstream end. Both the flood wall and flood bank are designated flood defences and were constituent parts of Rivers Agency's flood alleviation scheme which was constructed in the early 1980s. Asset Management Unit's comments from their most recent inspection carried out in November 2010 stated that the wall is in good condition (Grade 2) with just a few joints required to be repointed.

4.3.5 Flood Bank ID 86

Fig. 4.8 – Designated Flood Bank

This flood bank is a designated flood defence structure and was constructed as part of the Rivers Agency's flood alleviation scheme in the early 1980s. Asset Management Unit's most recent inspection was carried out in November 2010. The report stated that a build up of spoil on the bank meant that a full inspection could not be carried out. The bank was considered to be Grade 4 due to the amount of vegetation growing on it and the report highlighted that the defence does not tie into high ground at its downstream end. During the August 2008 flood event, only the playing pitches were affected by the gap between the defence and the high ground.

5. HYDROLOGY AND HYDRAULICS

Hydrological analysis

5.1 There are no gauging stations along the Leitrim River – the catchment is therefore ungauged. The nearest gauging stations in the locality are along the adjacent Burren River, one at O'Hare's Shop, Castlewellan and the other known as The Burren, Castlewellan Road, near the Burrendale Hotel, Newcastle. Neither of these stations are listed on the Environment Agency's HiFlows UK website which contains flood peak data of around 1000 river flow gauging stations throughout the UK and allows the stations to be used within the FEH analysis software. Data from each of these gauging stations, given by hydrometrics Single Site Analysis provided by Jacobs in 2009, would estimate the flooding in August 2008 at approximately a Q40 – Q50. The catchment area for both these gauging stations is small in comparison to the catchment area for Annsborough, however there are similar characteristics in their soil type, gradient and rainfall. Additional gauging station data from Annalong (Annalong River) and Bannfield (Upper River Bann) gauging stations were also considered during analysis. Further information on these stations and more detailed calculations are contained in Appendix C.

Flood Estimation

The following methods were used to estimate flood flows in the Leitrim River at Annsborough:-

<u>FEH Statistical Pooled Analysis</u>

5.3 As there is no gauging station based on the Leitrim River a "pooled analysis" was carried out using gauged catchments within the UK that are of similar characteristics to the Leitrim River. This group of gauging stations, called a "pooling group" was evaluated and adapted to provide an estimated index flood (Qmed); this pooling group growth curve was applied to the index flood estimate to derive the estimated flood frequency discharges at Annsborough.

FEH RefH Spreadsheet (Revitalised Flood Hydrograph Method)

5.4 The RefH spreadsheet is a simplified version of the Revitalised Flood Hydrograph Method which is another method of flood estimation within the FEH. The spreadsheet generates flood hydrographs for a specified anticedent soil moisture content and a design rainfall event of the required return period. It is useful when estimates of flood volumes are required e.g. for a flood storage solution.

Hanna & Wilcock (FSR based methodology)

5.5 This method is a variant of the Flood Studies Report methodology developed specifically for Northern Ireland catchments. It was used by Rivers Agency for the prediction of mean annual floods on medium-large rural catchments but is now superseded and is used only for comparison with FEH methods.

Specific Discharge from similar catchments

5.6 Since the Leitrim River is an ungauged catchment, flows from a gauged “donor” catchment (in as close proximity as possible to the subject catchment) are used to estimate flows. This is based on a proportional ratio of discharge/km^2. Ideally the catchment should be hydrologically similar to subject catchment and have good quality flood data. More than one donor can be used where Qmed is estimated as a weighted average of individually transferred estimates.

Donor Adjusted

5.7 This method is similar to the FEH Statistical Pooled Analysis and Specific Discharge method. Gauged donor catchments in the vicinity of the subject catchment are used to establish a modified Qmed before it is applied to the pooling group growth curve. As with the Specific Discharge method, the donor catchments should be hydrologically similar to the subject catchment and have good quality flood data.

Results and preferred choice of method

The detailed calculations for each method are contained in Appendix C. The results are shown in the table below:

ESTIMATED FLOWS (CUMECS)						
	Qmed	Q5	Q10	Q25	Q50	Q100
POOLED ANALYSIS	8.88	11.82	13.92	16.84	19.27	22
REFH	15.7	19.9	23.2	27.5	31.3	35.9
HANNA WILCOCK	17.43	20.76	23.85	27.76	30.55	31.96
DONOR ADJUSTED	12.039	16.14	18.99	22.98	26.3	29.97
DONOR SPECIFIC DISCHARGE	19.89	25.06	28.60	33.41	36.96	40.92

Fig. 5.1 – Estimated flows for various return periods and methodology

5.8 The choice of method is based on the individual merits of the methodology for the given situation. This depends on the type of problem, data available, catchment descriptors, general assumptions and engineering judgement.

5.9 The following points were considered when determining the suitability of the various estimated flows :

- No gauging station is located on the subject catchment, so single site analysis is not feasible.
- The standard pooled analysis produced the lowest flows for a given return period. These flows imply that the August 2008 flood event was vastly in excess of a Q100 based on recorded data. Also, because events of a similar magnitude occurred in November 1997 and December 1978, this would suggest that the pooled analysis should be treated with caution.

- The RefH method is an updated version of the FSR/FEH rainfall run-off method using flood data from a large number of UK catchments. It has added processes relating to the seasonal variation of soil moisture and design flood. As with all methods it has limitations, furthermore no Northern Ireland catchments were used in its calibration.
- The donor adjusted and specific discharge methods use gauging stations which are not currently in the HiFlows UK dataset and are therefore not available for use in pooling groups. However, these gauged catchments still provide valid recorded data and, given the close proximity and similarity of these to the subject catchment, they could be considered suitable for estimating flood frequency.

Hydrological Conclusion

5.10 Assessing the various methods and results, it was determined that the most suitable in this instance was the RefH method. The RefH model is based on robust hydrological modelling techniques and allows a direct and transparent assessment of its methodology.

Its Q100 results compare well with flows generated by other estimation methods such as its similarity to the Hanna Wilcock results and the fact that it is the median of the Donor Specific and Donor Adjusted methods. Two independent Flood Risk Assessments were carried out by separate consultants (Scott Wilson and WYG) for sites in Annsborough in 2009, both of which had estimated flows similar to the RefH results.

5.11 The Pooled Analysis, which is the standard FEH method in these circumstances, provided results which are deemed to be unrealistically low and did not compare well with other available methods. In Design Section's opinion, Pooled Analysis isn't suitable for the model due to the lack of suitable similar catchments in the HiFlows database for Qmed estimation or growth curve pooling.

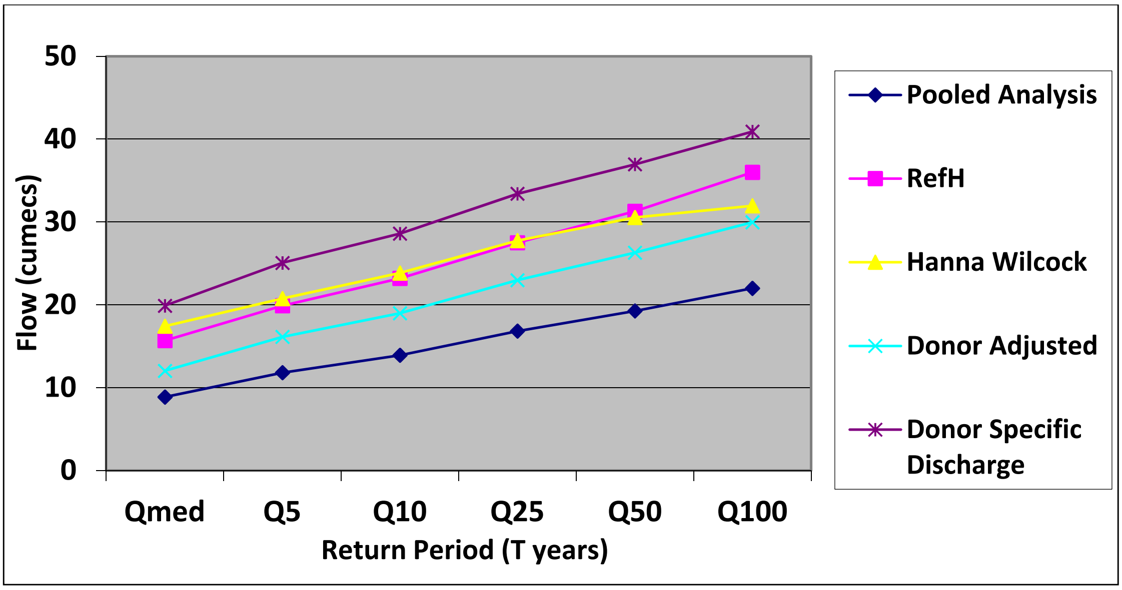


Fig. 5.2 – Comparison of Hydrological Estimates.

Hydraulic analysis

5.12 The watercourse and bridges have been analysed using InfoWorks RS flood modelling software to assess the flood risk and to highlight locations where riverbank overtopping may occur. InfoWorks RS uses the ISIS flow simulation engine combined with GIS functionality.

5.13 The model consists of 61 cross-sections, including the three bridges detailed in Section 4, merged with an Ordnance Survey LIDAR 5-metre grid Digital Terrain Model (DTM). The total model covers a 1.44 km reach of the Leitrim River and an area of 0.21 km^2 with the LIDAR mesh.

