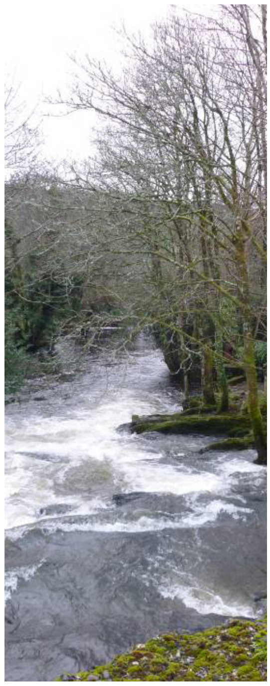

South Western CFRAM Study

Preliminary Options Report UoM 18

July 2016

The Office of Public Works

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Issue and Revision Record

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B	May 2016	T. Donovan	B O'Connor	F McGivern	Draft Final
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Contents

Figures

Tables

Executive Summary

The Office of Public Works (OPW) is undertaking six catchment-based flood risk assessment and management (CFRAM) studies to identify and map areas across Ireland which are at existing and potential future risk of flooding. Mott MacDonald Ireland Ltd. has been appointed by the OPW to assess flood risk and develop flood risk management options in the South Western River Basin District. This Preliminary Options Report is one of a series of reports being produced as part of the South Western Catchment Flood Risk Assessment and Management Study (SW CFRAM Study). This report details the analysis undertaken to identify the preferred measures and options to manage flood risk in Unit of Management 18 (The Munster Blackwater Catchment) which will form the basis for the Flood Risk Management Plan for this Unit of Management.

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for UoM 18 are set out below.

- Planning Control
- Building Regulations
- SUDS
- Flood Forecasting and Warning Systems
  - Build on Mallow / Fermoy Forecasting and Warning System
- Public Awareness
- Individual Property Flood Resilience
- Land Use Management

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for each of the AFAs in UoM 18 are set out below:

The preferred option for Kanturk as identified in the MCA is Storage and Flood Defences. There was limited feedback provided at the Kanturk PCD which indicated that the public agreed with the preferred option indicated in the MCA.

The preferred option for Ballyduff as identified in the MCA is Flood Defences. There was limited feedback provided at the Ballyduff PCD which indicated that the public agreed with the preferred option indicated in the MCA. As an interim measure, before the preferred option is implemented, extending the existing Mallow / Fermoy Flood Forecasting and Warning System to Ballyduff would be of benefit.

The preferred option for Aglish as identified in the MCA is Flood Defences. There was limited feedback provided at the Aglish PCD which indicated that the public agreed with the preferred option indicated in the MCA.

The preferred option for Youghal as identified in the MCA is Monitoring and Flood Defences. As an interim measure, before the preferred option is implemented, the installation of a tide gauge and a flood forecasting and warning system would be of significant benefit in Youghal.

The preferred option for Rathcormac is Flood Defences. This is based on feedback received at the PCD and the MCA including the economic cost benefit ratio.

1 Introduction

1.1 Background

Flooding is a natural process that occurs throughout Ireland as a result of extreme rainfall, river flows, storm surges, waves, and high groundwater. Flooding can become an issue where the flood waters interact with people, property, farmland and protected habitats.

Flood risk in Ireland has historically been addressed through the use of structural or engineered solutions (arterial drainage schemes and / or flood relief schemes). In line with internationally changing perspectives, the Government adopted a new policy in 2004 that shifted the emphasis in addressing flood risk towards:
- A catchment-based context for managing risk;
- More pro-active flood hazard and risk assessment and management, with a view to avoiding or minimising future increases in risk, such as that which might arise from development in floodplains;
- Increased use of non-structural and flood impact mitigation measures.

A further influence on the management of flood risk in Ireland is the 'Floods' Directive [2007/60/EC]. The aim of this Directive is to reduce the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity.

The Office of Public Works (OPW) is the lead agency in implementing flood management policy in Ireland. The OPW have commissioned a number of Catchment Flood Risk Assessment and Management Studies in order to assess and develop Flood Risk Management Plans (FRMPs) to manage the existing flood risk and also the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

Mott MacDonald Ireland Ltd. has been appointed by the OPW to undertake the Catchment-Based Flood Risk Assessment and Management Study (CFRAM Study) for the South Western River Basin District, henceforth referred to as the SW CFRAM Study. Under the project, Mott MacDonald Ireland Ltd. will produce FRMPs which will set out recommendations for the management of existing flood risk in the Study Area, and also assess the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

1.1 SW CFRAM Study Process

The overarching aims of the SW CFRAM Study are as follows:
- Identify and map the existing and potential future flood hazard;
- Assess and map the existing and potential future flood risk; and,
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the South Western River Basin District.

In order to achieve the overarching aims, the study is being undertaken in the following stages:

- Data collection;
- Hydrological analysis;
- Hydraulic analysis;
- Development of flood maps;
- Strategic Environmental Assessment and a Habitats Directive Appropriate Assessment;
- Flood risk assessment of people, economy and environment;
- Development and assessment of flood risk mitigation options; and,
- Development of the Flood Risk Management Plan (FRMP).

The resultant FRMP will set out recommendations for the management of existing flood risk and the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

The South Western River Basin District is split into five Units of Management (UoM). These Units follow watershed catchment boundaries and do not relate to political boundaries. The Units are as follows;

- The Blackwater Catchment (UoM 18)
- The Lee / Cork Harbour Catchment (UoM 19)
- The Bandon / Skibbereen Catchment (UoM 20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM 21)
- The Laune / Maine / Dingle Bay Catchment (UoM 22)

1.2 Report Structure

Table 1.1: Report Structure

Chapter	Key Contents of Chapter
1. Introduction	▪ Context of the Study ▪ The SW CFRAM process and aims ▪ Scope of Work
2. Description of the Unit of Management	▪ Description of study area ▪ Description of spatial scales of assessment
3. Screening of Possible Flood Risk Management Measures	▪ Description of the screening process ▪ Outcome of the screening process
4. Possible Flood Risk Management Measures	▪ Description of non-structural FRM measures ▪ Description of Structural measures
5. Development of Potential Flood Risk Management Options for AFAs	▪ Description of potential FRM options
6. Environmental Assessment	▪ Assessment of environmental impacts of potential FRM options
7. Stakeholder Input	▪ Summary of public consultations undertaken ▪ Summary of feedback received at public consultations
8. Flood Risk Assessment	▪ Description of the flood risk assessment process ▪ Description of receptors ▪ Description of flood risk maps
9. Estimate of Costs	▪ Estimate of costs of potential options
10. Appraisal of Options	▪ Description of the derivation of local weightings ▪ Description of the multi criteria analysis process
11. Selection of Preferred Options	▪ Description of preferred options

2 Description of the Unit of Management

2.1 Spatial Scales of Assessment

The South Western River Basin District covers an area of approximately 11,160 km^2. The Study Area includes most of County Cork, large parts of Counties Kerry and Waterford, along with small parts of the counties of Tipperary and Limerick. The Study Area contains over 1,800 km of coastline along the Atlantic Ocean and the Celtic Sea. There are five Units of Management within the South Western River Basin District, which are listed below:

- The Blackwater Catchment (UoM 18)
- The Lee / Cork Harbour Catchment (UoM 19)
- The Bandon / Skibbereen Catchment (UoM 20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM 21)
- The Laune / Maine / Dingle Bay Catchment (UoM 22)

Within the CFRAM Study, the screening, assessing and developing of Flood Risk Management (FRM) methods and options is to be considered on a range of Spatial Scales of Assessment (SSAs) that shall include:

- The Units of Management (UoM)
- Each Sub-Catchment within the Unit of Management
- Areas for Further Assessment (AFAs)
- Individual Risk Receptors (IRRs)

2.2 Spatial Scales of Assessment for Unit of Management 18

Within UoM 18 the River Allow could be considered as a Sub-Catchment SSA as Freemount and Kanturk have been identified as AFA's. However, based on the Flood Risk Assessment and Mapping described in this report there is low risk in Freemount and there are no structural flood risk management options proposed.

Kanturk on the River Allow to Ballyduff on the River Blackwater could be considered as a Sub-Catchment SSA. However, hydraulically the AFA's are far removed and the towns of Mallow and Fermoy are located between the AFAs. Mallow and Fermoy are not being considered for options as they have existing flood relief schemes in place.

Rathcormac and Tallow on the River Bride could be considered as a Sub-Catchment SSA. However, based on the Flood Risk Assessment and Mapping described in this report there is low risk in Tallow and there are no structural flood risk management options proposed.

Aglish is located on the Aglish Stream which is a tributary of the River Blackwater. Due to the difference in scale of flows between the Aglish Stream and the River Blackwater it is unlikely that any works in Aglish could provide a benefit downstream. Furthermore, the only downstream AFA is Youghal which is not at risk of fluvial flooding.

Therefore, no Sub-Catchment SSAs are considered within UoM 18.

No IRRs have been identified within the South Western RBD and as such are not considered.

Based on the above, UoM 18 is split into 2 Spatial Scales of Assessment (SSAs). These are:

- The Unit of Management (UoM)
- Areas for Further Assessment (AFAs)
  - Freemount
  - Kanturk
  - Ballyduff
  - Rathcormac
  - Tallow
  - Aglish
  - Youghal

3 Screening of Possible Flood Risk Management Methods

3.1 General

A flood risk management option consists of one or, more commonly, a combination of flood risk management (FRM) methods or measures. The OPW have identified a range of possible FRM methods that could apply to areas at risk from flooding. The screening of possible FRM methods to determine their applicability and viability is carried out in this section.

3.2 Screening of Possible Flood Risk Management Methods

A preliminary assessment was carried out to identify which Flood Risk Management (FRM) methods were applicable to each of the SSAs within UoM 18.

The applicability and viability of each of the FRM methods was considered in terms of the following criteria:

- Applicability to the SSA
- Economic (potential benefits, impacts, likely costs etc.)
- Environmental (potential impacts and benefits)
- Social (impacts on people, society and the likely acceptability of the method) and
- Cultural (potential benefits and impacts upon heritage sites and resources)

The viability of each of the methods was assessed to a preliminary degree only. The purpose of the screening process was to identify the FRM methods that are clearly not applicable or viable within UoM 18. The FRM methods considered and the outcome of the screening process are shown in Table 3.1 below.

Table 3.1: Screening of Possible Flood Risk Management Methods

Measures / Methods	UoM	Sub-Catchment	AFA						
	18		Freemount	Kanturk	Ballyduff	Rathcormac	Tallow	Aglish	Youghal
Do Nothing	Not Viable	N/A	Viable	Not Viable	Not Viable	Not Viable	Viable	Not Viable	Not Viable
Existing Regime	Not Viable	N/A	Viable	Not Viable	Not Viable	Not Viable	Viable	Not Viable	Not Viable
Do Minimum	Not Viable	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
Non-structural Measures									
• Planning Control	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
• Building Regulations	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
• SUDS	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
• Flood Forecasting	Viable	N/A	Viable	Viable	Viable	Not Viable	Not Viable	Not Viable	Viable
• Public Awareness	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
• Individual Property Flood Resilience	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
• Land Use Management	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
Structural Measures (Future Risk)									
• Strategic Development Management	Viable	N/A	Viable	Viable	Viable	Viable	Viable	Viable	Viable
Structural Measures (Current Risk)									
• Fluvial Storage	Viable	N/A	Not Viable	Viable	Not Viable	Viable	Not Viable	Not Viable	Not Viable
• Flow Diversion	Not Viable	N/A	Not Viable	Not Viable	Not Viable	Viable	Not Viable	Viable	Not Viable
• Increase Conveyance	Not Viable	N/A	Not Viable	Viable	Viable	Not Viable	Not Viable	Viable	Not Viable
• Flood Defences	Not Viable	N/A	Not Viable	Viable	Viable	Viable	Not Viable	Viable	Viable
• Improve existing defences	Not Viable	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Viable
• Relocate Properties	Viable	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
• Localised protection works	Not Viable	N/A	Not Viable	Viable	Viable	Viable	Not Viable	Viable	Viable
Channel or Flood Defence Maintenance Works	Viable	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Viable
Other Works	-	N/A	-	-	-	-	-	-	Tidal Barrage

3.3 Screening of UoM scale FRM Methods

3.3.1 Do Nothing / Existing Regime / Do Minimum

These measures are not viable due to the significant flood risk within UoM 18 to the economy and society for extreme events in the current and future scenarios.

3.3.2 Structural Measures (Current Risk)

Structural measures are typically not applicable to UoM scale SSAs due to cost and the likely significant social and environmental impacts of such works. Also, within UoM scale SSAs there are areas and receptors which are less vulnerable to flooding. Structural measures are more appropriate and applicable to AFA scale SSAs.

However, structural measures such as upstream storage and relocation of properties can be viable structural measures on a UoM scale.

3.4 Screening of Sub-Catchment scale FRM Methods

As outlined in Section 2.2 there are no sub-catchments within UoM 18.

3.5 Screening of AFA scale FRM Methods

This section details each of the non-viable measures which have been screened out from further assessment. The remaining viable Flood Risk Management measures are assessed further in Chapter 4 and Chapter 5.

3.5.1 Do Nothing / Existing Regime

For the majority of the AFAs these measures are not viable due to the significant flood risk to the economy and society for extreme events in the current scenario and for future scenarios.

However, as part of the Flood Risk Assessment and Mapping, Freemount and Tallow were identified as having a low existing risk as there are less than 5Nr. properties within the 1% AEP fluvial event flood extent. As a result, Freemount and Tallow are excluded from the development of FRM Options on the basis that there is a low likelihood of achieving a cost-beneficial solution and/or the low priority that would be given to the AFAs for any such works. Therefore, for Freemount and Tallow, the Do Nothing / Existing Regime is a viable measure while all other structural measures are deemed to be not viable.

3.5.2 Do Minimum (e.g. Infilling of gaps etc.)

Within the AFAs considered there are no identifiable points or locations where minimum works such as infilling of gaps etc. would lead to a reduction in flood risk. Therefore, the do minimum approach is not applicable.

3.5.3 Kanturk – Flow Diversion

Any reasonable flow diversion between the Allow and Dalua would require the demolition of properties. Furthermore, the town is located on the confluence of the rivers and any diversion would likely not reduce water levels in the town. Diversion to another watercourse would be over a significant length and would also require demolition of properties. This measure is not economically viable.

3.5.4 Kanturk – Improve Existing Defences

There are no existing flood defences in Kanturk. This measure is not applicable.

3.5.5 Kanturk – Relocate Properties

There are no isolated properties at risk within Kanturk. There are 152 properties at risk of flooding. The available capped benefit in Kanturk is €11,023,136. The available budget to relocate each property is €72,520. It is not likely that a property could be relocated in Kanturk for this sum. This measure is therefore not economically or socially viable.

3.5.6 Kanturk – Channel or Flood Defence Maintenance Works

Kanturk does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.7 Ballyduff – Fluvial Storage

Due to the magnitude of flows in the River Blackwater (573m3/s for the 1% AEP fluvial event) and lack of suitable storage areas it is not feasible or economical to store flows. Fluvial storage is not applicable

3.5.8 Ballyduff – Flow Diversion

Due to the magnitude of flows in the River Blackwater (573m3/s for the 1% AEP event) and its location within a valley it is not applicable or economical to divert flows. This measure is not economically viable.

3.5.9 Ballyduff – Improve Existing Defences

There are no existing flood defences in Ballyduff. This measure is not applicable.

3.5.10 Ballyduff – Relocate Properties

There are no isolated properties at risk within Ballyduff. There are 13 properties at risk of flooding. The available capped benefit in Ballyduff is €2,961,254. The available budget to relocate each property is €227,788. It is not likely that a property could be relocated in Ballyduff for this sum. This measure is therefore not economically or socially viable.

3.5.11 Ballyduff – Channel or Flood Defence Maintenance Works

Ballyduff does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.12 Rathcormac – Flood Forecasting

Flood warning on the Kilbrien Stream is likely to be ineffective as the flood risk is driven by a small flashy catchment. This measure is not applicable.

3.5.13 Rathcormac – Increase Conveyance measures

Replacing the existing culvert on the TOBE watercourse with one of a greater size was considered. The precise location and condition of this culvert could not be ascertained during the survey. For this reason and because for this measure to work it would be necessary to construct a new culvert possibly under or adjacent to existing buildings this option was not considered further. This measure is not applicable.

3.5.14 Rathcormac – Improve Existing Defences

There are no existing flood defences in Rathcormac. This measure is not applicable.

3.5.15 Rathcormac – Relocate Properties

There are no isolated properties at risk within Rathcormac. There are 31 properties at risk of flooding. The available capped benefit in Rathcormac is €4,591,569. The available budget to relocate each property is €148,155. It is not likely that a property could be relocated in Rathcormac for this sum. This measure is therefore not economically or socially viable.

3.5.16 Rathcormac – Channel or Flood Defence Maintenance Works

Rathcormac does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.17 Tallow – Flood Forecasting

The time to peak is less than 5 hours, which limits the time available for flood warning. This measure is not applicable.

3.5.18 Aglish – Flood Forecasting

The time to peak is less than 5 hours, which limits the time available for flood warning. This measure is not applicable.

3.5.19 Aglish – Fluvial Storage

There is limited storage available upstream of the flood risk area to enable any storage or attenuation measure because Aglish is located in the upstream limit of the catchment. This measure is not applicable.

3.5.20 Aglish – Improve Existing Defences

There are no existing flood defences in Aglish. This measure is not applicable.

3.5.21 Aglish – Relocate Properties

There are no isolated properties at risk within Aglish. There are 5 properties at risk of flooding. The available capped benefit in Aglish is €261,834. The available budget to relocate each property is €52,366. It is not likely that a property could be relocated in Aglish for this sum. This measure is therefore not economically or socially viable.

3.5.22 Aglish – Channel or Flood Defence Maintenance Works

Aglish does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.23 Youghal – Fluvial Storage

Youghal is at risk of tidal flooding. Fluvial storage is not applicable.

3.5.24 Youghal – Flow Diversion

Youghal is at risk of tidal flooding. Flow diversion is not applicable.

3.5.25 Youghal – Increase Conveyance

Youghal is at risk of tidal flooding. Increase Conveyance is not applicable.

3.5.26 Youghal – Relocate Properties

There are no isolated properties at risk within Youghal. This measure would require relocation of a number of properties which is not economically or socially viable.

4 Possible Flood Risk Management Measures

4.1 General

A flood risk management option consists of one or, more commonly, a combination of flood risk management methods / measures. This section assesses the possible flood risk management measures as screened in Table 3.1.

4.2 Non-Structural Measures

Non-structural measures such as Land Use Management, Natural Flood Management, Green Infrastructure etc. are terms used to cover a suite of measures that are intended to reduce flood risk by working with natural systems and, where possible, provide environmental benefits. While in small catchments they can effectively manage flood risk to a certain degree in their own right, in larger catchments they can work in a complimentary way with other measures to achieve flood risk management targets.

Due to the time required to initiate, establish and prove the flood risk management targets of such measures, they are not deemed viable to mitigate the current flood risk and any potential reductions in flood risk should not be considered when developing other options based on structural measures.

Where there is existing flood risk, the implementation of non-structural measures such as Planning Control, SUDS etc. at any spatial scale of assessment will not mitigate flood risk, unless those measures are retrospectively applied. As this is unrealistic and not economically viable, such non-structural measures can only be applied to new development to maintain the status quo of the current flood risk scenario or mitigate future flood risk. The application of non-structural measures such as individual property resilience, public awareness and flood forecasting, to redevelopment or new development may reduce potential damage costs.

The non-structural measures described in this section are complimentary to structural measures and should be implemented as national policy to the SSAs where appropriate. However, at this stage they should not be considered in the development of options based on structural measures.

4.2.1 Planning Control

In November 2009, the Guidelines on the Planning System and Flood Risk Management, jointly developed by DECLG and the OPW, were published under Section 28 of the Planning Acts. These Guidelines provide a systematic and transparent framework for the consideration of flood risk in the planning and development management processes, whereby:

A sequential approach should be adopted to planning and development based on avoidance, reduction and mitigation of flood risk.

A flood risk assessment should be undertaken that should inform the process of decision-making within the planning and development management processes at an early stage.

Development should be avoided in floodplains unless there are demonstrable, wider sustainability and proper planning objectives that justify appropriate development and where the flood risk to such development can be reduced and managed to an acceptable level without increasing flood risk elsewhere (as set out through the Justification test).

The proper application of the Guidelines by the planning authorities is essential to avoid inappropriate development in flood prone areas, and hence avoid unnecessary increases in flood risk into the future. The flood mapping provided as part of the FRMP will facilitate the application of the Guidelines.

In flood-prone areas where development can be justified (i.e., re-development, infill development or new development that has passed the Justification Test), the planning authorities can manage the risk by setting suitable objectives or conditions, such as minimum floor levels or flood resistant or resilient building methods.

4.2.2 Building Regulations / Planning Conditions

The risk of damage to properties from flooding can be mitigated by the use of appropriate construction techniques and materials. For example the damage caused to an internal wall of a property by flooding can depend on the materials and methods of its construction. A timber stud partition covered with plasterboard with low level electrical wiring would have to be completely replaced following immersion in flood water. However, a solid concrete block wall covered with tiles and high level electrical wiring on the other hand would only have to be washed down following a flood.

If for a particular town or high flood probability areas, certain building regulations or planning conditions were adopted that ensured structures were flood resilient through specified construction methods, building fabrics and uses, a decrease in the risk of damage could be achieved. The question of whether such regulations or planning conditions could be imposed upon developers, business owners or householders in flood prone areas would need to be addressed if this were to be brought forward as a flood risk management measure.

A link to a UK guidance document "Improving the Flood Performance of New Buildings" prepared by the Department for Communities and Local Government is provided below.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf

4.2.3 Sustainable Urban Drainage Systems (SUDS)

Sustainable Urban Drainage (SUDS) involves the management of surface water run-off from developments in a manner which attempts to replicate the natural behaviour within catchments and watercourses, which is typically achieved through attenuation.

Within existing urban or developed areas there is typically little space available for the attenuation of storm water flows to a degree which would mitigate or reduce current flood risk. Therefore, it is not considered practical to implement SUDS for the mitigation of current risk at any SSA. However, within all SSAs every new developments (and where possible redevelopment), should apply the principles of SUDS.

A separate Strategic SUDS report has been prepared for UoM 18 outlining potential SUDS measures in the AFAs. These measures focus on areas that are zoned for future development.

4.2.4 Flood Forecasting and Warning

Flood forecasting is a means of providing advanced warning of an impending flood event. A reliable advance warning system allows protective measures to be put in place and protective actions to be carried out in advance of a flood event. These actions and measures can reduce the damage caused in a flood event.

Flood forecasting is not a possible FRM measure at all SSAs. This is because the time between transmitting a flood forecast in which the authorities have reasonable confidence and the arrival of flood waters may not be long enough for people to take effective action to reduce flood damage. The minimum time to take effective action is deemed to be 6 hours. This time limit is set on the basis that once rainfall has been recorded it can take up to 2 hours to run a complex model and get meaningful forecasts. Following this forecast it is assumed that it can take people up to 3 hours to travel to their home and take the necessary measures to protect their property from flooding.

Flood forecasting and warning has been identified as a possible FRM measure for the SSAs highlighted in Table 4.1. Table 4.1 highlights the time to peak for the critical event (Fluvial = 1% AEP event / Tidal = 0.5% AEP event) and summarises the infrastructure required to implement a flood forecasting and warning system. The infrastructure required is based upon the layout of the catchment and the arrangement of watercourses that could contribute to flood flows. Gauges are located at critical locations in the catchment so that data on precipitation and rising river levels can be collected and analysed to feed into the forecasting system.

The accuracy of the forecasting system will depend on the number of river level and rain gauges collecting data. The more gauges there are the greater the accuracy of the system. The cost and complexity of the system will also increase with more gauges. This will give more accurate forecasts but it will take longer for the system to generate them.

Table 4.1: SSAs Suitable for Flood Forecasting

Spatial Scale of Assessment	Time to Peak of Event	Infrastructure
AFA		
Freemount (River Allow)	> 6 Hours	Rain gauges River level gauges Build on existing Mallow / Fermoy Flood Early Warning System
Freemount (Knockeen Stream)	< 5 Hours	Short time to peak, flashy flood warning likely to be ineffective
Kanturk	> 6 Hours	Rain gauges in the Allow and Dalua catchments River level gauges on the Allow and Dalua Connect to Mallow / Fermoy Flood Warning System
Mallow	-	Existing flood warning systems in place
Fermoy	-	Existing flood warning systems in place
Ballyduff	> 6 Hours	Add to Mallow / Fermoy Flood Warning System

Spatial Scale of Assessment	Time to Peak of Event	Infrastructure
Rathcormac	< 5 Hours	Short time to peak, flashy catchment, flood warning likely to be ineffective
Tallow	< 5 Hours	Short time to peak, flood warning likely to be ineffective
Aglish	< 5 Hours	Short time to peak, flood warning likely to be ineffective
Youghal	> 6 Hours	Use the existing OPW storm surge forecasting system to predict high tide levels.
UoM		
River Blackwater	> 6 Hours	Build on the existing Mallow / Fermoy Flood Warning System Use the existing OPW storm surge forecasting system to predict high tide levels.

Source: UoM 18 Hydraulics Report

An equation to estimate the impacts of flood warnings on flood damages has been developed by Green & Penning-Rowsell. This equation determines that the estimated actual flood damage avoided owing to flood warnings is approximately 13% of potential damages.

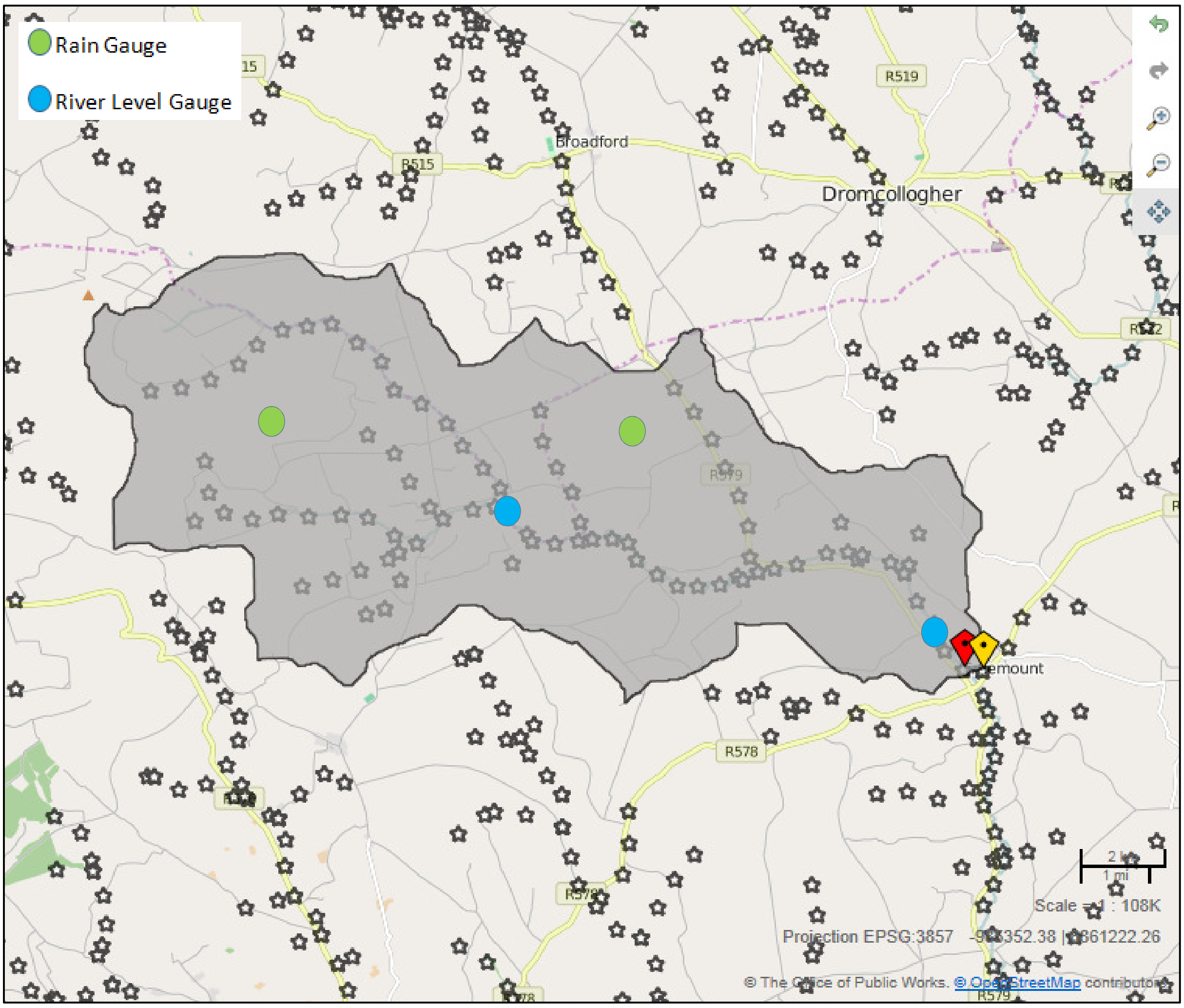
4.2.4.1 Freemount

The infrastructure required for a flood forecasting and warning system in Freemount (AFA) is listed in Table 4.2 and the proposed locations are shown in Figure 4.1.

Table 4.2: Freemount – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	2
River Level Gauge (Hydrometric Gauging Station)	2

Figure 4.1: Freemount – River Allow – Proposed Gauges



4.2.4.2 Kanturk

The infrastructure required for a flood forecasting and warning system in Kanturk (AFA) is listed in Table 4.2 and the proposed locations are shown in Figures 4.2 and 4.3.

Table 4.3: Kanturk – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	8
River Level Gauge (Hydrometric Gauging Station)	9

Figure 4.2: Kanturk – River Dalua – Proposed Gauges

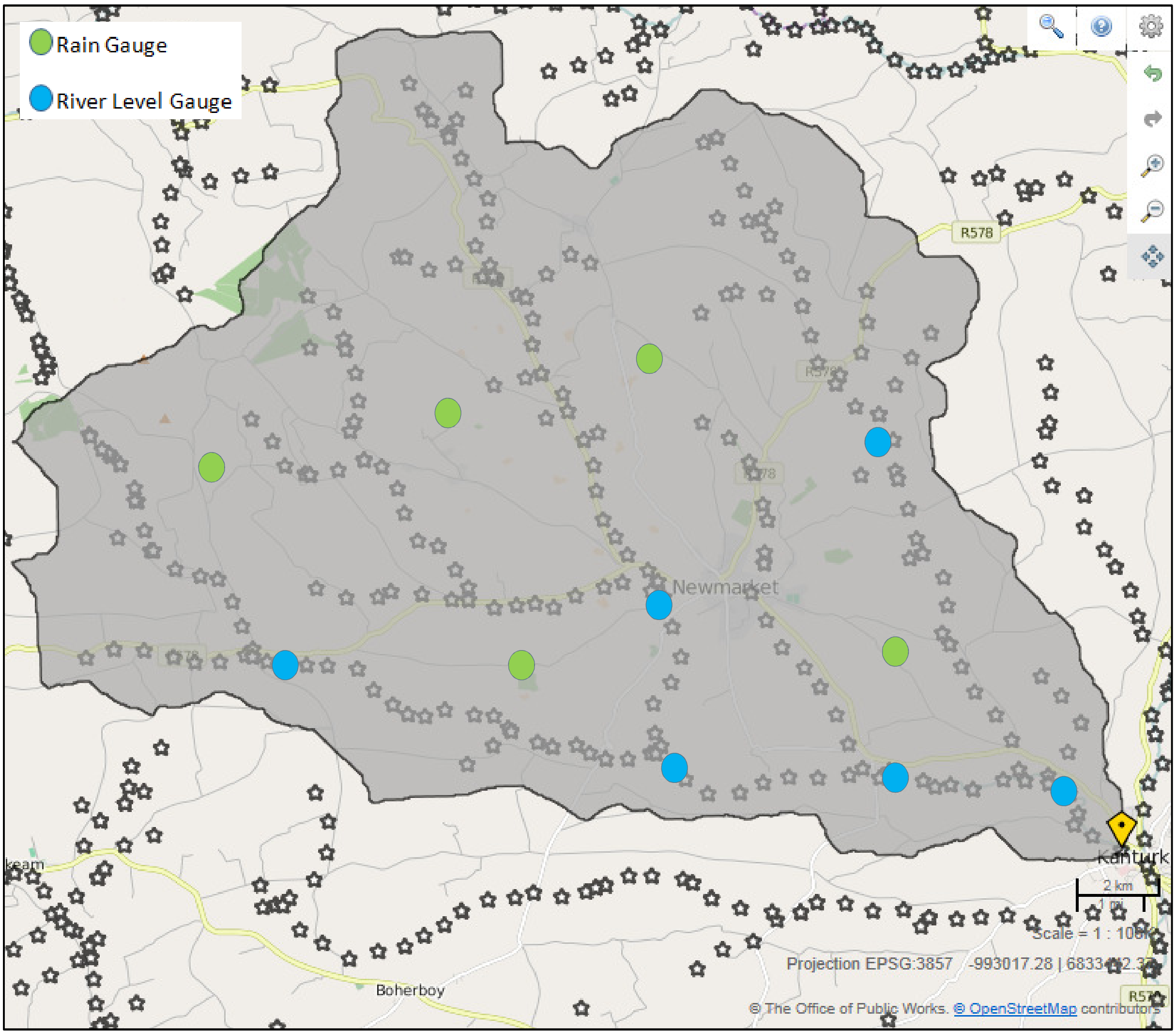
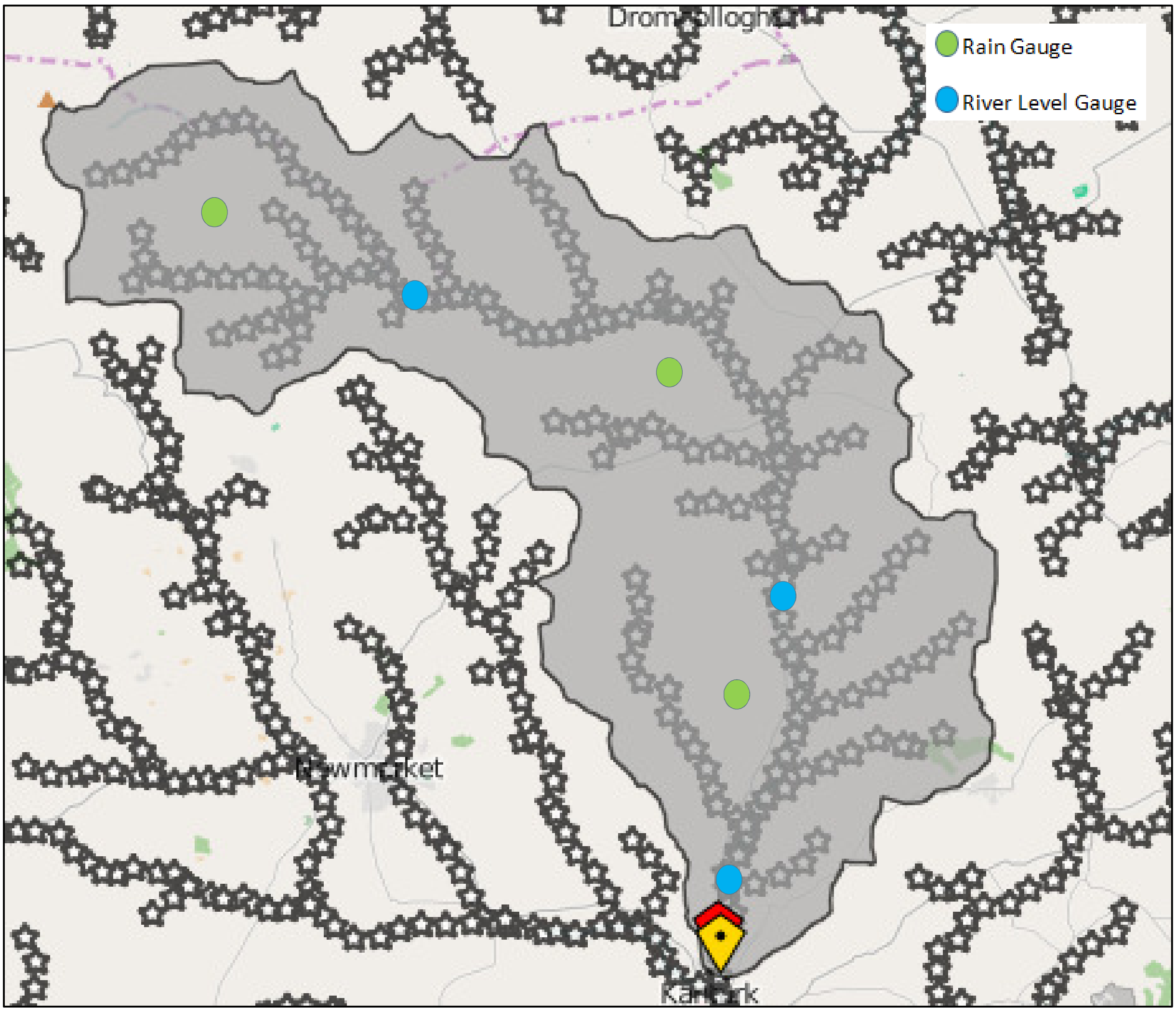


Figure 4.3: Kanturk – River Allow – Proposed Gauges



The infrastructure listed and shown above would also be required for a UoM / Sub-Catchment scale forecasting system which would build on the existing Mallow / Fermoy Flood Warning System (FEWS).

Cost estimates for the proposed flood forecasting and warning systems are included in Section 9.0.

4.2.5 Public Awareness

Many of the measures to mitigate and manage flood risk and the potential consequences for flooding will involve the public at large. It is therefore important that the public is made aware of where to find information, what the information means and what actions the public and business owners can take to reduce the damage that would occur to their properties, possessions and interests in the event of a flood.

Public awareness measures will engender the public's recognition of the potential of the risk of flooding and the potential consequences thereof. Knowing in advance means that actions can be taken in a timely manner.

Measures to increase and promote public awareness include:

- Identifying the areas prone to flooding
- Information on measures to be implemented to reduce and / or manage the risk of flooding
- Measures in place to provide advance warning of flooding
- Establishment of methods to interface with the public and in particular the owners of vulnerable properties, i.e. workshops and meetings, Facebook, Twitter, text messaging, newsprint, websites, etc.

Flood risk maps and flood hazard maps have been produced for the UoM 18 AFAs. The dissemination of this information to the public will increase awareness.

4.2.6 Land Use Management

Land Use Management can be utilised as a non-structural measure to prevent or reduce the impact of flooding on properties, roads and other critical infrastructure. Land Use Management includes strategies to control overland flow, such as improving agricultural and forestry practices in key catchment areas. Local natural flood management measures such as the creation of wetlands or forestry to retain overland flow could also be adopted.

4.2.7 Emergency Response Planning

Well prepared and executed emergency response plans can significantly reduce the impact of flood events, particularly for human health and welfare.

The Framework for Major Emergency Management was developed in 2005 and was adopted by Government decision in 2006. Its purpose is to set out common arrangements and structures for front line public sector emergency management in Ireland. The Framework is based on the internationally recognized systems approach that, in essence, proposes an iterative cycle of continuous activity through five stages of emergency management:

- Hazard Identification
- Mitigation
- Preparedness
- Response
- Recovery

Under the Framework, Local Authorities are designated as the lead agency for co-ordinating the response to severe weather events, and each Local Authority should have, as a specific sub-plan of its Major Emergency Plan, a plan for responding to severe weather emergencies, whether a major emergency is declared or not. The other principal response agencies should include sub-plans for responding to notifications from the Local Authorities of severe weather warnings.

A Guide to Flood Emergencies (MEM Guidance Document 11, July 2013) has been published to assist the Principal Response Agencies in meeting their responsibilities, under the Framework for Major Emergency Management, and to deliver on the responsibilities of the OPW and the Local Authorities with respect to emergency planning as set out in the Report of the Flood Policy Review Group. The Guide provides advice on the development and implementation of consistently effective flood emergency response and short-term recovery planning by the Principal Response Agencies and others, and includes a template plan.

4.3 Structural Measures

4.3.1 General

As highlighted above, a flood risk management option consists of one or, more commonly, a combination of flood risk management methods / measures. Therefore, please note that some of the following structural measures may be required in combination to provide a potential flood risk management option that will mitigate both fluvial and tidal flood risk.

The possible flood risk management measures for each of the AFAs being considered are detailed in Table 4.4 below.

Table 4.4: Possible Structural Measures

AFA	Kanturk	Ballyduff	Rathcormac	Aglish	Youghal
Fluvial Storage	Y	N	Y	N	N
Flow Diversion	N	N	Y	Y	N
Increase Conveyance	Y	Y	N	Y	N
Flood Defences	Y	Y	Y	Y	Y
Improve Existing Defences	N	N	N	N	Y
Relocate Properties	N	N	N	N	N
Localised Protection Works	Y	Y	Y	Y	Y
Channel or Flood Defence Maintenance Works	N	N	N	N	N
Other works	N	N	N	N	Y

Details of the possible flood risk management measures and how they can be combined into potential options are included in Section 5.

5 Development of Potential Flood Risk Management Options for AFAs

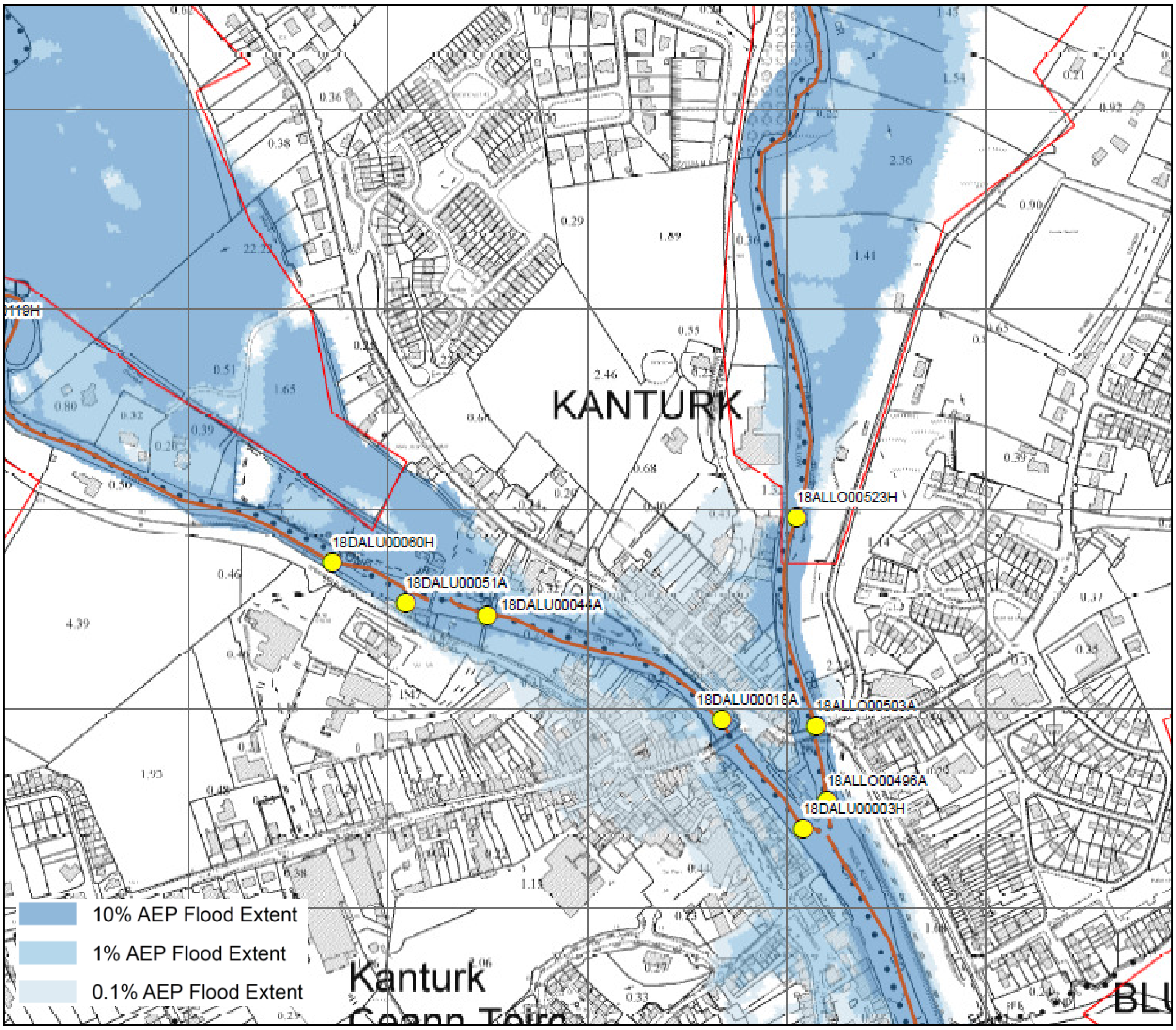
5.1 General

A Flood Risk Management (FRM) option consists of one, or more commonly a combination of FRM measures. This section outlines the development of the potential Flood Risk Management (FRM) options for each of the AFA's within UoM 18.

5.2 Kanturk, Co. Cork

Kanturk is located at the confluence of the Dalua and Allow Rivers in County Cork. Kanturk is at risk of fluvial flooding. The AFA and the existing fluvial flood risk are highlighted in Figure 5.1.

Figure 5.1: Kanturk – Current Scenario Fluvial Flood Extents



5.2.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

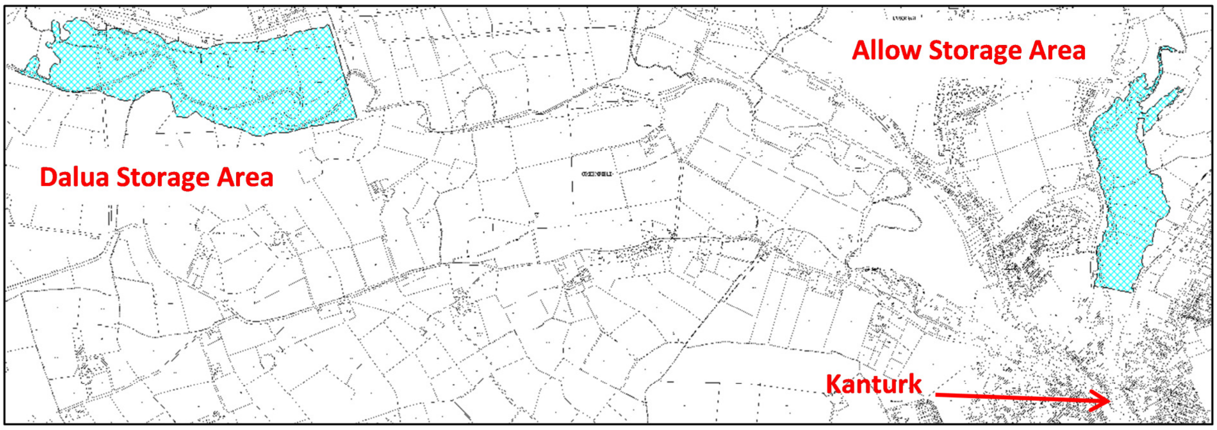
- Storage
- Increase Conveyance
- Flood Defences (Fluvial)

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.2.1.1 Storage

Kanturk is located at the confluence of the Dalua and Allow Rivers. Potential locations for the storage of fluvial flows were identified on both rivers and an assessment of the available storage capacity was carried out. The locations of the potential storage areas are shown in Figure 5.2.

Figure 5.2: Kanturk - Location of Storage Areas



The required capacities of the storage areas are derived using the catchment hydrology as applied in the hydraulic modelling. No allowances for uncertainties in the estimate of the index flood flow or flood growth curve have been made.

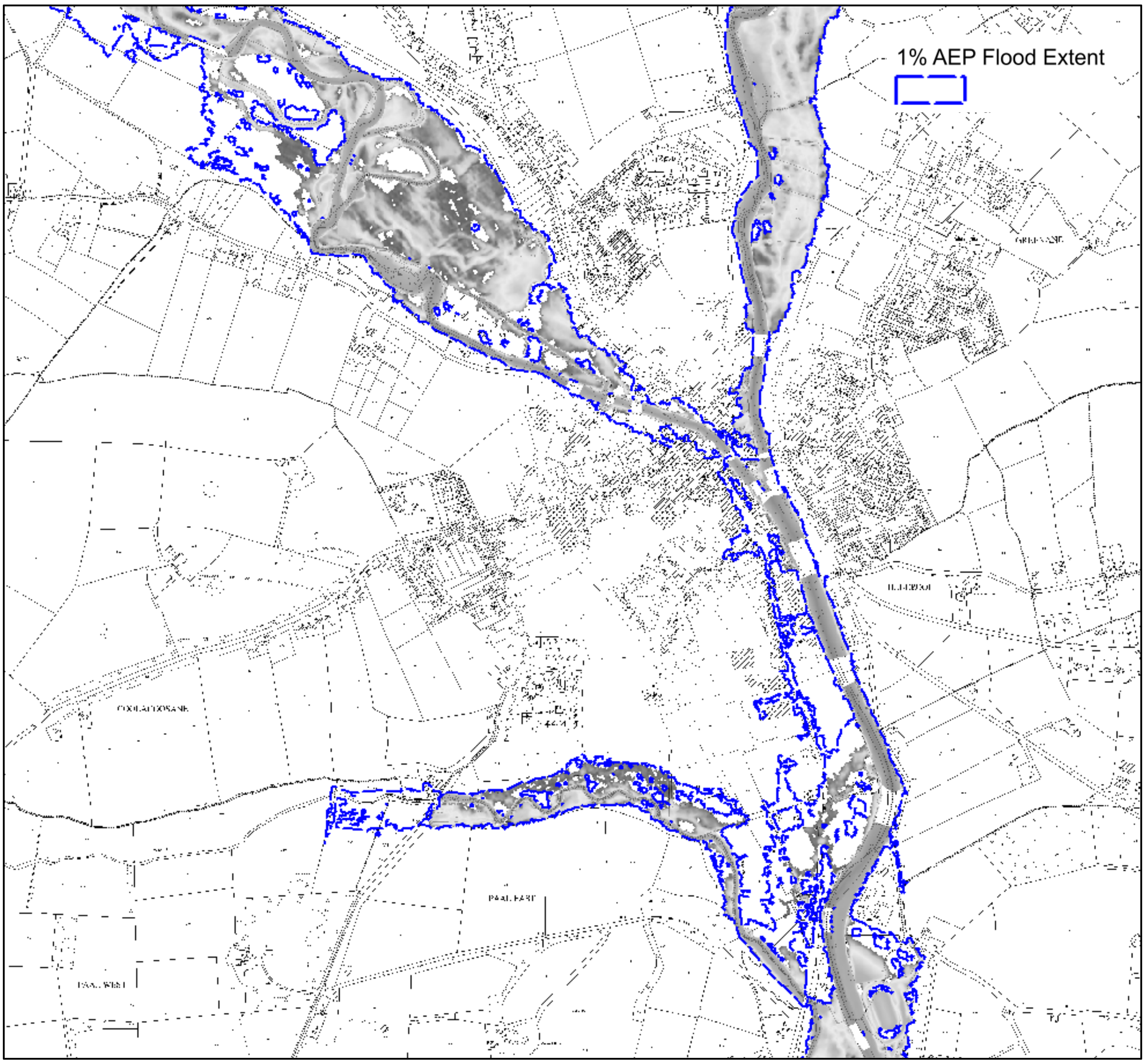
The peak flow in the Allow for the 1% AEP event is 111m3/s which results in significant flooding along the watercourse and in Kanturk. The biggest storage area feasible on the Allow is approx. 176,300m2 with a capacity of 231,544m3 which is only sufficient to reduce flows to approx. 96m3/s. This equates to the peak flow of the 2% AEP event for which there is also significant flooding. Based on this assessment, storage on the Allow is not a viable measure.