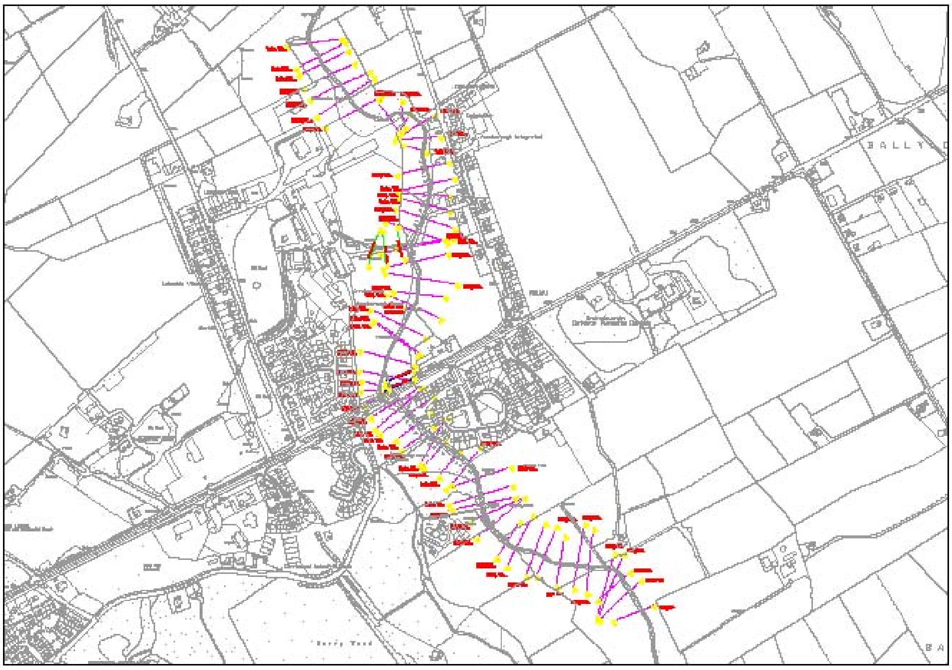


Fig. 5.3 – Location of Cross-sections

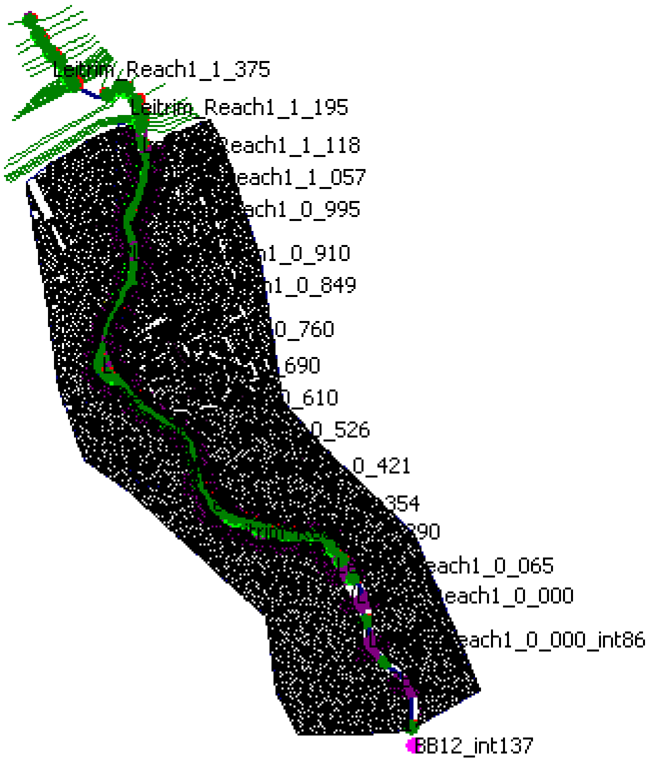


Fig 5.4 –Overview of Hydraulic model including the LIDAR mesh.

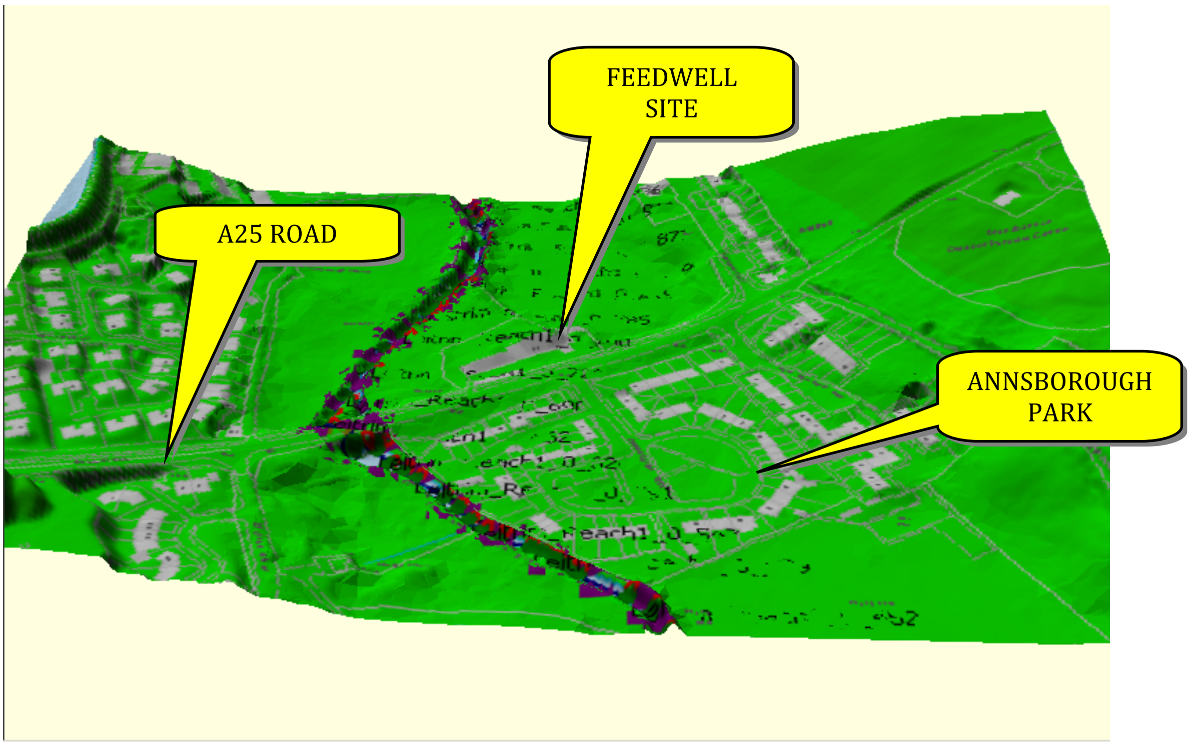


Fig 5.5 – 3D Overview of a section of the hydraulic model.

5.14 After initial analysis it was determined that there are a number of locations where high flows get out of bank on both sides of the river. These locations have been visually confirmed on the ground. The flood waters then pond in the adjacent fields and, during large events, flows will eventually overtop the A25 road bridge to flood the development of Annsborough Park. The 3D overview (fig. 5.5) shows the raised profile of the A25 which results in it acting as a barrier which attenuates flows and surcharges thus raising the flood levels. The flood flows cross over the A25 at the lowest sections of road adjacent to the Feedwell Animal Feeds Factory. These can be seen in the photographs from the 2008 event in Appendix A and the 3D overview.

5.15 The model indicates that the designated flood wall adjacent to Annsborough Park has an average 800mm freeboard above the estimated Q100 flood level at this location. During the August 2008 flood event residents of Annsborough Park stated that the flood level was much closer to the top of the wall than the model suggests. It is suspected that this was as a result of blockages occurring in the channel combined with extensive overland flow due to the inundated road drainage network. There is also anecdotal evidence that additional overland flow came from Castlewellan Lake, however this has not been confirmed.

5.16 The overland flow, steep road layout, channel blockages and Castlewellan Lake possibly having an effect on the flood levels (particularly downstream of the A25 bridge) during the August 2008 event indicates that there are inherent problems in calibrating the river model. Design Section undertook a preliminary calibration of the model using flood wrack levels obtained in the aftermath of the August 2008 flood. However further investigations and a sensitivity analyses will be required during scheme detailed design stage. Due to this current degree of uncertainty it is considered prudent to increase the standard 600mm freeboard usually applied to flood defence projects. This can be modified as required during the design stage of any scheme should accuracy of modelling be improved.

5.17 The millrace which flows into the river at the listed bridge (Bridge 1) has not been modelled as a separate watercourse, however it is incorporated in the LIDAR mesh and, as such, will act as a flow channel. No additional flows have been input into it in the model.

5.18 The Mannings “n” roughness values used in the model are consistent for majority of the model reach, using 0.045 for the channel and 0.06 for the floodplains. The only exception is the area of floodplain adjacent to the existing flood wall where a value of 0.10 was used.

A Mannings value of 0.045 indicates a channel which is clean, winding and with some pools, shoals and stones, and is a common value for many rivers in Northern Ireland. The out of channel figure of 0.06 denotes a floodplain consisting of light brush and trees.

Conclusion of Hydraulic Analysis

5.19 The river model provided an overview of the floodplain extents for a number of return periods. The Q100 extents are shown below:

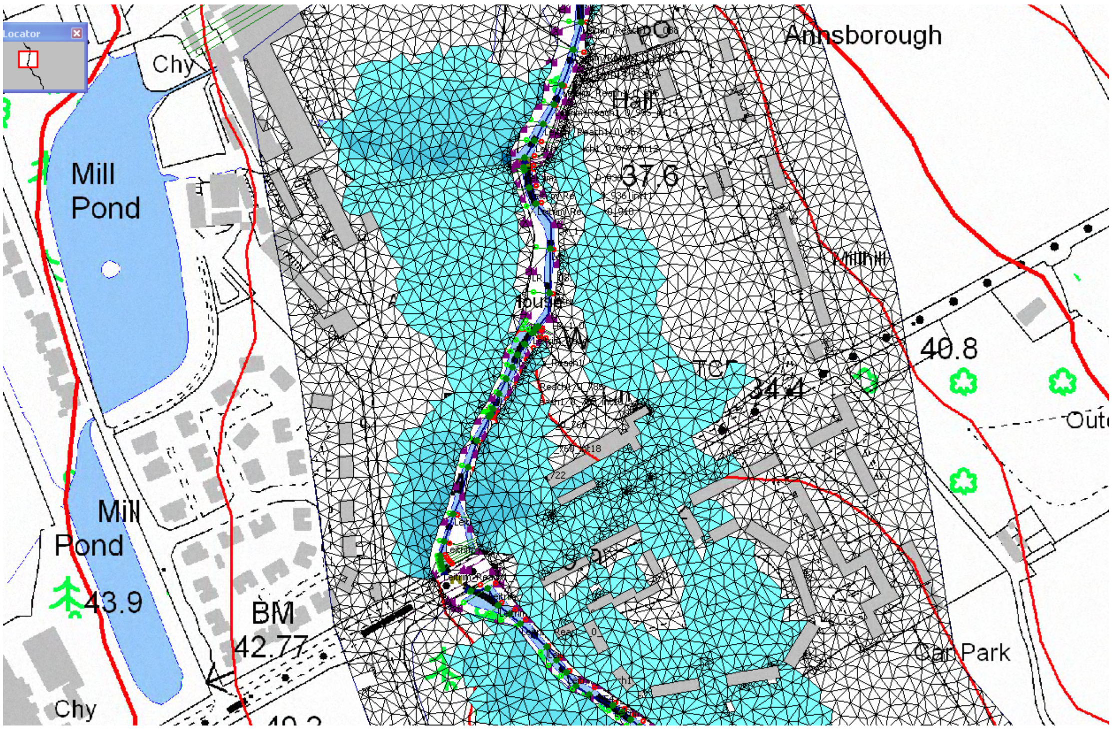
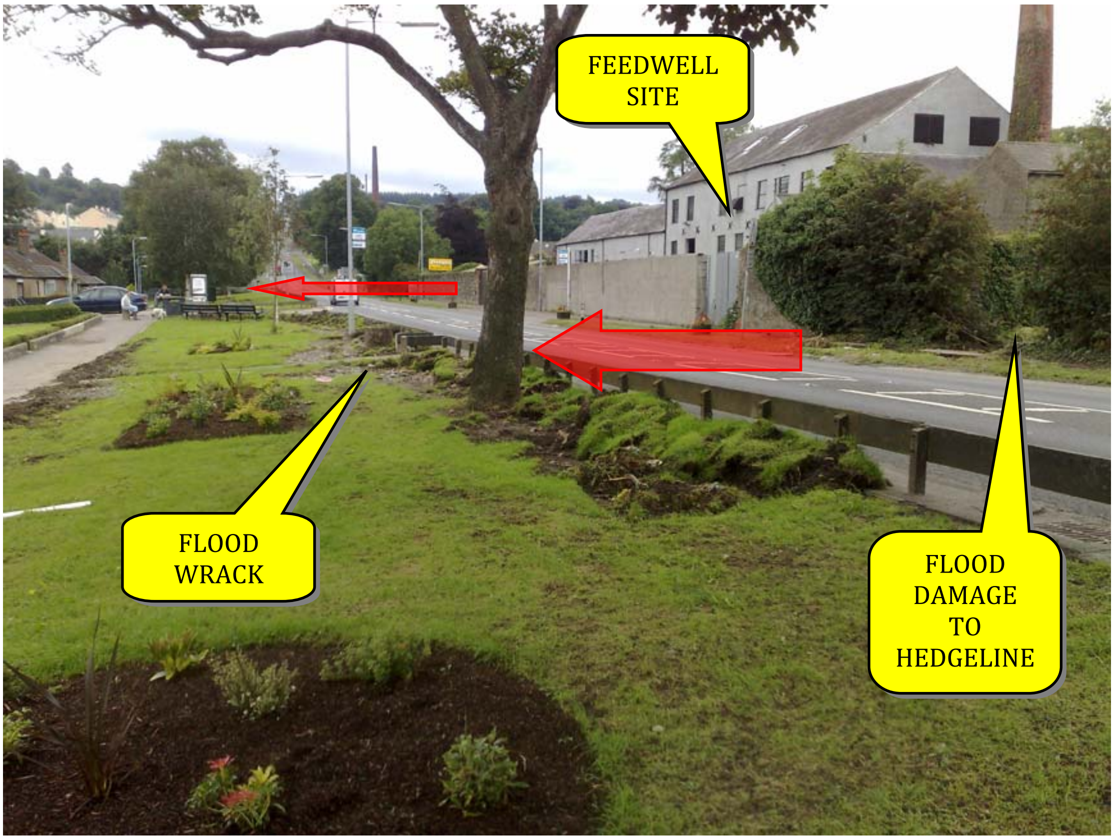


Fig 5.6 –Q100 Floodplain Extents.

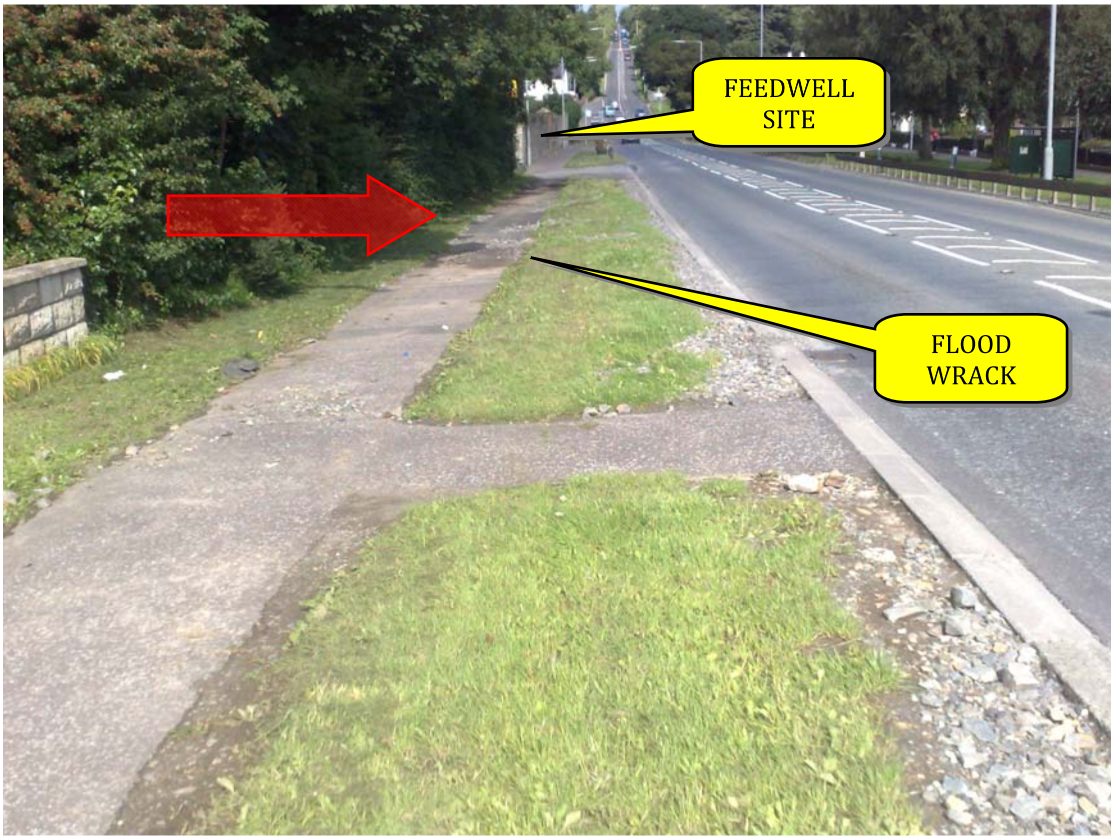
Fig.5.6 shows the points at which flows get out of bank and where flood flows cross the A25 into Annsborough Park. The number of properties affected in a Q100 event is estimated to be 34, including the Feedwell site and NI Water's Waste Water Treatment Works.

The Q50 extents, shown in Fig. 5.9, are comparable to what occurred in the August 2008 event. The two distinct locations where flows crossed the A25 correspond with the flood wrack and hedgeline damage shown in Photographs 5.7 and 5.8.

After the August 2008 event, 20 properties claimed compensation although the hydraulic model indicates that 15 properties should have been affected. However, within residential areas, factors such as fences, hedges and walls, which are not included in the model, can cause localised increases in the flood level which account for this variation in the number of properties affected.



Figs 5.7 & 5.8 –Routes of overland flow across A25 into Annsborough Park, August 2008.