The peak flow in the Dalua for the 1% AEP event is 97m3/s which results in significant flooding along the watercourse and in Kanturk. The storage area on the Dalua is approx. 330,000m2 with capacity to limit the outflow to approx. 44m3/s. This equates to the peak of the 50% AEP event. Based on this assessment, storage on the Dalua is a viable measure.

Hydraulic modelling of the storage area on the Dalua was carried out which limited the flow in the river to 44m3/s. The key results are as follows:

- Significant reduction in flood extent and depth along the Dalua and through the town.
- No reduction in extent or depth on the Allow, upstream of the town.
- Flood extents are similar downstream of the WWTP and the race course but depths reduced by approx. 300mm.

Figure 5.3: Kanturk – Dalua Storage Area – Reduction in Flood Extent



The measure of storage on the Dalua does not achieve the standard of protection by mitigating the flood risk associated with the 1% fluvial AEP. However, it significantly reduces flood risk and is a viable measure which may be used in combination with others.

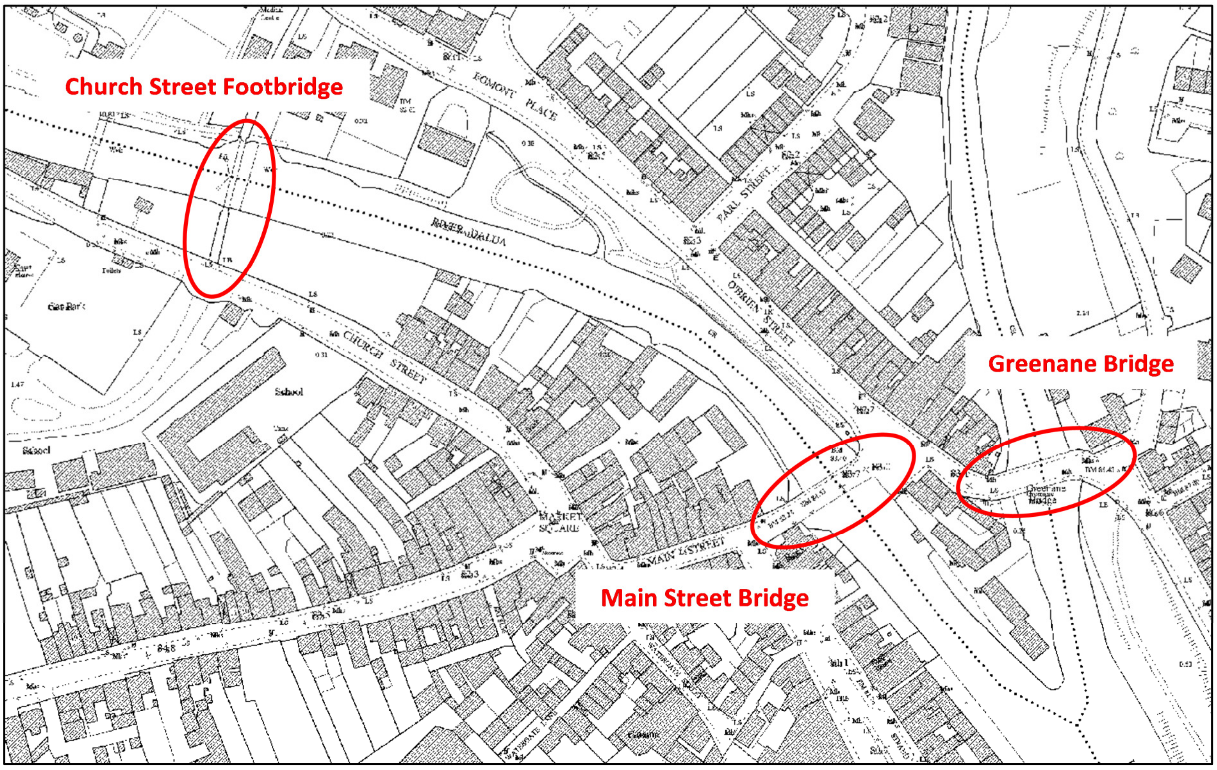
5.2.1.2 Increased Conveyance – Replace Bridges

As part of the hydraulic modelling for the flood risk mapping a number of bridges were identified which restrict the channel capacity and have an impact on flooding. These bridges are:

- Main Street Bridge
- Greenane Bridge
- Church Street Footbridge

This measure aims to mitigate the flood risk by improving the conveyance of these structures. All three bridges are currently arch bridges with piers restricting flow in the channel. This measure aims to achieve the maximum improvement in conveyance by replacing the arch bridges with single span bridges with the soffit level set as high as possible. The permanent removal of these bridges was not considered as they are key infrastructure within the town. Figure 5.4 shows the location of the bridges.

Figure 5.4: Kanturk – Location of Bridges



The arch bridges in the hydraulic model were replaced with single span bridges. The model indicated that there was an extremely minor reduction in the 1% AEP flood extent on the Dalua with a maximum reduction in flood depth of 0.1m which occurred at Main Street Bridge. There was no reduction in the flood extent or depth on the Allow, upstream or downstream of the confluence. This measure is not deemed to be a viable measure individually or in combination as the reduction in flood extent / level / risk is minimal.

5.2.1.3 Increased Conveyance – Replace Bridges & Remove Weirs

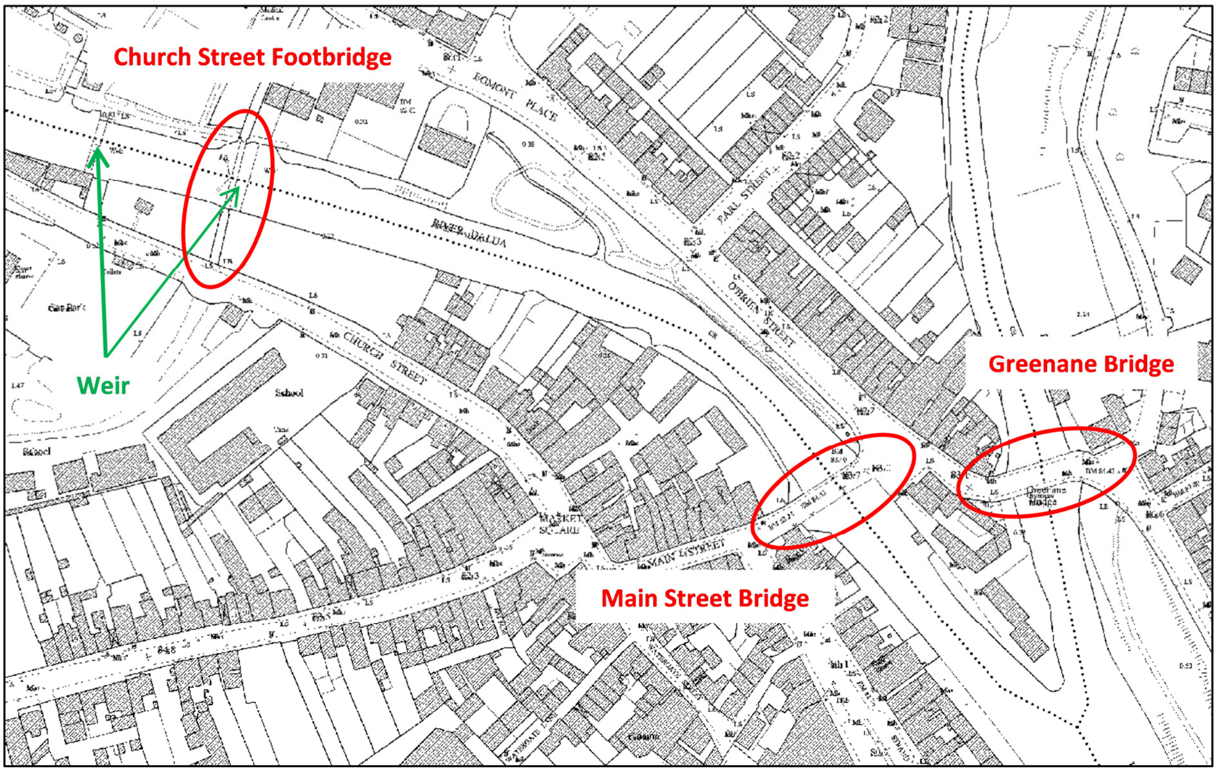
As part of the hydraulic modelling for the flood risk mapping a number of bridges were identified which restrict the channel capacity and have an impact on flooding. These bridges are:

- Main Street Bridge
- Greenane Bridge
- Church Street Footbridge

In addition, the weirs at the Church Street Footbridge on the Dalua where identified as having a significant influence on conveyance and water level.

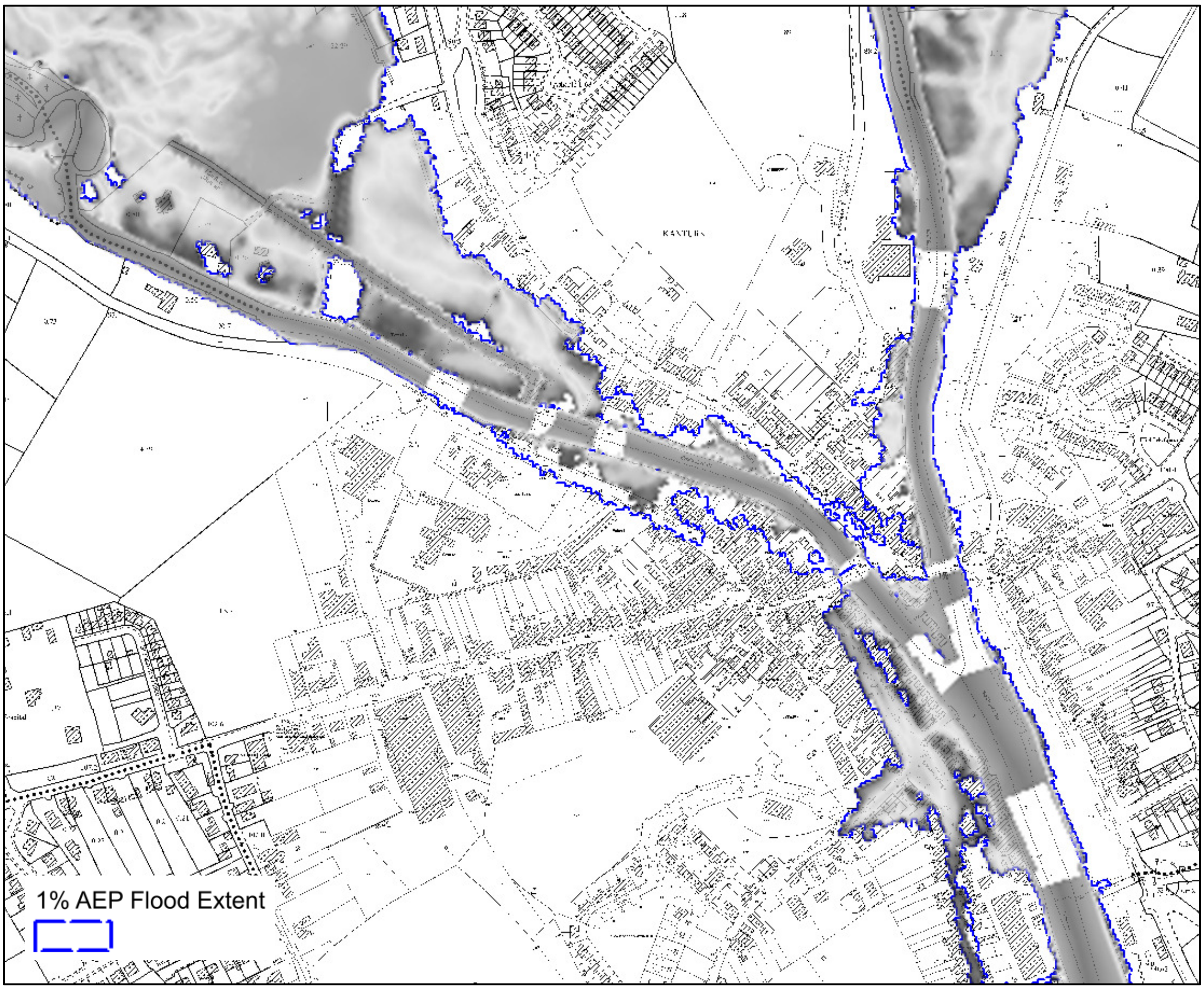
This measure aims to mitigate the flood risk by improving the conveyance of the bridges and by removing the existing weirs. All three bridges are currently arch bridges with piers restricting flow in the channel. This measure aims to achieve the maximum improvement in conveyance by replacing the arch bridges with single span bridges with the soffit level set as high as possible. Figure 5.5 shows the location of the bridges and the weirs.

Figure 5.5: Kanturk – Location of Bridges & Weirs



The arch bridges in the hydraulic model were replaced with single span bridges and the weirs were removed. The model indicated that there was a reduction in the 1% AEP flood extent and depth on the Dalua immediately upstream of the confluence. The maximum reduction in flood depth of 1.1m is due to the removal of the weirs at Church Street Footbridge. There is no reduction on the Allow upstream or downstream of the confluence. Figure 5.6 shows the reduction in flood extent.

Figure 5.6: Kanturk – Increased Conveyance at Bridges & Removal of Weirs



Based on this assessment the reduction in flood extent is primarily due to the removal of the weirs and not the improvements to bridge conveyance. As identified previously, the improvement of bridge conveyance is not deemed to be a viable measure individually or in combination as the reduction in flood extent / level / risk is minimal.

However, while the removal of the weirs is not deemed a viable measure individually it could be utilised in combination with another measure such as storage or flood defences etc.

5.2.1.4 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. These defences include walls and embankments. The locations of the defences are shown in Figure 5.7 with details on heights shown in subsequent figures. This measure would also require the provision of a surface water pumping station to pump surface water flows into the river when the river is high and there is no outlet by gravity to the river.

Figure 5.7: Kanturk – Flood Defences

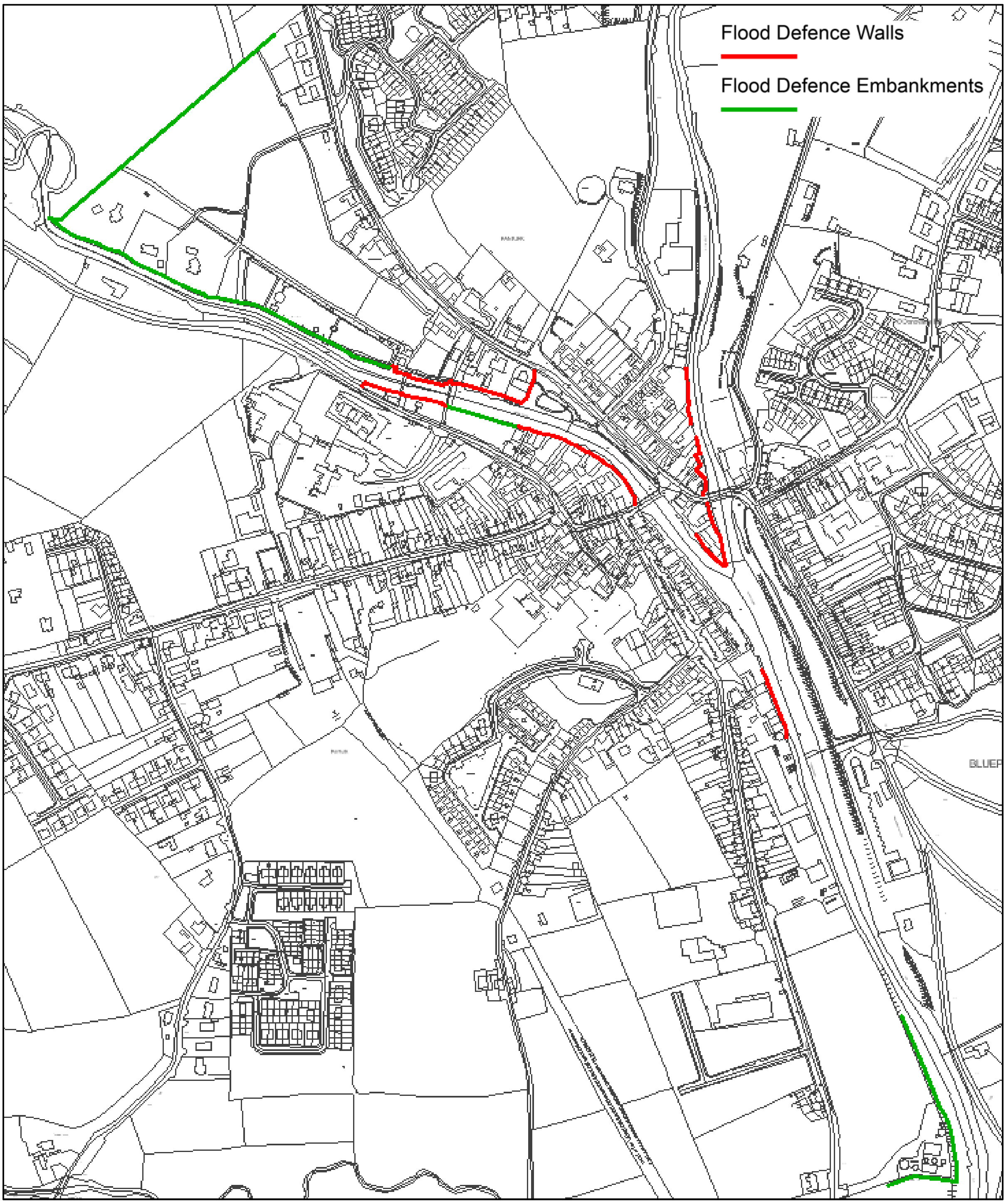


Figure 5.8: Kanturk – Heights of Flood Defences on the Dalua

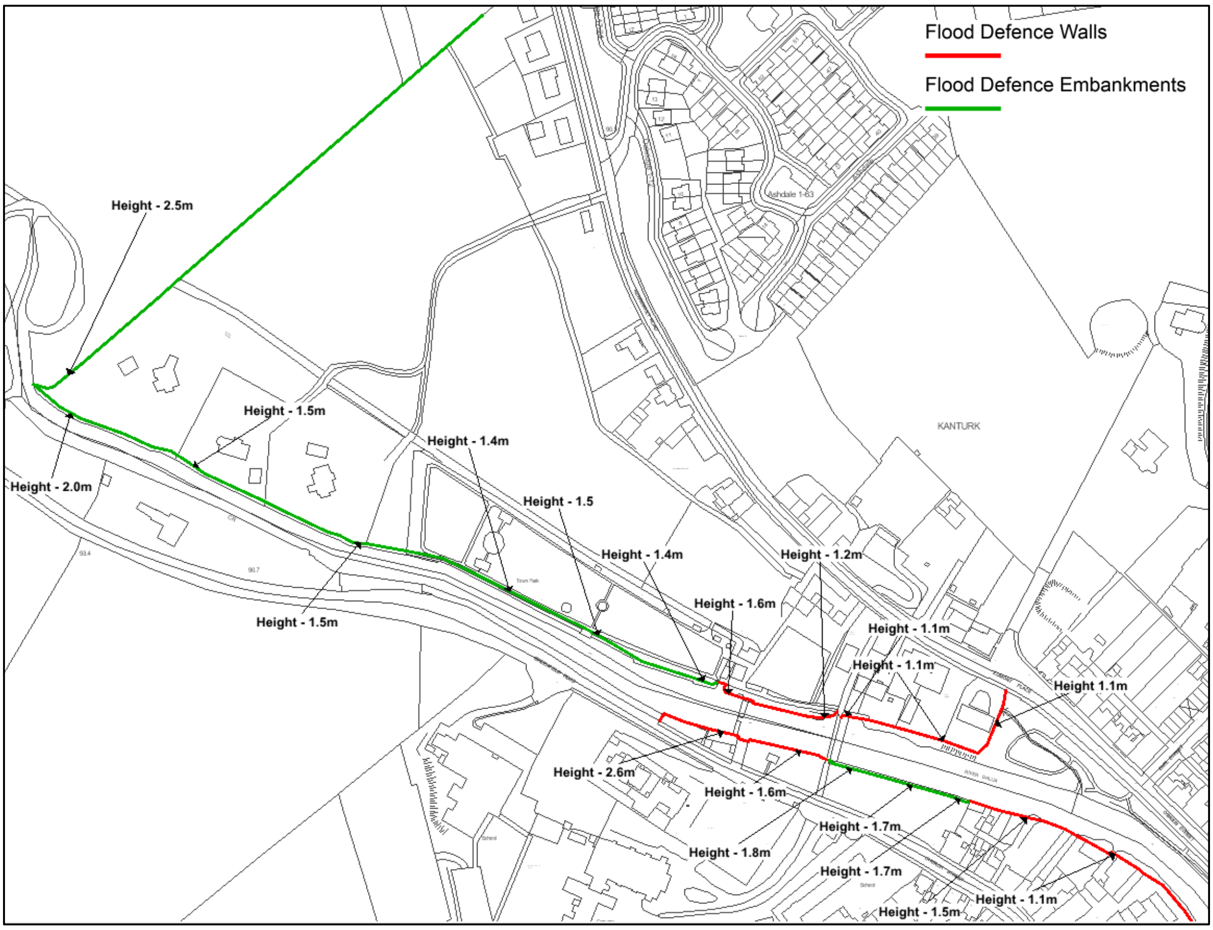


Figure 5.9: Kanturk – Heights of Flood Defences in Town Centre

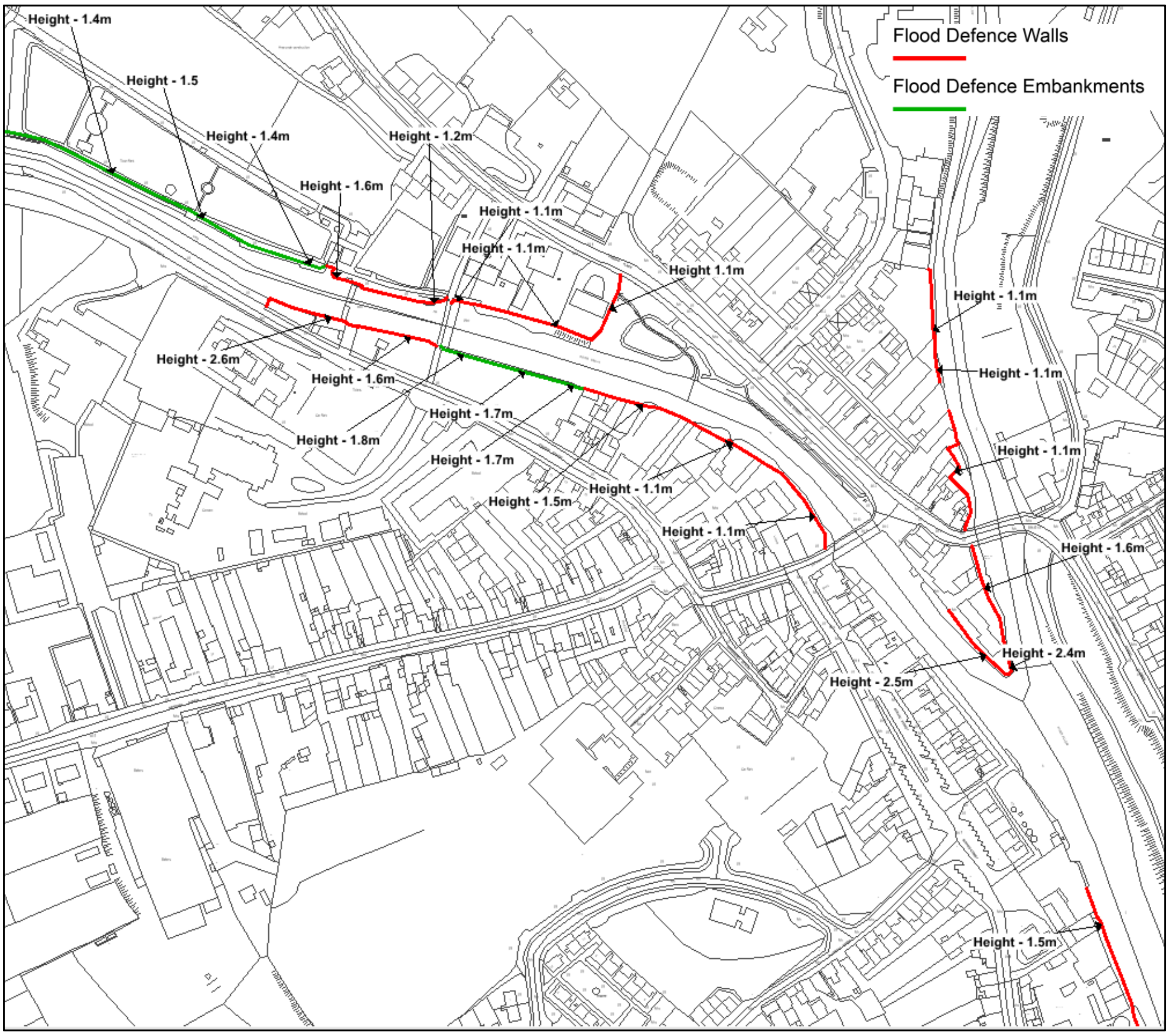
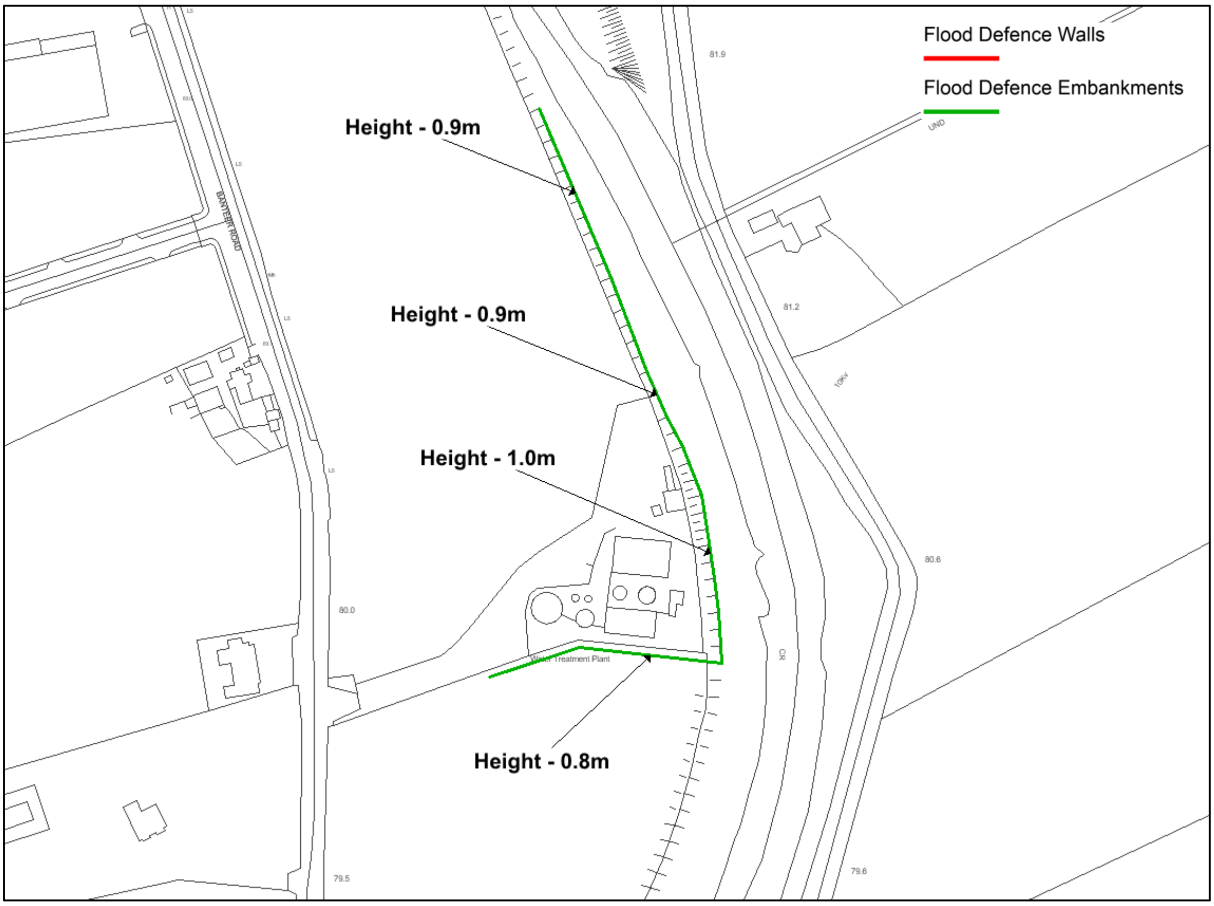


Figure 5.10: Kanturk – Heights of Flood Defences at WWTP



The hydraulic modelling of the proposed flood defences as outlined in the above figures indicates that the measure fully achieves the required standard of protection for the 1% AEP fluvial event. The maximum increase in water level is 0.5m and this occurs upstream of the embankment shown in Figure 5.8. This embankment restricts the flow across the floodplain diverting the flood water back to the river channel. The maximum reduction in water levels is 0.1m which occurs downstream of the town. This is deemed to be a viable measure / option.

5.2.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Storage – Dalua (in combination with other measures)
- Increase Conveyance – Removal of Weirs (in combination with other measures)
- Flood Defences

5.2.3 Potential FRM Options

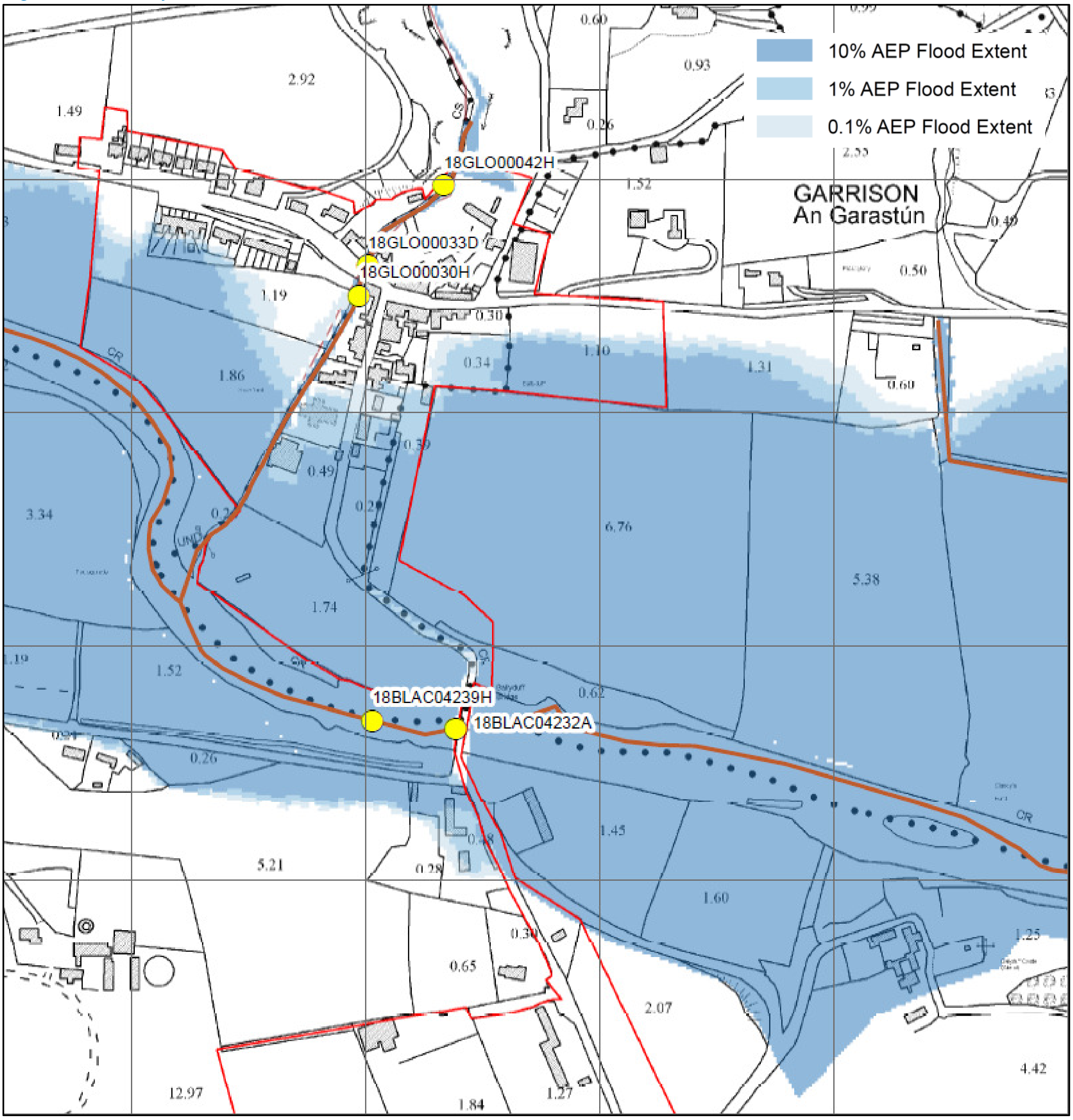
Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences
- Option 2 – Storage & Flood Defences
- Option 3 – Conveyance (Removal of Weirs) & Flood Defences

5.3 Ballyduff, Co. Waterford

Ballyduff is located along the Blackwater and is at risk of fluvial flooding. The AFA and the existing fluvial flood risk from the 1% AEP is highlighted in Figure 5.11.

Figure 5.11: Ballyduff – Current Scenario Flood Extents



5.3.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

- Increase Conveyance
- Flood Defences (Fluvial)

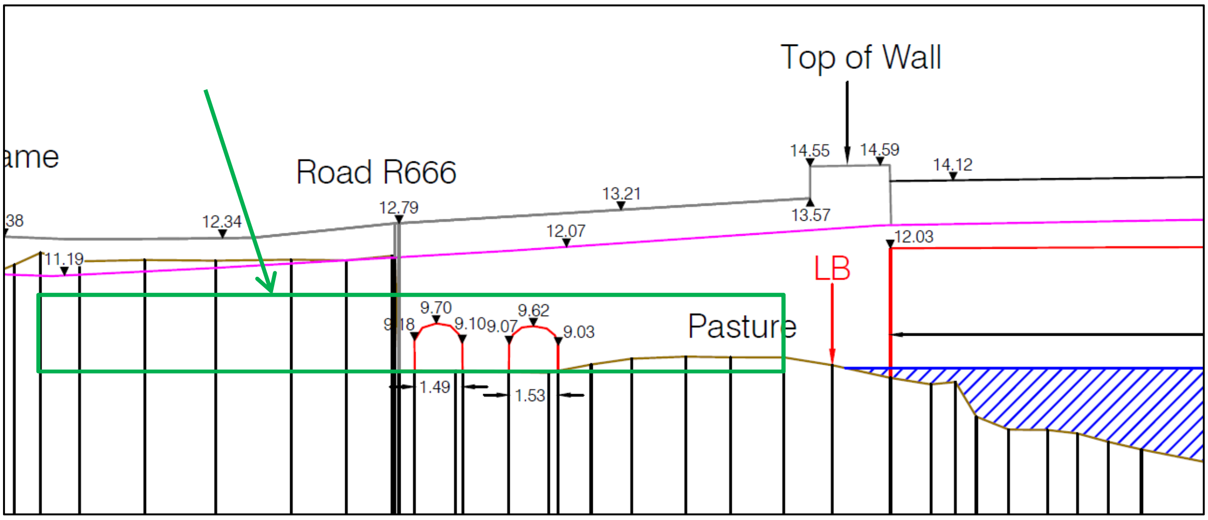
The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.3.1.1 Increase Conveyance – Flood Relief Culvert in Ballyduff Bridge

The bridge and connecting approach roads in Ballyduff are significantly raised above the floodplain. The bridge has two existing flood relief culverts on the left bank each approximately 1.5m wide by 1.5m high.

This measure included for replacing the existing culverts with one significantly larger culvert under the approach road to allow flow on the floodplain to bypass the bridge. The culvert was sized at 20m wide and 2m high. This is shown in Figure 5.12.

Figure 5.12: Ballyduff – Increase Conveyance – Flood Relief Culvert



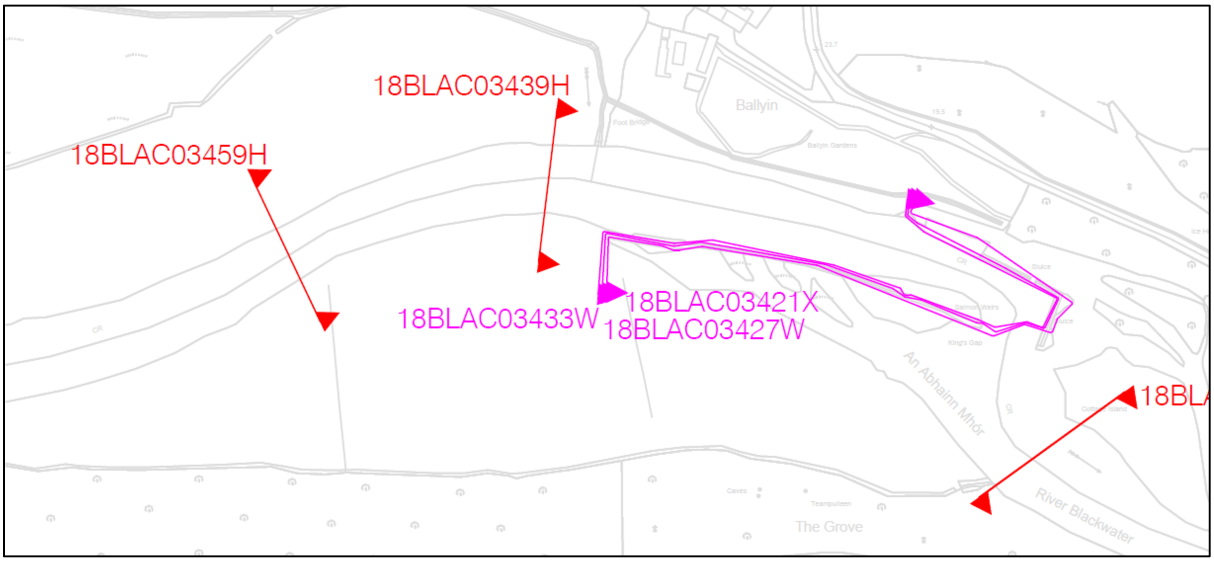
The hydraulic modelling of the proposed flood relief culvert determined that there was no reduction in flood extent and the maximum decrease in flood depth was 0.03m. This measure is not deemed to be a viable measure individually or in combination as the reduction in flood extent / level / risk is minimal.

5.3.1.2 Increase Conveyance – Removal of Lismore Weir

Lismore Weir is located approximately 8.5km downstream of Ballyduff. The weir includes a number of sluice gates but it is currently not operational. However, it still acts as a flow control on the Blackwater.

This measure considers the removal of the weir to improve conveyance and any potential backwater effect in Ballyduff. The weir is approximately 180m long and is shown in Figure 5.13.

Figure 5.13: Ballyduff – Increase Conveyance – Removal of Weir

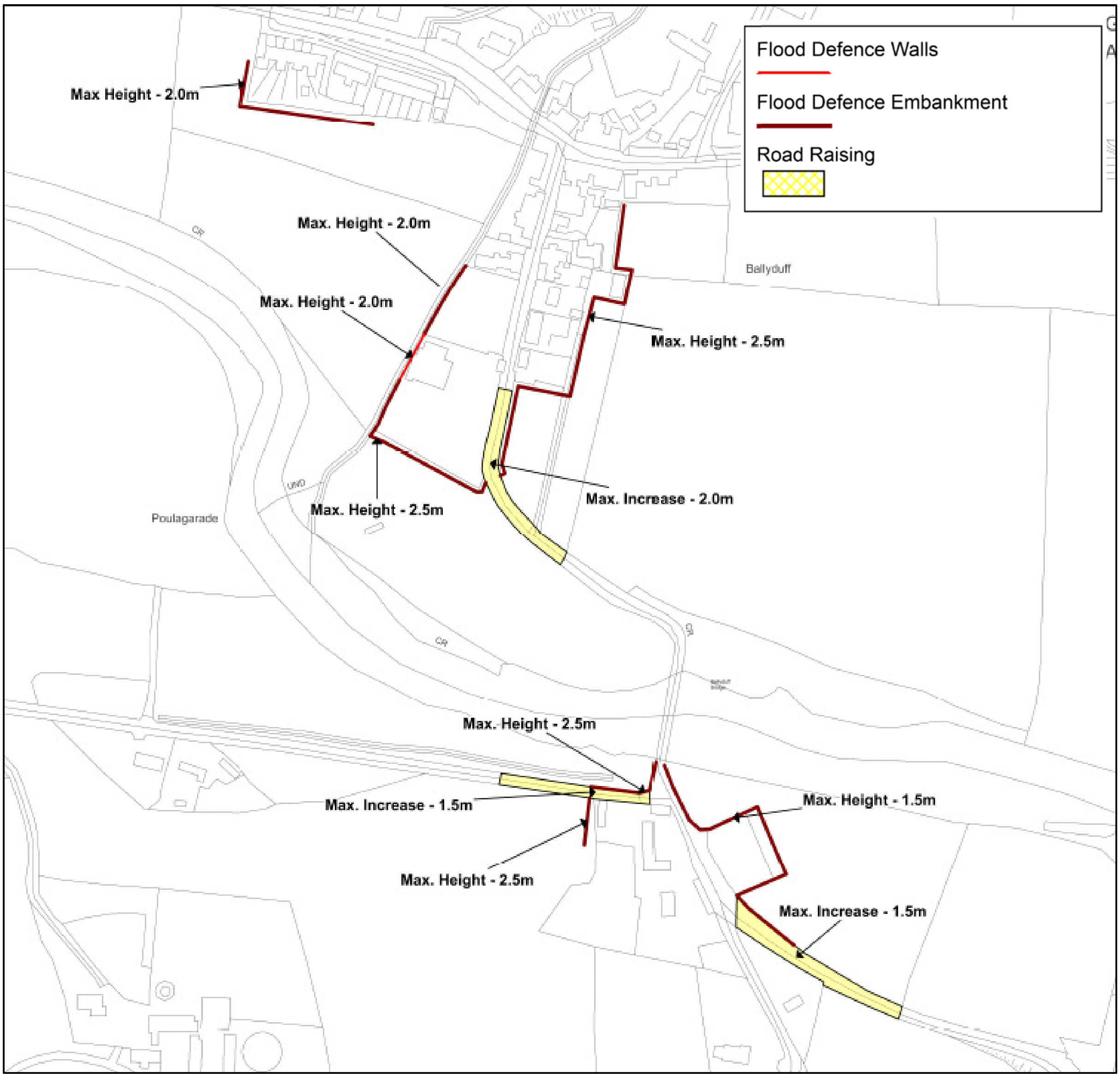


The weir was removed from the hydraulic model and the results indicated that there was no significant change in flood extent in Ballyduff for the 1% AEP event. However, there was a slight decrease in the depth (0.02m) and duration of flooding in properties in Ballyduff. Larger reductions in depths were identified further downstream of Ballyduff (i.e. closer to the weir). This measure is not deemed to be a viable measure individually or in combination as the reduction in flood extent / level / risk is minimal.

5.3.1.3 Flood Defences

This measure considers the mitigation of flood risk through the construction of fluvial flood defences. These defences include walls, embankments and road raising. The locations and maximum height of the defences is shown in Figure 5.14.

Figure 5.14: Ballyduff – Flood Defences



The hydraulic modelling of the proposed flood defences as outlined in Figure 5.14 indicates that the measure fully achieves the required standard of protection for the 1% AEP fluvial event. The defences result in an increase in water level of less than 0.1m the effects of which extend approximately 2km upstream and 400m downstream of the bridge. This is deemed to be a viable measure / option.

5.3.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Flood Defences

5.3.3 Potential FRM Options

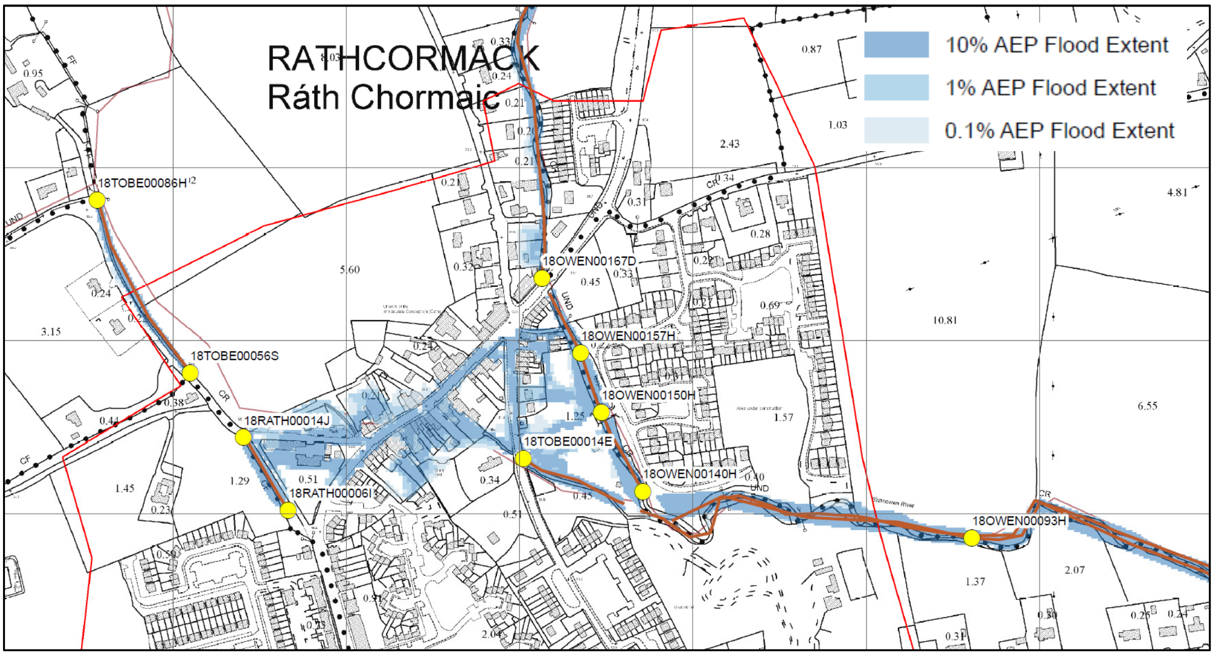
Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences

5.4 Rathcormac, Co. Cork

Rathcormac is located at the confluence of the Kilbrien Stream and the Shanowen River in County Cork. Rathcormac is at risk of fluvial flooding. The AFA and the existing fluvial flood risk are highlighted in Figure 5.15.