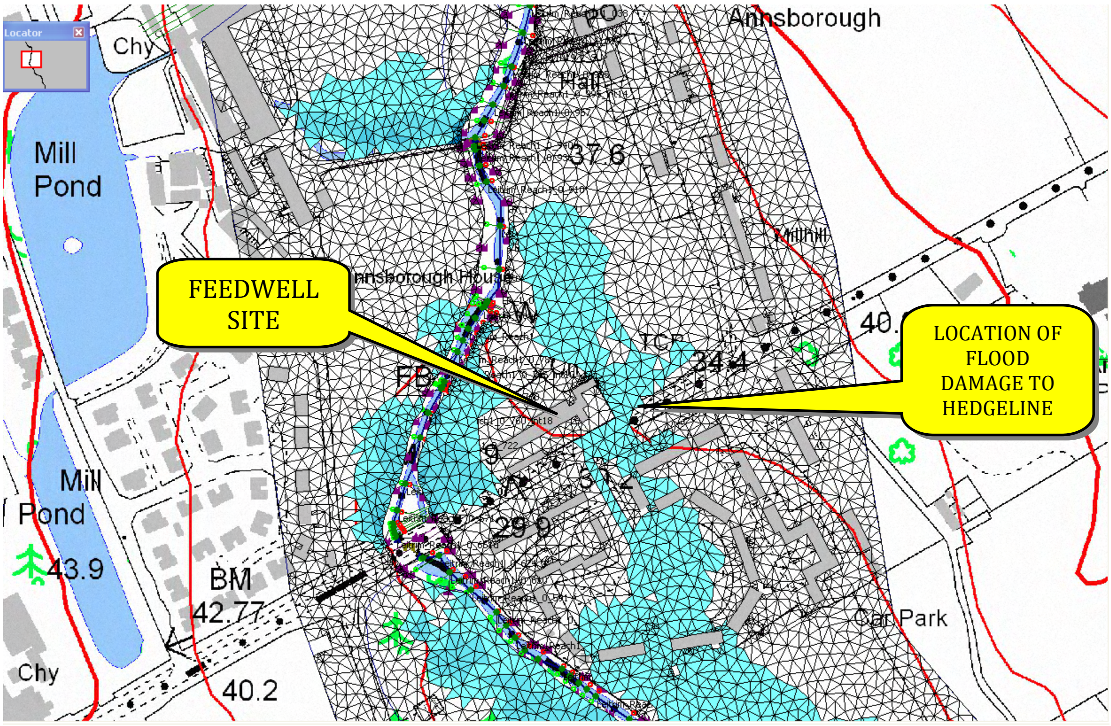


Fig 5.9 –Q50 Floodplain Extents.

It was established from the model that the minimum flood event which would result in overtopping of the A25 and a flow into Annsborough Park, would be between a Q10 and a Q25 (as shown in Figures 5.10 and 5.11). The flood levels would not breach property thresholds but could still cause damage and disruption to assets, services and infrastructure.

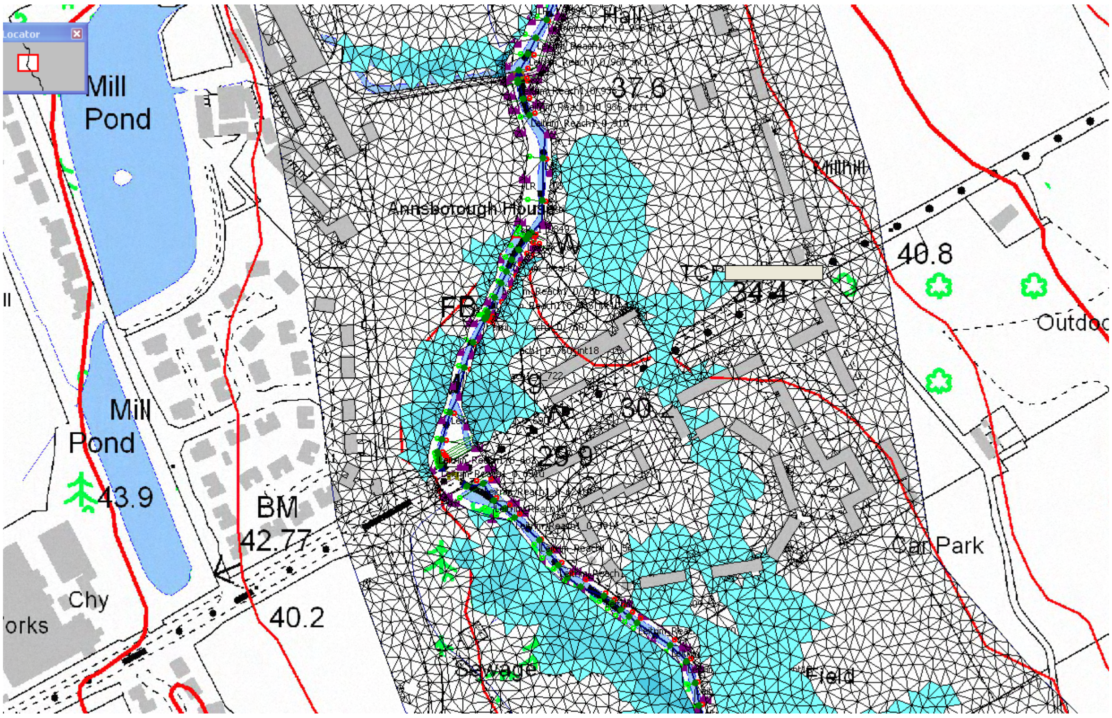


Fig 5.10 –Q25 Floodplain Extents.

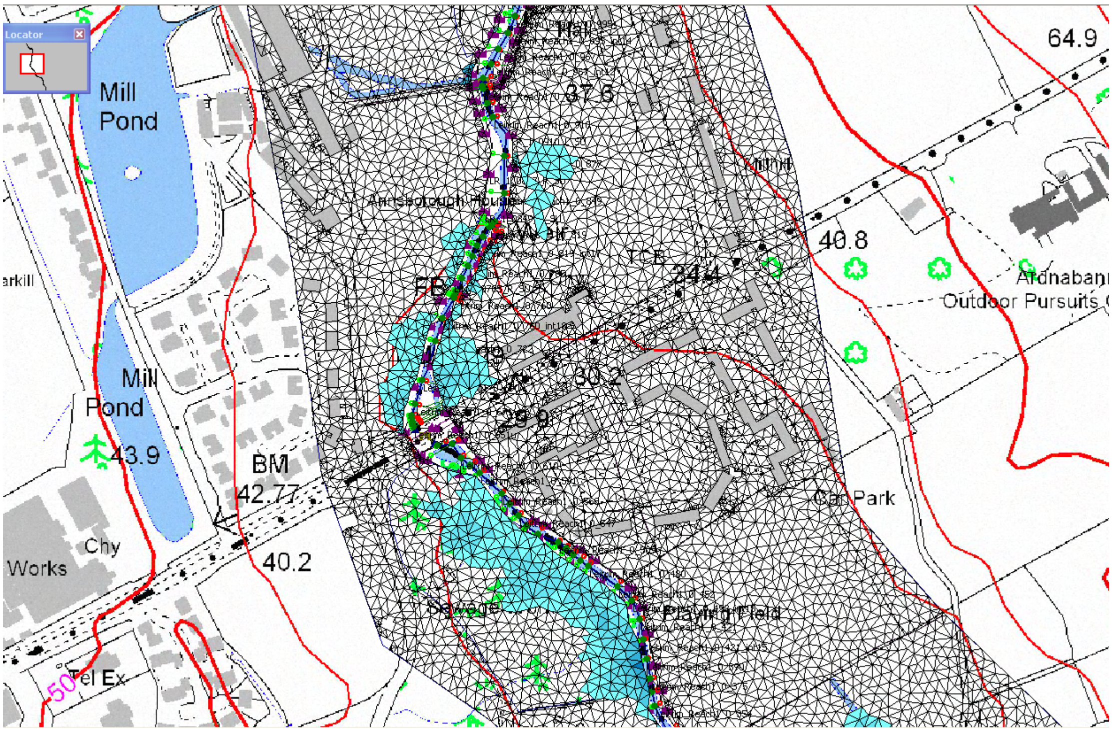


Fig 5.11 –Q10 Floodplain Extents.

6. POLICY AND PRACTICE

Rivers Agency Functions

6.1 The Agency aims to improve social conditions and to support economic development in Northern Ireland through reducing risk to life and damage to property from flooding from rivers and the sea, and also preserving the productive potential of agricultural land.

6.2 In support of these aims the Agency's operational objectives are to: identify flooding risks and execute viable works to minimise such risks, and to maintain a network of free flowing watercourses to provide adequate outlet for land drainage and urban storm drainage.

Floodplain Policy

6.3 Future development should not take place on land that has an unacceptable risk of flooding. That is, damage where there is a risk or danger to life and/or from flooding to property with resulting pressure for expenditure on flood protection works. Additionally future development should not create or exacerbate flooding elsewhere within a catchment and existing floodplain areas should be retained to fulfil their natural function.

6.4 Furthermore, Rivers Agency in line with its own floodplain policy, endorses DoE Planning Service policy that future development should be restricted to lands lying outside the floodplain, as per "PPS 15 - Planning & Flood Risk."

Feasibility and Design Brief

6.5 The study brief was to:-

- Ascertain the sources of flooding in Annsborough
- Identify the current level of flood risk
- Provide a feasible solution to minimise flood risks and to ensure that flooding of lands is not exacerbated elsewhere because of the alleviation measures.

6.6 This brief is consistent with the Agency's policy and practice in relation to floodplains and floodplain development.