Figure 5.15: Rathcormac – Current Scenario Fluvial Flood Extents



5.4.1 Possible FRM Measures

As outlined in Section 2.0, the screening process identified the following possible flood risk mitigation measures:

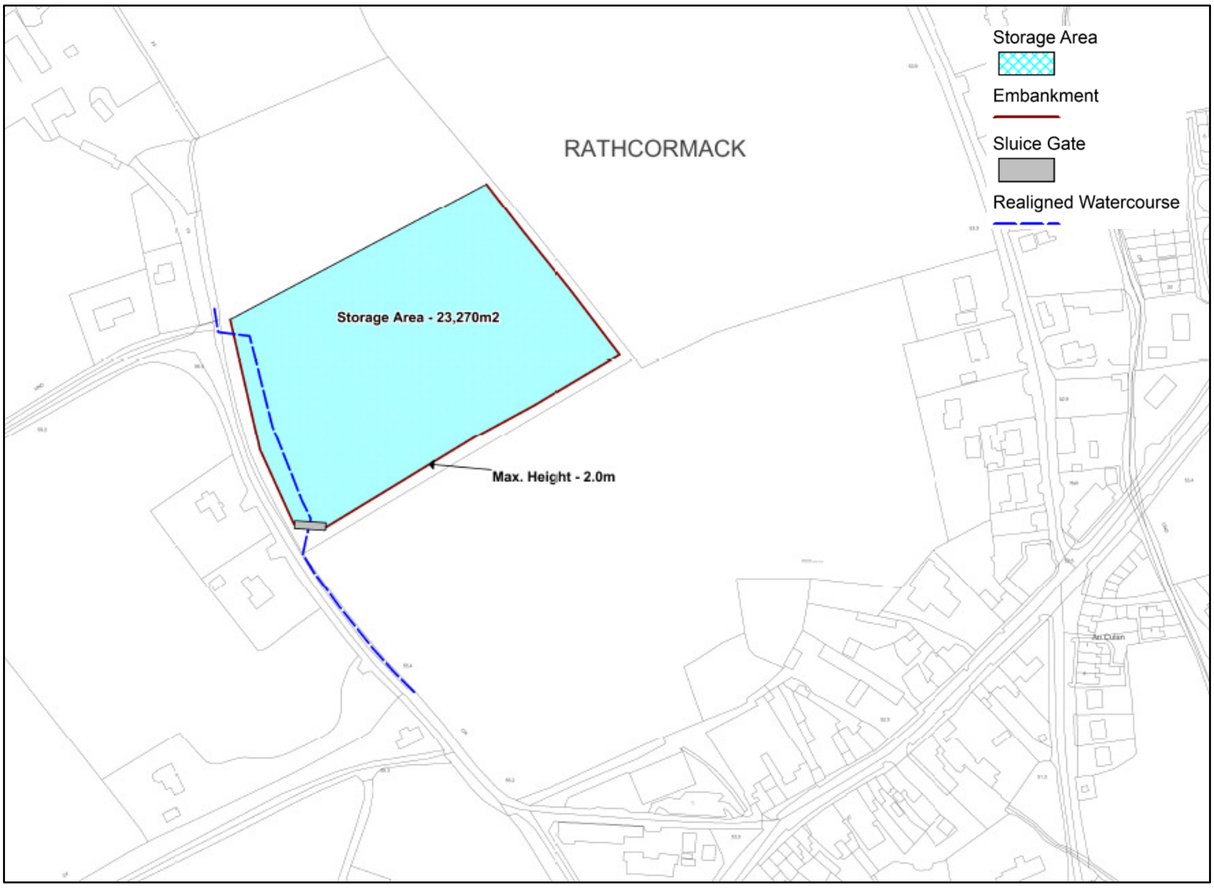
- Storage
- Flow Diversion
- Flood Defences (Fluvial)

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.4.1.1 Storage

Rathcormac is located at the confluence of the Kilbrien Stream and the Shanowen River. A potential location for the storage of fluvial flow was identified on the Kilbrien Stream and an assessment of the available storage capacity was carried out. The location of the potential storage area is shown in Figure 5.16.

Figure 5.16: Rathcormac – Location of Storage Area



The required capacity of the storage area was derived using the catchment hydrology as applied in the hydraulic modelling. No allowances for uncertainties in the estimate of the index flood flow or flood growth curve have been made.

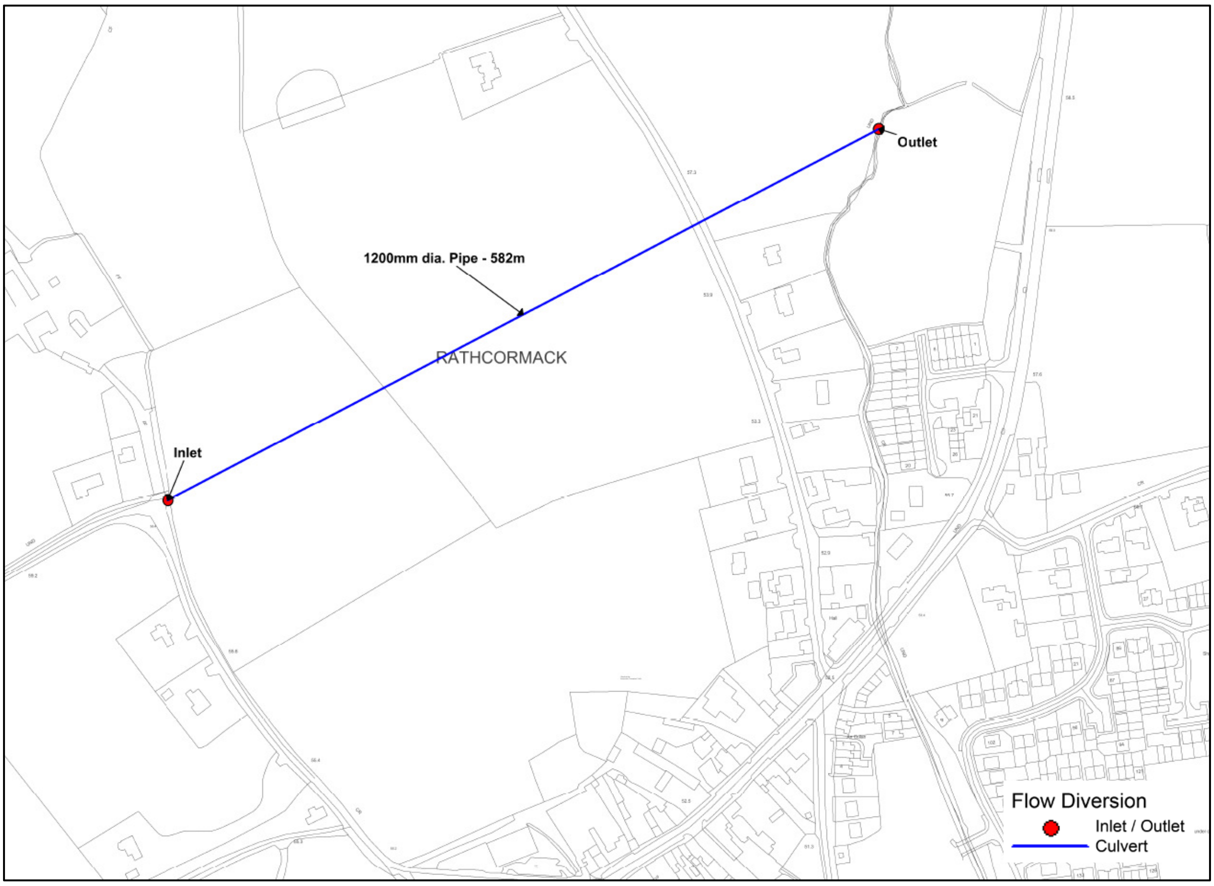
The peak flow in the Kilbrien Stream for the 1% AEP event is 1.2m3/s which results in flooding at the downstream culvert and through the town. The storage area on the Kilbrien Stream is 23,270m2 with sufficient capacity to reduce the peak flow to approx. 0.4m3/s. Hydraulic modelling of the storage area was carried out which resulted in no flooding through the town. Based on this assessment, storage on the Kilbrien Stream is a viable measure. However, it should be noted that this measure is dependent on the

downstream culvert being in good condition and having sufficient capacity. Before this measure is progressed an assessment and CCTV survey of the culvert is required.

5.4.1.2 Flow Diversion

This measure aims to mitigate the flood risk by diverting the flow from the Kilbrien Stream to the Shanowen River upstream of the town. Figure 5.17 shows the location of the flow diversion culvert.

Figure 5.17: Rathcormac – Location of Flow Diversion Culvert



The flooding in Rathcormac occurs due to the insufficient capacity of the culverts along the Kilbrien Stream. This measure aims to divert the flow from the Kilbrien Stream to the Shanowen River. Alternative locations and routes were considered for flow diversion but these would require a number of diversions of equal or greater length. The proposed diversion captures the flow downstream of the confluence to minimise the number of diversions required.

The peak flow in the Kilbrien Stream for the 1% AEP fluvial event is 1.2m3/s. The peak flow in the Shanowen River immediately upstream of the confluence with the Kilbrien Stream for the 1% AEP fluvial

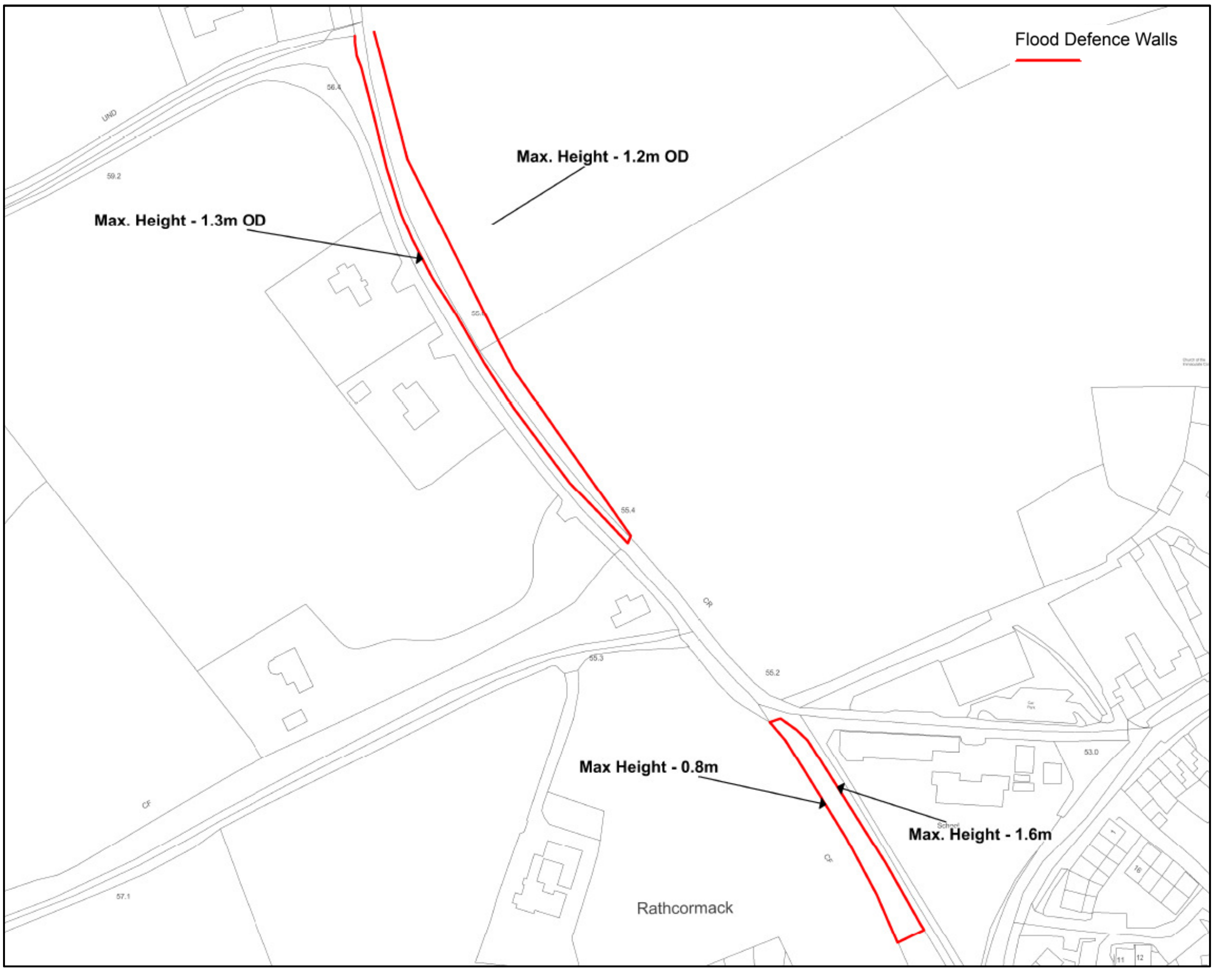
event is 5.7m3/s. Assuming a worst case scenario of no phasing between peak flows, diverting the Kilbrien Stream would result is a maximum peak flow in the Shanowen of 6.9m3/s.

This is significantly lower than the MRFS peak flow of 9.2m3/s in the Shanowen River for the 1% AEP fluvial event. There is no flooding from the Shanowen River during the MRFS 1% AEP event. Based on this assessment, the flow diversion is a viable measure.

5.4.1.3 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. Flooding in Rathcormac occurs due to the insufficient capacity of the culverts along the Kilbrien Stream. This measure aims to construct flood defence walls to keep the flows in channel. The locations and heights of the defences are shown in Figure 5.18.

Figure 5.18: Rathcormac – Flood Defences



The hydraulic modelling of the proposed flood defences as outlined in the figure above indicates that the measure fully achieves the required standard of protection for the 1% fluvial event. This is deemed to be a viable measure. However, it should be noted that this measure is dependent on the downstream culvert being in good condition and having sufficient capacity. Before this measure is progressed an assessment and CCTV survey of the culvert is required.

Widening the channel and distance between the walls may allow for a reduction in wall height. However, this would result in greater interference with lands.

5.4.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Storage
- Flow Diversion
- Flood Defences

5.4.3 Potential FRM Options

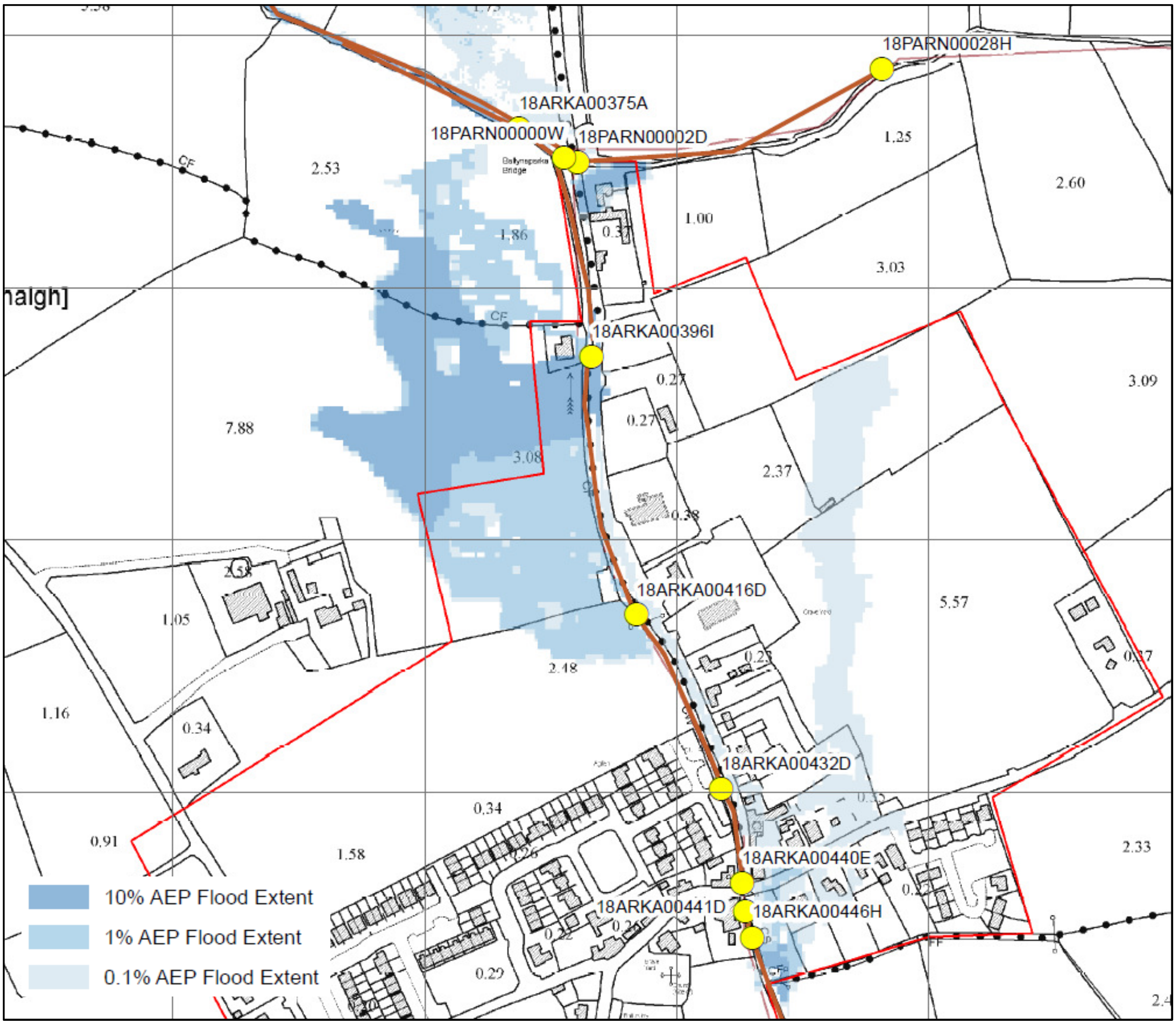
Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Storage
- Option 2 – Flow Diversion
- Option 3 – Flood Defences

5.5 Aglish, Co. Waterford

Aglish is located in County Waterford and is at risk of fluvial flooding. The AFA and the existing fluvial risk are highlighted in Figure 5.19.

Figure 5.19: Aglish – Current Scenario Tidal Flood Extents



5.5.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

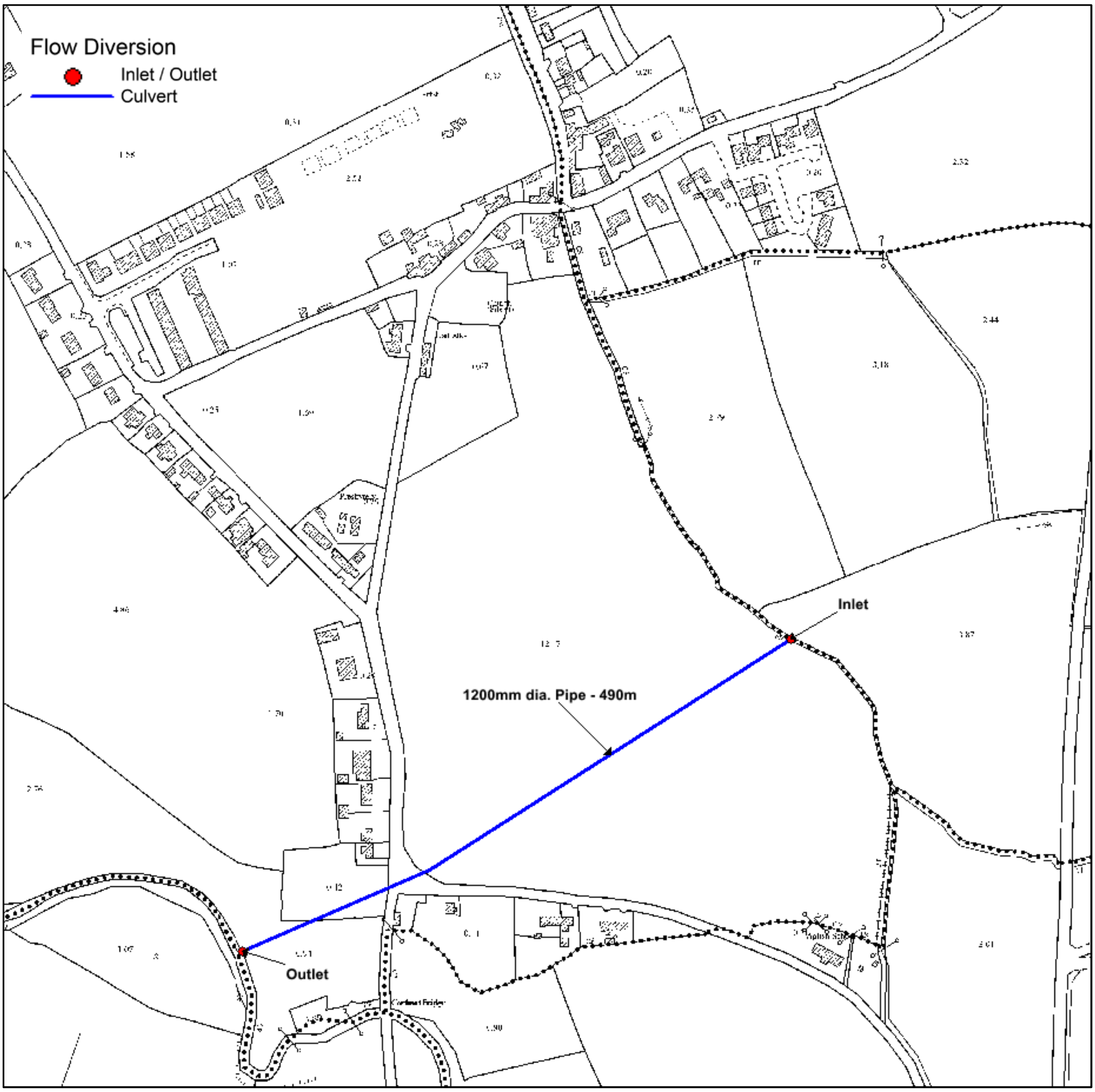
- Flow Diversion
- Increased Conveyance
- Flood Defences

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.5.1.1 Flow Diversion

This measure aims to mitigate the flood risk by diverting the flow from the Aglish Stream to the Goish River upstream of the village. Figure 5.20 shows the location of the flow diversion culvert.

Figure 5.20: Aglish – Flow Diversion



The peak flow in the Aglish Stream for the 1% AEP fluvial event is 2.0m3/s. It is proposed to limit the flow in the Aglish Stream to less than Qmed (0.9m3/s) in order to mitigate flooding along the watercourse. However, based on the hydraulic modelling, flooding still occurs along the Aglish Stream due to the limited capacity of structures and the influence of water levels at the downstream confluence with the Ballnaparka River. Based on this assessment, flow diversion is not deemed to be a viable measure.

5.5.1.2 Increased Conveyance

As part of the hydraulic modelling for the flood risk mapping a number of structures were identified which restrict the channel capacity and have an impact on flooding. These structures are:

- Quad culverts upstream of Aglish Bridge
- Twin culverts at property entrance
- Ballynaparka Bridge

This measure aims to mitigate the flood risk by improving the conveyance at structures.

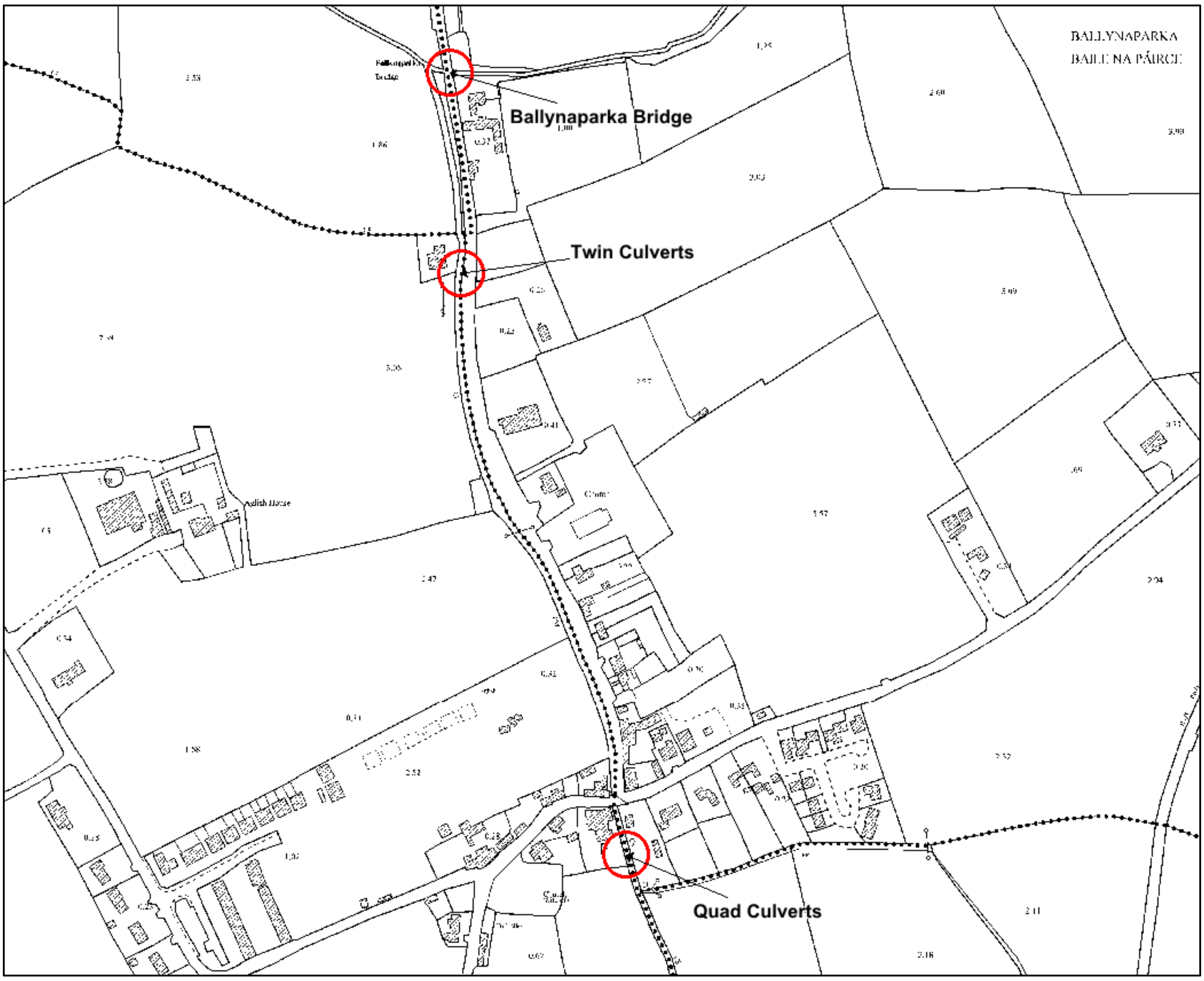
Currently the quad culverts are required as part of an access to a garden. If these were to be removed alternative access would be required. However, this could be readily accommodated. The quad culverts were removed from the hydraulic model to determine their impact on flooding locally and downstream. While removing the culverts reduced the localised flooding, it was not eliminated for the 1% AEP fluvial event. There was also a minor increase in water levels downstream.

The twin culverts are required as part of an entrance to a non-residential property. It is not feasible to permanently remove these as alternative access is not readily available. The two culverts were replaced by a single culvert in the hydraulic model which was sized as large as possible. The hydraulic model indicated that there was a reduction in flood extent but flooding of the property still remains for the 1% AEP fluvial event.

The Ballynaparka Bridge is a two arch bridge. In the hydraulic model the bridge was replaced with a single span bridge with the soffit level set as high as possible to simulate the maximum improvement in conveyance. The hydraulic model indicated that there was a minor reduction in flood extent and depth.

Based on the assessments as detailed above, conveyance is not a viable measure.

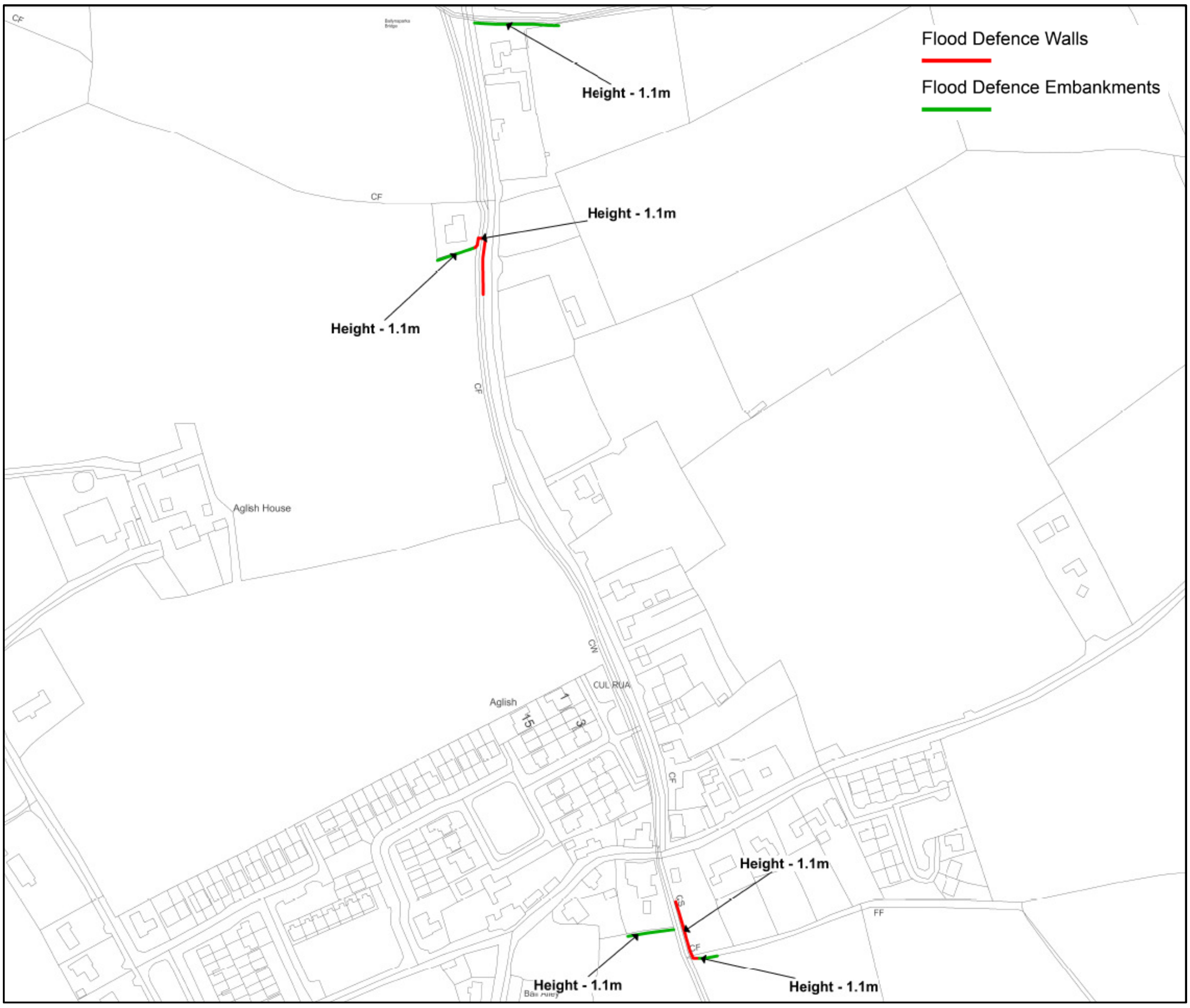
Figure 5.21: Aglish – Location of Critical Structures



5.5.1.3 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. These defences include walls and embankments. The locations of the defences are shown in Figure 5.22 with details on heights shown in subsequent figures.

Figure 5.22: Aglish – Flood Defences



The hydraulic modelling of the proposed flood defences as outlined in the figure above indicates that the measure fully achieves the required standard of protection for the 1% fluvial event. The average increase in water levels is 0.01m with a maximum increase of 0.1m occurring immediately upstream of Ballynaparka Bridge. This is deemed to be a viable measure.

5.5.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Flow Diversion
- Increased Conveyance
- Flood Defences

5.5.3 Potential FRM Options

Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences

5.6 Youghal, Co. Cork

Youghal is located in east Cork at the mouth of the Blackwater and is at risk of both fluvial and tidal flooding. However, the fluvial flood risk is minor and there are no receptors at risk. The AFA and the existing tidal risk are highlighted in Figure 5.23.

Figure 5.23: Youghal – Current Scenario Tidal Flood Extents

The water level (tide plus surge) for the current scenario 0.5% AEP tidal event is 2.65m OD Malin which is based on the ICPSS data. Concern has been raised in relation to this level as it has been exceeded by a number of flood events in recent years. Based on a review of recent flood events it is was decided to assess the preliminary flood risk mitigation options for Youghal using the water level for the Mid-Range Future Scenario (MRFS) 0.5% AEP tidal event which is 3.11m OD Malin.

Due to the topography of the area the difference in flood extent between the Current Scenario and the MRFS is not hugely significant. However, there is a significant increase in flood depth and due to the density of properties, which are mostly businesses there is a significant increase in damages. Figure 5.24 shows the flood extent for the MRFS.

Figure 5.24: Youghal – Mid-Range Future Scenario Tidal Flood Extents

Further analysis is required on the relationship between extreme offshore and nearshore water levels to get certainty on the depths of extreme flooding in Youghal. This can be gained by the installation of a water level gauge in Youghal and observing the relationship between the nearshore and offshore levels for a range of tide and surge conditions. As an interim measure, before the preferred option is implemented, the installation of a tide gauge and a flood forecasting and warning system would be of significant benefit in Youghal.

5.6.1 Possible FRM Measures

Any of the measures outlined below will require further analysis of the relationship between coastal levels at the sea front in Youghal and offshore water levels. For this reason each of the measures considered include water level monitoring in their description. As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

- Flood Defences
- Tidal Barrage

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.6.1.1 Flood Defences

This measure considers the mitigation of tidal flood risk through the construction of flood defences. The locations and heights of the defences are shown in the following figures.

Figure 5.25: Youghal – Flood Defences – Overview

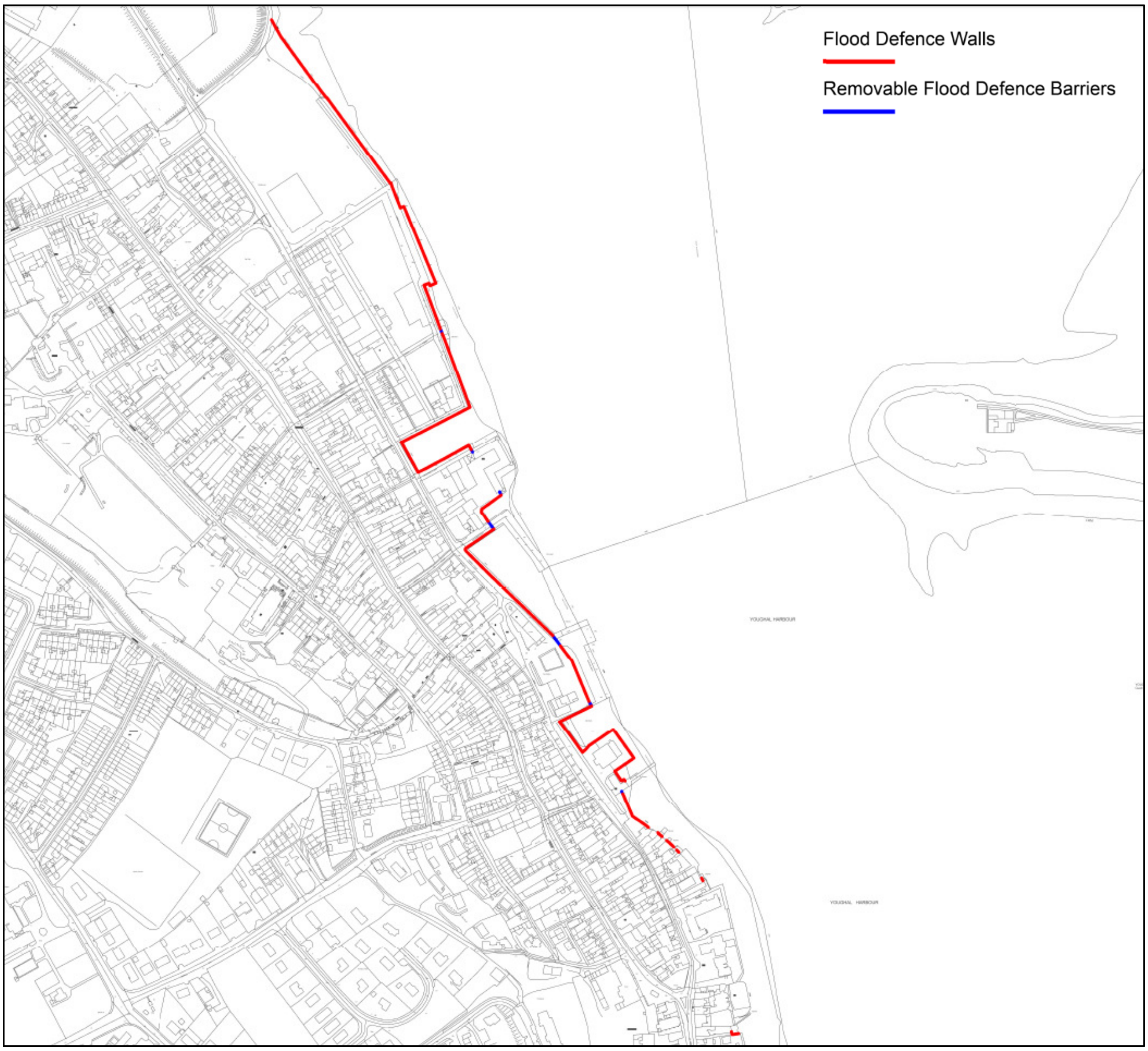


Figure 5.26: Youghal – Tidal Flood Defences 1

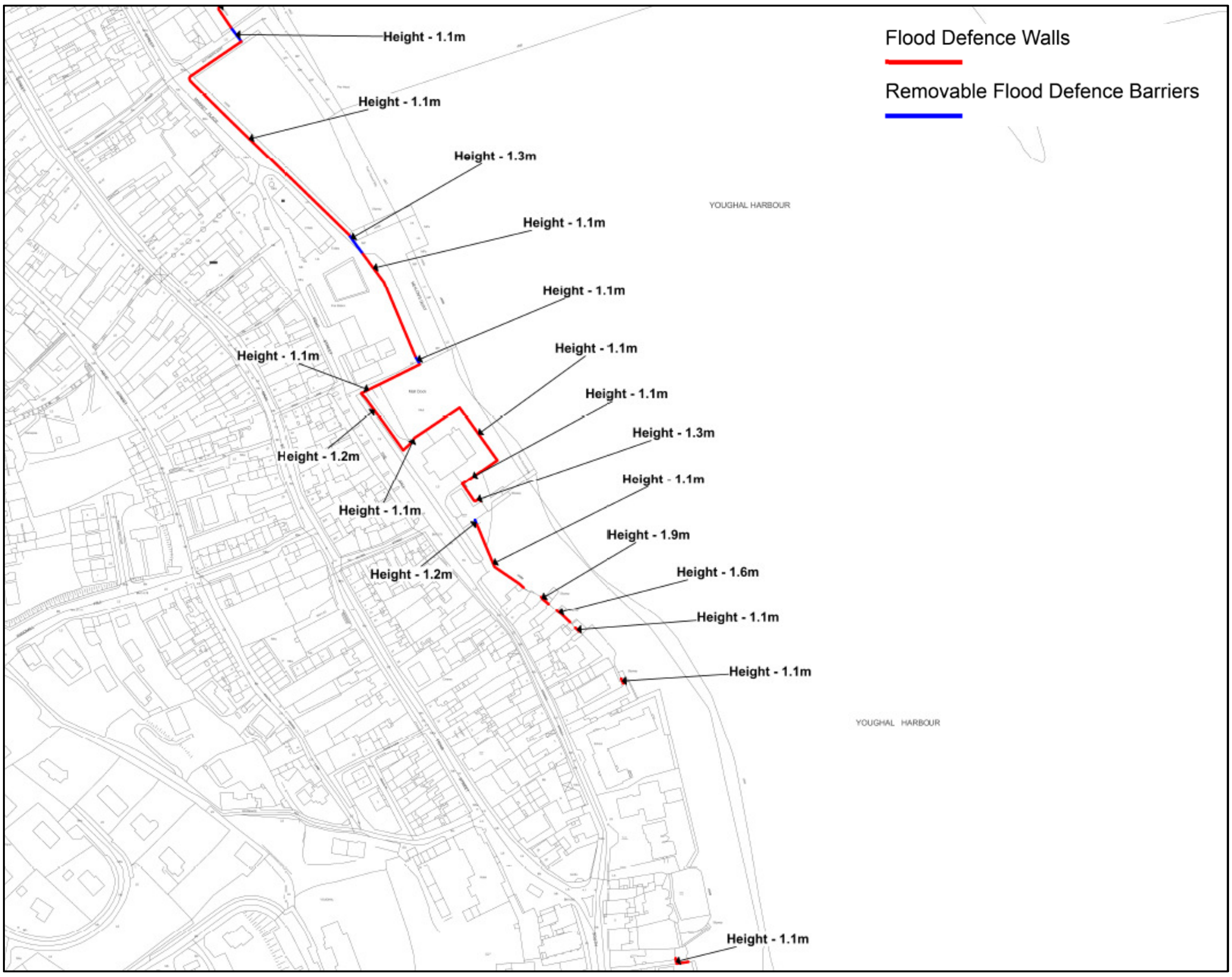
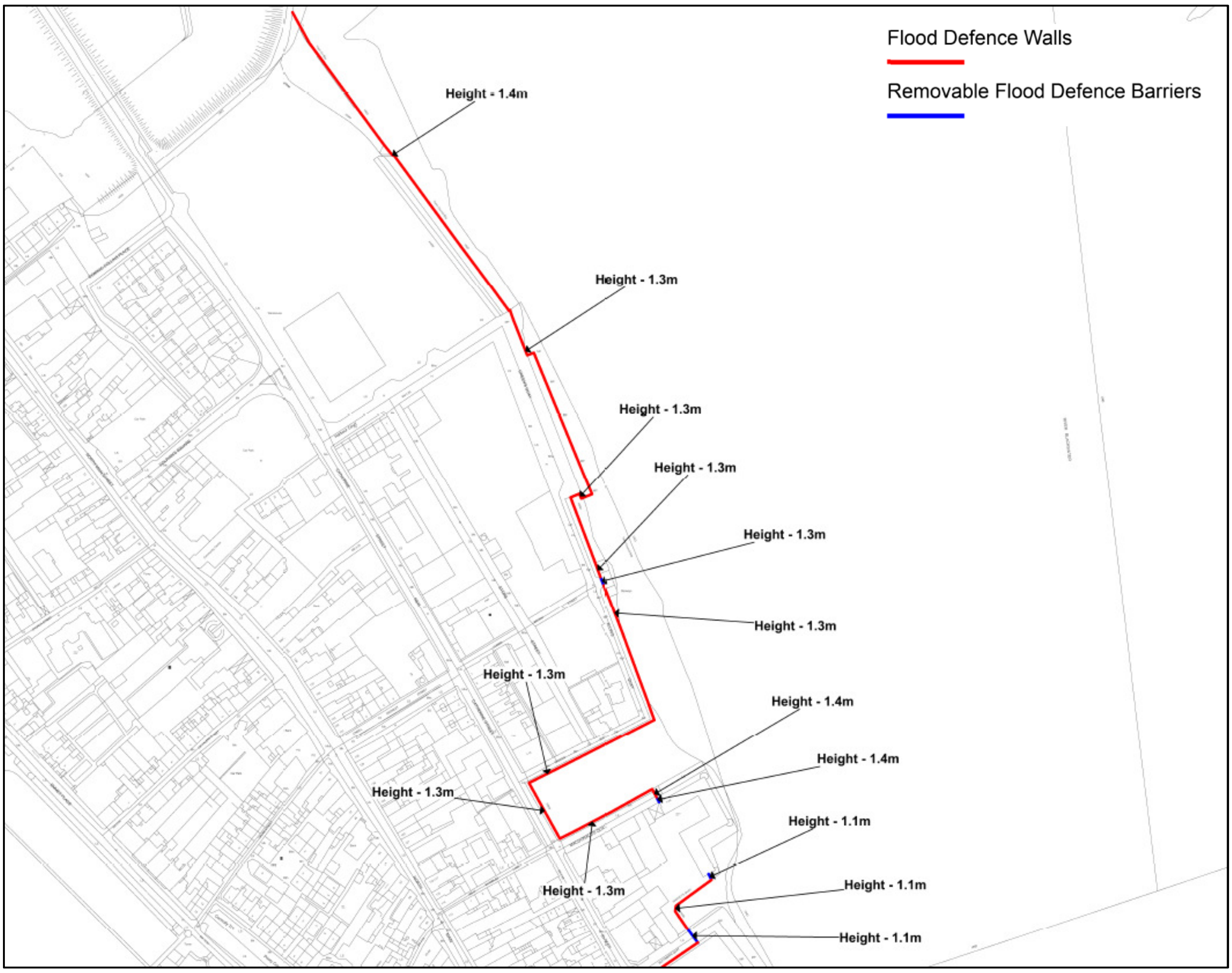


Figure 5.27: Youghal – Tidal Flood Defences 2

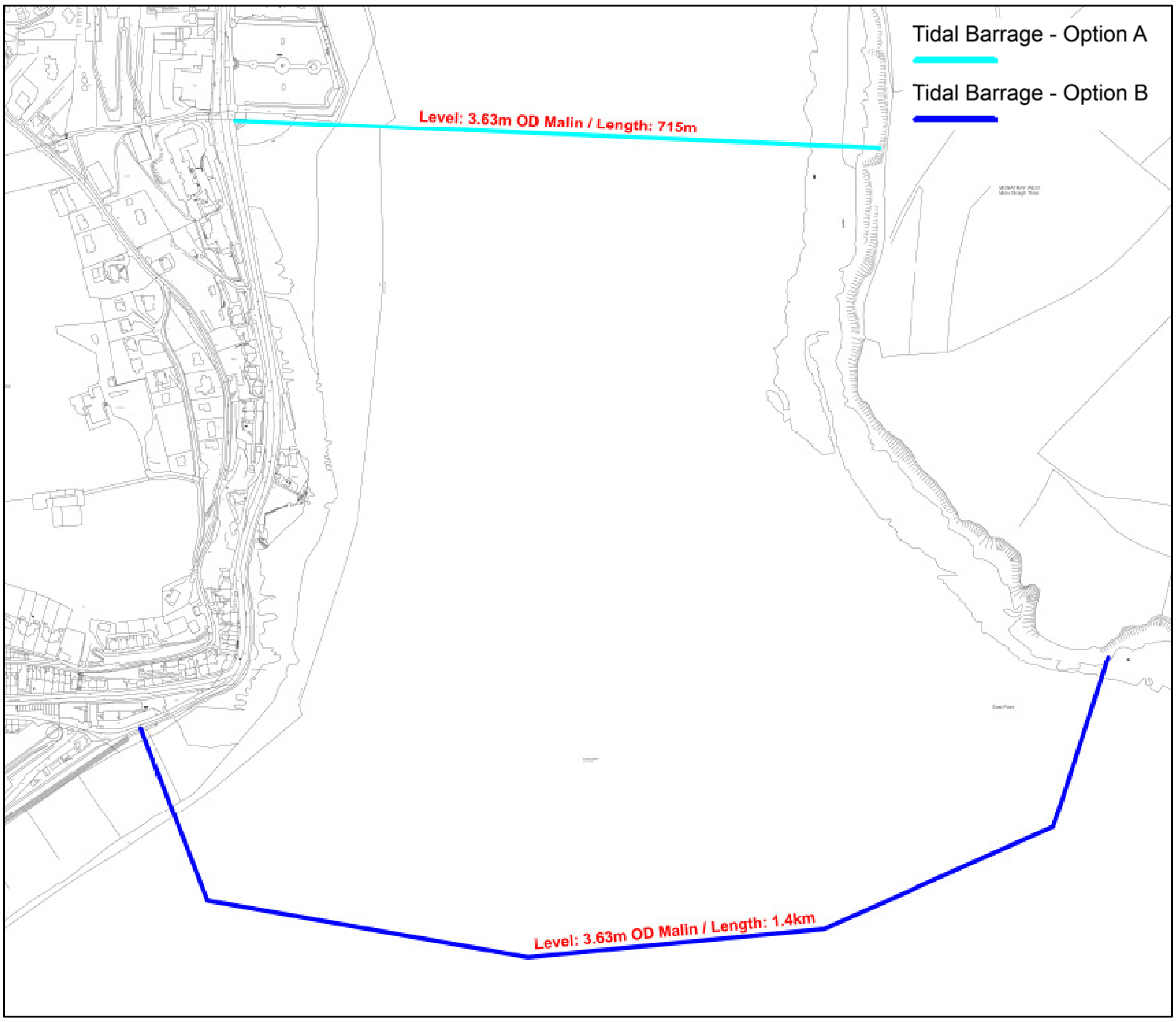


The proposed flood defences as outlined in the figures above are designed to achieve the required standard of protection for the 0.5% AEP tidal event. Flood defences are deemed to be a viable measure.

5.6.1.2 Tidal Barrage

This measure aims to mitigate the tidal flood risk through the construction of a tidal barrage. The level of the tidal barrage and the two locations assessed are shown in Figure 5.23.

Figure 5.28: Youghal – Tidal Barrage



Two potential locations for the tidal barrage were assessed as the narrowest part of the channel (Option A) is within a conservation area.

In order for the tidal barrage to be an effective measure it must have sufficient storage within the barrage to accommodate the fluvial flows during the 0.5% AEP tidal event. To maximise the potential storage area for fluvial flows the barrage should be closed at the low tide preceding a tidal event.

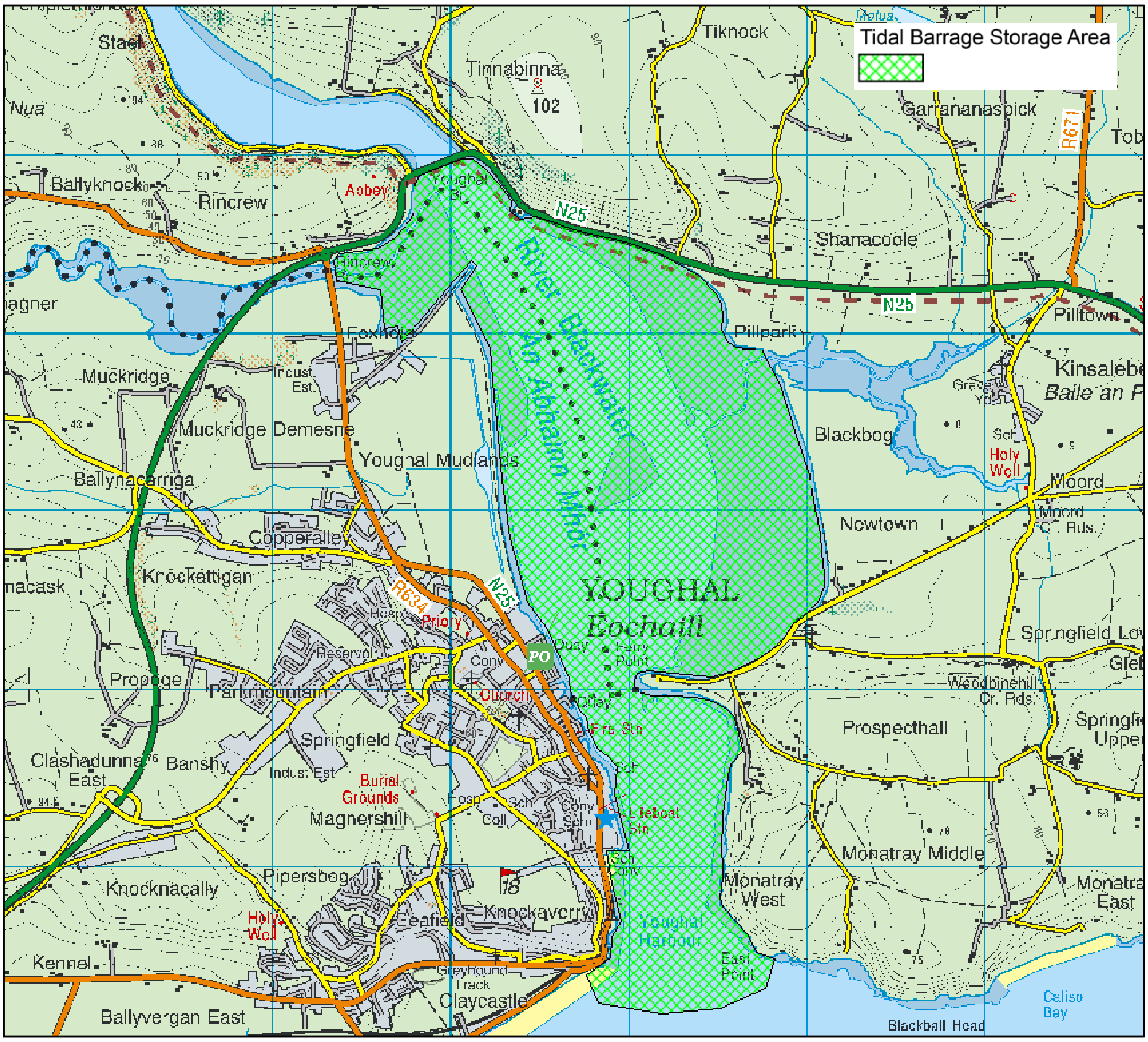
The lowest tide level within the bay preceding a 0.5% AEP tidal event is -1.19m OD Malin. The typical low bank level within the harbour is 1.6m OD Malin. If the barrage is closed at low tide, this gives an average depth of available storage for fluvial flows within the barrage of 2.49m.