7. OPTIONS FOR FLOOD ALLEVIATION

7.1 The hydraulic analysis indicates that, during significant flood events, there is bank overtopping at multiple locations on the Leitrim River within Annsborough village. Flood events over a Q10 are sufficient to result in risk to the Feedwell site. Events between a Q10 and Q25 will result in out of channel flow overtopping the A25 road and flowing into Annsborough Park.

A number of the options will result in flood worsening, however this will affect open space rather than any existing properties. There is currently outline planning approval, granted in September 2009, for part of this open space which is affected by both the increase in flood levels and the existing Q100 floodplain. Since this is only outline approval, Rivers Agency should be re-consulted by Planning Service at the full application stage and any issues can be addressed at that time. For the purpose of this report it is not possible to take these into consideration as planning policies and/or decisions may change in the future.

The hydraulic model indicates that a Q100 flood could be contained in-bank upstream of the A25 road, at locations where properties will be affected, if land at the overtopping locations is raised and gaps in the riverbanks are repaired. However the present condition of the existing banks and their structural integrity is questionable and a breach during large flood events is considered likely. A landowner has, at one location, removed a section of the earth bank to accommodate a land drain which the model indicates will cause out of channel flooding. Since these banks are not designated defences, there are no regulations to prevent a landowner carrying out work which may be detrimental. Any scheme which may be carried out by Rivers Agency would need to be approved by Drainage Council and the defences constructed would therefore be protected under the Drainage (NI) Order 1973.

Option 1. Do Minimum

7.4 The "Do Minimum" option would entail maintenance of the Leitrim River, a designated watercourse, and the existing flood defences at their current level and continuation of emergency response in the event of a flood. The hydraulic analysis indicates that the current degree of flood protection in the vicinity of Annsborough Park is approximately 1 in 25 years.

Option 2. Flood protection to the Feedwell site and adjacent land.

7.5 This option considers the construction of hard engineered flood defences around the Feedwell site and continuing east along the land adjacent to the A25 road to the Ballylough Road junction; the height of the defence would incorporate a freeboard of at least a 600mm to protect against a Q100 flood event. The defence would comprise a combination of a new concrete flood wall and a clay-core embankment. It is estimated that these defences would be a maximum of 2 metres in height from existing ground levels.
This option would entail:

- striping topsoil and excavation along the bank.
- Construction of approximately 315 metres of new defences:-
  - o construction of a reinforced concrete floodwall using the bedrock as a foundation for the key and to provide a cut-off for seepage.
  - o construction a new earth bank with a re-usable spoil and general fill.
- layered compaction of the construction materials and reinstatements
- removal of debris and vegetation in the vicinity of the flood wall at Annsborough Park.

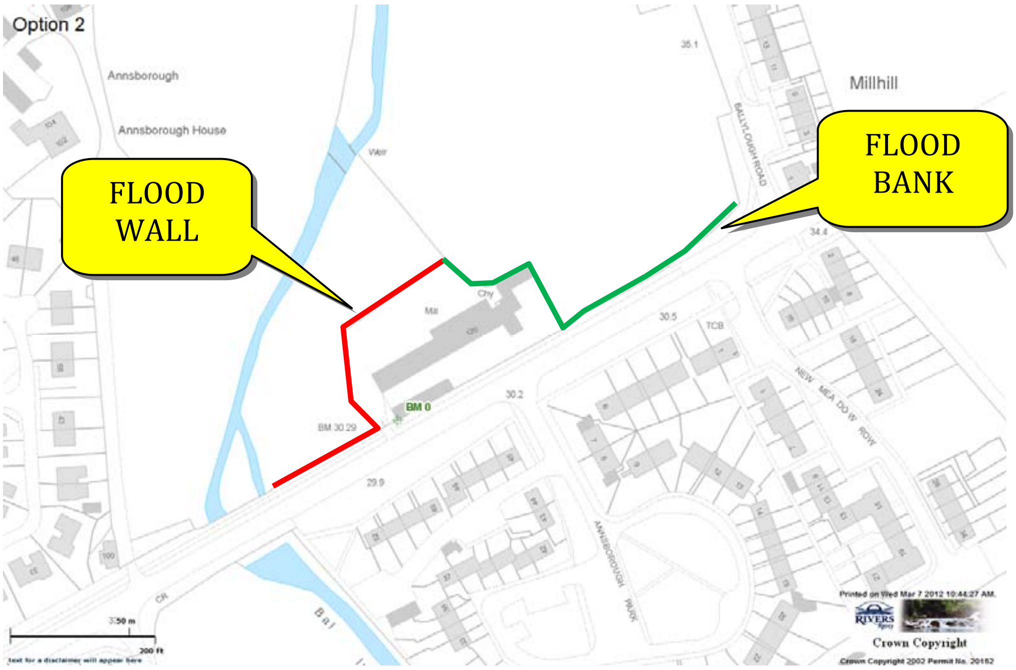


Fig 7.1 – Option 2 New engineered flood defences

Option 3. Flood Storage

7.7 This option would require construction of the same flood defences detailed in Option 2 but with the addition of using the field to the northeast of the Feedwell factory as flood storage. The addition of the storage would alleviate flooding elsewhere by storing water until the flood has sufficiently receded, at which point it will naturally return to the channel.

This option would entail: -

- construction of approximately 315 metres of new defences
- lowering of an access lane on left bank to encourage high flows to discharge into the adjacent field
- re-grading of field levels to provide increased storage capacity
- construction of an overflow to return water to channel
- removal of debris and vegetation in the vicinity of the flood wall at Annsborough Park.

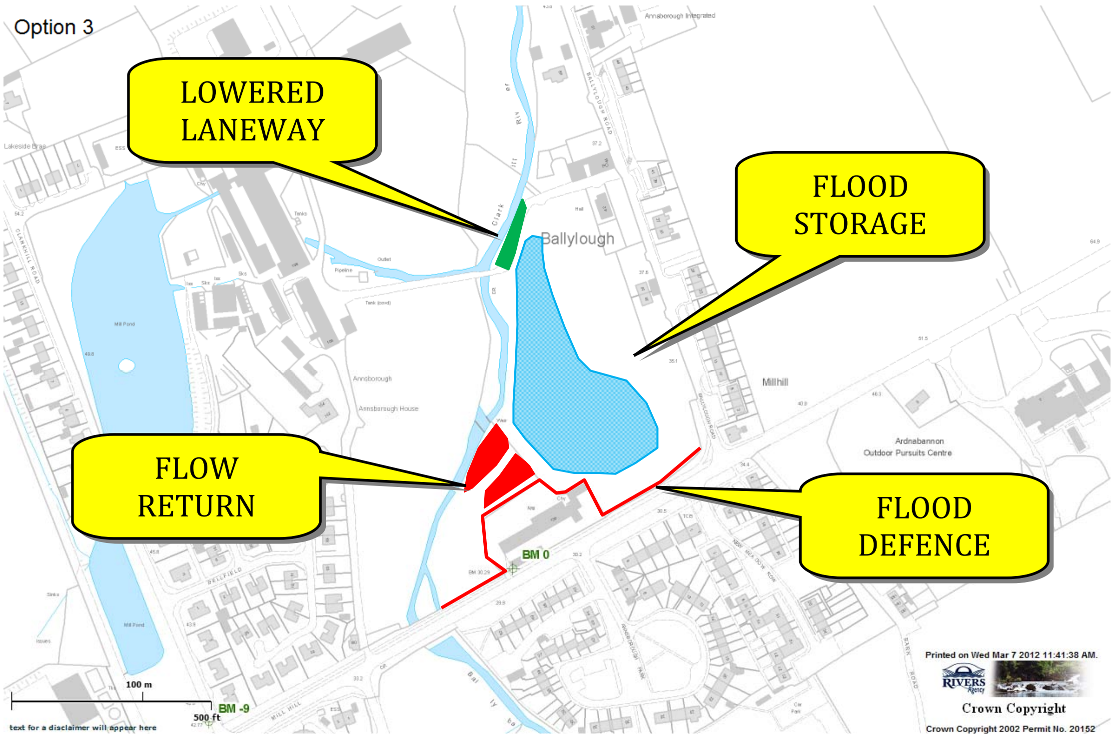


Fig 7.2 – Option 3 Flood Storage

Option 4. Multi-stage Channel

7.9 This option would involve channel works to increase the cross-sectional area while avoiding the widening of the river bed. The floodplain is used to increase capacity the sections, which enables the low flow channel to remain untouched.

There are currently raised embankments along sections of the river which would be required to be reconstructed adjacent to the new channel. The proposals would necessitate replacement of Bridge 2. It is a single span reinforced concrete slab with no parapet, which is used as an access to farmland, and for the purposes of this study it is envisaged that any replacement will be of similar size and construction. The small cross-sectional area has a minimal hydraulic impact on high flows.