The barrage should remain closed until the tide level outside is lower than the maximum water level within the barrage (1.6m OD Malin). Therefore, the barrage should remain closed for approx. 7 hours. Allowing for the 50% AEP fluvial event (543.6m3/s) to coincide with the 0.5% AEP tidal event, the tidal barrage must be able to store approx. 13.5Mm3 of fluvial flow. Based on the average depth of available storage of 2.49m, the tidal barrage should have an inside area of approx. 5,497,078.65m2. Figure 5.29 highlights the area inside the barrage which would be required to storage fluvial flows.

The maximum water level for the 0.5% AEP tidal event is 3.11m OD Malin. Allowing for wave height of 0.43m (total height) and freeboard of 0.3m the minimum level of the proposed tidal barrage is 3.63m OD Malin.

The proposed tidal barrage is deemed to be a viable measure for mitigating tidal flooding for the 0.5% AEP tidal event.

Figure 5.29: Youghal – Tidal Barrage Storage Area



5.6.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Flood Defences
- Tidal Barrage

5.6.3 Potential FRM Options

Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Monitoring and Flood Defences
- Option 2 – Monitoring and Tidal Barrage

6 Environmental Assessment

6.1 General

Refer to Appendix C for Draft SEA Options Appraisal Report and Appendix D for Draft Habitats Directive Screening (for Appropriate) Assessment.

7 Stakeholder Input

7.1 Draft Flood Mapping Public Consultation Days

Public Consultation Days (PCDs) were held in Unit of Management (UoM) 18 between December 2014 and February 2015. The purpose of the PCDs were to present the public with the Draft Flood Maps that have been prepared as part of the South Western CFRAM Study, to seek their feedback on those maps and on the Flood Risk management Objectives that apply to this area.

Details of the Public Consultation days held in the UoM 18 AFAs are shown in Table 7.1 below.

Table 7.1: Draft Flood Mapping PCDs

AFA	Date	Venue	Nr of Attendees
Freemount	2nd of December 2014	Freemount Community Centre	6
Kanturk	2nd of December 2014	Kanturk Library	2
Mallow	20th of February 2015	The Hibernian Hotel, Mallow	7
Fermoy	23rd of February 2015	The Grand Hotel, Fermoy	17
Ballyduff	16th of December 2014	Carnegie Library, Ballyduff	11
Rathcormac	3rd of February 2015	The Community Centre, Rathcormack	9
Tallow	20th of January 2015	Tallow Community Centre	6
Aglish	29th of January 2015	Aglish Community Centre	7
Youghal	14th of January 2015	Mall Arts Centre, Youghal	33

7.2 Flood Risk Management Measures

At the Draft Flood Mapping PCDs, attendees were asked to indicate what they thought should be done to manage flood risk in their AFAs. The responses are shown in Table 7.2 below.

Table 7.2: Flood Risk Management – Public Opinion

AFA	What needs to be done to manage flood risk?
Aglish	Some defence work and ongoing regular effective maintenance
Tallow	Clear Glenaboy between West Street and Mill Street. Clear trees to prevent blockage.
Youghal	Put in concrete wall defences
	Raise the wall right hand side of Town Hall and Lifeboats Station. Proper flood defences - possibly like Waterford City (glass over wall)
	Flood defences and raising of quay walls
	Dredge river
	Raise quay walls
	Make the existing quay walls higher, as already has been done at Nealon's Quay (an area that does not flood?). This needs to be done at McDonald's Quay, Fisherman's Dock. This will solve the flooding onto the back street and onto North Main Street. The quay wall would also need to be extended at Grattan Street.
	1. Continuation of wall up the quay 2. Pointing of wall (old) alongside RNLI Station to prevent collapse * As has already commenced in the UK, some low-lying rural areas will have to be sacrificed as they cannot be cost-effectively defended.
	Flood alert early warning system to be available to all residents in at-risk flood areas, i.e., text alerts, phone calls/emails. Designated resident to be appointed to ensure all residents are prepared to take action to secure safety property, sandbags readily available at drop-off points for homeowners.
	(1) The flood risk in the lower part of this catchment (Claycastle) arises because of inadequate outfalls for the watercourse to the sea (this has resulted from works done on the beach so far as I am aware). (2) The culvert at Seafield Estate is newly constructed and without the necessary statutory consent to the best of my knowledge. The above matters need to be addressed by the responsible body. (3) Flooding at the Greyhound Track seems to have been because of a lack of capacity in the channel possibly exacerbated by a need for maintenance which has been facilitated since 2002. (4) Flooding at the Seafield Textile Factory site - not sure what the cause of this event was. There may be a number of locations where culverts on the watercourse are inadequate and these may need to be upgraded, particularly if significant increase in flood risk is anticipated from increasing development. See Fig. 12 for locations as numbered above.

7.3 Preliminary Options PCDs

On the 4th of November 2015 and on 29 February stakeholder workshops were held with local Authority Engineers to discuss the emerging preferred options. Feedback received at this workshop was used to revise the proposed options in advance of the Public Consultation Days.

Between September 2015 and March 2016 PCDs were held to display various Flood Risk Management Options in each of the UoM 18 AFAs under consideration. Details of the PCDS are shown in Table 7.3 below.

Table 7.3: Details of Public Consultation Days

AFA	Date	Venue	Nr of Attendees
Kanturk	24th November 2015	The Library	10
Ballyduff	8th September 2015	Carnegie Library	6
Aglish	11th March 2016	Aglish Community Centre	8
Youghal	10th March 2016	Mall Arts Centre, Youghal	34
Rathcormac	25th November 2015	Parish Hall	13

At the Preliminary Options PCDs Attendees were asked to indicate their preference for the Flood Risk Management Options under consideration in each of the UoM 18 AFAs. Their responses are summarised in Table 7.4 below.

Table 7.4: Public Preference for Potential Options

AFA	Option	Nr of Rank 1 Received	Rank
Kanturk	Flood Defences	-	-
	Storage & Flood Defences	2	1
	Conveyance & Flood Defences	-	-
	Do Nothing	-	-
Ballyduff	Flood Defences	1	1
	Do Nothing	-	2
Aglish	Flood Defences	1	1
	Do Nothing	0	2
Youghal	Flood Defences	7	1
	Tidal Barrage (Inner)	1	2 (tied)
	Tidal Barrage (Outer)	1	2 (tied)
	Do Nothing	0	4

AFA	Option	Nr of Rank 1 Received	Rank
Rathcormac	Storage	2	2
	Flow Diversion	1	3
	Food Defences	-	4
	Do Nothing	5	1

8 Flood Risk Assessment

8.1 General

Flood risk mapping for the UoM 18 AFAs and Medium Priority Watercourses (MPWs) has been undertaken as part of this Study. The mapping includes the receptors that are at risk from flooding in the following categories:

- Society
- The Environment
- Cultural Heritage
- The Economy

The Flood Risk Maps for UoM 18 are included in an Annexe to the Preliminary Options Report: Annex I, Flood Risk Maps.

8.2 Receptors

Examples of the receptors in each of these categories are included in Table 8.1 below:

Table 8.1: Flood Risk Receptors

Category	Receptor
Society	People Homes Fire Stations Garda Stations Hospitals Care centres
The Environment	Protected Areas Pollution Sources
Cultural Heritage	Protected Archaeological Sites Protected Buildings
The Economy	Business Premises Roads Railway Ports Utilities

The numbers of receptors at risk from flooding in each AFA and each MPW are listed in tables 8.3 to 8.12 below. These numbers were calculated by counting the number of receptors that existed in a location that had a positive depth of flooding. These tables indicate the receptors at risk from the current scenario, the Mid-Range Future Scenario (MRFS) and the High End Future Scenario (HEFS) and are split into the Annual Exceedance Probability of the flooding concerned.

Annual Exceedance Probability, henceforth referred to as AEP, is a term used throughout this report and the wider CFRAM studies to refer to the rarity of a flood event. The probability of a flood relates to the likelihood of an event of that size or larger occurring within any one year period. For example, a one in hundred year flood has a one chance in a hundred of occurring in any given year; 1:100 odds of occurring in any given year; or a 1% likelihood of occurring. This is described as a 1% annual exceedance probability (AEP) flood event.

Table 8.2 converts the 'return periods' to %AEP for key flood events as a reference to previous studies.

Table 8.2: Flood Probabilities

% Annual Exceedance Probability (%AEP)	Odds of a Flood Event in Any Given Year	Chance of a Flood Event in Any Given Year or Previous 'Return Period'
50%	1:2	1 in 2
20%	1:5	1 in 5
10%	1:10	1 in 10
5%	1:20	1 in 20
2%	1:50	1 in 50
1%	1:100	1 in 100
0.5%	1:200	1 in 200
0.1%	1:1000	1 in 1000

Table 8.3 below lists the number of Inhabitants at risk from fluvial flooding in each AFA.

Table 8.3: Risk to Society: Nr. of Inhabitants

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	3	3	6	6	6	8	17	22	3	6	6	6	11	17	20	31	6	17	34
Ballyduff	0	0	3	3	3	8	11	11	0	3	3	3	11	11	11	17	3	11	20
Fermoy	0	0	0	3	3	3	3	210	0	3	3	3	3	157	213	224	3	213	227
Kanturk	6	6	8	11	31	148	207	370	6	8	22	106	202	283	342	389	104	288	398
Mallow	14	22	28	31	50	45	204	613	17	28	45	76	280	445	594	703	101	468	706
Rathcormack	3	45	48	53	53	56	56	59	45	48	53	53	56	56	56	62	53	56	64
Tallow	3	6	6	6	6	6	8	17	6	6	6	6	6	8	11	70	6	8	90
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	253	253	253

Table 8.4 below indicates the number of Residential Properties at risk from fluvial flooding in each AFA.

Table 8.4: Risk to Society: Nr. of Residential Properties

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	1	1	2	2	2	3	6	8	1	2	2	2	4	6	7	11	2	6	12
Ballyduff	0	0	1	1	1	3	4	4	0	1	1	1	4	4	4	6	1	4	7
Fermoy	0	0	0	1	1	1	1	75	0	1	1	1	1	56	76	80	1	76	81
Kanturk	2	2	3	4	11	53	74	132	2	3	8	38	72	101	122	139	37	103	142
Mallow	5	8	10	11	18	16	73	219	6	10	16	27	100	159	212	251	36	167	252
Rathcormack	1	16	17	19	19	20	20	21	16	17	19	19	20	20	20	22	19	20	23
Tallow	1	2	2	2	2	2	3	6	2	2	2	2	2	3	4	25	2	3	32
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	95	95

Table 8.5 below lists the number of high vulnerability properties at risk from fluvial flooding in each AFA. High vulnerability properties include Hospitals, Nursing Homes, Schools, Prisons, Camping / Halting sites.

Table 8.5: Risk to Society: Nr. of High Vulnerability properties

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ballyduff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fermoy	0	0	1	1	1	1	1	2	0	1	1	1	1	2	2	2	1	2	2
Kanturk	0	0	0	0	0	1	2	3	0	0	0	0	2	3	3	4	0	3	4
Mallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rathcormack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.6 below lists the number of Social Amenity Sites at risk from fluvial flooding in each AFA

Table 8.6: Risk to Society: Nr. of Social Amenity Sites

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Ballyduff	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1
Fermoy	0	0	0	0	0	0	0	7	0	0	0	0	0	5	7	7	0	7	7
Kanturk	0	0	0	0	1	3	4	6	0	0	1	3	4	5	5	6	3	5	6
Mallow	2	2	2	2	2	2	2	3	2	2	2	2	2	2	3	3	2	2	3
Rathcormack	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12	12

Table 8.7 below lists the number of properties on the National Inventory of Architectural Heritage at risk from fluvial flooding in each AFA

Table 8.7: Risk to Cultural Heritage: Nr. of NIAH Buildings

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	0	0	0	0	2	2	0	0	0	0	0	2	2	2	0	2	2
Ballyduff	2	3	3	4	4	4	4	4	2	4	4	4	4	4	5	5	4	5	5
Fermoy	0	0	0	0	0	1	1	82	0	0	0	0	0	41	93	101	0	89	104
Kanturk	0	1	2	3	3	6	7	22	1	2	2	6	10	14	22	23	9	25	25
Mallow	5	5	7	8	10	10	16	39	5	6	7	8	18	24	34	39	9	32	42
Rathcormack	0	0	1	1	1	1	1	3	0	1	1	1	1	2	3	3	1	3	3
Tallow	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	2	3	6
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	31	32

Table 8.8 below lists the number of Archaeological Monuments at risk from fluvial flooding in each AFA.

Table 8.8: Risk to Cultural Heritage: Nr. of RMPs

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ballyduff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fermoy	2	2	2	2	2	2	2	3	2	2	2	2	2	2	4	5	2	4	5
Kanturk	0	1	1	1	3	3	4	5	1	2	4	4	5	6	6	6	5	7	7
Mallow	5	7	8	8	9	9	9	12	6	9	9	9	10	11	11	12	6	12	12
Rathcormack	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1
Tallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8

Table 8.9 below lists the number of Non–Residential Properties at risk from fluvial flooding in each AFA

Table 8.9: Risk to the Economy: Nr of Non–Residential Properties

AFA	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	1	1	1	2	2	2	4	1	1	1	2	2	3	4	6	2	3	7
Ballyduff	5	6	7	8	10	10	10	11	6	7	8	10	10	10	11	13	10	11	13
Fermoy	1	1	7	9	9	9	9	174	1	9	9	9	9	85	190	206	9	190	214
Kanturk	19	23	25	35	55	99	139	203	22	28	44	80	137	181	196	215	79	174	219
Mallow	8	10	12	13	20	26	89	123	10	13	19	24	96	103	119	136	52	110	141
Rathcormack	1	10	10	11	11	11	11	11	10	11	11	11	11	11	11	11	11	11	11
Tallow	3	3	3	4	6	7	7	7	3	3	4	7	7	7	7	7	6	7	9
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	85	90

Table 8.10 below lists the number of Roads at risk from fluvial flooding in each AFA

Table 8.10: Risk to the Economy: Nr. of Roads

AFA	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	1	2	2	2	2	2	0	0	0	0	0	0	0	0	1	2	2
Ballyduff	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
Fermoy	0	1	1	1	1	1	1	6	1	1	1	1	1	6	6	6	1	10	10
Kanturk	0	0	0	0	1	4	4	4	0	0	2	4	4	4	4	4	4	4	4
Mallow	1	2	2	4	5	6	8	8	1	4	6	6	7	8	9	9	7	10	12
Rathcormack	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Tallow	2	2	2	2	3	3	3	3	2	2	2	3	3	3	3	4	3	3	4
Youghal	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	5	6

Table 8.11 below lists the number of Utilities at risk from fluvial flooding in each AFA

Table 8.11: Risk to the Economy: Nr. of Utilities

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Aglish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ballyduff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fermoy	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
Kanturk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mallow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rathcormack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Youghal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In addition to fluvial flood risk, Youghal in UoM 18 is at risk from tidal flooding. Table 8.12 below lists the receptors at risk from tidal flooding in this AFA.

Table 8.12: Tidal Flood Risk

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
Receptor	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	0.5%	0.1%
Inhabitants	0	3	5	13	59	85	120	274	232	285	338	378	394	410	511	644	684	807	873
Residences	0	1	2	5	22	32	45	103	87	107	127	142	148	154	192	242	257	303	328
High Vulnerability Properties	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Archaeological sites	0	0	0	0	4	5	7	12	10	13	16	16	16	16	16	16	16	16	16
Architectural Sites	0	0	0	0	6	8	9	30	21	31	39	41	46	48	60	71	83	88	101
Non-residential properties	0	1	1	1	13	20	30	93	68	102	133	142	156	175	195	215	220	247	264
Roads	0	1	1	1	1	2	2	3	5	5	6	6	6	6	6	6	6	6	6
Utilities	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1

8.3 Flood Risk Maps

Flood Risk Maps have been prepared to represent the various receptors at risk from flooding in each of the AFAs and MPWs. These maps are described in the following sections below.

8.3.1 Inhabitants Maps

Maps have been prepared to represent the number of people at risk from flooding of various frequencies. The number of people per house was taken from CSO data. For UoM 18 the average occupancy is 2.8 people per house. For each AEP flood extent the number of residential properties at risk was counted and multiplied by that occupancy. The numbers of people at risk are represented as a density per hectare on the maps.

8.3.2 Economic Activity Maps

The types of economic activity at risk from flooding in UoM 18 are shown on the economic activity risk map. The types of activities considered are:

- Property
- Infrastructure
- Rural Land Use
- Economic

8.3.3 Economic Risk Density Maps

Maps have been prepared to represent the economic risk from flooding of various frequencies. The economic risk is represented on the maps as a density of the Annual Average Damage value per hectare.

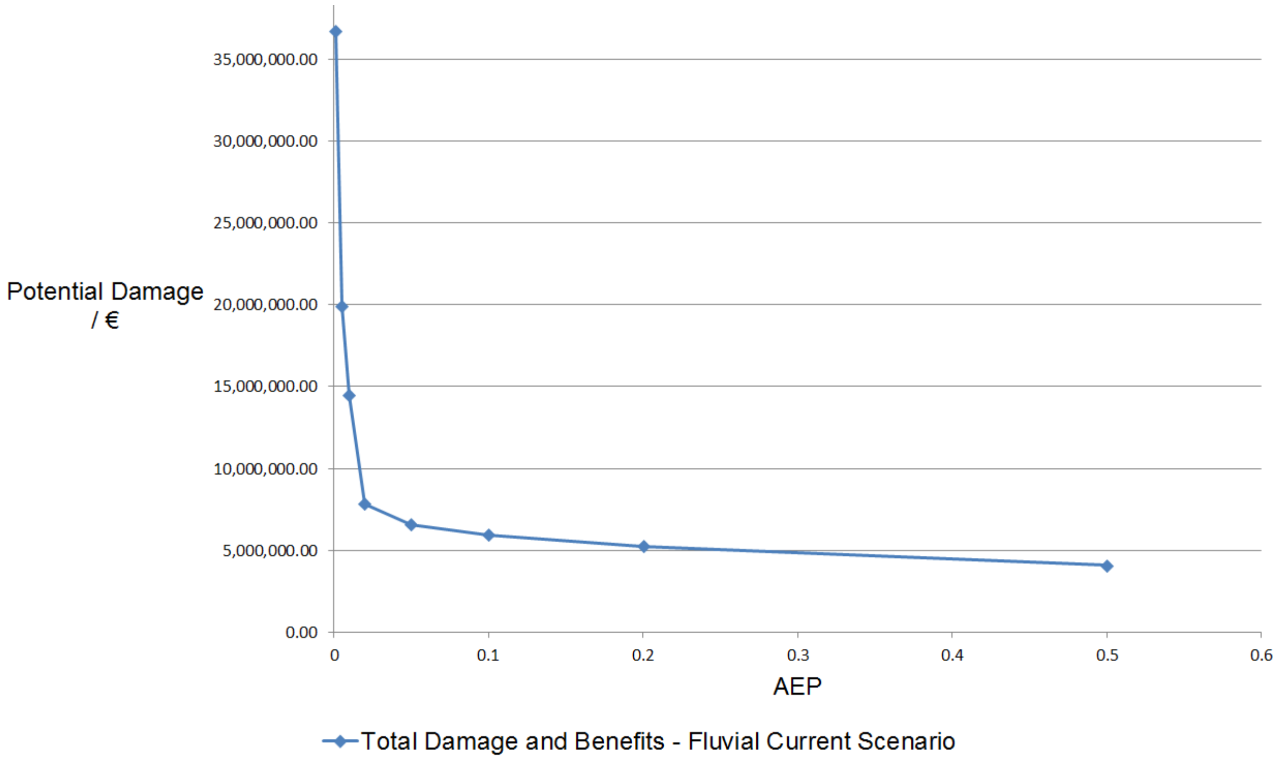
8.3.3.1 Annual Average Damage

The potential economic damage that could be caused by flooding was calculated for every property in each of the UoM 18 AFAs. The damage to a property is related to the type, use and the predicted depth of flooding within the property. It is possible to calculate the damage that could arise from a series of floods of different Annual Exceedance Probability (AEP). Using these damage values the Annual Average Damage for the AFA can be calculated by measuring the area under the Damage / Probability Curve.

For each property, the depth of flooding was extracted from the hydraulic model for the full range of design scenarios (i.e. 50% AEP to 0.01% AEP for both fluvial and tidal flooding). Using the research from the FHRC Multi-coloured Handbook, damage costs were calculated for each property for the range of scenarios.

The damage costs are based on property type and/or area. The total damages for each design scenario were summed and plotted on the annual average flood loss curve which is shown in Figure 8.1. The area under the curve is the Annual Average Damage (AAD).

Figure 8.1: Typical Damage / Probability Curve (Annual Average Flood Loss Curve)



The Annual Average Damage for each AFA is listed in Table 8.13 below.

Table 8.13: Annual Average Damage €

AFA	Current Scenario €	Mid-Range Future Scenario €	High End Future Scenario €
Freemount	0.00	0.00	0.00
Kanturk	780,678.99	3,136,886.27	4,451,584.57
Mallow	373,700.91	1,579,850.35	2,090,430.90
Fermoy	185,845.10	801,939.47	1,342,208.21
Ballyduff	197,676.80	261,577.08	299,904.59
Aglish	21,263.85	31,640.70	32,749.39
Youghal	72,504.29	5,910,457.90	17,034,541.33
Rathcormac	316,394.87	450,845.23	463,334.87
Tallow	178.14	2,058.92	3,034.44

In Mallow and Fermoy there are existing flood relief schemes in place. The figures above reflect the potential residual damages from flood events exceeding the design standard of the schemes and flooding in areas currently not included in the schemes.

8.3.3.2 Present Value Damage (PVd)

The Present Value Damage (PVd), based on a scheme that will have to be renewed after 50 years and a discount rate of 4%, has also been calculated. The PVd is calculated for each individual property in order to allow capping of PVd values where the PVd exceeds the current market value of the property.

Where a property's estimated potential damage for an event of 0.1% AEP is equal to or exceeds €0.5M, a threshold survey was carried out as a spot check on the ground level as determined by the DTM. Where a discrepancy was noted, the damage assessment was updated and damages recalculated. Spot checks were also carried out on properties where the PVd of a property is 1% or more of the total PVd for the AFA.

Table 8.14 lists all properties with damages for the 0.1% AEP event exceeding €0.5M or with a PVd greater than 1% of the Total AFA PVd

Table 8.14: List of properties with damages exceeding €0.5M or a PVd greater than 1% of the Total AFA PVd

AFA	Property Type	Object ID	Fluvial Damages 0.1% AEP €	Tidal Damages 0.1% AEP €	PVd - 1% of Total
Kanturk	Bungalow	2027760	107,258.93	n/a	3.00%
	Bungalow	2027809	63,202.02	n/a	1.54%
	Semi	2031594	61,032.47	n/a	1.92%
	Warehouse	2027327	32,413.71	n/a	1.47%
	Warehouse	2027367	83,997.47	n/a	8.27%
	Warehouse	2027395	150,432.19	n/a	12.23%
	Warehouse	2027610	67,754.40	n/a	3.14%
	Filling	2027656	116,489.16	n/a	6.18%
	Warehouse	2027802	91,352.67	n/a	5.69%
	Filling	2027808	50,409.43	n/a	3.29%
	Office	2027412	217,906.64	n/a	1.45%
	Office	2027767	13,313.62	n/a	1.27%
	Pub	2027432	56,128.72	n/a	2.81%
	Retail Warehouse	2027278	800,382.38	n/a	0.62%
	Shop	2027543	123,811.20	n/a	2.33%
	Shop	2031592	241,085.46	n/a	4.25%
	Shop	2031620	263,530.73	n/a	11.04%
	Storage	2027647	32,427.54	n/a	2.18%
	Surgery	2027437	133,123.31	n/a	4.28%
Ballyduff	Detached	679257	94,575.66	n/a	8.20%
	Bank	679254	92,353.14	n/a	1.06%

AFA	Property Type	Object ID	Fluvial Damages 0.1% AEP €	Tidal Damages 0.1% AEP €	PVd - 1% of Total
	Church	679105	81,008.48	n/a	1.22%
	Warehouse	679147	159,628.18	n/a	71.26%
	Storage	679219	54,831.62	n/a	1.11%
	Storage	679357	14,047.92	n/a	2.14%
	Storage	679469	136,184.97	n/a	13.36%
Aglish	Bungalow	1487070	29,651.02	n/a	2.11%
	Detached	1490352	61,565.42	n/a	89.94%
	Terrace	1487083	19,141.78	n/a	1.21%
	Terrace	1488364	22,803.69	n/a	1.12%
	Terrace	1490353	18,035.12	n/a	4.01%
Youghal	Bank	242887	0.00	100,447.35	1.06%
	Car Showroom	242917	0.00	73,843.42	2.22%
	Shop	242927	0.00	96,076.20	2.38%
	Shop	248243	0.00	63,279.90	2.24%
	Shop	242874	0.00	60,868.51	1.90%
	Shop	242564	0.00	109,148.63	2.64%
	Storage	242903	0.00	138,797.53	3.29%
	Shop	10130	0.00	280,438.14	4.12%
Tallow	Bungalow	3247875	0.00	n/a	7.65%
	Bungalow	3247933	0.00	n/a	4.96%
	Bungalow	3247937	0.00	n/a	1.37%
	Bungalow	3247943	0.00	n/a	4.96%
	Bungalow	3248018	0.00	n/a	4.96%
	Bungalow	3248020	0.00	n/a	7.39%
	Bungalow	3248357	0.00	n/a	3.28%
	Bungalow	3248358	0.00	n/a	1.93%
	Bungalow	3248359	0.00	n/a	4.96%
	Bungalow	3248360	0.00	n/a	1.93%
	Detached	3248218	1,724.70	n/a	1.97%
	Detached	3248414	0.00	n/a	7.90%
	Semi	3247739	0.00	n/a	6.31%
	Semi	3247812	0.00	n/a	5.13%
	Semi	3247931	0.00	n/a	2.13%
	Semi	3247968	2,308.66	n/a	3.27%
	Semi	3248058	8,291.75	n/a	3.46%
	Semi	3248096	0.00	n/a	2.71%
	Terrace	3247743	0.00	n/a	5.26%
	Terrace	3247777	0.00	n/a	3.40%
	Terrace	3247822	0.00	n/a	1.07%
	Storage	3248190	340.86	n/a	3.24%
	Storage	3248415	5688.98	n/a	10.14%

Following the survey spot check, adjustments were made as required and property damages were capped. For Residential properties, the damages were capped at the market value of the property and non-residential properties were capped at ten times the rateable value of the property. The capping process was carried out in line with Guidance Note 27. Market values for residential properties were determined within each AFA. Typical capping values for residential properties are as follows:

- Detached = €250k - €300k
- Semi-detached = €150k - €250k
- Terrace = €100k - €150k

The annual average damage and present value damages for each of the AFAs is listed in Table 8.15. The benefit of a flood risk management option (Scheme) was also calculated which is the damage avoided by implementing a scheme to the required Standard of Protection (SOP).

Table 8.15: Summary of Damages & Benefit of Scheme Benefit

AFA	AAD €	PVd	Capped PVd	Benefit of Scheme (Damage Avoided) €
Freemount	0.00	0.00	0.00	0.00
Kanturk	780,678.99	16,770,690.12	13,509,503.33	11,023,136.26
Mallow	373,700.91	8,027,911.97	8,027,911.97	4,374,802.81
Fermoy	185,845.10	3,992,358.72	3,992,358.72	856,539.36
Ballyduff	197,676.80	4,246,529.47	3,170,954.12	2,961,254.22
Aglish	21,263.85	456,793.94	297,327.81	261,834.89
Youghal (MRFS)	5,910,457.90	126,969,547.68	63,139,266.55	60,127,317.25
Rathcormac	316,394.87	6,796,853.05	4,854,795.07	4,591,568.95
Tallow	178.14	3,826.76	3,826.74	2,219.12

As outlined in Section 5.0, due to concerns over the water level for the 0.5% AEP tidal event in Youghal, the MRFS water level and associated damages have been adopted for the development of FRM options.

Table 8.16 lists the benefit or damage avoided by implementing a flood forecasting and warning system.

Table 8.16: Benefit of Implementing a Flood Forecasting & Warning System

Spatial Scale of Assessment	Infrastructure	Benefit € (13% of PVd)
AFA		
Freemount (River Allow)	Rain gauges River level gauges Build on existing Bandon Flood Early Warning System	0.00
Freemount (Knockeen Stream)	Short time to peak, flashy flood warning likely to be ineffective	0.00
Kanturk	Rain gauges in the Allow and Dalua catchments River level gauges on the Allow and Dalua Connect to Mallow / Fermoy Flood Warning System	2,180,189.72
Ballyduff	Add to Mallow / Fermoy Flood Warning System	552,048.83
Rathcormac	Short time to peak, flashy catchment, flood warning likely to be ineffective	0.00
Tallow	Short time to peak, flood warning likely to be ineffective	0.00
Aglish	Short time to peak, flood warning likely to be ineffective	0.00
Youghal	Use the existing OPW storm surge forecasting system to predict high tide levels.	16,506,041.20
UoM		
River Blackwater	Build on the existing Mallow / Fermoy Flood Warning System Use the existing OPW storm surge forecasting system to predict high tide levels.	20M +

Source: UoM 18 Hydraulics Report

The benefit of implementing a flood forecasting and warning system at the sub-catchment and UoM scale is likely to be greater than shown in Table 8.16 as it has the potential to reduce damages along MPWs and other watercourses not assessed as part of this study. However, there is a corresponding cost increase due to additional gauges etc.

8.3.4 General Risk Maps

General Risk Maps have been prepared for each of the watercourses modelled in UoM 18. These maps show the receptors at risk and the flood extents for three AEPs. The general risk maps are categorised by Flood Risk Receptor type. That is;

- Society
- The Environment
- Cultural Heritage
- The Economy

The AEPs of flooding shown on the general Risk Maps are the 10% AEP, the 1% AEP and the 0.1% AEP.

9 Estimates of Cost

9.1 Flood Forecasting and Warning Systems

The cost of the flood forecasting and warning systems were calculated using the rates and methods contained in the Unit Cost Database developed by the OPW for use in the CFRAM studies. The estimates in Table 9.1 include costs for specifications, site surveys, gauging and telemetry equipment, forecast model setup and development along with training, operation and maintenance. In addition, in order to take account of the high level nature of the estimate and include for unseen costs, optimism bias is included in these estimates. The costs are exclusive of VAT. Full details of the costs are included in Appendix A.

Table 9.1: Estimate of Costs – Flood Forecasting and Warning Systems

Spatial Scale of Assessment	Infrastructure	Benefit € (13% of PVd)	Estimated Cost / €
AFA			
Freemount (River Allow)	2 Nr. Rain Gauges 2 Nr. River Level Gauges (Hydrometric Station)	0.00	567,456.00
Kanturk	8 Nr. Rain Gauges 9 Nr. River Level Gauges (Hydrometric Station)	2,180,189.72	1,086,277.00
Ballyduff	Add to Mallow / Fermoy Flood Warning System	552,048.83	< 100k
Youghal	Use the existing OPW storm surge forecasting system to predict high tide levels.	16,506,041.20	< 100k
UoM			
River Blackwater	Build on the existing Mallow / Fermoy Flood Warning System Use the existing OPW storm surge forecasting system to predict high tide levels.	20M +	< 1.5M

From Table 9.1 it can be seen that flood forecasting is not a viable measure for Freemount.

Details of the existing forecasting system in Mallow and Fermoy are not readily available to fully assess the additional infrastructure required to include Ballyduff. However, based on the damages avoided and economies of scale, building on the existing system for Ballyduff is likely to be a viable measure.

In addition, extending the existing system to areas within the UoM that are at risk and where effective warnings can be achieved could be a viable measure.

It should be noted that the implementation of a measure / option at another SSA (i.e. AFA flood relief scheme) has the potential to reduce the benefit of a flood forecasting and warning system. Depending on the standard of protection this could be a significant reduction as the benefit would be reduced to less than 13% of the residual risk.

9.2 Structural Options

The cost of each option was calculated using the rates contained in the Unit Cost Database developed by the OPW for use in the CFRAM studies. This database contains rates for constructing various types of flood risk management measures depending on their height (depth), length and location.

The estimates in Table 9.2 below include costs for construction, maintenance, operation, land acquisition, and professional fees. In addition, in order to take account of the high level nature of the estimate and include for unseen costs, optimism bias is included in these estimates. The costs are exclusive of VAT. Full details of the costs are included in Appendix A.

Table 9.2: Estimate of Costs for Potential Options

AFA	Option	Estimated Cost / €	Benefit of Scheme €
Kanturk	Flood Defences	7,945,384.07	11,023,136.26
	Storage & Flood Defences	8,220,675.24	
	Conveyance & Flood Defences	7,445,726.85	
Ballyduff	Flood Defences	836,026.42	2,961,254.22
Aglish	Flood Defences	230,373.88	261,834.89
Youghal	Monitoring & Flood Defences	7,130,781.63	60,127,317.25 (MRFS)
	Monitoring & Tidal Barrage (Location A)	186,236,473.26	
Rathcormac	Storage	534,134.09	4,591,568.95
	Flow Diversion	1,151,800.52	
	Flood Defences	700,060.12	

10 Appraisal of Options

The effectiveness and potential impacts of each of the potential options is assessed using a Multi Criteria Analysis, (MCA). This MCA process assigns a score for each option that relates to how effective that option is in terms of achieving set goals under a set of objectives. The MCA can then be used to guide the decision on which particular option is the preferred option to manage flood risk in a particular area.

10.1 Flood Risk Management Objectives

The effectiveness of each of the potential options is measured in terms of how it achieves a set of Flood Risk Management Objectives. These objectives are split into a number of categories. These are:

- Technical
- Economic
- Social
- Environmental

Some of these objectives are further split into sub-objectives, where this is not the case the sub objective is the same as the objective. The Objectives and Sub objectives are shown in Table 10.1 below.

Table 10.1: Flood Risk Management Objectives

Criteria		Objective		Sub-Objective
1 Technical	a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust
	b	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	I)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options
	c	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change
2 Economic	a	Minimise economic risk	i)	Minimise economic risk
	d	Minimise risk to transport infrastructure	i)	Minimise risk to transport infrastructure
	c	Minimise risk to utility infrastructure	i)	Minimise risk to utility infrastructure
	d	Minimise risk to agriculture	i)	Minimise risk to agriculture
3 Social	a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents
			ii)	Minimise risk to high vulnerability properties
	b	Minimise risk to community	i)	Minimise risk to social infrastructure and amenity
			ii)	Minimise risk to local employment
4 Environmental	a	Support the objectives of the WFD	i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.

Criteria		Objective		Sub-Objective
	B	Support the objectives of the Habitats Directive	i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.
	c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.
	d	Protect, and where possible enhance, fisheries resource within the catchment	i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.
	e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.
	f	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.
			ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.

:Source ; GN28

10.2 Global and Local Weightings

In order to take account of the relative importance of some objectives in comparison other objectives, each sub-objective is given a Global Weighting. These global weightings are set at a national level and are the same across all of the CFRAM Studies.

The Global Weightings for each sub objective are shown in Table 10.2 below.

Table 10.2: Global Weighting of Flood Risk management Objectives

Objective Ref	Sub Objective	Global Weighting
1(a)(i)	Ensure flood risk management options are operationally robust	20
1(b)(i)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	20
1(c)(i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	20

Objective Ref	Sub Objective	Global Weighting
2(a)(i)	Minimise economic risk	24
2(b)(i)	Minimise risk to transport infrastructure	10
2(c)(i)	Minimise risk to utility infrastructure	14
2(d)(i)	Minimise risk to agriculture	12
3(a)(i)	Minimise risk to human health and life of residents	27
3(a)(ii)	Minimise risk to high vulnerability properties	17
3(b)(i)	Minimise risk to social infrastructure and amenity	9
3(b)(ii)	Minimise risk to local employment	7
4(a)(i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.	16
4(b)(i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	10
4(c)(i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.	5
4(d)(i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.	13
4(e)(i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.	8
4(f)(i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.	4
4(f)(ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.	4

Source: GN28

In order to take cognisance of the local perspective on the relative importance of objectives, each sub objective is also given a local weighting. Local weightings vary from 0 for not locally important to 5 for very important locally.

During the Draft Flood Mapping Public Consultation Day (PCD) the public were invited to consider each of the sub-objectives and provide a weighting on its importance. The local weightings listed below, which have been used in the MCA, are based on an assessment of the importance of these sub-objectives which has been informed by the input of the public at the PCD.

The Local Weighting for each FRM objective is shown in Table 10.3 below. The table also outlines the manner in which the Local weighting is derived. In some instances the Local Weighting is determined through local consultation. In other instances they are calculated based upon the number of receptors affected. The data used for calculating the local weighting are included in Appendix F1.

Table 10.3: Local Weighting

Sub Objective	Kanturk	Ballyduff	Aglish	Youghal	Rathcormac	Calculation Method
1(a)(i)	5	5	5	5	5	Constant
1(b)(i)	5	5	5	5	5	Constant
1(c)(i)	5	5	5	5	5	Constant
2(a)(i)	5	5	0.16	0.63	5	AAD(excluding intangible damages) / €75,000
2(b)(i)	1.05	5	5	5	5	Based on calculated assessment, adjusted by professional judgement
2(c)(i)	0	0	0	0	2.5	Based on calculated assessment, adjusted by professional judgement
2(d)(i)	0	0	0	2.66	0	By professional judgement assisted by local advice
3(a)(i)	3.75	0.25	1.25	2.03	5	Based on calculated assessment, adjusted by professional judgement
3(a)(ii)	5	0	0	0	0	Based on calculated assessment, adjusted by professional judgement
3(b)(i)	1.18	1.25	0	2.63	5	Based on calculated assessment, adjusted by professional judgement
3(b)(ii)	5	5	1.11	3.12	5	Based on calculated assessment, adjusted by professional judgement
4(a)(i)	5	5	5	5	5	Constant
4(b)(i)	5	5	0	5	3	By professional judgement assisted by local advice
4(c)(i)	5	5	2	5	2	By professional judgement assisted by local advice
4(d)(i)	4	3	0	5	0	By professional judgement assisted by local advice
4(e)(i)	4	3	0	3	0	By professional judgement assisted by local advice
4(f)(i)	3	3	0	3	1	By professional judgement assisted by local advice
4(f)(ii)	3	3	0	3	1	By professional judgement assisted by local advice

Source: GN 28

10.3 MCA Scoring

Each sub objective has a basic requirement and an aspirational target associated with it. The basic requirement for each sub objective equates to a no change scenario. That is the status quo before the FRM option is adopted. The aspirational target in most cases is set to the highest achievement that is reasonably possible against the sub-objective in implementing the FRM option. The performance of each FRM option is measured against the basic and aspirational targets for each sub objective and assigned a score in accordance with the principals in Table 10.4 below.

Table 10.4: MCA Scoring

Option Performance	Score
Meets Aspirational Target	5
Partially Achieving Aspirational Target	Score in proportion to performance
Meeting Basic Requirement (No Change)	0
Just Failing Basic Requirement	Score in proportion to performance
Fully Failing Basic Requirement	-5
Totally Failing Basic Requirement (Option Illegal or Totally Unacceptable)	-999

In the MCA the technical objectives measure if an option is robust in terms of operation. Higher scores are allocated to options that do not rely on mechanical, electrical or human intervention to operate effectively. Examples of such interventions include sluice gates, storm water over pumping, or erection of demountable barriers. The technical objectives also consider if the options can be constructed safely and if they can be adapted to future changes.

The adaptability of each option to the possible impacts of climate change is assessed through a qualitative decision tree. This involves identifying what flood risk management measures might be required in the future, what is required now and ensuring that decisions made now are adaptable to permit an effective and efficient transition to the management of potential future flood risk. The decision tree is a graphical representation of how the option can be adapted over time and of the scores given to each option. The decision trees are included in Appendix C.

The scoring for a given option reflects the cost and the degree of difficulty and potential impacts of future adaptions that would be necessary to maintain the Standard of Protection of the option under the MRFS and/or HEFS, whereby the greater the cost, difficulty and impact, the lower the score. The decision tree and scores for each SSA are included in Appendix E. The scores from the decision trees are used in the MCA.

The measurement of the performance of the options against the objective to avoid economic damage is measured in terms of the percentage of economic damage avoided by that option. Certain receptors in Coastal AFAs are at risk from fluvial and tidal flooding. On the basis of historical flood records it can be

said that these flooding mechanisms are independent of each other. For this reason when assessing the potential damage to properties in Coastal AFAs this report considers that the total potential damage is equal to the total potential fluvial damage added to the total potential tidal damage. Similarly when assessing the damage avoided by a particular option the total damage avoided is equal to the total fluvial damage plus the total tidal damage avoided. When calculating the percentage reduction in damage for a particular option this is calculated relative to the total potential damages in the town. The economic objectives also measure the performance of the option in terms of reducing the risk to transportation routes, utility infrastructure and agricultural land.

The social objectives in the MCA include the reduction of flood risk to people, high vulnerability properties such as hospitals and fire stations and to social infrastructure and amenities. Under social objectives the MCA also measures the performance of the option to reduce the risk to local employment in relation to the number of non-residential properties at risk.

Under the Environmental criteria the MCA measures the performance of the option under environmental headings such as:

- Promote achievement of good status in waterbodies
- Avoiding damage to protected habitats
- Minimising the risk of environmental pollution
- Avoid damage to the flora and fauna of the catchment
- Avoid damage to fisheries habitats
- Protect landscape character and visual amenity within the river corridor
- Avoid damage to features of architectural value
- Avoid damage to features of archaeological importance

Once all of the options have been analysed with reference to their performance against each of the sub-objectives the MCA score for each criteria can be calculated. This is done by multiplying the score for each sub objective by the Global and the local Weighting and then by summing the weighted scores for all the sub objectives under that criteria.

The **MCA Benefit Score** is calculated by adding the weighted score for the Economic, Social and Environmental Criteria together. This score represents the net benefits of the option.

The **Option Selection MCA Score** is calculated by adding the weighted scores of all the criteria together. This score includes the technical score and therefore includes all of the aspects that should be taken into account in considering the preferred option for a given location.

The **Total Construction Cost €** is the cost of the FRM option as outlined in Section 9.

The **MCA Benefit – Cost Ratio** is calculated by dividing the **MCA Benefit Score** by the cost of the option. This is a numerical but non monetised ratio that indicates the overall benefits that can be delivered per euro of investment.

The **Economic Benefit €** is the cost of the damage avoided for the FRM Option.

The **Economic Benefit – Cost Ratio** is calculated by dividing the cost of the damage avoided by adopting the FRM Option by the cost of the option. This is the traditional method used by OPW in assessing the economic case for proceeding with a flood relief scheme. In general terms a flood relief scheme would be considered economically viable if the benefit cost ratio is greater than 1.

10.4 Measures Being Undertaken under Other Policy Areas

Flood related measures being undertaken under other policy areas have the potential to have an impact on flood risk in the UoM. The relevant policy areas may relate to EU Directives 85/337/EEC (EIA Directive), 96/82/EC (Seveso II Directive), 2001/42/EC (SEA Directive) and 2000/60/EC (Water Framework Directive).

11 Selection of Preferred Options

11.1 Preferred Flood Risk Management Options – UoM

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for UoM 18 are set out below:

- Planning Control
- Building Regulations
- SUDS
- Flood Forecasting and Warning Systems
  - Build on Mallow / Fermoy Forecasting and Warning System
- Public Awareness
- Individual Property Flood Resilience
- Land Use Management

11.2 Preferred Flood Risk management Options – Sub-Catchment

There are no sub-catchments in UoM 18.

11.3 Preferred Flood Risk Management Options – AFAs

11.3.1 MCA Scores

The Scores achieved by each viable option under consideration are listed in Table 11.1 below. The initial rank is based on the MCA Benefit Cost Ratio. Details of the MCA undertaken for each AFA are contained in Appendix F.

Table 11.1: MCA Scores for Potential Options

AFA / Option	Cost Estimate €	Capped Scheme Benefit €	MCA Benefit Score	Option Selection MCA Score	MCA Benefit Cost Ratio (Millions)	Economic Benefit Cost Ratio	Initial Rank
Kanturk							
Do Nothing	-	-	-801.00	-801.00	0.00	0.00	4
Flood Defences	7,945,384.07	11,023,136.26	1375.20	2275.20	173.08	1.39	2
Storage & Flood Defences	8,220,675.24	11,023,136.26	1145.20	1978.20	139.31	1.34	3
Conveyance & Flood Defences	7,445,726.85	11,023,136.26	1769.2	2669.20	237.61	1.48	1
Ballyduff							
Do Nothing	-	-	0.00	0.00	0.00	0.00	2
Flood Defences	836,026.42	2,961,254.22	665.92	1715.92	796.53	3.54	1
Aglish							
Do Nothing	-	-	0.00	0.00	0.00	0.00	2
Flood Defences	230,373.88	261,834.89	35.40	1085.40	153.66	1.14	1
Youghal							
Do Nothing	-	-	-72.00	-72.00	0.00	0.00	3
Monitoring & Flood Defences	7,130,781.63	60,127,317.25	500.94	1033.94	70.25	8.43	1
Monitoring & Tidal Barrage (A)	186,236,473.26	60,127,317.25	-337.06	762.94	-1.81	0.32	2
Rathcormac							
Do Nothing	-	-	-80.00	-80.00	0.00	0.00	4
Storage	534,134.09	4,591,568.95	1638.35	2538.35	3067.30	8.60	1
Flow Diversion	1,151,800.52	4,591,568.95	1238.35	2238.35	1075.14	3.99	3
Flood Defences	700,060.12	4,591,568.95	1168.35	2168.35	1668.93	6.56	2

11.3.2 Feedback Provided on Options

At the public consultations for Preliminary Flood Risk Management Options the public were asked to rank the potential options in terms of their preference. The feedback received is included in Table 11.2 below.

Table 11.2: Public Preference for Potential Options

AFA	Option	Nr of Rank 1 Received	Rank
Kanturk	Flood Defences	-	-
	Storage & Flood Defences	2	1
	Conveyance & Flood Defences	-	-
	Do Nothing	-	-
Ballyduff	Flood Defences	1	1
	Do Nothing	-	2
Aglish	Flood Defences	1	1
	Do Nothing	0	2
Youghal	Flood Defences	7	1
	Tidal Barrage (Inner)	1	2 (tied)
	Tidal Barrage (Outer)	1	2 (tied)
	Do Nothing	0	4
Rathcormac	Storage	2	2
	Flow Diversion	1	3
	Food Defences	-	4
	Do Nothing	5	1

In addition to the options selected for the UoM, the preferred options for each of the AFAs are listed below.

The selection of the preferred Flood Risk Management Option for each of the AFAs is based on the MCA and the feedback provided during the public consultation.

11.3.2.1 Kanturk

The preferred option identified in the MCA is Conveyance and Flood Defences. There was limited feedback provided at the Kanturk PCD which indicated that the preferred option was storage and flood defences. Feedback provided by the Local Authority indicated that the conveyance measure would be detrimental to local angling activities in this area. For this reason, exercising our professional judgement we have determined that storage and flood defences is the preferred option for Kanturk.

11.3.2.2 Ballyduff

The preferred option identified in the MCA is Flood Defences. There was limited feedback provided at the Ballyduff PCD which indicated that the public agreed with the preferred option indicated in the MCA. As an interim measure, before the preferred option is implemented, extending the existing Mallow / Fermoy Flood Forecasting and Warning System to Ballyduff would be of benefit.

11.3.2.3 Aglish

The preferred option identified in the MCA is Flood Defences. There was limited feedback provided at the Aglish PCD which indicated that the public agreed with the preferred option indicated in the MCA.

11.3.2.4 Youghal

The preferred option identified in the MCA is Flood Defences. However, further analysis is required on the relationship between extreme offshore and nearshore water levels to get certainty on the depths of extreme flooding in Youghal. This can be gained by the installation of a water level gauge in Youghal and observing the relationship between the nearshore and offshore levels for a range of tide and surge conditions. As an interim measure, before the preferred option is implemented, the installation of a tide gauge and a flood forecasting and warning system would be of significant benefit in Youghal.

11.3.2.5 Rathcormac

The preferred option identified in the MCA is Storage and this was displayed at the Rathcormac PCD. The feedback provided at the PCD indicated that public preference is the “Do Nothing” option. Public opinion is that flooding is due to blockage of culverts and regular maintenance is required. This is not a viable option due to the risk and economic damages associated with the design event.

Furthermore, strong opposition was received at the PCD to the storage option. Based on this feedback and the MCA, the preferred option is now Flood Defences which is also cost beneficial.