This option would involve: -

- striping and storing the topsoil of the existing bank.
- removal of vegetation along banks
- removal of materials to re-grade channel and floodplain (both banks for approx. 230m and right bank for approx. 170m)
- reconstructing a raised embankment adjacent to new channel
- replacement of Bridge 2
- minimal re-grading of the bed slope

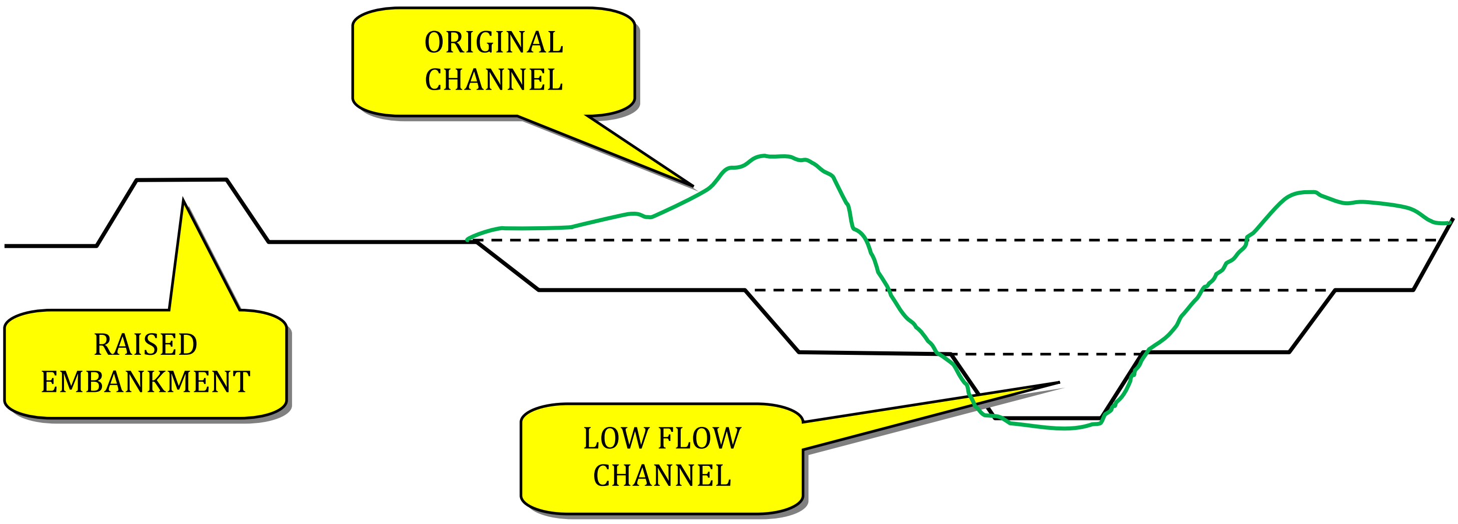


Fig 7.3 – Option 4 Multi-stage channel

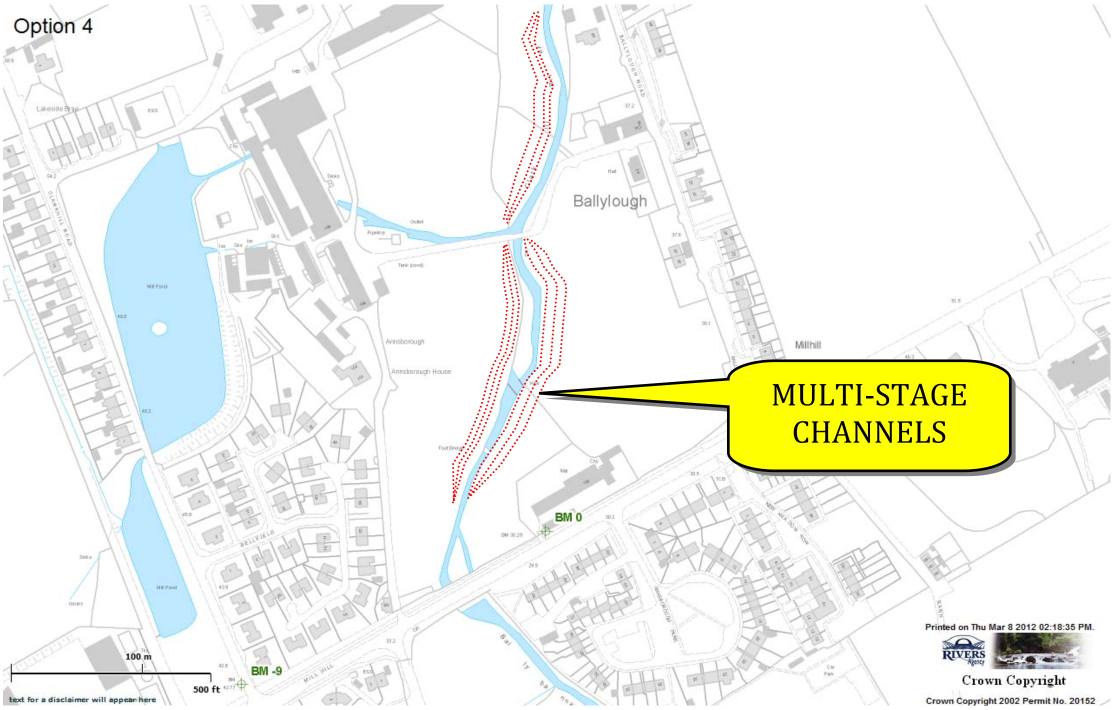


Fig 7.4 – Option 4 Multi-stage channel

Option 5. Increase hydraulic capacity of A25 Road Bridge

7.11 This option considers the provision of additional flow capacity at the A25 road bridge. The present situation consists of twin Armco pipe culverts along with an additional 2100mm diameter concrete culvert. This option involves adding an additional 2100mm culvert to increase flow capacity through the bridge, resulting in a reduction of flood levels upstream where out of bank flow occurs. To accommodate the additional culvert between the existing Armco pipes and the concrete culvert, an island which separates the channel at the bridge will require removing.

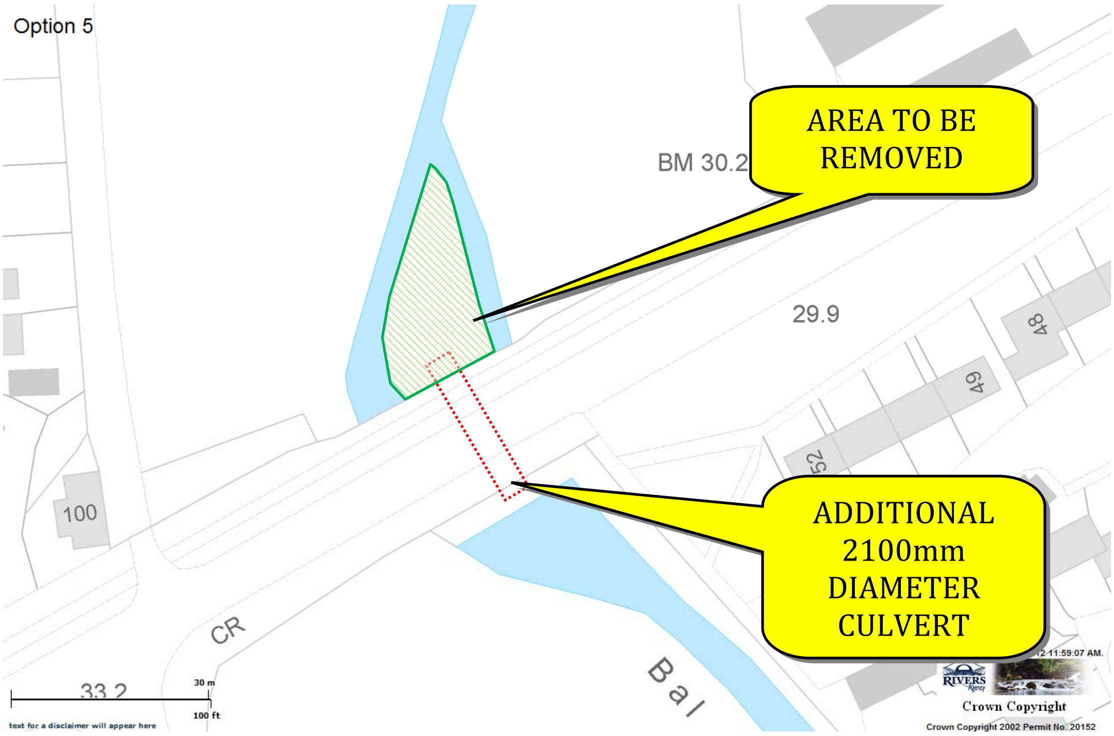


Fig 7.5 – Option 5 - A25 bridge culvert

This option is not considered viable as, despite investigation, it did not result in a sufficient enough reduction in the Q100 flood levels to alleviate the flood risk. Additional defences, similar to those in Options 2 or 3, would be required to make this a feasible option. Since the other Options provide suitable flood alleviation on their own, combining them with Option 5 would be unnecessary.

Additional Works

7.17 Options 2 and 3 which involve the flood defences around the Feedwell Factory will require a replacement access into the field to the rear of the site. The current access would be obstructed by the defences, however it could be relocated to the adjacent higher ground.

7.18 The disused millrace, which is to the rear of the Feedwell Factory, has been blocked off from the Leitrim River and was dry on all previous site visits. However during flood situations overland flow or a breach could result in a flow entering the channel and possibly bypassing any flood alleviation works.
It may be necessary to carry out works on this millrace, including the possibility of infilling the channel to prevent bypass. Consultation will need to take place with the landowners regarding this.

7.19 Furthermore, the Leitrim River system is important from a fisheries perspective. Consequently any re-grading of the bed slope will necessitate the inclusion of environmental work and fisheries enhancement measures (groynes, pools and riffles etc.) as part of the reinstatements and in line with Rivers Agency policy and legislation to protect fisheries and other habitats. These works, along with re-grading of the bed would probably require regular maintenance to ensure future hydraulic efficiency.

8. ENVIRONMENTAL CONSIDERATIONS

8.1 Consultation has taken place with the OSU Environment Section and their initial comments indicate that no major problems are envisaged with a proposed flood alleviation scheme. Nevertheless there are some environmental issues which would need to be addressed.

8.2 The Leitrim River has a significant fisheries interest. These interests will have an impact on any proposed scheme such as timing of work (out of the spawning season), retention of overhanging branches for shade and food, sediment control, retention/enhancement of fishery habitats etc.

Photo 8.1 – Overhanging trees and bushes.

8.3 The impact of any loss of trees on habitat systems would be high. Trees and shrubs would need to be retained where possible to minimise overall environmental impact on existing habitats with consideration given to the timing of the works to avoid nesting season. Replanting would take place where any flora is lost.

8.4 In addition, “Japanese Knotweed” is present on a section of the left bank. As this is an invasive species, a specific knotweed plan will be required for its removal and/or disposal and treatment pre-scheme, during works and post-scheme.

Photo 8.2 - “Japanese Knotweed”

9. ECONOMIC APPRAISAL – VIABILITY OF OPTIONS

General

9.1 Economic Appraisal is undertaken in compliance with "The Green Book – Appraisal & Evaluation in Central Government (HM Treasury 2003)." Benefit-Cost analysis is a tool used to aid decision making in policies plans and projects. In the case of flood management schemes it involves quantifying the various benefits associated with scheme proposals and comparing them against potential whole-life costs. Flood damages (direct-tangible costs), are the main source of quantifiable benefits used to estimate the overall project benefit figure i.e. the costs of the damage that would be avoided over the design life of the project. Other costs which are considered are the indirect and intangible costs. The total benefits are compared against the whole-life capital and maintenance costs of providing flood defence structures (See Appendix D).

Methodology

9.2 The flood damage cost figures have been taken from data published in "The Benefits of Flood and Coastal Risk; A Manual of Assessment Techniques (Multi-Coloured Manual (MCM))" which is published by the Flood Hazard Research Centre at Middlesex University. The flood damage costs are related to the depth of flooding to residential and non-residential properties for various flood return periods.

9.3 The total flood damage avoidance cost is factored into the exceedence probabilities of the different flood return periods to produce an Average Annual Damage (AAD). This is the theoretical cost of annual flood damage which will be avoided through the execution of the scheme proposals. Therefore, the AAD is discounted over the 100-year design life of the project. The discounting technique is carried out in accordance with the Government's "Green Book". The summation of the AAD is known as the Present Value (PV) and this is Benefit figure that is used in comparison against whole-life project costs to assess the viability of any option.

Scheme Benefits-Costs

9.4 The residential and non-residential properties considered to be at risk were investigated regarding land use, property type and age, floor area, floor levels and the estimated depth of flooding for standard return periods. The depth/damage costs were uplifted to 2012 prices as per MCM guidance (using the Consumer Price Index) and following the methodology outlined; the resultant project damages figure for Annsborough is estimated to be **£3,485,130** (£3.485M PVd); see Appendix D - Benefit Analysis.

9.5 With the “Do Minimum” scenario (Option 1) it is assumed that there will be no enhancement work carried out, only the undertaking of the existing annual maintenance regime. As a result, recurring flooding over the next 100-years will result in extensive flood damages, disruption and development blight.

9.6 The damages that will occur under Option 1 “Do Minimum” provide the base case damage figure for which all the other alternative options can be assessed and compared. For the purposes of the Economic Appraisal, the costs of any proposed works options are compared against the costs of the “Do Minimum” flood damage scenario. Therefore Option 1 flood damage PVd costs is assumed to be £3,485,130. The costs of the other Options are summarised below.

Proposals for Annsborough	**Capital Cost**
Option 2 Flood Defences – Floodbank & Floodwall adjacent to Feedwell & A25	£411k
Option 3 Flood Storage – Defences and Floodplain reprofiling.	£ 427k
Option 4 Multi-stage Channel – River channel reprofiling	£ 451K
Option 5 Bridge Replacement – Increase A25 road bridge capacity	£ 78K

Table 9.1 - costs summary for works for Annsborough

9.7 The above capital and maintenance costs include the risk component uplift factors for Optimism Bias as recommended in the supplementary notes of Flood & Coastal Defence Project Appraisal Guidance (FCDPAG3) -

Economic Appraisal, April 2003. A starting value for the Optimism Bias was the 60% upper bound, which was reduced in proportion to the amount that each contributory factor has been mitigated. The breakdown of the Optimism Bias for each Option is contained in the detailed Cost/Benefit analysis.

9.9 It can be seen from table 9.2 that all the proposed options are feasible for Annsborough. Additional factors must then be taken into consideration to determine the suitability of the each option. These are outlined in the Conclusions and Recommendations.

	Costs and benefits £k				
	Op 1 - No Project	Op 2 -	Op3 -	Op4 -	Op5 -
PV costs from estimates	9	321	338	343	58
Optimism bias adjustment	14	90	89	108	20
Total PV Costs for appraisal (PVc)	22	411	427	451	78
PV damages	3,485	317	317	317	317
Total PV damages (PVd)	3,485	317	317	317	317
PV damage avoided (benefits)		3,169	3,169	3,169	3,169
Total PV benefits (PVb)		3,169	3,169	3,169	3,169
Net Present Value NPV		2,757	2,742	2,717	3,091
Average benefit/cost ratio		7.71	7.42	7.02	40.68
Incremental benefit/cost ratio					
		-	-	-	Highest b/c

Table 9.2 – Annsborough Benefit-Costs summary

10.0 ADDITIONAL CONSIDERATIONS

Secondary Flooding

10.1 As previously mentioned, a number of the Options will exacerbate the flood risk elsewhere within the catchment. However the hydraulic modelling has shown that the land affected is open space and no additional property will be affected.

10.2 Hydraulic modelling also indicates that the existing flood defences adjacent to Annsborough Park will not be adversely affected by an increase in flood levels and will still have sufficient freeboard above the Q100 levels.

10.3 Other locations along the area of study were investigated for secondary flooding, such as the Sewage Treatment Works and the existing designated flood defences adjacent to Annsborough Park. Secondary flooding was not found to be an issue at any of these locations.

Climate Change

10.4 As per guidance from DEFRA Environment Agency and the UK Climate Impacts Programme (UKCIP), a sensitivity analysis has been carried out along the study area with 20% added to Q_{100} discharges in the hydraulic model. This is necessary to consider additional flows due to anticipated climate change.

10.5 The effect of the anticipated additional flows caused by climate change was an average increase of 300mm to the current estimated Q_{100} flood levels over this reach of the Leitrim River, with a 670mm maximum increase upstream of the A25 bridge. This maximum rise in levels is larger than the 600mm freeboard usually included on any preferred flood alleviation option. A larger freeboard would be recommended at this location.

Riparians & Stakeholders

10.6 Although contact has been made with some landowners and property owners, the proposed options have not yet been discussed formally with the local riparians and stakeholders. This will be carried out at the detailed design stage of the project. The outline planning approval for development to take place on parts of the open land adjacent to the watercourse is likely to become an issue if a full planning application is submitted. Since this has not yet happened, Rivers Agency has not taken this into account in the feasibility study. Should a full application be submitted then any post-scheme floodplain will be used to determine development extents, finished floor levels etc.

Timing of Works

10.7 The only timing constraints would appear to relate to environmental issues such as seasonal fisheries and bird nesting. The Feedwell factory is likely to be affected by a number of the proposed options and discussions with the owners will be required regarding the scope of the works at this location.

Health & Safety and CDM Regulations

10.8 Should a flood alleviation scheme go ahead no particular H&S problems are anticipated, nevertheless an "Information File" will be prepared in accordance with CDM Regulations (Northern Ireland) 2007.

11 CONCLUSIONS & RECOMMENDATIONS

Conclusions

11.1 The pros and cons of the 5 options are considered both on their own merits and in comparison with the others.

Option 1 – Do Minimum

11.2 The option to not carry out a scheme should always be assessed in a cost – benefit evaluation. It is used as a benchmark to determine whether the other options are economically feasible. This option involves maintaining the status quo which includes emergency responses from Rivers Agency staff in flood events and maintenance of the existing flood defences.

Option 2 – Flood Defences at Feedwell Site and adjacent to A25

11.3 This option is deemed economically viable and does not involve any in channel works. The locations where flood events are known to get out of bank due to lower sections and gaps can be improved; the model indicates that this will prevent flooding to existing properties. However the condition and structural integrity of the existing earthen banks are not known and breaches during high lows are considered highly likely. This option assumes a breach in the existing banks will occur in a significant flood event.

The defences would contain Q100 events which bypass the banks, alleviating the risk to the Feedwell site and Annsborough Park. Although the extents of the floodplain will be increased as a result of this option, only land which is currently open space will be affected.

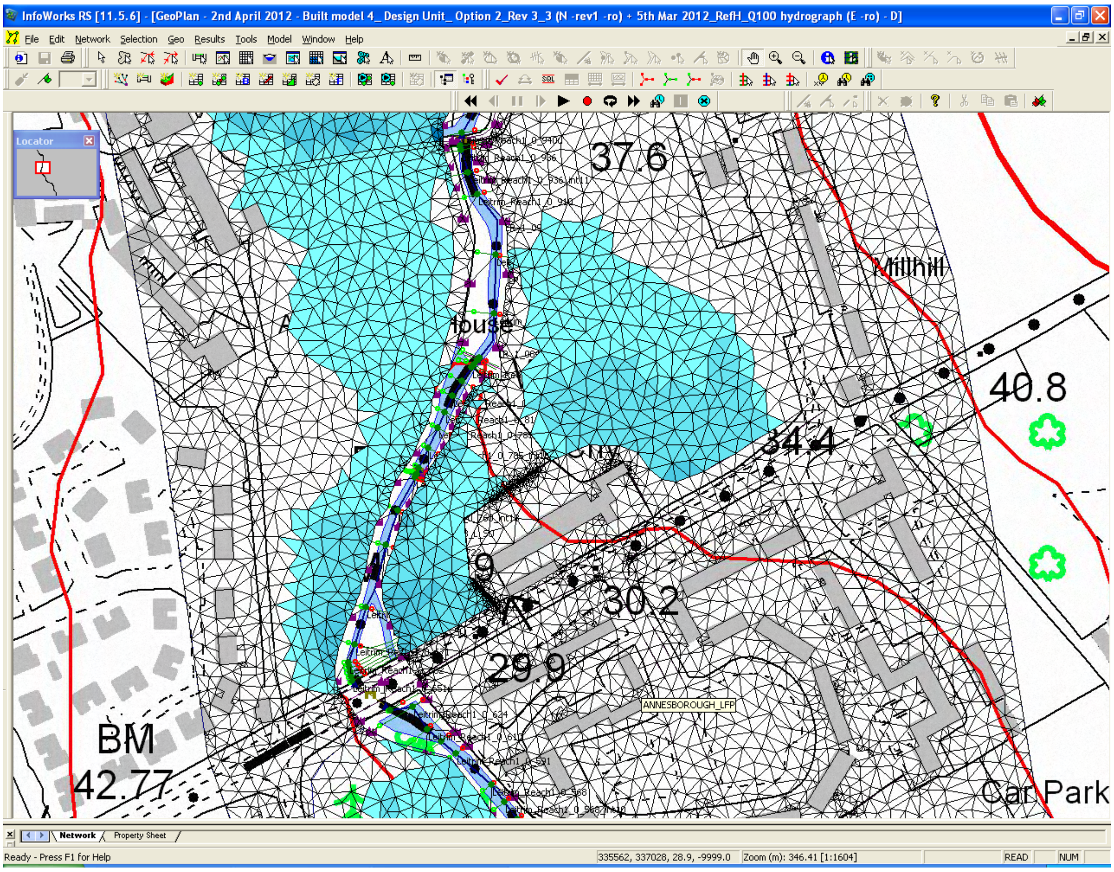


Fig. 11.1 – Option 2 Q100 Floodplain

Option 3 – Flood Storage

11.4 This option is similar to Option 2 with the addition of a flood storage area to alleviate flooding elsewhere in the catchment. The additional cost of providing the necessary flood storage is approximately 10% of the cost of the flood wall and flood bank. The additional benefit of the flood storage will be reduced flood levels elsewhere in the catchment; this will compensate for the increase in levels caused by the engineered defences. If it is proposed to carry out Option 2 and if, during further meetings, riparian owners raise concerns about the increases in the flood levels and floodplain extents, then the additional storage works are viable and should be considered at a later date.

The lowering of the existing laneway to provide an inlet to the storage area will result in the route being inaccessible during large flood events, however there is an alternative route which is outside of the floodplain extents of a Q100 event.

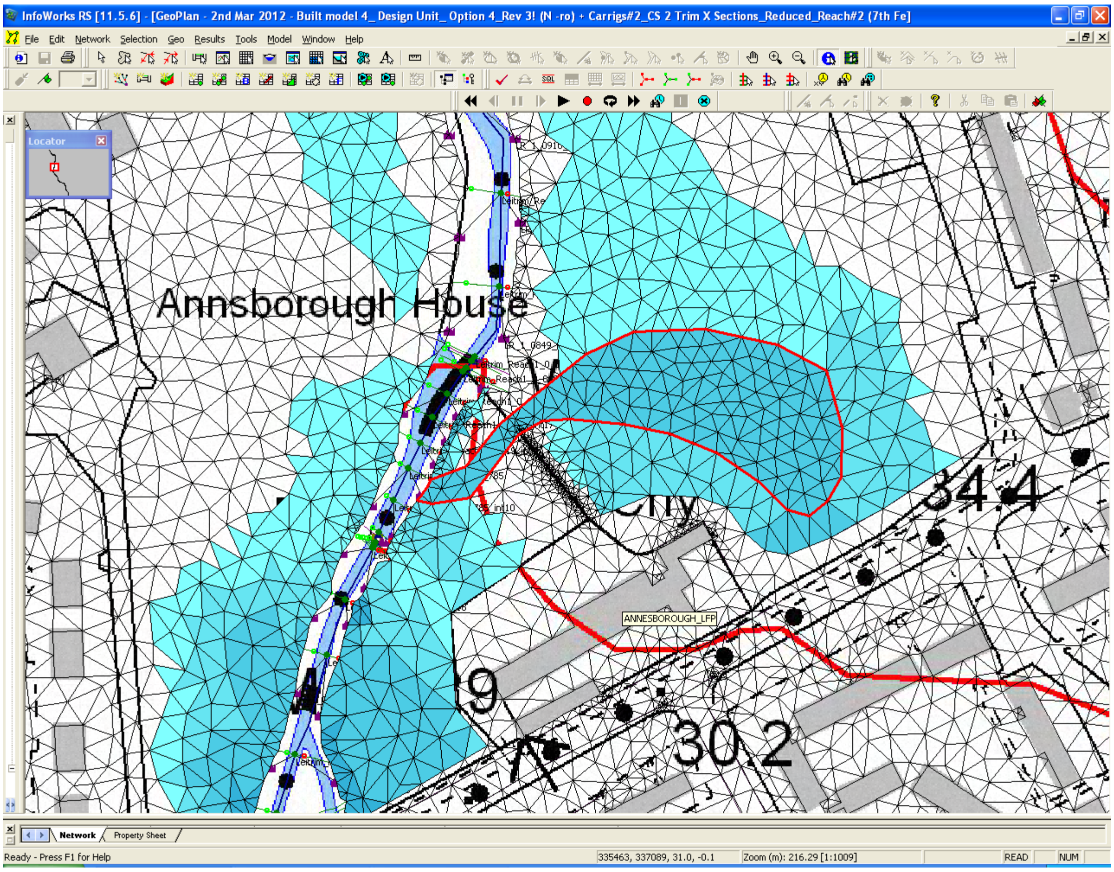


Fig. 11.2 – Option 3 Q100 Floodplain

Option 4 – Multi-Stage Channels

11.5 This option will result in a lowering of flood levels in a Q100 event by approximately 400mm along the reach where the measures would be carried out. This will prevent flood waters from overtopping the A25 into Annsborough Park. There may still be a risk to the lower sections of the Feedwell site adjacent to the A25 bridge.

This option involves substantial in-channel works, as such it will have a greater impact from an environmental aspect. There will be limits as to when these works could be carried out due to fisheries restrictions. A scheme such as this would require considerable construction time and extensive maintenance. Furthermore, the estimated cost of this option is higher than for Options 2 and 3.

Option 5 – Increase hydraulic capacity of A25 Bridge

11.6 Adding another relief culvert to the A25 bridge will result in an approximate reduction in Q100 flood levels of 150mm immediately upstream of the bridge. The reduction in levels continues for a distance of 135m upstream.

As previously stated, this option is not considered viable as, despite investigation, it did not result in a sufficient enough reduction in the Q100 flood levels to alleviate the flood risk to the Feedwell Factory and Annsborough Park. Additional defences, similar to those in Options 2 or 3, would be required to make this a feasible option. Since the other Options provide suitable flood alleviation on their own, combining them with Option 5 would be unnecessary.

Recommendations

11.8 Overall, due to the risk to life and property and considering all the relevant factors including economic, technical and environmental criteria, the overall investigation confirms that providing flood alleviation measures up to a Q_{100} return period (1% exceedence probability) can be fully justified in accordance with current Government guidelines and methodologies. The scheme will yield a high return for the investment in capital works proposed.

11.9 It is recommended that in accordance with current practice, Q_{100} flood protection (with a 750-mm freeboard) should be provided in Annsborough in the form of a Floodwall and Floodbank as detailed in **Option 2**; at an estimated cost of approximately £411k. This option can be more rapidly constructed, have minimal disruption, and have less visual and environmental impacts.

	Costs and benefits £k				
	Op 1 - No Project	Op 2 -	Op3 -	Op4 -	Op5 -
PV costs from estimates	9	321	338	343	58
Optimism bias adjustment	14	90	89	108	20
Total PV Costs for appraisal (PVc)	22	411	427	451	78
PV damages	3,485	317	317	317	317
Total PV damages (PVd)	3,485	317	317	317	317
PV damage avoided (benefits)		3,169	3,169	3,169	3,169
Total PV benefits (PVb)		3,169	3,169	3,169	3,169
Net Present Value NPV		2,757	2,742	2,717	3,091
Average benefit/cost ratio		7.71	7.42	7.02	40.68
Incremental benefit/cost ratio					
		-	-	-	Highest b/c

Table 11.1 - Annsborough Water Flood Alleviation Scheme, Benefit-Costs summary.

Prepared By: ______________________ Date March 2012

N Henderson

Countersigned By: ______________________ Date March 2012

J Kelly

Approved By: ______________________ Date March 2012

S Dawson
